XXVII. SOME SPONGES PARASITIC ON CLIONIDAE WITH FURTHER NOTES ON THAT FAMILY.

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(Plate XXXIV.)

In a recent paper on the Clionidae of Indian seas (*Rec. Ind. Mus.* XI, pp. 1-24) I referred incidentally to other sponges parasitic in their burrows. I now propose to give an account of these sponges adding some additional notes on the Indian Clionidae.

The systematic position of the different species may be considered first, in taxonomic order, and then their biological relationships.

Part I.—SYSTEMATIC.

The following is a list of the species to be considered; all belong to the order Tetraxonida.

Grade **TETRAXONELLIDA.**

Family PACHASTRELLIDAE.

Stoeba plicata var. *simplex* (Carter).

Family STELLETTIDAE.

Stelletta vestigium, Dendy.

Grade **MONAXONELLIDA.**

Family EPIPOLASIDAE.

Coppatias penetrans (Carter).
Coppatias investigatrix, sp. nov.

Family CLIONIDAE.

Cliona carpenteri, Hancock.
Cliona mucronata, Sollas.
Cliona quadrata, Hancock.
Cliona kempi, sp. nov.
Thoosa hancocci, Topsent.

Family DESMACIODONIDAE.

Subfamily *ECTYONINAE.*

Rhabderemia prolifera, sp. nov.

Family AXINELLIDAE.

Amorphinopsis excavans, Carter.
A. e. var. *digitifera*, nov

Family CHONDROSIIDAE.

Chondrilla nucula, Schmidt.
Chondrilla mixta, Schulze.
Chondrilla distincta, Schulze.

Grade TETRAXONELLIDA.

Family PACHASTRELLIDAE.

Stoeba plicata (Schmidt).

1868. *Corticium plicatum*, Schmidt, *Die Spong. d. Kuste v. Algier*, p. 2, pl. iii, fig. 11.
1880. *Samus simplex*, Carter, *Ann. Mag. Nat. Hist.* (5) VI, p. 60, pl. v, fig. 26.
1888. *Stoeba simplex*, Sollas, '*Challenger*' *Rep. Zool., Tetractinellida* (vol. XXV), p. 102.
1888. *Calcabrina plicata*, *id.*, *ibid.*, p. 281.
1889 (1887). *Samus simplex*, Carter in Anderson's *Faun. Mergui* I, p. 75.
1894. *Dercitus plicata*, v. Lendenfeld, *Denk. Ak. Wien.* LXI, p. 105, pl. ii, fig. 10, pl. iii, fig. 43.
1895. *Dercitus plicatus*, Topsent, *Arch. Zool. expérim.* (3) III, p. 531, pl. xxii, figs. 6-10.
1903. *Dercitus simplex*, Thiele, *Abh. Senckenb. Natur. Gesellsch.* XXV, p. 20, pl. ii, fig. 1.
1903. *Dercitus simplex & D. plicatus*, v. Lendenfeld, *Das Tierreich*, *Tetraxonia*, pp. 81, 82.
1905. *Stoeba simplex & S. plicata*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, pp. 71, 230.

Carter mentions spicules of his *Samus simplex* as being among those he extracted from a specimen of dead coral in the late Dr. Anderson's Mergui collection. From the same specimen I have been able to extract numerous pieces of this sponge in sufficiently good condition to study its general structure and spiculation; the latter is evidently more varied than either Carter himself or Sollas realized and is apt to be not fully understood because certain spicules are practically confined to certain parts of the sponge. I am of the opinion that Topsent's suggestion (1895, p. 536) as to the specific identity of the species with Schmidt's *Corticium plicatum* is fully justified by the specimens I have examined.

The sponge, as it exists in dead coral, forms small oval or globular masses which entirely fill corresponding cavities. From these are given out slender, cylindrical or flattened branches, some of which join them to other similar masses, while others terminate in flattened and often ramifying lamellae. The latter make their way among interstices of the calcareous material. The larger masses contain a dense crowd of well-formed triaenes arranged with their sharply pointed shafts pointing outwards, but in the connecting branches the macroscleres are more scanty and more delicate in form, while they are practically absent in the distal parts of the lamellae. In the proximal parts thereof they have precisely the form of the small slender spicules figured by Topsent (1895, pl. xxii, *o'*, *d'*), whereas in the larger masses they agree equally well with the figures *o* and *d* on the same plate. The proportions of all these types of spicules also agree with Topsent's description. Spicules of the "calthrops" type are extremely scarce in my specimens. Indeed, I was for some time of the opinion that they were altogether absent. After a prolonged search through spicule-preparations, however, I at last succeeded in

finding one. The microscleres are a little larger than in Topsent's European specimens, measuring about 0·0162 mm. in length, and their spines are much shorter and more slender than is indicated in Schmidt's original figure. They are extremely numerous in the ectosome all over the sponge, but almost absent from the choanosome. The large cells containing brown granules to which Topsent and other authors refer are still conspicuous, after about 28 years in spirit.

S. plicata is common in dead coral in Indian seas, but in all the specimens I have examined seems to be associated with some species of *Cliona*. In places where the coral is of a crumbling consistency the external surface of the sponge is often covered with small calcareous granules of irregular form, while the larger masses of sponge often contain in their interior larger granules of a similar nature. These granules are larger than those produced by the activities of *Cliona*. The more slender processes of the *Stoeba* are as a rule in contact with the *Cliona* and often contain *Cliona*-spicules in their ectocyst and choanosome.

In consideration of its method of life and growth this Indian form of *Stoeba plicata* is perhaps worthy of a varietal name and should be known as *S. plicata* (Schmidt) var. *simplex* (Carter), for Topsent (1895) in his elaborate account of the species, as it occurs in the Mediterranean, makes no mention of the peculiarities noted in the preceding paragraph.

Family STELLETTIDAE.

Stelletta vestigium, Dendy.

1905. Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 78, pl. ii, fig. 7.

My specimens of this species are from the same fragments of dead coral as those in which the specimens of *Stoeba plicata* var. *simplex* described above were found. They permeate the coral in a fine network of slender strands and in part, at any rate, occupy the excavations of *Cliona viridis* (Schmidt), spicules of which adhere to their ectosome. The original specimen is described as "irregular in shape, massive, encrusting, and containing many foreign bodies." Possibly it commenced its growth in the same manner as the example from Mergui, which agrees with it closely in spiculation and, so far as it is possible to say, in general structure.

The species is only known from Ceylon and Tenasserim.

Grade MONAXONELLIDA.

Family EPIPOLASIDAE.

Coppatias penetrans (Carter).

1880. *Tisiphonia penetrans*, Carter *Ann. Mag. Nat. Hist.* (5) VI, p. 141, pl. vii, figs. 44*a–d*.

1905. *Coppatias* (*Tisiphonia*) *penetrans*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 231.

A minute sponge of which the spicules agree well with Carter's description and figures occurs in abundance in dead reef-coral from Port Mouat in the Andamans, occupying the burrows of various boring organisms and in particular those of *Cliona ensifera* and *C. lobata*. The form of the sponge is precisely that of the cavity it occupies. It is of solid structure, the natural cavities being small except when occupied, as is often the case, with fragments of calcareous matter. Specimens treated with acid are apt to appear cavernous owing to these fragments being dissolved. The ectosome, which is in contact with the wall of the burrows occupied, is thin but somewhat impenetrable by liquids and it is difficult to clear specimens in oil of cloves. The whole structure of the organism is on so minute a scale that it could only be elucidated properly by means of sections of specially preserved material, which I do not possess.

Coppatias investigatrix, sp. nov.

(Plate xxxiv, figs. 1, 2.)

This sponge is closely related to *C. penetrans*, with which it agrees in habits, but the macroscleres are as a rule spined near the tips and the microscleres exhibit much greater diversity of form. Unlike *C. penetrans* it is a deep-sea species.

Sponge.—In its early stages the sponge consists of minute masses of an irregularly oval form. These penetrate into the burrows of Clionids in shells, then increase in size and assume the shape of the spaces they occupy; before doing so completely, they give out relatively slender, blunt, finger-like processes. The internal structure appears, so far as can be seen, to resemble that of *C. penetrans*.

Spicules.—Both macroscleres and microscleres are very variable. The majority of the latter are slender, spindle-shaped amphioxi about 15 to 30 times as long as broad, smooth for the greater part of their length, but bearing scattered, sharp, erect spines near the two extremities, the actual tips being smooth. Smaller absolutely smooth amphioxi also occur.

The microscleres are of three kinds, *viz.* (*a*) oxyasters with spined tips, (*b*) spherasters with spined tips, and (*c*) smooth spherasters. Intermediate forms occur, however, in all cases.

The spiny oxyasters have as a rule six cladi, but may have only four, or occasionally more than six. The tips are sharply and gradually pointed and bear sharp erect spines scattered rather densely. There is no distinct central nodule and the bases of the cladi are smooth.

The spiny spherasters are merely more compact forms of the same type, with a larger number of shorter and stouter cladi fused together at the base. They are, as a rule, smaller than the oxyasters, but every intermediate form of spicule can be found.

The smooth spherasters have still shorter and more numerous cladi than the spiny ones and a relatively larger central sphere.

The degree to which the spines are developed on the spherasters is, however, as variable as the proportions of their several parts

Measurements of Spicules.

Length of spiny macroscleres	..	0·098—0·205 mm.
Length of smooth macroscleres	..	(average) 0·115 ,,
Diameter of oxyasters	..	0·0126—0·0252 ,,
Diameter of spiny spherasters	..	(average) 0·0126 ,,
Diameter of smooth spherasters	..	,, 0·0115 ,,

FIG. 1.—Spicules of *Coppatias investigatrix*, sp. nov.

Type.—No. 64 5/7 ZEV, *Ind. Mus.*

Locality.—Off Ceylon in 703 fathoms: with *Thoosa investigatoris* in a dead Gastropod shell (in alcohol).

At points at which the *Coppatias* comes in contact with the *Thoosa*, the latter secretes a thick horny covering through which the tips of its own macroscleres penetrate (pl. xxxiv, fig. 2).

Family CLIONIDAE.

The following notes on the Clionidae are based on a small collection recently made by Mr. S. W. Kemp at Port Blair in the Andamans. All the specimens are from shallow water and, except the first, from dead reef-coral.

Cliona carpenteri, Hancock.

Shells of edible oysters (*Ostrea viriginiana*, Gmel.) from the head of Port Blair harbour are riddled with the galleries of this sponge, precisely as shells of the same species of oyster are riddled with those of *C. vastifica* in lagoons on the east coast of continental India.

Cliona mucronata, Sollas.

Well preserved specimens of this peculiar sponge occur in fragments of dead reef-coral with those of the two following species. They agree closely with Sollas's original figures in respect of the structure of the characteristic diaphragms.

Cliona quadrata, Hancock.

1849. *Cliona quadrata*, Hancock, *Ann. Mag. Nat. Hist.* (2) III, p. 344, pl. xv, fig. 6.
1881. *Cliona warreni*, Carter, *ibid.* (5) VII, p. 370, pl. xviii, fig. 6.
1900. *Cliona quadrata*, Topsent, *Arch. Zool. expérim.* (3) VIII, p. 54.

Topsent is undoubtedly right in regarding Carter's *C. warreni*, which came from the Gulf of Manaar, as synonymous with Hancock's species of unknown *provénance*. Well-preserved specimens are present in Mr. Kemp's collection.

Cliona kempi, sp. nov.

This species is closely allied to *C. lobata*, Hancock and *C. michelini*, Topsent, but is distinguished from both by the complete absence of microscleres.

The galleries are almost cylindrical but swell out slightly at intervals. They branch sparingly, giving off slender lateral branches that bifurcate acutely. The whole growth is slender and sparse. Diaphragms containing spicules that lie transversely occur at irregular intervals. The galleries lie completely in one plane, parallel to and only a short distance below the surface of the coral.

The papillae are numerous but of very small size. They are each guarded by a dense mass of upright spicules which, at any rate in the centre of the papilla, have a somewhat spiral arrangement.

There are numerous large cells in the parenchyma that contain granules of a comparatively pale brown colour.

The *spicules* are small, moderately slender and all of one kind. They are by no means numerous except in the papillae; in the galleries, except in the diaphragms, they lie parallel to the surface. They are somewhat variable in form, but are all tylostyles with well-developed heads. These are usually subglobular but may be trilobed or irregular; occasionally they contain a single relatively large dilatation of the axial canal There is occasionally a projecting annulus a short distance below the head. The shaft is as a rule slightly curved; its curvature may be of a general nature or confined to the uppermost third. Immediately below the head the shaft is slightly constricted; lower down it swells slightly but never becomes quite as broad as the head; the broadest part is usually situated in the upper half and the lower half tapers very gradually to a fine point.

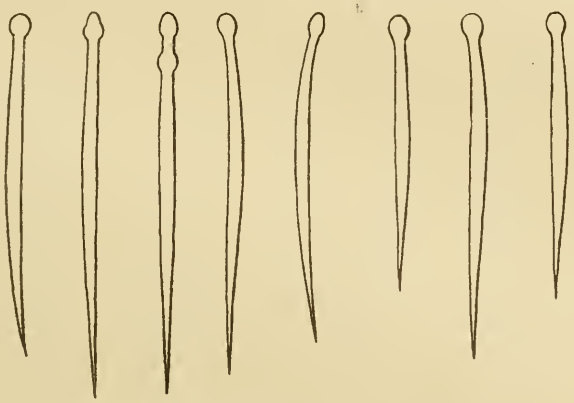

FIG. 2.—Spicules of *Cliona kempi*, sp. nov.

Measurements of Spicules.

Length of spicule	0·127—0·205 mm.
Greatest breadth of shaft ..	0·0041—0·0082 ,,
Diameter of head	0·0082—0·0125 ,,

Type.—No. 6956/7 ZEV, *Ind. Mus.* (on slide in Canada balsam).

Locality.—Port Blair, Andaman Is., Bay of Bengal: in dead reef-coral with *Cliona lobata* and *C. mucronata.*

Thoosa hancocci, Topsent.

1915. *Thoosa hancocci,* Annandale, *Rec. Ind. Mus.* XI, p. 21.

The species is evidently common in dead coral in the Andamans. Specimens in Mr. Kemp's collection all possess nodular amphiasters, but these spicules, which are confined to the papillae, are present only in very small numbers. In some papillae they are altogether absent, and there are never more than about half a dozen in any one papilla. These specimens, therefore, which

are well preserved in spirit and had evidently reached their full or about their full development, on the whole bear out what I have said in the paper cited on the possible disappearance of the nodular amphiasters in certain phases of the species.

Family DESMACIODONIDAE.

Subfamily *ECTYONINAE.*

Rhabderemia prolifera, sp. nov.

(Plate xxxiv, fig. 3.)

The *sponge* forms an excessively thin film, much less than 1 mm. thick, and coats the burrows of *Cliona* in dead coral. Its surface bears numerous small rounded buds, each of which con-

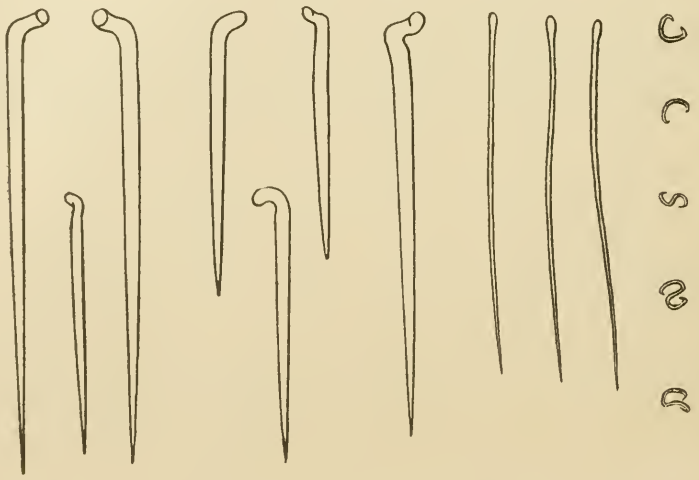

Fig. 3.—Spicules of *Rhabderemia prolifera,* sp. nov.

tains in its centre a particle of calcareous matter. In dried specimens the surface is hispid, but this character may be artificial. The apertures are very small and cannot be detected with certainty in dried specimens. There is a very thin, colourless basal membrane. Owing to the manner of growth, specimens extracted from the coral by the use of acid often appear to be turned completely inside out, or else to contain large irregular cavities in their interior; both appearances are easily explained if the small size of the chambers occupied by the sponge is remembered, and also its own filmy form. The masses that seem to be inside out are merely hollow membranes that have lined the walls of small chambers of corresponding form and size and the surface exposed when the coral is dissolved away is the basal surface of the sponge that was in contact with the wall, while the existence of relatively large spaces of irregular shape in masses in which the true

external surface is outermost is due to the fact that they have grown round projecting fragments of coral at the angles of the Clionid's galleries and that these fragments have disappeared owing to the action of the acid.

Spicules.—There are three kinds of spicules, *viz.* (*a*) comparatively stout, smooth styli of the type called rhabdostyles by Topsent[1] in his definition of the genus, (*b*) much more slender, almost hair-like tylostyli, which are shorter than the longest rhabdostyles and (*c*) small, much contorted sigmata.

The rhabdostyles are perfectly smooth and have their heads almost truncate, not at all swollen and as a rule spirally contorted in two whorls. They are actually rather slender and vary greatly in length; indeed, two series may perhaps be distinguished as regards size, but intermediate forms occur. Those of the larger series are on an average about 0·176 mm. in length; those of the smaller series not more than 0·099 mm. The shaft tapers gradually to a fine point.

The dermal tylostyles are curved or sinuous, perfectly smooth, very slender and almost hair-like in appearance; they are longer than the shorter rhabdostyles. Their heads are of an elongate oval form and often not at all clearly differentiated.

The sigmata are fairly uniform in size, small and slender, variable in shape but never having a complete twist or knot in the centre and never enlarged at the extremities.

Skeleton.—The skeleton is very degenerate and the number of spicules present is comparatively small. The rhabdostyles stand separate and semi-erect, with their contorted heads resting on the basal membrane and their shafts pointing obliquely upwards. The tylostyles lie horizontal in ill-defined bundles, which are often comparatively broad and sometimes form as a whole well-marked curves, but are never reticulate. The sigmata are scattered sparsely without definite arrangement. The slender tylostyles are more numerous than either of the other two kinds of spicules.

Measurements of Spicules.

Length of rhabdostyles ..	..	0·0902—0·209 mm.
Diameter of shaft of rhabdostyles	..	0·0057—0·0082 ,,
Length of slender tylostyles	..	0·147 mm.
Length of sigmata ..	..	0·0123 ,,

Type.—No. 6420/7 ZEV, *Ind. Mus.* (mounted in Canada balsam on a slide).

Locality.—Port Mouat, Andaman Is., Bay of Bengal ('*Investigator*').

The type-specimen occupies the galleries of *Cliona viridis* in a piece of dead Madreporarian coral. The external surface of the

[1] *Rés. Camp. Sci. Monaco*, fasc. II (Spongaires de l'Atlantique Nord), p. 115 (1892).

coral is much eroded owing to the attacks of various burrowing organisms and part of the galleries excavated by the *Cliona* have completely broken down, leaving a fairly large open cavity. The growth of the *Rhabderemia* appears to have commenced in this cavity and then to have proceeded inwards along the excavations of the other sponge, parts of which it had completely surrounded and was apparently in the act of engulfing.

The buds to which reference has been made are merely portions of the sponge that have grown over projecting fragments of coral in the angles of the galleries and have then become constricted at the base.

The specimen, though dry, is in good condition, having originally been preserved in spirit.

The species is very closely related to *R. pusilla* (Carpenter)[1], of which it should perhaps be regarded as a variety. It is distinguished, however, by its larger sigmata, which are of a slightly different type, its longer slender styli (or tylostyli), and its stouter and more variable rhabdostyli. Topsent describes *R. pusilla* as an excessively thin "éponge jaune pâle revêtante." The only Indian sponge hitherto referred to the genus *Rhabderemia* is Dendy's *R. indica*[2] from Ceylon. It has short roughened styli and sigmata that are often twisted into a complete knot in the centre; the skeleton is reticulate.

Family AXINELLIDAE.

Genus **Amorphinopsis**, Carter.

1887. *Amorphinopsis*, Carter, *Journ. Linn. Soc. London* (*Zool.*) XXI, p. 77.
1896. *Spongosorites*, Topsent, *Mém. Zool. Soc. France* IX, p. 117.
1900. *Spongosorites*, *id.*, *Arch. Zool. exbérim.* VIII, p. 265.
1905. *Spongosorites*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 182.

In examining a fragment of the piece of dead sponge-riddled coral described by Carter in 1887 I came across a small sponge that afforded me much difficulty, until I had compared my preparations with others made from the material sorted out and named by that author. On making a comparison I could not remain in doubt that this sponge was the same as the one named by him *Amorphinopsis excavans*; indeed, it was probably a schizotype of that species. Carter's descriptions are as a rule remarkably clear and accurate, but this was not the case in the present instance, in which his figures are actually misleading. He gave no separate description of *Amorphinopsis*, the generic characters of which he left to be inferred mainly from his specific diagnosis.

The sponge agrees with Topsent's description of *Spongosorites*, except in the fact that its spicules are not "biangulate." In Car-

[1] *Microciona pusilla*, Carter, *Ann. Mag. Nat. Hist.* (4) XVIII, p. 239, pl. xvi, fig. 51 (1876) and Topsent, *Mém. Zool. Soc. France* 1889 (II), p. 41, fig. 7.
[2] In Herdman's *Ceylon Pearl Fish.* III, p. 180, pl xii, fig. 10 (1905).

ter's figure the amphioxi are shown as having a regular curve, but this is by no means always the case and though they are not swollen in the middle they are often distinctly geniculate at or near that point. With Dendy's redefinition of *Spongosorites* the species agrees precisely. All this is made abundantly clear when *A. excavans* is compared with the form here described as *A. excavans* var. *digitifera*.

The genus *Amorphinopsis* may now be redefined as follows :—

> Axinellidae of encrusting, reticulate or massive shape, sometimes bearing upright branches or conuli ; the skeleton composed of stout spicule-fibres containing little horny material and forming a coarse and irregular reticulation. The fibres consist of large, smooth styli or amphioxi, or of a mixture of smooth styli and amphioxi, lying parallel to one another. Smaller spicules of the same types surround the fibres and as a rule form a horizontal layer in the ectosome. Some or all of the spicules are geniculate in the middle; sometimes they are also inflated at this point.

Amorphinopsis excavans, Carter.

1887. *Amorphinopsis excavans,* Carter, *op. cit.*, p. 77, pl. v, figs. 12-15.

The sponge in Carter's specimen consists of a thin external crust and a network of fine cylindrical basal branches that ramify in the excavations of Clionidae in dead coral. The external crust is remarkable for the curious little prominences or bosses with which it is ornamented and for the strands of spicules that radiate from them. The regularity of their arrangement is somewhat exaggerated in Carter's figures. The prominences seem to me to be no more than incipient, or possibly abortive, conuli or branches. Each probably contains an osculum obliterated by contraction. There is a dense external covering of smaller spicules lying horizontally and matted together on the surface of the sponge. The internal or basal branches rarely contain more than a single stout strand of spicules, but they ramify and anastomose in accordance with the ramifications and anastomosings of the cavities they occupy. A horizontal reticulation of fibres occurs near the surface.

The spicule-fibres, whether on the surface or inside the coral, consist mainly of the larger spicules, which are for the most part true amphioxi. Occasionally a slender sub-stylote spicule is to be found amongst them, while a comparatively large number of true styli are also present. The last are as stout as the stoutest amphioxi, but usually shorter. All the amphioxi are more or less curved and most are crescentic in form ; a few are, however, distinctly geniculate at or near the middle and forms (which must be regarded as mere abnormalities) may be found in which there is a regular angle near one end.

The smaller spicules, which surround the fibres in an irregular manner as well as forming a layer on the surface of the sponge, comprise both amphioxi and styli. The former resemble the

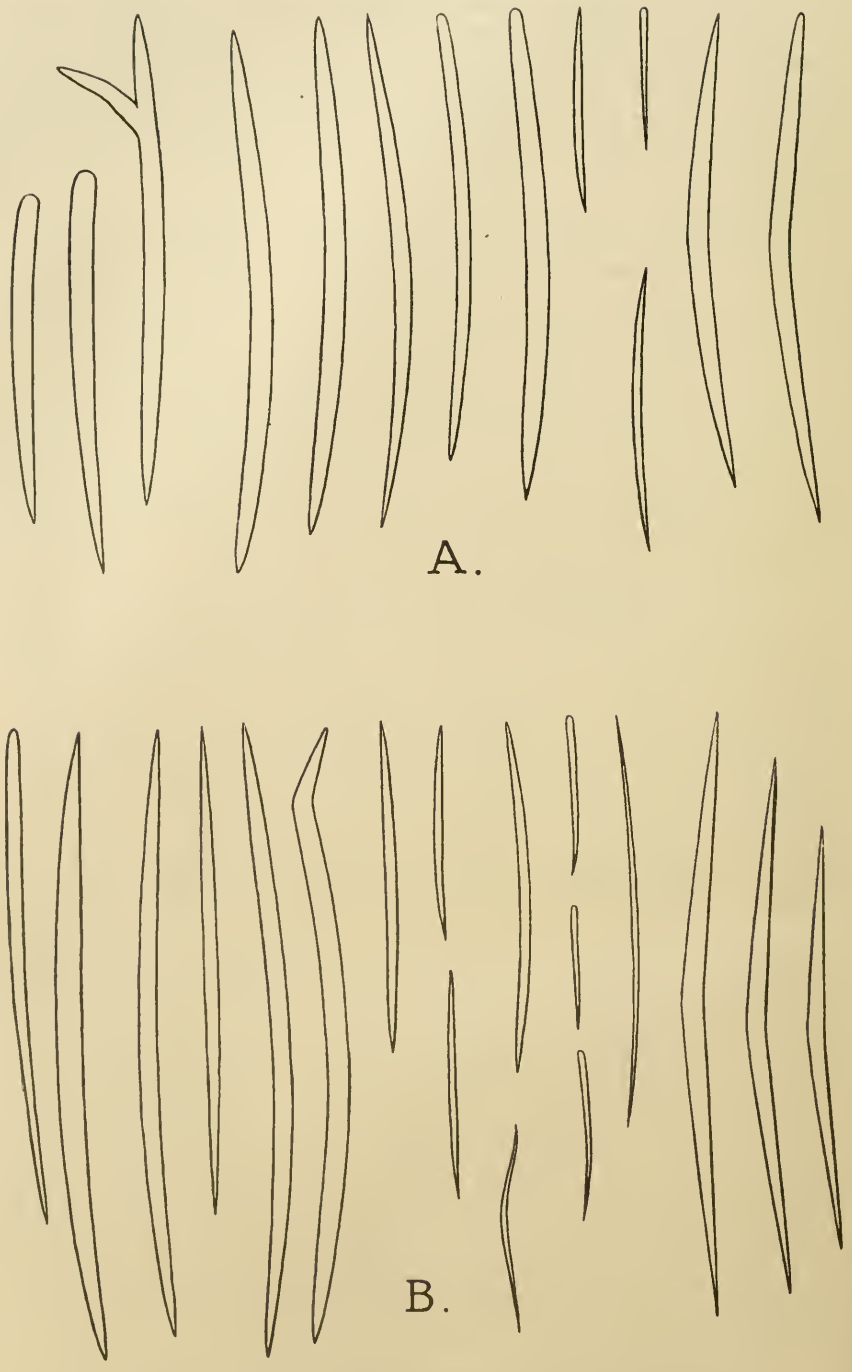

Fig. 4.—Spicules of *Amorphinopsis excavans*, Carter.

A. From the type of the species.
B. From the type of var. *digitifera*, nov.

larger amphioxi in shape and proportions, but the latter are usually straight or nearly so.

Schizotype.—No. 6597/7 ZEV, *Ind. Mus.* (dried specimen).

Spicules of *Chona* often occur in the parenchyma and films of *Chondrilla* sometimes envelop the basal branches.

var. **digitifera**, nov.

1913. *Spongosorites* sp., Sewell, *Journ. As. Soc. Bengal* (n.s.) IX, p. 346.

I have had by me for some years a sponge that I identified provisionally for Capt. Sewell as a new species of *Spongosorites*. A comparison with Carter's *A. excavans* shows an absolute identity of skeletal structure, though the external form is very different and slight differences in spiculation can be detected. I propose therefore to regard this sponge as a variety of *A. excavans*, of which it may be no more than a growth-phase.

The sponge consists of a number of short, pointed, somewhat compressed upright branches of rather irregular outline, united by means of a crust in which are embedded numerous small stones (non-calcareous) and dead shells of Lamellibranchs and Balanidae. The longest branches are about 30 mm. long and about 14 mm. broad at the broadest point; their thickness is about 7 mm. The shortest axis is directed towards the centre of the mass. The whole specimen is about 100 mm. long by 40 mm. broad, but has probably formed part of a larger mass. In spirit the colour is dirty white. The sponge is rather hard but can be torn easily.

The external surface is in places obscurely and minutely reticulate, elsewhere distinctly hispid. No external orifices

FIG. 5.—Vertical section through the skeleton of the distal part of a branch of *Amorphinopsis excavans* var. *digitifera* (enlarged).

can be detected and it is probable that both oscula and pores are highly contracted.

The internal structure of the sponge is somewhat cavernous and several large canals run vertically up each branch, one situated in the middle being as a rule of greater calibre than the others. Probably the oscula are situated near the tips of the branches and the pores on the hispid parts of the surface.

The skeleton forms a dense, irregular network. In the branches its fibres curve upwards and outwards towards the external surface; as a rule they are directed mainly towards the inner side of the branch. They frequently fuse together to form strands of great thickness, but seem to contain little or no horny matter. There is a horizontal reticulation of fibres below the external layer of small spicules. The larger spicules are closely packed together in the fibres and lie quite parallel to one another. The external layer of small spicules is horizontal over the greater part of the surface but in the hispid parts the spicules are vertical and little upright bunches can sometimes be detected that project through the dermal membrane. The bunches are arranged with considerable regularity at fairly equal distances. Sometimes they coincide in position with the terminations of skeletal strands, but this is not always so.

The spiculation differs from that of the typical form in the complete absence of large stout styli and in the fact that the large amphioxi are on an average considerably shorter.

Type.—No. 5010/7 ZEV, *Ind. Mus.* (in spirit).

Locality.—Rock-pool at Fisher Bay, Tavoy I., off the coast of Tenasserim.

This sponge approaches *Dactyella*, Thiele[1] in structure and fully bears out Dendy's[2] suggestion as to a possible relationship between the two genera. Indeed, I doubt whether they are distinct.

Family CHONDROSIIDAE.

Chondrilla nucula, Schmidt.

1862. Schmidt, *Spong. Adriat. Meeres*, p. 39, pl. iii, figs. 22, 22*a*.
1877. Schulze, *Zeitschr. Wiss. Zool.* XIX, p. 108, pl. ix, figs. 11-18.
1881. Carter, *Ann. Mag. Nat. Hist.* (5) VII, p. 384.
1889 (1887). ? *Id. (Cliona stellifera ?)* in part, Anderson's *Fauna of Mergui* I, p. 62.
1891. Keller, *Zeitschr. Wiss. Zool.* LII, p. 327.
1892. Topsent, *Rés. Camp. Sci. Monaco*, fasc. II, p. 54.

A re-examination of part of Carter's original material leaves no doubt that the provisional species he described in 1889 under the name of *Cliona stellifera* ? was founded on the association of spicules of a *Cliona* with those of a *Chondrilla*. The *Cliona* was in all probability *C. viridis*, while the *Chondrilla* was either *Ch. nucula*, *Ch. mixta* or *Ch. distincta*, if it was not composed of all

[1] Stüd. ü. pacif. Spongien, *Bibl. Zool.* XXIV (i), p. 55 (1898).
[2] In Herdman's *Ceylon Pearl Fisheries*, III, p. 182 (1905).

three species. *Cliona viridis* is particularly abundant in the masses of dead coral from which he extracted the spicules on which he based his description, or rather indication, and it is frequently covered by a thin film, of one or other of the Chondrillae. The only other species of *Cliona* [1] present is *C. ensifera*, which Carter distinguished from "*stellifera*."

The specimens of *Ch. nucula* I have examined from this material consist of extremely thin films much less than 1 mm. thick and spread out over the surface of *Cliona viridis*, *C. ensifera* and *Stoeba simplex* in their excavations in dead coral. The spicules correspond well with the figures cited above and agree in dimensions (diameter 0·01 to 0·2 mm.) with those of a specimen from the Red Sea examined by Keller. They are densely crowded in the ectosome and frequently touch one another in that part of the sponge. The colour, after some 28 years in spirit, is pale brown. The film is usually uniform, but sometimes reticulate. The fragments extracted have been very imperfect.

Ch. nucula is cosmopolitan in distribution. It has been recorded from the Mediterranean, the Azores, the Red Sea and the Gulf of Manaar. The specimens referred to above are from King I. in the Mergui Archipelago, which lies off the coast of Tenasserim, the southern extension of Burma.

Chondrilla mixta, Schulze.

1877. Schulze, *op. cit.*, p. 113.
1891. Keller, *op. cit.*, p 327.

In the same fragments of dead coral, and in precisely similar conditions, I find imperfect examples of another *Chondrilla* which agrees well enough with Schulze's description of *Ch. mixta* so far as the shape and arrangement of the spicules are concerned. The film it forms in these circumstances is still more delicate than that formed by *Ch. nucula* and is quite colourless. The spicules include both oxyasters and spherasters, the largest of both of which are not more than 0·012 mm. in diameter.

Distribution.—Red Sea (*Schulze*); Mergui Archipelago, Burma.

Chondrilla distincta, Schulze.

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

1877. Schulze, *op. cit.*, p. 133, pl. ix, fig. 19.
1903. Thiele, *Abh. Senckenb. Natur. Gesellsch.* XXV, p. 67, pl. iii, fig. 20.

Still in the same fragments of coral from Burma a third species of *Chondrilla* occurs, in the same circumstances. It is undoubtedly *Chondrilla distincta*, Schulze, with which its spicules agree in every respect.

[1] Not having Carter's full material in my hands, I have been unable to find the spicules he associated in his provisional species *Cliona sceptrellifera?*. In any case this species, if it exists as such, is clearly not a *Cliona*.

Owing to the more robust form of this sponge it has been possible to extract larger and more complete pieces, which exhibit its manner of growth in the burrows of *Cliona*. The specimens were found in the centre of a piece of coral about 4 cm. thick. No part of the sponge was visible on the surface of the coral. It consisted of irregular cylindrical, ramifying and even reticulate masses, the component branches of which were about 2 mm. thick. The colour was deep purple-brown, except at the extremities, where it was much fainter, if not altogether absent. The surface was for the most part smooth, but crater-like pits surrounded by a particularly dense zone of spicules occurred sparingly. Large oval cells containing brown pigment-granules could be detected in the choanosome. At many points the greater part of the ectosome was entirely concealed by spicules, mostly spherasters. Oxyasters occurred sparingly in the choanosome.

The most interesting feature of the sponge, however, consisted in little tentacle-like club-shaped branches (pl. xxxiv, fig 4*a*) the free extremities of which were densely covered with spherasters, while the cylindrical portions were bare of spicules or almost so. In some cases the tips of these branches were in contact with the surface of other sponges or of tubes constructed among them by Polychaete worms. Wherever this occurred the tip was splayed out and, if the sponge touched was a *Cliona*, the latter was protected by a dense layer of its own macroscleres and by a chitinous sheath (pl. xxxiv, fig. 4). Some cases were seen in which the expanded tip of a branch of the *Chondrilla* was actually spreading out in a thin, colourless film over the surface of another sponge or of a worm-tube. We have here proof of actual aggression on the part of the *Chondrilla*, and evidence of the methods by which *Cliona* defends itself against such aggression. This subject is discussed later (p. 476). In every case, on the other hand, in which *Stoeba plicata* is the sponge attacked by this or other species of *Chondrilla* its ectosome, with the microscleres abundant in that part of the sponge, had disappeared where the attacking sponge had covered it.

Part II.—BIOLOGICAL.

The large proportion of the sponges referred to in this paper were found in two small pieces of dead Madreporarian coral, neither weighing more than a few ounces. One piece came from the Andamans, the other from the Mergui Archipelago. The former is a portion of a somewhat larger specimen examined by Carter many years ago and described by him in his account of the sponges collected by the late Dr. John Anderson. He found in it examples of no less than 8 species of sponges and yet it is clear that his examination was not exhaustive, for (in addition to the majority of the species he noticed) the fragment now in the Indian Museum contains at least four others. There seems to be a stage in the decay of the more solid Madreporarian corals at which their

skeletons become peculiarly attractive to a large number of small sponges, some of which are true excavators, while others are primarily thin encrusting forms able to exist on a solid even surface but preferring an irregular one, and capable of penetrating into its interstices. Sponges of both kinds play an important part in the final disintegration of both corals and calcareous algae.[1]

I have recently pointed out elsewhere [2] that sponges which excavate their burrows in molluscan shells are often liable to be killed by the growth of encrusting forms. The association of such species as *Cliona vastifica* and *Laxosuberites aquaedulcioris*, though it may be physically intimate, is evidently quite fortuitous; the *Laxosuberites* merely happens to grow on the surface of the oyster-shells in which the *Cliona* has burrowed, and its presence, though ultimately fatal, is not correlated with the presence of the other sponge; it grows on many shells that the Clionid has not attacked and is in no way prejudiced by so doing.

Off the coast of Orissa and the north of the Madras Presidency oyster-shells are often attacked by another species of *Cliona*, recently described as *Cliona acustella*,[3] which ultimately eats away the entire surface, leaving it deeply and densely pitted. Apparently the excavator retires deeper into the shell when this occurs. The roughened surface it has produced is, however, attractive to at least two kinds of very thin encrusting sponges, both of which belong to the genus *Eurypon*. They are not content with the surface, however, but pursue the *Cliona* into its retreats, coating the walls of its galleries and apparently driving it before them. In other Lamellibranch shells (of *Ostrea*, *Malleus* and *Tridacna*) from Indian seas I have found the remains of sponges of similar habits that belong to allied but probably undescribed genera and have little doubt that the species originally described by Hancock as *Cliona purpurea* [4] is a form of the kind There is no evidence that any of these Desmaciodonid sponges actually attack the Clionid with which it is associated, and I have never found spicules of the latter family embedded in the substance of one of the former; they merely overwhelm them or suffocate them and usurp their place. Unfortunately the remains of sponges of this kind now in my hands are insufficiently preserved to justify technical descriptions.

The Tetraxonellid sponge *Stelletta vestigium* (*antea*, p. 459) goes a little further. It is a more massive species than those alluded to in the preceding paragraph, and makes its way into the burrows of Clionidae, not by merely growing along their walls, but by thrusting practically solid processes into them. When these processes come in contact with the rightful owner of the burrow

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[1] Carter has described a collection of boring organisms from calcareous algae from the Gulf of Manaar. See *Ann. Mag. Nat. Hist.* (5) VI, p. 150 (1880).

[2] *Mem. Ind. Mus.* V, p. 35 (1915).

[3] *Rec. Ind. Mus.* XI, p. 14 (1915).

[4] See Topsent, *Arch. Zool. expérim.* (4) VII, p. xvi (1907).

its spicules adhere to and are even incorporated in what we may call for this purpose the "skin" of the aggressor.

Amorphinopsis excavans has similar habits, but takes the borrowed spicules into its own internal parts.

Stoeba plicata var. *simplex* differs from these species in that it possesses independent powers of excavation and only uses the burrows of Clionidae as the basis of its own operations. It adapts and enlarges these burrows and at the same time not merely attaches the spicules of its host to its own surface, but takes them into its own inner parts and possibly even utilizes them in strengthening its own attenuated and delicate terminal processes.

Coppatias investigatrix—and possibly also *C. penetrans*—attack in a similar manner, but its parasitic character is more marked, in that, having once penetrated into the burrows of a Clionid, it is content with them and so far as its external form is concerned becomes a mere cast of them. Moreover, it enters the burrows at a comparatively early stage of development and appears to have only a short-lived and very inconspicuous encrusting phase.

All these sponges may be classed, in greater or less degree, as parasites, in that they appropriate the fruit of the labours of other species and even possibly make use in some cases of the spicules of the sponges they attack. There is no evidence, however, that they feed on the bodies of their victims. In the case of the three species of *Chondrilla* and of *Rhabderemia prolifera* it is possible that the attacking species does so, for the Clionid is actually overwhelmed and engulfed, not merely thrust before the invader. The method of attack is not the same in the case of the Chondrillae as in that of the *Rhabderemia*. The former give rise to peculiar capitate tentacle-like processes when they approach the Clionid or any other body with which they may come in contact. The heads of these processes, which are armed with spicules, spread out over any surface that they happen to touch. If they do so on the surface of another sponge they surround it and absorb it completely.

The *Rhabderemia*, on the other hand, which forms a much thinner film as a whole, spreads bodily round portions of the Clionid, which it ultimately absorbs in a similar manner.

It is noteworthy that the great majority of all these parasitic sponges are known to have free encrusting phases or varieties, which are able to exist independently of the labours of other species. *Coppatias penetrans* and *C. investigatrix*, and possibly *Rhabderemia prolifera*—if the latter is to be regarded as specifically distinct from *R. pusilla*—are apparently exceptions. They seem to have become specially adapted for a parasitic life, but it is very desirable that further investigations should be made into their minute structure.

Most of these sponges are probably able to enlarge the burrows that they occupy, though there is no evidence that *C. investigatrix* and *C. penetrans* do so, by the mere expansion of their

growth. If the material into which they have penetrated is at all soft or crumbling this causes it to split or even to fall in pieces, and the final result of the parasitism of most of the invading sponges must be to produce a state of affairs in which it is necessary for them, unless they are to perish altogether, to assume again an independent form of existence. Sooner or later they destroy the walls of their retreat and so are once more exposed.

The species of *Stoeba* and *Coppatias* do not depend solely on expansion as a means of penetration, for they are able to break off fragments of calcareous matter. These are more or less rounded in form and are stored up in the interior of the sponge. How the fragments are broken off we do not know, but it is evident that the sharp points of the spicules play an important part in the operation. Even in the case of the Clionidae the precise method by which the burrows are excavated is not yet by any means clear. It has been shown [1] that the action of acid is absent, and it seems most probable from the disposition of the spicules in the growing points of the sponge that little pieces of shell or coral are broken off, not merely by impact of the spicules, but also by a rotary action. The points of a number of macroscleres are probably directed in a circle covering a small area of the surface on which they are to work. The heads of these spicules may be then rotated by what would be called in an animal more highly organized than a sponge, muscular action. The fragments observed in the interior of *Coppatias* and *Stoeba* are as a rule larger and of less regular shape than those produced by the activities of *Cliona* or *Thoosa*, and it seems probable that the operation by which they are produced is of a less specialized nature than in the case of the Clionidae. Moreover, the manner in which the spicules are arranged appears to be much more haphazard, and we can only suppose that their action is less concerted.

The fragments of calcareous matter removed by *Rhabderemia prolifera* are certainly separated by an entirely different process. The species of *Coppatias* and *Stoeba* that invade Clionid burrows grow forwards as bodies that are practically solid, whereas the *Rhabderemia* merely coats the walls of the excavations it invades as an extremely thin film. This film grows round projecting fragments of coral and separates them from the walls by constricting itself round their bases. There is no evidence that the contained particles of calcareous matter are of any utility to the other species, but to this sponge they are probably directly useful. The film that surrounds each fragment contracts away from the main body of the sponge and forms a bud that separates itself from its parent and doubtless aids in the distribution of the species by so doing. The fact that it has a solid core of relatively heavy material must aid it considerably by causing it to fall away more readily.

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[1] For a full discussion see Topsent, *Arch. Zool. expérim*, (2) V [2], pp. 59-71 (1887).

The fact that a considerable number of small encrusting sponges are in the habit of invading and occupying the excavations of Clionidae to the detriment of the latter is quite clear from the foregoing notes, and I have abundant evidence that the parasitic species described form only a very small proportion of the sponges of similar habits that exist in Indian seas, more particularly on the decaying parts of coral reefs. The question naturally arises, How do the Clionidae protect themselves? No direct observations on this point have been made in the field but in the case of *Thoosa investigatoris* and *Coppatias investigatrix* the fact that the invading sponge was evidently in a comparatively early developmental phase enabled some interesting deductions to be made. Fig. 1 on pl. xxxiv shows a young sponge of *C. investigatrix* which has just penetrated into the outer part of a burrow of *T. investigatoris*. The shell has been dissolved away and one sees in the lower part of the figure the base of an exhalent papilla from below, the middle of the figure is occupied by the *Coppatias*, while in the upper part a confused mass of spicules belonging to the Clionid is shown. The invading sponge appears to have made its way through an inhalent papilla that has degenerated into a mere confused mass; it is shown in the upper part of the figure. The *Coppatias*, however, has not merely penetrated the papilla, for it contains small cavities that apparently represent fragments of calcareous matter detached by itself. Fragments of precisely the same shape and size were observed *in situ* in preparations in which the action of the acid used in extracting them from the shell had not gone so far.

There are several points of interest to be noted in this preparation. Firstly, the Clionid has secreted a horny membrane [1] (*h.c.*) wherever it is in contact with the invading sponge. Secondly, the exhalent papilla (*e.p.*) at the base of which the invading sponge has entered the shell is distorted and has its armature of macroscleres greatly extended and increased. Thirdly, the inhalent papilla through which the *Coppatias* has apparently made its way is as already stated completely disorganized. Fourthly, the invader is very minute and forms a compact mass that does not spread out over the surface of the shell.

Fig. 2 represents a later stage in the attack in the same case. The *Coppatias* has penetrated well into the burrows of the Clionid and has to some extent adapted itself to their form. The Clionid has shrunk considerably in its excavation and has secreted round itself a thick horny coat, not merely where it is in actual contact with the *Coppatias*, but also at those points at which it was liable to

[1] It is noteworthy that there are none of the characteristic nodular amphiasters present in the parenchyma of the Clionid. As I pointed out in my original description of this species (*Rec. Ind. Mus.* XI, p. 20), these spicules often occur in great abundance in association with a horny membrane covering projecting parts of the sponge, in circumstances that suggest that they are utilized in excavating fresh papillae. It is now evident that the secretion of horny substance is not necessarily correlated with their development.

be attacked by a flank movement. A number of its macroscleres project through the horny covering into the body of the invader.

When *Cliona ensifera* or *C. viridis* is attacked by a *Chondrilla* a similar horny coating is produced and a mass of macroscleres is formed lying parallel to the tranverse axis of the part with which the attacking sponge is in contact. This also occurs when *C. viridis* is attacked by *Rhabderemia prolifera,* but the horny coating is very thin.

It therefore appears that the mode of defence adopted by the Clionid is not always precisely the same, even in cases in which it can be adduced with practical certainty from observations made on preserved material. There are other methods of defence that can only be surmised from general considerations. One of these is possibly the production of diaphragms in the galleries of the Clionidae. In *C. mucronata* these structures are remarkably well developed and are protected by highly specialized spicules. It is perhaps more than a coincidence that I have not found any examples of this species that were overwhelmed or even attacked by other sponges.

I have pointed out elsewhere[1] that the gemmules of the Clionidae are possibly useful in permitting regeneration after the parent sponge has been suffocated by the growth of encrusting forms over its papillae. The production of gemmules in *C. annulifera* and *Thoosa investigatoris* at a depth of over 700 fathoms is particularly interesting, because at depths of such magnitude it is probable that conditions remain identical, so far as temperature, currents, etc., are concerned, throughout the year. It is only in a very few species of Clionidae that resting bodies of the kind have been discovered and I am convinced that they are not as a rule produced in Indian species other than the two just mentioned and the shallow-water form *C. vastifica.* In both the deep-sea species the gemmules are of a highly specialized character. In *C. annulifera* they are provided with spicules of a type that does not occur in the vegetative part of the sponge. These spicules are microscleres of an unusually large size ; they cover one surface of the somewhat lens-shaped gemmule in a dense horizontal layer, forming a regular shield, but are entirely absent from the other surface. The surface that they protect is the one in contact with the parent sponge, that is to say the one with which an invading sponge would come in contact if it made its way along the galleries already excavated. The naked surface is in contact with the walls of the excavations, which protect it in the natural position.

The gemmule of *T. investigatoris* is very different from that of *C. annulifera.* It has neither a horny covering nor spicules of any kind, but is hidden away in a special chamber excavated in some unknown manner for its reception, and is only connected with the parent sponge by an extremely fine strand of living matter enclosed in a narrow canal.

[1] *Mem. Ind. Mus.* V, p. 35 (1915).

Both these Clionids are known only from specimens taken in a single haul of the ' Investigator's ' net, and it is impossible therefore to say much about their enemies. We know, however, that *T. investigatoris* is attacked by *C. investigatrix*, and I have not been able to find any example of the latter that is drawn out into a sufficiently fine filament to make its way into a gemmular chamber of the Clionid.

The information conveyed in the foregoing biological notes may be summarized as follows :—

1. The Clionidae are liable to be attacked in their burrows by a large number of small sponges belonging to several different families.

2. The majority of these invading species are known to exist also as ordinary encrusting forms but in a few instances (*e.g.* that of *Coppatias investigatrix*) the sponge has possibly become a pure parasite.

3. In most cases the invader merely occupies the burrow of the Clionid, which it thrusts before it, but in some instances it is possible that it actually engulfs and digests the proper occupant.

4. Different species of Clionidae protect themselves against invasion in slightly different manners, but all secrete a horny coat where the invader comes in contact with them.

5. The production of transverse diaphragms in the galleries of the Clionidae is possibly a means of protection against invading sponges, especially in the case of *C. mucronata*, in which these diaphragms are of an unusually elaborate nature.

6. The production and elaboration of gemmules in the Clionidae is perhaps another means of defence against similar enemies, particularly in the case of the deep-sea species *C. annulifera* and *T. investigatoris*.

7. The cases of invasion investigated represent only a small proportion of those in which similar phenomena occur.

EXPLANATION OF PLATE XXXIV.

Figs. 1, 2.—*Thoosa investigatoris* attacked by *Coppatias investigatrix*.

1. A young *Coppatias* that has just made its way into the burrows of the *Thoosa* in a Gastropod shell, seen from below (× 16).

2. Portion of an older sponge of the same species in contact with the *Thoosa*, seen from the side (× 65).

A, A′ = the *Thoosa*: B = the *Coppatias*: S = Gastropod shell in section: *c* = cavity from which calcareous matter has been removed by acid: *e p.*=exhalent papilla of the *Thoosa*: *h.c.*=horny coat secreted by the *Thoosa*.

In fig. 1 the young invading sponge has apparently made its way through an inhalent papilla of the *Thoosa*, which is represented by a confused mass of spicules (A′) The adjacent exhalent papilla (A) is distorted and greatly enlarged.

Fig. 3.—*Cliona viridis* attacked by *Rhabderemia prolifera*.

A = *C. viridis*; B = *Rh. prolifera*: *c* = cavity from which calcareous matter has been removed by acid: *c′* = passage between two calcareous masses coated with the sponge.

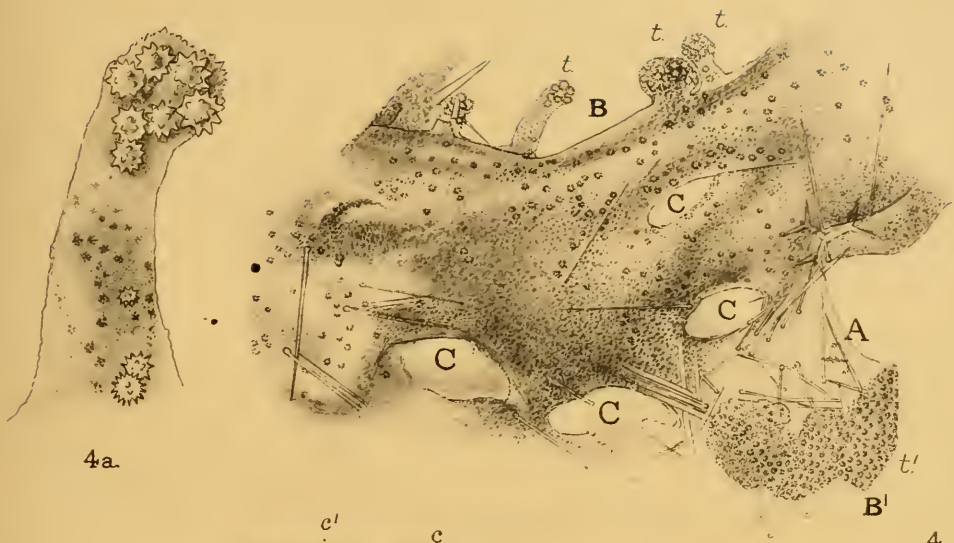
Figs. 4, 4a.—*Chondrilla distincta* attacking *Cliona ensifera*.

4. A mass of the *Chondrilla* sending out tentacle-like branches to envelop the *Cliona* in dead coral (× 75).

4*a*. A single tentacle-like branch more highly magnified (× 255).

A = *C. ensifera*: B, B′ = *Ch. distincta*: C = cavity from which calcareous matter has been removed by acid: *t* = tentacle-like branch.

At B′ a tentacle-like branch has grown out from behind over the surface of the *Cliona*, which it is enveloping.

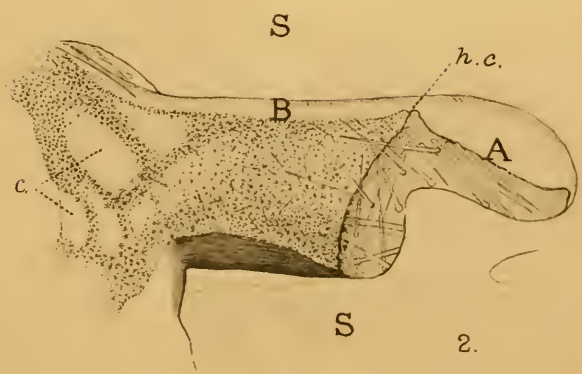


4a.

4.

3.

1.



2.

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SPONGES PARASITIC ON CLIONIDAE.