FAUNA OF THE CHILKA LAKE

SPONGES.

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

(Plates III–V.)

CONTENTS.

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,[1] very little about the littoral sponges of the Bay of Bengal, and the biological conditions that prevail

[1] *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.				
Spongilla alba .. .	x	x	India ; Egypt (*fresh and brackish water*)	1 000—1·0065
*Spongilla nana**	x	..	. . .	*ca.* 1·006
CLIONIDAE.				
Cliona vastifica	x	x	Cosmopolitan (*marine*) ..	1·000—1·0265
SUBERITIDAE.				
Suberites sericeus	x	x	Japan (*marine*)	1·000—1·0145
Laxosuberites aquae-dulcioris ..	x	x	Madras (*brackish water*) ..	1·000—1·0265
*Laxosuberites lacustris** ..	x	..	. . .	1·000—1·0150
TETRAXONELLIDA.				
TETILLIDAE.				
Tetilla dactyloidea var. *lingua**	..	x	Typical form in Arabian Sea and off Mergui (*marine*) ..	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. 8*b* (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 idiosyncracy. 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 subtance, which there forms a kind of veil[1] 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.

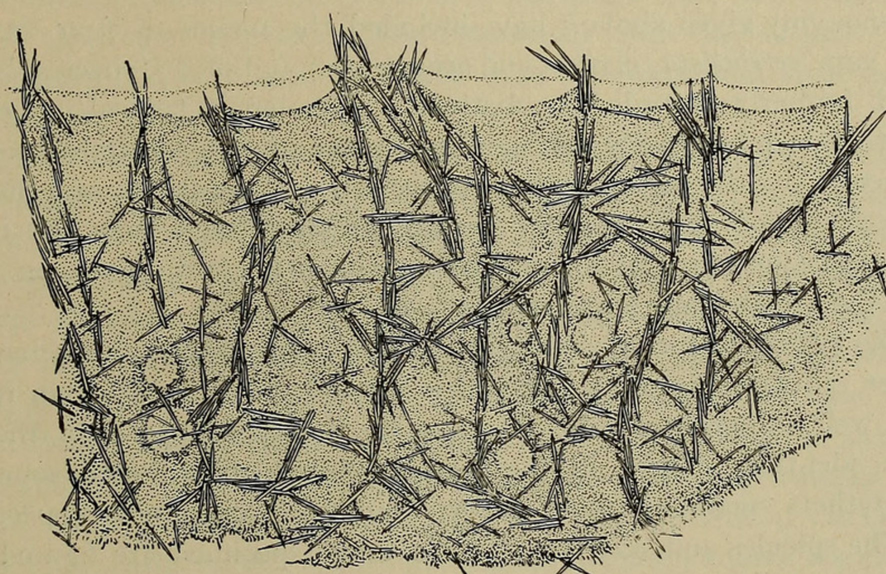

FIG. 1.—*Spongilla alba*, Carter.
Vertical section of a moderately hard sponge from Pigeon Id. in the Chilka Lake, × 30.

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

[1] Apparently this veil is never deposited in distinct concentric layers as in *Lubomirskia*, *cf.* Annandale, *Rec. Ind. Mus.* X, p. 144, pl. ix, fig. 1*a* (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*.[1] 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, 1*a* 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.

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[1] 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[1] doubtless serves a similar purpose, or at any rate saves it from being overwhelmed

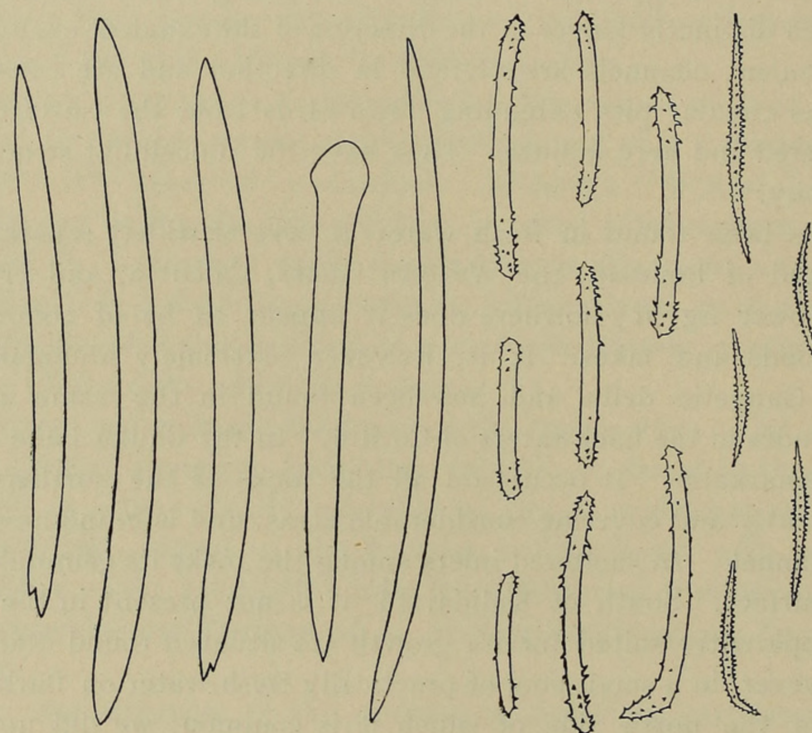

FIG. 2.—*Spongilla alba*, Carter.
Spicules of a normal specimen from the Chilka Lake, × 255.

by the deposition of silt. The green algae that grow in it are parasitic, or at any rate incidentally destructive.[2]

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,

[1] 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).

[2] 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

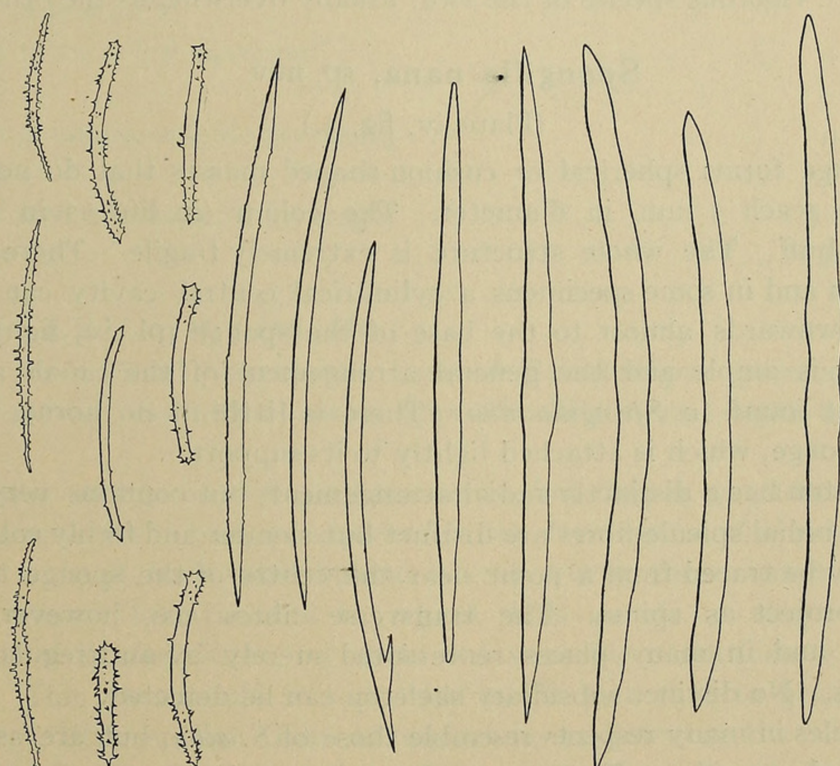

FIG. 3.—*Spongilla nana*, sp. nov.
Spicules of one of the type-specimens, × 255.

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*[1] often give shelter to large numbers of small animals of

[1] *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 chilkensis*, Stewart[1]) 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*[2] 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.

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[1] *Rec. Ind. Mus.* X, pp. 245, 247 (1914).

[2] 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-i-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*.[1] 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

[1] *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 ASTROMONAXONELLIDA.

Family *CLIONIDAE*.

Genus **CLIONA**, Grant.

1888. *Cliona*, Topsent, *Arch. Zool. expérim.* (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).

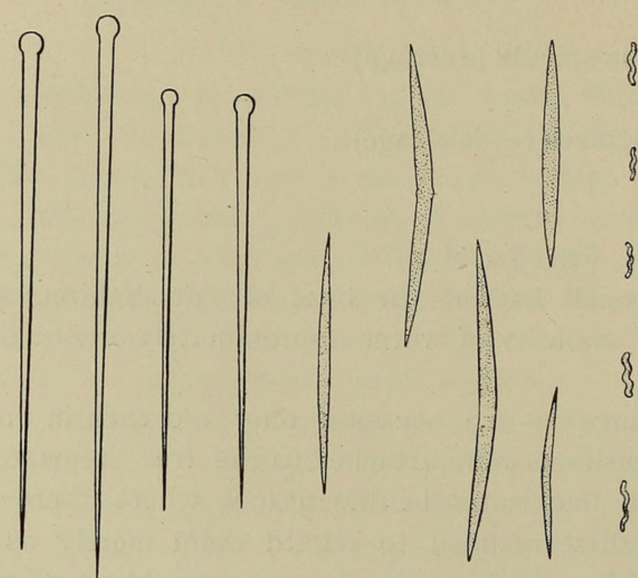

FIG. 4.—*Cliona vastifica*, Hancock.
Spicules of a specimen from the oyster-beds at Manikpatna.

Cliona vastifica, Hancock.

(Plate iv, fig. 7.)

1900. *Cliona vastifica*, Topsent, *Arch. Zool. expérim.* (3) VIII, p. 56, pl. ii, figs. 3—9.
1915. *Cliona vastifica*, Annandale, *Rec. Ind. Mus.* XI, p. 8.

A full description and synonomy 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[1]) 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. expérim.* (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*

[1] *Rec. Ind. Mus.* XI, p. 12, pl. i, fig. 2 (1915).

carnosus (Johnston),[1] *S. inconstans,* Dendy[2] and *S. cruciatus* of the same author.[3] 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[4] 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,*[5] an example of which was recently obtained by Mr. S. W. Kemp at Kilakarai on the Gulf of Manaar, is a *Pseudosuberites.*

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

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[1] Most fully described by Topsent in the paper cited (1900), p. 233.

[2] *Ann. Mag. Nat. Hist.* (5) XX, p. 154, pls. ix, x (1887).

[3] In Herdman's *Ceylon Pearl Fisheries* III, p. 131, pl. v, fig. 10.

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

[5] *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

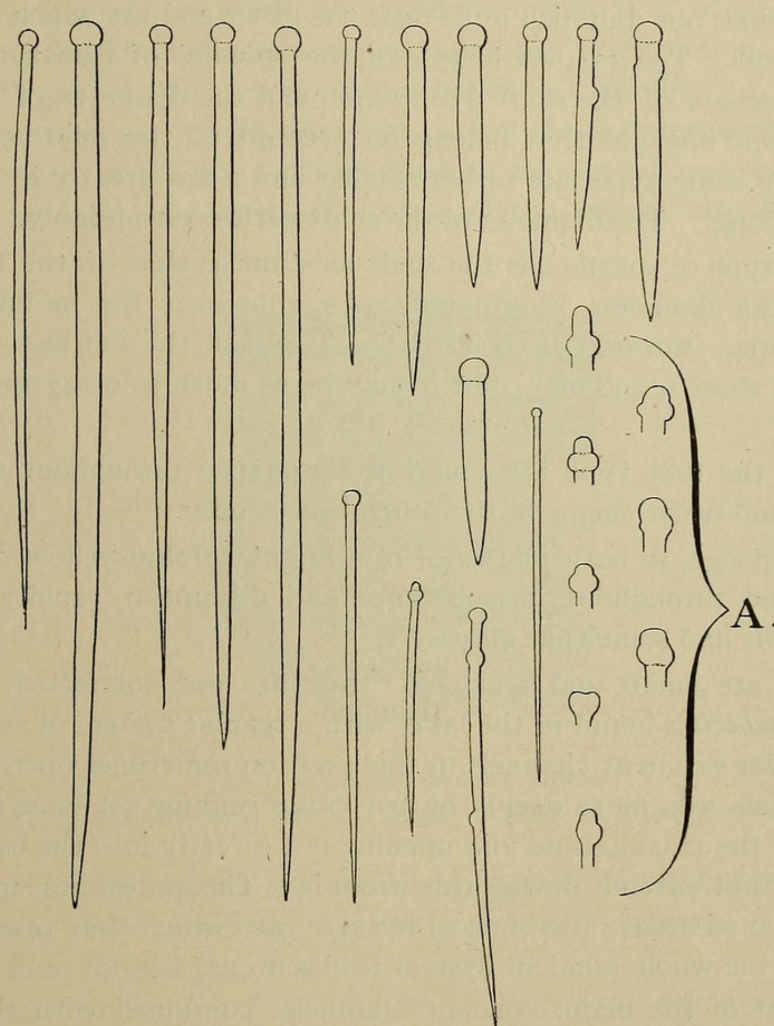

FIG. 5.—*Suberites sericeus*, Thiele.
Spicules of a specimen in phase B, × 255.
A.—Heads of spicules further enlarged.

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

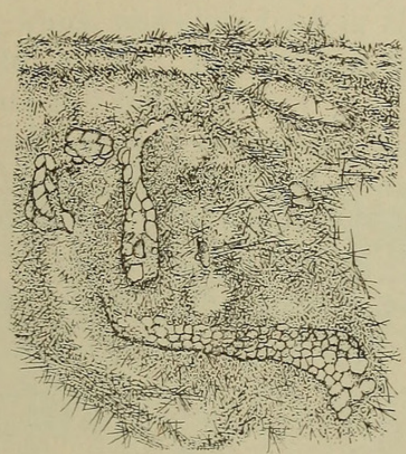

FIG. 6.—*Suberites sericeus*, Thiele.
Vertical section through the outer part of a sponge in phase B, showing gemmules, × *ca.* 10.

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.

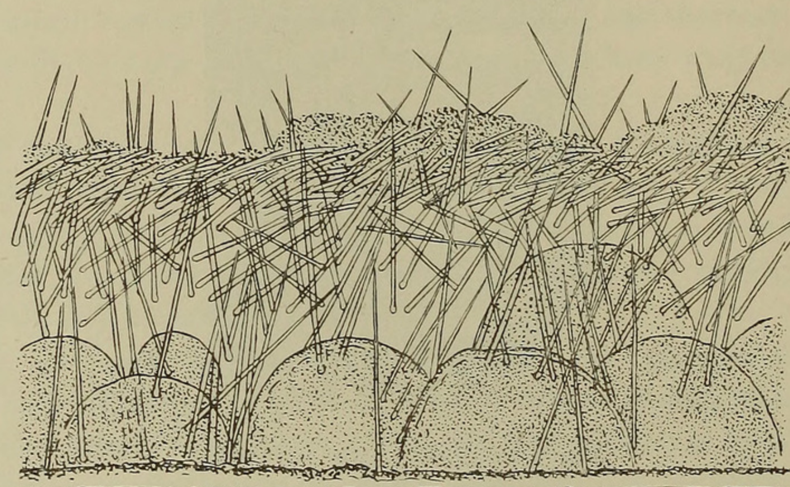

FIG. 7.—*Suberites sericeus*, Thiele.
Vertical section through a sponge in phase A with gemmules, × 150.

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 (*Bimeria*) 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. 4*a*).

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,[1] for the fact that sponges of different kinds frequently grow over molluscs or their eggs[2] 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.[3]

Genus LAXOSUBERITES, Topsent.

1896. *Laxosuberites*, Topsent, *Mém. Soc. zool. France*, IX, p. 126.
1900. ,, *id.*, *Arch. Zool. expérim.* (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. 6*a*) 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

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[1] Annandale, *Faun. Brit. Ind.*, *Freshw. Sponges*, etc., p. 94 (1911).
[2] Herdman, *Journ. Linn. Soc.* (Zool.) XXXII, p. 271 (1914).
[3] 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[1] 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.

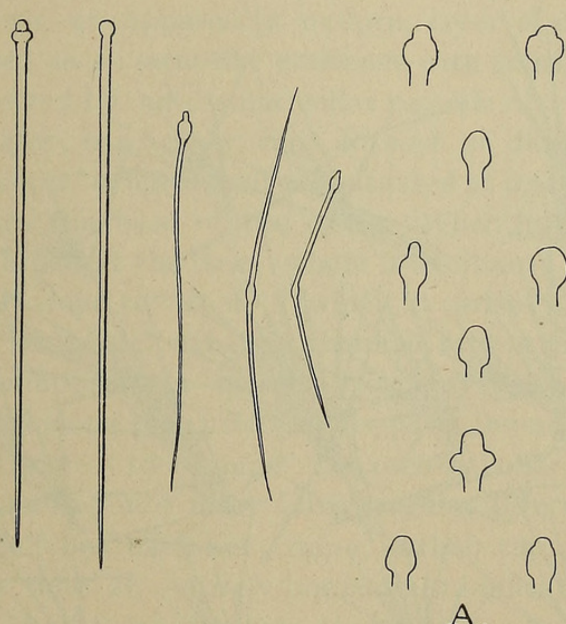


FIG. 8.—*Laxosuberites aquae-dulcioris* (Annandale).
Spicules from type-specimen, × 255.
A.—Heads of spicules further enlarged.

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

[1] 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. 11, 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

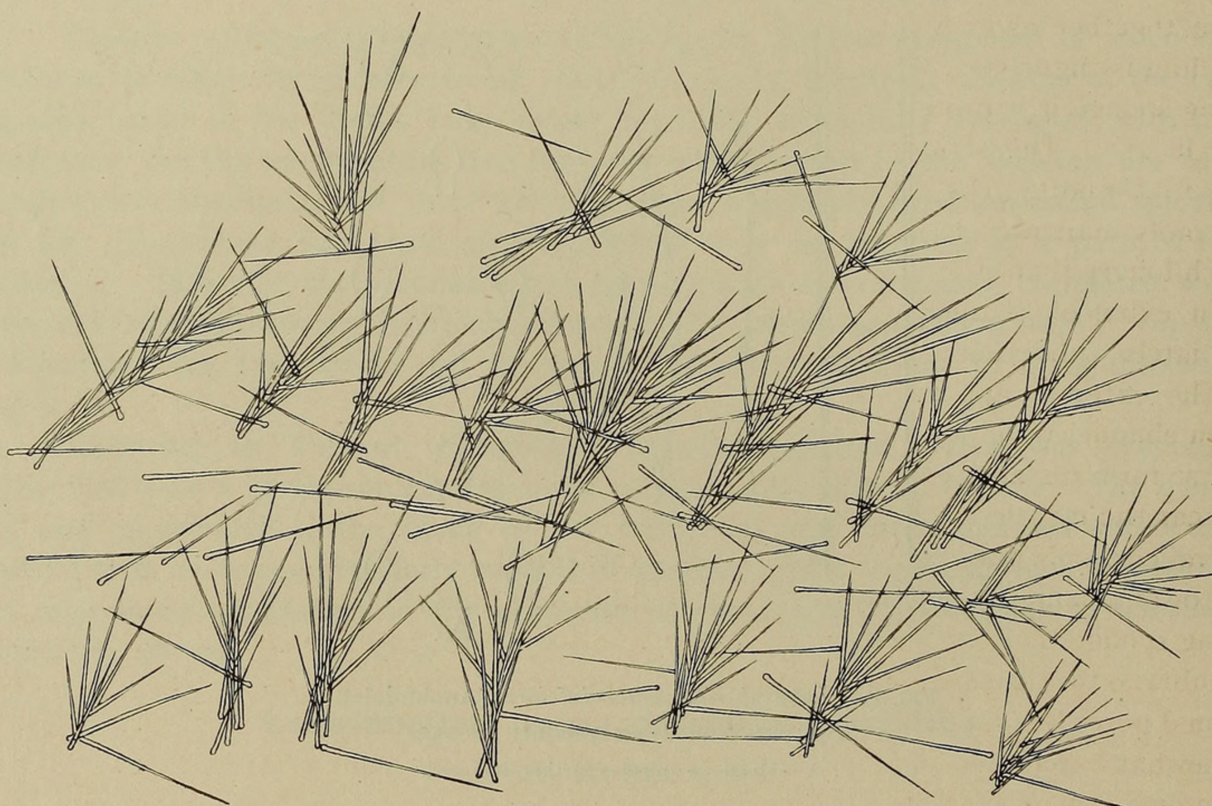


FIG. 9.—*Laxosuberites aquae-dulcioris* (Annandale).
Part of the skeleton of a sponge on a leaf of *Halophila*, × 100.

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

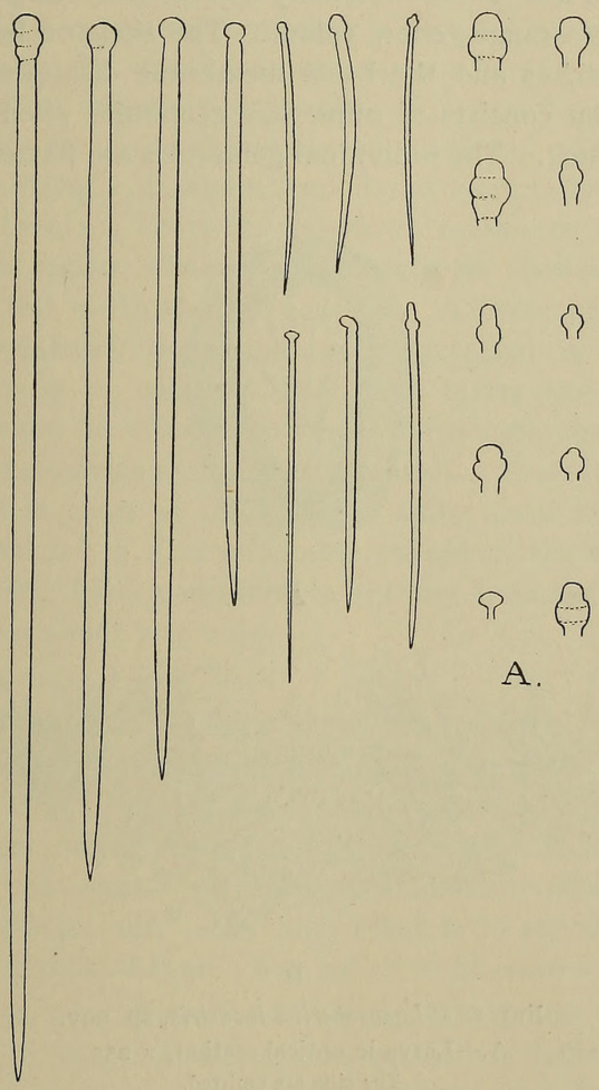


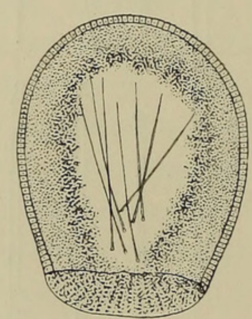
FIG. 10.—*Laxosuberites lacustris*, sp. nov.
Spicules from a typical specimen, × 255.
A.—Heads of spicules further enlarged.

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.[1] In *L. lacustris*, however, some of the shorter-spicules

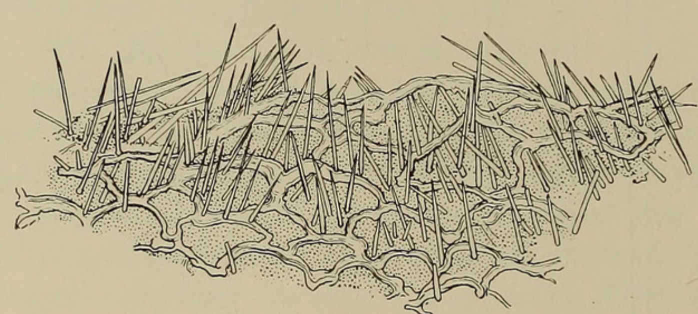
[1] "0·033" in the original description (*Rec. Ind. Mus.* X, p. 158) is a printer's error. In some specimens the spicules are smaller than in others.

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-



A



B

FIG. 11.—*Laxosuberites lacustris*, sp. nov.
A.—Larva in optical section, × 255.
The cilia are omitted.
B.—Vertical section though a mass of gemmules, × 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 larvae (fig. 11A) 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)[1], 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[2], 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

[1] Topsent, *Arch. Zool. expérim.* (3) V, p. 185, pl. v, figs. 1-4.

[2] "Tetraxonida" in Michaelsen and Hartmeyer's *Faun. Südw. Australiens* II, pp. 389, 391 (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 [1], 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 [2], 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 [3] of which there is apparently no trace in marine types. I have commented elsewhere [4] on the essential resemblance of the Spongillid larva,

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[1] 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.

[2] *Arch. Zool expérim.* (5) VII, pp. xiii and xiv (1911).

[3] This is clearly shown in a figure recently published by Nöldeke. *Zool. Jahrb.* (*Anat.*) VIII, fig. 1 (1913).

[4] *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.[1]) 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.

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[1] 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[1] 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.[2] 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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[1] "Report on the Sponges" in Herdman's *Ceylon Pearl Oyster Fisheries* III, p. 94 (1905).

[2] *Journ. Asiat. Soc. Bengal* (n. s.) IX, p. 76 (1913).