

FAUNA OF THE CHILKA LAKE

INTRODUCTION.

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(Plates I and II.)

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# FAUNA OF THE CHILKA LAKE

## PREFACE.

Some years ago a series of short papers on the fauna of brackish pools at Port Canning in the Gangetic delta was published in the *Records of the Indian Museum*. I had intended to make these the basis of a much more comprehensive study of the fauna of brackish water in Bengal and other parts of India, but as time went on it became evident that the area of these pools was too limited, and their biological equilibrium too subject to interference on the part of man, for them to be regarded as in any way typical. On several occasions I had visited the Chilka Lake for the purpose of collecting the animals of its shores and islands, but it was not until July, 1913, when bottom-nets were used for the first time, that the real interest of the lake fauna became apparent. On this occasion I was so struck by the association of marine and freshwater forms that I sent to Calcutta for Mr. Kemp to join me at Barkul and we drew up together a scheme for a comprehensive, zoological survey of the lake.

In due course our plan was laid before the Trustees of the Indian Museum, who accepted it in a most generous spirit and put aside ample funds for its realization. With their approval we hired the only steam-launch on the lake, obtained the necessary apparatus by purchase from Europe or from local sources and arranged to spend, together or severally, a considerable part of the year 1914 on the lake or its shores.

I take this opportunity to state that all the physical observations whereby the positions of our collecting-stations were established and the varying salinity of the water ascertained were made by Mr. Kemp, whose practical experience of marine investigations is more extensive than my own.

So far as the preparation of this volume is concerned, we have worked in the strictest collaboration, and even those reports that are issued in the name of one of us have had the benefit of revision at the hands of the other. Our acknowledgment of the assistance we have received is expressed in a general manner in the Introduction that follows; in the case of reports on the groups that we have not ventured to discuss ourselves from a taxonomic point of view, the papers themselves will provide the best proof of our indebtedness.

CALCUTTA:  
May 14th, 1915.

N. ANNANDALE,  
*Superintendent of the Indian Museum.*

# FAUNA OF THE CHILKA LAKE

No. 1.

JULY, 1915.

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# FAUNA OF THE CHILKA LAKE

## INTRODUCTION.

By N. ANNANDAIE and STANLEY KEMP.

### GEOGRAPHY OF THE LAKE.

The Chilka Lake is a lagoon situated on the east coast of Peninsular India and connected with the Bay of Bengal. Its area is about 350 sq. miles; its depth rarely exceeds two fathoms; its water undergoes great changes of salinity in the course of the year and at any one season differs greatly in this respect at different places. The precise geographical situation of the lake is between latitudes  $19^{\circ}28'$  and  $19^{\circ}54'$  N. and longitudes  $85^{\circ}6'$  and  $85^{\circ}35'$  E.; the greater part of it lies in the Puri District of the Province of Bihar and Orissa, while one corner extends into the Ganjam District of the Madras Presidency.

*Its position and character.*

A glance at the map (plate II) will show that the lake consists of two parts,

*Its divisions.*

(i) an outer channel opening to the sea and (ii) what may conveniently be called the main area.

The outer channel is peculiar in that its course is not direct from the sea to the lagoon, but runs parallel to both for some miles. Its total length is about twelve miles and the breadth of the outer part nowhere more than one and a quarter. The actual mouth of this channel changes from time to time both in position and in breadth; in 1914 it was situated opposite the village of Arakhuda and was not more than 300 yards broad. Near the opening the channel turns abruptly at right angles to its former course and communicates with the sea by a narrow passage several hundred yards in length and apparently of no great depth. There are records that on several occasions the mouth has been completely blocked up by sand carried along the coast by northerly currents, especially in the south-west monsoon.<sup>1</sup> It has then been opened artificially by digging to prevent flooding of the surrounding country.

From the inner opening of the sea-passage the channel runs almost directly south-west. On one side it is separated from the sea by a narrow sand-spit and on the other from the main area of the lake by a series of comparatively broad peninsulas and islands. On reaching the apex of the Satpara peninsula the channel divides into two branches, one of which continues in the original course until it becomes gradually merged in a network of swamps and narrow water-ways. The broader branch, however, turns at a right angle and, continuing round Satpara peninsula,

---

<sup>1</sup> The origin and direction of the local currents on this coast are still very imperfectly known, and it is probable that more than one factor plays a part in the phenomenon to which we refer.

finally reaches the main area at the point called Mugger-Mukh<sup>1</sup> (Shark mouth). In the flood-season this is one of two openings into the main area, for there is another south-west of the large flat island of Barnikuda which lies in the midst of the inner part of the channel; but even the opening at Mugger-Mukh becomes extremely shallow in the dry season, while the other disappears altogether. In March there is not more than a foot and a half of water on the bar<sup>at</sup> the former point.

The main area of the Chilka Lake is the real lagoon and occupies by far the greater part of the lake-system. It is roughly pear-shaped, the longer axis running south-west and north-east. Its length is about forty miles in the height of the dry season and its greatest breadth about twelve and a half miles. The broadest point is situated toward the north-east extremity.

The shores of the Chilka Lake have considerable variety of character. Smooth green lawns, diversified by clumps of trees, slope down to the water's edge: rocky headlands rise as pyramids, seemingly composed of loose boulders piled one on another with bamboos and other vegetation springing up in the interstices; islands, some bare and rocky, others like the headlands, others again low and sandy, rise from the surface of the water; naked sand-hills contrast with the dark green foliage in which fishing villages lie hidden.

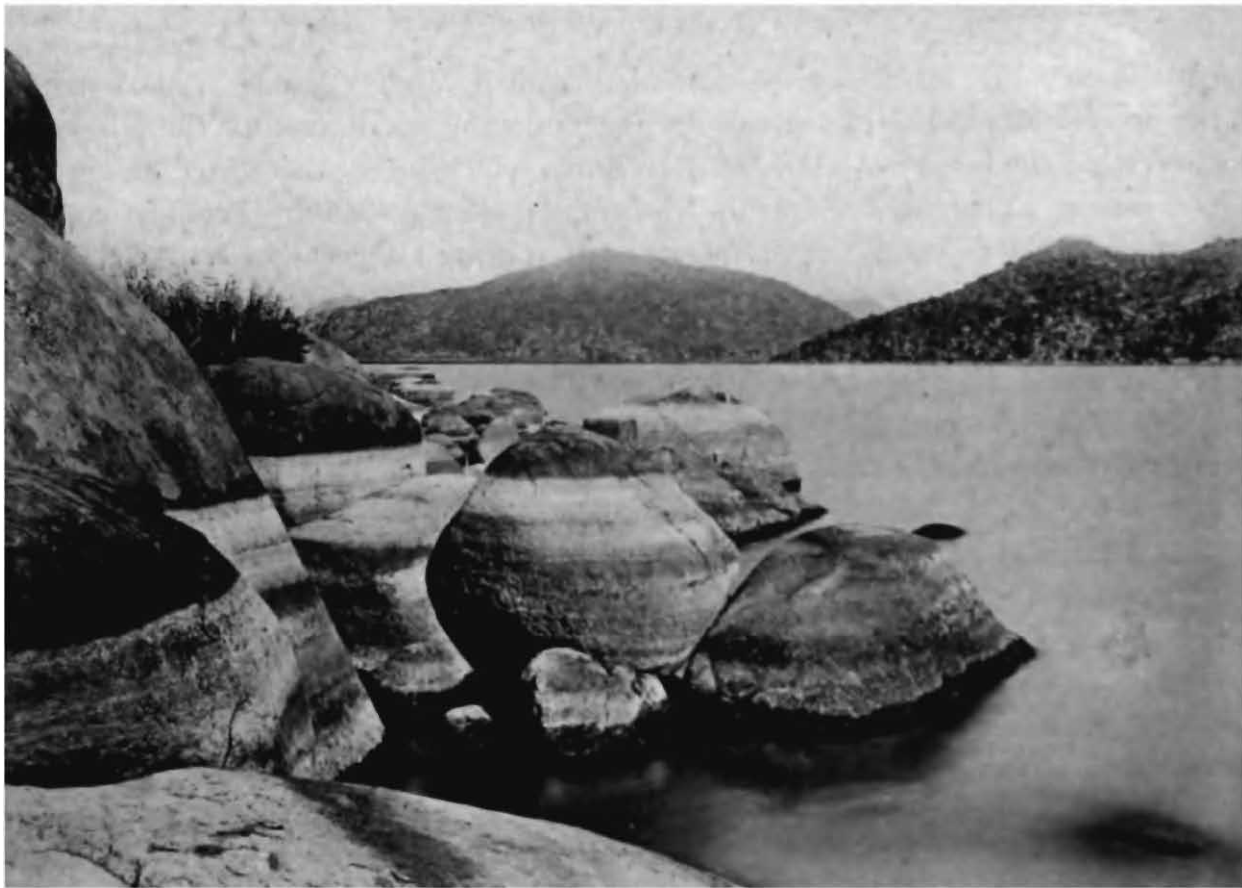
On a near approach the green lawns are not attractive, for in dry weather their margins are edged with decaying weed and in the rainy season lie deep in evil-smelling mud: the headlands and islands are difficult of access at all times of the year. Our present business, however, is not to discuss the beauties or the discomforts of the Chilka Lake but to describe the features of its shores that have a bearing, direct or indirect, on the nature and distribution of its fauna.

At the northern end of the main area the silt brought down by several branches of the Mahanaddi system, of which the most important is the Dayanaddi, has formed a margin so ill-defined that, when the floods are high and the water in consequence fresh, there is no perceptible boundary between rice-fields and lake; the former terminate only at the point at which the water becomes too deep for rice to grow. As the water-level sinks in late autumn wide stretches of muddy foreshore are left bare.

Along the outer side of this area, as the distance from the mouth of the streams increases, a large quantity of sea-sand is mixed with the mud, and even where the proportion of alluvium present is very small, the periodic decay of vegetation and the fine silt usually held in suspension in the water but deposited when a dead calm prevails, produce a thinner or thicker layer of mud above the sand. Along the whole of this shore the extent of mud or sand left bare when the water sinks is considerable and the depth of the lake at and near the margin extremely small, to be measured in inches rather than feet.

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<sup>1</sup> In several Indian dialects the word "mugger" (more correctly *magar*) means crocodile; but the Uriya fishermen of the Chilka Lake use it to signify either a crocodile, a porpoise or a shark. The last is sometimes distinguished as *magar-mach* and the porpoise (*Orcella brevirostris*) as *sús-magar*.



Nov 1914

Rocks near Patsahempur



Nov 1914

Foreshore near Barpu

6111-10-11

VIEWS OF THE CHILKA LAKE

The inner side of the main area has a far more varied character. For some miles north-east of Barkul, almost to the point at which the delta of the branches of the Mahanaddi may be said to commence, the shore consists of a series of little bays separated by headlands of the kind described above. Most of these headlands are spurs running out from a range of rocky hills that lies almost parallel to and at no great distance from this shore; others are isolated fragments of the same formation. Between the promontories the edge of the lake is flat and resembles that of the outer shore of the same area, except that the proportion of mud to sand is greater at most points and the slope a little less gentle; single rocks and groups of stones, most of which are left entirely bare in winter, occur sparingly; the grass that covers the shore is short and coarse.

South-west of Barkul point, which forms a lower and less pyramidal promontory than those that lie to the north-east, there are several wider bays in which the margin is of a similar kind, but without the headlands

The south (strictly south-west) end of the lake is occupied by two long and rather narrow bays separated by a mass of rocky hills, the highest of which, a regular pyramid named Ganta Sila, rises almost straight from the water to a height of over 500 feet and is one of the most conspicuous land-marks over the greater part of the whole area. Round its base single rocks of considerable size form what may almost be called small cliffs; when the lake is flooded or moderately full the water round them is several feet deep, but in spring and early summer a narrow muddy foreshore is left bare in front of them. The shores of the two bays resemble those adjacent to them.

Near the south-western corner of the outer bay lies the mouth of a small canal that formerly ran to the town of Ganjam, which is connected by another canal with the Bay of Bengal. The Chilka-Ganjam canal is now, however, completely blocked up and the locks with which it was provided must always have rendered any direct communication between the lacustrine fauna and that of the sea practically impossible.

The inner shore of the outer channel, except in the immediate neighbourhood of the sea-opening, resembles the outer shore of the lagoon. The bar that separates the channel from the Bay of Bengal is, however, composed almost entirely of clean sea-sand sloping down into the water, and it is only at the point at which the channel turns landwards, and in particular opposite Barhampur Id., that the margin becomes muddy or swampy.

The only streams of any size that find their way into the lake are the branches of the Mahanaddi that enter the north-eastern part of the main area, for the hills that run parallel to the inner shore are practically waterless for the greater part of the year and even at the southern end the small water-courses dry up more or less completely by the beginning of the hot weather.

In the main area of the lake there are a number of rocky islands of different sizes, none of them really large, that have a certain biological importance in that

their bases remain under water throughout the year. In this area there are also a few flatter and more sandy islands the margins of which slope gradually, but the most remarkable and the largest island in the whole lake is Nalbano, which lies not very far within the Mugger-Mukh. Nalbano is a great sand-bank completely covered with tall reeds, the roots of which are submerged when the water is high, so that only the leaves and inflorescences are visible above the surface.

The islands of the outer channel, including Barnikuda, are also sand-banks, but at most support in the way of vegetation no more than a scanty growth of short grass with, in the case of Barnikuda, a few stunted shrubs.

Generally speaking the bottom of the main area is muddy, while that of the outer part of the outer channel is sandy. In the former its nature is so uniform, notwithstanding the admixture of a certain amount of sand at some places, that the small actual differences have as a rule little effect on the fauna, and it is only in the neighbourhood of Nalbano and on the shores of some of the other islands that true arenicolous species occur in this area. The mud forms two quite distinct layers, one of which remains practically undisturbed except in very rough weather, while the other is usually held suspended in the water and only deposited in very sheltered places or at times of unusual calm. This floating layer is of course very finely divided and habitually stains the water a dirty clay-colour. Its occasional deposition is an unfavourable factor in the life of many sessile organisms. The permanent layer is gray and of a clayey consistency, but not so tenacious or so heavy as that of creeks and canals in the Gangetic delta. It is mixed with a considerable amount of decayed vegetable matter, which sometimes stains it black, and often with a large number of small dead shells of genera such as *Clementia*, *Theora*, *Nassa*, *Stenothyra*, etc. These apparently do not remain long intact; but at certain points, notably in the neighbourhood of Gopkuda Id., there are fairly large deposits of dead *Placuna*-shells, which are evidently more permanent, while at the edge of Rambha Bay masses of crude lime are dug from the mud when the water sinks and with them occur large numbers of dead shells of *Arca* and *Meretrix*. These deposits of calcareous matter do not, however, seem to have any direct effect on the fauna found amongst them.

In the inner part of the outer channel there is a great mixture of mud and sand, some of the latter being black and extremely heavy. Mr. G. H. Tipper of the Geological Survey of India informs us that this is due to the presence of monazite in small quantities.

In the part of the outer channel that runs parallel to the Bay of Bengal, the bottom is composed of almost pure yellow sand similar to that which forms the beach along the greater part of the eastern shore of Peninsular India. The only natural solid bodies found in this part of the lake are the large masses of dead and living oyster-shells that lie in beds round the small islands opposite the village of Manikpatna. The faunistic importance of the absence of solid bodies is illustrated by the fact that on a small post set up to mark the channel near Satpara we found several species not obtained anywhere else in the lake.

The main area of the Chilka Lake is exceedingly shallow. In the dry season, when the water-level is at its lowest, the depth rarely exceeds 8 ft. at the southern end ; while over an immense area towards the northern extremity it nowhere reaches 4 ft. The deepest sounding we obtained at this season was 10 ft., at a point close to the eastern end of Kalidai Id., whence a comparatively deep trough extends towards the shores of Parikudh. At many places we found it impossible to approach within a mile of the shore even in a small row-boat.

We have already referred to the shallowness of the water at Muger-Mukh and to the depth of the outer channel at this season. The deepest water is said to be situated off Arakhuda and our boatmen talked of five fathoms ; but the deepest soundings we ourselves obtained did not exceed 20 ft.

In the flood-season all depths are increased by 5 or 6 ft., the exact amount probably varying from year to year.

It is evident that the differences in depth, relatively great though they may be, are actually insufficient to produce any appreciable effect on the fauna of different parts of the lake, except in so far as they imply a great rise of temperature in extremely shallow water.

The origin of the Chilka Lake was thus explained by the late Dr. W. T. Blanford in his "Sketch of the Geology of Orissa"<sup>1</sup> :—

"The lake itself is a part of the sea first rendered shallow by deposits from the mouths of the Mahanaddi and from silt carried up the bay round the hills near Ganjam by the violent southerly winds of the monsoon, and then entirely cut off by a spit, formed, by the same agency, of sand drifted along the coast. Near the south-western extremity of this spit there is a considerable deposit of estuarine shells, at a height of 20 to 30 feet above the present flood level of the Chilka."

For our special purpose it is unnecessary to elaborate this concise statement, with which we are in general agreement.<sup>2</sup> We may point out, however, that even stronger evidence for the belief that the lake was once an open bay than that adduced in the passage quoted, is to be found in the occurrence on the rocks at the base Ganta Sila of the remains of solitary corals, organisms that flourish only in a pure sea-water. The beds of dead *Placuna*-shells to which we have already alluded provide evidence less strong, for *Placuna* flourishes in the Tampalakaman (Tamblegam) Lake<sup>3</sup> on the coast of Ceylon, in which conditions are not very dissimilar to those of the Chilka Lake.

#### HYDROGRAPHY OF THE LAKE.

Of the varied elements that compose the physical environment of the fauna of the lake by far the most noteworthy is the great periodic change in salinity to which

<sup>1</sup> *Rec. Geol. Surv. India*, V, p. 56 (1872).

<sup>2</sup> Hunter, in his "Orissa" (p. 25; 1872) cites a legend which implies that the bed of the lake was dry land as late as the 4th century A.D.

<sup>3</sup> Hornell, "Report on the *Placuna Placenta* Pearl Fishery of Lake Tampalakaman": *Rep. Ceylon Marine Biol. Lab.*, I, p. 41 (1906).

its waters are subject. This factor undoubtedly exercises a continual selective influence on the animals of the lake and it is to it, in the main, that the special interest of the fauna is due.

The methods which we adopted in determining the salinity of the water are explained on p. 17.

As is pointed out below (p. 18) our investigations were made chiefly at two periods, in each of which we attempted, so far as was possible, to visit all parts of the lake. Observations were, of course, made at other seasons and we have in fact, in 1914 and in previous years, paid visits to the lake in practically every month; on these occasions, however, our investigations were of a more or less restricted nature, concerning only a portion of the area to be investigated.

The more comprehensive surveys effected in the two periods mentioned above were made respectively in the salt- and the freshwater seasons. In the first, in which our observations extended from February 12th to March 18th, the entire lake was filled with water of varying but comparatively high density, while in the second, from September 1st to September 23rd, the water throughout a great part of the system was quite fresh, owing to the floods which enter the lake at the close of the monsoon.

The charts on p. 9 showing the corrected specific gravity of the water will give a good idea of the enormous variation in density at these two periods. It is of course improbable that they represent the maximum and minimum with any exactitude. Somewhat higher specific gravities are doubtless to be found in early summer, that is to say in the period immediately preceding the monsoon, and subsidiary investigations made in July tend to prove that this is the case. It is also possible that the general density indicated in fig. 2 is capable of further reduction in exceptionally high floods so far as the southern end of the lake is concerned.

In giving an account of the general configuration of the lake-system, we noticed that it could be divided into two parts, the main area, which comprises the bulk of its waters, and the outer channel that forms the communication with the sea. This division is not founded entirely on geographical considerations; there are also very marked differences in the range of density of the water in the two regions and therefore notable faunistic distinctions.<sup>1</sup> The division is consequently based on both physical and biological features of considerable importance.

In March we found that the specific gravity of the sea, taken at a point some miles below the mouth (and therefore, owing to the strong north-easterly currents that prevail along the coast, uncontaminated by any discharge from the lake) was 1.0270. An additional observation made a few days later just inside the mouth gave a reading of 1.02825. At this period there was no appreciable outflow from the lake and the water in the channel over an area extending from Barnikuda Id. to Arakhuda yielded specific

<sup>1</sup> The prevalence of a sandy bottom over a large part of the outer channel must also of course be taken into account in considering the faunistic differences.

gravities varying from 1.02625 to 1.02650.<sup>1</sup> It is clear that in this region, during March, the water was for all practical purposes as salt as the sea.

In September the conditions were markedly different. The level of the water was some five feet higher than in March and many of the low-lying islands in the channel were almost or entirely submerged, a strong current was flowing out of the lake and the water throughout the length of the channel was entirely fresh up to the point where it entered the sea. Ebb and flow at this period made no alteration in salinity and the maximum effect even of a high spring tide could only have been a slight banking of the water at the mouth. The specific gravity of the sea a little to the south of the entrance to the lake was at this period 1.01675, a reading considerably lower than those obtained in March of the same year.

By December the freshwater floods had in a large measure subsided and samples taken in the early part of this month at Satpara and near Manikpatna gave readings respectively of 1.00325 and 1.01250. At this time a small outflow from the lake probably still persisted, salt water entering the channel only at high tide or under specially favourable conditions of wind.

In the outer channel, then, the range of salinity is the greatest possible, and animals that live permanently in this region are able to exist for some eight months in water almost or quite as salt as the neighbouring sea (sp. gr. 1.0270) and for at least three months in water that is entirely fresh.

The change from salt to fresh water that takes place annually towards the close of the monsoon season is probably effected gradually. The discharge from the rivers at the northern end of the lake must in the first place drive before it the saline water with which the main area was previously filled, and there can be no doubt that the first slow currents that pass down the outer channel have a comparatively high salinity, which slowly decreases with the augmenting volume of the flood. The change from fresh to salt water, on the other hand, probably takes place more suddenly. After the floods have subsided and the head of water in the lake has disappeared, there must, under suitable conditions of tide and perhaps also of wind, come a time when a volume of salt water enters the sea-mouth and it is possible that far-reaching alterations take place in the channel in the course of a single day.

Both periods of change must have marked effects on the fauna of the outer channel and on each occasion there is probably a high mortality; freshwater forms must be largely exterminated on the entrance of salt water, while many marine species that have established themselves during the salt-water period must succumb in the flood season. We have direct evidence that this occurs.

Though less extensive than is the case with the outer channel, the changes of density to which the waters of the main area are subject are nevertheless great; the specific gravity varying, according to our observations, from 1.000 to 1.0150.

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<sup>1</sup> A sample taken in a swamp south-east of the northern extremity of Barhampur Id. and separated by a bar from the main channel gave a reading 1.02376. The water in this place was probably mixed with a certain amount of surface drainage from land in the vicinity.

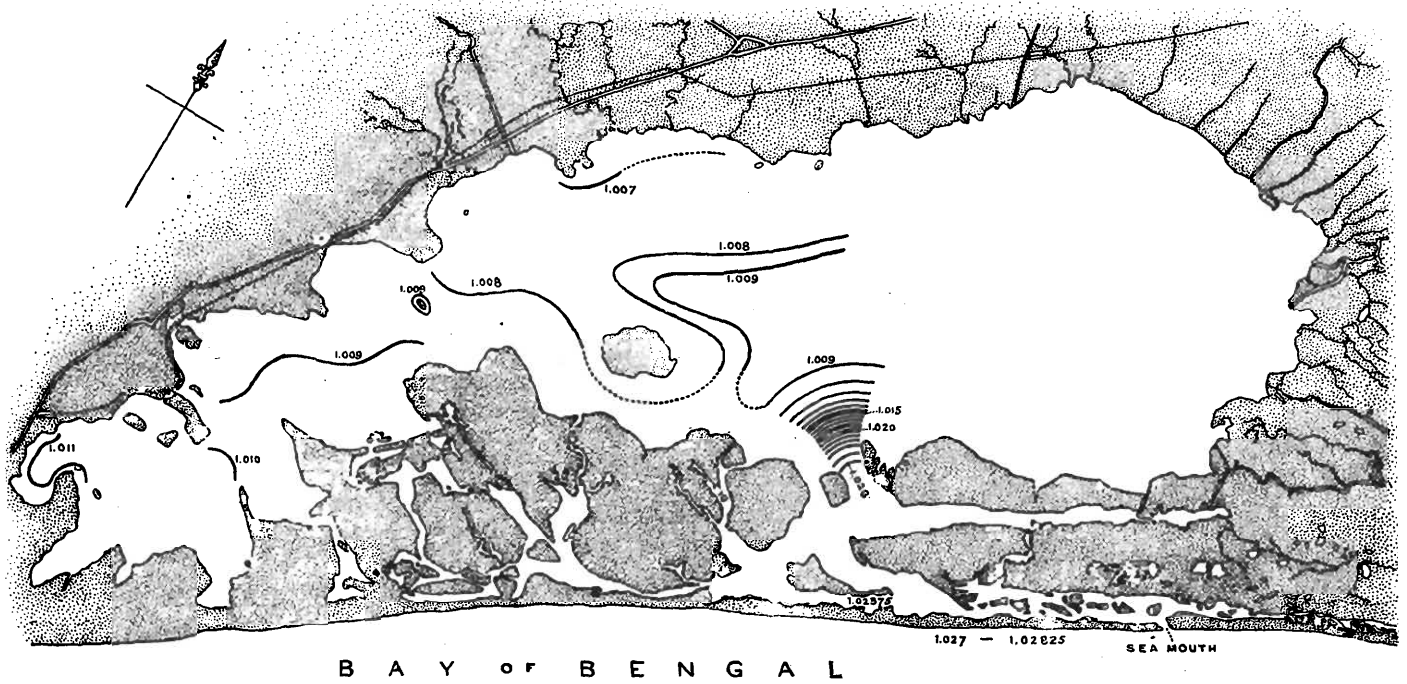
In February and March, as will be seen from the chart on p. 9, an abrupt change in density was encountered at Mugger-Mukh on the bar that separates the main area from the outer channel—a bar covered at this period by water only some eighteen inches or two feet in depth. The specific gravities in little more than a mile changed from 1.026 to 1.010. The floods of the previous year's monsoon had not only altogether subsided, but a considerable quantity of salt-water had entered from the Bay of Bengal. The most noteworthy feature of the specific gravities in this large region was that the denser water was accumulated at the south end. The highest readings were obtained at the southern extremity of Rambha Bay and from this point to Nalbano the specific gravities regularly decreased. North of Nalbano, water of greater density was again met with, while the lowest readings were obtained along the north-western shore in the vicinity of Patsahanipur. At this period the specific gravities we obtained ranged from 1.00675 to 1.01150. Owing to the extreme shallowness of the lake we were unable, however, to visit a considerable region at the northern end and the comparatively small amount of water that enters from the rivers probably produces specific gravities lower than any we actually recorded.

Subsidiary observations made in the middle of April at the southern end of the lake seem to indicate that no great change in the conditions had taken place, though the position of the isohalines (as indicated by the lines of equal specific gravities) had probably altered to a certain extent. Samples taken in Rambha Bay and off Breakfast and Chiriya Ids. gave readings identical with those of February; but off Barkuda the specific gravity was lower (1.00975) and off Maludaikuda higher (1.00975). By July, however, a notable change had occurred and there is little doubt that during May and June a considerable volume of salt water had entered the lake; the specific gravities were higher than any previously observed and the entire area southwest of Samal Id. was filled with water varying from 1.0145 to 1.0150. At Barkul the specific gravity was still much the same as in February, *viz.*, 1.00750.

The conditions in the main area were very different in September, 1914. In this month, as shown in fig. 2, p. 9, the greater part of the area was filled with fresh or almost fresh water.

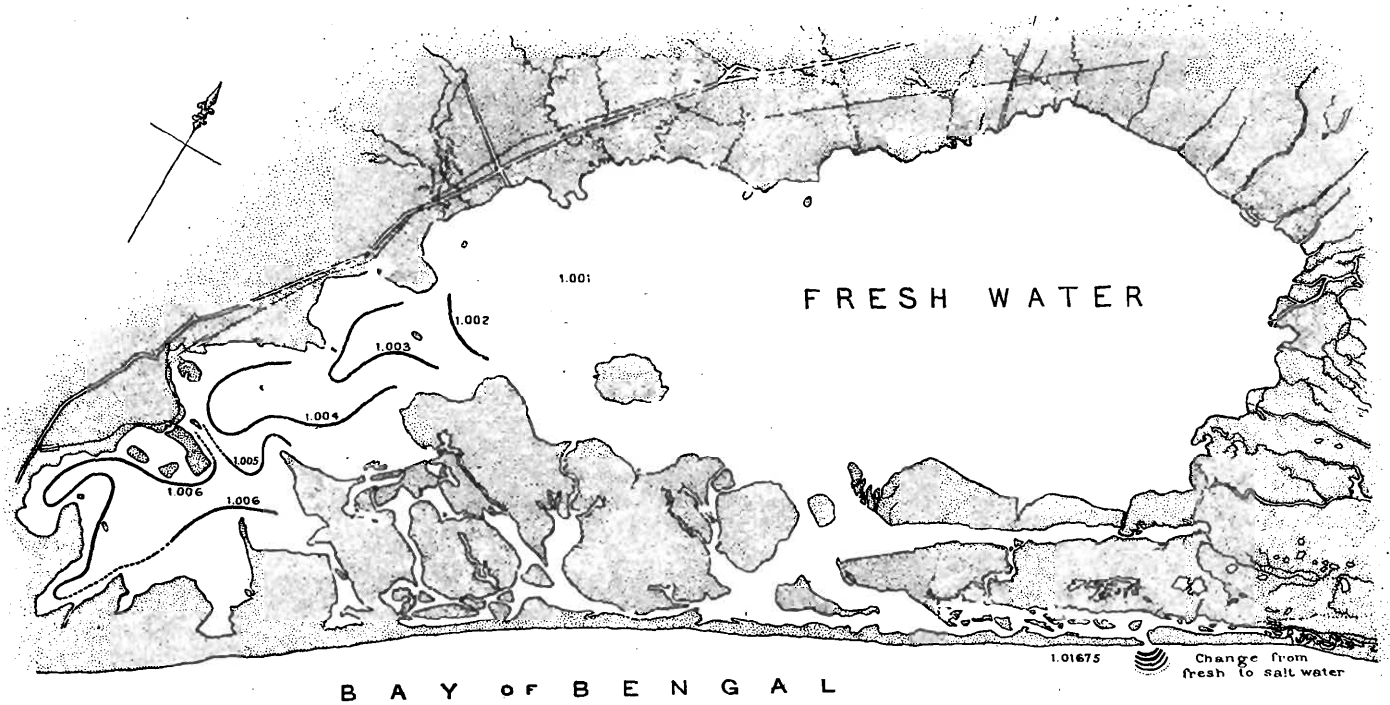
The great volume of silt-laden water brought down into the northern end by the branches of the Mahanaddi system had expelled all that of higher salinity—a phenomenon already noted with reference to the outer channel. It is evident that, in these parts of the lake at any rate, the changes are not due to admixture so much as to the expulsion of one volume by another.

In September slight traces of a higher specific gravity were met with between Nalbano and Patsahanipur, the water varying from fresh to 1.001, and southwards of this line there was a gradual rise in density up to sp. gr. 1.0065 in Rambha Bay. The latter reading, the maximum observed in September, is about the same as the minimum recorded in the salt-water season. It will be noticed that specific gravities of 1.006 and over were only met with near the shore in the extreme south and that



TEXT-FIG. 1.—The specific gravity of the water of the lake in February and March, 1914.

At this period we were unable to visit the north-east end of the lake owing to the shallowness of the water. The specific gravities recorded in the main area varied from 1.00575 to 1.0115. A sudden change occurred at Muggur-Mukh,<sup>1</sup> the outer channel being filled with water as salt as that of the Bay of Bengal.



TEXT-FIG. 2.—The specific gravity of the water of the lake in September, 1914.

During this month the water-level was some 6 ft. higher than in February and March; Nalbano<sup>1</sup> and several of the islands in the outer channel were submerged. The north-eastern part of the main area was filled with fresh water, as was also the outer channel as far as the sea-mouth. In the south-western end of the main area the specific gravities ranged from 1.002 to 1.0065.

<sup>1</sup> See detailed map, Plate II.

throughout the southern part of the lake the water in the middle was of lower specific gravity than that nearer the shores.

A short series of observations made in November indicates that the conditions in this month did not differ largely from those observed two months earlier, the highest specific gravity (1.006) being obtained at the south end of Rambha Bay. Water of appreciable salinity was, however, not so closely restricted to the southern area, for a sample obtained off Kalidai gave a reading of 1.0035 and others off Barkul of 1.003. The flood-water, had somewhat abated, with the result that the level had decreased and the saline water, confined during September at the extreme south, had spread further north.

It is noteworthy that the rocks on the inner shore of the main area appear to indicate that the water sinks mainly in a series of sudden falls, for, as will be seen from the upper photograph on Plate I, the stone is marked in the dry season with three or four horizontal bands of a superficial nature. The distinct demarcation of these bands is apparently due to the fact that the upper limit of each has indicated the highest water-line for some considerable period, and after a high south-westerly wind we noticed in one case that a band actually represented an area of half-dried alga just left bare by a sudden reduction of level.

An attempt to discuss in detail the various other agencies that affect the salinity of the lake would be beyond the scope of our present enquiry and would certainly demand an experience of hydrography and meteorology which neither of us possesses. It has been our object to obtain, so far as was practicable within the limits of a single year, a general idea of the alterations in salinity to which the fauna of the lake is subject and of the more important causes to which these changes are due.

It is evident that the changes are to a large extent correlated with differences in water-level and that the monsoon floods are by far the most potent of the agencies at work. Other causes must, none the less, have a marked effect. Although the rivers at the north bring with them by far the greater part of the fresh water that enters the system, the streams which occur in the monsoon at other points but are for the most part dry during the remainder of the year, must also have some influence on the conditions and during periods of heavy rain surface drainage even from the small watersheds at the southern end must be considerable.

Unfortunately no precise data are available as to the amount of rain that falls actually on the lake, in our experience it was decidedly less (in 1914) than that which fell on the surrounding country. Storms coming up from the south often either followed the hill ranges to the north-west of the lake, or else split in two before they reached it, one part skirting these hills while the other keeps to seaward, following the line of sand-hills along the coast.

An important factor in local changes in salinity is the direction of the wind. Owing probably to the topography of the surrounding country the monsoon currents are to some extent diverted and the prevalent wind throughout the greater part of the year is south-westerly. From this quarter it often blows with considerable

force and for protracted periods. We are informed that on occasions, when its violence is extreme, the greater part of Rambha Bay is entirely emptied of water and in February, 1914, the effect of even a moderate breeze was brought home to us by a sudden lowering of the water-level so great that the "Lady of Chilka" grounded at her moorings. Sudden changes of the kind must result in the water being banked up towards the northern end and must produce a considerable admixture of volumes hitherto distinct. Observations made at Barkuda Id. in February, before and after several days' strong breeze, showed a definite rise in density, the salter water having doubtless been brought from the southern end by the wind.

Tides have of course no effect during the flood season, as at this period the outer channel is filled with fresh water to a level some feet above that of the sea. Even when the lake was at its lowest we were unable to observe any regular ebb and flow in the main area. The influence of wind, indeed, seemed to us sufficient to account for any diurnal changes in level that were actually noted. Any effects that the tides may have had were doubtless masked by this agency, while we made no attempt to investigate less obvious movements.

In the outer channel tide had of course a slight effect at this season; but the rise and fall, owing to the narrowness of the sea-mouth, was probably much smaller than in the Bay of Bengal immediately outside. It is clear, nevertheless, that the tides, assisted probably by changes in the wind, must have a much greater effect on the isohalines than is indicated by diurnal changes in water-level, for to this agency in a large measure must be assigned the influx of salt water at the time when the autumn floods have subsided.

In a lagoon of the size and shallowness of the Chilka Lake evaporation must, especially in a tropical climate, be more than considerable and doubtless plays a great part in the phenomena we have been discussing. We have no means of estimating the exact influence of this factor, but it is not unreasonable to suppose that beyond compensating for the comparatively small amount of fresh water that comes from the Mahanaddi system in the dry season, it also plays an important part in inducing an inflow from the sea.

The great changes in the salinity of the Chilka Lake are due, as has already been explained, to the floods of fresh water which enter it each year at the northern end from several branches of the Mahanaddi system; the annual sequence of events, as it concerns the lake as a whole, may be stated briefly as follows:—

The floods that enter the lake at the close of the monsoon from the Mahanaddi delta expel all salt water from the northern portion, driving it through the outer channel to the sea, and are of sufficient volume to raise the level of the lake some 5 or 6 ft. above the mean of the dry season. There being no outlet at the southern end, the comparatively saline water which had accumulated there is banked up by the flood, becoming, however, diluted to a considerable extent both by admixture with water from the north and by surface drainage from the land in the vicinity. Towards the end of the year the floods subside. The first effect of the alteration

in level is that the water of low salinity, hitherto confined at the southern end, spreads further north. In course of time the level sinks to a minimum and subsequently, under suitable conditions of wind and tide, volumes of salt water enter from the sea and entirely fill the outer channel. This in 1914 had already taken place before the month of February. Under normal conditions the waters of the main area probably rise in salinity, owing to successive inflows from the Bay of Bengal, until a maximum is reached in July. By August the monsoon floods have commenced, the water-level rises rapidly and a repetition of the annual cycle begins.

The important subject of salinities may therefore be summarized as follows:—

- (1) In the dry season the water of the outer channel is practically as salt as that of the Bay of Bengal, while that of the main area is distinctly brackish.
- (2) At the end of the wet season the water of the whole of the outer channel and of a great part of the main area is fresh, while that of the south-western part of the latter is but slightly saline.
- (3) At all times of year the change from water of low to that of comparatively high salinity take places abruptly in a very limited area, so that the isohalines are closely crowded together.
- (4) In the dry season this area of abrupt change is situated at the junction of the outer channel with the main area, but by the end of the wet season it has shifted to the sea-mouth.

Variations in the temperature of the water of the lake have probably, except in extreme cases, but little influence on the distribution of the fauna. According to our observations, the surface temperature ranges from 25° to 35°C. and is probably higher to a marked extent than that of the Bay of Bengal. The cooler water is naturally found in the more central parts, while nearer the shores, and especially in the vicinity of rocky headlands, the temperature is noticeably higher. Even comparatively short periods of hot weather must obviously have a marked effect in raising the surface temperature and the maximum must be reached in very shallow water or in small more or less isolated pools at the margin. In one such spot we obtained, in March, a reading of 43°C.; this temperature must be inimical to many forms of life and as a matter of observation few living animals are to be found in situations of the kind. Seasonal variation in temperature is certainly not very great: but our data are not sufficiently extensive to permit of a more precise statement.

#### VEGETATION

In most parts of the lake the aquatic vegetation is scanty, but in a few sheltered bays in the main area a species of *Potamogeton*<sup>1</sup> with slender, grass-like leaves grows

<sup>1</sup> Probably *P. pectinatus*, Lam. We have to thank Dr. D. Hooper for the name of this plant.

luxuriantly, forming dense thickets that extend upward from the bottom to the surface for a height of at least four feet. This plant dies down in the rainy season and masses of dead and dying weed then break loose, float on the water and are thrown up on the shore or entangled amongst rocks at the edge. The new growth makes its appearance in autumn and is well advanced by the middle of November, when the plant is in flower on the surface. Its maximum luxuriance is not, however, reached until February or March, after the flowering season is practically over.

A plant more widely distributed in both parts of the lake, but much less conspicuous and luxuriant, is *Halophila ovata*, a species that creeps along the bottom sending up stems of four to six inches high at short intervals. These bear relatively large ovate leaves which form a favourite basis for a few simply organized sessile animals. *Halophila*, which is practically confined to a muddy bottom, is found all over the main area and in the inner part of the outer channel, in patches that often reach a considerable size. Small masses of this plant are constantly being detached, probably by diving ducks and other water-birds, and float from place to place. The plant is found in an active condition at all times of the year.

Several other aquatic Phanerogams occur in the lake, but are not of sufficient abundance to have any faunistic interest.

Among semi-aquatic flowering plants by far the most conspicuous is the reed (*Phragmites*) that covers Nalbano and grows among the rocks on many of the promontories. It reaches a height of at least 10 feet. Several other smaller grasses and at least one species of rush also grow in the shallows of the main area, but not in sufficient quantities to attract a special fauna.

The higher algae are absent from the lake and those of the less specialized groups that occur are not as a rule of any great zoological interest. Several unicellular forms are found, however, in considerable quantities in the plancton at some seasons, notably species of Dinoflagellata, while a certain number of diatoms live on the bottom or elsewhere. Submerged rocks and stones are usually coated with simple and branched filamentous algae of a bright green or a brown colour, but the growth is never very luxuriant. A slimy dark green species with an offensive odour sometimes covers small patches of the bottom in the main area and is fairly common along the shore of the Satpara peninsula. Its presence seems to be peculiarly inimical to animal life. As the water sinks after the rains, this alga, in drying, forms a thin felt-like substance and is gathered by the villagers at Satpara and used by them instead of paper for wrapping up parcels.

From a zoological point of view the most important feature of the vegetation on the shores of the lake is the total absence of mangrove swamps. Except where the beach is sandy, as along the outer parts of the outer channel, or stony, as around many of the islands and promontories of the main area, cultivated fields or grazing grounds extend down to the water's edge, if the former do not actually encroach upon the water. There are, therefore, comparatively few trees close to the margin; firewood is also scarce and trunks and branches are not allowed to go to waste or to float away. This fact is of faunistic importance in reference to the

general scarcity of solid bodies to which attention has already been called with respect to the outer channel. The hedges of screw-pines by which the fields are protected from trespassing cattle are, however, when the water is high, sometimes partially submerged; they then afford shelter to many Decapod crustacea, while broken fragments stranded on the shore give lodgment to amphibious insects and crustacea, as well as to several terrestrial vertebrates that feed on these animals.

#### GENERAL CHARACTER OF THE FAUNA

When all the reports contributed by specialists to this volume have been completed we propose to discuss the fauna of the Chilka Lake in considerable detail. It will be well, however, to preface these reports by a brief statement as to the general nature of the fauna with which they will deal. To do so it will be convenient to consider the animals first under the following headings:—

- |                 |  |
|-----------------|--|
| (1) Mud fauna   | (4) Weed fauna                           |
| (2) Sand fauna. | (5) Free-swimming organisms.             |
| (3) Rock fauna. | (6) Plankton and surface fauna generally |

1. The organisms that live in mud or crawl on its surface form what is perhaps from a zoological point of view the most conspicuous element in the fauna of the lake. Considering the great proportion of the bottom that is covered with mud this fact is not surprising. Among the mud-dwellers are included several coelenterates, several polychaete worms, a large proportion of the molluscs, several Decapod and other crustacea, a few small Teleostean fish and several comparatively large rays. In nearly every case the number of species present in any one group is extremely small, indeed it is probable that in many cases even families are each represented by a single form. The number of individuals on the other hand is as a rule very large. In this section of the fauna we find many noteworthy adaptations for burrowing and for protecting the gills or other breathing apparatus from being clogged with particles of silt.

2. The arenicolous animals of the lake are mainly confined to the outer part of the outer channel and have as a rule a less specialized character than the mud-dwellers. Among them are to be found at least one species of sponge, two species of oligochaete worms, several polychaetes, and the majority of the Decapod crustacea and molluscs. This element is not entirely confined to the outer channel, for several of its representatives are found on the shores of Nalbano Id. and a few even so far inland as Barkuda Id. near the mouth of Rambha Bay.

3. The rock fauna is much more restricted as to number of species and genera than might at first sight seem probable. The sponges are represented by two abundant forms, the coelenterates by a single hydroid, the crustacea and worms by a few small species that crawl among sponges and algae or hide under stones; the molluscs by one or two sessile Lamellibranchs and one or two Gastropods. The poverty of this element is due very largely to two facts, firstly that most of the rocks are only covered by water for a small part of the year, and secondly that any animal

which settles on a flat surface is liable to be smothered by the deposition of fine silt in calm weather.

4. The majority of the animals that can be classed under the heading of weed fauna are associated either with *Potamogeton* or with *Halophila*. Young fish of many species take shelter amongst the dense thickets of the former plant, to which the insects of the lake are, at any rate in the salt-water season, almost entirely confined. Several species of Decapod crustacea and at least one very abundant Lamellibranch mollusc are also characteristic of these thickets. The comparatively large leaves of *Halophila* act as a base for several small sponges, coelenterates and polyzoa. On the whole the scantiness of the fauna associated with weeds is a little surprising.

5. Under the heading of free-swimming organisms we must include the majority of the fish, as well as a few medusae and at least one Ctenophore, also several Decapod crustacea and at least three species of Mysidacea. As a rule the animals falling under it are perhaps the least interesting with which we have to deal, and it has been impossible, except in a very few instances, to add materially to our knowledge of their biology or distribution.

6. We are hardly in a position as yet to say much about the plancton beyond stating that in the main area of the lake it is never abundant and almost disappears for a time in the earlier part of the rainy season, while in the outer channel it becomes, in the salt-water season, both more abundant and more varied than it ever is inside Mugger-Mukh. One point may be noted, however, *viz.*, that in most of our samples from the main area Copepods and larval molluscs greatly predominate.

We have not included among the headings tabulated above that of 'amphibious fauna,' as perhaps we might have done. There are of course a certain number of crustacea, insects and other animals that would naturally fall into this category; but the amphibious fauna fades so gradually into the terrestrial one, with which we do not propose to deal, that it has seemed best to consider separately the status of each species that lives only partially in water.

Regarded as a whole, the fauna of the lake may be described as mainly of marine origin. A few freshwater forms have, however, established themselves, while there is also a marked faunistic element that appears to have originated actually in estuaries or backwaters subject to great changes of salinity and temperature. This element is also well represented in the Gangetic delta and in lagoons on both coasts of Peninsular India. A fourth element consists of species that immigrate at appropriate seasons either from the sea or from neighbouring streams, ponds and rice-fields, while a fifth—of little importance—is composed of mere casual visitors that drift, swim or crawl into the lake and exist there for a period without establishing their species among its permanent inhabitants.

The abundance of individuals and poverty of species noticed under the heading of mud fauna is to a very large extent characteristic of the fauna generally and in particular of that of the main area.

Perhaps the most striking feature of the biology of the permanent residents in the lake is the extraordinary power of individual adaptability to physical changes

in environment that most of them possess. It seems strange to find a *Rhizostomous* medusa or an *Oxystome* crab living in lacustrine conditions, but it is even more remarkable that individuals of such forms are able to flourish at one season in fresh and at another in salt water.

#### AIMS OF THE ZOOLOGICAL SURVEY OF THE LAKE.

The origin of our zoological survey of the Chilka Lake has been explained in the note prefixed to this volume; the main object we have had before us in its execution has been to lay a foundation for the study of the fauna of brackish water and of water of variable salinity on the coast of India on the same lines as our predecessors in the Indian Museum have done for that of the abyssal fauna of Indian seas. For this object it has seemed necessary in the first place to make our collections as comprehensive as possible, noting the circumstances of each capture and deducing from our notes facts as to the biology of the commoner species. It has not been possible, and perhaps it has been hardly desirable, to make any attempt at a detailed biological or morphological study of any particular group or species. That can come later, and if our researches prove useful to future naturalists who may undertake investigations of the kind, we feel that our labours will be amply rewarded. In a field so little explored we think it is as well not to specialize too soon.

The methods employed and the apparatus used in the survey may be described in some little detail.

#### METHODS AND MATERIAL.

In making our investigations we were fortunate in obtaining from the *Kallikotara* the use of a small launch, the "Lady of Chilka", the only steamship on the lake. From this launch we were able to trawl systematically over a considerable part of the main area and, in the flood-season, over the whole of the outer channel. In the latter area, in the salt-water season, we worked from a row-boat kindly lent us by the Salt Department.

The very soft mud of which the bottom is for the most part composed proved a considerable difficulty, and we believe that a really satisfactory instrument for the zoological investigation of regions such as the Chilka Lake yet remains to be devised. A net with mesh fine enough to retain small bottom organisms, such as *Cumacea* and minute *Mollusca*, does not permit the mud to escape and in a very short space of time becomes filled to bursting point.

For bottom work we used chiefly two sorts of net. The first of these was a miniature beam-trawl, six feet in breadth, of a size that could be fished comfortably from the stern of the launch. At the cod-end the mesh of this net was  $\frac{1}{2}$  in. (stretched) and it therefore permitted the greater part of the mud to escape, except in particular places where it was of a lumpy character. To the back of this net, on the outside, we attached a shaped bag of mosquito-netting or coarse-meshed canvas, placed in the path of the swirl caused by the foot-rope. This net caught numbers of small

animals which would otherwise have escaped, and compensated in some measure for the large mesh of the main bag: none the less it was frequently drawn up half full of mud.

The second type of net employed for bottom work was a  $\square$ -net, that is to say a light frame of  $\frac{5}{8}$  in. iron (shaped in the form of a  $\square$  and towed by three bridles) to which by means of brass rings a long bag of coarse-meshed canvas was attached. This net produced excellent results; but it was only possible to make very short hauls as the bag rapidly filled with mud.

Mud we dealt with by means of a series of large rectangular sieves with brass meshing, fitted in a frame to keep them above the level of the deck.

A larger net, an otter-trawl with head-rope 28 ft. in length and 3 in. mesh at the cod-end, was also employed occasionally and was successful in obtaining large fish that were able to avoid the smaller nets, especially in thickets of *Potamogeton* near the shore.

The larger free-swimming organisms were obtained by towing the  $\square$ -net in midwater and at the surface; but for many of the fish we were dependent on indigenous methods, which will be described in a special paper in this volume. Plancton we collected in silk tow-nets of the ordinary type supplied by the Marine Biological Station at Plymouth. Hand-nets were of course employed in shore-collecting, in which we found a hammer and chisel an essential part of our outfit.

As regards determinations of salinities it seemed unnecessary, in view of the enormous seasonal changes, to employ the elaborate titration method advocated by the Bureau International pour l'Exploration de la Mer, a method designed to demonstrate extremely slight differences in oceanic and coastal waters. We realized at the outset that to obtain a complete or even an approximate knowledge of the varied physical conditions that affect the salinity of the lake would be beyond our powers and that it was improbable that observations carried out in a single year, however complete, would render possible a true account of the actual changes that take place. Variations in rainfall, temperature, wind, tide and possibly other factors must all produce different effects in different years.

In making our observations on the density of the water we used a hydrometer kindly lent us by Capt. R. B. Seymour Sewell, Surgeon-Naturalist to the Marine Survey of India, and our results are therefore expressed in the form of specific gravities. The scale of the instrument, which is calibrated for 15°C., is about 7 cms. in length and is graduated from 1.00 to 1.04 in 40 divisions. Readings were taken to the nearest 0.00025. In order to give corrected readings of specific gravities of 1.0015 and under it was necessary, at the temperature at which we were working, that the hydrometer should be scaled below 1.000. This unfortunately was not the case and we are in consequence unable to insert the line representing sp. gr. 1.001 in the chart reproduced in fig. 2 on p. 9.

Water-samples were collected in bottles provided with a spring top and rubber washer and were, as a rule, tested the day they were taken. The determinations quoted are in every case reduced to 15°C. by the use of a correction table. This table is based on a series of laboratory experiments made with the same instrument

in waters of different salinities at temperatures ranging from 10° to 35°C. We are under great obligation to Dr. W. A. K. Christie, Chemist to the Geological Survey of India, for advice and practical assistance in this matter.

The positions of our stations in the lake were determined by the use of a sounding quintant and station-pointer kindly lent us by the Survey of India.

The specimens on which the reports in this volume are based are at present in the Indian Museum, in which all the types of new species described, as well as a complete set of all other forms, will be preserved. The oldest specimens from the Chilka Lake that we possess are a few shells collected by the late Dr. W. T. Blanford and his agents, mostly, as is evident from the species represented, in the outer channel. The Museum collector obtained a considerable number of fish in the neighbourhood of Gopkuda Id. in 1907, while Dr. J. Travis Jenkins made collections, also mainly of fish, in the outer channel in 1908. One of the present authors paid a short visit to Rambha in the following year and obtained there, among other material, the types of several new shells described by Mr. H. B. Preston. It was not, however, until August, 1913, that any concerted attempt was made to investigate the bottom-fauna. In that year we used bottom-nets for the first time in the lake, mainly in the immediate neighbourhood of Barkul. In October of the same year we commenced preliminary work at Satpara and Rambha, and subsidiary trips were made in November and in the following January. Our actual survey commenced in February, 1914. Apart from a number of short visits to one or other region of the lake, it was conducted, as has already been stated, mainly at two periods, representing respectively the middle of the salt-water and that of the fresh-water season. In February and March we spent altogether about six weeks on the lake, on which we trawled practically every day, while in September a period of about three weeks was occupied in the same manner. Our own shorter trips were made in April, July, November and the beginning of December, while Dr. B. L. Chaudhuri collected fish at Barkul and elsewhere in December of the same year and in January, 1915.

We have in our log particulars of 171 collecting stations. In some cases the data of two or more stations refer to the same place at different seasons, but many specimens were collected, on the subsidiary trips and at other times, in circumstances not noted in the log, though recorded on the labels.

The bulk of the collections is of course very considerable and it will therefore be possible for us to distribute to other museums by the only means open to us (*i.e.*, that of exchange) a number of sets of duplicates.

#### LIMITATIONS OF THE WORK.

Neither the time nor the funds at our disposal were unlimited and even within the somewhat narrow boundaries to which the survey was confined, we were obliged to observe certain limitations in collecting. Generally speaking we made no special effort to capture and preserve representatives of microscopic groups such as the

Protozoa and Rotatoria. The smaller Entomostraca were collected merely as they occurred in tow-nettings. In the majority of groups larval forms, with a few specific exceptions, were also neglected, while certain other small and inconspicuous organisms (*e.g.*, the free-living Nematodes) were obtained only in small numbers.

We regret that we were unable to study the ornithology of the lake, which is remarkably attractive at different seasons to different kinds of water-birds, though comparatively few breed there habitually.

In a few groups of animals of which we did make fairly comprehensive collections, it has not been possible in the present state of international affairs to find specialists able and willing to investigate the specimens. The most noteworthy of these groups are the Nemertea and the aquatic beetles. Of the former at least three species are common in the main area of the lake, while both the Dytiscidae and the Hydrophilidae are represented by a considerable, but not a large, number of forms. We failed to get the two species of Nudibranch molluscs that occur identified, while the single Tunicate we obtained (an immature Appendicularian common in the outer channel in March) is probably not determinable specifically.

Among internal parasitic species we preserved a certain number of Helminthes, especially Cestoda from the alimentary canal of sting-rays. Mr. T. Southwell has also collected specimens of this group in the lake and is preparing a report upon his and our collections.<sup>1</sup> The parasitic Nematodes are poorly represented and there is only one Acanthocephalon, which was found in the intestine of a Teleostean fish. The Trematodes are represented by at least three species, a large and common form from the body-cavity of a ray and two minute Distomids, one occurring in the canals of a Ctenophore and the other in the body-cavity of a Copepod. We do not propose to discuss these internal parasites further except in reference to their hosts.

Of the groups that appear to be actually absent from both the outer channel and the main area, the most conspicuous are the Echinoderms and the Cephalopod<sup>2</sup> molluscs. Certain other divisions of the latter phylum, *e.g.*, the Pteropoda, seem also to be unrepresented in the fauna, as is the case with several groups of coelenterates, notably the Cubomedusae and the stony corals. The aquatic insects are naturally represented by but a few of those families which possess aquatic larvae.

Apart from such limitations, there are also others dependent on mechanical difficulties in collecting. Our collections from the main area of the lake, considering the multitude of individuals and the paucity of forms, are probably almost complete; a few rare species may have escaped our notice, but it is doubtful whether this is the case with the common animals, which are, of course, very much more important from a faunistic point of view. If any of the latter are missing it is probably among the fish that gaps occur. In the fauna of the outer channel on the other hand there are probably many gaps both in the vertebrates and in the invertebrates. All

<sup>1</sup> *Rec. Ind. Mus.*, *ined.*

<sup>2</sup> Goodrich (*Trans. Linn. Soc., Zool.* (2) VII, pp. 5, 7, 1896) records specimens of *Sepiella inermis* (van Hasselt) and *Loligo indica*, Pfeffer, from the "Chilka Bight" but they were probably obtained outside the mouth of the lake, as they are from the 'Investigator' collections.

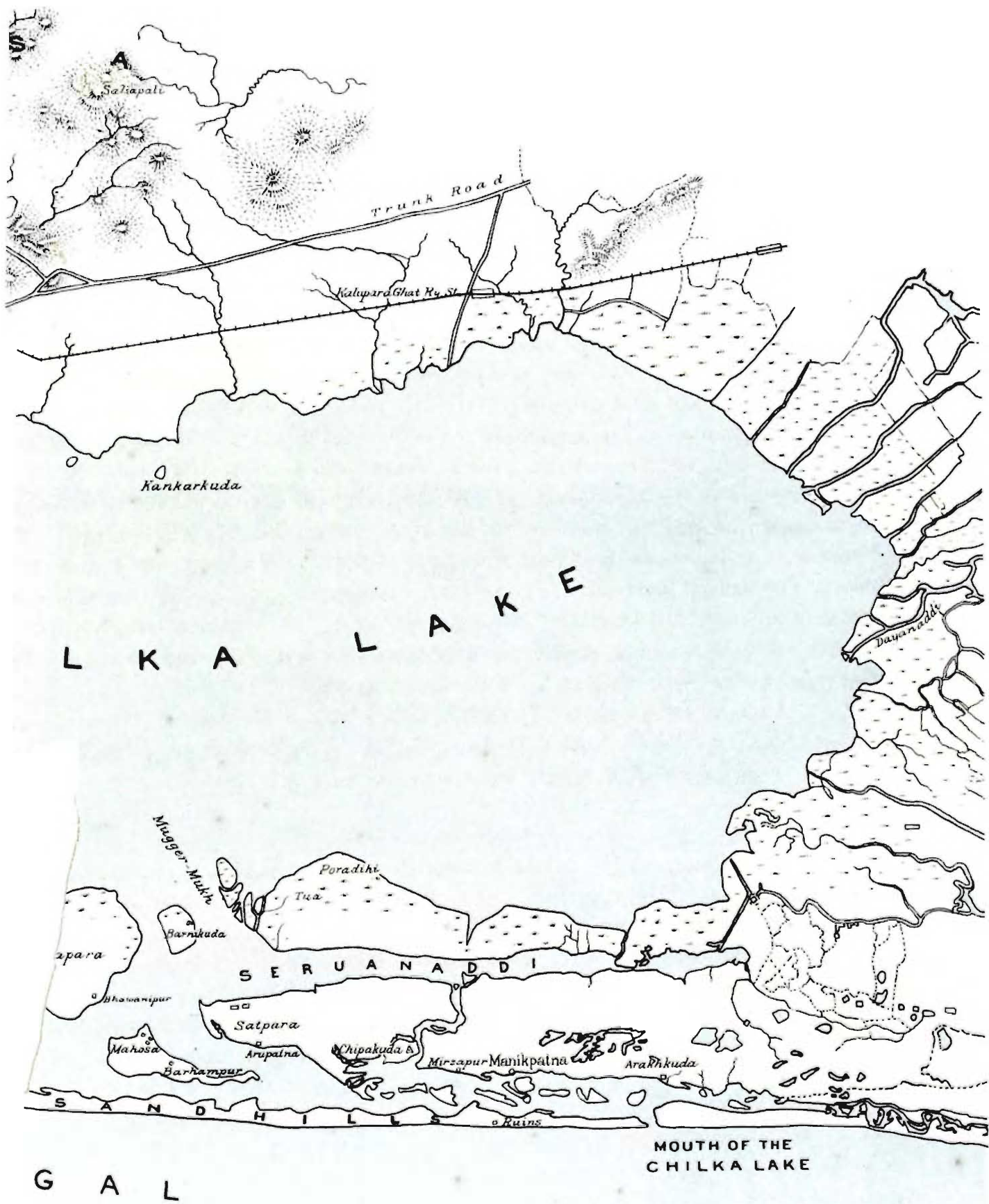
the evidence available points to the fact of there being a large number of species in both divisions of the animal kingdom which occasionally enter this part of the lake from the sea in the salt-water season, and it would not be unreasonable to expect to find in the channel at that season stray individuals of any member of the littoral fauna of the adjacent parts of the Bay of Bengal.

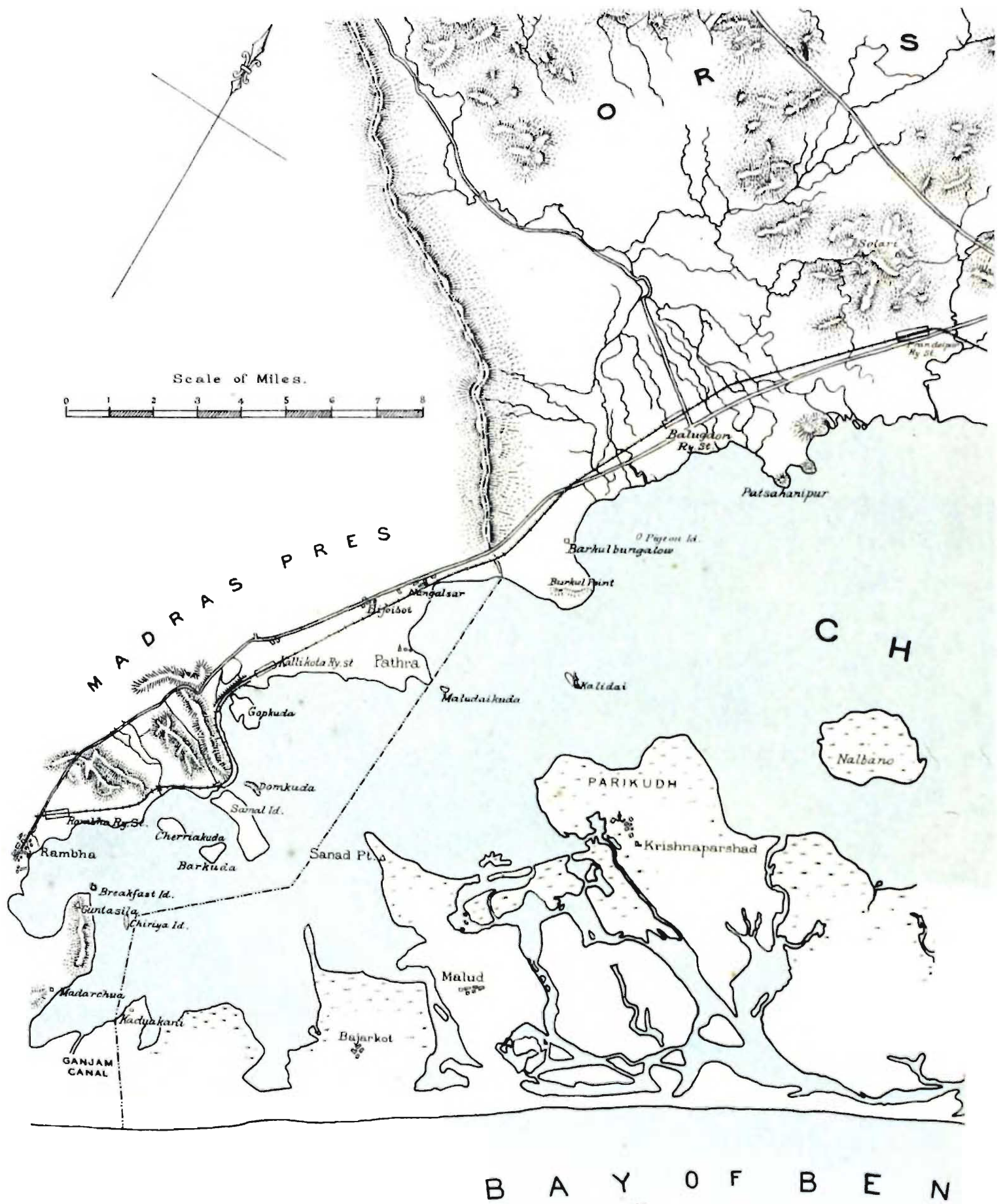
The shallowness of the water on the bar at Mugger-Mukh and in the northern part of the main area generally makes it impossible for any but a small boat to enter the outer channel or to proceed much north of Nalbano between October and August, and consequently we were unable to make use, except in September, of our larger nets either in the channel or in the shallows of the northern region. A considerable number of the marine species found in the former part of the lake in September but not in March probably escaped our notice in spring for this reason, and it is also probable that our series of fish and possibly of reptiles would have been considerably augmented if we had had the use of the launch between Satpara and the mouth of the lake at all seasons. The freshwater season (roughly the middle of August to the middle of October) is, however, the critical period in the study of those animals that are able to withstand great changes in salinity and September is therefore perhaps the most interesting month in the year so far as the outer channel is concerned. There is, moreover, no reason to postulate any great difference between the faunas of the northern and central parts of the main area, except in so far as extreme shallowness of water is indirectly destructive of animal life owing to increased temperature. So far as the main area is concerned, the only faunistic boundary that we are able to distinguish extends from Kalidai Id. towards Parikudh.

In our own papers we have included notes on and descriptions of species allied to those from the Chilka Lake but found in the Gangetic delta or in lagoons on the Indian coasts, in cases in which this course seemed desirable.

#### ACKNOWLEDGMENTS.

In the first place we have to thank both the specialists abroad who are helping us in the preparation of this report and our colleagues in Calcutta who have assisted us in the field and in the laboratory. The artists of the Museum and of the Marine Survey of India, Babus A. C. Chowdhury, S. C. Mondul and D. N. Bagchi, have devoted their usual skill to the preparation of the plates and figures that illustrate our papers, while Mr. G. M. Henry of the Colombo Museum has prepared several sketches of living animals that have been of great use in describing the species. To our assistant in the field, Mr. R. Hodgart, much of the success of our collecting is due. Mr. C. Dodsworth, agent for the Kallikota estates, helped us considerably at Rambha and elsewhere, and we have to thank the Superintending Engineer, Orissa Circle, and the Inspector of Salt Revenue at Satpara for the use of bungalows or boats on the lake. Last but not least of our obligations are those to Colonel Sir S. G. Burrard, F.R.S., and other officers of the Survey of India, who gave us invaluable technical advice and placed at our disposal the scientific instruments that rendered the necessary physical observations possible.





FAUNA OF THE CHILKA LAKE  
SPONGES.

*By* N. ANNANDALE, *D.Sc., F.A.S.B.*

(Plates III-V.)

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## SPONGES.

By N. ANNANDALE.

The sponges of the Chilka Lake, though few in number of species, are of great biological interest, not merely because they consist of both freshwater and marine forms growing together in an intimate manner, but also because at least one of the latter has become modified in accordance with conditions of life more proper to an inland lake than to any part of the sea, while the true freshwater sponge *Spongilla alba* has developed peculiarities that are correlated with conditions only to be described as marine. The following is a list of the species obtained in the course of our survey. All are siliceous sponges belonging to the order Tetraxonida.

### MONAXONELLIDA.

#### Fam. SPONGILLIDAE.

*Spongilla alba*, Carter.

*Spongilla nana*, sp. nov.

#### Fam. CLIONIDAE.

*Cliona vastifica*, Hancock.

#### Fam. SUBERITIDAE.

*Suberites sericeus*, Thiele.

*Laxosuberites aquae-dulcioris*,  
Annandale.

*Laxosuberites lacustris*, sp. nov.

### TETRAXONELLIDA.

#### Fam. TETILLIDAE.

*Tetilla dactyloidea* (Carter) var. *lingua*, nov.

With the exception of *Spongilla nana*, these seven sponges are common either throughout or in parts of the lake. *Spongilla alba*, being apparently unable to live in water that is distinctly brackish or salt at all seasons of the year, is found only in the outer channel and in the northern part of the main area of the lake itself, but flourishes in a pool of fresh water on an island in the southern part. *Spongilla nana* was found, on one occasion only, in the northern part of the same area; it is possibly no more than a modified form of the other species. The boring sponge *Cliona vastifica* is abundant in oyster-shells in the outer channel and also occurs in those of *Purpura* in Rambha Bay and the neighbourhood. *Suberites sericeus* and *Laxosuberites aquae-dulcioris* grow all over the lake, while *L. lacustris* has been found only in rocky localities in the main area, and the *Tetilla* in sandy parts of the outer channel.

We know at present, as I have recently pointed out elsewhere, very little about the littoral sponges of the Bay of Bengal, and the biological conditions that prevail

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<sup>1</sup> *Rec. Ind. Mus.* X, p. 194 (1914).

on the coast north of Palk Straits differ greatly from those occurring in the Gulf of Manaar, whence several large collections have been described. It is not surprising, therefore, that the Chilka sponges cast little light on the distribution of the Indian sponge-fauna as a whole. Of the two Spongillidae one is apparently endemic in the lake, while the other has been found in Egypt as well as in different parts of India. The species belonging to marine families also are for the most part either endemic or of wide distribution. To the latter category belong *Cliona vastifica*, which is cosmopolitan, and *Suberites sericeus*, an Indo-Pacific species originally described from Japan and not as yet found in any intermediate locality. *Tetilla dactyloidea*, of which the variety *lingua* is apparently endemic, is known from the Arabian Sea and from the Mergui Archipelago on the east side of the Bay of Bengal. Both species of *Laxosuberites*, so far as their distribution is at present known, are confined to lagoons on the east coast of India and it is not improbable that *L. lacustris* may have been evolved from *L. aquae-dulcioris* in the Chilka Lake.

The main interest of these sponges is, as I have already indicated, of a strictly biological nature. Attention may be drawn in the first place to the remarkable variations exhibited by most of the species and to the fact that these can be definitely correlated with differences in environment. It is evident that all the species in the list are able to withstand, by one means or another, great changes of salinity. The peculiar modification of the simple gemmule characteristic of the Suberitidae whereby *Laxosuberites lacustris* has fitted itself to survive periodical desiccation (p. 50) is a noteworthy instance of adaptation to environment—a series of phenomena also illustrated to a degree hardly less striking by the manner in which the skeleton of *Spongilla alba* is modified to withstand the violence of the waves in exposed positions in the lake (p. 28).

The only sponge not included in the Chilka fauna with which I am acquainted from other Indian lagoons or estuaries is a minute representative of the order Myxospongida found in October, 1913 on oyster-shells in the backwater at Ennur a few miles north of Madras. It accompanied *Laxosuberites aquae-dulcioris*, to young examples of which it bore so close a resemblance in the field that I failed to distinguish the two species. Specimens were therefore preserved without any special care and are so shrivelled and distorted that I can only say in reference to them that they seem to represent an undescribed genus. I failed to find this sponge again at Ennur in January, 1915.

The table on the opposite page shows at a glance the distribution, in the Chilka Lake and elsewhere, of the different species. The names of those that are apparently endemic are marked with a star.

For particulars as to the biological conditions that prevail in different parts of the Chilka Lake at different seasons reference may be made to the Introduction to this volume. The specific gravities of water quoted in the paper are not readings obtained in the field but have been corrected to a standard temperature of 15°C.

## GEOGRAPHICAL LIST OF SPECIES.

m.a. = main area : o.ch. = outer channel : sp. gr. = specific gravity of water.

	CHILKA LAKE.		FURTHER DISTRIBUTION.	sp. gr.
	m.a.	o.ch.		
MONAXONELLIDA.				
SPONGILLIDAE.				
<i>Spongilla alba</i> ..	X	X	India; Egypt ( <i>fresh and brackish water</i> )	1.000—1.0065 ca. 1.006
<i>Spongilla nana</i> *	X			
CLIONIDAE.				
<i>Cliona vastifica</i>	X	X	Cosmopolitan ( <i>marine</i> )	1.000—1.0265
SUBERITIDAE.				
<i>Suberites sericeus</i> ..	X	X	Japan ( <i>marine</i> )	1.000—1.0145
<i>Laxosuberites aquae-dulcioris</i>	X	X	Madras ( <i>brackish water</i> )	1.000—1.0265
<i>Laxosuberites lacustris</i> *	X			1.000—1.0150
TETRAXONELLIDA.				
TETILLIDAE.				
<i>Tetilla dactyloidea</i> var. <i>lingua</i> *		X	Typical form in Arabian Sea and off Mergui ( <i>marine</i> )	1.000

## Suborder SIGMATOMONAXONELLIDA.

## Family SPONGILLIDAE.

## Genus SPONGILLA, Lamarck.

## Subgenus Euspongilla, Vejdovsky.

*Spongilla alba*, Carter.

(Plate iii; plate iv, figs. 1, 2; plate v, fig. 1.)

1849. *Spongilla alba*, Carter, *J. Bomb. Asiat. Soc.* III, p. 32, pl. i, fig. 4.  
 1849. „ „ *id.*, *Ann. Mag. Nat. Hist.* (2) IV, p. 83, pl. iii, fig. 4.  
 1863. „ „ Bowerbank, *Proc. Zool. Soc.*, p. 463, pl. xxxviii, fig. 15.  
 1863. „ *cerebellata*, *id.*, *ibid.*, p. 465, pl. xxxviii, fig. 16.  
 1881. „ *alba* var. *cerebellata*, and Carter, *Ann. Mag. Nat. Hist.* (5) VII, p. 83.  
 1895. „ *cerebellata*, Weltner, *Arch. Naturg.* LXI (i), p. 117.  
 1899. „ *alba*, Petr, *Rozp. Ceske Ak. Praze* II, pl. i, figs. 3-6.  
 1906. „ *lacustris* var. *bengalensis*, Annandale, *Journ. Asiat. Soc. Bengal*, p. 56.  
 1907. „ *cerebellata*, Kirkpatrick, *Ann. Mag. Nat. Hist.* (7) XX, p. 523.  
 1907. „ *alba*, Annandale, *Rec. Ind. Mus.* I, p. 388, pl. xiv, fig. 2.

1907. *Spongilla alba* var. *marina*, *id.*, *ibid.*, p. 389.  
 1909. „ *travancorica*, *id.*, *op. cit.*, III, p. 101, pl. xii, fig. 1.  
 1911. „ *alba* var. *cerebellata* and var. *bengalensis*, Annandale. *Faun. Brit. Ind.*, *Freshw. Sponges*, etc., pp. 76, 77, fig. 8b (p. 71), pl. i, figs. 1-3.  
 1911. „ *travancorica*, *id.*, *ibid.*, p. 81, fig. 11.  
 1913. „ *lacustris* var. *cerebellata*, Susswasserschwämme in *Wiss. Ergebn. Deutsch Zentralafrika-Exped.* 1907-1908, Zool. 11, p. 475.

The characters usually employed in distinguishing the species of *Spongilla* completely break down in separating *S. alba* from *S. lacustris*. Nevertheless, I believe them to be distinct, for the following reasons:—

1. Even when *S. alba* is growing side by side with green forms of *S. lacustris*, as is sometimes the case, its cells never contain chlorophyl-corpuscles (cells of the alga *Chlorella*).

2. In the living sponge, even when it is fully expanded and in full activity, the oscula are not protected by conical dermal collars, but can be partly or completely closed by horizontal or oblique membranous diaphragms, as in *S. (Eunapius) carteri*.

3. The oscula are not surrounded by radiating exhalent canals of small width and running immediately below the dermal membrane; single canals similarly situated but of much greater size often open into them after running along the surface for a considerable distance.

4. The main exhalent canals in the interior of the sponge are of much greater calibre than in *S. lacustris*.

5. There is a much thicker horny membrane at the base of the sponge.

6. There is often a subsidiary skeleton in *S. alba*, consisting of single macroscleres fastened together to form a dense irregular network by a secretion of chitinoid substance.

The fact that these characters are for the most part difficult or impossible to recognize in ordinary preserved specimens does not invalidate them from a theoretical point of view, although it renders them inconvenient to the systematist.

There are other distinguishing characters that can usually be applied to individual specimens even when these are not in particularly good condition, but they are not constant and both species are of extreme variability in accordance with environment, locality and individual idiosyncrasy. The most notable of the usually differential characters exists in the structure of the skeleton.

In the typical form of *S. lacustris* (*i.e.* the form usually found in normal circumstances in Northern Europe) the radiating or vertical spicule-fibres are compact though slender, and often run for some distance without branching. The spicules of which they are mainly formed are cemented together by a secretion of horny substance, which does not, however, form a sheath on the surface of the fibre. These fibres are joined together, often at considerable intervals, by more slender

transverse ones or even by single spicules: at places there is also an irregular network of single spicules or very fine fibres. At all points at which spicules of the skeleton meet one another at an angle there is a more profuse secretion of horny substance, which there forms a kind of veil<sup>1</sup> often produced for some little distance along the surface of individual spicules.

In the typical form of *S. alba* (*i.e.* the form represented by the type specimen, which is from fresh water on the island of Bombay) the structure of the skeleton is essentially the same, but the radiating fibres branch and anastomose more freely and the transverse ones are more numerous, so that a closer and harder network is formed. Moreover, the subsidiary skeleton of single spicules to which I have alluded already is characteristic, in its full development, of the harder phases of this species, although but slight traces of it can be detected in the more fragile forms thereof.

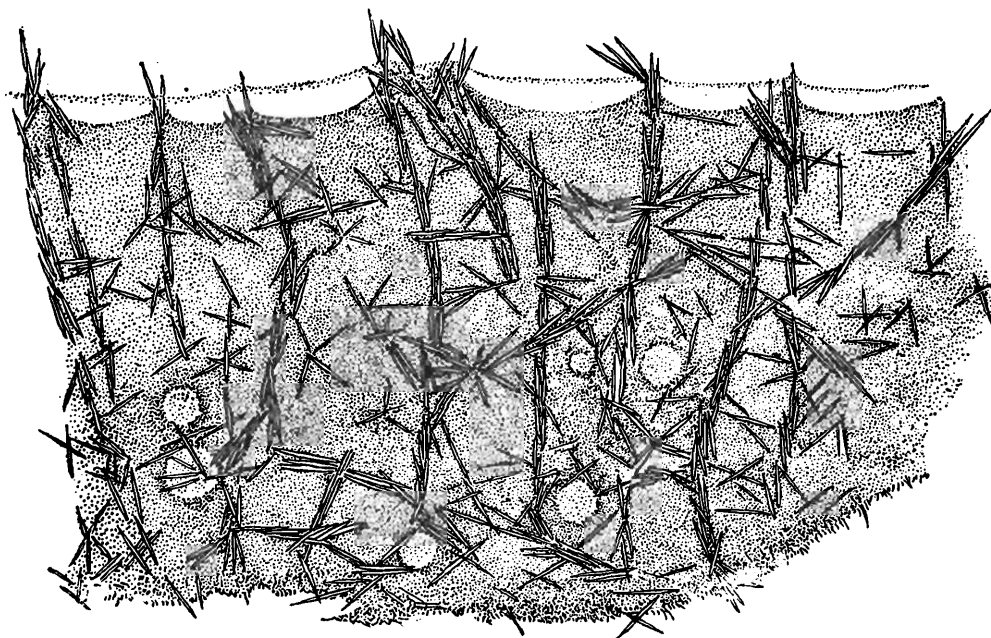


FIG. 1.—*Spongilla alba*, Carter.

Vertical section of a moderately hard sponge from Pigeon Id. in the Chilka Lake, × 30.

If a long series of specimens from different localities be examined it will be found that some of them agree in skeletal structure almost precisely with the typical *S. lacustris*. In the Chilka Lake and its immediate vicinity we obtained specimens not only providing a complete transition, but even going further in some cases than the typical *S. lacustris* in the direction of simplicity of skeleton, and, in other cases, than the typical *S. alba* in that of complexity. In simple forms the secretion of horny matter is much reduced and it does not produce veil-like films at the nodes of the skeleton (see pl. iv, figs. 1, 2, and pl. v, fig. 1).

Neither the spicules nor the gemmules afford any constant differential character. The macroscleres are simple, sharply pointed, smooth amphioxi, very variable in size

<sup>1</sup> Apparently this veil is never deposited in distinct concentric layers as in *Lubomirskia*, *cf.* Annandale, *Rec. Ind. Mus.* X, p. 144, pl. ix, fig. 1a (1914).

and proportions in the case of both species, but not essentially different from those of many other sponges. The free microscleres, although also variable, are identical or practically identical in the two species. The microscleres of the gemmule of all forms of *S. alba* with which I am acquainted differ from those of the typical form of *S. lacustris* in being relatively more slender and in never having a very strong curvature, but both these features are found in some forms of *S. lacustris* also, e.g. in the common Indian varieties *reticulata* and *proliferens*.<sup>1</sup> The number of free microscleres present is extremely variable. Sometimes they are practically absent from the choanosome. The spicules of a specimen of moderate hardness are figured, on p. 3.

The number of spicules present in and on the pneumatic coat of the gemmule—in some forms of *S. lacustris* both spicules and coat are practically absent—is extremely variable; their precise arrangement is correlated with their number and with the thickness of the coat, another variable character.

In the synonymy given above I have included the names of four varieties (the typical form, vars. *cerebellata*, *marina* and *bengalensis*) and of a "species" (*S. travancorica*) that I formerly regarded as distinct. Although "typical" (i.e. extreme) specimens of these can be readily distinguished, so many intermediate sponges occur that any attempt to distinguish them consistently is vexatious and unprofitable. The form *travancorica* is perhaps more strongly differentiated than the others, but the original description of it was founded on a single degenerate specimen and many of those from the Chilka Lake approach it closely.

Among the latter are included the types of the var. *marina*: also many sponges that are even further removed from the typical *S. lacustris* than is the type of *S. alba*, as well as others clearly referable to the typical form of the latter, to *bengalensis* or, identical, except in the features noted above, with some forms of *S. lacustris*. Others, again, are much harder than the forms of either species hitherto described. The spicules and skeleton of an average specimen are figured in figs. 1 and 2, pp. 27, 30.

Variation in the structure of the skeleton is definitely correlated, in sponges from the lake, with environment. Generally speaking, those that grow on rocks exposed to the violence of waves in open water are hard, their skeleton-fibres being thick, branching and anastomosing freely and containing much horny matter, while the subsidiary skeleton is well developed; those that grow among loose filamentous algae have remarkably slender fibres forming a very open network and containing very little horny matter (compare figs. 1, 1a with fig. 2 on pl. iv). In such sponges the subsidiary skeleton is practically absent.

But intermediate forms occur. The softest specimens of the species I have seen anywhere were growing among loose weeds in a small pool of practically fresh water on Barkuda Id.; sponges from rocks in the same pool were much harder, though not as hard as those from similar positions in the lake.

<sup>1</sup> The tubular form of foraminal armature characteristic of *S. proliferens* is not constant and the sponge cannot therefore be regarded any longer as a distinct species.

The species may be described as essentially an encrusting sponge, but short branches, as a rule distinctly compressed rather than cylindrical, often arise from the surface. Sometimes they are so thin as to be almost filamentous, often they are short and stout and of irregular, triangular or trilobed cross-section (pl. v, fig. 1). In most cases these branches (pl. iii) are mere crusts enclosing fine filaments of algae or the stems of water plants, but sometimes it is not possible to detect in them any extraneous core.

In the phase that occurs on rocks in the Chilka Lake the larger waterways have a distinctly radial arrangement and the main exhalent channels converge, near and on the surface of the parenchyma, to a central primitive osculum. The external surface has a reticulate appearance owing to the arrangement of the skeleton and the meshes are often distinctly longer in the direction of the exhalent channels than in any other. The inhalent channels are vertical in direction and are conspicuous in the dried sponge as circular pits extending downwards from the surface. The dermal pores are scattered and very minute. They have the unicellular structure characteristic of the family.

*S. alba* has been found in fresh water at several widely separated localities in India: the island of Bombay, the Western Ghats, Calcutta, and Hyderabad: also near Cairo in Lower Egypt; nowhere does it appear to be of common occurrence in ordinary ponds and lakes. It is, however, extremely abundant in brackish water in the Gangetic delta and has been found in the same medium on the west coast of India in the backwaters of Cochin. In the Chilka Lake its distribution is somewhat remarkable. It occurs on all the rocks of the northern region, often growing luxuriantly and covering considerable areas, and is found among loose algae in the outer channel. In sheltered inlets among the rocks its gemmules often form a scum on the surface. South of Kalidai Id it is not present in the lake, although many rocks apparently suited for its growth are situated round Rambha Bay. It does grow, however, in a small pool of practically fresh water on Barkuda Id. Even on Kalidai, on the north side of which it is common, we did not find it on the south side. A very careful search at low water on Maludaikuda Id. failed to reveal a single specimen, and no gemmules could be detected on the surface of the water. The sponge evidently flourishes best at depths of from 2 to 10 feet. We found it growing actively and producing larvae in water of a sp. gr. of 1.0065, but it cannot exist in water that never becomes fresh or practically fresh; specimens taken in salt water in the outer channel were all dead.

The larvae are of the true Spongillid type and resemble those of *S. lacustris* in their ovoid shape.

The colour of *S. alba* varies greatly but depends on external circumstances. As its name indicates, the sponge is, when growing in clean water, of a glistening white very characteristic in its purity, but if the water it inhabits is muddy, as is usually the case, it assumes the hue of the surrounding soil. In the pond on Barkuda Id., where the earth and rocks contain much iron, it is reddish; in the lake and in the creeks and canals of the Gangetic delta it is grey, but this tint is usually concealed

by a dull green flush sometimes so strong as to predominate. In these cases the colour is due to nothing inherent in the sponge but either to minute particles of silt in its parenchyma cells or to the growth in its substance of green filamentous algae, which belong to several quite distinct groups. In the Chilka Lake a chain-forming diatom is often responsible for the green tint.

In its power of engulfing particles of silt without apparent detriment to itself this sponge shows itself peculiarly adapted for existence in muddy water in which the solid particles are extremely small, as is the case both in the lake and in most other places at which it has been found. The minuteness of its dermal pores<sup>1</sup> doubtless serves a similar purpose, or at any rate saves it from being overwhelmed

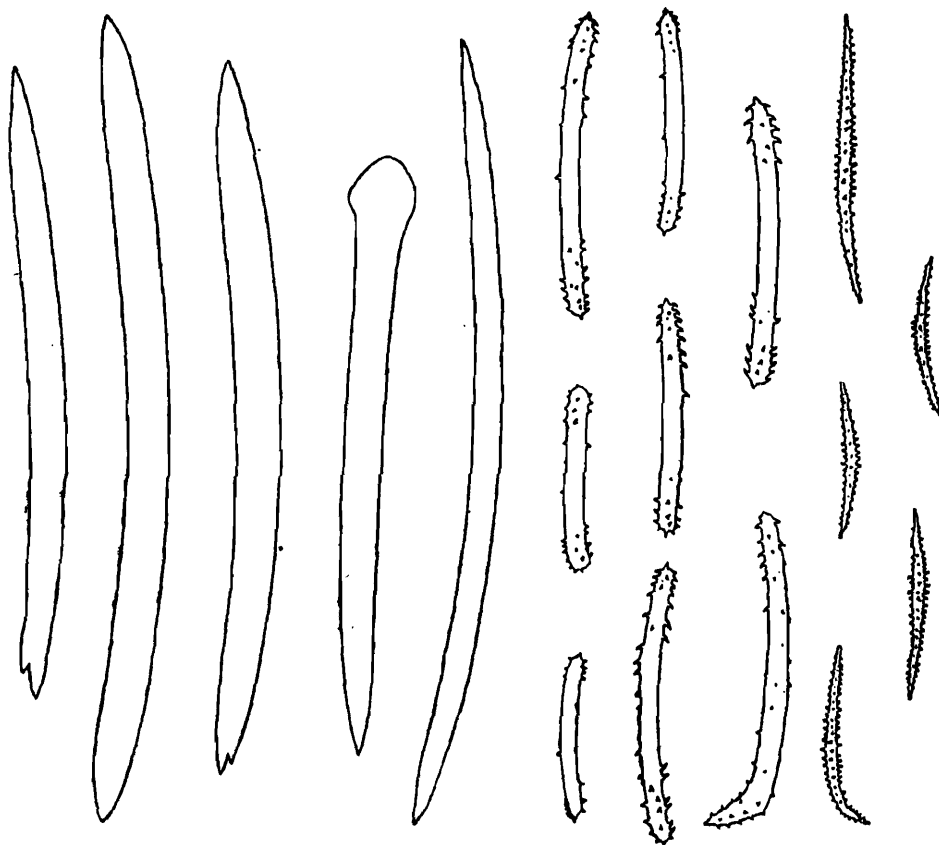


FIG. 2.—*Spongilla alba*, Carter.  
Spicules of a normal specimen from the Chilka Lake,  $\times 255$ .

by the deposition of silt. The green algae that grow in it are parasitic, or at any-rate incidentally destructive.<sup>2</sup>

Where rocks occur *S. alba* is literally attracted to them, for as the gemmules are set free from the sponge by the gradual disintegration of its skeleton, they gravitate towards the rocks on the same principle that floating bodies of all kinds are attracted one to another or to fixed objects. Their liberation takes place, owing to the decay of the sponge and the disintegration of the skeleton on the death of its cells, mainly between February and June, but may occur at any time of the year,

<sup>1</sup> These pores have been actually observed, so far as *S. lacustris* is concerned, only in the var. *proliferens*. See *Journ. As. Soc. Bengal* (n. s.) IX, p. 69, pl. v, fig. 1 (1913).

<sup>2</sup> See *Faun. Brit. Ind., Freshw. Sponges, etc.*, p. 49 (1911).

and many of them are retained *in situ*, for the skeleton is rarely destroyed completely ere the return of the waters. In the pond on Barkuda Id. only dead sponges were found in April; in July the gemmules were beginning to sprout, and in September the sponges were in full activity, new gemmules being formed. A mass of sprouting gemmules kept in a dish of water on the island in July produced in five days a small sponge with a single osculum. It is worthy of note that they did not each produce a different "individual", but built, as it were, a single edifice in common. The sponge is in full vigour in the lake in November and continues in this condition until the rocks on which it grows become dry or the water round them grows foul owing to the decay of vegetation. As late as the beginning of March some extremely

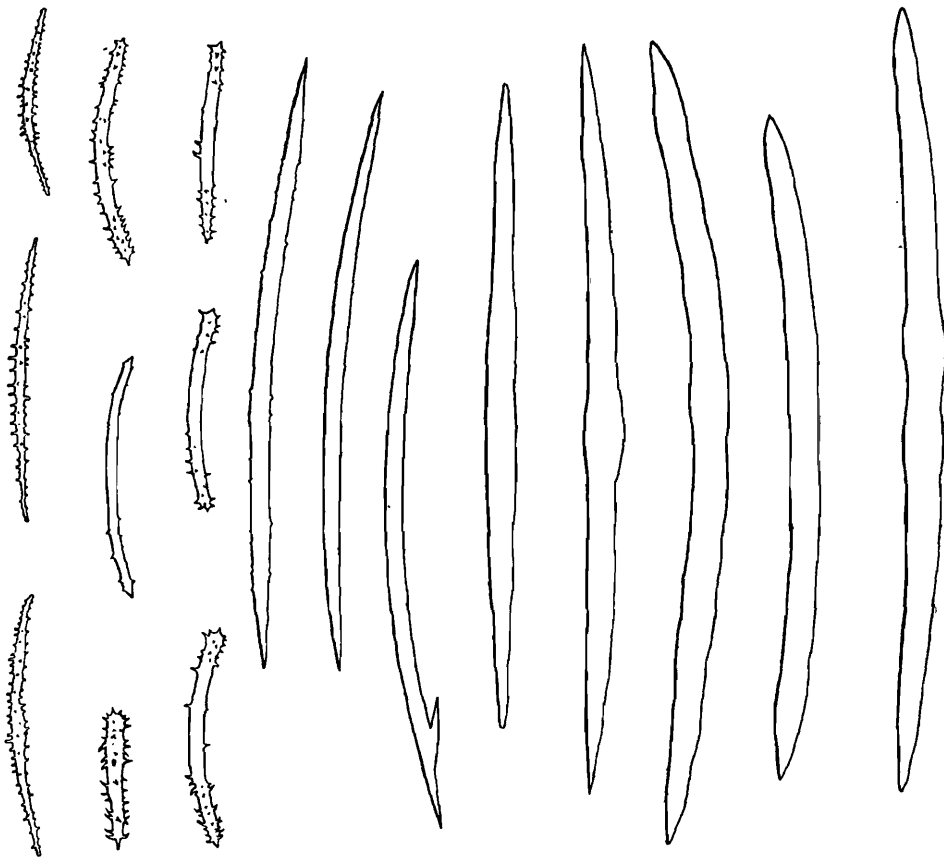


FIG. 3.—*Spongilla nana*, sp. nov.  
Spicules of one of the type-specimens,  $\times 255$ .

hard living specimens were obtained on a little rock out in the lake near Patsahanipur. The water was free from decaying weeds and covered a considerable depth of rock. The earliest date at which we saw sponges of the species in a vigorous condition was the end of September; a large specimen was obtained a few days before the end of that month on a reed at Nalbano Id. in 1913. The sponges taken in March (in water of a specific gravity sometimes as high as 1.0065) contained many mature embryos and young larvae as well as gemmules. The two kinds of reproductive body were evidently produced in close proximity.

The canals of *S. alba*<sup>1</sup> often give shelter to large numbers of small animals of

<sup>1</sup> *Faun. Brit. Ind., Freshw. Sponges* p. 76 (1911).

various kinds, but this is not so commonly the case in the Chilka Lake as in some other localities. We found in them, however, at least two species of Nematode worms (*Dorylaimus* sp. and *Oncholaimus chilkenis*, Stewart<sup>1</sup>) as well as Polychaeta of the family Nereidae. Molluscs of the genus *Modiola* are often overwhelmed by the growth of the sponge, but we did not find in sponges from the lake the shells of *Corbula*<sup>2</sup> so common in those from the ponds at Port Canning.

One of the most striking illustrations of admixture of marine and freshwater fauna that the lake provides is the occurrence on the same rocks, and often even intermingled, of *Spongilla alba* and a sponge of the marine family Suberitidae (*Laxosuberites lacustris*, p. 49 *postea*). When they come in contact, the Spongillid, being the more vigorous species of the two, usually overwhelms the other.

### *Spongilla nana*, sp. nov.

(Plate iv, fig. 3.)

The sponge forms spherical or cushion-shaped masses that do not exceed and indeed rarely reach 5 mm. in diameter. The colour (in life as in spirit) is pale yellowish or buff. The whole structure is extremely fragile. There is as a rule a single osculum and in some specimens a cylindrical central cavity can be detected, extending downwards almost to the base of the sponge (pl. iv, fig. 3). The subdermal cavity is ample and the general arrangement of the canals and apertures resembles that found in *Spongilla alba*. There is little or no horny matter at the base of the sponge, which is attached lightly to its support.

The skeleton has a distinctly radial arrangement, but contains very little horny matter. The radial spicule-fibres are distinct but slender and feebly coherent. They can frequently be traced from a point near the centre of the sponge to its surface, where they project as spines. The transverse fibres are, however, imperfectly differentiated and in many places represented merely by an irregular network of single spicules. No distinct subsidiary skeleton can be detected.

The spicules in many respects resemble those of *S. alba*, but are as a rule more attenuated and irregular. The macroscleres in particular are remarkable in the latter respect. Some are sparsely and minutely spiny, but their irregularity of outline, the precise nature of which is best indicated by a figure (fig. 3, p. 31), is often of a more general nature. The spicules of this type are sharply pointed at both ends and as a rule slightly and regularly curved.

The gemmule-spicules are slender and also exhibit a slight and regular curvature. As a rule they are distinctly mucronate at both extremities, but sometimes one end is blunt. They bear short, straight, sharp spines, which are fairly numerous at and near the extremities and sometimes a little retroverted in this region. The middle of the shaft is often bare or has only a few isolated spines.

<sup>1</sup> *Rec. Ind. Mus.* X, pp. 245, 247 (1914).

<sup>2</sup> See Preston, *Ann. Mag. Nat. Hist.* (7) XIX, p. 215 (1907) and Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 78 (1911).

The free microscleres are slender, spindle-shaped, sharply pointed, slightly curved-amphioxi, covered fairly uniformly with short, straight, blunt spines. They are numerous both in the parenchyma and in the dermal membrane.

The gemmules, though the sponge is never bulky enough to contain many of them, are fully formed and relatively large. They possess a thick pneumatic coat including many spicules. The single foramen is armed with a horny cup or short tubule. The spicules are for the most part tangential to the inner coat but a large number stand upright or nearly upright, giving the surface an irregular appearance like that of the gemmules of the form of *S. alba* that I called *travancorica*. There are also a few horizontal spicules on the surface.

Diameter of gemmule	..	0.27 mm.
Length of macrosclere (average)		0.192 ,,
Thickness	,,	0.010 ,,
Length of gemmule-spicule (average)		0.098 ,,
Thickness	,,	0.005 ,,
Length of free microscleres (average)		0.0102 ,,
Thickness	,,	0.001 ,,

*Type.* No. Z.E.V 6455/7 *Ind. Mus.*

*Locality.* In a small bay at the base of Patsahanipur promontory, Chilka Lake, Orissa, 26-1-14. Salinity of water approximately 1.006: depth not more than 2 feet.

We found this sponge on one occasion only, but then in considerable numbers. The little spheres or cushions were attached to the free stems of a water-plant. As they were in a small backwater behind a rock where there was much decaying vegetation, I was at first inclined to regard them merely as abortive or abnormal individuals of *S. alba* which, owing to unfavourable conditions, had developed prematurely. This view would be supported by the fact that in general structure they resemble a little sponge from an aquarium in Calcutta that I regard as an abortive form of *S. (Eunapius) carteri*.<sup>1</sup> Although, however, the skeleton-spicules of young sponges of *S. carteri* are often irregular in outline, this feature is by no means strongly marked in the abortive sponge. Both in it and in some forms of *S. lacustris* that have been found growing in unfavourable environments the gemmules are poorly developed, being not only small but devoid or practically devoid of special microscleres; this is also the case in large sponges of *S. carteri* induced by confinement in an aquarium to produce gemmules prematurely. It is, therefore, an important point in considering the status of *S. nana* that its gemmules are fully developed and relatively large: it is clear that the sponge, in the case of the type-specimens, has produced the gemmules and not the gemmules the sponge, for their surface shows no signs of wear or of having been exposed unprotected to the water and many of them were actually in the course of formation when killed, the outer part of their coat not

<sup>1</sup> *Faun. Brit. Ind., Freshw. Sponges, etc., p. 126, etc., pl. i, fig. 4 (1911).*

being as yet complete. It is mainly this consideration that has induced me to describe the species as distinct, but no other sponge in the subgenus has skeleton-spicules of quite the same nature.

Suborder ASTROMONAXONELIIDA.

Family CLIONIDAE.

Genus CLIONA, Grant.

1888. *Cliona*, Topsent, *Arch. Zool. expériment. (2) V bis*, p. 76.

1891. ,, *id., ibid.*, (2) IX, p. 556.

1915. ,, Annandale, *Rec. Ind. Mus.* XI, p. 1.

Elsewhere I have given a key to the Indian species of the genus (1915, p. 5).

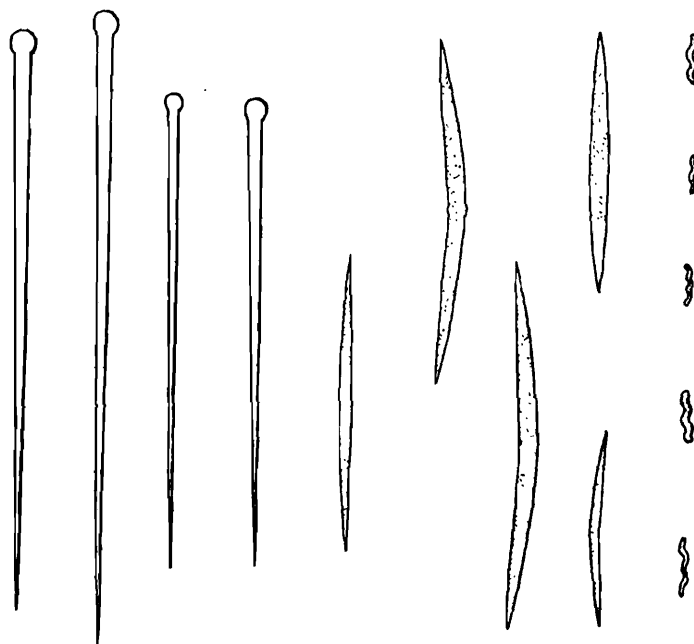


FIG. 4.—*Cliona vastifica*, Hancock.  
Spicules of a specimen from the oyster-beds at Manikpatna.

***Cliona vastifica*, Hancock.**

(Plate iv, fig. 7.)

1900. *Cliona vastifica*, Topsent, *Arch. Zool. expériment. (3) VIII*, p. 56, pl. ii, figs. 3—9.

1915. *Cliona vastifica*, Annandale, *Rec. Ind. Mus.* XI, p. 8.

A full description and synonymy of this well-known species will be found in Topsent's paper of 1900. I give here (fig. 4) a figure of the spicules of a specimen from the outer channel of the Chilka Lake.

As I have recently pointed out (1915, p. 8) *C. vastifica* is the commonest species of boring sponge on the coasts of India in quite shallow water; it is cosmopolitan in its distribution. In the Bay of Bengal it is very abundant; apparently it does great injury to oysters and similar bivalve molluscs both there and in the Persian Gulf. In the seas of France it is, according to Topsent, less vigorous than *C. celata*, Grant;

but this is not the case in Indian waters. I figure on plate iv a fragment of an oyster-shell from Manikpatna destroyed by it.

In the Chilka Lake *C. vastifica* is abundant in the oyster-beds of the outer channel. We found it in a flourishing condition both in September, 1913, when the water was fresh or practically so, and in March, 1914, when it was as salt as that of the Bay of Bengal (sp. gr. 1.0265). In the main area, towards the south end of the lake, we took a few shells in which it occurred in February, March, and November in water of a sp. gr. of from 1.006 to 1.010. In the outer channel it was always obtained in the shells of *Ostrea*, in which it was also found in the Ennur back-water and the Adyar river near Madras in October, 1913; whereas in the main area of the Chilka Lake it was only seen alive in shells of *Purpura (Thais) carinifera*. In the latter region, however, burrows that agree with those made by it in oyster-shells elsewhere were noticed in dead shells of *Placuna* and *Ostrea*.

At both seasons of the year at which we took this species in the outer channel its burrows contained many gemmules as well as living sponge-tissue, and were numerous and of a relatively large size; but examples found in shells of *Purpura* in and in the neighbourhood of Rambha Bay contained few gemmules and were otherwise feeble, though their spicules were well-developed and typical. Curiously enough, *C. vastifica* shares with a deep-sea species of its genus (*C. annulifera*, Annandale<sup>1</sup>) the power of producing gemmules. Their utility is, I believe, in both cases connected with the fact that the shells in which the sponge makes its excavations are liable to be invaded by other boring sponges or covered over by species of encrusting or parasitic habits. We found numerous examples of *Laxosuberites aquaedulcioris* on the outside of oyster-shells whose substance was permeated by the galleries of *C. vastifica*. Where the Suberitid was very thin the excavator maintained itself alive and thrust its papillae right through the substance of the encrusting form, but this became impossible as the latter grew thicker and the hidden sponge was soon overwhelmed. Encrusting sponges that coat small areas such as the external surface of shells cannot be long-lived and it is not improbable that the gemmules lie concealed in the interior of the shell when their parent-sponge is overwhelmed, and sprout *in situ* if favourable conditions return.

#### Family SUBERITIDAE.

#### Genus SUBERITES, Nardo.

1900. *Suberites*, Topsent, *Arch. Zool. expériment.* (3) VIII, p. 224.

The genus *Suberites* as now restricted consists of massive sponges with a confused skeleton, without detachable ectosome, but with vertical bunches of spicules on the surface. Although a considerable number of Indian species were assigned to it in days when the name had a much wider significance, only three that have hitherto been recorded from Indian seas can now be assigned to the genus: *Suberites*

<sup>1</sup> *Rec. Ind. Mus.* XI, p. 12, pl. i, fig. 2 (1915).

*carneus* (Johnston),<sup>1</sup> *S. inconstans*, Dendy<sup>2</sup> and *S. cruciatus* of the same author.<sup>3</sup> The first of these is a cosmopolitan species found by Carter in the late Dr. J. Anderson's collection from the Mergui Archipelago: the two latter were described by Prof. Dendy from Mr. E. Thurston's and Prof. Herdman's collections from the Gulf of Manaar. Thiele<sup>4</sup> states that *S. inconstans* is a *Spirastrella*, but I have not succeeded in finding the characteristic microscleres of that genus in specimens from the Gulf of Manaar; possibly the sponges from Celebes examined by Thiele represented a distinct species. Carter's *Suberites vestigium*,<sup>5</sup> an example of which was recently obtained by Mr. S. W. Kemp at Kilakarai on the Gulf of Manaar, is a *Pseudo-suberites*.

One species of *Suberites* (s.s) is well represented in our collection of the Chilka fauna, namely *S. sericeus*, Thiele, a very distinct form that shows a relationship in one of its phases to *Pseudosuberites*, though better developed sponges clearly belong to the parent-genus of the family. This species was originally described from Japan.

### **Suberites sericeus, Thiele.**

(Plate iv, fig. 4.)

1898. *Suberites sericeus*, Thiele, Stud. ü. pacif. Spongien (*Bibl. Zool.* X, 24), p. 39, pl. viii, fig. 10.

Thiele's species was described from two small specimens that had grown on the shells of Gastropods. Apart from his account of the spicules, of which he gave a good figure, the description was by no means full and all that we learn from it is that the specimens, which were dry, formed thin films of small size and that the skeleton of one was amorphous while that of the other was "somewhat reticulate." Fortunately the spicules are characteristic. Although all are macroscleres and tylostyles, they may be separated into two classes, the more distinctive of which is remarkable for its short, stout form (fig. 5).

In the Chilka Lake this sponge is found in two phases, one of which is apparently identical with that of the type-specimens, while the other is much more robust. The former may be called phase A, the latter phase B.

In phase A the sponge is restricted in area, forms a film not more than 2 mm. thick and has a minutely hispid but otherwise smooth surface; whereas in phase B it extends over areas of considerable extent, may attain a depth of at least 50 mm., and is not only hispid on the surface but also produces irregular projections and, occasionally, curious ear-like horizontal outgrowths.

The two phases are not absolutely distinct, for the extreme periphery of large masses of sponge closely resemble phase A and when masses of the kind grow out

<sup>1</sup> Most fully described by Topsent in the paper cited (1900), p. 233.

<sup>2</sup> *Ann. Mag. Nat. Hist.* (5) XX, p. 154, pls. ix, x (1887).

<sup>3</sup> In Herdman's *Ceylon Pearl Fisheries* III, p. 131, pl. v, fig. 10.

<sup>4</sup> Stud. ü. Pacifisch. Spongien (*Bibl. Zool.* X, 24), p. 10, pl. i, figs. 3, 3a, pl. v, fig. 4 (1899).

<sup>5</sup> *Ann. Mag. Nat. Hist.* (5) VI, p. 52, pl. v, fig. 21 (1880).

over leaves that come in contact with them or the shells of mussels attached to the same support, the thin film that they first produce over these bodies, before incorporating them, is indistinguishable from the less robust phase. The differences between the skeletons of the two phases are no less striking than those between their external forms, and just as in *Laxosuberites aquae-dulcioris* one phase of the species approaches the genus *Prosuberites* in certain details of structure (p. 43 *postea*), so

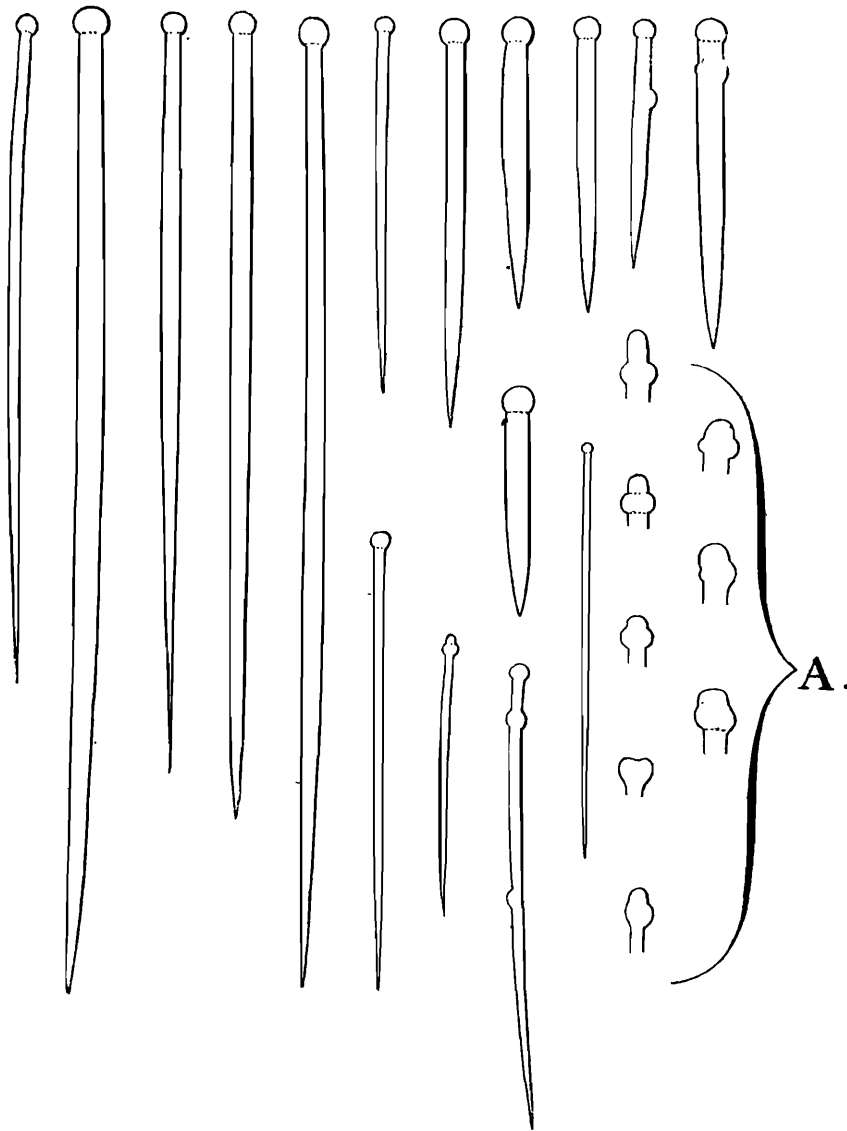


FIG. 5.—*Suberites sericeus*, Thiele.  
Spicules of a specimen in phase B,  $\times 255$ .  
A.—Heads of spicules further enlarged.

in *Suberites sericeus* one phase, in this case as in that of the other species the less robust, approaches the genus *Pseudosuberites*.

Before discussing the peculiarities of the two phases in detail it will be as well to say something of the specific characters.

The most constant of these is the occurrence both of short, relatively stout spicules and of much larger ones in which the shaft is relatively more slender.

Those of the larger type have small subglobular heads which are not separated from the shaft by a constriction. As a rule the heads are only prevented from being spherical by the fact that they are flattened at the point at which they are attached to the shaft, but trilobed, acorn-shaped and other forms occur among them (fig. 5) and these are often asymmetrical. The shafts are long, relatively slender and as a rule straight, if curved but slightly so and usually only towards the distal extremity. The maximum diameter is already attained at the point at which they are joined to the head and does not diminish until near the other end, at which the shaft tapers to a very fine point. The greatest length of the spicules of this type is 0.44 mm., the greatest thickness of the shaft 0.0117 mm. and the diameter of the head about 0.0126 mm. Some spicules that belong on account of the relative slenderness of their shafts to the same type are rather smaller and a few greatly so, being not more than 0.105 mm. long. The diameter of the shaft varies considerably.

The second type of spicule has the shaft as stout as that of the largest spicules, but the maximum diameter is situated as a rule near the middle of the length and the shaft tapers towards the head. The length of the shortest spicules of this type is not more than 0.098 mm., but it may be as much as 0.147 mm. and is usually about 0.12 mm.

Spicules of the first type are found in abundance throughout the sponge, but those of the second occur singly in the central parts only.

The living sponge, in both phases, is of a bright sulphur-yellow colour, which is evenly distributed throughout its substance and disappears rapidly in spirit. The consistency is soft and somewhat elastic.

The oscula are small and scattered; they are not connected, as in the two species of *Laxosuberites* found in the lake, with a regular system of subdermal canals, but a few irregular exhalent channels in this position sometimes open into them. As a rule these canals are more deeply buried, often running for some distance parallel to the surface in the choanosome and opening not directly into the osculum but into vertical canals that extend downwards from it. The pores are minute and not confined to restricted areas; the vertical lacunae into which they open are small and the structure of the whole inhalent system is obscure.

The position of the main exhalent channels, combined with the rather dense structure of the outer parts of the sponge, indicates some approach to the differentiation between ectosome and choanosome that reaches a much higher degree of development in *Pseudosuberites*. There are always, moreover, horizontal spicules in the external parts, though this is much more marked in certain conditions of the sponge than in others and in some cases their number is very small.

There is a stout horny membrane at the base of the sponge.

#### *Phase A.*

The skeleton in this phase is fragile and the exercise of pressure immediately reduces it to an amorphous state. If sections be made of carefully preserved material a definite structure is apparent, especially if the part sectioned does not contain

gemmules. In those parts of the sponge in which reproductive bodies are absent, numerous spicules will be found with their heads embedded in the basal membrane and their points projecting upwards. In most cases they do so at an angle less than a right angle, but regular ascending columns of an entirely non-plumose character can be distinguished. The lowest spicules in these columns project straight upwards from the basal membrane, while the highest form brushes on the surface of the sponge, where they are to some extent splayed out.

Otherwise the skeleton forms an indefinite network in which the strands are formed mainly of single spicules and no very distinct fasciculation can be detected. On and near the surface there are numerous horizontal spicules.

Where gemmules are present the lower part of the skeleton becomes partially or wholly disorganized, while the spicules tend to be massed in a horizontal layer a little below the surface. As the cellular parts of the sponge also degenerate on the

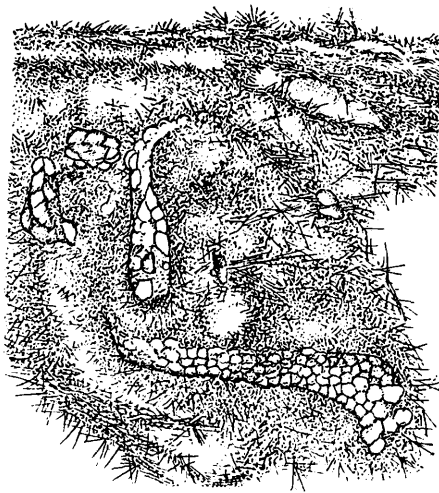


FIG. 6.—*Suberites sericeus*, Thiele.

Vertical section through the outer part of a sponge in phase B, showing gemmules,  $\times$  ca. 10.

production of gemmules and are less completely destroyed where furthest from these bodies, the flesh is also massed together above and an "ectosome" distinct from the choanosome is thus formed (fig. 7, p. 40).

Gemmules are produced in large numbers. They form a single layer at the base of the sponge firmly connected with the adherent basal membrane. They vary greatly in size and shape but are always flattened at the base and strongly convex above. Their horny coat is thin, but the fact that it is deposited in several layers can sometimes be ascertained from its laminated structure. There is no foramen (micropyle). The structure of the actual reproductive body is that usually found in the gemmules of sponges. Spicules do not as a rule penetrate the gemmule-coat.

#### *Phase B.*

The skeleton in this phase is much more complex (fig. 4, pl. iv). The spicules that have their heads embedded in the basal membrane form a dense irregular mass, all or practically all of them meeting the membrane at an angle less than a right angle.

Only obscure traces of vertical fasciculation can be detected in the basal parts immediately above this mass, but on the surface of the sponge the vertical tufts of spicules so characteristic of several genera of Suberitidae are well developed. They arise directly from vertical, entirely non-plumose columns in which all the spicules point directly upwards and which can be traced downwards to different levels in the sponge, some of them for at least one-third of its depth. The section figured on pl. iv passes through the outer wall of a large horizontal canal probably belonging to the exhalent system and it will be readily seen that the spicules here lie horizontally parallel to one another. Had the section passed outside the canal altogether no such horizontal stratum would have been shown, and had it passed through the lumen instead of the wall there would of course have been a longitudinal gap. In the former case it would have been possible to trace the vertical columns much further down, and they would have merged gradually into the confused intermediate zone of the skeleton instead of being sharply divided from it by a horizontal layer.

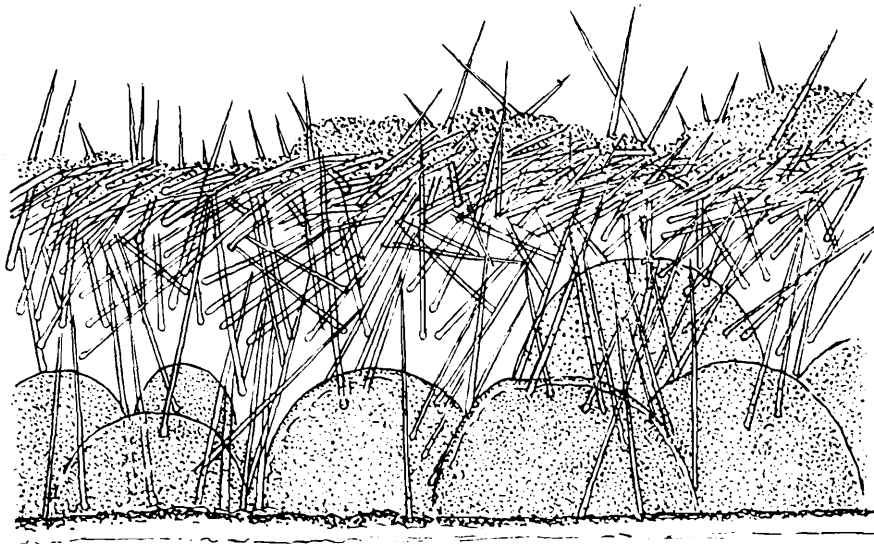


FIG. 7.—*Suberites sericeus*, Thiele.

Vertical section through a sponge in phase A with gemmules,  $\times 150$ .

If fragments of this confused intermediate layer be removed from the sponge they will be found to be surprisingly coherent; it is even possible to macerate the flesh from them and preserve them intact. The explanation lies in the fact that many of the spicules are cemented together in slender and often irregular fascicles by a scanty but strong secretion of transparent horny substance and that both the fascicles and single spicules not included in them are fastened to one another in a similar manner at the points at which they impinge. This is particularly noteworthy in the neighbourhood of foreign bodies such as the stems of Hydrozoa (*Bimera*) that lie buried in the sponge. The heads of many spicules are embedded in a horny secretion covering such bodies in exactly the same manner as at the base of the sponge and these spicules seem to form as it were a nucleus from which the reticulation of the skeleton arises (pl. iv, fig. 4a).

Gemmules are developed abundantly. Individually they resemble those found in the other phase of the species, but they form, instead of a flat basal layer, serpentine masses (fig. 6, p. 39) that meander through the sponge-like veins of mineral in a rock. Each of these masses has in its centre some foreign body such as a filament of alga or a branch of *Bimeria* and there is no essential difference in the two phases except that the gemmules in phase B are attached to foreign bodies of the kind instead of to the basal membrane.

*Suberites sericeus* was described from Kagoshima in Japan and has not hitherto been recorded, so far as I am aware, from any other locality. In the Chilka Lake we found it both in the outer channel and in the main area. In the latter we discovered accidentally that the bottom of the 'Lady of Chilka', which then lay off Barkuda Id., was coated with masses of the sponge in its more robust phase. This was in July, 1914. In the outer channel specimens of the less robust form were taken in September, 1914, at four stations, in all cases in very small quantities.

The sp. gr. of the water, which was quite fresh in the outer channel in September, was 1.0145 at Barkuda Id. in July. The depth at which the sponge was collected varied from about 2 feet to about 2 fathoms.

The species seems to stand alone in the genus; from other species the structure of its skeleton, as well as the form of its spicules, separates it. It has no close relationship to the genus *Laxosuberites*, to which Topsent, who had evidently not seen a specimen, proposed to assign it (*op. cit.*, 1900, p. 184).

The phase A was found in the Chilka Lake coating the leaves and stems of *Halophila ovata* and other plants, while in Japan it was taken on the shells of Gastropod molluscs. The phase B has only been found on the bottom of a steam-launch. The small size and feeble development of the former may possibly be connected with the small area to which it was confined, while the circumstances in which the robust sponge was growing, on the only occasion on which it has yet been seen, were perhaps unusually favourable for its growth. The fact that one phase was taken in brackish and the other in fresh water was probably accidental. Gemmules were found in both forms in the circumstances described.

On the 'Lady of Chilka' the sponge had grown over an assemblage of small mussels (*Modiola striatula*) as well as many colonies of the hydroid *Bimeria fluminalis*. Some of the latter seemed to be quite dead, but others were valiantly holding their own and budding out fresh polyps on the surface of the sponge. Of the mussels a few also survived and had succeeded in keeping open, over the tips of their shells, slit-like apertures through which they could obtain food and water. But the majority had perished and been completely buried. In some cases the two valves were found still cohering at the narrow end but forced widely apart at the other and coated inside and out with living sponge. In others the valves were shut or almost so, and the remains of the animal, not yet completely liquified, were still held between them. In yet others the sponge was beginning to force the shells apart at the broad end and to invade their inner surface; the remains of the animal, rendered liquid by putrefaction, were being gradually absorbed. These facts are

interesting as suggesting a reason, or rather as supporting a suggestion already advanced,<sup>1</sup> for the fact that sponges of different kinds frequently grow over molluscs or their eggs and that the shells or egg-cases are found full of sponge-substance.

The case of hydroid colonies buried in sponges is somewhat different. In instances such as the present one their vital parts may serve as food for the sponge, but in others the association is apparently symbiotic and the two organisms afford mutual support the one to the other without suffering in consequence.<sup>3</sup>

### Genus **LAXOSUBERITES**, Topsent.

1896. *Laxosuberites*, Topsent, *Mém. Soc. zool. France*, IX, p. 126.  
 1900. „ „ *id.*, *Arch Zool. expériment.* (3) VIII, p. 184.

Topsent (1900) defines this genus as having the skeleton composed of ascending columns in which the spicules are all orientated in one direction. Neither of the two species found in the Chilka Lake agrees precisely, when fully developed, with this definition, for the spicule-fibres that form the main element in the skeleton are to a large extent horizontal and there are also many non-fasciculated horizontal spicules in the choanosome and basal membrane that may be regarded as a part of the skeleton. However, the peculiarities of these species are obviously correlated with the method of growth and certainly do not justify generic separation from *L. rugosus* (Schmidt), the type-species of the genus. Their relationship to it is discussed on p. 50.

According to Topsent, Schmidt's *Suberites paludum*, which was originally described from a Mediterranean lagoon, is synonymous with *L. rugosus*. The genus is also represented in the fauna of the Black Sea and other enclosed waters and would seem to be one peculiarly capable of adapting itself to life in such situations. A remarkable adaptation of the gemmules of one of the Chilka species is described here (pp. 48, 49).

### **Laxosuberites aquae-dulcioris** (Annandale).

(Plate iv, figs. 5, 6.)

1914. *Suberites aquae-dulcioris*, Annandale, *Rec. Ind. Mus.*, X, p. 157, pl. xi, fig. 1.

I have little to add to the description of this sponge published in 1914, so far as its structure is concerned. Attention may be invited, however, to the peculiar spiral arrangement of the spicules round the broader vertical canals (pl. iv, fig. 6a) and to the fact that the sponge occurs in two somewhat distinct phases of growth in accordance with the nature of the surface to which it is attached. When it is growing on an oyster-shell or a stick it is rather more robust and has the skeleton distinctly better developed than when it is attached to the leaves and

<sup>1</sup> Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 94 (1911).

<sup>2</sup> Herdman, *Journ. Linn. Soc. (Zool.)* XXXII, p. 271 (1914).

<sup>3</sup> Alcock, *Ann. Mag. Nat. Hist.* (6) X, p. 208 (1892).

slender stems of weeds. In the latter situation it is naturally dwarfed, owing to the limited area to which it is restricted, and its skeleton is so simplified (fig. 9, p. 44) that it resembles that of Topsent's genus *Prosuberites*, which is defined as having all the tylostyles with their heads in contact with the basal membrane and their shafts projecting upwards. At the edges even of sponges of the more vigorous phase a similar arrangement occurs; but, as Dendy<sup>1</sup> has pointed out, the different genera into which the old genus *Suberites* have recently been divided are, in some instances, not very clearly separated one from another. In any case, *L. aquae-dulcioris* is never devoid of horizontal spicules and always, in at least some spicule fibres, some of the spicules are not in contact with the basal membrane.

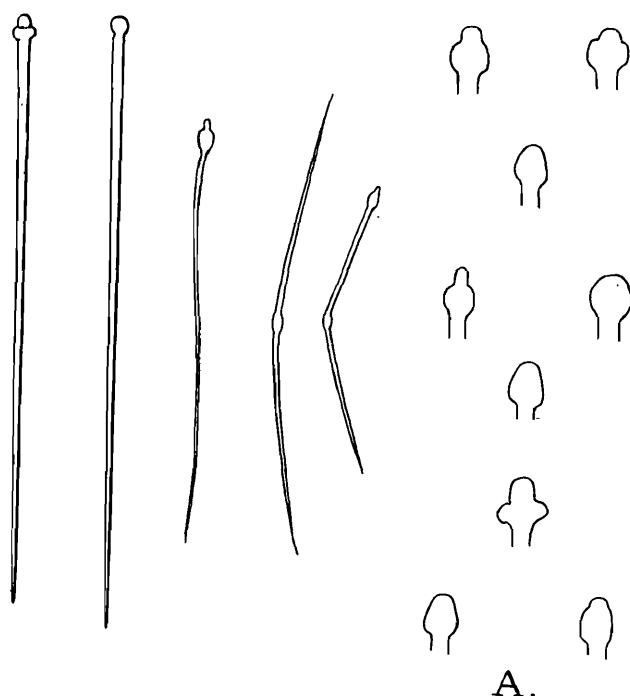


FIG. 8.—*Laxosuberites aquae-dulcioris* (Annandale).

Spicules from type-specimen,  $\times 255$ .

A.—Heads of spicules further enlarged.

The species is abundant on the oyster-shells of the beds near Manikpatna in the outer channel of the Chilka Lake and has also been found, in its less vigorous phase on the stems and leaves of the plant *Halophila ovata* both in the outer channel and at various places in the neighbourhood of Barkul and Barkuda Id. in the main area. It occurs in water as salt as the Bay of Bengal, of different degrees of salinity and quite fresh, and is found vigorous in all (and at all times of the year) at depths varying from a few inches to 2 fathoms.

Ripe embryos, which closely resemble those of *L. lacustris* (p. 49) in colour, size and external form, were found in a sponge growing on a leaf of *Halophila* at Barkuda Id. in July. Gemmules were seen only in specimens taken in fresh water

<sup>1</sup> In Herdman's *Ceylon Pearl Fisheries*, III, p. 131 (1905)

(both in the outer channel and in the main area) in September, but several sponges from oyster-shells from Manikpatna taken in that month do not contain these bodies. They are only present in specimens on leaves and stalks. Possibly the stimulus necessary for the development of gemmules in this species may be set up by the decay of vegetable matter, but more evidence is necessary before a definite opinion can be expressed. In structure the gemmules differ considerably from those of *L. lacustris* (fig. II, p. 48) and are hardly distinguishable from those of the less robust phase of *Suberites sericeus* (fig. 7, p. 40), having thin shells without foramina and being arranged in a single adherent layer at the base of the sponge.

*L. aquae-dulcioris* differs in colour in different circumstances. Often it is hyaline

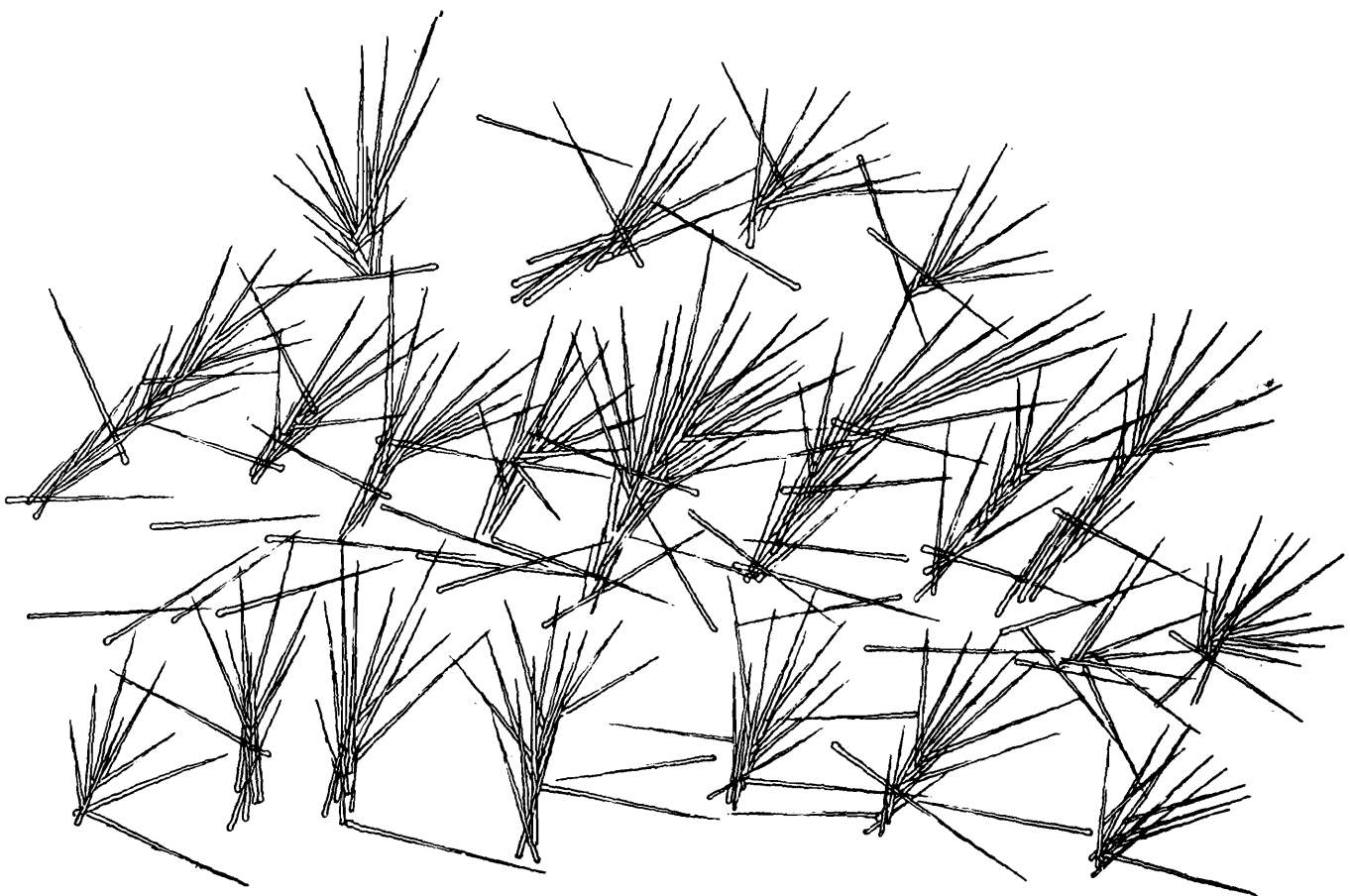


FIG. 9.—*Laxosuberites aquae-dulcioris* (Annandale).  
Part of the skeleton of a sponge on a leaf of *Halophila*,  $\times 100$ .

and quite colourless; sometimes it is of a more or less deep orange-yellow, and occasionally bright green. The yellow colour seems to be due, probably in all cases, to the accumulation of food-material in cells that have taken part or are about to take part in the formation of eggs or gemmules, while the green is due to the growth in the substance of the sponge of a branching alga of simple structure, which only grows if the organism is exposed to light. As the sponge usually affects sheltered situations, this is not very often the case.

I will discuss the affinities of this sponge together with those of *L. lacustris* on a subsequent page (p. 50).

**Laxosuberites lacustris**, sp. nov.

(Plate v, figs. 2, 3).

The sponge forms thin and fragile films, sometimes a little less so than those of *L. aquae-dulcioris*, on stones and rocks. Its colour varies in the same manner and for the same reasons as that of the latter species. In spirit any that may be present (except the yellow of the gemmules, which is remarkably permanent) disappears and the whole specimen assumes a milky opacity. The external surface, except immediately round the gemmules and on the roofs of the superficial canals, is level and minutely hispid. These areas are smooth and, in the living sponge, convex.

Probably each sponge possesses only one osculum, but many frequently grow so close together as to form an apparently uniform layer of considerable area. The osculum is slightly raised on a crater-like eminence with gently sloping sides. In the living sponge it is protected by an oscular collar capable of expansion to a considerable length. This structure is a hollow cone formed of dermal membrane without skeletal support. The actual exhalent orifice is situated at its free extremity and is considerably narrower than the base of the cone. When fully expanded the latter is much longer than it is broad at the base, where it is almost equal in width to the main exhalent channel from the roof of which it arises. The external (*i.e.* immediately subdermal) horizontal exhalent channels form a very conspicuous feature in the external appearance of the sponge. Each system of the kind consists of a main channel which runs along the surface of the parenchyma in a straight or sinuous course for a distance of some 5 to 10 mm. The oscular collar arises from its roof at or near the middle. Running into it at fairly regular intervals on either side are lateral channels like itself but narrower; these, in their turn, receive yet other, still narrower channels, so that an entirely horizontal ramification is formed. In the living sponge the roofs of all those channels, that is to say those parts of the dermal membrane that cover them, are markedly convex and quite hyaline. The inhalent dermal pores lie scattered in the intervals between the lateral channels. They are somewhat variable in size, but always minute; the largest I have seen were not more than 0.08 mm. in diameter. In the preserved sponge apertures of both kinds are as a rule obliterated, the oscular collars disappear and the roofs of the exhalent channels collapse. In both living and preserved specimens ridges may frequently be observed on the surface, sometimes marking off enclosed areas. These are, however, due not to any peculiarity in the structure of the sponge, but to the growth in its substance or below its base of algae, of the stolons of a Hydroid (*Bimeria*) or of a Polyzoon (*Loxosomatoides*), or else to the tubes made by a minute Polychaete worm.

The dermal pores open directly, as is so often the case in thin encrusting Monaxon sponges of different families, into cylindrical channels of considerably greater diameter than themselves and running in a vertical direction. The upper part of these channels, which is wider than the lower, represents the subdermal cavity, but the lower part extends nearly to the base of the sponge. Finer afferent channels are given off radially from the lower part of the main ones, run in a horizontal

or inclined plane and, probably after branching at least once, ultimately reach the small, ill-defined lacunae round which the ciliated chambers are arranged. The chambers are oval in outline and about 0.0026 mm. long by 0.002 mm. broad. Fine exhalent channels run from the lacunae and, after combining once or more, reach the superficial canals; their course is naturally upwards in a sloping direction. The soft parts of the sponge may be described as compact in comparison with those of other species of the genus.

The skeleton consists of two distinct parts: plumose spicule-fibres that terminate in free brush-like bunches of spicules on the surface of the sponge, and a basal horny membrane containing isolated spicules, which are as a rule smaller and more slender than those of the fibres.

The spicule-fibres differ but slightly as a rule from the type characteristic of the genus. Sometimes, however at the extreme margin of growing sponges and in stunted specimens they resemble the simple upright bunches of *Prosuberites*. In those sponges that may be regarded as fully formed and well developed the primary fibres are directed for a short distance vertically upwards from their base, then bend over gradually and run for some distance horizontally (that is to say parallel to the surface of the sponge), and finally protrude upwards. The spicules all point away from the basal extremity of the fibre. Except at the base, I have not been able to detect any binding substance in the fibres, and the extreme readiness with which the whole structure is disorganized by the exercise of pressure would seem to prove that substance of the kind is not more, at most, than very scantily present. The primary fibres terminate in the usual manner in bunches of spicules directed outwards as well as upwards; the tips pierce the dermal membrane. The whole disposition of the skeleton is closely correlated with that of the osculum and exhalent channels, and, indeed, with that of the water-system generally. The direction of the spicules is away from the osculum, so that the fibres they form radiate outwards from it between the main exhalent channels, parallel to which they run. At the margins of these channels the primary fibres give off short lateral branches that have a somewhat fan-like arrangement individually and lie in the dead sponge horizontally and practically parallel to the surface. Those from the primary fibre on either side of the channel nearly meet in its middle. When, however, a current of water passes through towards the osculum it raises these lateral fan-like branches and causes them to arch over immediately under the dermal membrane, to which they give support. The tips of their spicules, which are directed outwards from the primary fibre, do not penetrate it as do those of the spicules which form the terminal brushes. Single spicules lie scattered in a horizontal direction on the floor of the superficial channels.

At the base of the sponge there is a delicate but distinct horny membrane in which, as already stated, spicules usually smaller than those of the fibres lie scattered horizontally. This structure is very liable to be overlooked as it can be separated from the stone to which the sponge is attached only with some difficulty.

All the spicules are normally tylostyles and there are no microscleres. The

tylostyles have a very distinct head, which is variable in shape and may be irregular ; it is much more frequently spherical or symmetrically elliptical than in *L. aquae-dulcioris*. The shapes that it may assume in the two species are shown in figures 8 and 10. The shaft is usually straight or slightly and regularly curved. It is always slender and tapers gradually to a sharp point. There is practically no dilation

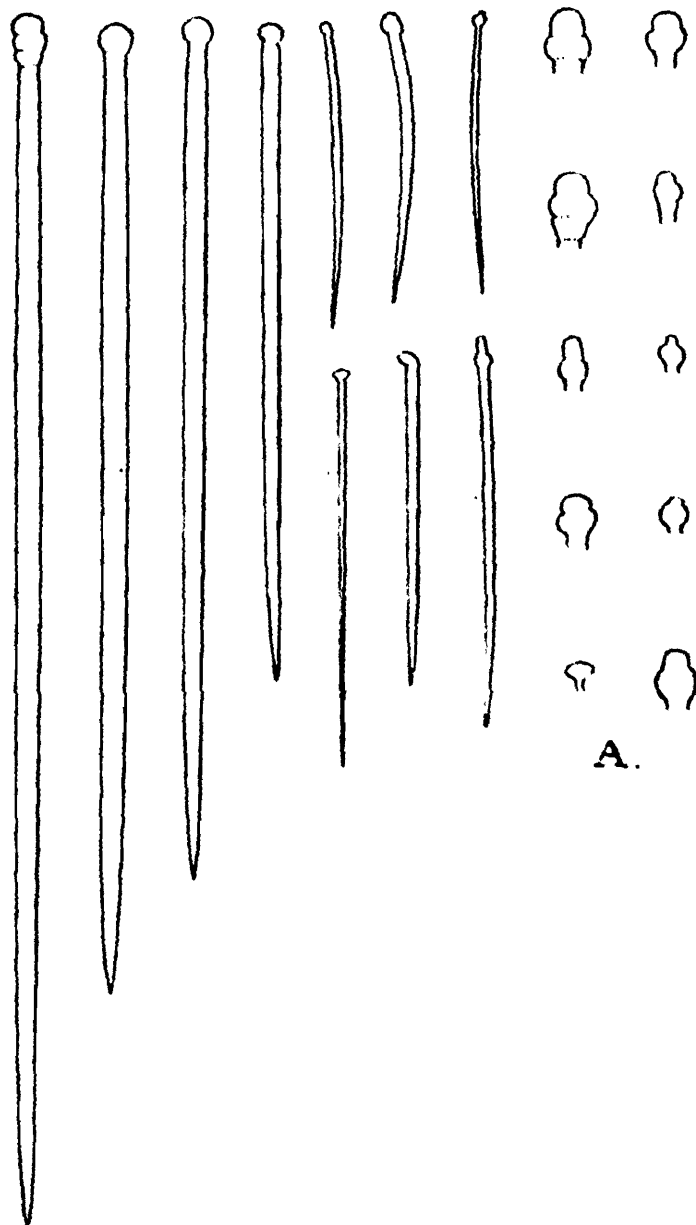


FIG. 10.—*Laxosuberites lacustris*, sp. nov.  
Spicules from a typical specimen.  $\times 255$ .

A.—Heads of spicules further enlarged

of the axial canal in the head, and this canal is never broad or conspicuous. The length of the largest spicules is 0.56 to 0.58 mm., and the breadth of the thickest part of the shaft 0.008 mm., the corresponding measurements in *L. aquae-dulcioris* being 0.33 mm. and 0.005 mm.<sup>1</sup> In *L. lacustris*, however, some of the shorter-spicules

<sup>1</sup> "0.033" in the original description (*Rec. Ind. Mus.* X, p. 158) is a printer's error. In some specimens the spicules are smaller than in others.

are often actually stouter than those of greatest length. The breadth of the head is slightly greater than that of the shaft. The measurements of the spicules are extremely variable both individually and in different sponges, but some of them are always much larger than any in *L. aquae-dulcioris*.

Gemmules are produced in large numbers. They are formed in groups at the base of the sponge and are visible externally as relatively large patches of lichenoid outline and of a deep orange-yellow colour. The skeleton becomes completely disorganized in these patches and the basal membrane disappears as an independent structure. Each group consists of numerous gemmules piled one on the top of the other several layers thick. The individual gemmules are flattened on the lower sur-

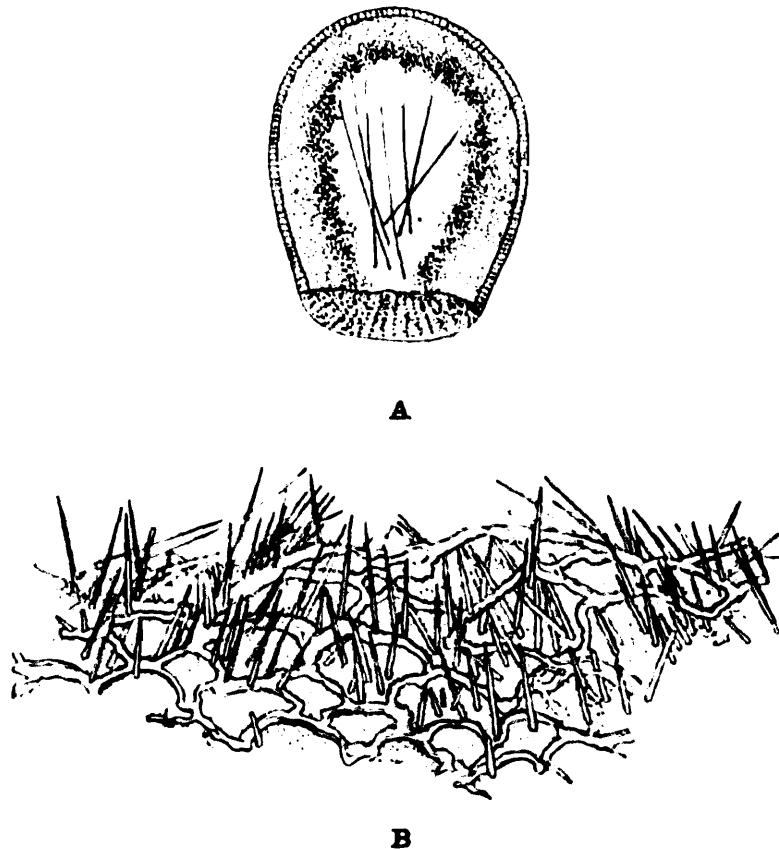


FIG. 11.—*Laxosuberites lacustris*, sp. nov.

A.—Larva in optical section,  $\times 255$ .

The cilia are omitted.

B.—Vertical section through a mass of gemmules,  $\times 30$ .

face, distinctly convex above, and polygonal in outline. The whole mass (fig. 11B) is fixed together by spicules of the normal type which transfix the coats of the gemmules vertically or tangentially, their heads being lower than their tips. The actual reproductive body consists of a congeries of cells of the usual form gorged with globules of food-material of a bright yellow colour. It is to this substance that the colour of the whole mass is mainly due, but it is intensified by the tint of the horny coat. Each gemmule has its own coat, but the different gemmules of one patch are so closely pressed together that their coats become intimately connected.

There is no orifice, but the coat, which is about 0.007 mm. thick, is deposited in several layers, between which there is air or some other contained gas, so that, when dry, the structure has a slight silvery lustre. The gemmules vary in size, but the greatest transverse diameter does not exceed 0.21 mm. The biological significance of the whole structure is discussed below (pp. 51, 52).

The larvæ (fig. IIA) is, when set free, a minute ovoid body distinctly truncated at the broader end. Its colour is a uniform clear yellow not quite so deep as that of the gemmules. Cilia cover the whole external surface except the broad truncated end, which forms a hernia of relatively large cells. I have not been able to make a detailed examination of living material, but in well-preserved and stained specimens the cells of the external ciliated epithelium (endoderm) seem to be slightly elongated immediately round the hernia. There is, therefore, reason to think that a ring of longer cilia surrounds this region. The greatest length (in Canada balsam) is about 0.139 mm., and the greatest width about 0.102 mm. A distinct segmentation-cavity of irregular shape and relatively large size can be detected in the interior of the larva anterior to the mass of enlarged cells that forms the (posterior) hernia. A single fascicle of spicules is already present. Although the spicules are very slender, they are clearly tylostyles with a distinct head. Their heads rest, approximately in a ring, a little in front of the enlarged cells; their shafts point forward and a little outwards and lie to a considerable extent in the segmentation-cavity. Their points are separated by a considerable distance from the anterior extremity. The fascicle is composed of about 7 spicules.

*Type.* No. Z.E.V 6442/7. *Ind. Mus.*

*L. lacustris* has been found as yet only in the main area of the Chilka Lake, in which it occurs abundantly, often together with *Spongilla alba* wherever there are rocks or stones at the edge. It can live, at any rate for a season, in pure fresh water and has not yet been found in that of a greater sp. gr. than 1.0150. It grows at all times of the year, but is most vigorous at the season when the water of the lake is brackish but the level still fairly high (that is to say about December and January), and occurs in depths of from a few inches to at least 2 fathoms.

It is with considerable hesitation that I describe this sponge as a species distinct from *L. aquae-dulcioris*, but on the whole, to do so seems less liable to cause confusion, should my opinion be ultimately proved incorrect, than to regard the sponge, without experimental evidence, as merely a highly specialized phase of that species. The most important differences between the two forms are the following:—

1. The spicule-fibres of *L. lacustris* are longer—branch more freely and maintain a horizontal direction for a greater part of their length than those of *L. aquae-dulcioris*.
2. The spicules are even more variable in size but have spherical or slightly elliptical heads in a great proportion of instances; some of them are always considerably larger than any of those of *L. aquae-dulcioris*.
3. The gemmules are piled together in *L. lacustris*, one on the top of another in

several layers, and are held in this position by vertical spicules which transfix them. Lichenoid coherent masses of gemmules, which can be detached as a whole, are thus formed, instead of a single adherent layer as in *L. aquae-dulcioris*.

In general structure the two sponges resemble *L. rugosus* (Schmidt)<sup>1</sup>, except that they are much less vigorous in their growth and that their main exhalent channels and the main component parts of their skeleton exhibit a greater tendency to be horizontal. The two facts are probably correlated. The spicules of both species differ from those of Schmidt's in having the heads practically always differentiated, though often irregular. They are also more variable in size. In these respects they come nearer the spicules of *L. ectyoninus*, Topsent, from which they differ in that by no means all of them are directed "towards the periphery of the body" (Topsent, *op. cit.*, p. 189, pl. vii, figs. 11, 12). As regards the form of the spicules both species agree closely with the variable Australian *L. proteus*, Hentschel<sup>2</sup>, but from all varieties of this sponge they are separated by the structure of their skeleton and the general smoothness of their surface.

*L. lacustris* was always found on stones or rocks except in one instance in which it was on a dead bamboo. On rocks it grows on vertical faces and on the lower surfaces of overhanging projections; on stones it occupies the lower side only, unless the stone is protected by others above it. This seems to be not so much due to avoidance of light as to the fact that its comparatively flat surface renders it liable to be completely smothered by the settling of silt if it spreads out in an exposed position. If sponges of the species are placed alive and surface uppermost in an aquarium full of lake-water they rapidly become covered with fine mud and débris, through which their oscular collars project upwards. The convexity of the roof of the superficial exhalent channels, combined doubtless with the steady movements of the water in the canals, keeps the roofs free of extraneous matter for some time and the plan of the canals is mapped out in a very conspicuous manner by clear hyaline streaks in the general area of mud; but the dermal pores are soon choked, and the sponge dies.

Larvae were found in April ready to be liberated in the canals of sponges which also contained gemmules. Gemmules are produced at all times of the year but particularly at the approach of the hot weather. At this season most of the rocks on which the sponge flourishes are gradually exposed by the retreat of the water. As it dries up it naturally dies. Sponges that suffer thus before producing gemmules, as is not infrequently the case, cling tightly as dried skeletons to the stone, their horizontal fibres being pressed against their adherent basal membrane (pl. v, fig. 2); but no fibres persist in the gemmule-masses and the basal membrane has practically disappeared below them. When these masses are thoroughly dry, therefore, they begin to curl up round the edges owing to the unequal contraction of the

<sup>1</sup> Topsent, *Arch. Zool. expériment.* (3) V, p. 185, pl. v, figs. 1-4.

<sup>2</sup> "Tetraxonida" in Michaelsen and Hartmeyer's *Faun. Südwest. Australiens* II, pp. 389, 394 (figs. 20, 21), 392 (figs. 22, 23), pl. xxii, figs. 1-3 (1909).

component parts during desiccation, and are finally detached intact by the wind, which wafts them away and, sooner or later, drops them in many cases, on the surface of the water. There they float. We may imagine that a large number are carried by wind or water to quiet nooks among the rocks where they germinate when the floods return, while others are submerged by heavy rain. The majority of these are probably smothered in the mud at the bottom of the lake, but some may fall on stony ground. The masses are rendered extremely light by the spaces between the different layers of horny substance on the surface of the gemmules<sup>1</sup>, and probably some are transported for long distances. The whole mechanism of these structures affords a most interesting example of adaptation on the part of a sponge of recent marine origin, as *L. lacustris* undoubtedly is, to conditions that can rarely, if ever, occur in the sea.

Smaller masses of gemmules of the same constitution as the large ones remain embedded in small cavities on the rock on which they were deposited, and their gemmules germinate *in situ*. This seems to occur mainly at the beginning of the salt-water season, that is to say in November and the beginning of December. At this time of the year I have found many young sponges at different stages of development. In gemmule-masses of the kind, as in the case of *Spongilla alba* (p. 31, *antea*), each mass of gemmules produces a single sponge with one osculum. A number of small sponges often arise from different masses deposited close together on a rock or stone. They do not, however, fuse, when, in the course of growth, they come in contact, but remain distinct, apparently throughout life, although their margins are co-terminous. It is in this way that large areas are often covered with what appears at first sight, but not on careful inspection, to be a uniform layer of sponge.

Another instance of adaptation to environment is probably to be found in the reproduction of this sponge, *viz.* in the large irregular cavity which occupies a considerable proportion of the interior of the larva (fig. 11A). Topsent discussing the structure of the larva in the different families of Halichondrine sponges, points out that a series of lacunae normally occurs in the primitive epiderm of the embryo and regards these as identical, not merely homologous, with the much larger single cavity found in the larva of Spongillidae. He does not, however, notice that in that larva the cavity is not only of much more regular form but is actually lined by a specialized membrane<sup>2</sup> of which there is apparently no trace in marine types. I have commented elsewhere<sup>3</sup> on the essential resemblance of the Spongillid larva,

Possibly the horny coat of the gemmules of Suberitidae is always deposited in layers; this is clearly the case in *Ficulina* (see Miss Sollas's figure reproduced on p. 230 of Vol I of the *Cambridge Natural History*). In most cases, however, it is extremely thin, and I can find no reference in literature to spaces between the layers.

<sup>1</sup> *Arch. Zool. expériment.* (5) VII, pp. xiii and xiv (1911).

<sup>2</sup> This is clearly shown in a figure recently published by Nöldeke. *Zool. Jahrb. (Anat.)* VIII, fig. 1 (1913).

<sup>3</sup> *Journ. As. Soc. Bengal* (n. s.) IX, p. 222 (1913).

in its mechanism and functions, to that of Polyzoa Phylactolaemata and have suggested that in both cases the bladder-like body is an adaptation for life in fresh water. The fresher water is, the lower its specific gravity. The yolk contained in larvae that grow without feeding is heavy, and a body that has to progress through fresh water to obtain a situation suitable for subsequent changes is greatly hindered if it is much heavier than the medium through which it moves. If it is hollow, and if the cavity is filled with water, as that of the larvae under consideration presumably is, the weight of the yolk is compensated for and the specific gravity of the moving body becomes practically identical with that of the surrounding medium. The cavity in the larva of *L. lacustris* is not relatively so large as that in the larvae of *Spongilla*, *Nudospongilla* and *Ephydatia*, nor has it the same specialized structure, but it is at any rate considerably more ample than in most marine types. Its size is, therefore, not improbably correlated with the fact that the larva lives in water of low salinity and consequently of low specific gravity.

*L. lacustris* is too thin a sponge to afford shelter to any but very small animals. Nematode worms (*Dorylaimus* sp.<sup>1</sup>) are, however, common in its canals; at least one minute species of tubicolous polychaete, probably a Capitellid, was found on one occasion, while another, tubicolous and plumigerous species is nearly always abundant. The rhizomes of the Hydrozoon *Bimeria fluminalis* and the Polyzoon *Loxosomatoides laevis* are also often found at the base of the sponge, sending up their branches or polyps through its substance to the surface. Lamellibranch molluscs of the genus *Modiola* are sometimes overwhelmed in its growth.

### Grade TETRACTINELLIDA.

#### Suborder SIGMATOPHORA.

#### Family TETILLIDAE.

#### Genus TETILLA, Schmidt.

#### [*Tetilla dactyloidea* (Carter) ]

1869. *Tethya dactyloidea*, Carter, *Ann. Mag. Nat. Hist.* (4) III, p. 15, fig.  
 1872. „ „ *id.*, (4) IX, p. 82, pl. x, figs. 1-5.  
 1887. „ „ *id.*, *Journ. Linn. Soc. Zool.* (Fauna Mergui, I), p. 79.  
 1888. *Tetilla* „ Sollas, *Challenger Rep., Zool.* XXV, p. 1.  
 1891. „ „ Keller, *Zeitschr. wiss. Zool.* LII, p. 335.  
 1903. „ „ v. Lendenfeld, *Das Tierreich*, Tetraxonia, p. 18.

*Distribution*: S. Arabia; Bombay; Mergui Archipelago, Burma (Carter).

The typical form of *T. dactyloidea* was not obtained in the Chilka Lake, but another, so near that I think it must be regarded as a variety, is represented in our collection by several specimens. For this form I propose the name *lingua* in reference to its peculiar shape.

<sup>1</sup> Stewart, *Rec. Ind. Mus.* X, p. 247. When Capt. Stewart's paper was written *L. lacustris* was not distinguished from *L. aquae-dulcioris*.

var. **lingua**, nov.

(Plate v, fig. 4).

The var. *lingua* differs from the *forma typica* of the species in the following characters :—

1. The sponge is tongue-shaped and compressed instead of being sausage-shaped.
2. The minute spherical spicules found by Keller in Carter's specimens from Arabia (the types of the species) are absent.
3. The basal tuft of spicules is much reduced, being visible to the naked eye merely as a slight shagginess.
4. The single osculum at the central cavity of the sponge is even smaller, or perhaps capable of more complete contraction.
5. The pores are apparently confined to the upper three quarters of the superficial area of the sponge.

I have been able to compare our specimens with several of those from the Mergui Archipelago examined by Carter. As Sollas has pointed out, the latter do not altogether agree with the original specimens and I cannot find in them, any more than in the types of the new variety, the minute siliceous spheres found by Keller in Carter's Arabian examples.

The sponges from the Chilka Lake agree well in general structure with those from Mergui, from which they differ notably in their compressed, tongue-like shape and in the still greater reduction of the basal tuft. The spicules, except that those of the basal tuft are of course much shorter, appear to be practically identical. The osculum is more completely closed and the central cavity into which it opens almost obliterated. The fact, however, that the external surface is thrown in the larger specimens into strong vertical folds in the anterior part of the body, and the manner in which these folds radiate from the osculum, would indicate that the sponges were killed in a highly contracted state. The shape of the posterior end is somewhat variable, this extremity being tapering and rounded in some sponges and obliquely truncate in others. In the latter there is no trace of external injury. The largest, which has this shape, is 58 mm. long and 22 mm. broad in the middle, where it is 10 mm. thick. This specimen is less compressed in the anterior region than the others. A photograph of it, with one of a smaller example from the same station, is reproduced on plate v, fig. 4. The colour of the sponge (in life and in spirit) is pale greenish grey.

Specimens of *T. dactyloidea* var. *lingua* were taken in the outer channel of the Chilka Lake in September, 1914, at depths of about 2 fathoms. All were on a sandy bottom. The water at the time was fresh, but there can be little doubt that the sponge is also to be found at the same place when it is salt. It evidently lived in groups at more than one point.

The species has always been taken in shallow water apparently anchored in sand by its basal tuft. The reduction of this tuft is probably correlated with the compressed form of the new variety, and both characters, as well as the position of the

pores, seem to indicate that it lives more deeply buried than the typical form. Its superficial resemblance to *Sphenopus marsupium*, an Actinian that lives buried in mud and is common off the mouths of the Ganges, is noteworthy and affords an interesting instance of convergence. Dendy<sup>1</sup> has pointed out that *T dactyloidea* is closely related to the species he described under the name *T limicola*, except in the important feature that in the latter "the sponge is very compact throughout, and there are no wide tubes in it, the excurrent canals being very narrow and opening by numerous minute apertures in the floor of a somewhat flask-shaped cloacae with slit-like vents on the surface of the sponge." He rightly regards this feature as an adaptive one connected with the fact that the sponge lives in very fine soft mud in Lake Tamblegam, a comparatively small lagoon on the coast of Ceylon that closely resembles the Chilka Lake in many respects. So far as its compact structure and the absence of broad channels go, the Chilka sponge is very like the Tamblegam one, but the nature of its single exhalent aperture is totally different. Although it lives in sand, the water above it is always full of fine silt held in suspension. The case seems to be in some respects parallel to one I have recently discussed elsewhere, viz. that of *Corvospongilla barroisi* and *Nudospongilla aster* in the Lake of Tiberias.<sup>2</sup> In both cases we find sponges structurally related and living in the same, or a very similar, environment, but adopting diametrically opposite means of protecting their water-system; in both cases the disadvantages of their environment are due to minutely separated mineral matter held in suspension in the water or settling on the surface of the sponge.

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<sup>1</sup> "Report on the Sponges" in Herdman's *Ceylon Pearl Oyster Fisheries* III, p. 94 (1905).

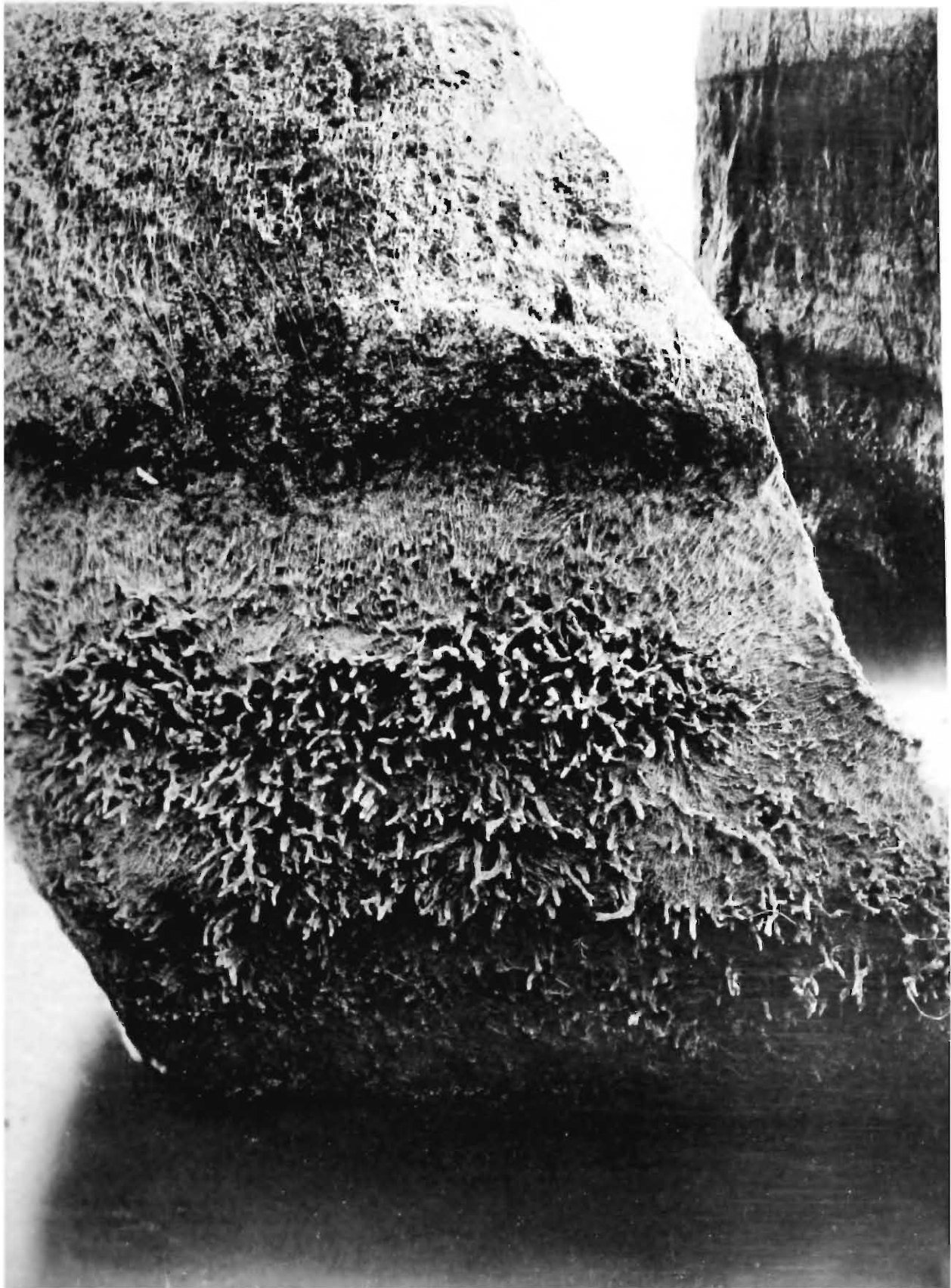
<sup>2</sup> *Journ. Asiat. Soc. Bengal* (n. s.) IX, p. 76 (1913).

### EXPLANATION OF PLATE III.

*Spongilla alba*, Carter.

A rock at the edge of the Chilka Lake partly covered by the sponge.

The photograph was taken in November after the level of the lake had sunk about 5 feet, leaving the sponge dry. The rock was 2 ft. 11 in. in width and was covered with a somewhat sparse growth of filamentous alga. The sponge had grown over this alga on the lower part of the rock and the apparent branches on its surface were actually thin incrustations of the filaments.



Bamrose, Colla, Derby.

SPONGES OF THE CHILKA LAKE.

## EXPLANATION OF PLATE IV

### Figs. 1, 1a, 2. *Spongilla alba*, Carter.

1, 1a. Fragments of the skeleton of a very hard specimen from a rock in the Chilka Lake,  $\times 50$ .

The preparations had been cleaned and stained with pyrogallic acid to show the horny substance. Some of the single spicules forming the subsidiary skeleton may be noted *in situ*.

2. Fragments of the skeleton of a very soft specimen from weeds in a pond on Barkuda Id., treated in the same way,  $\times 50$ .

### Fig. 3. *Spongilla nana*, sp. nov.

A complete sponge stained with borax carmine and mounted in Canada balsam, seen from below,  $\times 15$ .

c.c.—central cavity. s.c.—subdermal cavity. g.—gemmule.

### Figs. 4, 4a. *Suberites sericeus*, Thiele.

4. Vertical section through the skeleton of a sponge in the more vigorous phase,  $\times 15$ .

4a. Fragments of the skeleton from the interior of the same sponge in the neighbourhood of an engulfed colony of the hydroid *Bimeria fluminalis*, more highly magnified. The preparation has been stained with pyrogallic acid.

s.f.—vertical spicule-fibres on the surface of the sponge. i.c.—the position of one of the main horizontal canals. b.m.—horny basal membrane.

### Figs. 5, 6, 6a. *Laxosuberites aquae-dulcioris* (Annandale).

5. Type-specimen on an oyster-shell from Manikpatna in the outer channel of the Chilka Lake,  $\times 2$ .

6. A single branched spicule-fibre in lateral view,  $\times 100$ .

6a. A fragment of the skeleton in the neighbourhood of a large vertical and a superficial horizontal canal,  $\times 75$ .

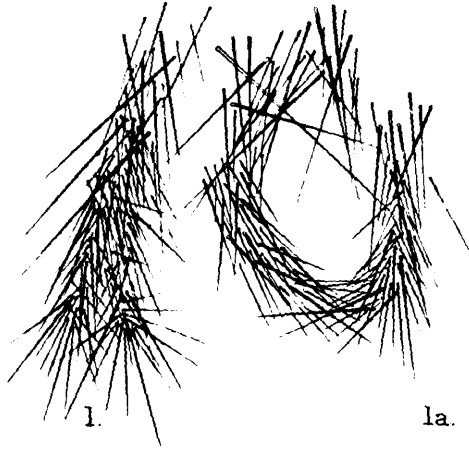
v.c.—position of vertical canal. h.c.—position of horizontal canal.

### Fig. 7. *Cliona vastifica*, Hancock.

Part of an oyster-shell from the Manikpatna beds destroyed by the sponge,  $\times 1$ .



7.

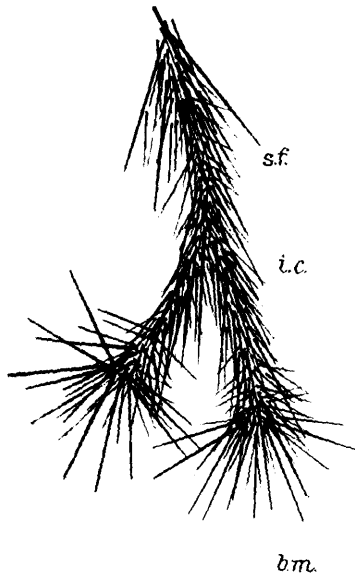


1.

1a.



2.

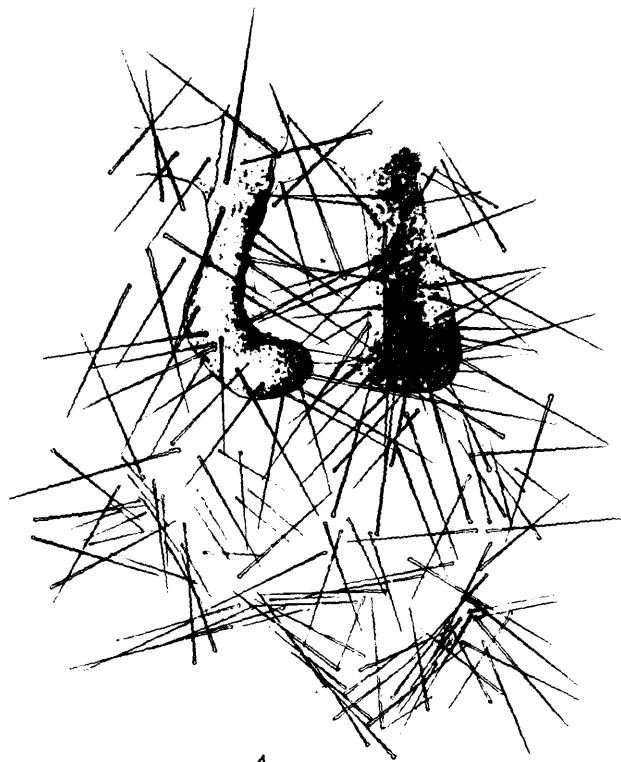


s.f.

i.c.

b.m.

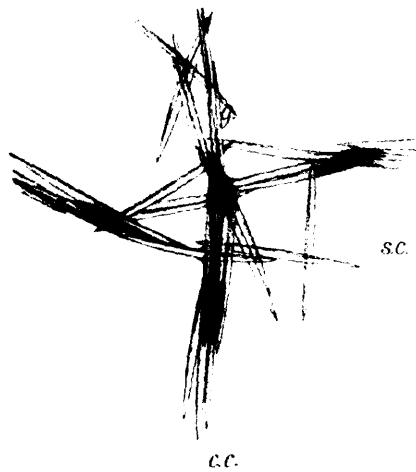
4.



4a.



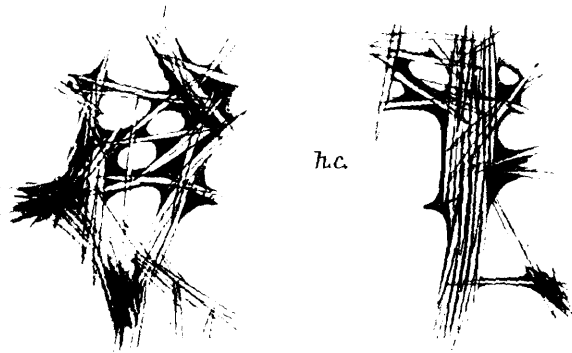
6.



s.c.

c.c.

3.



h.c.

6a.



5.

## EXPLANATION OF PLATE V

### **Fig. 1.** *Spongilla alba*, Carter.

A thick section through the base of a branch in the neighbourhood of an osculum,  $\times 10$ .

The soft parts of the sponge have been entirely removed ; the filmy substance shown particularly in the lower lobes of the section is the subsidiary skeleton.

### **Figs. 2, 3, 3a.** *Laxosuberites lacustris*, sp. nov.

2. Dried specimen on a stone, somewhat enlarged.
3. Mass of gemmules removed from a rock by the wind, seen from above and considerably enlarged.
- 3a. Part of the same specimen, seen from below.

### **Fig. 4.** *Tetilla dactyloidea* (Carter) var. *lingua*, nov.

Two of the type specimens, nat. size.

The figures on this plate are reproductions of direct photographs.

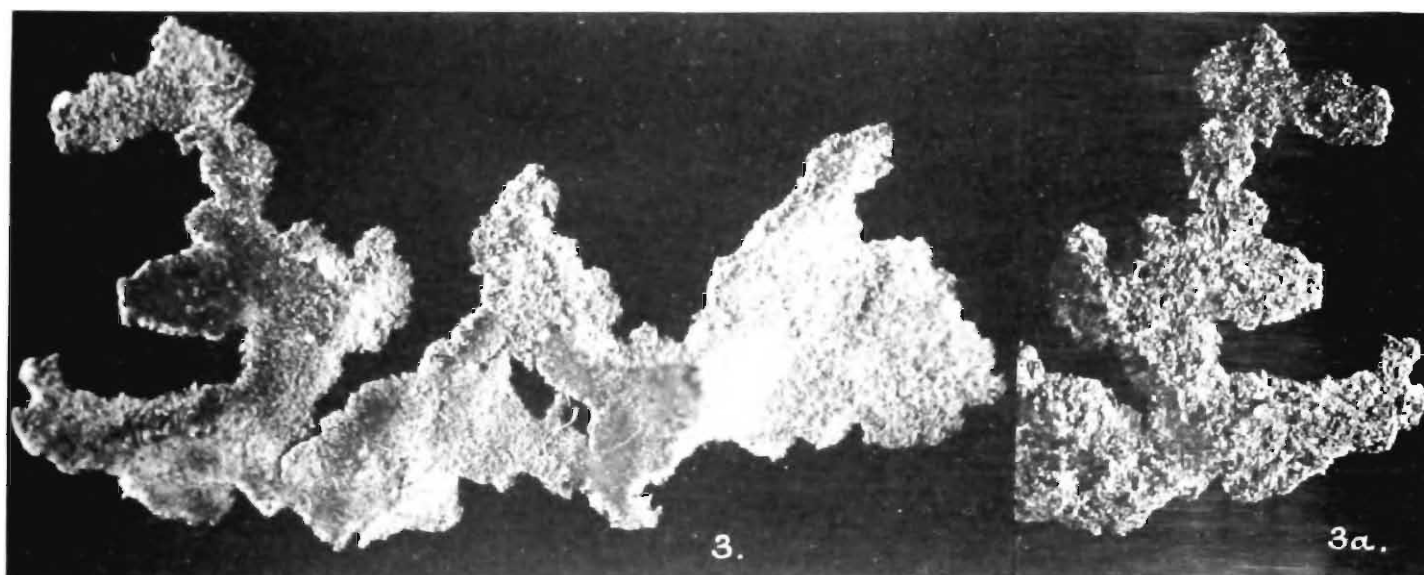
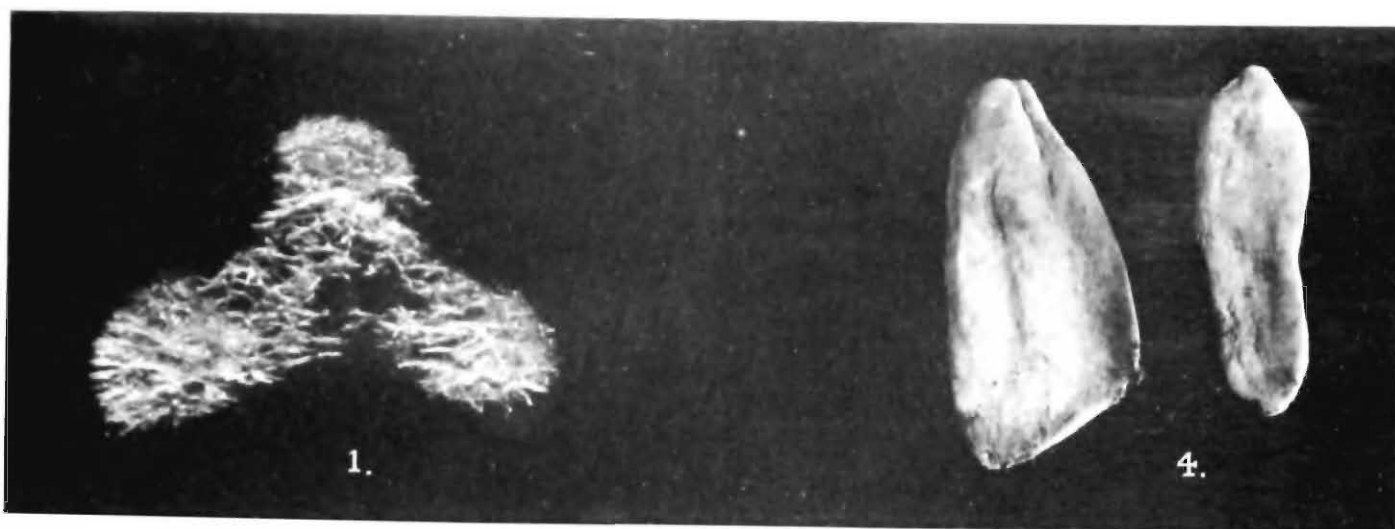


Photo by S C Mondul & A Chowdhury.

Bermoxe Coll. Berry

SPONGES OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE  
THE ECHIUROIDEA OF THE LAKE AND OF THE  
GANGETIC DELTA.

*By* N. ANNANDALE, *D.Sc.*, *and* STANLEY KEMP, *B.A.*

(With 2 text-figures.)

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## ECHIUROIDEA.

By N. ANNANDALE and STANLEY KEMP.

The Gephyrea are represented in the fauna of the Chilka Lake by a single Echiuroid belonging to the genus *Thalassema*, Gaertner. The species, which appears to be undescribed, is of interest on account of its close relationship to *T sabinum*, Lanchester, from the Talé Sap in lower Siam (a lagoon that closely resembles the Chilka Lake in many respects) and of the fact that a third closely related species occurs in canals of brackish water on the outskirts of Calcutta.

These three forms belong, in a sense, to the group typified by *T neptuni*, Gaertner (the type species of the genus) and characterized by the comparatively simple nature of the anal trees, by the possession of two pairs of nephridia and by the undivided sheath of longitudinal muscles. They have, however, certain very noteworthy peculiarities—especially in the structure of the proboscis—that may ultimately be considered to be of generic importance. The following key to the species of the *neptuni* group, to which we assign provisionally those described here, may be useful:—

- I. Proboscis long and slender, pointed or bifid at the tip, extremely extensile, without dendritic or finger-shaped outgrowths.
  - A. Proboscis when expanded much longer than body, pointed *T neptuni*, Gaertner.
  - B. Proboscis when expanded not much longer than body, expanded and bifid at tip *T semoni*, Fischer.
- II. Proboscis short and stout, truncate at tip, not very extensile, with dendritic or finger-shaped outgrowths.
  - A. Proboscis tubular, (the lateral margins being fused together), and containing internal finger-shaped outgrowths *T sabinum*, Lanchester.
  - B. Proboscis with the lateral margins not fused together, though capable of close apposition, bearing dendritic marginal outgrowths.
    - i. Dendritic outgrowths of proboscis small, less than half as long as it is wide *T dendrorhynchus*, sp. nov.

2. Dendritic outgrowths gill-like, nearly as long as the proboscis is wide *T. branchiorhynchus*, sp. nov.

We have to thank Dr. A. E. Shipley and Mr. Forster Cooper for sending us the two type specimens of *T. sabinum* for comparison with those of our new species.

Genus **THALASSEMA**, Gaertner.

1913. *Thalassema*, Wharton, *Philippine Journ. Sci.*, VIII, p. 243.

***Thalassema dendrorhynchus***, sp. nov.

Like all Echiuroids this species is contractile; but the body is much more so than the proboscis (though the latter is capable of undergoing considerable change of form) and neither region appears to be so extensile as in many other species.

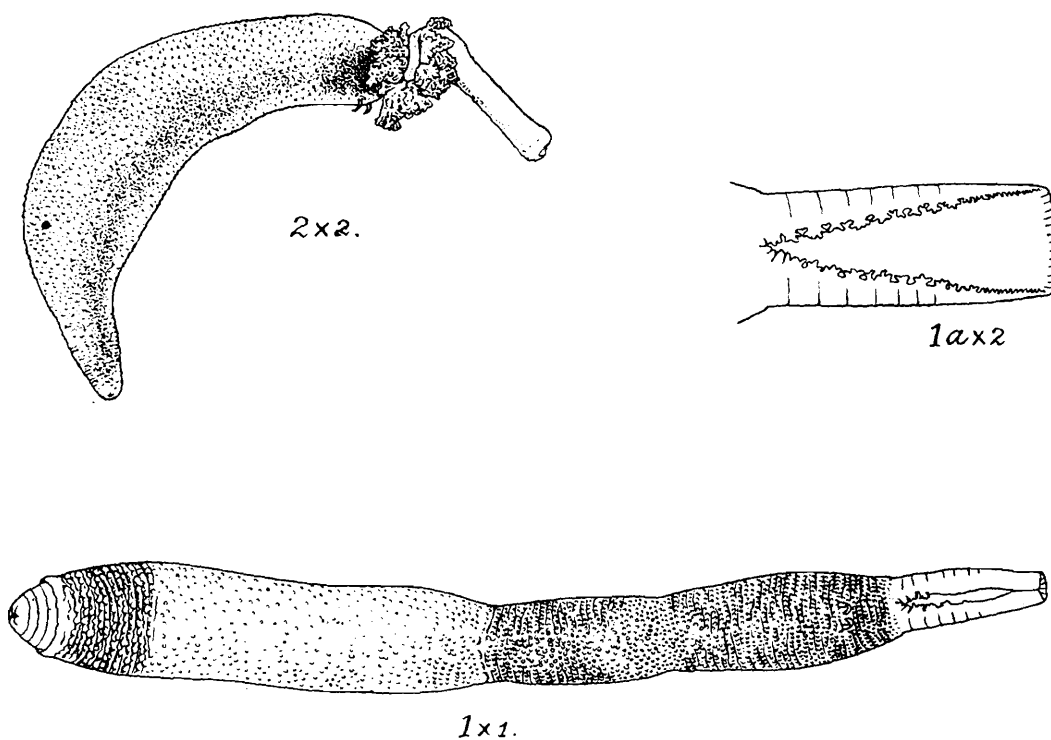


FIG. 1.—*Thalassema dendrorhynchus*, sp. nov. (nat. size); 1a, ventral view of proboscis with lateral margins separated ( $\times 2$ ).

FIG. 2.—*Thalassema branchiorhynchus*, sp. nov. ( $\times 2$ ).

Our largest specimen (fig. 1), preserved fully expanded, is 120 mm. in total length, of which 18 mm. is occupied by the proboscis. The greatest breadth is 12 mm., the point at which this measurement was taken being near the posterior extremity. The animal is, however, able to contract its body at different points and the position of the greatest breadth differs from time to time. In our smallest specimen, preserved in a contracted condition, the length is 46 mm., of which about 8 mm. is occupied by the proboscis; the greatest breadth, situated near the centre of the body, being again about 12 mm. In general form this specimen may be described as sausage-shaped.

The proboscis, the length of which is thus about one-sixth or one-seventh that of the entire animal, is shovel-shaped; the distal extremity is truncate and the lateral (ventral) margins are capable of being applied together in such a way as to form a cylindrical tube. When separated the space between them is narrowly V-shaped. The dorsal surface is smooth or nearly so. There is no longitudinal ridge on the ventral surface and the ciliated groove is inconspicuous. A striking feature of the margins is that they are distinctly serrated, the serrations towards the proximal end gradually taking the form of dendritic outgrowths, which, however, are always shorter than half the width of the whole organ (fig. 1a).

In certain conditions of expansion the basal part of the proboscis has the appearance of being annulated and the distal extremity is marked by short parallel longitudinal grooves.

The body is covered with papillae which are most numerous towards the two extremities, where they tend to be arranged in concentric rings emphasized by corresponding circular folds in the integument. This is more marked in the posterior region, where the papillae are also larger, than in the anterior. There is a considerable area in the posterior half of the body where they are scattered and comparatively small. The ventral hooks are of a bright golden colour but in two of our specimens the tips appear to have been broken off. Even when complete they are small and only conspicuous on account of their colour. They are situated close together and their distance from the base of the proboscis is considerably shorter than its length. The exact point at which they occur is not, however, constant.

The circum-anal region is devoid of papillae, but surrounded in a more or less definite manner by several concentric folds, the most conspicuous of which separates it from the densely papillate region immediately in front. As a whole it is conical, but the part actually bordering the anus can be thrust out to form a short tubular process.

The longitudinal muscles form a continuous sheath.

There are two pairs of nephridia, both of which open behind the level of the ventral hooks. The internal funnel of each is provided with a pair of very long, fine, spirally-twisted filaments which arise at either side of its orifice. The vesicle is narrow and finger-shaped, tapering to a blunt apex which points inwards.

The anal trees are short and simple, nearly half the length of the body in a contracted specimen. They have a slight brownish tinge and the walls are very thin; the distal part is narrowly cylindrical, but the apex is blunt; the basal or proximal part is somewhat swollen, but there is no definite vesicle. No funnels are visible with the aid of a hand-lens and there are no muscular strands attaching the organs to the body-wall. Examined under the microscope, each tree is seen to possess two longitudinal rows of minute ciliated funnels, the mouth of which does not exceed 0.047 mm. in breadth, while the length is not greater than 0.168 mm. The two trees open separately into the intestine close to the anus.

The alimentary canal is extremely long and intricately but irregularly coiled. Its calibre is small at all points and the walls are thin and transparent. For a

considerable part of its length it is closely packed with small oval pellets of mud. The canal is joined to the body-wall by numerous slender muscular strands which are very easily detached.

The natural colouration is much less conspicuous than in some species of the genus. The body-wall is translucent in life with a pale vinous tinge; but the mud in the alimentary canal makes it seem much darker, sometimes nearly black. The circum-anal region is dead white, the proboscis cream-coloured, with the free edges and the dendritic outgrowths tinged with brown. There are several opaque longitudinal streaks on the body which simulate muscle-bands. Specimens become opaque in spirit and lose their colour completely.

Apart from the Gangetic species (which we describe as *T. branchiorhynchus*) *T. dendrorhynchus* is most nearly related to *T. sabinum*, Lanchester.<sup>1</sup> The only published description of the latter is very incomplete; but, as has already been stated, we have been able to examine the type-specimens. The most important diagnostic character is the fact that the lateral margins of the proboscis are fused, so that the organ is tubular. Comparatively long finger-shaped processes arise from its internal surface and protrude at the opening of the tube. Otherwise, except for its small size and comparatively smooth external surface, the species closely resembles *T. dendrorhynchus*.

Fischer's description of *T. semoni*,<sup>2</sup> which was based on specimens that had lost their proboscis, shows that the internal anatomy is similar in most respects to that of the Chilka species; but Shipley's figure of a living individual<sup>3</sup> proves that a wide difference exists in the structure of the missing organ. Wharton, in the paper cited above, has recently redescribed *T. semoni*, which is an Indo-Pacific form.

So far as published figures of the entire animal are concerned, *T. dendrorhynchus* most closely resembles *T. kokotoniense*, Fischer,<sup>4</sup> another form widely distributed in the Indo-Pacific region, but in the latter species the longitudinal muscles are divided into bands and the body-wall is apparently much stouter.

Specimens from the Chilka Lake were very sluggish when removed from the mud in which they were taken. The only movements exhibited were quite unrhythmic contractions, both transverse and longitudinal, of the body-wall and proboscis; the latter showed no signs of great extensibility or of readiness to break off, and its movements did not suggest that it was employed in burrowing.

A female killed in February contained immature ova.

We found only three specimens of *T. dendrorhynchus*, all in the southern part of the main area of the Chilka Lake. They were living, probably rather deeply buried,

<sup>1</sup> *Proc. Zool. Soc. London*, 1905 (I), p. 40, pl. ii, fig. 5.

<sup>2</sup> In Semon's *Zool. Forsch. Australien*, V, p. 338, fig. 4 (1896).

<sup>3</sup> In Gardiner's *Faun. Geogr. Maldives and Laccadives* I, p. 129, pl. vi, fig. 4 (1903).

<sup>4</sup> See Shipley in Willey's *Zool. Res. New Britain and New Guinea*, p. 337, pl. xxxiii, fig. 3 (1898-1902).

in dense mud. The largest of the three was brought up on the anchor of the launch between Barkuda Id. and the mainland in April; the other two were taken out in the lake between Barkuda and Chiriya Ids. in February; the specific gravity of the water varying from 1.006 on the former occasion to 1.009 01 the latter. The species is doubtless a permanent inhabitant of the southern part of the lake and must at times be brought in contact with water that is almost fresh. The habits of the species render it unlikely to be captured except occasionally and we have no means of ascertaining whether it is actually scarce.

Our specimens of *T dendrorhynchus*, the types of the species, are numbered Z.E.V 6800-6803/7 in the register of the Indian Museum collection.

### ***Thalassema branchiorhynchus*, sp. nov.**

This species (fig. 2, p. 58) is closely related to *T dendrorhynchus*, but differs in the following characters:—

- (1) The proboscis is relatively longer and more slender, its length when fully expanded being more than one-third that of the body.
- (2) The dendritic outgrowths of its margin are much more highly developed, having a gill-like appearance (fig. 3) and being of a blood-red colour in life; they are confined to the proximal third of the margin, the distal part of which is quite smooth.
- (3) There is a conspicuous longitudinal ridge (in place of the ordinary ciliated groove) on the proximal part of the ventral surface of the proboscis between the two rows of dendritic outgrowths. These it resembles in colour.
- (4) The external (dorsal) surface of the proboscis is minutely tubercular instead of being smooth.
- (5) The integument of the body remains translucent even in spirit, the nerve cord being visible externally as an opaque white line.
- (6) The surface papillae of the body are less prominent than in *T dendrorhynchus*; they are, as a rule, distinctly of two kinds, large and small, the large papillae being most numerous towards the two extremities. Near the posterior end they are conical and show some tendency to be arranged in transverse rings. There is, however, no smooth circum-anal region.

The length of the body in the type-specimen (fully expanded) is about 32 mm. and the greatest breadth about 7 mm.; the length of the proboscis nearly 15 mm.

In the living animal the whole body was of a deep reddish vinous tint, translucent, but not markedly so. The posterior extremity was somewhat paler than the remainder and the colour seemed to be due mainly to the fluid of the body-cavity. The proboscis was purplish pink, contrasting notably with the bright red colour of its dendritic outgrowths and the ridge on the ventral surface. The hooks were golden yellow tipped with black.

The internal structure of this species agrees closely with that of *T dendrorhyn-*

*chus*, the only differences detected being that the processes of the nephridial funnels were less distinctly coiled and the anal trees possibly longer. In the fully expanded specimen the latter are about half as long as the body but it was noticed in the living animal that their relative length varied with the state of general expansion and that they were not so extensile as the body as a whole. The arrangement and form of the minute funnels on the trees seem to be identical in the two species.

Our specimen from the Gangetic delta was active. When placed in a dish of mud and water, the animal formed for itself, by irregular movements of the body and proboscis, a shallow groove on the surface of the mud. It made no attempt to burrow downwards, but lay on one side in this groove. When first removed from the water it writhed vigorously and changed its shape rapidly in diverse regions, sometimes extending itself to a considerable length and assuming a worm-like form, sometimes

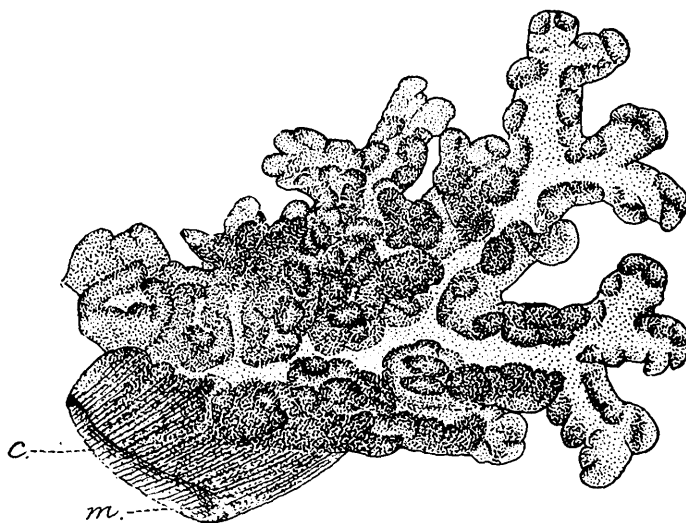


FIG. 3.—*Thalassema branchiorhynchus*, sp. nov.

Gill-like outgrowth from base of proboscis, seen from ventral surface,  $\times 30$ .

*c* = lumen of base of outgrowth, which is cut off a little obliquely; *m* = muscles entering base.

expanding the extremities or other parts of the body into bulbous or annular swellings. When it was replaced in its natural element these movements continued for a short time, but soon became less vigorous, though without ceasing completely. The natural attitude of the proboscis appeared to be flexed backwards, so that its dorsal surface was in contact with that of the body. The distal parts of the lateral borders were applied together so as to form a complete tube; but the proximal parts were everted (fig. 2, p. 58), the dendritic outgrowths being thus displayed. They were somewhat contractile and, when fully extended and spread out, formed a double series of short feathery tentacles. The whole proboscis was, however, sometimes twisted spirally, as is shown in the figure.

The only known specimen of *T. branchiorhynchus* was taken in about 3 feet of water in a small tidal creek connected with a canal near Chingrighatta on the outskirts of Calcutta in December, 1914. The specific gravity of the water was then 1.006.

We have failed to obtain further specimens, but this does not necessarily mean that the species is scarce, for, from the point of view of the collector, the Gangetic mud is very difficult to deal with in a satisfactory manner.

The specimen bears the number Z.E.V 6807/7 in the Indian Museum books.

*T dendrorhynchus*, the Gangetic species, and *T sabinum*—despite the specific name of the last—all live in peculiarly dense mud, and we believe that the unusual structure of the proboscis in the three species is correlated with this fact. It is noteworthy that the gill-like outgrowths are better developed in the species from the Gangetic delta than in that from the Chilka Lake, for the mud of the former region is extremely fine and therefore forms a peculiarly dense and sticky mass.

In most species of *Thalassema* the proboscis seems to be the most active agent in burrowing or in insinuating the body into crevices, but apparently this is not the case in the three mud-living species just discussed. In these species the excavations are formed by movements of both the body and the proboscis, and the latter has probably a respiratory as well as a muscular and a nutritive function, for the dendritic outgrowths of its margins or ventral surface have much the appearance and structure of gills and are situated in such a position that all water which enters the mouth must first pass over them. Externally, in *T dendrorhynchus* and *T branchiorhynchus*, they are covered with ciliated epithelium; they contain spacious lumina that communicate with the body-cavity by means of a longitudinal canal at their base. The other parts of the proboscis are highly muscular, the bulk of the organ consisting of a gelatinous substance that contains numerous bundles of longitudinal muscle-fibres. In *T dendrorhynchus* these are most numerous towards the ventral surface, from which they proceed outwards, in transverse section, in somewhat irregular bands that become gradually attenuated. Single transverse fibres run in the opposite direction among the bundles and shorter fasciae also occur in the ventro-dorsal axis between the bands. Immediately below the ectoderm on both ventral and dorsal surface, there is a relatively broad horizontal muscle running across the proboscis.



FAUNA OF THE CHILKA LAKE  
THE COELENTERATES OF THE LAKE,  
WITH AN ACCOUNT OF THE ACTINIARIA OF BRACKISH WATER  
IN THE  
GANGETIC DELTA.

*By* N. ANNANDALE, *D.Sc., F.A.S.B.*

(Plates VI-IX.)

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## COELENTERATES.

By N. ANNANDALE.

As will be seen from the list on p. 69, we obtained specimens of sixteen species of coelenterates in the Chilka Lake, *viz.* six Actinozoa, one Scyphomedusa and nine Hydrozoa. Five of the Actinozoa are Actiniaria and one an Alcyonarian; the Scyphomedusa belongs to the order Rhizostomata; one of the Hydrozoa is a Narcomedusa and one a Siphonophoran, while the remainder are true hydroids or hydromedusae, including four Calyptoblastea and three Gymnoblaster. Of the Calyptoblastea it is possible that a hydroid and a medusa actually represent the different generations of a single true species.

Of the Alcyonarian (a species of *Virgularia* probably not yet named) I propose to say no more at present than that it also occurs in the Gangetic estuaries. Our specimens are in the hands of a specialist, who will doubtless describe them in due course.

The Actiniaria are perhaps the most interesting group represented, for not only do they include species of the primitive genera *Edwardsia* and *Halianthus*, neither of which appears to have been found hitherto in the Indian Ocean, but they also include two species of Metridiine Sargatiidae that are here described as the types of new genera. These genera are apparently specialized for different phases of life in conditions such as occur in the Chilka Lake and in the Gangetic delta. Notwithstanding their high degree of apparent secondary specialization, it is possible that the type-species of one of them is in reality no more than a permanent post-larval form of *Metridium schillerianum*, long known from the estuarine tracts of the Ganges. All the species of Actiniaria found in the Chilka Lake occur in its main area, in which it is evident that they are permanent residents. Most of them, if not all, are, however, to some extent affected by the seasonal irruption of fresh water and probably only a few individuals of each survive annually to perpetuate their kind.

The only Scyphomedusa we obtained is also a permanent inhabitant of the main area of the lake, in which we have evidence that it breeds regularly, though it occurs also in the Bay of Bengal. A fortunate accident made it possible to study the direct effect of fresh water on the general physiology and the structure of this species, not only in the Chilka Lake but more particularly in the Ennur backwater near Madras.

The Coelenterata of the lake fall into three classes biologically: (1) casual visitors from the sea; (2) periodic immigrants from the Bay of Bengal; and (3) permanent inhabitants of brackish water or of water subject to great changes in salinity. The first group consists of a few surface or midwater forms of which individuals are

occasionally carried into the outer channel, and of at least one hydroid washed into the main area on drifting weed. To the second category belong several hydroids that are able to establish themselves in the salt-water season in the outer channel but perish in the summer floods; while to the third must be assigned all the Actiniaria, the one Alcyonarian, the one Scyphomedusa and at least two hydroids. The number of species that may be tabulated under each of the three headings is as follows:—

<i>Casual visitors</i>	.	4
<i>Periodic immigrants</i>	..	3
<i>Permanent inhabitants</i>	.	9
		—
TOTAL	.	16
		—

The casual visitors include one Narcomedusa, one Siphonophoran and two Calyptoblastic Hydrozoa, one of which is represented by the medusoid generation only; the periodic immigrants consists of one Gymnoblasic and one Calyptoblastic hydroid, with a medusa that may be no more than the fertile generation of the latter; while as permanent residents may be classed five Actiniaria, one Alcyonarian, one Scyphomedusa and two Gymnoblasic hydroids.

## ACTINIARIA.

(Plate vi (in part), plates vii, viia).

The Actiniaria of the Chilka Lake belong to three families, five genera and five species. The three families are the Actiniidae, the Sagartiidae and the Edwardsiidae. The first is represented by a single new species of the genus *Gyrostoma*, the second by two species each of which is placed in a new genus, and the last by new species of *Halianthus* and *Edwardsia*. With one exception (that of a Sagartiid previously found in the Gangetic delta) all the species are here described or named for the first time—a fact that is not surprising in view of our present ignorance of the actinian fauna of the Bay of Bengal<sup>1</sup> and of the estuaries and lagoons connected therewith.

From a geographical point of view the most interesting feature of the Chilka species is the occurrence among them of *Edwardsia* and *Halianthus*, genera known from both northern and southern regions but apparently represented but poorly in the Tropics.

Biologically the most important forms are those here accepted as the types of new genera of Sagartiidae. Their significance is discussed at some length on pp. 72-76, *postea*. The apparent effect of the irruption of fresh water into the lake on the species of *Halianthus* is another interesting feature of the fauna (see p. 91), and may

<sup>1</sup> The only papers on the sea-anemones of the Bay of Bengal that I can trace are those by Alcock in the *Journal of the Asiatic Society of Bengal* (vol. LXII, part 2, pp. 151 and 169: 1893), and by Haddon in the *Journal of the Linnean Society* (Zool., vol. XXI, p. 247: 1888). These papers deal with a few species only.

## COELENTERATES OF THE CHILKA LAKE.

m.a. = main area : o.ch. = outer channel : sp. gr. = specific gravity of water in the lake.

Species whose names are marked with a star have been found only in the Chilka Lake.

	CHILKA LAKE.		FURTHER DISTRIBUTION.	Sp. gr.	
	m.a.	o.ch.			
<b>ANTHOZOA.</b>					
<b>Actinaria.</b>					
Actiniidae.					
<i>Gyrostoma glaucum</i> *	..	x	x	1'0075—1'02575	
Sagartiidae.					
<i>Phytocoetes chilkaeus</i> *	..	x	x	1'0105—1'0265	
<i>Pelocoetes exul</i>	..	x	Gangetic delta ( <i>brackish water</i> ).	1'005—1'010	
Edwardsiidae.					
<i>Halianthus limnicola</i> *	..	x	x	1'000—1'0257	
<i>Edwardsia tinctorix</i> *	..	x	x	1'000—1'0257	
<b>Alcyonaria.</b>					
Virgulariidae.					
<i>Virgularia</i> sp.	..	x	Gangetic delta (? <i>salinity</i> ).		
<b>SCYPHOMEDUSAE.</b>					
<b>Rhizostomata.</b>					
Rhizostomata Triptera.					
<i>Acromitus rabanchatu</i>	..	x	x	Bay of Bengal ( <i>marine</i> ).	1'000—1'02575
<b>HYDROZOA.</b>					
<b>Narcomedusae.</b>					
Aeginidae.					
<i>Solmundella bitentaculata</i> ..			x	Practically cosmopolitan ( <i>marine</i> ).	1'02575
<b>Siphonophora.</b>					
Diphyidae.					
<i>Diphyes bojani</i> ..			x	Indian and Pacific Oceans ( <i>marine</i> ).	1'02575
<b>Calyptoblastea.</b>					
Campanulinidae.					
<i>Campanulina ceylonensis</i> ..			x	Bay of Bengal; G. of Manaar; Gangetic delta ( <i>salt and brackish water</i> ).	1'02575
Campanulariidae.					
<i>Obelia spinulosa</i> ..		x		N. S. Wales; Java; Andamans ( <i>marine</i> ).	1'02575
<i>Clytia serrulata</i> ..			x	N. S. Wales ( <i>marine</i> ).	ca. 1'000
<i>Phialidium cruciferum</i> *	..		x	Perhaps the medusa of <i>C. serrulata</i>	1'02575
<b>Gymnoblastera.</b>					
Bougainvilliidae.					
<i>Bimeria fluminalis</i> ..		x	x	Gangetic delta ( <i>brackish water</i> ).	1'000—1'02575
Corynidae.					
<i>Dicylocoryne filamentata</i> ..		x		Gangetic delta ( <i>brackish water</i> ).	ca. 1'0150
Hydractiniidae.					
<i>Clavactinia gallensis</i> ..			x	G. of Manaar ( <i>marine</i> ).	1'02575

be compared with that noted in greater detail in the case of the medusa *Acromitus rabanchatu* (see p. 101); generally speaking, this change in environment seems in both cases to induce a period of physiological quiescence accompanied by a shrinkage of the mesogloea and is probably fatal to a large number of individuals, though not to the species as a whole.

With my account of the Chilka species I have included a description of a new Gangetic anemone co-generic with one of the former, and also some notes on another Gangetic species that has long been known but is of particular interest in reference to the question of the origin of the fauna of brackish water. These Gangetic species are *Phytocoetes gangeticus*, sp. nov. and *Metridium schillerianum* (Stoliczka).

#### Family ACTINIIDAE.

##### Genus **Gyrostoma**, Kwietniewski.

1900. *Gyrostoma*, Carlgren, *Mitt. Naturh. Mus. Hamburg*, XVII, p. 55.  
 1905. „ McMurrich, *Zool. Jahrb.*, Suppl. VI (III), p. 226.

The only representatives of the Actiniidae found in the Chilka Lake belongs to the genus *Gyrostoma* as redefined by the authors cited. The genus is represented in all the warmer seas and species have been described from East Africa, South Australia, Torres Straits and the West Indies.

##### **Gyrostoma glaucum**, sp. nov.

(Plate viia, fig. 1.)

In life the animal is of an almost uniform glaucous green colour, but in some individuals there are darker V-shaped cross-bars on the upper surface of the tentacles. The column is slender and more or less vase-shaped, much longer than broad when fully extended. The external surface is smooth to the naked eye, except when the circular muscle is strongly contracted, but is covered with scattered microscopic prominences provided with nematocysts. The contracted muscles are visible as distinct annuli which, in preserved specimens, are more opaque than the expanded parts of the column.

The oral disk is rather narrow, circular in outline, flat but ridged and grooved radially. The mouth, which is provided with not very prominent lips, is almost linear and occupies about two-thirds of the circle in its longer axis. The tentacles are moderately long and slender; when fully expanded they are pointed, but even a slight contraction produces a faint ovoid swelling of the tips due to a greater thickness of the wall (mainly the ectoderm) in this region. The outer circle consists of about 24 tentacles distinctly longer and stouter than any of the others. Within this circle there are four others, but neither the number nor the arrangement is at all regular. Some of the tentacles of the innermost circle, though smaller than the outermost ones, are larger than the majority. These are often thrust into the mouth.

The basal disk, though small and not extending beyond the margin of the column,

is thick and muscular. It is capable to some extent of retraction, the margin of the retracted portion being angular in vertical section. There is a minute central aboral pore.

There are twelve complete and thirty-six incomplete mesenteries, the latter being situated in the intermesenterial spaces only, six in each. The two central incomplete mesenteries in each space are fertile. The longitudinal muscles are very feebly developed and in strictly horizontal sections the width of the mesenteries is almost uniform throughout, the folds at the base on both sides in particular being diffuse and poorly developed. The two pairs of directive mesenteries are very short.

The stomodaeum is ample and extends much more than half way down the column in a state of expansion.

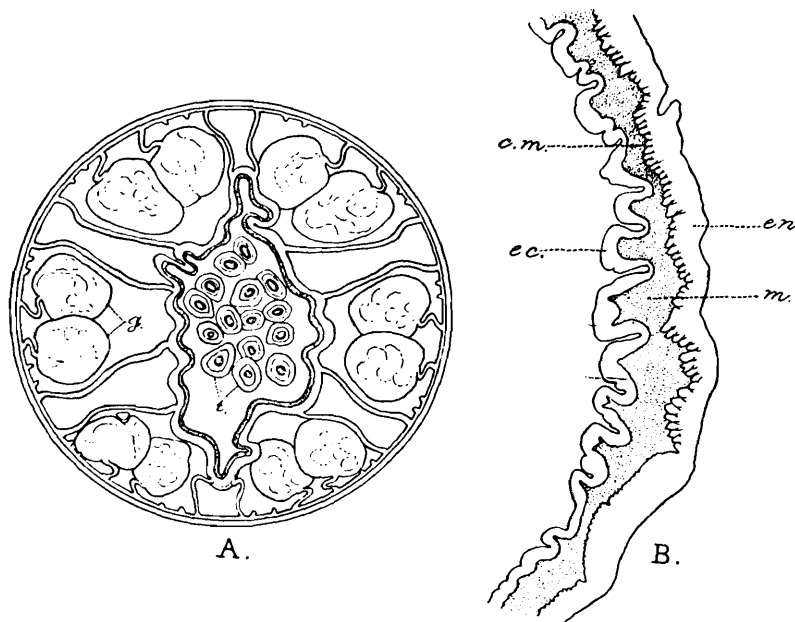


FIG. 1.—*Gyrostoma glaucum*, sp. nov.

A. Transverse section through the column in the lower part of the stomodaeum.

B. Vertical section of the lower part of the sphincter.

*c.m.* = circular muscle : *ec.* = ectoderm : *en.* = endoderm : *g.* = gonad : *m.* = mesogloea : *t.* = tentacles thrust into mouth.

The column-wall is thin, the mesogloea in particular being scanty. The circular muscles lie at the base of the endoderm and are not very highly developed. The sphincter is little if at all differentiated from any other part of the sheath in a state of contraction. When the tentacles are fully everted there is, indeed, a region just below the disk in which its folds are a little stronger than in the region immediately succeeding it; but similar folds may also be observed in the aboral half of the column. These features are indicated by increased opacity and stronger annulation of the body-wall (pl. viia, fig. 1).

The length of the column of our largest specimen was, fully expanded, 10 mm.; that of the other adults about half as much.

*Type.* No. Z.E.V 6825/7, *Ind. Mus.*

In this brief description I have not attempted more than to give a concise statement of the characters that seem to be of specific importance. Only five adult specimens are available for examination and, so far as I can judge from the species of other families that I have examined in much larger numbers, the so-called anatomical characters of the Actiniaria are liable not only to great individual variation but also to much momentary change in correlation with expansion and contraction of the muscles and mesogloea, apart altogether from the fact that distortion is almost inevitably produced in the course of preservation.

In external appearance *Gyrostoma glaucum* bears some resemblance to von Ehrenberg's figure of *Entacmaea olivacea*<sup>1</sup> (= *Paractis olivacea*, Klunzinger), but differs therefrom in the greater relative length of its outer tentacles.

*G. glaucum* has been taken as yet only in the Chilka Lake, in which it appears to be very scarce. It occurs both in the main area and in the outer channel. A single specimen was taken near the mouth of Rambha Bay in February, at a depth of between 5 and 7 feet and in water of a sp. gr. of 1.0075, while four others of much smaller size were obtained in the channel between Satpara and Mahosa in March, from about the same depth and in water of sp. gr. 1.02575. Three others<sup>2</sup> of still smaller size and evidently immature were found in the oyster-beds at Manikpatna in the same month.

#### Family SAGARTIIDAE.

##### Subfamily METRIDIINAE.

In discussing the species of this subfamily found in the Gangetic delta inexperience led me in 1907 into a taxonomic error, but this error, having some biological justification, has proved not unprofitable in considering the actinians of the Chilka Lake. In 1907<sup>3</sup> I ascribed three forms from Port Canning to the genus *Metridium* and to the species described by Stoliczka<sup>4</sup> in 1868 and 1869 as *Sagartia schilleriana*. One of these, there is no doubt, was identical with that species, of which my specimens were topotypes in the strictest sense of the term and of which the actual types are still available for comparison in Calcutta; another I described as a variety (*exul*), while the third I regarded as the young of the second. These three forms are here placed in three distinct genera, of which two are described as new, while Stoliczka's species is left in *Metridium*.

As the two new genera are both represented in the Chilka Lake, it will be convenient to discuss here the relationships of one to the other and of both to *Metridium*. Differences may first be noted. The species of *Metridium* are all anemones with a well-developed basal disk by means of which they cling firmly to solid objects.

<sup>1</sup> See Zoologica 11, Phytozoa, pl. viii. fig. vi, in *Symbolicae Physicae*, edited by O. Carlgren (1899) and Klunzinger's *Korallthiere des Rothen Meeres* 1, p. 70, pl. v, fig. 7, pl. viii, fig. 8 (1877).

<sup>2</sup> These had only 24 tentacles arranged in two circles, an outer circle of 8 and an inner one of 16; the latter was, however, incompletely differentiated into two subsidiary circles.

<sup>3</sup> *Rec. Ind. Mus.* I, p. 35.

<sup>4</sup> *Proc. Asiat. Soc. Bengal*, 1868, pp. 174, 263, and *Journ. Asiat. Soc. Bengal*, XXXVIII (2), p. 31 (1869).

Their body-wall is thin and not particularly muscular; they have twelve complete mesenteries, an ample oral disk and a large number of slender tentacles arranged in several or many cycles. For the two new genera I propose the names *Pelocoetes* and *Phytocoetes*. The former, as its name indicates, is a dweller in mud, while the latter lives, free or lightly attached, among weeds, in sponges or in holes in logs of wood. The generic peculiarities of *Pelocoetes* are so marked that at first sight it might be placed in a different family from *Metridium*. It is a typical burrower with an elongated vermiform body, and a muscular though by no means thick body-wall. Its oral disk is highly specialized, the arrangement of its tentacles peculiar. *Phytocoetes* has an elongated, but not a vermiform column. Its oral disk remains normal, but the number of its tentacles, which exhibit no marked peculiarity in arrangement, is somewhat reduced. In both genera little practical use is made of the aboral disk, but it has not entirely disappeared and is to some extent functional. In both genera, notwithstanding this fact, the lower extremity of the column bears, both functionally and structurally, a remarkable resemblance to the physa of such types as *Edwardsia* and *Cerianthus* that totally lack an aboral disk.

If this were all that could be said about the three genera it would appear that they were very distinct, and that *Pelocoetes* and *Phytocoetes* differed considerably, one from another and both from *Metridium*. But an examination of the anatomy and even of the external characters reveals very striking resemblances, and, although there would be no difficulty in distributing a set of living anemones into their respective genera, there is often a very real difficulty in sorting out specimens preserved in alcohol. The colouration of the known species is identical or almost so; all have the same translucent watery appearance, the same absence of intrinsic pigment;<sup>1</sup> the arrangement of the mesenteries is the same, except that the cycles of incomplete septa differ in number, while the musculature of the body-wall is very similar; the structure of the gonads, of the muscle-banners and of the individual tentacles appears to be practically identical.

The fact that these three genera live together in circumstances very unfavourable to their group as a whole (*viz.* in estuaries, creeks, pools and lakes in which the water is much fresher than normal sea-water and subject, moreover, to great and even sudden changes in salinity; in which the bottom is composed of soft mud; in which rocks covered at all seasons and even stiff water-weeds are practically absent) must not be forgotten in considering their relationships.

*Metridium schillerianum*, the species originally described from the Gangetic delta, maintains itself by clinging tightly to floating logs, which are by no means common in the Gangetic delta, and to posts fixed on the edge of canals and creeks. It is a normal member of its genus, which is probably cosmopolitan in distribution and essentially marine. Of the three genera, *Metridium* is certainly the most primitive and, indeed, may be the ancestral form of the other two, both of which are

---

<sup>1</sup> The colouration of all these brackish-water species appears to be due to the presence of Zoochloellae and of a minute purple alga in the endoderm.

evidently adapted in structure for life in different phases of the same environment. The peculiarities of *M. schillerianum* are mainly physiological; to these are added, in the case of *Pelocoetes* and *Phytocoetes*, special structural characters.

In 1907 (*op. cit.*) I expressed the opinion, somewhat tentatively, that the type now called *Pelocoetes* was a variety, local race, or possibly an unfixed phase of *Metridium schillerianum* produced by isolation, and that the form here recognized as a distinct genus under the name *Phytocoetes* was merely the young of *Pelocoetes*. This view ignored, perhaps rightly, the fact that many individuals of the *Phytocoetes* type are sexually mature. In any case it is rendered untenable in its entirety by the discovery in the Chilka Lake of anemones of both the *Pelocoetes* and the *Phytocoetes* types. Stress must be laid, nevertheless, on the resemblance between the latter type and the young of the Sagartiidae. In *Sagartia troglodytes*<sup>1</sup> the young, at any rate in some cases, is born as a small actinian differing from its parents mainly in the smaller number of its tentacles and mesenteries, in the poorly developed condition of its basal disk, in the tendency displayed by its column to assume at one time a spherical or subspherical, at another an elongated shape, and in its much more mobile habits. These are precisely the differences between *Phytocoetes* and *Metridium*. Some years ago I obtained the young of *M. schillerianum* from individuals taken from a post in the Mutlah estuary, and kept them in an aquarium full of water from one of the brackish pools at Port Canning. The adults of this species are almost invariably found in hollows on a rough surface (*e.g.* in the empty shells of *Balanus* or among masses of worm-tubes), but the walls and bottom of my aquarium were quite smooth. The young anemones closely resembled those of *S. troglodytes* and were apparently devoid of a columnar collar; they lived for some months and increased considerably in size, without losing their juvenile form. Unfortunately, during my absence from India, the aquarium was allowed to dry up and they perished before a detailed examination could be made. All that can be said about them therefore is that they continued for some months to resemble both *Phytocoetes* and the young of *Sagartia* in outward appearance.

The species of *Phytocoetes* found in the Chilka Lake is distinct from that originally obtained at Port Canning and since taken in the immediate neighbourhood of Calcutta. I have given the latter the name of *P. gangeticus* and the former that of *P. chilkaeus*.

Although on taxonomic grounds I now propose to regard *Phytocoetes* as distinct generically from *Metridium*, the facts of the case, regarded from a biological point of view, seem to point to the probability of the former being no more than a permanent or quasi-permanent larval (or rather post-larval) phase of the latter. In other words, it seems likely that *Phytocoetes gangeticus* bears to *Metridium schillerianum* much the same relationship as the axolotl does to *Amblystoma tigrinum*. *P. chilkaeus* may either be related in the same way to an unknown species of *Metridium* or be a direct descendant of either *M. schillerianum* or *P. gangeticus* in which evolu-

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<sup>1</sup> Ashworth and Annandale, *Proc. Roy. Soc., Edinburgh*, XXXV, p. 4 (1904).

tion has produced definite structural changes: the former view seems to me the more probable.

At Port Canning and in the Chilka Lake examples of both *Pelocoetes* and *Phytocoetes* may be found within a radius of a few yards. In both localities the *Pelocoetes* will be deeply buried, at least up to the base of its oral disk, in dense mud. At Port Canning *P. gangeticus* is most abundant in the cauals of the sponge *Spongilla alba* and in hollows on its surface, but is also found in abandoned burrows of *Teredo* in the few wooden posts that exist in the pools, and occasionally quite free among filamentous algae; in other parts of the Gangetic delta it occurs, often half-buried in mud, on the roots of reeds. At Rambha *P. chilkaeus* occurs mainly among algae, but there are neither Spongillidae nor worm-bored posts in those parts of the lake in which it has been found.

It is thus evident that while *Phytocoetes* has to some extent the habits of a young Sargartiid, *Pelocoetes* has adopted a mode of life differing from that of any phase of *Metridium*, indeed of any other allied form. All its generic peculiarities—its vermiform body, its reduced disk, even its incapacity to withdraw its tentacles—are correlated with this mode of life, but apart from these features it retains the structure of a Metridiine Sargartiid, and its basal disk is still functional, for if a living individual is examined immediately after being dug out from the mud it will be seen in most instances that the disk, small as it is, adheres to a particle of shell or some other hard body. Although, therefore, the type must be regarded as quite distinct from *Metridium* and *Phytocoetes*, I still believe that it is genetically related to *Metridium schillerianum*, from which it has been evolved directly, most probably in the Gangetic delta. Whether its evolution is due to natural selection (*i.e.* to the survival of individuals that exhibited a slight tendency to burrow, and of their offspring) or to mutation (*i.e.* the sudden appearance of a burrowing strain in the species) there is no evidence to prove; the fact that *Phytocoetes* is intermediate in structure between the two extreme types might seem to support the natural selection theory, but there is as a matter of fact nothing definite to show that the two new genera do not represent different offshoots from the main stem of *Metridium*; and if *Phytocoetes* is a permanent larval form it is difficult to imagine it as an actual step in the ladder of evolution.

My present views on these Metridiinae of Indian estuaries and lagoons, therefore, may be summarized as follows:—

- (1) Stoliczka's *Sagartia schilleriana* is a *Metridium*.
- (2) The form I described in 1907 as a variety of *M. schillerianum* under the name *exul* is a distinct species and represents a new generic type, for which the name *Pelocoetes* is proposed.
- (3) What I took for the young of this form represents a second new generic type, for which I now suggest the name *Phytocoetes*.
- (4) *Phytocoetes* is probably a permanent or quasi-permanent post-larval form of *Metridium*.
- (5) *Pelocoetes* is probably related genetically to *Metridium schillerianum*, but

has become structurally adapted, without losing certain essentially Metridiine characters, to life as a burrower in mud.

(6) The species of *Phytocoetes* found in the Chilka Lake is distinct from that found at Port Canning, while the *Pelocoetes* is specifically identical in the two localities.

(7) *Metridium schillerianum* does not occur in the Chilka Lake.

The following key to the species of Metridiinae that occur in brackish water in India may be useful to naturalists in this country:—

1. Basal disk large and strongly adherent; column in normal state no longer than wide.  
Tentacles about 168, arranged round the disk in 5 circles *Metridium schillerianum*.
2. Basal disk reduced, feebly adherent; column elongated.
  - A. Tentacles arranged in one circle of 12 and in 12 groups of 5 to 9 each, 72 to 120 in all *Pelocoetes exul*.
  - B. Tentacles less than 60, arranged in uninterrupted circles.
    - i. Tentacles 21–24; anterior sphincter well differentiated, visible on the surface as a prominent ring *Phytocoetes chilkaeus*.
    - ii. Tentacles about 36; anterior sphincter practically absent, not visible on the surface *Phytocoetes gangeticus*.

#### Genus *Metridium*, Oken.

1905. *Metridium*, McMurrich, *Zool. Jarhb.*, Suppl. VI, (III), p. 276.

#### *Metridium schillerianum* (Stoliczka).

(Plate vii, fig. 1.)

1868. *Sagartia schilleriana*, Stoliczka, *Proc. As. Soc. Bengal*, pp. 174, 263.

1869. *Sagartia schilleriana*, *id.*, *Journ. As. Soc. Bengal XXXVIII* (2), p. 31, pls. x, xi.

1882. *Sagartia schilleriana*, Hertwig, “*Challenger*” *Rep. Zool. VI, Actiniaria*, p. 71.

1907. *Metridium schillerianum* (typical form), Annandale, *Rec. Ind. Mus. I*, p. 45, pl. iii, figs. 1, 2, 5.

My description of “the typical form” of this species (1907) should render the identification of specimens a comparatively easy matter, but there are one or two points both in its anatomy and its ecology on which further notes may be useful.

Strictly speaking it is perhaps incorrect to talk of the existence of a sphincter in *M. schillerianum*, for all that can be said is that the circular muscle of the column is thrown into more conspicuous folds a short distance below the disk than elsewhere,

but that the condition of these folds varies considerably in different stages of expansion and contraction of the column. There are as a rule no independent muscle-fibres in this region, but in one specimen (fig. 2) I have found a few widely separated in the mesogloea and without any definite arrangement. When the disk is retracted but the column expanded horizontally, the differentiated region of the muscle-sheath extends over a considerable area; part of it is introverted, while part still remains external.

The facts relating to expansion and contraction of the column and to retraction of the tentacles were not fully understood by me in 1907. When the animal is left dry by the retreat of the tide its tentacles are always retracted, but its column fully expanded. The oral disk is withdrawn for some distance into the column and the walls of the latter are partially closed by a constriction above the tips of the tentacles, but as a rule a small opening remains patent. In this condition the actual body-wall is much swollen and remarkably translucent. If the animal is touched, water is squirted violently from the orifice above the tentacles. I was wrong, however, in thinking (1907, p. 64) that any part of this water was contained between the layers of the wall or in its mesogloea. In specimens killed with the body fully expanded—this is easily accomplished by pouring boiling formalin upon them in a small dish—the column wall will be found to be very thin and to be expanded by liquid within the mesenterial chambers. The mesenterial filaments lie bathed in this water in the middle of the body-cavity. A sudden contraction of the circular muscles of the column causes part of the water to be shot violently out of the mouth and consequently out of the orifice lying immediately above it.

When the tentacles are fully retracted the whole of the visible part of the column is smoothly rounded, but as they are extruded a distinct convex ring<sup>1</sup> makes its appearance round the upper extremity. When the oral disk has been completely extruded the column itself contracts strongly both in a transverse and a vertical direction, becoming relatively short and slender. This is due partly to muscular action and partly to the fact that water is expelled from the body-cavity. In the living animal the column in this condition is more or less completely hidden by the tentacles, but if a specimen is bisected vertically a very distinct fold of the body-wall can be seen (pl. viia, fig. 2) some little distance below the base of the tentacles. It is in this fold that the circular muscle of the column is most distinctly strengthened and differentiated.

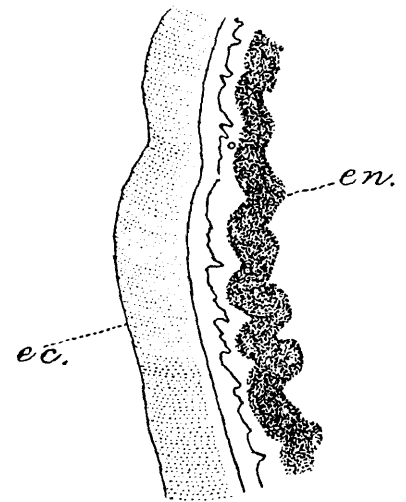


FIG. 2.—*Metridium schillerianum* (Stoliczka).

Vertical section through the sphincter.

ec. = ectoderm; en. = endoderm.

<sup>1</sup> See Stoliczka, 1869, pl. x, fig. 6.

*Metridium schillerianum* has recently been found in great abundance on posts and bridge-piers in canals and creeks of brackish water on the outskirts of Calcutta. In such positions it is often surrounded by sponge-like masses formed of the tubes of a small Sabellariid worm that builds in mud. On one occasion the water under a bridge on the piers of which the anemone occurred had a specific gravity of only 1.006, but individuals from this bridge lived for less than three days in pure fresh water, whereas others placed in water of a much higher salinity flourished.

The species has as yet been found only in brackish water in the Gangetic delta:— at Port Canning on the Mutlah river, in canals and creeks connected with the same system near Calcutta, and in the Hughli at Diamond Harbour. It does not occur in the Chilka Lake, in which suitable conditions are very rarely to be found. Mr. T. Southwell, however, recently took a specimen on a muddy bottom near the edge of the river at Diamond Harbour.<sup>1</sup>

### Genus **Phytocoetes**, nov.

The genus may be defined concisely as follows:—

Thin-walled Metridiinae without a collar, with the column capable of considerable elongation but protean in form, with the basal disk small and unmuscular, never strongly adhesive, with the aboral region capable of assuming a physa-like shape and appearance, with retractile tentacles arranged round the margin of an undivided and non-lobulate oral disk; the tentacles thread-like when fully expanded but highly contractile.

In both the species assigned to this genus the body-wall is very thin in a state of expansion, but can be considerably thickened at any point by the contraction of the circular muscle. This muscle lies on the mesogloea at the base of the endoderm, upon which it does not encroach; it forms a continuous sheath over the whole of the column, but, though uninterrupted anatomically, can be differentiated physiologically into numerous transverse strands almost visible to the naked eye and capable of independent contraction and expansion. When the animal is floating in the water or supported amidst filamentous algae or other similar plants the anterior region of the column is as a rule somewhat narrower than the aboral part, which may be swollen and bladder-like; but when it is at rest in mud, on roots or in sponges, the latter region is strongly contracted and cylindrical while the anterior part is more or less barrel-shaped (pl. vii, fig. 2). In all stages of expansion the basal disk is distinct. If the animal be subjected to abnormal or unhealthy conditions the column may assume almost any form, for the thin muscular walls permit constant and almost instantaneous changes of shape. In one species there is a distinct mesogloea sphincter, in the other it is absent. The contractions and expansions of the circular muscles cause very great changes in the microscopic appearance of the column-wall.

The tentacles are never very numerous; in one species the normal number is from 48 to 60, in the other 24. In the living animal they sometimes exhibit a

<sup>1</sup> Cf. Gosse on *Sagartia troglodytes* in *Actin. Brit.*, p. 95 (1860).

tendency to be arranged in groups, but these groups are never pedicellate. In a state of extreme contraction the individual tentacles may become knob-like, but they are always elongate and very slender when fully expanded.

The walls of the column are either smooth or covered with minute solid tubercles produced by swellings of the mesogloea. The cinclides, which are scattered on the upper part of the column, are conspicuous in the living animal but difficult to detect in preserved specimens. The central part of the column is often encased in a loose sheath of mucus and extraneous particles.

The number of mesenteries is never great. The normal number is 12 complete and 12 incomplete; the latter are almost vestigial, lacking muscle-banners, filaments and gonads. All the complete mesenteries are normally fertile and the species appear to be dioecious. Owing to the presence of large mesenterial stomata (which vary greatly in size, shape and position but are as a rule internal), transverse sections through the stomodaeal region frequently show gaps in the membrane of the complete mesenteries. It is possible, however, that the stomata are capable of almost incomplete obliteration by contraction.

So far as can be judged from published figures,<sup>1</sup> the species of *Phytocoetes* bear a remarkable if superficial resemblance to the aberrant genus *Scytophorus*, but they have no morphological relationship to that genus and have probably been derived, as I have already indicated, from *Metridium* in an environment in which solid objects of attachment are scarce and the bottom is almost uniformly soft and muddy.

The type-species of *Phytocoetes* is *P. gangeticus*, sp. nov.

The genus is only known from brackish water and water of variable salinity on the east coast of India.

### ***Phytocoetes gangeticus*, sp. nov.**

(Plate viia, figs. 3, 3a, 3b.)

1907. *Metridium schillerianum* var. *exul* (in part), Annandale, *Rec. Ind. Mus.* I, p. 48, pl. iv.

The animal is colourless in spirit; in life it may be described as being of a pale, translucent greenish flesh-colour. When the tentacles are retracted the uppermost visible part of the column is tinted with olivaceous green, but the retractile region immediately below the oral disk is pale. The tentacles are greenish or yellowish, with a pale purplish tinge due to the presence of algae in the cells of the endoderm; they bear no definite markings. When the column is fully expanded the body-wall is remarkably transparent, especially in the anterior parts.

The column is protean in form, sometimes contracted into a subspherical or barrel-shaped mass, sometimes elongate and almost cylindrical and at least four times as long as wide; in either condition it is frequently divided transversely by clear-cut circular constrictions. Sometimes the aboral region is fully extended and very narrow, while the anterior parts are contracted and broad; often the converse is the

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<sup>1</sup> Hertwig. "Challenger" *Rep. Zool.*, VI (1), *Actiniaria*, p. 104, pl. iii, fig. 6 (1882).

case. Preserved specimens may have practically any form, except that the basal disk is always narrow and inconspicuous; the aboral extremity as a whole is often swollen and bladder-like. In the living animal, when the tentacles are retracted but the column expanded, the anterior end is cone-shaped, the orifice above the tentacles being closed by a constriction of the column-walls.

Large specimens attain a length of 30 mm.

The tentacles are extensile but rarely or never exceed the column in length; when contracted they are bluntly pointed and minutely annulated; each has a terminal pore. The disk is ample and not at all emarginate. The tentacles are arranged

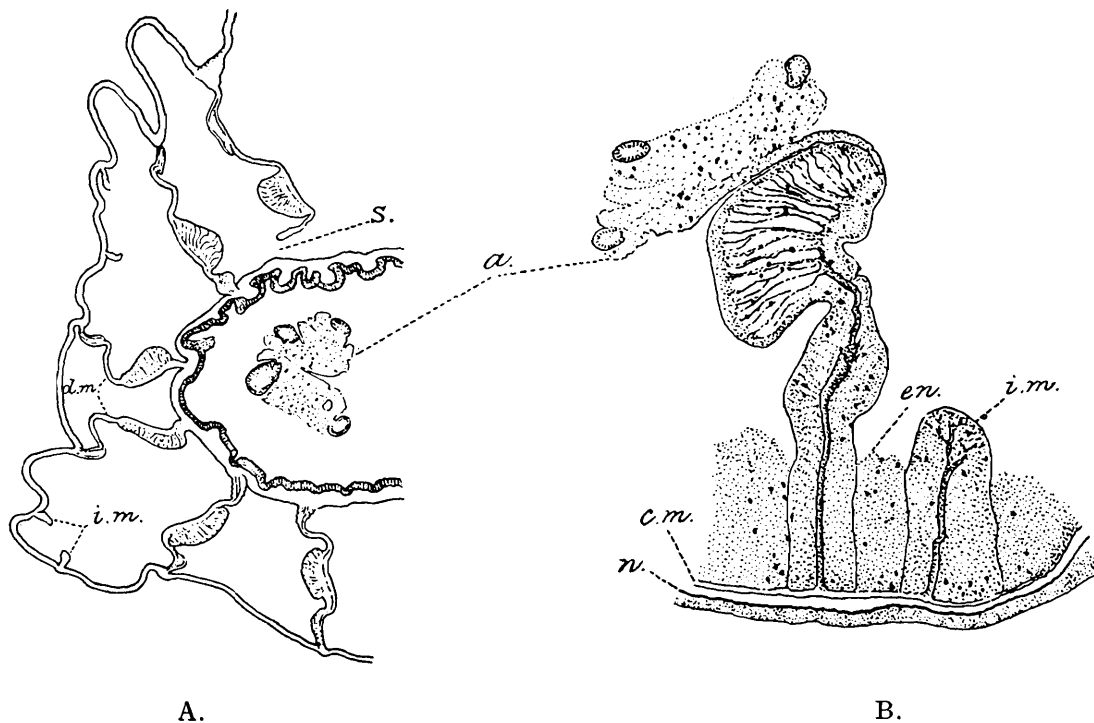


FIG. 3.—*Phytocoetes gangeticus*, sp. nov.

A. Transverse section of column in the upper part of the stomodaeum.

B. Transverse section of a complete and incomplete mesentery in the lower part of the column (more highly magnified).

*a.* = acontium in section: *c.m.* = circular muscle: *d.m.* = directive mesenteries: *en.* = endoderm:  
*i.m.* = incomplete mesenteries: *n.* = nervous layer: *s.* = mesenterial stoma.

round its margin. The mouth extends for about three-quarters of the breadth of the disk when the latter is fully expanded, but in some preserved specimens seems to be less extensive. The lips are not prominent, but there are six shallow transverse ridges on each side of the mouth.

The number of the tentacles is very variable; there are usually between 50 and 65; but some as a rule are very small. These small tentacles usually occur together in pairs or groups of three and are situated externally. The normal number of fully developed tentacles is probably 48 or 60.

The basal disk has the generic characters.

The surface of the column is smooth, except for the cinclides. These, though

difficult to demonstrate on the preserved specimen, are conspicuous in the living animal. They are confined to a region separated by a short imperforate "neck" from the disk and otherwise occupy approximately the anterior fifth of the expanded column. They have thin but sometimes rather prominent lips and run across from mesentery to mesentery, but only in the spaces separating complete mesenteries and not always in these. Their arrangement is irregular, but their relation to the mesenteries renders it necessary for them to form vertical rows, which contain from 3 to 7 cinclides each. When the apertures are closed they have the appearance, in the living animal, of fine white transverse lines bridging the mesenterial spaces into which they open (pl. viia, fig. 3a).

The stomodæum extends when expanded for about one-third the length of the expanded column, but can contract independently of the body as a whole. Its walls are not very thick, but the endoderm forms a series of distinct ridges. Transversely, in the sulco-sulcular axis, it is relatively wide, occupying by far the greater part of the diameter of the column; it is, however, strongly compressed.

There are as a rule twelve imperfect, infertile mesenteries as well as the twelve complete ones. Sometimes all of the latter bear filaments and gonads, but in some individuals not more than one-half or two-thirds do so; the incomplete mesenteries are almost vestigial. Owing to the great width of the stomodæum the directive mesenteries are relatively very short. The basilar muscles are small and feeble and the muscle-banners fairly strongly developed. On the directive mesenteries the latter have in some cases a narrow, elongate form in cross-section, while in others they are shorter and distinctly kidney-shaped. Most mesenteries have a stoma, but this aperture is sometimes absent and when present varies greatly in size, shape and position. As a rule it is very large, of a broad transverse or oblique oval or ovoid form and distinctly internal in position; but sometimes it is much reduced in size and situated nearer the column-wall than the stomodæum. I have seen one mesentery in which not only was the stoma, which was external in position, very large, but the whole of the membrane between the muscle-banner and the body-wall reduced to a narrow band by a great gap or emargination in the lower part of the mesentery. The band was bounded above by the stoma and below by this gap.

As a rule acontia, which are never well developed, are only present on a few of the mesenterial filaments. The upper trilobed portion of the filaments is short—as a rule shorter than the stomodæum, and the simple portion relatively long; but the proportionate length of the different parts of the filaments varies greatly even in the mesenteries of a single individual.

The gonads are normal in structure, and as far as I can ascertain the animal is dioecious.

The anterior sphincter is even less differentiated than in *M. schillerianum*, but in carefully preserved expanded specimens which have been rendered transparent, a few folds of the muscle-sheath can be detected in the region occupied by the cinclides. These folds lie in the mesogloea at the base of the endoderm and are not accompanied by any independent muscle-spaces. The rest of the muscle-sheath

resembles that of *M schillerianum*, except of course that there is no basal disk-sphincter. The walls of the column are for the most part very thin, chiefly owing to a reduction of the mesogloea, in this respect resembling those of the other Gangetic species. In the region of the false physa (fig. 3A, p. 80) the endoderm is, however, greatly thickened.

*Types*.—Nos. Z.E.V 6804-6/7, *Ind. Mus.*: from the vicinity of Calcutta.

The species has not been found in the Chilka Lake but occurs abundantly in pools of brackish water at Port Canning in the Gangetic delta and in canals and creeks near Calcutta. In the latter district it was on one occasion found in water of a specific gravity of 1.006.

*P. gangeticus* is distinguished from *P. chilkaeus*, the only other species as yet known in the genus, mainly by its more numerous tentacles and by the lack of a true sphincter; other differential characters are shown in the table on the opposite page.

At Port Canning *P. gangeticus*, which is markedly gregarious, is found in large numbers ensconced in masses of the sponge *Spongilla alba* that have probably grown round it on the roots of grasses. It is also found in the same pools in deserted burrows of *Teredo* in wooden posts. In both situations it is lightly attached by its degenerate basal disk to foreign bodies. Near Calcutta its favourite situation is among the roots of reeds that grow at the edge of small tidal creeks. Here it is frequently accompanied by masses of the polyzoon *Victorella bengalensis*. Although it is found in small holes in mud, I do not think that the anemone is able to burrow, for in this situation it occurs actually attached to roots and accompanied by the polyzoon, which certainly is not a burrower. In both cases the mud seems to be deposited round the animal; the anemone saves itself from suffocation by elongating its column, while the colonial organism buds freely and so forms a dense mass practically impervious to mud, and is thus able to expand the tentacles of its individuals upon the surface. At Port Canning I have seen an individual of *P. gangeticus* lying exposed in the sun at the edge of a pool. The tentacles were retracted, the orifice above them closed and the column fully expanded owing to the amount of water it contained; in the creeks near Calcutta large numbers of individuals may be found in mud between tide-levels. Very few individuals found in winter are sexually mature; probably the real breeding-season begins about February. The species does not seem to be exclusively nocturnal in habits. In an aquarium healthy individuals often cling to the glass in an upright position by means of the mucus that exudes from the surface of the column. They are able to drag themselves upwards by means of their tentacles as well as to progress in a lateral direction.<sup>1</sup>

### **Phytocoetes chilkaeus, sp. nov.**

(Plate vii, fig. 2; plate viia, fig. 4.)

This species, examined alive, resembles *P. gangeticus* very closely so far as the external characters are concerned, except that it has not more than 24 tentacles

<sup>1</sup> For further details of this mode of progression see *Rec. Ind. Mus.* I, p. 67.

and that almost the whole of the external surface of the column is covered with minute papillae. The internal structure of the two species is also very similar, except that *P. chilkaeus* has a true mesogloea sphincter situated a short distance below the oral disk. This species is also more sensitive to drugs than its Gangetic ally and therefore much more difficult to preserve in a natural condition. Consequently, preserved specimens of the two look as a rule very different (*cf.* figs. 3 and 4, pl. viia). Those of *P. chilkaeus* are darker in colour, being of a glaucous grey shade, and, owing to the strong contraction of the circular muscles, much more opaque; the column is elongated and cylindrical for the most part and the physa-like appearance of its aboral extremity exaggerated, while the tentacles are reduced to mere knobs, though in full expansion they are as long and slender as those of *P. gangeticus*. The position of the sphincter is clearly indicated externally by a convex annulus (pl. viia, fig. 4).

The specific characters in which the two species differ may be tabulated thus:—

	<i>P. gangeticus.</i>	<i>P. chilkaeus.</i>
<b>Tentacles</b> ... ..	50-65. Never contracted to mere knobs. Concolorous.	21-24. Liable to be contracted to mere knobs. Sometimes with dark angulate rings and a dark tip.
<b>Surface of column</b> ..	Smooth ..	Covered, except at the aboral extremity, with minute tubercles and bearing a convex annulus a short distance below the disk.
<b>Sphincter</b> ..	Absent	Well developed, with elongate muscle-spaces.
<b>Body-wall</b>	Very thin	Much thicker, at any rate in a state of contraction.

The tentacles are normally 24 in *P. chilkaeus*, but one or more may be aborted and I have examined a specimen in which there were only 21. Even in specimens preserved in alcohol the darkening of their tips occasionally persists, though the dark angulate rings disappear rapidly. The markings are due to accumulations of minute algae in the cells of the endoderm. In preserved specimens there appear to be two concentric circles of tentacles arranged alternately, but in the living animal they are distinctly grouped in threes with a single tentacle between each triad. The extreme contraction to be noted in most of our examples took place before death and was apparently due to the fact that unsuccessful attempts were made to paralyse the animals with drugs.

The minute papillae on the surface are produced by swellings of the mesogloea

(fig. 4) and cover the whole of the anterior two-thirds of the column. Towards the posterior extremity they gradually disappear and in some specimens are scanty if



FIG. 4.—*Phytocoetes chilkaeus*, sp. nov.

Transverse section of the column in the lower part of the stomodaeum; from a highly contracted specimen.

*c.m.* = circular muscle.

not altogether absent between the sphincter and the disk. On the anterior part of the body they are arranged in vertical rows.

The sphincter (pl. vii, fig. 2) consists of numerous strands, most of which are somewhat elongate in vertical section. They are grouped in a band-like figure, usually with a few that are shorter than the rest lying separated in the mesogloea, to which layer the whole muscle is confined. The muscle extends outwards in an oblique direction from near the base of the endoderm into an external annulus produced by a thickening of the mesogloea. The circular muscle-sheath is not interrupted in this region.

The internal structure of *P. chilkaeus* very closely resembles that of *P. gangeticus*. The body-wall appears to be as a rule thicker in the former, but this is due partly to the fact that it is more highly constricted in the specimens examined. When it is not contracted there is comparatively little difference.

Large specimens of *P. chilkaeus*, with the column constricted and elongated, are about 22 mm. in length and 4 mm. in diameter.

*Type-specimens.* No. 6803/7, Z.E.V *Ind. Mus.*: from Rambha Bay, Chilka Lake.

*P. chilkaeus* has as yet been found only in the Chilka Lake, but in both the outer channel and the main area. The only localities in which it was obtained were the head of Rambha Bay and the channel between Satpara and Mahosa. The actual specific gravity of the water in which it was taken varied from about 1.0105 at Rambha to 1.0265 at Satpara. It was collected in January and March.

At Rambha the anemones were found either floating a few inches below the surface or with their aboral disks lightly attached to a filmy alga that grows luxuriantly on mud in very shallow water. Off Satpara they were brought up from a muddy bottom overgrown with weeds in about 12 feet of water. To judge from their muddy bases they had been attached to the roots of the weeds. The aboral extremity was contracted and cylindrical in these specimens, expanded in those from Rambha. The examples from Rambha were taken in January and March;

those from off Satpara in the latter month. At both seasons some individuals were sexually mature. The species is not markedly gregarious.

### Genus *Pelocoetes*, nov.

This genus is closely allied to *Phytocoetes* and may be diagnosed as follows:—

Thin-walled Metridiinae without a collar, with a vermiform column, with the basal disk much reduced, with the aboral extremity capable of assuming a physa-like appearance and shape, with the majority of the tentacles arranged in groups each of which is placed on a flattened pedicel or out-growth from the reduced oral disk; the tentacles slender, thin-walled and not very highly contractile; the oral disk not retractile.

In the structure of its body-wall the single species of *Pelocoetes* closely resembles *Phytocoetes*, but the circular muscle-sheath is even stronger and has a more intimate relationship with the endoderm, with which it interdigitates when highly contracted (pl. vii, fig. 3b). Moreover, there is a considerable region on the upper part of the column in which this muscle is to some extent differentiated, being more powerful and more readily thrown into physiologically independent folds than elsewhere and occasionally being associated with a few scattered muscle-spaces. This region does not extend upwards quite as far as the base of the oral disk, but otherwise is approximately co-terminous with the stomodaeum. There is no separate sphincter. The nervous layer of the mesogloea is particularly well differentiated.

The animal lives buried in mud and its vermiform column, plainly correlated with this mode of life, is not so protean as that of *Phytocoetes*.

The tentacles are more numerous than in the allied genus, but variable in number. There is an inner circle of twelve solitary tentacles and an outer circle of twelve pedicellate groups; but the number in each group varies considerably.

The outer wall of the column is for the most part smooth, but bears a certain number of small vesicular swellings on the upper part. The cinclides are arranged definitely in vertical lines on the upper muscular region.

There are more incomplete mesenteries in *Pelocoetes* than in *Phytocoetes*, but fewer than is usual in *Metridium*, the actual number in *P. exul* being 36. None of these are situated in the intramesenterial spaces. Both internal and external mesenterial stomata may be present, but, as in *Phytocoetes*, their size, shape and position are very variable. Speaking generally, the mesenterial filaments are comparatively well developed in *Pelocoetes*; some of the incomplete mesenteries are occasionally fertile; the acontia are long and relatively stout and are normally present on all the fertile mesenteries. The animal is monoecious and protogynous.

The one species known occurs in the Gangetic delta and the Chilka Lake and has been found only in brackish water.

**Pelocoetes exul** (Annandale).

(Plate vi, fig. 1; plate vii, figs. 3, 3a, 3b.)

1907. *Metridium schillerianum* var. *exul* (in part), Annandale, *Rec. Ind. Mus.* I, p. 48, etc., figs. 1, 2, 3, 4; pl. iii, figs. 3, 4.

My original description of the "variety *exul*" of Stoliczka's Gangetic Anemone applies for the most part to *Pelocoetes exul* but is vitiated by the fact that I regarded *Phytocoetes gangeticus* as the young of the species now to be discussed. In the actual diagnosis, however, on p. 48 of the paper cited the characters distinctive of what I regarded in 1907 as young and adult individuals respectively are clearly differentiated. All that is necessary now, therefore, in the way of actual description, is to give a fuller account of the tentacular system, which can only be investigated satisfactorily in specimens killed in a fully expanded condition;<sup>1</sup> for the living animal is too sensitive to permit a very detailed investigation, while specimens killed in the ordinary way do not illustrate the peculiarities of the oral disk to anything like the full extent.

The tentacles, as is stated in the diagnosis of the genus, are disposed in a single inner circle of twelve and in twelve external pedicellate groups. The twelve primary internal tentacles represent the twelve complete chambers, each arising above either an inter- or an intramesenterial space, which is continued into its lumen. In the case of the intramesenterial tentacles the base of each occupies practically the whole of the inner part of the roof of the chamber, while in that of the intermesenterial tentacles it is situated opposite the central incompletely separated compartment formed by two of the six incomplete mesenteries that project into the chamber from the column-wall. These primary tentacles do not differ in structure or form from the others.

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<sup>1</sup> I find by far the most satisfactory method of killing these Gangetic species with degenerate basal disks is to allow them to expand themselves fully in a small vessel of water in which natural conditions are so far as possible reproduced. In the case of *P. exul* I fill the vessel half full of mud, make a hole some two and a half inches deep in the mud by thrusting in a pencil, and plant the anemone, basal disk downwards, in the hole. I then leave it until after dark with just sufficient water from its own habitat to allow full expansion of the tentacles. In the evening, after they are fully expanded, I sprinkle on the surface of the water a few crystals of menthol. In the morning the animals are found completely paralysed. Without disturbing them, a considerable amount of commercial formalin (about sufficient to make up a solution of 5% formaldehyde) is poured into the vessel. The whole is left standing for an hour and the specimens are then removed and cleaned. If they are wanted for histological purposes they are subsequently treated with corrosive acetic solution precisely as though they were fresh material. In cool weather at any rate, I do not find that they suffer from this process to any material extent so far as general histology is concerned, but if any delicate cytological work is to be performed it is better to kill them in a contracted condition. The specimens of anemones of which photographs are reproduced on pls. vi and viia were killed and preserved in the way described; it is apparently applicable rather to species with very thin muscular walls than to ordinary fixed forms, and I have not found it altogether successful in the case of *Metridium schillerianum*. In that of *P. chilkaeus* it failed, possibly on account of the use of too much menthol.

There are two pedicellate groups, alternating with the single tentacle, above each complete intermesenterial space; each group is associated with one complete and three incomplete mesenteries and its lumen is continuous with that of three incompletely separated compartments; one of its internal walls is practically co-terminous with a complete and the other with an incomplete mesentery, while the upper extremities of two other incomplete mesenteries are continued into it. The pedicel itself is a hollow process of the margin of the oral disk; its length is considerably greater than its breadth; it is compressed from above downwards; it has parallel sides. At some little distance from its point of origin the process bifurcates in a horizontal plane and just within the fork a single tentacle, which we may call the furcal tentacle, arises on the upper surface. Each branch of the pedicel bears two, three or four tentacles; the number is variable, sometimes even on the disk of a single individual.

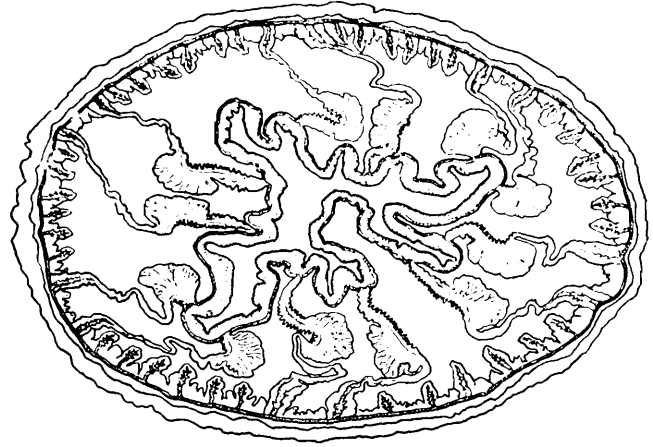


FIG. 5.—*Pelocoetes exul* (Annandale).

Transverse section of the column in the muscular region, from a highly contracted specimen.

In the lower or posterior wall of the pedicel there are, projecting into its lumen, four muscular ridges, two practically at the lateral margins and two in the middle. These ridges are actual prolongations upwards and outwards of the four mesenteries with which this process is associated; above and opposite each of them on the upper or anterior wall a similar ridge is developed, so that the whole lumen is divided incompletely into three chambers, the two outer pairs of ridges being close to the sides of the pedicel. The separation is incomplete because the united depth of the two ridges of each pair is not so great as that of the lumen. The furcal tentacle is produced at the distal extremity of the central chamber, while each of the lateral chambers corresponds to one branch of the pedicel. The number of tentacles developed on each branch is evidently a matter of secondary importance.

Although one of the lower ridges in each pedicel is connected with a complete mesentery while three are continuations of incomplete mesenteries, no difference in structure can be observed; nor is there any difference between these lower ridges and the corresponding upper ones.

The walls of the pedicel and of the tentacles are very thin, the mesogloea and the circular muscles being poorly developed in them. The longitudinal muscles, though by no means thick are, in spite of the non-retractile and not highly contractile state of the disk, well developed. The mesenteries closely resemble those of *Phytocoetes*, except that there are 36 instead of 12 incomplete mesenteries and that the filaments are more uniformly developed on the complete ones.

In the case of *Phytocoetes* the difference between the microscopic appearance of the

body-wall in specimens in which the circular muscles are contracted or relaxed has already been noted (p. 78); in *Pelocoetes* it is even more marked. When the column is fully expanded the total thickness of the wall is reduced to about 0.02 mm. and the mesogloea is a mere thread even under high powers, whereas in examples killed with these muscles contracted the wall is about 0.17 mm. thick and the mesogloea, including the muscle-band, 0.028 mm. thick.

If the muscles are at all contracted there is always a tendency for the column of *P. exul* to assume an oval form in cross-section and this feature may be observed to some extent even in the living animal; the main axis of the section is sulco-sulcular (fig. 5, p. 87).

The types of the species, which are from Port Canning, are numbered Z.E.V 2419-21/7 in the books of the Indian Museum.

*P. exul* has been found only in small pools of brackish water at Port Canning in the Gangetic delta and in the main area of the Chilka Lake, but its habits render it very difficult of detection and capture and it is actually, in all probability, distributed more widely than we know. In the lake it was taken close inshore at Rambha in a few inches of water in January and off Kalupara Ghat in the northern part of the area in very shallow water in April. The salinity of the water is not precisely known, but the specific gravity must have been between 1.005 and 1.010.

This anemone lives, as already stated, buried in the mud up to the base of its oral disk, which can be pulled downwards with great rapidity on disturbance. It is nocturnal in habits to this extent—the tentacles are never fully expanded by day and remain with their tips extending from the hole in the mud for a short distance only, whereas by night they are completely extended. These facts were observed in the case of anemones *in situ* at the edge of the lake in January. A bright light directed on the disk, however, did not cause contraction. Although in early life the animal must be an active burrower as it lives in a vertical burrow several inches deep, adults are very helpless when removed from their proper environment and show no inclination to make a fresh hole. Their vermiform column prevents them from assuming an upright position, and it is very difficult to keep them alive in captivity unless they are literally planted in mud in the way described in the footnote on p. 86. Further particulars as to the habits of *P. exul* will be found in my paper of 1907.

In specimens taken in the Chilka Lake in January the ovaries were mature; this was also the case with specimens taken at Port Canning in December; but in others taken at the latter locality in January it was the testes that were ripe.

#### Family EDWARDSIIDAE.

1905. Edwardsiidae, McMurrich, *Zool. Jahrb.*, Suppl. VI (III), p. 218.

Remarkably few species of this family have been found in the warmer seas and the occurrence of two genera, representing respectively the *Edwardsia* and the *Hal-campa* sections of the family, in a locality so peculiar as the Chilka Lake is therefore noteworthy.

Genus **Halianthus**, Kwietniewski.

1896. *Halianthus*, Kwietniewski, *Jena. Zeitsch. Naturwiss.* XXX, p. 585.

The species hitherto assigned to this genus are mainly Arctic, but McMurrich (*op. cit.*, 1905, p. 223) has described one from the Pacific coast of South America. I can find no previous record from the Indian Ocean.

**Halianthus limnicola**, sp. nov.

(Plate vi, fig. 2; plate vii, figs. 4, 4a, 4b.)

When at rest the living animal has a conical shape, slightly swollen in the middle region and slightly constricted at the truncated end, *i.e.* just below the oral disk. The aboral end is bluntly pointed and often not at all inflated; externally there is no apparent separation of capitulum, scaphus and physa, but the last is to some extent retractile. The body can assume practically any shape from spherical to cylindrical and sharp constrictions at one or more points are often a noticeable feature of preserved specimens; when the tentacles are retracted the upper part of the column assumes a subspherical form, while the aboral region is constricted into a cylindrical peduncle; or the whole organism may have an elegant vase-like outline. There is no external cuticle or sheath.

On the external surface there are twelve longitudinal rows of relatively large, though not very prominent, solid tubercles, which correspond roughly in position with the twelve mesenterial spaces; they are mainly due to thickenings of the mesogloea. Towards the aboral extremity these rows, and also the individual tubercles, tend to become obsolete. The whole of the body-wall and the wall of the disk and tentacles is hyaline and practically colourless, but the tentacles are often ornamented on the upper surface with V-shaped translucent bars and the disk is not so transparent as the column. The mesenterial filaments and the gonads are of a bright yellowish flesh-colour, which is communicated by reflection to the remainder of the animal, especially in a state of contraction. Specimens in spirit or even formalin become more or less opaque.

The oral disk is ample, its outline in contraction is broadly oval, the longer axis being that of the mouth, which occupies the greater part of the disk in this axis. The lips are by no means prominent when the mouth is closed; there are six low transverse ridges at each side. The normal number of tentacles is twelve, but occasionally one or more subsidiary tentacles are produced asymmetrically; the normal arrangement is that the tentacles form two concentric circles of equal numbers and alternate round the margin. There is no structural difference between ordinary and subsidiary tentacles; both when fully expanded are stout, cylindrical and blunt and hardly longer than the longer diameter of the disk; they can be contracted into little wart-like projections. The disk is usually flat but can assume a conical or even a clavate form.

The aboral extremity is perforate, but the pore is always small.

Our largest specimens, which have shrunk very little, are about 5 mm. long.

The circular muscle of the body-wall is well developed and in the living animal can be detected readily with the aid of a hand-lens as a series of transverse rings

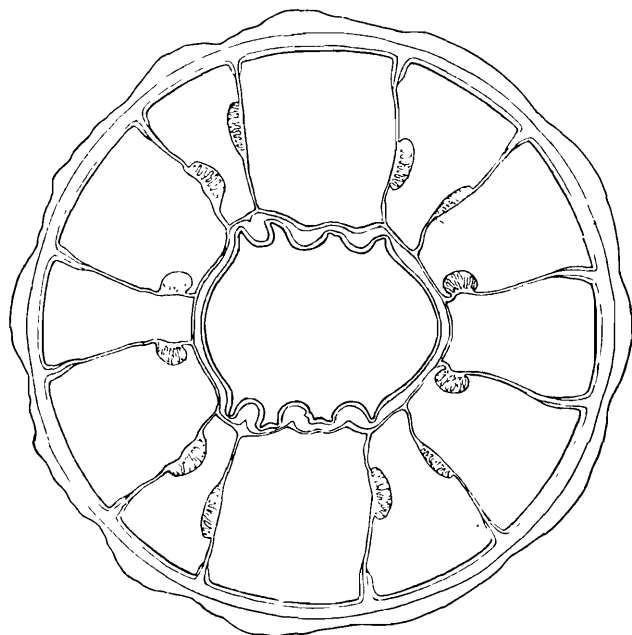


FIG. 6.—*Halianthus limnicola*, sp. nov.

Transverse section of the column in the middle of the stomodaeum.

strands surrounding distinct muscle-spaces and well separated by mesogloea from the muscle-sheath.

The stomodaeum is spacious in cross-section; the walls, which are moderately thick, are thrown internally into three distinct though not very deep folds on either side; the sulcus and sulculus are very broad. The sulco-sulcular length in a state of expansion occupies a little less than a half of the width of the column.

There are no rudimentary or incomplete mesenteries. The twelve complete mesenteries are normally fertile. The kidney-shaped muscle-banners are moderately small and separated by some little distance from the wall of the stomodaeum; they contain a considerable number of moderately long and slender folds of the mesogloea. The parietal muscles are slightly and irregularly folded, the projections of the mesogloea on which they are based being by no means clearly defined in sections.

The gonads are normal in structure and not very much folded transversely. The animal appears to be dioecious.

The specific characters of *Halianthus limnicola* may, therefore, be summarized as follows:—

- (1) The whole animal (except the internal organs) is colourless and translucent or hyaline, the markings on the tentacles being due to relative degrees of transparency and not to pigmentation.
- (2) The normal shape of the column is conical and there is no external differentiation of capitulum, scaphus and physa.
- (3) There is no external sheath or cuticle.

capable of independent contraction and expansion. The differentiation is, however, physiological rather than anatomical and in vertical sections the muscle forms a continuous sheath of minute fibres, having the general appearance of an irregularly serrated line more conspicuously folded at some points than at others. In transverse sections the fibres lie at the base of the endoderm (as of course they do also in vertical sections) but run across the mesogloea at the base of the mesenteries. The muscular sheath is most strongly developed in the wall of the physa.

The sphincter (pl. vii, fig. 4) is well developed but short. It lies close below the base of the tentacles and consists of a number of relatively stout isolated

strands surrounding distinct muscle-spaces and well separated by mesogloea from the

muscle-sheath.

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- (2) The normal shape of the column is conical and there is no external differentiation of capitulum, scaphus and physa.
- (3) There is no external sheath or cuticle.

- (4) There are twelve vertical rows of solid tubercles on the column.
- (5) The tentacles are normally 12 in number, but extra subsidiary tentacles are sometimes produced asymmetrically; both the normal and the subsidiary tentacles are (even when fully expanded) stout, blunt and hardly longer than the longer diameter of the disk.
- (6) The mouth is relatively wide.
- (7) The stomodaeum is spacious, its sulco-sulcular axis occupying nearly one half of the diameter of the column.
- (8) The muscle-banners are small, though not so small as in some forms, and separated from the walls of the stomodaeum.
- (9) There are no incomplete mesenteries.
- (10) The parietal muscles are feebly developed and accompanied merely by somewhat indistinct projections of the mesogloea.

*Types.* No. Z.E.V 6032/7, *Ind. Mus.*

This species has been found as yet only in the Chilka Lake, in the main area of which it is abundant at all seasons except the end of the rains; it is also found, much more sparingly, in the muddy parts of the outer channel. It is commonest in from 6 to 12 feet of water and has been found throughout the range of salinities occurring in the lake.

*Halianthus limnicola* is gregarious, and was usually taken on a muddy bottom in which there was a fairly large admixture of dead Lamellibranch shells. It is very active and not at all shy. When removed from the water or otherwise disturbed it retracts its tentacles instantaneously but extrudes them again the moment that it is comfortable. In a vessel half filled with mud and shells and half with lake-water it begins to burrow almost immediately. This it prefers to do among shells, among which it progresses in an almost horizontal direction, lying prone and dragging itself along with fair rapidity by means of its tentacles. Their movements are accompanied and assisted by rhythmical longitudinal expansions and contractions of the column. No rhythmical transverse contractions of the column were observed, but constrictions often appeared suddenly at different points. The animal has a strange habit of alternately retracting and extruding the proximal part of the physa. No attempt was made to form an external sheath or cuticle, the transparent wall of the column remaining remarkably clean. If left to itself the anemone sometimes formed a vertical burrow, in which, however, it never remained for very long. The muscular nature of the physa would suggest that it is employed in making burrows of the kind, but the process was not observed.

Although numerous individuals of the species were obtained in most hauls of our nets on suitable ground throughout the greater part of the year (even in July, when the rains were established, and in September, when the water had become fresh), yet in November it was found to be very scarce and only a few specimens were obtained. These were, moreover, in a quiescent condition, exhibiting none of the normal muscular activity, and were so contracted and shrivelled that they could not at first

be identified. There can, therefore, be little doubt that prolonged exposure to fresh water has much the same effect as it has on the medusa *Acromitus rabanchatu* (p. 101, *postea*). A larger proportion of the actinians, however, probably perish and the physiological changes are produced more slowly.

*H. limnicola* does not seem to have any fixed breeding season, for individuals were found with apparently ripe gonads at all times of the year, even in November.

#### Genus *Edwardsia*, Quatrefages.

1889. *Edwardsia*, Haddon, *Trans. Roy. Dublin Soc.* (2) VI, p. 326.

1895. ,, Faurot, *Arch. Zool. expériment.* (3) V, p. 108.

*Edwardsia* has been generally regarded as characteristic of temperate seas both north and south of the Tropics, and I can find no reference to any undoubted species from the Indian Ocean. Carlgren<sup>1</sup> has examined a representative of the closely allied genus *Edwardsiella* from the Red Sea and East Africa, which was originally described by Klunzinger<sup>2</sup> under the name *Edwardsia pudica*, and thinks that *Edwardsia adenensis*, Faurot<sup>3</sup> from Aden is probably a synonym. *E. arenosa*, Klunzinger, is also an *Edwardsiella*.

#### *Edwardsia tinctrix*, sp. nov.

(Plate vi, fig. 3; plate vii, figs. 5, 5a; plate viia, fig. 5.)

When fully extended the whole animal is vermiform, and narrowly sausage-shaped when the capitulum is introverted. The distinction between capitulum, scaphus and physa is well marked in the former condition and that between the two last regions in the latter. The scaphus is relatively long and slender, the capitulum, which is not constricted, short. The naked physa is also short, but not so short as in some species, it has a rather narrow ovoid form when expanded and bears at the tip a circle of eight minute finger-shaped processes. These, however, are apt to disappear in preserved specimens and in any case are so small that they can only be seen under a high power of the microscope; in structure they are solid outgrowths, mainly of ectoderm and containing a large number of minute intracellular refractive granules. On the scaphus there are eight vertical rows of small but prominent mamilliform tubercles corresponding in position to the eight mesenterial spaces. The structure of these tubercles will be discussed presently. Not only the whole of the capitulum but also a considerable part of the scaphus can be introverted.

The sixteen tentacles are long, slender and pointed. The oral disk is narrow but more or less tumid; the mouth runs across the greater part of it. The tentacles are not very highly contractile, but can be thrust into the mouth so far that their tips extend into the physa.

The capitulum, with the disk and tentacles, is translucent and often colourless,

<sup>1</sup> *Mitt. Naturh. Mus. Hamburg*, XVII (2), p. 46 (1900).

<sup>2</sup> *Die Korallthiere des Rothen Meeres* I, p. 81, pl. vi, fig. 3.

<sup>3</sup> *op. cit.*, *supra*, p. 121.

but is usually tinged more or less deeply with olive-green; sometimes the endoderm of the tentacles is marked with alternate green and white rings, the pale rings being narrower than the dark. The most characteristic features in the colouration is, however, a series of eight blackish vertical bars that ornament the capitulum just below the disk, one outside each mesentery. Each bar is double, being completely bisected longitudinally by a colourless or pale line, and expands at the upper end, which is sometimes separated as a distinct spot or rather pair of spots. The scaphus has a bright orange-scarlet colour, which, unlike the markings of the capitulum, retains its intensity in spirit; this colour is not intrinsic in the tissues of the animal but due to a staining of the particles of mud incorporated in the delicate "cuticle" that clothes the scaphus.<sup>1</sup> The physa, both in living and in preserved specimens, is of a fairly opaque white.

The tubercles on the scaphus are a characteristic feature of the species, not only on account of their prominent nature but also of their internal structure. In most sections of the column they appear merely as hollow outgrowths of the wall due mainly to a thickening of the mesogloea accompanied by the apparent formation of a large lacuna; but if specimens of the whole animal be mounted for microscopic examination after being rendered transparent it will be readily seen that each lacuna contains, in addition to a quantity of mucus, what appear to be a number of long slender chaetae arranged for the most part almost at right angles to the circumference of the column but converging somewhat to the tip of the papilla, which contains a minute aperture. In a few sections of several large series some of these peculiar bodies remain *in situ* and can be recognized in the slender nematocysts of the type figured more than fifty years ago by Gosse in his *Actinologia Britannica* (pl. xi, fig. 10, 1860). Their threads can be occasionally detected emerging from the pore in the papilla (pl. vii, figs. 5, 5a). The cavity of the tubercle has a diameter of about 0.09 mm.

The body-wall is very thin in the capitulum, but considerably thicker in the scaphus, the difference lying mainly in the relative amount of mesogloea present; in the physa the mesogloea is thin but the endoderm rather thick. There is no special sphincter, but the circular muscle, which lies at the base of the endoderm, is well developed both in the scaphus and in the physa. The nervous layer is well developed. The wall of the tentacles is thick, but their mesogloea relatively thin.

The stomodaeum is ample at its upper extremity, occupying in its longer axis more than half of the diameter of the column and having a rather narrowly oval shape in cross-section; it is very short vertically and does not quite reach the lower end of the capitulum.

There are, in addition to the usual eight complete mesenteries, eight rudimentary ones, but these are confined to the upper part of the stomodaeum. They have the arrangement apparently normal in the genus, *i.e.* there are two in each sulco-lateral

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<sup>1</sup> A similar staining of muddy particles is often produced at the edge of the mantle in some of the Chilka Lamellibranchs (*e.g.* *Theora opalina*) and in the tubes of Maldanid worms.

chamber and one in each of the other chambers except the sulcar and sulcular. Most of these rudimentary mesenteries consist merely of the basal (parietal) longitudinal muscles and the folded mesogloea that supports them, but those in the sulcolateral chambers are distinctly better developed and possess a rudiment of the

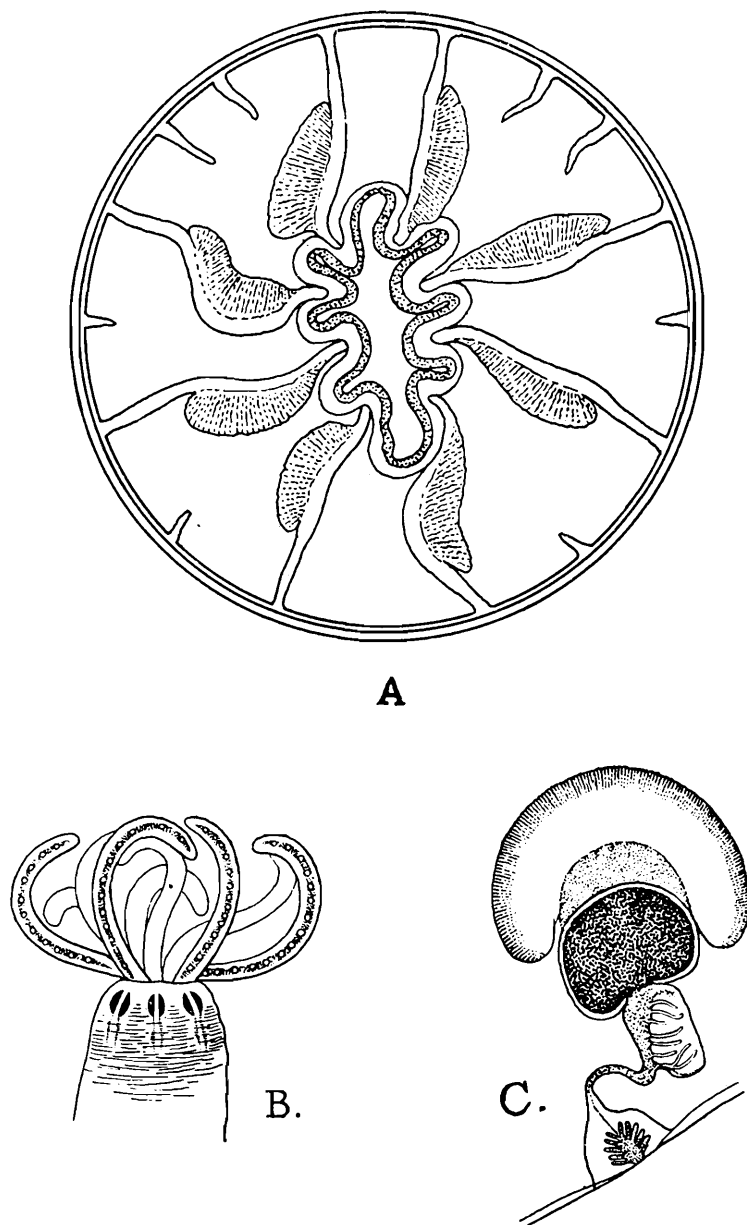


FIG. 7.—*Edwardsia tinctoria*, sp. nov.

- A. Lateral view of the capitulum (from a sketch by Mr. G. Henry).  
 B. Transverse section through the upper part of the capitulum.  
 C. Transverse section of a fertile male mesentery through the upper end of the gonad.

membranous part as well; indeed, they are at least as well developed as the incomplete mesenteries of *Phytocoetes*.

The longitudinal muscles of the complete mesenteries differ in different regions of the column. In the upper part of the capitulum the parietal series are poorly developed, whereas the muscle-banners are large and powerful, occupying the greater

part of the width of the mesentery (fig. 7A, p. 94). A little lower down these latter structures become much thinner and weaker, practically disappearing at the lower end of the stomodaeum, while the parietal muscles become better developed. Below the stomodaeum the muscle-banners again become large. The mesogloea in the basal part of each mesentery is thrown on each side into five or six folds, all of which are moderately stout and have an approximately similar form and depth.

The gonads are normal and the animal is apparently dioecious.

Our largest specimen of this species is about 30 mm. long in a fully extended condition, the greatest transverse diameter of the scaphus being 3 mm. and the length of the tentacles 6.5 mm., but this specimen is unusually large.

*Types.*—No. Z.E.V 6819/7, *Ind. Mus.*

The most important specific characters of *Edwardsia tinctorix* lie in the shape and colouration of the column, the presence, peculiar structure and comparatively large size of the tubercles on the scaphus, the relative length of the sulco-lateral rudimentary mesenteries, the form and relative size of the longitudinal muscles of the mesenteries and the proportions of the stomodaeum; but in the identification of specimens of the genus attention must be paid to the general sum of characters rather than to separate features or to single organs or parts. Perhaps the most peculiar feature of the Chilka species is the structure and size of the tubercles, but those of *E. claparedi* (Panceri) are probably similar, if relatively smaller, for the nematocysts in these organs are very liable to disappear from sections.<sup>1</sup>

*E. tinctorix* is, for the greater part of the year, one of the most abundant members of the fauna of the main area of the Chilka Lake, over the whole of which it occurs from the shore to a depth of 16 feet; in the muddy parts of the outer channel it is much less common. It was found in water of which the specific gravity varied from that of the Bay of Bengal at the time to that of pure fresh water. Outside the Chilka Lake it has not yet been discovered.

The anemone lives buried in mud as far as the base of the disk. It is extremely shy and sensitive. When removed from mud individuals almost invariably have the disk and capitulum introverted into the scaphus, and it was not found possible to cause them to expand by daylight. If planted in mud covered with water in a glass they often did so by night<sup>2</sup>, but even then showed no tendency to shift their position or to construct fresh burrows for themselves.

*E. tinctorix* is much less common in the Chilka Lake at the end of the rains than at other seasons, but a few individuals were found even in November. They were much contracted and did not expand in captivity even at night. It is probable, therefore, that they are affected by long-continued residence in fresh water much in the same way as *Halianthus limnicola*.

In specimens taken between March and July inclusive the gonads were ripe, as

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<sup>1</sup> See Walton and Rees, *Journ. Mar. Biol. Ass. Plymouth* X, p. 64, fig. 2, 1913.

<sup>2</sup> Walton and Rees (*op. cit.*, p. 62) found that an individual of *E. claparedi* (Panceri) at first refused to expand by daylight but after a time did so.

they were occasionally in September; but this was not the case in those collected between November and February.

## SCYPHOMEDUSAE.

(Plate vi (in part); plate viii.)

The only medusa of this group found in the Chilka Lake belongs to the order Rhizostomata and the division Triptera. The species is here described as new and belongs to a genus recently discovered in the Philippines, in which the only form hitherto recognized occurs. The Chilka species is of considerable biological interest, not only because it has been able to establish itself as a permanent resident in water of very variable salinity, but also because we found it possible to estimate the direct effect of fresh water upon the physiology of individuals (p. 101, *postea*). Some post-larval forms were obtained and are here described briefly and figured; they throw light on the evolution of the Rhizostomatous mouth-arm. The species is also common in the Bay of Bengal.

### Order RHIZOSTOMATA.

#### Division RHIZOSTOMATA TRIPTERA.

#### Genus *Acromitus*, Light.

1914. *Acromitus*, Light, *Philippine Journ. Sci.* (D) IX, p. 210.

This genus has recently been described to contain a single species (*A. maculosus*, Light) from the Philippines. Its most striking diagnostic character is the possession at the tip of each mouth-arm of a single greatly elongated tentacle-like filamentous process. This process is very much longer and stouter than the small sensory filaments scattered among the mouths on the arms.

In describing a new species from the Chilka Lake and the Bay of Bengal I have closely followed the descriptions of representatives of the order published in Meyer's *Medusae of the World* (1910). In all the features accepted by Light (1914, *op. cit.*) as of generic importance this species agrees with *A. maculosus*, the only other member of the genus yet known.

#### *Acromitus rabanchatu*<sup>1</sup>, sp. nov.

(Plate vi, figs. 4-6; plate viii.)

The disk is no flatter, at any rate in living medusae and in specimens recently preserved in formalin, than a hemisphere. In large individuals its diameter is as

<sup>1</sup> *Raban-chatu* is the vernacular name given to this medusa by the Uriya fishermen of the Chilka Lake, who would probably apply it also to any other medusa of similar shape. It means "the umbrella of Ravana" the demon-king of Ceylon who plays the part of chief villain in the *Ramayana*.

much as 20 cm. The exumbrella is smooth to the naked eye, but under the microscope appears minutely granular each granule consisting of a little prominence beset with nematocysts. There are eight rhopalia, each flanked on either side by a small, elongate, tapering marginal lappet. A furrowed exumbrellar pit extends inwards down each rhopalium; as seen from above the outline of the pit is somewhat expanded towards the margin and constricted inwards. The rhopalar lappets, which are longer than the others, are not expanded inwards at the base and do not meet at any point. The velar lappets, of which there are four pairs in each octant, are short and broad; their tips are very broadly rounded or subtruncate, and the incisions that separate them short, those separating the two lappets that form a pair being shorter than those that separate one pair from another. There are thus 16 rhopalar and 64 velar lappets, or 80 in all.

The width of the arm-disk at its base is about two-thirds, and at the point at which the arms originate from it about one-half that of the bell.

There are four narrow genital ostia, each a little narrower than the pillar which separates one ostium from the next. Each is constricted below by a thick, wide, gelatinous process of the bell-disk, and a little distance outside each a broad triangular process with a bluntly pointed tip is directed downwards and inwards from the subumbrellar surface. It occupies a position immediately below one of the rhopalar canals. The arm disk is very slightly emarginate in each perradius. The subgenital cavity is broadly cruciform.

At their bases the eight mouth-arms are joined together in a circle for a short distance. Their relative length is somewhat variable and one or more, perhaps owing to accident, are sometimes shorter than the others; they are always comparatively long in proportion to the vertical axis of the bell. The lower, bifid portion of each arm occupies about four-fifths of its total length. In this region the mouths are arranged in a single row down each margin of each edge of the three lamellae. On the upper, simple part of the arm they extend up the inner edge, in the same formation, to its point of origin. The fringed lips, however, are so contorted, and the minute capitate stinging-tentacles so numerous upon them, that it is difficult to make out the precise arrangement without studying immature medusae. Normally the arm is bluntly pointed at the tip.

The sensory filaments on the sides of the arms are short, slender and bluntly pointed; they are often entirely concealed among the capitate tentacles and seem to be much better developed in some individuals than in others. Their arrangement is not very regular, but, generally speaking, they are set in short transverse lines parallel to and alternating with the mouths. The elongate terminal filament characteristic of the genus is rather stout at the base and tapers gradually. When fully formed it is of great length, but it is rarely well-developed on all the arms of an individual and may be altogether absent from some. This is probably due to accident, for the tip of the arm itself is sometimes lacking. Not infrequently the filament has one or more short branches at its base. Possibly this is due to regeneration after injury.

The stomach is cruciform. There are eight rhopalar and eight adradial canals. The former reach the broad zone of anastomosing circular canals externally, but the latter are usually separated therefrom by an inwardly projecting portion of this peripheral system. Even in adult medusae an adradial canal can sometimes be traced in a straight line through this projecting portion to the outer zone, but more frequently it loses its identity on entering the former. The gastric filaments are numerous but very small. They are short, cylindrical and bluntly pointed.

The colour of the bell, arm-disk and arms is milky white, neither transparent nor altogether opaque. As a rule the bell is ornamented with dark spots, but their size, number and arrangement are variable, and often they are absent. Sometimes (perhaps most frequently) there is a broad immaculate peripheral zone and the spots, which are about 2 mm. in diameter, are densely scattered over the remainder of the bell; but sometimes they extend outwards to the marginal lappets, and I have seen medusae, apparently quite uninjured, in which there were only some half a dozen minute specks on the central part of the dome. Sometimes the spots are rather large and fewer than usual; I have examined one individual in which they ran together to form large irregular blotches on the margin. The pigment appears, in the living medusa, almost black to the naked eye, but if the animal is allowed to die in water it streams out in a deep purple cloud. In spirit or formalin the spots fade to a reddish brown and gradually, after some months, disappear altogether. The gastric filaments and the gonads are naturally of a yellowish flesh-colour, but fade immediately to opaque white in spirit or formalin.

*Type*.—No. Z.E.V 6740/7, *Ind. Mus.* Preserved in 5% formol.

*Distribution*.—This medusa is common in shallow water on both sides of the Bay of Bengal and in backwaters in the Madras Presidency. I have examined specimens from the coast of Tenasserim and of Orissa. In the Chilka Lake it occurs at all times of the year both in the outer channel and in the main area. We found it in water of every degree of salinity up to that normal in the Bay of Bengal, and even in pure fresh water; it evidently breeds in brackish water. The effect of fresh water upon it is discussed below (p. 101).

*Acromitus rabanchatu* is closely allied to the type-species of the genus (*A. maculosus*, Light<sup>1</sup>), from which it differs in colouration, in having the velar lappets shorter and blunter than the rhopalar, the terminal arm-filaments stout and tapering at the base, in the shape of the rhopalar pits and rhopalar lappets and in several other minor characters.

#### *Young stages.*

Many small specimens were obtained in tow-nets, especially in November, 1914 in the immediate neighbourhood of Barkuda Id. The smallest are about 3 mm. in diameter and represent an interesting stage in the development of the species. Practically every other stage up to the full-grown medusa is represented in our collection.

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<sup>1</sup> *Philippine Journ. Sci.* (D) IX, No. 3, pp 210-216, figs. 4-6 (1914).

In our smallest specimens the disk is flat and membranous, with only a slight convexity in the central region of the exumbrella. The margins can, however, be everted upwards so that the structure becomes deeply concave, resembling a chalice in form (fig. 8). The muscular system is poorly developed and that of the canals is still in a primitive condition. The sixteen radiating canals are well developed, but they open outwards directly into a circular canal on the periphery. The walls of the latter canal are irregular in outline and somewhat indefinite projections can already be detected, representing the anastomosing channels that will be developed later. The actual margin is so delicate that it is invariably injured in specimens taken in a tow-net, but the rhopalar lappets are relatively large and conspicuous and the velar lappets short and broad and perhaps not very clearly separated. There appear to be four in an octant. The actual rhopalia are well-developed, but the furrowed pit above them is represented only by a slight depression in the exumbrella.

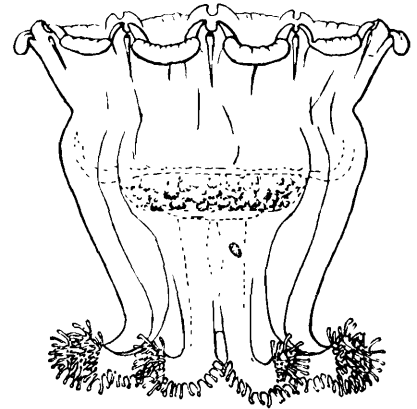


FIG. 8.—*Acromitus rabanchatu*,  
sp. nov.

A very young medusa with the bell everted upwards.

The most interesting features of these young medusae are to be found in the mouth-arms. The arm-disk has already assumed its final shape, but the ostia are relatively smaller than in the adult and are not protected by depending processes of the subumbrella. These processes do not appear until a much later stage in post-larval development is attained, and the ostia remain relatively small until the bell is considerably larger. In the smallest specimens the arms themselves (pl. viii, fig. 2) are still in the Semostoman stage and may be compared with those of the adult medusa in *Aurosa*. They are united in a circle at their base to a slightly greater relative extent than in the adult, to form what may be called a short manubrium, and are arranged in four pairs. Each arm is an elongate, membranous, flattened process of the margin of this manubrium, bilobed at the distal extremity and having the tips of the lobes slightly everted. The lobes are rounded and do not diverge widely. The inner (endodermal) surface is concave and a single row of minute capitate tentacles run round the whole arm (including the lobes), and also along the margin of the manubrium between the bases of the members of each pair of arms. The tentacles are least numerous in the latter position.

It would be out place to discuss the post-larval development in any great detail, but one or two points of general interest may be noted. It may be stated firstly that there appears to be very little correlation of a definite kind in the origin or full elaboration of different organs in different individuals. In some very small specimens the canal-system is already more elaborate than it is in others of much larger size; the bell is much deeper, and has a shape more near that of the adult, in some young examples than it has in others of more advanced development as regards the canal-system; the terminal filaments of the arms rarely appear at the

same time on all the arms of the same medusa, and are frequently absent in individuals of later growth than in some of those in which they are fully formed; the lateral sensory filaments of the arms usually appear later than the terminal ones, but can sometimes be detected in the form of minute buds before the latter make their appearance.

A second point of interest lies in the fact that in the development of the canal-system the inward projections of the peripheral plexus connected with the adradial canals first make their appearance as irregular processes of the primitive circular canal and are in no way connected with the radiating channels. Each projection is formed in two halves, one half on each side of the canal with which the whole is ultimately to fuse. Even after the two halves have become joined to the two sides of the radiating canal, it runs straight through them and maintains its identity to the margin of the disk. This condition prevails for a considerable period and may occasionally be found persisting as an abnormality in one or more octant of a large medusa.

But the most interesting feature of our series of young specimens of *Acromitus* lies in the clear manner in which it illustrates the evolution of the Rhizostomatous mouth-arm (plate viii, figs. 2 to 3*b*). The peculiarities of the structure of this organ are due in the first instance to unequal growth in its different parts. The everted terminal lobes of the arm of the young medusa grow more rapidly than the simple basal part, and the margins in both regions grow more rapidly than the middle portion. The first consequence of the accelerated growth of the terminal lobes is that the whole arm is definitely folded inwards along the middle line, while the fact that the margins become longer than the middle region causes them to be thrown into a series of short transverse pleats. This double folding causes certain parts of one side of the arm to be brought into close contact with the corresponding parts of the other side, and also certain parts of each margin to be pressed against others on the same side; but prevents the whole of one vertical half coming into contact with the whole of the other. In fact, a central vertical canal is left open down the mid-ventral line of the primitive arm, while lateral canals of smaller calibre diverge from it obliquely to the margin on either side. The whole figure thus formed is pinnate. Simultaneously with the production of this system of canals a great increase in the bulk of the mesogloea of the arm takes place. Where endoderm meets endoderm in the folding, the two surfaces fuse together and are invaded by mesogloea, which cuts off one canal from another, leaving those endodermal tracts free that have not been in contact. The endoderm in the interior of the greatly strengthened and thickened arm that is thus produced is now confined to the lining of the vertical and lateral channels formed by the folding of the originally membranous structure and its consolidation in the manner indicated. The distal extremities of the lateral canals remain open and form two linear series of mouths, extending, one on each side of the new margin, down the arm and along each of the terminal lobes.

Yet another folding takes place owing to the growth of these lobes. At first

slightly everted, they tend to grow upwards rather than outwards and so to be folded against the outer margin of the undivided part of the arm. Their ectoderm thus comes in contact with the ectoderm of that part. Ectoderm fuses with ectoderm and is invaded by mesogloea, but as the folding is a simple one no new channels are left open. The characteristic arm of the Triptera is thus produced, formed in its distal region of three lamellae meeting in a vertical line and having a >-shaped cross-section.

Another point that may be noticed is the large size of the gastric filaments in the young medusa, in which they are actually as large as—relatively of course much larger than—in the adult.

*Acromitus rabanchatu* is a sluggish medusa usually seen on the surface with its main axis nearly horizontal. Its pulsations are slow and feeble. Probably the fixed stage occurs on rocks or weeds near the south end of the lake, where the young were found in April, July, September and November, but not in January or February. Small copepods were noticed in the stomach of the young. The stinging-cells have little or no effect on the human skin. Personally I could detect none.

The most striking point in what we ascertained as to the biology of this medusa is the effect that an irruption of fresh water has on its habits and physiology. We noticed that medusae were absent from the surface of the northern part of the main area of the Chilka Lake for a considerable part of the year in which they were fairly common in Rambha Bay, although the prevailing wind had a tendency to drive them northwards. The season at which we did not find them on the surface off Barkul and Nalbano was that at which fresh water, which never penetrates fully into Rambha Bay, was prevalent in the northern parts of the lake. At this season our nets often brought up specimens of *Acromitus* from the bottom; they seemed to be unusually sluggish, to have unusually flat disks and long arms; but we did not notice anything very definitely peculiar. By a fortunate chance abnormal meteorological conditions made it possible to make a much more definite observation in the Ennur backwater near Madras in January, 1915. At that time, at a season at which the weather is usually dry, heavy rain had fallen and the specific gravity of the water in the upper reaches of the lagoon had sunk, probably quite suddenly, at least as low as 1.001. No medusae were seen on the surface, but every haul of the bottom-nets brought up specimens; in one case as many as twenty in a haul. At first sight they appeared to be dead; no movement of any kind could be detected and the circular muscles of the disk were uncontracted and flaccid. The disks were so flat, owing partly to the condition of the muscles but mainly to an actual shrinkage of the jelly, that the specimens were recorded provisionally as representing either a distinct species or a phase of *A. rabanchatu* in which the disk retained the post-larval form; the arms, in consequence of the shrinkage of the bell, appeared to be exceptionally long. That the medusae were not dead was proved by two facts—they exhibited no signs of decay and the spots on their umbrellas were clear and well-defined. The latter fact is particularly important, because in medusae of this species

that are allowed to die in water the pigment of the spots begin to "run" immediately, staining the surrounding medium. The Ennur specimens were of all sizes from a diameter of about 3 cm. to about 20 cm.

These facts, taken in conjunction with the observations recorded on *Halianthus limnicola* and *Edwardsia tinctoria* on pp. 91, 95 of this paper, justify an expression of the belief that some individuals of certain coelenterate species, if forced to live temporarily in water of very low specific gravity (*i.e.* greatly decreased salinity), are able to survive in a state of quiescence or torpidity for considerable periods, and that the most obvious direct structural effect of such conditions is a shrinkage of the mesogloea. If unduly prolonged these conditions cause the deaths of many individuals. The more marked results at Ennur, as compared with those noticed in the Chilka Lake, were probably due to the greater suddenness of the change.

In the Chilka Lake, but not at Ennur, a small amphipodous crustacean was almost invariably observed among the tentacles on the mouth-arms of large individuals of *A. rabanchatu* and occasionally also on the subumbrellar surface. It was not present on very young medusae. In the gastric cavity of these latter, among the gastric filaments, ova were frequently observed, giving, together with the large relative size of the filaments, a false appearance of sexual maturity. The ova, however, were not confined to the gastric cavity but occurred scattered throughout the vascular system and in particular in the circular canals; they are shown as white spots in the photographs of young medusae reproduced on plate vi. A microscopic examination revealed no ovarian tissue, and there can be no doubt that the ova were not proper to the medusae. Mr. T. Southwell has been kind enough to examine a series of well-preserved specimens. He agrees with me in thinking that the eggs are not those of the commensal amphipod but probably belong to some helminth parasite. They are in various stages of segmentation and the formation of a blastula, but unfortunately have not reached in any case a higher stage of development and have not as eggs any distinctive structural character. In size and shape, however, they closely resemble eggs found with immature Distomid Trematoda in the canals of a Ctenophore common in the Chilka Lake (p. 118). No eggs of the kind were observed in adult medusae.

The main breeding season of *A. rabanchatu* occurs in the Chilka Lake, to judge from the condition of the gonads in specimens, towards the end of the cold weather, *i.e.* in February and March.

## HYDROZOA.

(Plate ix, in part.)

We obtained in the Chilka Lake specimens of eight or nine species of Hydrozoa, representing four orders, seven families and eight or nine genera. The alternative numbers in species and genera are due to doubt as to the association of a medusa

with its hydroid generation. All the orders of the group except the Trachomedusae and the Hydrocorallinae are represented, but the Narcomedusae and the Siphonophora each include only one casual visitor. The true hydroids are better represented; among the Calyptoblastic families, the Campanulinidae have a single medusa (a casual visitor), and the Campanulariidae two hydroids, each belonging to a separate genus, as well as a medusa that may very well be co-specific with one of the hydroids. One Calyptoblastic hydroid is a casual visitor, while another establishes itself in the outer channel, in which a medusa belonging to the same group was also found as a casual visitor, in the salt-water season. The Gymnoblasterae are represented by three hydroids, two of which are permanent inhabitants of the main area of the lake, while the third was found only in the outer channel and in the salt-water season.

Most of the casual visitors and periodic immigrants are marine species of wide distribution. Of the four free-swimming forms included in these categories one is cosmopolitan and one Indo-Pacific, one is widely distributed in the Bay of Bengal and the neighbouring seas, while the fourth, though only known as a medusa from the outer channel of the lake, is perhaps the other generation of an Indo-Pacific hydroid found with it. Of the three fixed forms that are not permanent residents two are Indo-Pacific while one was described from Ceylon.

The two permanent residents, on the other hand, are both species that were originally described from the Gangetic delta and are as yet known only as inhabitants of brackish water on the east coast of India.

## Order NARCOMEDUSAE.

### Family AEGINIDAE.

#### Genus *Solmundella* Haeckel.

#### *Solmundella bitentaculata* (Quoy and Gaimard).

1904. *Solmundella bitentaculata*, Browne, *Faun. Geogr. Maldives and Laccadives* II, p. 741, pl. lvi, fig. 3.  
 1905. *Solmundella bitentaculata*, *id.*, *Rep. Ceylon Pearl Fish.* IV, p. 153, pl. iv, figs. 1-6.  
 1910. *Solmundella bitentaculata*, Mayer, *Medusae of the World* II, p. 455, fig. 301 (p. 457).

An excellent figure of this peculiar little medusa as it appears when contracted is given by Browne (1904). In his paper of 1905 he gives further particulars. Mayer regards the *Aeginopsis mediterranea* of Müller as no more than a variety. If this is so, the species occurs in all seas but has become sufficiently differentiated in the Mediterranean to be distinguished there as an endemic race. As Mayer points out, referring to Vanhoffen's report on the Narcomedusae of the 'Valdivia' (*Narcomedusen der 'Valdivia' Exp.*, p. 45), "*Solmundella* is the most widely distributed Narcomedusa known, ranging from the North Atlantic, through the tropical Pacific

and Indian Oceans to the Antarctic. Living at temperatures of 27° to 1° C, and in depths ranging from 1,500 fathoms to the surface."

A single small specimen was taken in a tow-net on the surface of the outer channel of the Chilka Lake near Barhampur Id. on March 14th, 1914. The salinity of the water at the time was practically identical with that of the Bay of Bengal outside the bar. The medusa must be regarded merely as a casual and perhaps involuntary visitor to the lake.

## Order SIPHONOPHORA.

### Family DIPHYIDAE.

#### Genus *Diphyes*, Cuvier.

#### *Diphyes bojani* (Chun).

1911. *Diphyes bojani*, Bigelow, *Mem. Mus. Zool. Harvard*, XXXVIII, No. 2, p. 251; pl. vii, figs. 2, 3; pl. viii, fig. 6; pl. ix, figs. 1, 2; pl. x, figs. 2, 3; pl. xi, fig. 5; pl. xii, fig. 1.

The synonymy of this species is discussed by Bigelow in the paper cited. Our specimens agree well with the figure of *Diphyes gegenbauri* published by Lens and Van Riemsdijk in their report on the Siphonophora of the 'Siboga' (*Siboga-Exp.* LX, pl. vii, fig. 57), or in some cases with that of *Doromosia pictoides* (*op. cit.*, pl. i, fig. 1). The species is evidently a variable one and the shape of the anterior nectophore depends to some extent on the condition of preservation of specimens.

In our collection from the Chilka Lake I have found anterior nectophores only.

*D. bojani* is widely distributed in the Indo-Pacific Region. It is not a permanent inhabitant of the lake, but is to be found in considerable numbers in the outer channel in the salt-water season. It was usually present in our tow-nettings obtained there in March, 1914.

## Order CALYPTOBLASTEA.

### Family CAMPANULINIDAE.

#### Genus *Campanulina*, van Beneden.

1868. *Campanulina*, Hincks, *Brit. Hydr. Zooph.*, p. 186.

#### *Campanulina ceylonensis* (Browne).

1905. *Irene ceylonensis*, Browne, *Rep. Ceylon Pearl Fish.*, p. 140, pl. iii, figs. 9-11.  
 1905. *Irene palkensis*, *id.*, *ibid.*, p. 141, pl. iii, figs. 12-16.  
 1907. ,, *ceylonensis*, Annandale, *Journ. As. Soc. Bengal* (n. s.) III, p. 79, pl. ii, fig. 5.  
 1907. ,, *ceylonensis*, *id.*, *Rec. Ind. Mus.* I, pp. 38, 142, fig. 2.  
 1910. *Phortis palkensis* + *Ph. ceylonensis*, Mayer, *Medusae of the World*, p. 309.

The position of the medusa of this species is somewhat enigmatical. Browne placed it in *Irene* (or *Eirene*), and Mayer, relying wholly on Browne's description, in *Phortis*. It seems to me to have affinities with *Tima*,<sup>1</sup> but does not altogether agree with that genus, although its gonads, when fully adult, reach practically from the base of the manubrium to the edge of the disk; there are no cirri and no conspicuous band of longitudinal muscles on the lower side of the tentacles. I have, however, been able to detect a very thin band of the kind in this position. As the hydroid is merely a dwarfed *Campanulina*, it seems best to place the species in that genus, in which the adult medusae have not been satisfactorily identified.

The hydroid<sup>2</sup> forms a minute colony barely visible to the naked eye. It consists of a sparsely branching adherent rhizome that gives origin at intervals to single hydrothecae borne on short ringed pedicels about one-seventh as long as the cup. The hydrothecae are nearly cylindrical and can be closed above by an operculum consisting of several triangular flaps. The hydranth has about 14 very long slender tentacles with regular rings of stinging-cells and but slightly webbed at the base. The hypostome, which is conical, is small and inconspicuous.

Medusae from Port Canning in the Gangetic delta exhibited every gradation between Browne's two nominal species (1907 (2), pp. 140, 141). An increase in the number of concretions in the otocysts was regularly correlated with the production of extra tentacle-bulbs that did not reach their full development. Both changes were apparently due to degeneration and took place towards the end of the season at which the medusa flourished (December to March), when the water of the pools in which it was found began to grow hot.

The hydroid was found on the leaves and stems of water-plants at Port Canning in November, December and January. Both medusa and hydroid have now disappeared from the pools.

The medusa is common off the coast of Burma in winter. It was taken in the Gulf of Manaar and Palk Straits in March and July. At Port Canning, the only locality at which the hydroid has been found, both generations flourished for a time in brackish water. Neither was, however, found in the main area of the Chilka Lake and the species is represented in our collection by a single medusa that was taken in the outer channel, in salt water, in March.

In the second of my papers published in 1907 I dealt with the feeding habits of the medusa, which sucks out the contents of filamentous algae as well as swallowing small Gastropod molluscs and finally ejecting their shells. It is the hardiest medusa with which I am acquainted and will survive for some hours corked up, several individuals together, in a small tube carried in the waistcoat pocket.

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<sup>1</sup> For definitions of the different medusoid genera here referred to see Mayer's *Medusae of the World* II, pp. 307, 311, 314.

<sup>2</sup> All my specimens of this hydroid are now in the hands of Dr. Ritchie of the Royal Scottish Museum, who will, I hope, give a full description in his account of the shallow-water hydroids of the Indian Seas. Dr. Ritchie will describe shortly in the *Records of the Indian Museum* a minute and very interesting hydroid from brackish water in the Gangetic delta.

## Family CAMPANULARIIDAE.

Genus **Obelia**, Peron and Lesueur.**Obelia spinulosa** (Bale).

1888. *Campanularia* (?) *spinulosa*, Bale, *Proc. Linn. Soc. N. S. Wales* (2) III, p. 756, pl. xii, figs. 5-7.

1910. *Campanularia* (?) *spinulosa*, Ritchie, *Rec. Ind. Mus.* V, p. 5.

A single specimen of this species was taken in the main area of the lake in July, 1913. It grew on a piece of drift-weed stranded among rocks near Patsahanipur and though many of the polyps were alive, was in a somewhat degenerate condition. A few gonothecae were present but did not contain gonosomes.

The information that the hydroid is an *Obelia* I owe to Prof. K. Ramunni Menon of Madras, in whose laboratory the medusa has been reared. I have also to thank him for the sketch reproduced (fig. 9), which was made from life by his pupil Mr. A. V. Narayananvami Ayer.

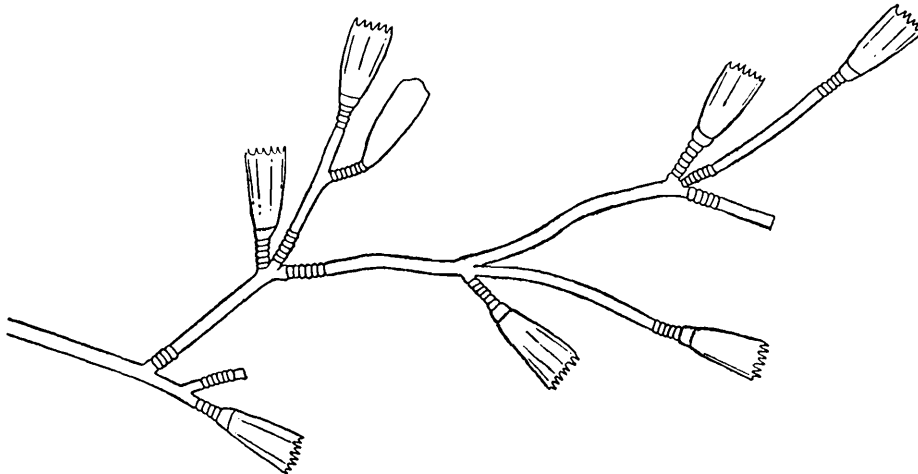


FIG. 9.—*Obelia spinulosa* (Bale).

*O. spinulosa* was originally described from N. S. Wales and has since been recorded from Java and the Andamans. It is very common (with *Clytia geniculata*, Thornely) in Madras harbour, in which it grows on the shells of mussels, etc.

Genus **Clytia**, Lamouroux (Hincks).

1868. *Clytia*, Hincks, *Brit. Hydr. Zooph.*, p. 140 (Hydroid).

1910. ,, Mayer, *Medusae of the World* II, p. 261 (Medusa).

**Clytia serrulata** (Bale).

(Plate ix, figs. 1, 1a, 1b.)

1888. *Campanularia* (?) *serrulata*, Bale, *Proc. Linn. Soc. N. S. Wales* (2) III, p. 257, pl. xii, fig. 4.

So far as can be judged from well-advanced embryos in the gonothecae, this species is a *Clytia*; it is certainly neither a *Campanularia* nor a *Gonothyraea*. The

possibility of its being the hydroid of a *Phialidium* is not, however, excluded, and it may be the vegetative generation of the medusa described below as *Phialidium cruciferum*. Of this there is no direct proof, but the fact that the medusae and hydroid were found together in a fauna so poor as that of the Chilka Lake is at any rate noteworthy.

The hydrothecae and the other purely vegetative parts of the colony agree well with Bale's description and figures. The hydranth is much stouter in structure (pl. ix, fig. 1) than that of *Obelia spinulosa* and has a wider and more trumpet-shaped hypostome. The tentacles are less attenuated. The basal part of the hydrotheca is separated off from the remainder by a delicate membrane.

The gonothecae are mostly produced in groups and arise directly from the anastomosing rhizome. They are placed vertically on very short, obscurely annulated stalks. Sometimes they also arise on the stems, near the base of the stalks of the hydrothecae; in this position their stalks are longer and more distinctly annulated. They are somewhat variable in form, and often distinctly irregular and asymmetrical in outline. Generally speaking, they may be described as being narrowly oval, ca. 4 times as long as broad and truncate distally, with a slight constriction near the distal extremity and sometimes another about half way down. They vary in length from 0.68 mm. to 0.85 mm. There are no annuli on the surface.

In the specimens of an *Obelia* from New Britain assigned by Miss Thornely<sup>1</sup> to this species the hydrotheca was evidently much shorter than in Bale's types.

*Clytia serrulata* was originally described (with *Obelia spinulosa*) from New South Wales. We found a considerable number of specimens at two stations in the outer part of the outer channel of the Chilka Lake in March, 1914, in salt water. The species is probably a periodic immigrant into this part of the lake.

The original Australian specimen was growing on another hydroid (*Tubularia*). Ours were on a fragment of *Pennaria* that had been washed in from the sea, on roots of grass, a dead leaf and dead Lamellibranch shells. Many hydranths of those taken at the mouth of the lake contain larval appendicularians in the gastric cavity and these animals would seem to constitute an important element in the food of the species.

#### Genus *Phialidium*, Leuckart.

1910. *Phialidium*, Mayer, *Medusae of the World* II, p. 265.

Although many medusae of this genus have been described none have been associated with the hydroid in a satisfactory manner. Probably it is identical with *Clytia*.

#### *Phialidium cruciferum*, sp. nov.

(Plate ix, figs. 2, 2a, 2b.)

As I have pointed out above, this may be the medusa of *Clytia serrulata* (Bale). Our specimens met with an unfortunate accident, owing to which they are all some-

<sup>1</sup> *Obelia serrulata*, Thornely, "The Hydroid Zoophytes" etc., in Willey's *Zoological Results*, p. 453, pl. xlv, fig. 5.

what distorted. This has made it impossible to obtain a satisfactory profile figure, but the medusa possesses several distinctive characters that can be illustrated in detail even from our material.

In outline the medusa resembles *Ph. globosum* (Mayer)<sup>1</sup> having abundant jelly and an evenly curved bell. The manubrium, gonads and tentacle-bulbs are deep flesh-colour. The bulbs are tinted with brown externally and there is a dark brown cross on the base of the manubrium as seen from the exumbrellar surface. It is composed of four pairs of parallel lines of equal length, one pair on the proximal part of the roof of each radial canal. As a rule the four lines do not quite meet in the centre. Specimens with fully developed gonads are about 6 mm. in diameter.

The number of tentacles is variable and their arrangement irregular. In all the specimens examined a considerable proportion of them are not fully developed and the number of perfected tentacles is often different in different quadrants of the same individual. The radial tentacles are no longer than some of the others. The number, as well as the arrangement, of the otocysts is also variable. Sometimes two are situated close together, but more often several tentacles intervene. They are very small and inconspicuous.

The velum is narrow.

The manubrium is relatively long and has four long deeply-fringed lobes.

The gonads are narrowly spindle-shaped and about equidistant when young from the margin of the bell and from the manubrium. When mature they occupy more than half the length of the radial canals and approach the margin, also becoming more band-like and somewhat contorted.

*Type*.—No. Z.E.V 6827/7, *Ind. Mus.*

*Distribution*.—Taken in large numbers on the surface in the outer channel of the Chilka Lake (Orissa) in salt water, March, 1914.

This species is apparently related to *Ph. iridescens*, Maas,<sup>2</sup> from which it differs in colour, in its much larger manubrial lips, and probably in other characters. *Ph. iridescens* has been found only in the Antarctic Ocean.

## Order GYMNOBLASTEA.

### Family HYDRACTINIIDAE.

#### Genus *Clavactinia*, Thornely.

#### *Clavactinia gallensis*, Thornely.

1904. *Clavactinia gallensis*, Thornely, *Rep. Ceylon Pearl Fish.* II, p. 111, pl. i, fig. 3.

In sorting out our collection we found on several small shells colonies of a minute Hydractiniid that agrees with Miss Thornely's description sufficiently well. The animal escaped our attention in the field.

<sup>1</sup> *Oceania globosa*, Mayer, *Bull. Mus. Zool. Harvard*, XXXVII, p. 51, pl. x, figs. 20, 20a (1900); *Phialidium globosum* (in explanation of plate "globulosum"), *id.*, *Medusae of the World* II, p. 272, pl. xxiv, fig. 4.

<sup>2</sup> *Exp. Antarct. Belgica Medusen*, p. 12, pl. i, fig. 6 (1906).

The colonies are evidently young or dwarfed. Only one bears fully developed gonosomes and even in this colony the basal crust is still imperfectly developed and remains at many points openly reticulate. In one colony it is still in the primitive condition of a branching and anastomosing rhizome bearing upright hydranths at intervals. The largest shell to which a colony was attached was only 23 mm. long.

The largest hydranths are not more than 2 mm. long and the majority are much shorter. The number of tentacles is variable, but I have not seen more than 14. Their nematocysts are very small. Even when fully expanded the tips are blunt.

There are no true dactylozooids, but young gonophores were at first sight mistaken for them. These individuals have a large central cavity at the base, which is somewhat inflated. The region on which the gonosomes are borne is elongated and slender. Its tip is blunt and not at all capitulate. In this region the structure forms a solid finger-shaped mass. Brownish granules occur abundantly in its internal cells. Each female gonosome bears three ova. Except in being a little more inflated at the base, the whole gonophore, in mounted specimens rendered transparent, somewhat resembles the larger spines but may be distinguished therefrom, in the absence of gonosomes, by its basal cavity and by the absence of a thickened chitinous external coat. The gonophores are shorter than the largest hydranths.

*Clavactinia gallensis* was originally taken in Galle Bay on the west coast of Ceylon in two fathoms. Our specimens were found close inshore in not more than two feet of water at Satpara in the outer channel of the Chilka Lake.

The former specimens were attached to shells of *Eburna* and *Neritina*; Miss Thornely does not say whether these shells were inhabited. Ours were in most instances on shells of *Potamides fluviatilis*, and in one on a shell of *Nassa labecula*. In both cases small hermit-crabs (*Diogenes avarus*, Heller) were living in the shells, both species of which are abundant at Satpara. The hydroid was present on a small proportion only of the shells collected, though many had been appropriated by hermit-crabs. Our specimens were taken in March, in water practically as salt as that of the upper part of the Bay of Bengal at the same season. It is probable, in view of the immature condition of most of the colonies in March, that the planulae are brought in by the tide in the season of salt water and that the species does not survive the irruption of fresh water that takes place later in the year.

A minute Campanularian hydroid accompanied *Clavactinia* on one shell, but the specimen was unfortunately too imperfect for even partial identification.

#### Family CORYNIDAE.

#### Genus *Dicylocoryne*, nov.

This genus may be defined as consisting of Corynidae in which the tentacles of the hydranth are all capitate and are disposed in two quite distinct circles. The gonosomes, which are borne on the proximal part of the hydranths, are free medusae and have, when liberated, four short, stout capitate tentacles, one at the end of each radial canal, but no ectodermal ocelli. The manubrium, at the same stage, is short,

conical and apparently imperforate. Nothing is known of the development of the gonads.

*Type-species*.—*Syncoryne filamentata*, Annandale.

The genus is at present known only from brackish water on or near the east coast of India.

***Dicylocoryne filamentata* (Annandale).**

(Plate ix, figs. 4, 4a, 4b, 4c.)

1907. *Syncoryne filamentata*, Annandale, *Rec. Ind. Mus.* I, p. 139, figs. 1, 2.

The colonies of this species often have a peculiarly lax appearance owing to the fact that the rhizome is adherent only in places and is sometimes produced into long filamentous free processes that bear terminal polyps. These, or rather the stalks from which they arise, may again become attached at their base to the object on which the colony is growing, so that loops of free rhizome are formed. The whole colony, except of course the hydranths, has a fairly thick chitinous investment. The rhizome branches sparingly and does not anastomose. Short vertical stems are produced at intervals, but as a rule bear only one (terminal) hydranth. A second (lateral) polyp is, however, sometimes present. The stems and rhizome, including the free portions of the latter, are often irregular in outline without being exactly annulate. Their diameter does not exceed 0.19 mm.

When fully expanded the hydranths are slender and spindle-shaped. They have a well-developed sheath of ectocyst at their base. As a rule there are about four tentacles in the proximal and six in the distal circle, but the number is variable and individual hydranths are occasionally found in which they are aborted and reduced in number. When normally developed they are capable of great extension and even in contraction the cylindrical part of the tentacle is longer than the terminal swelling. The latter is very large, circular and somewhat flattened. The largest hydranths are probably never more than 2.5 mm. long.

The gonosomes are borne at the bases of the proximal ring of tentacles or distinctly below them at the base of the hydranth.

The medusa is about 0.4 mm. in diameter when liberated. Its bell in life is slightly deeper than broad. In profile, the sides, except in extreme contraction, are nearly straight and the upper outline moderately convex. The cross-section is subquadrate. The surface is minutely tuberculate but has no conspicuous projections or specialized organs. The velum is broad. There are no marginal processes of any kind between the tentacles.

The tentacles are incapable of great elongation and in all circumstances remain shorter than the bell. They are somewhat flattened from without inwards and bear on each side a series of minute projections which decrease in size from above downwards. The terminal expansion, which is full of large nematocysts, is circular and somewhat flattened from above downwards. The tentacle-bulbs are relatively large but lack all traces of ocelli. As a rule they contain one or several large nematocysts. Immediately below them there is a broad band of stinging cells; below this band

there is another narrower and less prominent one of the same nature. In the living animal the two bands can hardly be distinguished.

The endodermal parts are colourless. The manubrium is a stout conical body much shorter than the bell. Its walls are very solid and I can detect no orifice. There is, however, a relatively large lumen at the proximal end.

The radial canals are simple and slender.

*Types*.—Hydroid, No. Z.E.V 2424/7: Medusa, No. Z.E.V 2436/7, *Ind. Mus.*

This species is closely allied to those that form the genus *Syncoryne* (Ehrenberg) as restricted by Allman, but the hydranth is distinguished from their hydranths by the arrangement of the tentacles. The medusa is distinguished from *Sarsia*, Lesson, by its capitate tentacles and lack of ocelli.

*Distribution*.—The hydroid, from which medusae were hatched in Calcutta, was originally found in a small artificial pool of brackish water at Port Canning in the Gangetic delta. In the Chilka Lake we found the hydroid, with developing medusae, on two occasions in the main area, in Rambha Bay and near Pigeon Island, in both cases on the surface.

The type-specimens, which were taken in December, 1907, were growing on a grass-stem in water of low salinity. Our examples from the Chilka Lake are on a leaf of *Halophila ovata* and on the stem of an indeterminate water-plant. They were collected in July, 1913. The salinity of the water was not ascertained at the time, but in July, 1914, the specific gravity in Rambha Bay was about 1.015. The species is evidently scarce in the lake, but is probably a permanent resident in the main area.

#### Family BOUGAINVILLIIDAE.

##### Genus *Bimeria*, Wright.

1868. *Garveia + Bimeria*, Hincks, *Brit. Hydr. Zooph.*, pp. 101, 103.  
 1871. *Garveia + Bimeria*, Allman, *Mon. Gymn. Hydr.*, pp. 249, 297.  
 1902. *Bimeria*, Torrey *Zool. Pub. Univ. California* I, p. 20.  
 1905. *Perigonimus* (in part), Motz-Kossowska, *Arch. Zool. expérim.* (4) III, p. 71.  
 1905. *Pruvotella*, *id.*, *ibid.*, p. 77.  
 1907. *Bimeria*, Browne, *Journ. Mar. Biol. Ass. Plymouth* VIII, p. 19.

##### *Bimeria fluminalis*, sp. nov.

(Plate ix, figs. 3, 3a.)

1907. *Bimeria vestita*, Annandale (*nec* Wright), *Rec. Ind. Mus.* I, p. 141, fig. 3.

I am acquainted with two phases of this species, a luxuriant bushy form and a dwarfed one consisting of simple pinnate stems arising at intervals from an adherent rhizome.

In the latter phase the stems are never much more than 20 mm. high and may be reduced to stalks less than a millimeter long and bearing only a terminal

hydranth. The bushy masses of the more robust phase may, on the other hand, reach a length of 20 cm. In both phases the stems are single and even when the colony is most luxuriant they never become agglutinated or even intertwined, its luxuriance being due solely to the profuse production of stems from the rhizome and their still more profuse branching in one plane. Even the largest masses are soft and lax, for the stems and branches are not thickened, and it is only when the former are very short that they are at all stiff.

The chitinous investment of the hydrophyton, though not hard, is thick and brown. It extends up the stalks of the hydranths, round the base of the latter and for a short distance up the tentacles, on which, however, it is thin and almost colourless. Consequently the exact point it reaches can be detected with difficulty. When the hydranths are contracted the thin investment of their bases is to some extent invaginated into the thicker and stiffer covering of the stalk (pl. ix, fig. 3).

The hydranths are spindle-shaped and fairly slender when fully extended, their tentacles are capable of great elongation. As a rule the tentacles, which are borne in two alternating circles, are 8 or 10 in number.

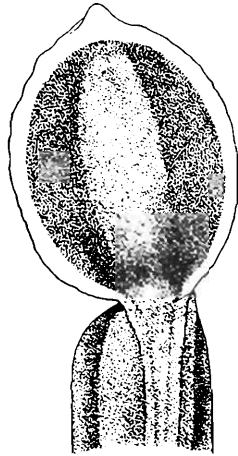


FIG. 10.—*Bimeria fluminalis*, sp. nov.  
Male gonophore, from a stained specimen.

The base of the stems and lateral branches is always annulated for a short distance, but the annulation is often very obscure. So far as I can see it is never spiral. This is also the case with the stalks of the gonophores, which (the stalks) are always shorter than the gonothecae.

These thecae are borne at the base of the considerably longer stalks of the hydranths. When immature they are almost spherical and when mature vary considerably in size and outline. Generally speaking, those of the female gonophores tend to become cylindrical as the ovum ripens, whereas those of the male gonophores assume an ovoid form with the growth of the gonad and become almost pointed distally. There is usually a small pimple-like projection at the extreme tip, especially in mature male gonothecae (fig. 10).

Traces of the circular canals persist at the base of the gonophores but are not well developed. In both sexes the spadix is a simple cylindrical or somewhat spindle-shaped body. In the female gonophore, which produces a single egg, the spadix extends up one side of the egg and arches over it slightly. The distal extremity is slightly emarginated outwardly, so that the spadix has precisely the shape of the human finger (pl. ix, fig. 3a). In this sex it is of an orange or brownish colour. The ovum and the young planula are usually white but, at any rate in the bushy form of the species, sometimes have a bluish tinge. The spadix of the male gonophore is symmetrical and somewhat less curved; it extends up the interior of the gonophore nearly to the tip of the latter and is invisible externally in the living animal.

*Type*.—No. Z.E.V 6643/7 *Ind. Mus.* The specimen belongs to the bushy phase and was taken in a canal of brackish water on the outskirts of Calcutta.

*Bimeria fluminalis* is common in both phases in canals, creeks, pools and backwaters of brackish water in the Gangetic delta. In the Chilka Lake the dwarfed form is abundant, especially in the main area, at all seasons.

The species is closely allied to *Bimeria vestita*, Wright, the type of its genus, which occurs in the North Sea and Irish Channel and in the Mediterranean and has been recorded from the Pacific side of South America.<sup>1</sup>

From the British form it differs only, so far as the hydrophyton is concerned, in the more obscure annulation of the stems and the thinner and less conspicuous covering of the base of the hydranth and the tentacles. The cup-like invagination produced at the base of the contracted hydranth is doubtless correlated with the latter feature and is certainly not a generic character. Until I was acquainted with the structure of the gonophore in both sexes I was of the opinion (see *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 140; 1911) that the Indian hydroid was at most a local race of the British one, but the spadix differs in the two, for in the male of *B. vestita* (*vide* Allman) it is branched instead of being simply cylindrical, while in the female,<sup>2</sup> instead of forming a cylindrical process on one side of the ovum, it forms a symmetrical cup in which the ovum rests.

*B. fluminalis* plays much the same part in the aquatic fauna of the Gangetic delta as *Cordylophora lacustris* does in that of the estuarine tracts at the mouths of the Thames and the Mersey. It reaches its maximum development on submerged timber and there provides a support or a refuge to numerous fixed and free Protozoa, while the Indian race or species (*bengalensis*) of the Polyzoon *Victorella* grows on its branches just as *V. pavida* does on those of *Cordylophora* in England. In the Chilka Lake the dwarfed form of the hydroid is found on rocks and stones and on the stems of water-plants, avoiding only those spots reached by direct sunshine. On stones it is confined to the lower surface, but on rocks it often covers vertical faces. In the Gangetic delta, where there are no stones, this form is usually found on hard artificial objects such as bricks and potsherds but also grows on water-plants in pools. I have never seen the species in places where the water was permanently fresh, but it flourishes in a medium of very slight salinity and can exist for a considerable period in fresh water. The positions it affects in the Chilka Lake are for the most part the same as those affected by *Laxosuberites lacustris*, except that, when the lake is full, it grows higher up the rocks than the sponge. The rhizome is very often completely buried in the sponge, through which the branches protrude. In these circumstances the hydroid is more completely dwarfed as a general rule than it is when growing free; often the hydranths die and the branches disintegrate, leaving only the rhizome, which retains its vitality and doubtless produces new stems if anything happens to the sponge.

<sup>1</sup> Hartlaub, *Zool. Jahrb.*, Suppl. VI, p. 534 (1905).

<sup>2</sup> I can find no published description of the female gonophore of *B. vestita*. My statement is based on a specimen from Port Erin that Mr. F. H. Gravely has kindly lent me.

The maximum vegetative growth of the hydrophyton, which in favourable conditions must be rapid, takes place in the lake in the salt-water season, but gonophores are produced in the greatest numbers at the time when the lake is inundated with fresh water. Indeed, the most favourable conditions for their production seem to be those most unfavourable for the survival of the hydranths. In the northern part of the main area in September, when the water was quite fresh, we found both male and female colonies covered with gonophores on stems of drift-weed that had been carried by the wind into corners among rocks and had begun to decay. Most of the hydranths had perished, but most of the gonads were developing normally, though a few were degenerate, especially in the male colonies—a circumstance that occurs even in conditions that seem to be more normal. In active colonies growing in water of moderate salinity gonophores were never found in profusion so great, but many are present on the type-specimens, which were taken in water of a specific gravity of 1.006. In these they are almost entirely confined to those parts in which the organism is congested by its own luxuriant growth. They are accompanied by few hydranths, though the younger and freer parts of the colonies were evidently in full nutritive vigour and well supplied with active polyps. It is thus clear that in *Bimeria fluminalis*, as in many other species, sexual reproduction is stimulated by changes in environment that ultimately prove fatal to the colony.

EXPLANATION OF PLATE VI.

ACTINIARIA AND MEDUSAE.

**Fig. 1.**—*Pelocoetes exul* (Annandale).

Specimens from the Chilka Lake, nat. size.

**Fig. 2.**—*Halianthus limnicola*, sp. nov.

Type-specimens, enlarged.

**Fig. 3.**—*Edwardsia tinctoria*, sp. nov.

Type-specimens, enlarged.

**Figs. 4-6.**—*Acromitus rabanchatu*, sp. nov.

4.—Half-grown specimen divided longitudinally (nat. size).

5.—Young specimen in Semostoman stage, much enlarged.

5*a.*—Same specimen as seen from above.

6.—Slightly older specimen seen from below.

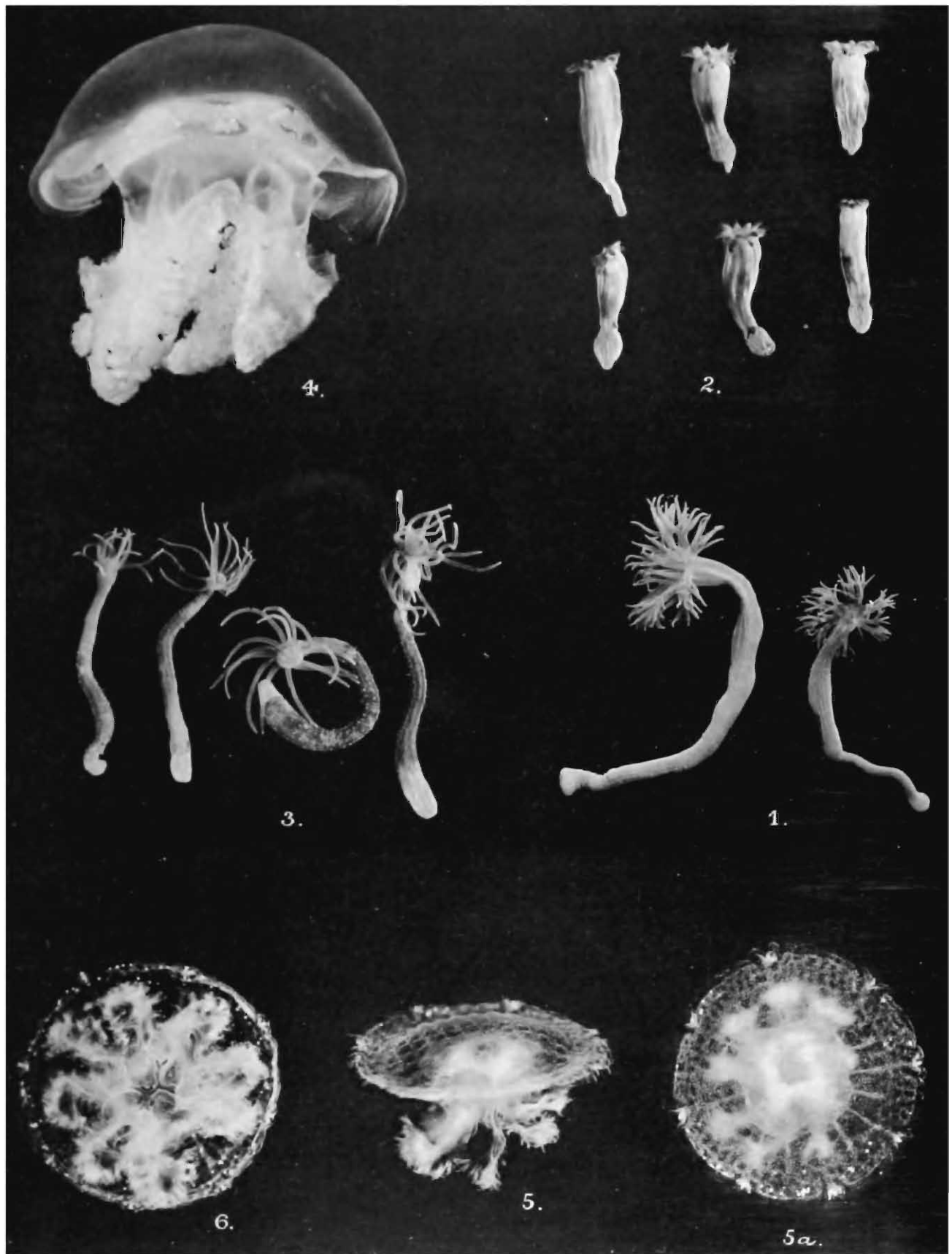


Photo by S C. Mondul.

Bemrose, Colln. Derby.

COELENTERATES OF THE CHILKA LAKE.

## EXPLANATION OF PLATE VII.

### ACTINIARIA.

#### Fig. 1.—*Metridium schillerianum* (Stoliczka).

Solid transverse section through the lower part of the column.

The sulcus and sulculus are shown at the ends of the longer axis of the stomodaeum.

#### Fig. 2.—*Phytocoetes chilkaeus*, sp. nov.

Vertical section of the body-wall in the region of the sphincter,  $\times 75$ .

#### Figs. 3, 3a, 3b.—*Pelocoetes exul* (Annandale).

3.—A living anemone in a contracted state (nat. size), showing the loose columnar sheath.

The figure is from a sketch made *ad nat.* by Mr. G. M. Henry.

3a.—Transverse section of a part of the body-wall in the lower region of the column,  $\times 100$ .

3b.—Vertical section of the body-wall of a small portion of the muscular (upper) region of the column,  $\times 250$ .

#### Figs. 4, 4a, 4b.—*Halianthus limnicola*, sp. nov.

4.—Vertical section of the body-wall in the region of the sphincter (highly magnified).

4a.—Transverse section of a mesentery passing through the trilobed region of the filament (highly magnified).

4b.—Transverse section through a male gonad (highly magnified).

#### Figs. 5, 5a.—*Edwardsia tinctrix*, sp. nov.

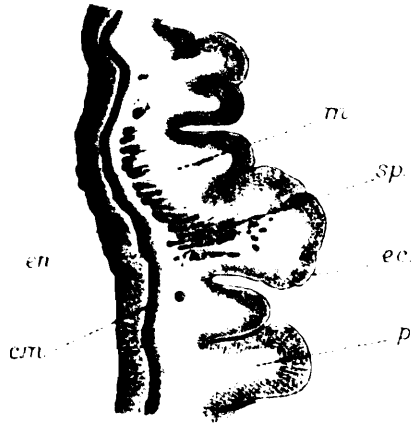
5.—A papilla on the column as seen in profile in a specimen mounted in Canada balsam, showing the nematocysts discharging their threads,  $\times 250$ .

5a.—Transverse section of a papilla passing a little to one side of the centre of the lumen,  $\times 250$ .

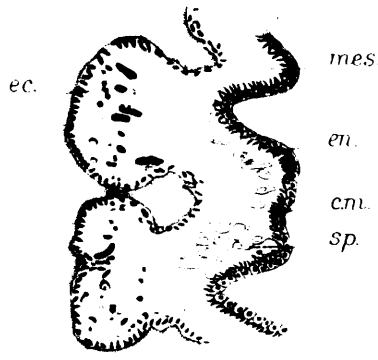
Figs. 1, 2, 3a, 3b, 4, 4a, 4b, and 5 are taken from specimens in which the column-wall was in a state of high contraction.

### LETTERING.

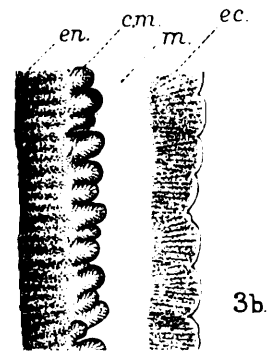
c.m.=circular muscle: ec.=ectoderm: en.=endoderm: i.me.=incomplete mesentery: m.=mesogloea: me.=complete mesentery: n.=nervous layer: p.=cavity of papilla: sc.=remains of nematocyst: sp.=sphincter.



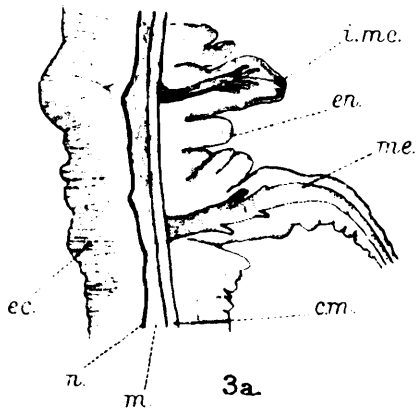
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4.



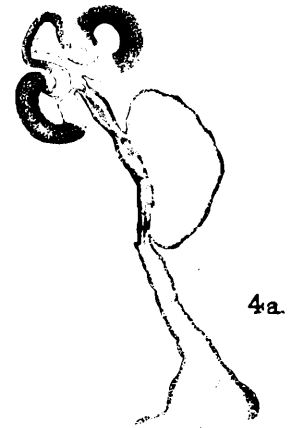
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3a.



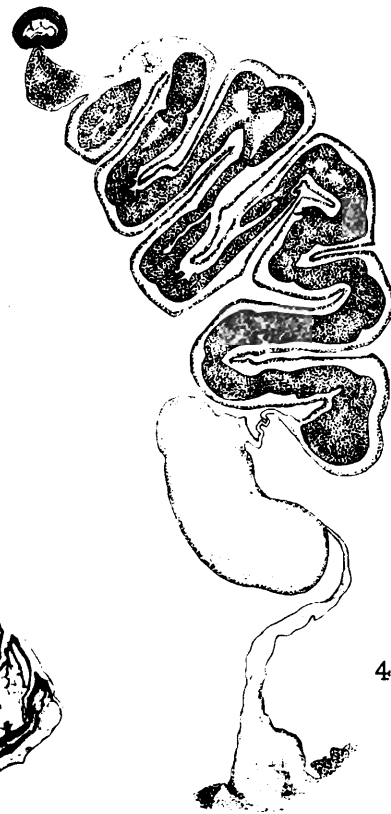
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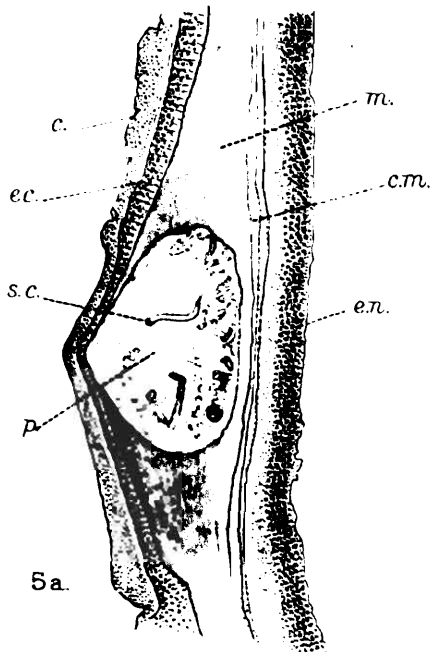
4a.



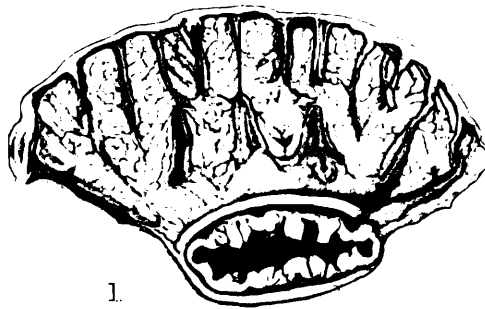
3.



4b.



5a.



1.

EXPLANATION OF PLATE VIIa.

ACTINIARIA.

**Fig. 1.**—*Gyrostoma glaucum*, sp. nov.

A specimen from the main area of the Chilka Lake, × 2.

**Fig 2.**—*Metridium schillerianum* (Stoliczka).

Thick vertical section through one half of the column of a specimen with fully expanded tentacles (enlarged); mounted unstained in Canada balsam.

The section passes through an intermesenterial chamber. The dark mass in the chamber is a much contorted acontium.

**Figs. 3, 3a, 3b.**—*Phytocoetes gangeticus*, sp. nov.

3.—Type-specimens of the species preserved in formalin, × 2.

3a.—A living specimen attached to the root of a reed and half buried in mud; the tentacles retracted, × 2.

In this figure the cinclides appear as small white spots on the upper part of the column.

3b.—A young specimen stained with borax-carminé and mounted in Canada balsam, × ca. 5.

**Fig. 4.**—*Phytocoetes chilkaeus*, sp. nov.

Type-specimens from the main area of the Chilka Lake, × ca. 2.

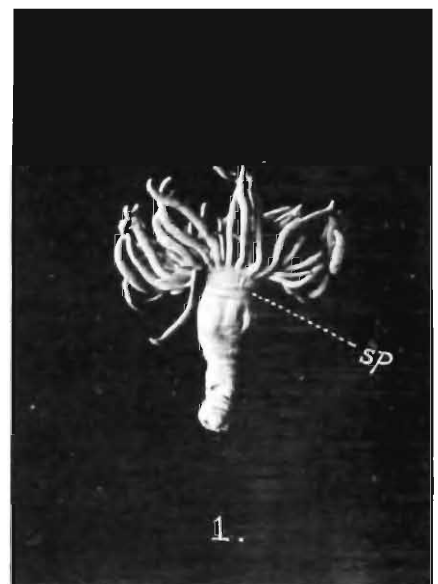
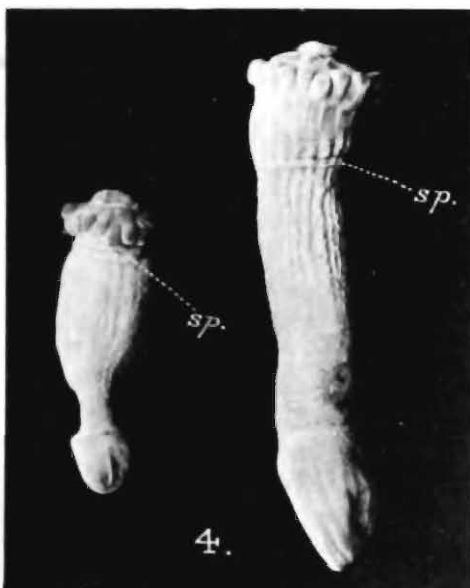
**Fig. 5** —*Edwardsia tinctorix*, sp. nov.

Transverse section (somewhat oblique) through the lower extremity of the stomodaeum, highly magnified.

All the figures in this plate are from direct photographs of specimens or preparations.

LETTERING.

b.= basal disk: c.= fold of body-wall that appears when the tentacles are extruded: sp.= sphincter: st = lower extremity of stomodaeum.



EXPLANATION OF PLATE VIII.

SCYPHOMEDUSAE.

*Acromitus rabanchatu*, sp. nov.

FIG. 1.—Adult specimen (reduced).

The specimen has been preserved in formalin for some time and the bell was therefore flatter than in life.

FIG. 1*a*.—Plan of the disk of the same specimen seen from below on the removal of the arms.

One octant (X) of the margin has been removed.

„ 1*b*.—A single arm seen in profile.

„ 1*c*.—The tip of an arm (enlarged) seen from in front.

„ 1*d*.—Sense organ as seen from above (greatly enlarged).

„ 2.—Arms of a very young medusa in the Semostoman stage as seen from below (much enlarged).

FIGS. 3, 3*a*, 3*b*.—Arms of a young medusa at a somewhat later stage of development.

LETTERING.

f.=terminal filament of arms: t.=short lateral filaments.



3



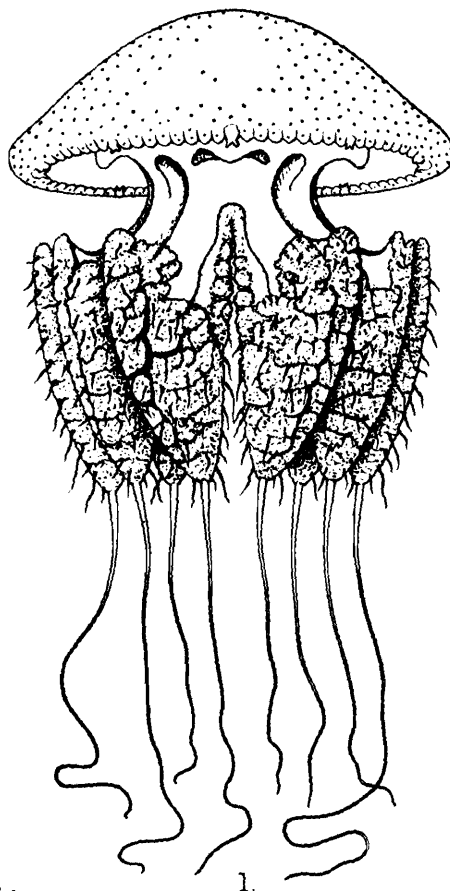
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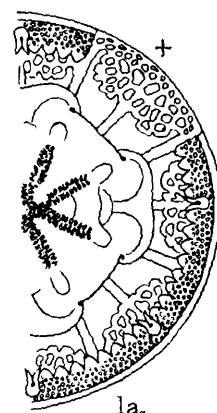
3b.



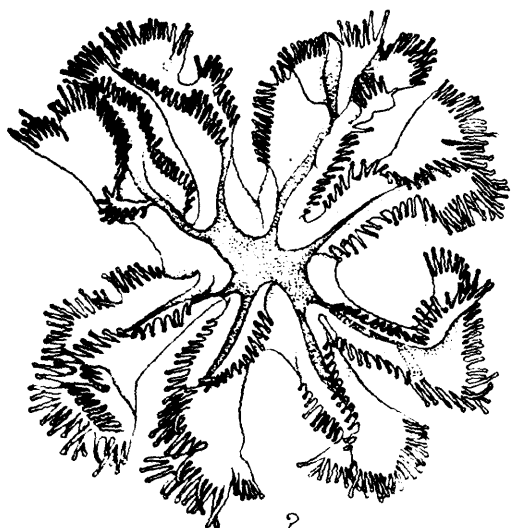
1b.



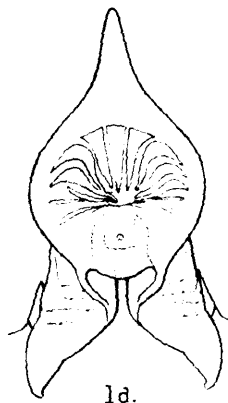
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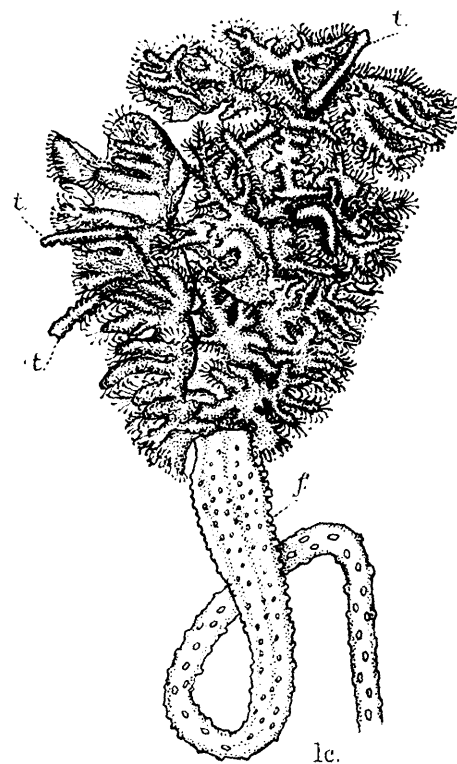
1a.



2.



1d.



1c.

S C Mondul & A Chowdhury, del.

Gemrose, Colls., Darby.

SCYPHOMEDUSAE OF THE CHILKA LAKE.

EXPLANATION OF PLATE IX.

HYDROZOA AND CTENOPHORA.

**Figs. 1, 1a, 1b.**—*Clytia serrulata* (Bale).

- 1.—Hydrothecae and hydranth (much enlarged).  
1a, 1b.—Gonothecae from the same specimen (same magnification).

**Figs. 2, 2a, 2b.**—*Phialidium cruciferum*, sp. nov.

- 2.—Type specimen of medusa as seen from below (much enlarged).  
2a.—Part of the margin of the bell in a slightly younger medusa (further enlarged).  
2b.—Dorsal surface of stomach of the type specimen with proximal part of radial canals (same magnification as in fig. 1).

**Figs. 3, 3a.**—*Bimeria fluminalis*, sp. nov.

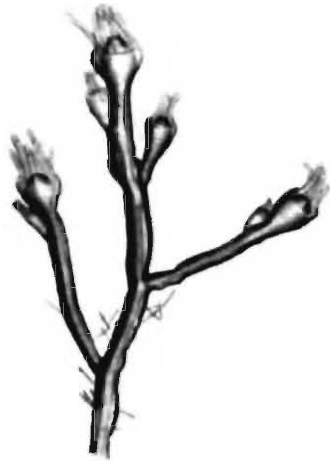
- 3.—Terminal part of a colony from the Chilka Lake (enlarged).  
3a.—Female gonosomes from a living specimen from near Calcutta examined under pressure (at a slightly greater magnification).

**Figs. 4, 4a, 4b, 4c.**—*Dicyclocoryne filamentata* (Annandale).

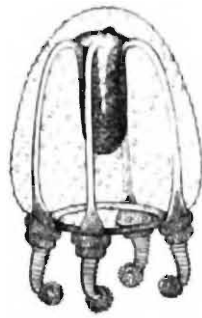
- 4.—Hydranth bearing gonosomes (much enlarged).  
4a.—Terminal part of a tentacle of the same hydranth (further enlarged) as seen from in front.  
4b.—Young medusa (much enlarged).  
4c.—A tentacle of the same specimen seen from the inner surface (further enlarged).

**Fig. 5.**—*Pleurobrachia globosa*, Moser var. *bengalensis*, nov.

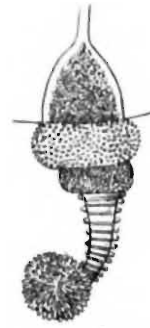
- Lateral view of a specimen preserved in formalin (enlarged).



3.



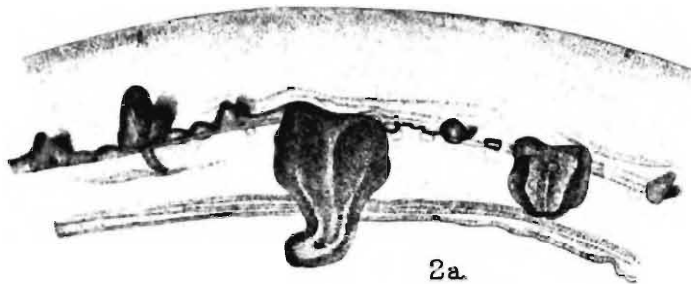
4b.



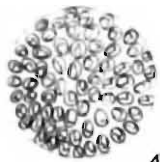
4c.



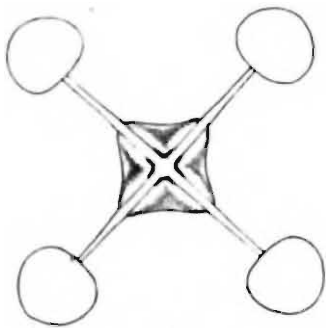
4.



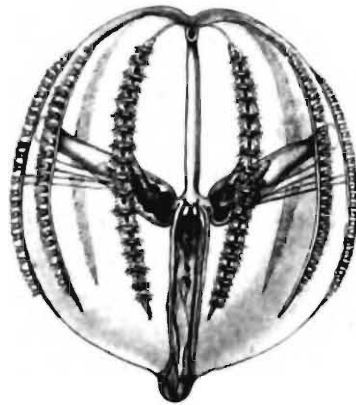
2a.



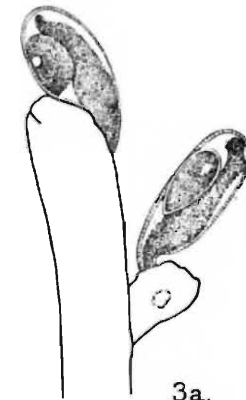
4a.



2b.



5.



3a.



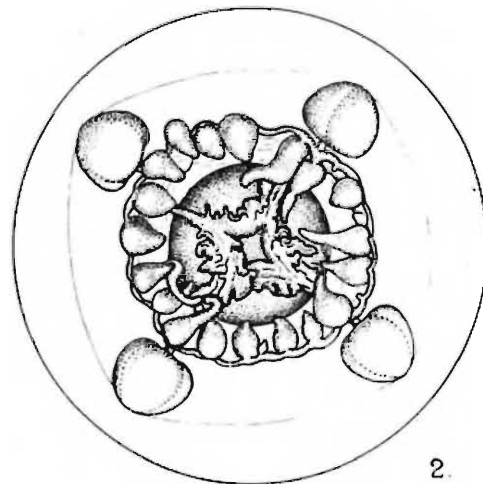
1a.



1b.



1.



2.

A.C. Chowdhury, del.

Benoist, Colla, Derby

HYDROZOA & CTENOPHORA OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE

CTENOPHORA.

*By* N. ANNANDALE, *D.Sc.*, *and* STANLEY KEMP, *B.A.*

(Plate IX, fig. 5.)

## CTENOPHORA.

By N. ANNANDALE and STANLEY KEMP.

The only member of this group represented in our collection is a representative of the order Cydippidea and of the genus *Pleurobrachia*, Flemming, forming a race of *P. globosa*, Moser a species originally described from the Malay Archipelago. For this race we propose the name *bengalensis*, as it occurs on at least one side of the Bay of Bengal and differs from the form found in the Gulf of Manaar to which Browne<sup>1</sup> has given the name *ceylonensis*.

*Pleurobrachia globosa bengalensis* must be classed as a periodic visitor to the Chilka Lake, over the whole of which it is found for a great part of the year. In the fresh-water season, however, it disappears, and does not re-appear until the water has regained a certain salinity. From observations made in the Ennur backwater, near Madras, in January, 1915 it would seem that it is able to live in a medium of sp. gr. 1.0045, but not in one of 1.0025.

In the outer channel of the lake, in the salt-water season of 1914, we captured in our tow-nets on several occasions a species of the order Lobata but the animal was so fragile that we failed to preserve specimens. In formalin it seemed literally to melt away and all attempts at narcotizing it had the same effect.

### *Pleurobrachia globosa*, Moser.

1903. *Pleurobrachia globosa*, Moser, *Siboga-Exp.*, XII (Ctenophora), p. 7, pl. i, figs. 1-4.

The typical form of this species has not been found in the Indian Ocean. We have already alluded to the race endemic in the Gulf of Manaar.

### Race *bengalensis*, nov.

(Plate ix, fig. 5.)

In all the more important structural features (*viz.* the relative position of the tentacle-sheaths, of the tentacle-openings, the canals and the stomodaeum and the proportions of the tentacle-sheaths) this race agrees with the typical form of the species, from which it differs in all the points noted by Browne in his description of his variety *ceylonensis*. From that form, however, it differs in that in the vast majority of individuals, the costae are still longer, being about twice as long as in the typical form and at least a quarter longer than in *ceylonensis*. The length of the meridional canals, which extend for the whole length of the costae, is also relatively longer than in the latter, but the opening into them of the adradial canals is also

<sup>1</sup> Herdman's *Ceylon Pearl Fisheries* IV, p. 161 (1905).

median. In most individuals each costa consists of about 28 ciliated plates, which diminish gradually in size towards both extremities. Neither the number of plates nor the exact proportions of the costae are quite constant and individuals occur in which one or more of the costae are shorter than the others; in one individual examined the number of plates varies from 16 to 23. In all our specimens the tentacle-base is pressed more or less closely against the stomodaeum and is, perhaps for this reason, concave, but in the living animal its precise relative position, like the precise outline of the whole organism, is liable to almost constant change. The tentacles are capable of great elongation; processes are absent from a considerable part of the distal half, but are uniformly developed on the remainder of each tentacle; to judge from specimens in which they are contorted, they are cylindrical and capable of being coiled in a close spiral with many whorls. In life the tentacles are yellow and the remainder of the animal colourless.

The longer axis never exceeds 1 cm. in length.

We have examined specimens of this form from the coast of Orissa and from the Ennur backwater near Madras, as well as from all parts of the Chilka Lake. The animal swims as a rule from 2 to 4 feet beneath the surface.

In many of our specimens taken in July the jelly, more particularly in the neighbourhood of the stomodaeum, funnels and tentacle-sheaths, contains a large number of minute and apparently immature Distomid trematodes. They are accompanied by eggs, hardly smaller than themselves, resembling those found in the canals of the young of *Acromitus rabanchatu* (p. 102, *antea*). On the external surface of a few individuals we found Protozoa of the genus *Trichodina*.

The type-specimens of the race are numbered Z.E.V 5936/7 in the books of the Indian Museum.

FAUNA OF THE CHILKA LAKE  
THE POLYZOA OF THE LAKE AND OF BRACKISH WATER  
IN THE GANGETIC DELTA.

*By* N. ANNANDALE, *D.Sc., F.A.S.B.*

(With 3 text-figures.)

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## POLYZOA.

By N. ANNANDALE.

Eight species of Polyzoa have been found in brackish water on the coasts of India, but of these only three occur, so far as we know, in the Chilka Lake. A fourth was abundant some years ago in small pools of brackish water near its inner shore, but has now disappeared and has not been taken in the lake itself.

A list of the eight species will be found in the Table of Contents on the opposite page. One half of these species are apparently endemic in estuarine tracts, maritime swamps and lagoons in India, while the other half are cosmopolitan or at any rate very widely distributed. The two series may be tabulated thus:—

### ENDEMIC INDIAN SPECIES.

*Membranipora bengalensis*,  
*Victorella bengalensis*,  
*Loxosomatoides colonialis*,  
*Loxosomatoides laevis*.

### WIDELY DISTRIBUTED SPECIES.

*Membranipora hippopus*,  
*Bowerbankia caudata*,  
*Alcyonidium mytili*,  
*Barentsia discreta*.

With one exception the genera are cosmopolitan. The exception is *Loxosomatoides*, which is only known from estuarine tracts and lagoons on the east coast of India. The two species of this genus, as well as the two other endemic forms in the list, have been found only in water of slight or variable salinity, while all the cosmopolitan species are known to occur in the sea. *Loxosomatoides* is closely related to the North American freshwater genus *Urnatella*.

The species found in the Chilka Lake are *Loxosomatoides laevis*, *Membranipora hippopus* and *Alcyonidium mytili*, while the one that formerly occurred in pools in the vicinity was *Bowerbankia caudata*. The first three of these are abundant or at least fairly common in both divisions of the lake, among the permanent inhabitants of which they must all be included. *L. laevis* also occurs in lagoons near Madras and is closely related to the Gangetic *L. colonialis*. The absence of *Victorella* and of *M. bengalensis* is rather strange, for both forms occur almost certainly at Bombay, while the Ctenostome has also been found at Madras. Both are very abundant where they do occur, and neither could well escape the notice of a collector accustomed to look for it. Possibly their absence is due to lack of suitable food.

The only important biological fact I have to add to our knowledge of these brackish-water Polyzoa is that *Loxosomatoides* produces resting buds. The structure of these buds is discussed on p. 130.

In addition to the indigenous Polyzoa of the lake we found within its boundaries specimens of two other species a marine Cheilostome and a freshwater Phylactola-

matous form. As the presence of both in the region to be considered was evidently adventitious, they may be dismissed here in a few words.

The marine species was *Membranipora tuberculata*, Bosc, a form common in the Atlantic and already recorded from Indian seas by Miss Thornely<sup>1</sup>. A number of young colonies were observed on a stick that had been washed in at the sea-mouth opposite Arakhuda. The species lives attached to floating objects, especially algae<sup>2</sup>; Miss Thornely's specimens, though taken over deep water, were on a floating *Fucus* and evidently came from near the surface.

The Phylactolaematous form I recently described under the name *Plumatella punctata* var. *longigemmis*<sup>3</sup>. It grows luxuriantly in a pond of practically fresh water on Barkuda Island, and in September we found its statoblasts in large numbers on the surface of the main area, on to which they had probably been blown by the wind. We could obtain no evidence that they germinated in the lake and the species can hardly be included in the fauna thereof.

#### GEOGRAPHICAL LIST OF CHILKA SPECIES.

*m.a.* = main area : *o.ch.* = outer channel : *sp. gr.* = specific gravity of water in the lake.

	CHILKA LAKE.		FURTHER DISTRIBUTION.	sp. gr.
	<i>m.a.</i>	<i>o.ch.</i>		
ECTOPROCTA.				
Cheilostomata.				
<i>Membranipora hippopus</i>	X	X	Cosmopolitan ( <i>marine and estuarine</i> ).	1.000—1.0275
Ctenostomata.				
<i>Bowerbankia caudata</i> *			European seas.	—
<i>Alcyonidium mytili</i>	X	X	Cosmopolitan ( <i>marine</i> ).	1.006—1.0275
ENTOPROCTA.				
<i>Loxosomatoides laevis</i>	X	X	Madras backwaters ( <i>brackish water</i> ).	1.000—1.0275

\* Occurred formerly in pools near shore of main area, not found in lake.

#### ECTOPROCTA.

#### CHEILOSTOMATA.

#### Genus MEMBRANIPORA, De Blainville.

1909. *Membranipora*, Levinsen, *Morph. Syst. Studies Cheilost. Polyzoa*, p. 144 (Copenhagen).

Both the species of Cheilostomata to be discussed belong to the genus *Membranipora* as restricted by Levinsen, having the armature of the lateral wall

<sup>1</sup> *Rec. Ind. Mus.* I, p. 185, fig. 3 (1909).

<sup>2</sup> Norman, *Journ. Linn. Soc. (Zool.)* XXX, p. 287 (1909).

<sup>3</sup> *Rec. Ind. Mus.* XI, pp. 168, 169, fig. 2 (p. 166), pl. iii, fig. 2 (1915).

of the zooecium completely covered by a membranous upper or dorsal wall. They are readily distinguished by the following characters:-

*M bengalensis* forms a slightly foliaceous colony with a faint silvery lustre and is by no means hyaline. The lip of the zooecium bears a pair of very long and slender bifid spines.

*M hippopus* forms an entirely flat colony that is transparent and hyaline; unless the polypides are gorged with food or forming brown bodies, all that is usually visible to the naked eye is a delicate network produced by the armature of the lateral walls of the zooecia; the lip bears no spines.

#### **Membranipora bengalensis, Stoliczka.**

1869. *Membranipora bengalensis*, Stoliczka, *Journ. As. Soc. Bengal* XXXVIII (2), p. 55, pl. xii.  
 1907. *Membranipora bengalensis*, Thornely, *Rec. Ind. Mus.* I, p. 186, fig. 4.  
 1911. *Membranipora bengalensis*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 175, fig. 33.

This species has not been found in the Chilka Lake, but is abundant in pools of brackish water in the Gangetic delta, within the limits of which it also occurs in the Salt Lakes near Calcutta. It has also been taken in creeks near Bombay, but Miss Thornely's record from Mergui is due to the misreading of an almost illegible label.

#### **Membranipora hippopus, Levinsen.**

1854. *Membranipora lacroixii*, Busk, *B. M. Cat. Polyzoa* II, p. 60, pl. lxix, pl. civ, fig. 1.  
 1880. *Membranipora lacroixii*, Hincks, *Brit. Marine Polyzoa*, p. 129, pl. xvii, figs. 5-8.  
 1909. *Membranipora hippopus*, Levinsen, *Morph. Syst. Studies Cheilost. Polyzoa*, pp. 144, 146.  
 1911. *Membranipora lacroixii*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., pp. 23, 175.

There has been considerable confusion about this species, but Levinsen has given good cause for considering it distinct from the one described by Audouin as *Flustra lacroixii*.

The armature of the lateral wall of the zooecium is very slight, consisting of two parallel calcified bands of no great depth, one situated at the base of the wall and the other superficial. The area between them remains membranous. Both margins may be either smooth, irregular or minutely denticulate; when denticulate they have a beaded appearance. In the numerous specimens I have examined I have failed to find a single ovicell, but in one a "tower-cell" was present. The small triangular abortive zooecia figured by Hincks (*op. cit.*, pl. xxii, fig. 6) occur rarely in Indian examples. The polypides have 12 very long and delicate tentacles.

The animal is extremely shy and in captivity never extends its tentacles for more than a few minutes at a time. If a healthy colony be observed in favourable conditions the different individuals will be seen to protrude and retract the lophophore frequently, but not either rhythmically or in unison.

Larvae of the Cyphonautes type were taken in our tow-nets at Rambha in January, but were very minute and did not provide any definite specific characters.

*M hippopus* is in the broadest sense a cosmopolitan species and seems to be equally at home in brackish and in salt water. It has been found in the Cochin backwaters and in the estuaries of the Ganges, in pools of brackish water, in lagoons and on the open coast of Orissa; off the British coasts it occurs both in brackish ditches, in the littoral zone and in deep water. It is abundant all over the Chilka Lake and flourishes at all seasons, in fresh, brackish and salt water; on the leaves of *Halophila*, the stems of *Potamogeton*, on reeds, on rocks and stones, on the shells (living and dead) of *Purpura* and in the deserted burrows of *Teredo* in a wooden post. On rocks it is frequently overwhelmed by the rapid growth of sponges, but often succeeds for a period in preserving for itself a bare space in the midst of *Laxosuberites lacustris*, which is a very thin encrusting form.

#### CTENOSTOMATA.

##### Division PALUDICELLINA.

##### Family VICTORELLIDAE.

##### Genus VICTORELLA, Kent.

1911. *Victorella*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 194.

1911. *Victorella*, *id.*, *Rec. Ind. Mus.* VI, p. 195.

It is perhaps best, as suggested in my volume in the *Fauna of British India*, to regard this genus as representing a family distinguished from the Paludicellidae by the fact that there is only a single funiculus which is not connected with the gonads. Braem<sup>1</sup> has recently shown that in *Paludicella* (as well as in *Victorella* and occasionally in *Pottsiella*) secondary buds may be produced in addition to the three primary ones characteristic of the division, and *Pottsiella*, though it resembles *Victorella* in external characters, agrees with *Paludicella* in internal anatomy. The separation of the two families must, therefore, depend on the structure and position of the gonads and funicular strands, and the Victorellidae must for the present be accepted as generically monotypic.

As I have pointed out in the paper cited (1911), the so-called species of *Victorella* are very closely allied and should perhaps be regarded as local races, varieties or phases of a single species. The form common in the Gangetic delta appears to be indistinguishable from one described from Central Asia and is also very doubtfully distinct from an African form found in Tanganyika and in the Egyptian salt lake Birket-el-Qurun.

<sup>1</sup> *Archiv f. Hydrobiol. und Planktonkunde* IX, 1913-14. Unfortunately the copy of this paper in my possession has been mislaid, and I am unable to refer to the page.

**Victorella bengalensis**, Annandale.

1907. ? *Victorella symbiotica*, Rousselet, *Proc. Zool. Soc. London* I, p. 255, pl. xv, figs. 7-8.
1908. *Victorella bengalensis*, Annandale, *Rec. Ind. Mus.* II, p. 12, fig. 1.
1911. *Victorella continentalis*, Braem, *Trav. Soc. Nat. St. Pétersb.* XLII, p. 30, figs. 18-21.
1911. *Victorella bengalensis*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., pp. 191-198, fig. 37.
1911. *Victorella bengalensis*, *id.*, *Rec. Ind. Mus.* VI, p. 197, pl. xii, figs. 3, 7, 8.

I cannot find any definite difference between this species and the form from Issyk-kul in Central Asia described by Braem as *Victorella continentalis*. The latter, however, seems to have been founded on young colonies just developing from resting buds. The features in which *V. bengalensis* differs from Rousselet's *V. symbiotica* are also of problematical value, perhaps depending rather on the direct influence of environment than on anything inherent in the organism. In *V. bengalensis*, to use the name provisionally, this influence is powerful in determining the method of growth, and four distinct phases may be noted. First, there are young colonies developing from resting buds on objects the surface of which provides abundance of space. In these the zooecia are short and almost entirely recumbent, closely resembling those of *Paludicella* in shape. Older colonies vary in accordance with the nature of the object to which they are attached. The phase most commonly found resembles a thick fur in which the hairs are represented by upright zooecia, and grows on the stems and roots of grasses and water-plants and occasionally on the shells of Gastropod molluscs. When the colony, attached to supports of the kind, is being overwhelmed by mud owing to the deposition of silt in tidal creeks, the stolons of the secondary buds become greatly elongated and by their entanglement produce a spongy mass; the individual zooecia in this phase of the species are almost entirely vertical and often of considerable height. The simplest adult phase is that found on the stems of the hydroid *Bimeria fluminalis*. In it the colony is much more diffuse than in the two others, and the zooecia, though mainly upright, are more definitely swollen at the base. This phase often approaches very close to the European *V. pavida*, which is commonly found on the stems of *Cordylophora lacustris*, a hydroid that resembles *B. fluminalis* in ecology and manner of growth.

I was surprised not to find this Polyzoon in the Chilka Lake; it is common in the tidal area of the Gangetic delta and has been taken at Madras and also probably at Bombay. In the Gangetic delta it usually affects brackish water, but has been observed with *Plumatella* in a pond of fresh water near a tidal canal. At Madras it was found on the carapace of a freshwater prawn. The food is perhaps restricted to diatoms of a kind that were not observed in the lake, but on this point further information is desirable.

## Division VESICULARINA.

## Family VESICULARIDAE.

## Genus BOWERBANKIA, Fane.

**Bowerbankia caudata**, Hincks.

1880. *Bowerbankia caudata*, Hincks, *Brit. Marine Polyzoa*, p. 521, pl. lxxv, figs. 7-8.
1880. *Bowerbankia gracillima*, *id.*, *ibid.*, p. 525, pl. lxxv, fig. 6.
1907. *Bowerbankia caudata*, Thornely, *Rec. Ind. Mus.* I, p. 196.
1908. *Bowerbankia caudata* race *bengalensis*, Annandale, *Rec. Ind. Mus.* II, p. 13.
1911. *Bowerbankia caudata* subsp. *bengalensis*, *id.*, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 189.

In the form I have named *bengalensis* the zooecia show every gradation between those of *B. caudata* and those of *B. gracillima* as figured by Hincks, and sometimes even surpass the latter in their elongation and relative slenderness. They also vary in colour, sometimes being quite hyaline and sometimes having a rather opaque brownish tinge. Generally speaking, the zooecia of young or poorly developed colonies and of the younger parts of more luxuriant ones are short, relatively stout, colourless and transparent, while those of more opulent colonies are longer and relatively more slender; it is only some zooecia that become darkened. I have found none in which the "tails" formed branching radicles, but occasionally they are forked. The racial name *bengalensis* can hardly be maintained in view of the variability of the form to which it was applied.

Waters<sup>1</sup> has pointed out that at present it is hardly possible to identify some of the supposed species of *Bowerbankia* and that the "tailed" condition of the zooecia is by no means confined to Hincks's *caudata*. The Indian form, however, is constant in its method of growth, except in so far as it is indicated above, and never produces upright or hanging branches. The gizzard (*i.e.* the part bearing horny teeth) is about 0.058 mm. in transverse diameter when expanded, the length in this condition being considerably less than the breadth, *viz.* about 0.046 mm. According to Waters (*op. cit.*, p. 242) the diameter of the organ is about 0.1 in *B. imbricata* "in an ordinary non-inflated condition." The anatomy of the polypide agrees closely with that of a specimen from the Irish Sea (Port Erin) lent me by Mr. F. H. Gravely, in particular in the structure of the gizzard. The figure of this organ reproduced on pl. xii, vol. VI of the *Records of the Indian Museum* (1911) for comparison with those of *Victorella* and *Hislopia* was drawn from Mr. Gravely's English specimen.

*B. caudata*, to judge from the few references<sup>2</sup> in literature to it, seems to be a scarce species in European waters. In India I have seen it only in the neighbour-

<sup>1</sup> *Journ. Linn. Soc. (Zool.)* XXXI, p. 241 (1910).

<sup>2</sup> For references see Waters, *op. cit.*, pp. 248, 249. Most of the works he cites are unfortunately not available in Calcutta.

hood of Port Canning in the Gangetic delta (where it is abundant with *Victorella bengalensis* in pools of brackish water) and at Rambha on the Chilka Lake. We did not find it in the lake itself, but in March, 1909, it was growing luxuriantly on water-plants of the genus *Nais* in pools of slightly brackish water near the shore. These pools have now become quite fresh, probably owing to the action of floods, and the Polyzoan has disappeared from them. *Bowerbankia caudata*, though it shares with other members of its genus the capacity of living in brackish water is essentially a marine species and can only have reached the pools *viâ* the lake, in which its apparent non-occurrence is therefore somewhat remarkable.

Division *ALCYONELLEA*.

Family *ALCYONIDIIDÆ*.

Genus *ALCYONIDIUM*, Lamouroux.

*Alcyonidium mytili*, Dalyell.

1880. *Alcyonidium mytili*, Hincks, *Brit. Marine Polyzoa*, p. 498, pl. lxx, figs. 2, 3.  
 1905. *Alcyonidium mytili*, Thornely in Herdman's *Ceylon Pearl Fisheries IV*, p. 127.

Specimens from the Chilka Lake agree well with Hincks's figures. The polypides have as a rule 12 to 14 tentacles; Hincks says 15 to 18.

We found the species fairly common on shells of *Potamides (Tympanotonos) fluviatilis* at Satpara both in the fresh- and the salt-water season, and on those of *Purpura (Thais) carinifera* near the south end of the lake at all times of the year. So far as we could see it was always attached to shells that contained either hermit-crabs or their own proper inhabitants. Mr. T. Southwell recently captured at Diamond Harbour in the Hughli estuary a sea-snake (*Enhydrina valakadien*) to the skin of which numerous small circular colonies of this Polyzoan were attached. It would seem, therefore, that in the conditions prevalent in the Chilka Lake and in Indian estuaries it is advantageous for the organism to be attached to animals possessing the power of progression; but in Europe *A. mytili* has been found—as its name indicates—associated with sedentary molluscs, and also on algae, stones, etc.

The species is cosmopolitan.

ENTOPROCTA.

Family *URNATELLIDÆ*.

1856. *Urnatellidae*, Allman, *Mon. Freshwater Polyzoa*, p. 117.

The family may be defined as follows:—

Deciduous colonial Entoprocta of fresh or brackish water that produce resting buds either by segmentation of the stalk or by the degeneration of a capitulum; that have a vertical or sloping lophophore with a well-developed web-like sphincter at its base, distinct tentacular retractors, a well-defined cloaca and a distinct water-vascular system.

Only two genera can at present be assigned to this family, namely *Urnatella*, Leidy, from fresh water in North America and *Loxosomatoides*, Annandale, from brackish water in India.

Genus **LOXOSOMATOIDES**, Annandale.

1908. *Loxosomatoides*, Annandale, *Rec. Ind. Mus.* II, p. 14.

Since this genus was described I have been able to compare specimens of *Urnatella* with the types. The relationship between the two genera is evidently very close and is shown even in the minute structure of the lophophore and tentacles and in the position of the different parts of the alimentary canal. I have not been able to detect any trace of a brood-pouch in *Loxosomatoides* and there is a distinct cloaca, most readily seen when the rectum is in a retracted condition. Spaces occur in the lophophore that are clearly homologous with the water-vascular system of *Urnatella*<sup>1</sup>, and tentacular retractors are conspicuously present.

*Urnatella*, therefore, differs from *Loxosomatoides* mainly in the segmented stalk of its polyps and in not possessing either an elongate stolon or a chitinous capitular shield.

Nothing is known of the embryology of either genus, but the asexual method of reproduction is similar, though not identical, in the two. In *Urnatella* the stalks of the polyps segment to form resting buds, while in *Loxosomatoides* buds are formed by the degeneration of capitula. It is not yet certain whether any capitulum may degenerate for this purpose, or only certain capitula do so, and I have no information as to the stage in the development of the capitulum at which degeneration commences; but it is noteworthy that in one instance a stalk was observed which bore three resting buds, arranged in a linear series one in front of the other at its extremity. It is perhaps legitimate in any case to regard the capitulum in *Urnatella* as the homologue of a single segment of the stalk, or rather to conceive of the segment as a degenerate capitulum.

The species of *Loxosomatoides* that occurs in the Chilka Lake and the lagoons of Madras is not identical with the one described from the Gangetic delta, but the two are closely related. They may easily be distinguished one from the other by the complete absence from the capitular shield of the Peninsular species (*L. laevis*) of the spines that always occur on that of *L. colonialis*, and by the much more regular ornamentation of the shield in the former species. The normal method of growth is also different, for whereas the polyps in *L. laevis* are borne singly at considerable intervals on stalks that arise from one side of a slender rhizome which branches sparingly, in *L. colonialis*, though the unilateral arrangement also obtains, the polyps are arranged in groups and the rhizome from which their stalks arise is somewhat flattened and irregular and branches rather less sparingly. These characters are liable to be obscured if growth is congested or inhibited, but they never disappear altogether.

<sup>1</sup> Davenport, *Bull. Mus. Comp. Zool. Harvard* XXIV, pp. 1-44, pls. i-vi (1893).

**Loxosomatoides colonialis**, Annandale.

1908. *Loxosomatoides colonialis*, Annandale, *Rec. Ind. Mus.* II, pp. 14-19, figs. 2-7.

Except for what has been said under the generic heading, I have nothing to add to my original account of the species.

*L. colonialis* has been found as yet only in pools of brackish water at Port Caning in the Gangetic delta.

**Loxosomatoides laevis**, sp. nov.

In general structure this species closely resembles the preceding one, from which it differs mainly in the ornamentation of its capitular shield. The differences, how-

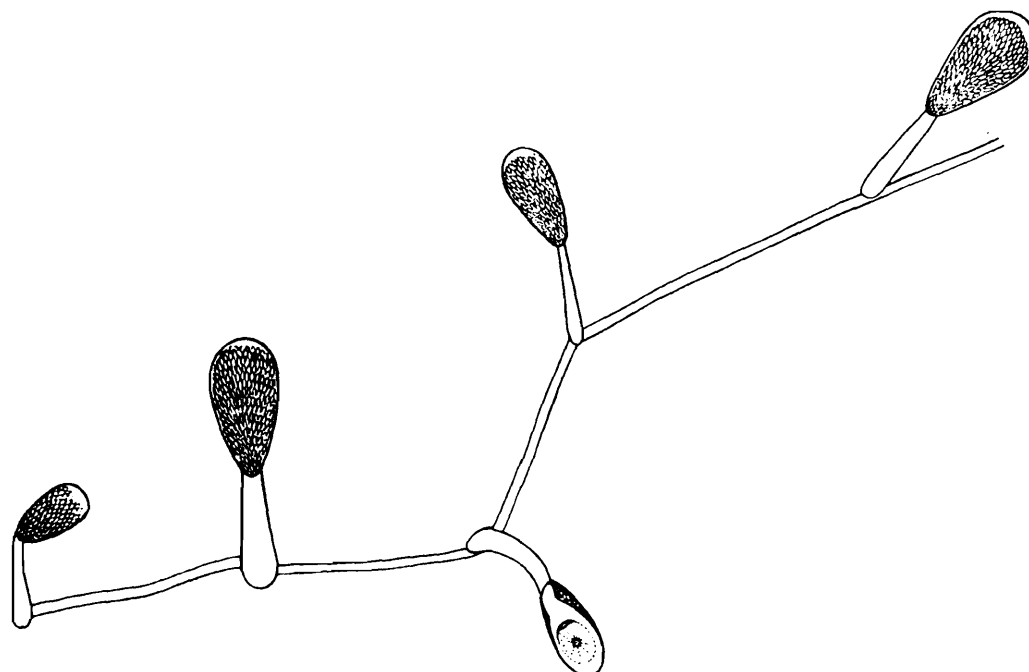


FIG. 1.—*Loxosomatoides laevis*, sp. nov.

Part of type specimen. One of the polyps has been turned back to show the oral surface.

ever, appear to be quite constant, and I have seen no intermediate forms, though the number of examples examined in the field and in the laboratory has been large.

The polyps (fig. 1) arise singly and at considerable intervals from a creeping rhizome that branches very sparingly or not at all. It grows mainly in one direction and follows the inequalities of the surface to which it is attached; the upper surface is convex, the lower surface flattened; its calibre is small and its surface smooth; it is never splayed out at the margins; the thin cuticle that covers it is usually colourless, but may be more or less tinged with brown.

The polyps all face in the same direction, away from the side of the rhizome to which the stalks of all of them are attached. The stalks are more or less swollen at the base and taper gradually; there is no specialized basal region. In normal

circumstances the stalk is very little if at all longer than the capitulum, but if the colony is overwhelmed by mud it may become greatly elongated; its cuticle is almost smooth and may be either colourless or have a distinct brownish tinge. The capitulum is rather narrowly ovoid, the blunter end being uppermost; in the opposite plane it is strongly compressed. When the lophophore is retracted, its direction is almost vertical, but when the tentacles are extended it slopes outwards and downwards in the same way as that of *L. colonialis* and *U. gracilis*. The normal number of tentacles appears to be 14.

The relative size of the capitulum shield varies considerably, but as a rule it does not completely cover the aboral surface, leaving bare a rim of variable width at the upper end. At the sides its margins are clear-cut; below the oral area they bend inwards towards the middle of the oral surface and are then obliquely truncated. There are never any spines on the shield; its ornamentation consists of numerous minute, closely compacted oval depressions arranged regularly in transverse rows. Those of the upper rows are a little larger than those nearer the narrowed basal

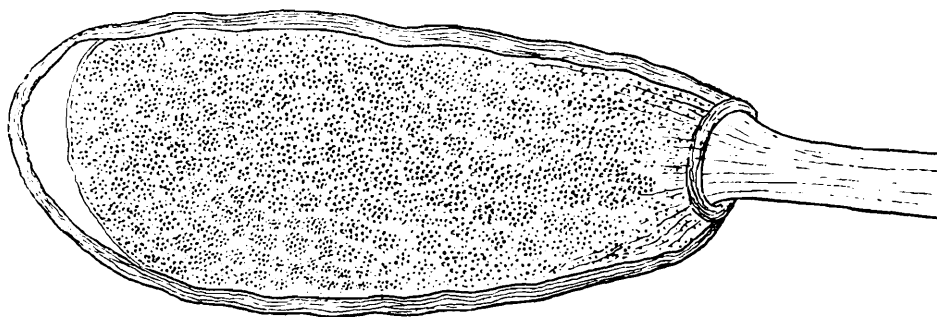


FIG. 2.—*Loxosomatoides laevis*, sp. nov.  
Resting bud as seen from above in optical section,  $\times 250$ .

extremity. The oral surface is completely devoid of spines or other armature and is always colourless. In life, as in spirit, the contrast between it and the shield, which is of a yellowish shade, is usually striking.

The length of the capitulum in the largest polyps is usually about 0.47 mm., the greatest breadth about 0.35 mm., and the thickness considerably less.

The most interesting fact ascertained with reference to the biology of this species was that of the production of resting buds. Seen from above these buds (fig. 2) closely resemble capitula lying, oral surface downwards, on the object to which the colony is attached. They are usually, however, rather narrower than ordinary capitula and their stalks, instead of standing upright or bending over in a semi-recumbent position, lie flat and adhere throughout their length. The upper surface of the bud is covered by a shield closely resembling that of a capitulum and ornamented in the same manner. At the broader end this shield is somewhat thinner and of a paler yellow. At the other extremity the bud bears a stout circular annulus of horny substance through which the stalk enters, the direction of this ring being at right angles to the surface on which it rests. The stalk, except in being

horizontal and adherent, resembles that of ordinary capitula. The lower surface of the bud is covered by a thin horny membrane that adheres to the object of attachment. The inner structure is very simple, consisting of a mass of circular cells filled with granular matter and contained in a delicate external epithelial membrane. Muscle-fibres can be seen making their way from the stalk into the proximal part of the cellular mass. There is a space at the broader end of the capsule. The granular cells are not packed closely but are separated by spaces that appear to be void of connecting substance. The length of the bud is about 0.27 and the breadth 0.15. It is thus smaller than the largest polyps.

I have found these buds on one occasion only, in the Ennur backwater in October, 1913. They take the place of ordinary polyps in the colony, but I cannot say whether they are produced by the degeneration of an ordinary active capitulum or by direct development. In the colonies in which they occurred I noticed that many

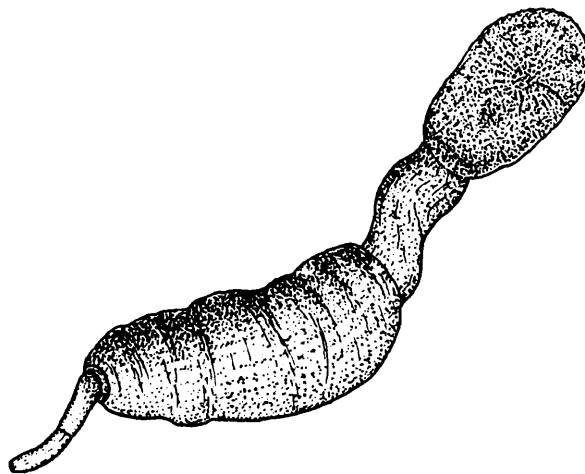


FIG. 3.—*Loxosomatoides laevis*, sp. nov.  
Resting bud giving rise to a new colony,  $\times 100$ .

normal polyps were lying prone on the surface of the oyster-shells to which they were attached, but this attitude is often adopted in normal circumstances, the shield being invariably uppermost. Among my specimens is one illustrating the origin of a young colony from a resting bud. It was in the substance of a thin encrusting Myxospongid sponge. This specimen is shown in fig. 3. The capsule of the bud has already degenerated somewhat, but traces of the characteristic ornamentation can still be detected under a high power. From the broader end a stalk bearing a young polyp has already emerged, while through the annulus at the other extremity a young stolon has made its way and is already producing at its tip the stalk of a polyp. It is evident that the original stalk of the bud had degenerated and disappeared; that this occurs commonly is substantiated by other specimens.

The polyps of *L. laevis* are very shy and I found it difficult to induce them to expand in captivity. When the lophophore was retracted they usually remained with the lower part of the stalk vertical and the upper part bent over in such a way

that the capitular shield was horizontal or had its broader end depressed. Sometimes, however, they lay quite prone as already indicated. The colonies were usually found either on stones or on oyster-shells, in both cases on protected surfaces, but they did not seem to avoid light so much as to seek protection from falling silt. In one instance we found a small colony on the stem of a water-plant. Its polyps did not differ from those of others. On stones the species was almost invariably associated with *Laxosuberites lacustris*, at the base of which its rhizome adhered, sending up the polyps through the substance of the sponge.

Though actually found in the Chilka Lake at three localities only, the species is evidently distributed widely in both divisions of the lake-system. The three localities were Barkuda Island and Gopkuda Bay in the main area and the oyster-beds of Manikpatna in the outer channel. At the first and the last of these places it was abundant, but at Gopkuda Bay only one specimen was taken. The organism is so minute and inconspicuous that it very readily escapes observation, and it was probably owing to the fact that at Barkuda we were able (living in a bungalow close to the lake and having every facility for microscopic work) to make a very thorough investigation of the stones of the little landing-stage, that we found it in such abundance there. Oyster-shells also are naturally much more easily transferred to headquarters and examined in the field than stray pieces of rock. Apart from the Chilka Lake, the species has as yet been discovered only on the oyster-beds of the Ennur backwater a few miles up the coast from Madras. At Barkuda Id. the species was taken in an active condition at all times of the year, in water of specific gravity varying from 1.010 to 1.006; at Manikpatna we found it in March and September and at Ennur in November and January. It is thus clear that *L. laevis* can live in water of a specific gravity of at least 1.0265 and can survive, at any rate for a limited period, in pure fresh water.

The type (registered No. ZEV 6211/7) is preserved in the Indian Museum.

#### Family PEDICELLINIDAE.

#### Genus **BARENTSIA**, Hincks.

1880. *Barentsia*, Hincks, *Ann. Mag. Nat. Hist.* (5) VI, p. 285.  
 1886. *Cercopodaria*, Busk, *Rep. Zool. 'Challenger'* XVII (2), p. 41.

#### **Barentsia discreta** (Busk).

1886. *Cercopodaria discreta*, Busk, *Rep. Zool. 'Challenger'* XVII (2), p. 44, pl. x, figs. 6-12.  
 1905. *Cercopodaria discreta*, Thornely in Herdman's *Ceylon Pearl Fisheries* IV, p. 128.  
 1912. *Barentsia discreta*, Annandale, *Rec. Ind. Mus.* VII, p. 205.

In my note of 1912 I recorded the occurrence of a dwarfed form of this species in the Mutlah estuary at Port Canning in the Gangetic delta, the water containing

a saline residue of about 25.46 *per mille*, that is to say being almost as salt as that of the Bay of Bengal.

*B. discreta* was originally described from a depth of over 100 fathoms in the South Atlantic and was found subsequently by Professor Herdman in comparatively shallow water off Ceylon.



FAUNA OF THE CHILKA LAKE

CIRRIPEDIA.

*By* N. ANNANDALE, *D.Sc., F.A.S.B.*

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## CIRRIPEIDIA.

By N. ANNANDALE.

There is not much to be said about the barnacles of the Chilka Lake, for only two species, both of which are common and widely distributed, are represented, namely *Dichelaspis cor* and *Balanus amphitrite*. Both were found abundantly in the outer channel of the lake. The only species observed in the main area was *B. amphitrite*, of which a few individuals were noticed on rocks and the bottom of boats.

*Dichelaspis cor* probably breeds in the outer channel and this may also be the case with *Balanus amphitrite*, but larvae of the latter almost certainly enter annually from the sea. Both species were found in the adult state in the fresh- as well as the salt-water season.

No Rhizocephala or other true parasitic forms were found.

### Suborder PEDUNCULATA.

#### Family LEPADIDAE.

In addition to the species discussed below, another member of this family (the common *Lepas anserifera*, Linn.) is represented by several specimens that were taken in a dead or moribund condition from a stick floating in the outer channel near Manikpatna in March, 1914. This species can hardly be included in the fauna of the lake on evidence so slight, for the stick had probably drifted in from the sea.

#### *Dichelaspis cor*, Aurivillius.

1909. *Dichelaspis cor*, Annandale, *Mem. Ind. Mus.* II, p. 119, pl. vi, figs. 7-10.

This species is common on the gills of the crab *Scylla serrata* in the outer channel at all times of the year. In the main area we failed to find it, though the crab was common. Some of our specimens are of very large size, the capitulum being 3 mm. in breadth and the peduncle 8 mm. long. All of them belong to Gruvel's var. A. *D. cor* has been found in the gill-chamber of *Panulirus* in the sea but is particularly common in that of *Scylla serrata* in estuarine tracts. Its distribution extends from East Africa to Sumatra.

The larvae are able to hatch from the egg and to live, at any rate for some hours, in pure fresh water. This I have seen in the case of specimens from the gills of crabs purchased in the Calcutta market. The adults which produced the eggs lived for at least twelve hours out of water.

## Suborder OPERCULATA.

## Family BALANIDAE.

**Balanus amphitrite**, Darwin.

1854. *Balanus amphitrite*, Darwin, *Mon. Cirripedia, Balanidae*, p. 240, pl. v, figs. 2a-2c.

All our specimens from the Chilka Lake belong to Darwin's var. *communis*, but they vary considerably in shape, some being much more depressed than others. The largest have a diameter of about 15 mm.

The species is abundant on oyster-shells, fish-traps and wooden posts in the outer channel of the Chilka Lake and occurs singly or in small numbers on the shells of *Potamides* and other Gastropods and Lamellibranchs. In the main area a few solitary living individuals of small size were observed on rocks, mostly towards the end of the dry season, while a relatively large number of dead shells were observed in the same situation. On one occasion in the season of low salinity the bottom of a boat in Rambha Bay was found to be covered with small living individuals, but it had possibly arrived recently from the outer division of the lake-system. In the outer channel the specific gravity of the water in which apparently healthy barnacles were observed varied from 1.000 to 1.0265. I have seen them in brackish or almost fresh water in the Gangetic delta, near Madras and in Cochin on the west coast of India. The species is common in all the warmer seas and is carried into those of the northern temperate zone on the bottom of ships. In the Bay of Bengal it is perhaps the commonest of the littoral Operculata.

Larval *Balani*, probably of this species, were abundant in our tow-nettings taken in the outer channel in March. This is also the case in collections made in the same month in the shallower parts of the Bay of Bengal.

*B. amphitrite* is remarkable for the rapidity of its growth and for its power of resisting unfavourable circumstances. Professor Herdman<sup>1</sup> found specimens of a diameter of 8 mm. on baskets that had been in the sea off Ceylon for 21 days. I have little doubt that the species breeds regularly in the outer channel of the Chilka Lake and that stray larvae are carried into the main area and occasionally find it possible to settle down and undergo their metamorphosis, without being able to survive it for more than a few months.

The vicissitudes undergone annually by barnacles attached to oyster-shells in the outer channel are sufficient proof of the strong vitality of the species, but even more remarkable evidence is afforded by the fate of those individuals that attach themselves to prawn-traps in the neighbourhood of Śatpara. The traps are placed in the lake in the evening and, remaining in the water all night, are removed at dawn. Throughout the heat of the day they lie on the shore, fully exposed to the sun's rays. Nevertheless, the barnacles on them survive. We saw many instances of this, more particularly in September, 1913, and in the same month of 1914. Specimens from such situations are small (not exceeding 9 mm. in diameter) and dull in colour, but otherwise apparently normal.

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*Ceylon Pearl Fisheries* V, p. 147 (1906). The dates were April 17th to May 9th.

FAUNA OF THE CHILKA LAKE

OLIGOCHAETA.

*By J STEPHENSON, M.B., D.Sc., Lieut.-Col., I.M.S., Professor of Zoology,  
Government College, Lahore.*

(Plate X).

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## OLIGOCHAETA.

By J STEPHENSON.

The Oligochaeta of brackish water are few, and do not form an independent ethological group. They seem to be forms belonging to the freshwater or littoral groups which possess the power of resisting a certain amount of admixture of salt or fresh water respectively.

Though the Oligochaeta have long been recognized as capable of contributing valuable results to zoogeography, these results have been gained almost entirely from a study of the terrestrial forms, to the exclusion of those of aquatic and littoral habit. Nor in view of the modes of dispersal can it be expected that it will be otherwise in the future. The following few remarks may serve briefly to illustrate this statement.

In the case of freshwater forms, it seems probable that birds are one of the chief agents of dispersal; the mud which adheres to the feet of waders offers an easy means of transport to small worms or their cocoons; and it is well known that small animals, such as Nematodes and Rotifers, have been cultivated from such mud after a prolonged flight, while small molluscs have also been found to be conveyed in this way. Speaking of the probable introduction of Australian worms into New Zealand in this way, Benham ("A note on the Oligochaeta of the New Zealand Lakes", *Trans. N. Z. Inst.*, XXXVI, 1903) calculates that a strong flier with the wind behind it could cover the distance in 36 to 48 hours. The comparative valuelessness for zoogeography of the data of distribution of freshwater Oligochaeta may be exemplified by the fact that *Nais paraguayensis*, first found, as the name implies, in material from Paraguay, has since been discovered in Lahore; that *Nais communis*, described first from Switzerland, has been found both in North and South India; *Stylaria lacustris*, also found at Lahore, occurs all over Europe, in the Baikal Sea, and in North America; while the genus *Chaetogaster*, represented by several species in India, is found throughout Europe, in North America, in the Baikal Sea, and in Australia, and is indeed probably absolutely cosmopolitan.

The littoral Oligochaeta are unfortunately capable of furnishing no more valuable results. "The animals usually lay their cocoons underneath and amongst the masses of detritus on the shore, often attaching them firmly to these. When at more than usually high tides these masses are again washed into the sea, they may be taken up by currents, carried far away, and thrown up with the cocoons they bear on to the shore at some distant point. In this way littoral Oligochaetes may spread not only along a continuous coast-line but over considerable stretches of

ocean. Probably shore-birds also contribute to their dispersal by carrying away cocoons which adhere in a chance manner to their feet. That such a trans-oceanic dispersal of littoral Oligochaeta is a fact may be seen from the case of geologically recent and isolated oceanic islands; these contain (apart from forms demonstrably introduced by man) no terrestrial Oligochaeta, but are colonized by littoral species, e.g. the small coral island Laysan of the Hawaiian Archipelago by a species of *Pontodrilus*" (Michaelson, *Die geographische Verbreitung der Oligochaeten*, 1903). So the genus *Pontodrilus* is apparently distributed over the coasts of all the warmer portions of the globe; while *Enchytraeus albidus* is found from Nova Zembla and Greenland to South Patagonia and Kerguelen Is.

#### Family ENCHYTRAEIDAE.

Genus ENCHYTRAEUS, Henle.

*Enchytraeus barkudensis*, sp. nov.

(Plate X, figs. 1-4.)

*Types*.—Barkuda Island, Chilka Lake, Ganjam Dist., Madras Presidency. In sand at edge of lake; 16-vii-1914. Five specimens (Reg. No. ZEV 6545/7, *Ind. Mus.*).

Length 15 mm. Filiform, breadth about 3 mm. Colour light brown. Segments 57-64.

The prostomium is rounded and very short.

The *setae* are of the same type (*Enchytraeus* type) in both lateral and ventral bundles; they are blunt rods, straight except for a curve at the inner or proximal end. In both lateral and ventral bundles they are three per bundle in segments ii—xi; segment xii has lateral bundles consisting each of two *setae*, but no ventral bundles; from segment xiii onwards the *setae* are two per bundle, both laterally and ventrally.

The *clitellum* is not distinguishable.

Not much of the anatomy of the worms could be observed with accuracy in the entire specimens, and most of the following account is based on the examination of longitudinal sections.

The *septa* in the anterior region are much bulged backwards, especially 7/8, 8/9 and 9/10, which form deep pockets filled with coelomic corpuscles. These three *septa* are also considerably thickened as compared with the others, and form stout sheets of muscular fibres (*cf.* septum 9/10 in fig. 2).

The *coelomic corpuscles* (fig. 2) are numerous and conspicuous even in the entire animal; they are nucleated flattened plates, oval or broadly spindle-shaped, of an average length (in the fixed and stained condition) of  $28\mu$ ; the maximum length observed was  $41\mu$ .

The *pharynx* (fig. 1) occupies segments ii and iii; it has the usual constitution, the epithelium of the roof being markedly columnar and forming a sucker-like plate. The *oesophagus* is a narrow and uniform straight tube, ciliated throughout, and showing no differentiation; it passes fairly suddenly into the *intestine*, distinguish-

able by its greater width, in segment xv (in one specimen), xvi or perhaps xvii (in a second).

The *salivary glands* (fig. 1) are apparently represented by a pair of short club-shaped backwardly directed evaginations of the pharynx; these take origin from the hinder part of the pharyngeal roof, behind the sucker-like epithelial plate, and are situated one on each side near the middle line.

The *septal glands* are situated on the anterior faces of septa 4/5, 5/6, and 6/7, causing these to bulge backwards. Those of each pair are continuous dorsally over the oesophagus; and each gland is continued forwards by an anteriorly projecting lobe situated ventro-laterally to the oesophagus. In entire specimens the glands appear to be in segments v, vi, and vii, and perhaps to be more than a single pair per segment; but the appearances are explained by the backward bulging of the septa, and the presence of the anterior lobes, as just described.

The *dorsal vessel* is certainly distinct as far back as segment xv,—probably further, as far as xvi, if not xvii.

The *nephridia* have a short ante-septal portion,—perhaps a quarter the length of the postseptal; the post-septal portion is elongated, narrow, and gives off the duct from its under surface at about one-third of its length from the posterior end; the duct is short, passes vertically downwards, and ends in front of the ventral setae.

The *cerebral ganglion* is in segment i; its shape could not be determined.

The description of the male genital organs (figs. 2, 3, 4) is most conveniently begun with the *sperm-sacs*. These are two in number, quite distinct from each other, of large size and ovoid shape (figs. 2, 3); they are continuous with and suspended by septum 10/11; they project forwards into segment x, and, still more, backwards into xi, so that they occupy the whole length of the latter segment; their walls are quite thin, but complete. Contained within this sac is a large mass of sperm-morulae, in various stages of development; but, in the two specimens which were sectioned, there were no wisps of fully developed spermatozoa. What is to be considered as the *testis* is a mass of cells (figs. 2, 3), adherent to the inner face of the sac-wall at its lower part, *i.e.* to the floor of the sac, approximately in the region where septum 10/11 joins it. This mass of cells may project not inconsiderably into the interior of the sac; or it may constitute merely a flattened plate, perhaps divided up into a number of smaller masses. The morulae within the sac are evidently developed from cells which are proliferated from the cell-mass or cell-plate; indeed there is a gradual transition from the one to the other. The *funnel* (fig. 4) is in segment xi; it is two or three times as long as broad; it has the usual cylindrical shape, but the cells of which it is composed have not the usual clear mucous appearance in stained sections; this might possibly be due to the specimens being in a rather early stage of sexual maturity. The *vas deferens* is situated in segment xii; it is long, thin, 16 $\mu$  in diameter, and coiled; fig. 4, sketched from an entire specimen in cedar oil, will give an idea as to its disposition and course. The *penial body* is a small hemispherical mass of cells round the termination of the *vas*

*deferens*, which latter pierces through it without interruption and reaches the surface at the position of the (absent) ventral setae of xii.

The *ovaries*, and masses of *ova*, are contained in segment xii. Funnels and oviducts were not observed.

The *spermathecae* are in segment v, and communicate with the oesophagus. The ampulla is small, ovoid in shape,  $50\mu$  in diameter; the duct is a narrow tube,  $14\mu$  in diameter, of considerable length and with a few slight bends in its course. There were no spermatozoa in the ampullae.

This little worm is stated to be practically colourless in life, but rather opaque.

The discovery of the present species is of interest in several ways. Though (like the Tubificidae) occurring in such abundance in the temperate regions of Europe, the Enchytraeidae seem to be very rare in India; the present is the fourth species which has been completely investigated. This rarity is probably partly apparent, partly real; and the same may be said of the Tubificidae also, of which too only four species have been recorded.

A feature that is worthy of note is the presence of sperm-sacs. These are not invariably present in the genus *Enchytraeus*; out of the two other Indian species of the genus they are absent in one (*E. indicus*), present in the other (*E. harurami*). In the present species the sacs are of the same nature as those of *E. harurami*, and differ from those of the Naididae and of the genus *Mesenchytraeus*, the only other Enchytraeid genus in which they are found. In *Mesenchytraeus* and the Naididae the sacs are pocket-like backward extensions of the septum which forms the posterior wall of the testis segment; here they are closed bags, seated on or suspended from the anterior wall of the segment, and containing both testis and developing sperm-morulae. The sacs do not include the funnels of the vasa deferentia; and since they are, in the stages at which I have examined them, completely closed, it is not obvious how the spermatozoa escape (*cf.* remarks on *E. harurami*, in a previous paper: "On a collection of Oligochaeta, mainly from Northern India", *Rec. Ind. Mus.*, vol. x, p. 321, 1914).

Another point of interest is the condition of the salivary glands ("peptonephridia"). In the species in which they occur, they are found usually as narrow curling tubes extending back for a few segments behind the pharynx, from the posterior end of which they take origin. In the present case there are a pair of small club-shaped structures, quite short and inconspicuous, discovered in the series of longitudinal sections, though they would probably have escaped notice during life; these originate from the posterior end of the pharynx, and seem to correspond to the salivary glands of other forms. Similar rudimentary salivary glands appear to have been described by Ude ("Beiträge zur Kenntnis der Enchyträiden und Lumbriciden", *Zeit. f. wiss. Zool.*, vol. 61, 1895) in *Bryodrilus ehlersi*, though I have not seen the original paper.

The above characters, together with the setal distribution, are sufficient to distinguish the form as a new species.

*E. barkudensis* was found at only one spot in the Chilka Lake, namely in a small patch of sand at one side of the landing-stage on Barkuda Id., in the main area. It lives there, with *Pontodrilus bermudensis* f. *ephippiger*, some inches below the surface and well below water-level. The months in which specimens were obtained were July and November. In the former the specific gravity (corrected) of the water immediately off Barkuda Id. was 1.015, while in November it was 1.005. The species was taken in January at the edge of the Ennur backwater near Madras, also in wet sand and with *P. bermudensis*, the specific gravity of the water being about 1.0025. On all three occasions sexually mature worms were obtained.

Family MEGASCOLECIDAE.

Genus PONTODRILUS, E. Perrier.

**Pontodrilus bermudensis**, Bedd., forma *ephippiger* (Rosa).

1914. *Pontodrilus ephippiger*, Stephenson, *Rec. Ind. Mus.* X, p. 256.

In life this worm has a bright pink colour.

In the Chilka Lake specimens were obtained both in the main area and in the outer channel at all times of the year. They occurred at the extreme margin in wet sand or sand mixed with mud, sometimes under stones with the amphibious Isopoda *Hemiporcellio carinatus* and *Arhina barkulensis*, Collinge,<sup>1</sup> the water being either fresh, brackish or as salt as that of the Bay of Bengal. Probably, however, the species does not breed in fresh water, as no fully mature individuals were found in the fresh-water season (July to September). The chief breeding-time seems to fall in late winter and early spring, when the water of the lake varies in corrected specific gravity from 1.008 to 1.026. At the edge of the Ennur backwater near Madras the same form was found in January, 1915, in sand wetted by water of specific gravity of about 1.0025. Some of the specimens were mature.

The species is very widely distributed on the warmer coasts of both hemispheres. Following Michaelsen (*Mitt. aus dem Naturh. Mus. Hamb.*, xxvii, 1909) I now recognize *P. ephippiger*, Rosa, as one of the numerous forms of *P. bermudensis*, Bedd. The form *ephippiger* is recorded from Christmas I., Celebes, and the Hawaiian Archipelago; the form *insularis* of the same species (formerly *P. insularis*, Rosa) has been found, among other places, in Ceylon.

Family GLOSSOSCOLECIDAE.

Genus CRIODRILUS (Hoffmstr.).

**Criodrilus lacuum**, Hoffmstr.

1914. *Criodrilus lacuum*, Stephenson, *Rec. Ind. Mus.* X, p. 256.

The identification of this worm is, as stated in the above paper, not absolutely certain, since the specimens were not fully mature.

The natural colour of this worm is tinged with a peculiar ochraceous shade.

<sup>1</sup> *Rec. Ind. Mus.* XI, pp. 145, 147, pls. vi, viii (1915).

The species is apparently common on the shore of the Chilka Lake somewhere near Satpara, where the beach is for the most part sandy. It is dug for bait by fishermen. Specimens obtained from them in March, 1914 were not quite mature. The corrected specific gravity of water from the lake at Satpara was in this month 1.026. In Palestine the worm lives in wet earth under stones at the edge of water.

This is a well-known European species, which occurs throughout Central Europe, in S. Russia, Syria and Palestine. It is interesting to find it in brackish water, since it is a typically limnic form, and so far as I know has not hitherto been recognized as littoral. That it can support a considerable amount of salt is, however, shown by its occurrence on the margin of the Lake of Tiberias, the water of which is markedly saline; and this being the case, it is perhaps remarkable that it has not so far definitely established itself as a littoral form.