BORING SPONGES DESTRUCTIVE TO ECONOMICALLY IMPORTANT MOLLUSCAN BEDS AND CORAL REEFS IN INDIAN SEAS

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ABSTRACT

Systematics, description and distribution are given of 32 species of boring sponges from the Indian seas, the frequency of occurrence of which can vary from time to time as any one or more species can at any time cause an outburst creating severe havoc in the economically important molluscan and coral beds and then disappear into a period of quiescent stage, while some others may continue to exhibit moderate incidence without causing any such deleterious effects.

During the period of the present study only some species were moderately active in the Indian seas, and those, in the order of abundance, were *Cliona celata*, *C. vastifica* and *C. carpenteri* on chanks; *C. vastifica* and *C. celata* on pearl oysters; *C. celata*, *C. vastifica* and *C. carpenteri* on edible oysters; *C. celata*, *Spirastrella cuspidifera*, *S. inconstans* and *S. aurivilli* on corals. The present composition of boring sponge in the Indian seas is likely to get altered in future, and such changes if any may be well affirmed by comparing with the observations presently reported.

The boring pattern, damage caused to the shell, the modes of reproduction of the sponges, etc., are discussed. Some of the common measures adopted for controlling the boring sponges in different parts of the world are reviewed.

Illustrations are provided for all the 32 species described.

INTRODUCTION

Boring sponges can cause severe damage to the submerged calcareous objects, and in temporate regions where good shell fishery exist, they can cause even wide-spread depletion of the beds. The French fishermen noticed such wide-spread depletion of the oyster beds even by the beginning of the nineteenth century and called it 'spice bread disease,' but were quite ignorant of the causative factor. Grant (1826) identified this 'zoophyte' as *Cliona celata* and later Hancock (1849) identified it as a sponge. Hancock (1849) established many species of *Cliona*, and according to him "it is a group of beings, hitherto almost entirely overlooked which play apparently a most important part in the economy of nature.,, He has, based on the study of fossil shells, acertained that *Cliona* existed during several geological periods. The various species described by Hancock (1849) include *Cliona celata* Grant, *C. radiata, C. gracilis, C. muscoides, C. howsei, C. northumbrica, C. alderi, C. corallinoides, C. frveri, C. spinosa, C. dendritica, C. canadensis, C. millepunctata, C. lobata, C. vastifica, C. rhombea, C. purpurea, C. angulata, C. quadrata, C. nodosa, C. labyrinthica, Thoosa cactoides* and *T. bulbosa.*

The family *Clioniadae* was created in 1867 by Gray to include the sponges "forming excavations in shells and lime stone" embracing the genera *Cliona* Grant, *Pione* Gray, *Myle* Gray, *Idomon* Gray, *Jaspis* Gray, *Pronax* Gray and *Samus* Gray. Subsequent workers have shown that the genera *Pione, Myle, Sapline* and *Idomon* are synonymous with the genus *Cliona* Grant and *Jaspis* Gray is not essentially a genus of boring sponges. de Laubenfels (1936) included those species with the basic character of boring in the family Clionidae.

Families and Genera of Boring Sponges as Now Understood

Species which bore into calcareous objects are distributed among different orders of the phylum Porifera. The family Clionidae Gray is rather unique in the respect that all the genera contained in it manifest this habit at least in their early life. It is true that some species of the genus *Cliona* can have a free living stage after disintegrating the substratum totally.

It is proved beyond doubt that some species of the family Spirastrellidae Hentschel, Jaspidae de Laubenfels, and Halinidae de Laubenfels are also capable of excavating tunnels into the calcareous matter.

I. Order HADROMERIDA Topsent

Family Clionidae Gray

This is a well distributed family consisting of about 14 genera including the most destructive and wide-spread genus *Cliona,* including several species.

de Laubenfels (1936) divided this family into 2 sub-division (Sub-families?). The first division is exemplified by the typical genus *Cliona* Grant, and the second by *Thoosa* Hancock. Old (1941) recognised these two groups as A and B respectively.

CLIONA Group

Microscleres, in this group, are simple spiraster type.

Genus *Amorphinopsis* Carter

Skeleton composed of an irregular reticulation of oxeas. and styles. Spongin is present. Type, *Amorphinopsis excavans* Carter.

Genus *Aka* de Laubenfels

Only oxeas are present; may form well developed fibres in papillae. Spongin is present. Type, *Acca insidiosa* Johnson.

Genus *Clionopsis* Thiele

Spicules mostly oxeas with stray tylostyles and spirasters. Type, *Clionopsis platei* Thiele. This genus is not represented in Indian Seas.

Genus *Donotella* de Laubenfels

Megascleres oxeas and microscleres, thick streptasters. Type, *Cliona acustella* Annandale.

Genus *Scantiletta* de Laubenfels

Spicules, oxeas and spirasters. Tye, *Scantilla spiralis* Johnson. Not represented in Indian Seas.

Genus *Cliona* Grant

Typical genus of the family. Megascleres, tylostyles and microscleres, oxeas, spirasters and streptasters. Type, *Cliona celata* Grant.

THOOSA Group

Microscleres, in this group, are elaborate astrose type. The following genera are included.

Genus *Alectona* Carter

Spiculation consists of tuberculate, centrotylote stongyles as megascleres and amphiasters for microscleres. Type, *Alectona millari* Carter. This genus is not represented in Indian Seas.

Genus *Annandalea* Topsent

Spicules are oxeas, microxeas and slender amphiasters. Type, *Thoosa laeviaster* Annandale.

Genus *Delectona* de Laubenfels

Spicules are rhabds with subspherical swellings, toxiform oxeas and asters with 8 or more capitate rays (not one type of spicule as given by de Laubenfels 1936). Type, *Alectona higgini* Carter.

Genus *Dotona* Carter

Spicules composed of styles and two types of spirasters. Type, *Dotona pulchella* Carter.

Genus *Dyscliona* Kirkpatrick

Characterised by diactinal megascleres (strongylote) and spined diactinal microscleres. Type, *Dyscliona davidi* Kirkpatrick. Not represented in India Seas.

Genus *Nisella* Johnson

Tylasters of 2 different sets are seen. Type, *Nisella verticillata* Johnson. Not represented in Indian Seas.

Genus *Thooce* de Laubenfels

Spicules amphiasters and discs. Type, *Thoosa socialis* Carter.

Genus *Thoosa* Honcock

Megascleres are tylostyles and oxeas; microscleres amphiasters of different sets and oxyasters. Type, *Thoosa cactoides* Hancock.

Family Spirastrellidae Hentschel

Some species of the genus *Spirastrella* Schmidt are also in the habit of boring into calcareous matter in their initial stages. The cavities formed inside the substratum are simple unlike those excavated by the species of the genus *Cliona*. de Laubenfels (1936) transferred such boring species to the genus *Cliona*, but this separation is not maintained here.

Genus *Spirastrella* Schmidt

Spiculation consists of tylostyles and spirasters. Type, *Spirastrella cunctatrix* Schmidt.

II. Order EPIPOLASIDA Sollas

Family Jaspidae de Laubenfels

Genus *Jaspis* Gray

Spiculation consists of oxeas microxeas and oxyasters. Type, *Vioa johnstonii* Schmidt.

III. Order CARNOSIDA Carter

Family Hailnidae de Laubenfels

Genus *Halina* Bowerbank

Spiculation consists of calthrops with dicho-modification and streptasters. Type, *Halina bucklandi*, Bowerbank.

Genus *Samus* Gray

Spicules amphitriaenes and sigmas. Type, *Samus anonyma* Gray.

Are the Boring Sponges Parasites?

The term 'parasite' is often used in literature while dealing with boring sponges. But the structure and physiology of the boring sponge are the same as those of any other free living sponge. The water is drawn into the interior by means of the flagella and expelled through the excurrent openings or oscules. In the case of boring sponges, the incurrent and excurrent channels are borne by separate contractile papillae. The water thus drawn in through the incurrent pores bring in oxygen and food for the cells. Since they do not obtain any form of food from the 'host' which harbours them, the boring sponges cannot be considered parasites.

Hornell (1904) in his Report on Pearl Oyster Fisheries recorded boring sponge as an enemy of Pearl Oyster since they cause damage in two ways: first by causing 'thickened deposits of nacre and other irregularities, and hence disturbance of function, at the attachment of the great adductor muscle' and second, as 'honeycombing the shell in all directions, rendering it so rotten that it can no longer hold together.' According to him (Hornell 1904) it is a 'disease of adult life' for young shells never harbour *Cliona*. Hornell also found that 'whenever the inroads of *Cliona* were extensive the sub-epidermal tissue in particular and the other tissues in general, were thin and diseased-looking.' The entire collections made by Herdman from the Pearl Banks of Ceylon in 1902 were studied by Dendy (1905) and recorded only one species (*Cliona margaritifera*). Since the publication of Dendy's monograph in 1905, several publications dealing with the Demospongiae in general and Clionidae in particular (Annandale 1915, 1915A) have appeared, but they made no substantial contribution towards the study on boring sponges infecting the economically important molluscs and corals of the Indian seas.

With a view to studying the boring sponges affecting the economically important molluscs of Indian Seas, this study was initiated in 1969 at the Central Marine Fisheries Research Institute, Mandapam Camp. This is the second contribution in this line, first being the coral boring sponges of the Gulf of Mannar and Palk Bay (*Symp. Corals and Coral Reefs* 1969), (*Thomas* 1972).

Material and Methods

Material for the present study was collected mainly from the Gulf of Mannar and Palk Bay considering their richness in economically important molluscs and corals. Shells were collected from the sea directly. Apart from these, about 2000 discarded shells found in the Jamalia Chank Industries, Kilakarai, Tamil Nadu, were also utilized. Shells obtained through the latter came from different beds like those of Nagapatnam, Laccadives, Andamans and Nicobars, Ceylon, Gulf of Kutch and Mangalore.

Spicule preparations were made according to the method suggested by Old (1941).

Descriptions of species which have not been collected by the present author, but were recorded from this region by earlier workers, are also included, for the comprehensiveness of the account.

SYSTEMATICS

Order HADROMERIDA Topsent

Family Cliona Gray

Cliona Group

Genus *AMORPHINOPSIS* Carter

1. *AMORPHINOPSIS EXCAVANS* Carter

(Fig. 1, A; Fig. 2, 1-J; Pl. IV, 1)

Amorphinopsis excavans Thomas, 1973, p. 58, pl. 3, fig. 8 (Synonymy)

Host: Coral.

Description: Sponge usually encrusting, rarely with upright branches. Papillae not seen. As the growth proceeds the area occupied by the sponge from a concavity due to the eating away of the substratum beneath. Colour green or pale white when alive.

Surface reticulated. Oscules circular, 1-1.5 mm in diameter. Pores in groups of 3-6 or solitary; oval or elliptical; diameter, 0.02-0.075 mm. Spongin may or may not be present. If present, usually well formed near the oscular vicinity. Dermal skeleton composed of oxeas and styles arranged in bands intersecting each other uniformly and regularly. Main skeleton rather illdefined, consisting of oxeas and styles. Spongin may be present but the quantity often less when compared to that in the surface. The outermost extremities of the main skeleton pierce the darmal part.

Substratum beneath presents a tessellated appearance, chambers irregular, 1-2 mm in diameter.

Spicules: (1) Oxeas; Geniculate or not; with considerable malformations. Size, 0.188-0.566 x 0.004-0.021 (0.016*). (2) Styles. Slightly curved; size, 0.112-0.185 (0.163) x 0.004-0.008 (0.005 mm).

Distribution: Indian Ocean, Australian region.

2. *AKA DIAGONOXEA* Thomas

(Fig. 1, B; Fig. 3, C)

Aka diagonoxea Thomas, 1970, p. 250, figs. 1-5.

Host: Coral

Description: Chambers formed inside the coral, large, up to 20 mm in diameter and irregular in outline. Papillae projecting from the substratum long, 20-50 mm; diameter, 2-4 mm, may or may not branch; when branch, may be dichotomous or polychotomous. Pore bearing papillae short and stumpy. Pores terminal, 0.046 mm diameter. Oscules terminal, single, 2-3 mm in diameter. Interchamberal connection two types (a) wide openings of about 3 mm diameter and (b) small opening in groups, which may or may not be located on pillar like structures projecting radially into the chamber.

Papillae pale white and the tissue inside the chamber, pale yellow.

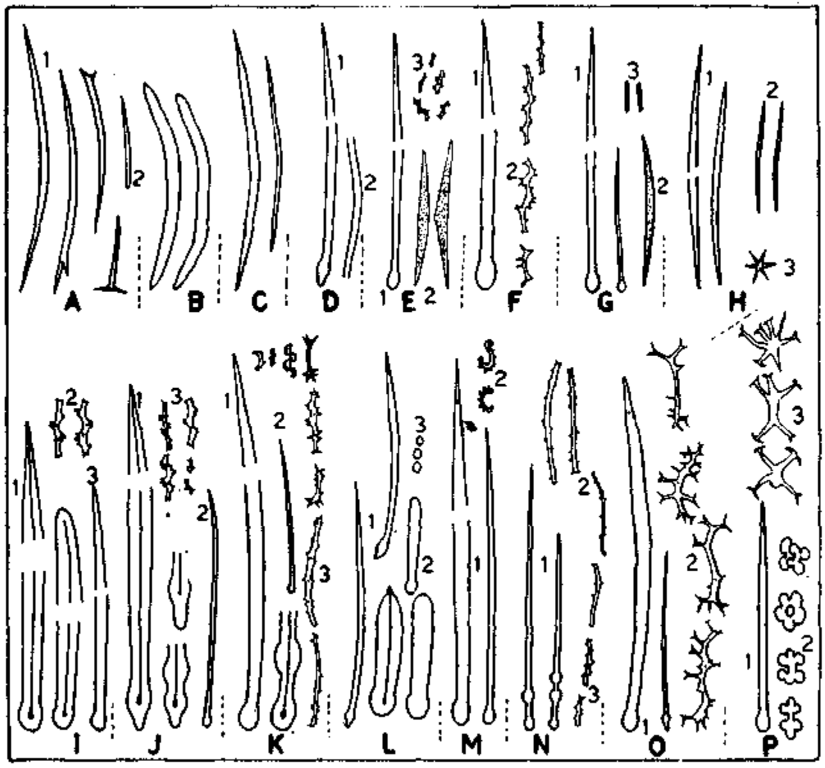

FIG. 1. A. *Amorphinopsis excavans*. 1. Oxea, 2. Style. B. *Aka diagonoxea*. Oxeas. C. *A. minuta*. Oxeas. D. *Cliona celata*. 1. Tylostyle, 2. Oxeas. E. *C. vastifica*. 1. Tylostyle, 2. Acanthoxeas, 3. Spirasters. F. *C. viridis*. 1. Tylostyle, 2. Spirasters. G. *C. carpenteri*. 1. Tylostyle, 2. Acanthoxeas, 3. Bacilliform spicule. H. *Jaspis penetrans*. 1. Oxeas, 2. Microxeas, 3. Oxyaster. I. *Cliona ensifera*. 1. Ensiform spicules (two types), 2. Spirasters, 3. Tylostyle. J. *Spirastrella inconstans*. 1. Tylostyle and its modifications, 2. Dermal tylostyle, 3. Spirasters. K. *S. cuspidifera*. 1. Tylostyle and its modifications, 2. Dermal tylostyle, 3. Spirasters. L. *Cliona mucronata*. 1. Tylostyles, 2. Mucronate spicules, 3. Spherules. M. *C. orientalis*. 1. Tylostyles, 2. Spirasters. N. *C. annulifera*. 1. Tylostyle, 2. Slender spirasters, 3. Ordinary spirasters. O. *Spirastrella aurivilli*. 1. Tylostyles, 2 different types, 2. Spirasters. P. *Thoosa hancocki*. 1. Tylostyles, 2. Nodular amphiasters, 3. Slender amphiasters.

Dermal membrane of the papillae thin and transparent; sometimes charged with brown pigment granules. Skeleton of the dermal part is composed of tangentially arranged oxeas, and without spongin. Main skeleton composed of well developed fibres, 0.75 mm thick. Meshes formed are rectangular or irregularly oval. Spongin well represented. Skeletal arrangement of the mass found inside the chamber is irregular.

Spicules: (1) Oxeas. Sharply pointed or rarely stylote or strongylote. They are often with two bendings. Size, 0.109-0.130 (0.123 mm) x 0.007-0.010 mm.

Distribution: Gulf of Mannar.

3. *AKA MINUTA* Thomas

(Fig. 1, C; Fig. 3, A, D; Pl. III)

Aka minuta Thomas, 1973, p. 59, pl. 3, fig. 9.

Host: Corals (*Pocillopora damicorinis*) and shells (*Crassostrea madrasensis*).

Description: Chambers found inside the substratum irregular or oblong. Size, 5 x 4 mm average. Wall between adjacent chambers thin, and the interconnections reduced to mere pores. Openings through which the incurrent and excurrent papillae project out of the surface about 1.5 mm in diameter.

Skeletal arrangement is irregular in the interior; and in papillae oxeas are arranged tangentially.

Spicules: Oxeas. Sometimes with a sharp curve at the centre; arms straight. Size, 0.085-0.141 (0.121 mm) x 0.001-0.007 (0.005 mm).

This species comes close to *Aka nodosa* (Hancock, 1849) and *Donotella acustella* (Annandale, 1915A) but differs from the former in the absence of angulated chambers and from the latter in the absence of thick streptasters.

Distribution: Gulf of Mannar.

4. *DONOTELLA ACUSTELLA* (Annandale)

(Fig. 5, A)

Cliona acustella Annandale, 1915A, p. 14, fig. 2.

Donotella acustella de Laubenfels, 1936, p. 156.

Host: Mollusc.

Description: Chambers formed inside the shell, subcircular or polygonal; diameter less than 3 mm and separated by narrow partitions. Interconnections slender and short. The openings found on the surface of the shell, small and scattered; diameter 0.4 mm.

Spicules: (1) Oxeas. Uniformly curved and sharply pointed. Size, 0.144 x 0.008 mm. (2) Streptasters. Very thick and with prominent spines; spines often arranged in 3 groups. Size, 0.012 x 0.008 mm.

Annandale (1915A) reported this species from the coast of Orissa and Ganjam district of Madras. According to Annandale, this is a very common pest of *Ostera imbricata* and *O. cucullata* in the above said localities.

Distribution: Bay of Bengal.

5. *CLIONA CELATA* Grant

(Fig. 1, D; Fig. 3, G; H-L, M; Pl. IV. Figs. 4-8; Pl. V. Fig. 2, 4-6.9;
Pl. VI Figs. 1, 3-5; Pl. VII. Figs. 3-6)

Cliona celata Thomas, 1973, p. 60, pl. 3, fig. 10 (Synonymy)

Host: Calcareous algae, Coral and shells.(*Xancus pyrum, Lambis lambis, Turbo intercostalis, Hemifusus cochlidium, Rapana bulbosa, Strombus* sp., *Babylonia spirata, Murex virgineus, M. tarpa, M. ramosus, Placuna placenta, Crassostrea madrasensis, C. cucullata, Pinctada fucata, Cardium* sp. *Conus* spp., *Tonna dolium* and *Euchelus asper.*

Description: The surface of the shell is perforated by openings of 0.5-2 mm diameter. These opening are distributed irregularly on the surface. The incurrent and excurrent papillae project out through these openings.

In corals usually the openings are larger, coming to about 2-5 mm in diameter. Outline of openings regular when on shell and irregular on coral; 10-20 openings per sq. cm. in shell. Pores are in groups at the tips of incurrent papillae. Oscules terminal and solitary, on excurrent papillae.

Colour of the papillae varies from green to golden yellow or even red in living condition.

Chambers found inside the shell about 1-3 mm; and in coral, 2-5 mm in diameter. The cavities have an etched out appearance in the interior. In advanced stages such chambers may occupy the entire thickness of the shell.

The skeletal arrangement inside the chamber is irregular whereas in the papillae it is dense towards the base and less dense and radical at the tips.

For morpology, anatomy, phisiology and development see Topsent, (1900), Vosmaer (1933), Hartman (1958) and Goreau and Hartman (1963).

Spicules: (1) Tylostyles. Smooth and slightly curved in the first half; tips sharply pointed or rarely blunt. Head trilobed: Measurements are given in the following table. (2) Oxeas. Slightly curved, with hair like dimensions; sometimes totally absent. (3) Spirasters. Not represented in the specimens examined

Host		*Tylostyles*	*Oxeas*	*Spirasters*
Coral		0.207-0.320 (0.283 mm)	0.147	Nill
	x	0.006-0.013 (0.010 mm)	0.201	
	Head	0.005-0.010 (0.009 mm)		
Lambis lambis		0.188-0.339 (0.301 mm)	Nil	Nil
	x	0.004-0.010 (0.007 mm)		
	Head	0.006-0.011 (0.009 mm)		
Xancus pyrum		0.150-0.320 (0.271 mm)	Nil	Nil
	x	0.004-0.010 (0.007 mm)		
	Head	0.006-0.009 (0.008 mm)		

It is reported that this species can enter into a 'free living' stage after disintegrating the substratum. But this form of growth is not seen in Indian seas. This species is very common in the Gulf of Mannar and Palk Bay and in Coral reefs it is found just below the low tide level along with *Spirastrella aurivilli* Lindgren.

Distribution: Cosmopolitan.

6. *CLIONA VASTIFICA* Hancock

(Fig. 1, E; Fig. 3, N, O, Q, R; Fig. 4, A, B; Pl. I Fig. 3; Pl. II, Fig. 3 Pl. III Fig. 2; Pl. IV Figs. 2, 7)

Cliona vastifica Thomas, 1973, p. 61 pl. 3, fig. 11 (Synonymy).

Host: Calcareous algae, Corals and shells (*Xancus pyrum, Hemifusus cochlidium, Thais rudolphi, Tonna dolium, Fasciolaria trapezium, Turbo intercostalis, Murex virgineus, Crassostrea madrasensis, Pinctada fucata, Chama reflexa*).

Description: The surface of the shell perforated by smaller openings of 0.5-1 mm. diameter and 0.5-1 mm apart. These openings may be arranged irregularly on the surface or distributed in a linear and recticulated pattern. When irregular the number of openings per sq. cm. varies from 20-40. Langer openings on the surface are always of the excurrent papillae.

Colour, when alive, yellow or pale gray.

Chambers found inside the shell small, up to 1.5 mm; sometimes angulated. Cavities have an etched out interior.

For morphology see Nassonow (1883, under *Cliona stationis*) (Lendenfeld, 1898), Topsent (1900) and Vosmaer (1933).

Spicules: (1) Tylostyles. Straight and sharply pointed. Head well developed and spherical; rarely malformed or with additional swellings. Size, 0.157-0.294 (0.223 mm) x 0.001-0.007 (0.004 mm). (2) Oxeas. Microspined in varying degrees or even smooth. Swellings may or may not be present at the centre. Stylote modification are rarely noted. Size, 0.046-0.142 (0.112 mm) x 0.001-0.006 (0.003 mm) (3) Spirasters. Distinctly angulated; with 3-6 bends. Spines prominent at angle or granulated throughout or even smooth. Size, 0.008-0.021 (0.011 mm) x 0.001-0.002 mm.

Apart from the above said species, the shells of *Ostrea, Purpura, Avicula, Margaritifera, Placenta, Oliva, Malleus* and *Voluta* were also found infested by this sponge in Indian Waters (Annandale, 1915).

Distribution: Cosmopolitan.

7. *CLIONA LOBATA* Hancock

(Fig. 2, H)

Cliona lobata Hancock, 1849, p. 341, pl. 12, figs. 4, 8. Topsent, 1900, p. 70, pl. 2, figs. 2, 10, pl. 3, fig. 1, pl. 1, fig. 1.

This species is not obtained by the present author, but it is recorded from Pamban bridge area (Gulf of Mannar) by Burton (1937). According to Burton's record it is bright red in life. Tylostyles measured 0.2 x 0.004 mm and spirasters, 0.01-0.065 x 0.002-0.005 mm. Oxeas not seen.

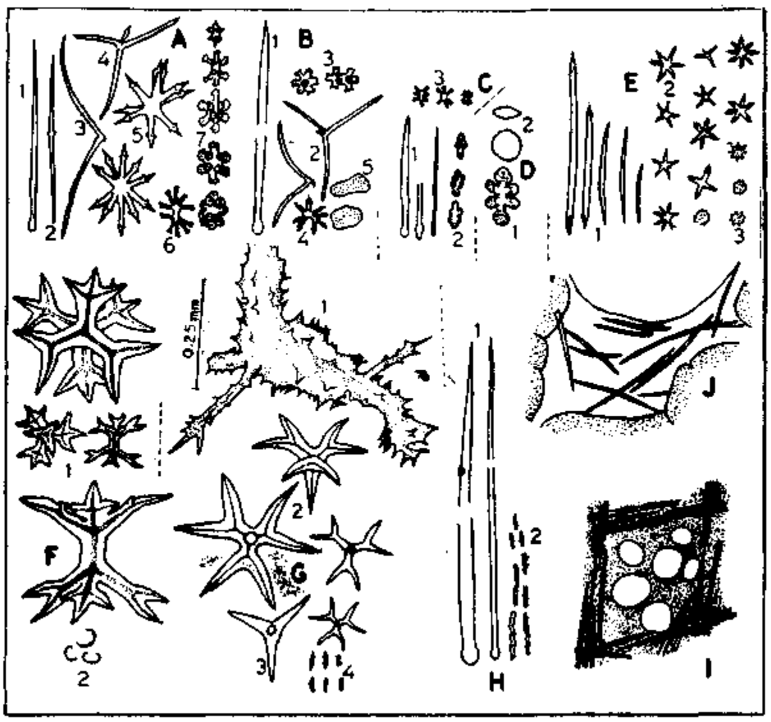

FIG. 2. A. *Thoosa armata*. 1. Tylostyle, 2. Oxea, 3 and 4. Oxyasters, 5. Amphiasters with lanceolate rays, 6. Amphiasters with capitate rays, 7. Nodular amphiasters, different growth forms. B. *Thoosa fischeri*. 1. Tylostyle, 2. Oxyasters, 3. Nodular amphiasters, 4. Ordinary amphiasters, 5. Corpuscles. C. *T. investigatoris*. 1. Tylostyle, 2. Nodular amphiasters, 3. Smooth amphiasters. D. Thooce socialis. 1. Amphiaster, 2. Discs, two views. E. *Jaspis investigatrix*. 1. Oxeas, different types, 2. Oxyasters, 3. Spherasters. F. *Samus anonyma*. 1. Amphitriaenes, different types and views, 2. Sigmas. G. *Halina plicata*. 1. Part of the specimen showing lateral branchlets. 2. Dichotriaenes, 3. Calthrops, 4. Streptasters. H. *Cliona lobata*. 1. Tylostyle, 2. Spirasters. I. *Amorphinopsis excavans*. Dermal skelton. J. *Amorphinopsis excavans*. Main skelton.

For mophology see Topsent (1900) and Volz (1939).

This species is often mistaken with spiraster bearing specimens of *Cliona celata*. But according to Topsent (1900) *C. lobata* has smaller papillae protruding from smaller perforation and also has a high frequency of trilobed tylostyles. *Cliona lobata* has, according to Hartman (1958), 0.2-0.5 mm diameter for incurrent papillae and for excurrent papillae, 0.8-1.6 mm. The spirasters are divisible into 2 categories (1) with spines arranged in a spiral pattern, spine being more prominent at angles and ends of the spicule and (2) with abundant spines distributed at random over the surface. This species also may perforate the substratum in a reticulate fashion as in *C. vastifica*.

Distribution: This is a common oyster pest of the Atlantic Ocean and is not met with in Indian oyster beds. It is found in west central Pacific infesting dead corals. Another report of the same is from Japan.

8. *CLIONA QUADRATA* Hancock

(Fig. 5, D)

Cliona quadrata Hancock, 1849, p. 344, pl. 15, fig. 6.

Cliona warreni Carter, 1880, p. 370, pl. 18, fig. 6.

This species is reported from Gulf of Mannar (Carter 1880) growing under *Melobesia*. Hancock's original record was from *Tridacna gigas*. This species is not obtained in the present survey.

Original description reads "sponge composed of large irregularly quadrate lobes 1/6th of an inch wide, with the angle obtuse connected without apparent order by several small, cylindrical stems passing irregularly from all sides, occasionally in pairs, sometimes enlarged and flattened and arising from a depression in the side of the lobe: terminal twigs rather tough, fine and linear; papillae not very numerous, about 1/24th of an inch in diameter, and placed rather far apart."

The chambers found inside the *Melobesia* vary from 1.5-3 mm (Carter 1880). Colour dark brown when dry.

Spicules: Tylostyles. Head spherical, shaft large and fusiform. Size, 0.4 x 0.015-0.018 mm.

Distribution: Mediterranean Sea, South Atlantic and Indian Ocean.

9. *CLIONA VIRIDIS* (Schmidt)

(Fig. 1, F)

Cliona viridis Thomas, 1972, p. 349, pl. 2, fig. 1.

Host: Coral

Description: Papillae small, 1-3 mm in diameter and 1-3 mm high; hard and lathery in texture. Colour, yellow when alive. Refringent granules of about 0.006 mm diameter are present inside.

Chambers inside the coral irregular, 3 mm in diameter but chambers measuring to about 10 mm are also rarely met with.

Spicules: (1) Tylostyles. Straight or slightly curved, head oval with the greatest diameter near the terminus. Size, 0.21-0.381 (0.285 mm) x 0.002-0.014 (0.008 mm) (2) Spirasters. With 4-5 curves. Spines long (0.008 mm), conical and at the convex parts. Size, 0.031-0.050 x 0.001-0.002 mm.

Distribution: Atlantic Ocean, Mediterranean Sea, Red Sea, Indian Ocean, Australian region, Pacific Ocean.

10. *CLIONA CARPENTERI* Hancock

(Fig. 1, G; Fig. 4, C, D, E; Pl. II Figs. 1, 7-8; Pl. III Fg.2)

Cliona carpenteri Hancock, 1867, p. 241, pl. 8, fig. 4.

Cliothosa carpenteri de Laubenfels, 1936, p. 156.

Host: Shells (*Xancus pyrum, Lambis lambis, Turbo intercostalis, Hemifusus cochlidium, Crassostrea madrasensis, Cardium* sp.).

Description: Surface perforated with circular openings varying between 0.2-1.5 mm in diameter and situated at 1-1.5 mm apart. Number of openings per sq. cm varies from 20-30. These openings are irregularly arranged on the surface. In thin shells the inner surface also is punctured by smaller opening of 0.5 mm diameter. Larger openings lodge excurrent and smaller, incurrent papillae. In some shells adjacent larger openings may partly fuse.

Colour, yellow when alive.

Chambers found inside the shell oval or angulated in outline; diameter 1.5 mm average. Connections in between the chambers are short; rarely reduced to mere openings on the wall. Inner surface of the chambers has an etched out appearance.

Spicules: Tylostyles. Straight, head globular. Size, 0.241-0.284 (0.253 mm) x 0.003-0.006 mm. Head, 0.009 mm in diameter. (2) Microxeas. Spined or granulated, with sharp bend at the centre. Size, 0.05-0.11 (0.09 mm) x 0.002-0.004 (0.003 mm). (3) Bacilliform spicules. Stout, fusiform and slightly curved. Surface spiny, granulated or even smooth. Size, 0.012-0.021 x 0.001-0.002 mm.

According to Annandale (1915A) this is a tropical species with world wide distribution. Other common shells which are riddled by this species in Indian Seas are of *Malleus, Serpula*, and *Ostrea virginiana*. In the Bay of Bengal the previous records of this species are from Port Blair (Andamans) and Mergui Archipelago.

Distribution: Atlantic Ocean, Indian Ocean, Australian Region, Pacific Ocean.

11. *CLIONA MUCRONATA* Sollas

(Fig. 1, L; Fig. 4, I, J)

Cliona mucronata Thomas, 1972, p. 347, pl. 1, figs. 8-8D (Synonymy)

Host: Coral and shell (*Chana* sp.)

Description: Chambers irregular in outline; diameter 3-5 mm in coral, and 1-2 mm in shell. Connection between chambers slender, provided with a sphincter formed of mucronate spicules. Incurrent papillae protrude out through small pores of 0.5-0.8 mm diameter and excurrent ones through larger openings of 1-1.3 mm (in shell).

Colour, pale yellow when dry.

Skeletal arrangement, physiological significance of the diaphragm, branching pattern and other details are given in Sollas (1878).

Spicules: (1) Tylostyles. Straight or slightly curved, head spherical or trilobed. Size, 0.151-0.182 (0.168 mm) x 0.003-0.005 (0.004 mm). (2) Mucronate spicules. Head spherical or trilobed; shaft end blindly or in mucrone. Axial canal well developed. Size, 0.063-0.084 (0.07 mm) x 0.006-0.025 (0.018 mm). Head, 0.008-0.025 (0.021 mm) in diameter. Spherules of 0.002-0.008 mm diameter are seen in plenty. Spirasters are not met with in any of the specimens examined.

Branches of the coral infested with this sponge normally show a stunted growth.

Remarks: This is the first record of this species from a molluscan shell.

Distribution: Indian Ocean, Australian region.

12. *CLIONA ENSIFERA* Sollas

(Fig. 1, 1; Fig. 3, P)

Cliona ensifera Thomas 1972, 346, pl. 1, figs. 7-7C (Synonymy)

Host: Coral

Description: Chambers spherical, 2-3 mm in diameter, and interchamberal canal, 0.2-1 mm in diameter. Openings through which the incurrent and excurrent papillae project out are small, 0.5-1 mm in diameter.

Morphology of this species is given in detail in Sollas (1878).

Spicules: (1) Ensiform spicules. Slightly curved, head spherical, tip sharply pointed or blunt. Size, 0.251-0.361 (0.330 mm) x 0.011-0.022 (0.015 mm). (2) Tylostyles. Slender, shaft slightly curved and sharply pointed. Head globular or trilobed. Size, 0.211-0.293 (0.282 mm) x 0.002-0.008 (0.004 mm). (3) Spirasters. With 3-5 bends. Spines sharp and prominent; at angles only. Size, 0.04 x 0.001 mm.

Distribution: Indian Ocean.

13. *CLIONA INDICA* Topsent

(Fig. 5, B)

Cliona indica Topsent, 1891, p. 574, pl. 22, fig. 15.

Host:?

Topsent (1891) described this species from Ceylon. Spicules consist of Tylostyles, 0.31-0.43 x 0.005-0.013 mm and spirasters of two sets; one measuring 0.015 x 0.001 mm and the other, 0.012 x 0.002 mm.

Distribution: Ceylon.

14. *CLIONA ORIENTALIS* Thiele

(Fig. 1, M; Fig. 4, F; Pl. IV. Fig. 1)

Cliona orientalis Thomas, 1972, p. 347, pl. 2, figd. 2A-B (Synonymy)

Host: Coral and shell (*Crassostrea* sp?).

Description: Sponge spreads over the surface extensively but never grow massive. Papillae not seen. Osules and pores often flush with the surface. Osules slit like, sphinctrate, diameter 2-5 mm, and contractile. Surface minutely hispid due to the presence of tylostyles in brushes.

Surface deep brown and interior pale yellow when alive. When dry the surface shrinks off following the contour of the cavities beneath.

Chambers found inside the substratum small, 1-1.5 mm when on shell, and 1-2 mm on coral. Outline irregular on shell, whereas circular in shell.

Skelton of the interior irregular, but in the surface it may be arranged in brush like pattern.

Spicules: Tylostyles. Straight or slightly curved. Head spherical, 0.015 mm in average diameter. Size, 0.172-0.442 (0.376 mm) x 0.003-0.016 (0.013 mm). (2) Spirasters. 'C' or rarely 'S' shaped. Spines blunt and at the convex parts only. Size up to 0.025 mm.

This is a common pest of corals in the Gulf of Mannar and palk Bay. The colour is quite distinct and hence very easily detectable. Growth by lateral spreading is quite characteristic. This species in here reported from shells for the first time.

Distribution: Red Sea, Indian Ocean, Australian region.

15. *CLIONA MARGARITIFERA* Dendy

(Fig. 5, C)

Cliona margaritiferae Dendy, 1905, p. 128, pl. 5, fig. 9.

Host: Shell (*Margaritifera vulgaris and Pinctada fucata*)

Description: Chambers rounded or oval; much crowded. Inner surface of the chamber presents an etched out appearance. Diameter of incurrent and excurrent papillae varies up to about 0.65 mm. Incurrent pores in groups and the excurrent ones protected by sphincter.

Spicules: (1) Tylostyles. Straight and sharply pointed. Head globular. Size, 0.25 x 0.004 mm. Head 0.006 mm in diameter. (2) Spirasters. Usually with 4 angulations; minutely spined. Size, 0.024-0.004 mm. (3) Spined microxeas. Angulated in the middle. Transitional stages between spirasters and microxeas are well represented. Size, 0.06 x 0.0027.

According to Dendy (1905) this species is widely distributed in the Pearl Banks of Ceylon, and are considered to be most destructive to Pearl oysters.

Distribution: Indian Ocean, Australian Region.

16. *CLIONA ANNULIFERA* Annandale

(Fig. 1, N; Fig. 4, G; Fig. 5, I, J, K; Pl. 2, Fig.9)

Cliona annulifera Annandale, 1915A, p. 9, pl. I, figs. 1-4, text fig. I.

Host: Shell (*Rapana bulbosa*)

Description: Papillae are of 2 types; poriferous and mixed. Poriferous papillae have a diameter of 0.225 mm; and the terminal part is flat and poriferous; often protected by spicules. The mixed papillae have a central oval or star shaped orifice surrounded by poriferous lobes bearing spicules. The diameter of mixed papillae is the same as that of the former.

Openings on the surface of shell very small, 0.1-0.5 mm in diameter and about 50-70 per sq.cm. Both the surfaces of the shell are perforated with the same intensity.

Chambers oval or subspherical; the shell being very thin can accommodate only one layer inside. Diameter of the chamber comes up to 1.5 mm and the interior has an etched out appearance.

The skeletal arrangement inside the chamber is irregular. On the papillae, the spicules are arranged longitudinally in the interior and at the surface they project vertically outwards.

Spicules: (1) Tylostyles. Straight or slightly curved; rarely sinuous. Head spherical or trilobed. A characteristic feature is the presence of an additional swelling at a short distance from the head. Size, 0.131-0.242 (0.211 mm) x 0.002-0.005 (0.004 mm). (2) Spirasters. Two types are noted. Small type, when well developed, up to 0.050 x 0.001-0.002 mm and larger up to 0.126 mm. The larger type is met with only in the gemmules. They are with 4-8 bends, and the spines are arranged spirally.

Annandale's (1915A) type specimen came from a depth of 703 fathoms off Ceylon. It was infesting the dead shell of *Xenophora pallidula* Rve. *Rapana bulbosa*, infested with this species, was collected by the present author from the Gulf of Mannar at a depth of 6 fathoms.

Distribution: Ceylon.

17. *CLIONA KEMPI* Annandale

(Fig. 5, E)

Cliona kempi Annandale, 1915, p. 462, fig. 2.

Host: Coral.

Description: Papillae numerous, small and guarded by upright spicules; spicules spirally arranged at the central part of the papillae.

Chambers cylindrical and branch sparingly. Diaphragm with transversly arranged spicules.

Spicules: (1) Tylostyles. Slightly curved and sharply pointed. Head subglobular or trilobed. Additional swelling may be seen near the neck. Size 0.127-0.205 x 0.0041-0.0082 mm. Head 0.008-0.012 mm in diameter.

The occurrence of swelling near the head is characteristic of *C. lobata* Hancock. But *C. kempi* differs from *C. lobata* in the total absence of spirasters.

Distribution: Andamans.

18. *ANNANDALEA LAEVIASTER* (Annandale)

(Fig. 5, F)

Thoosa laeviaster Annandale, 1915A, p. 22, fig. 4.

Annandalea laeviaster Topsent, 1928, p. 6.

Host: Coral

Description: Slender and cylindrical, branches ramify the dead coral Papillae, 0.3 mm in diameter.

Spicules: (1) Oxeas. Geniculate; size, 0.08 x 0.003 mm. (2) Amphiasters. Shaft straight, with a whorl of blunt branches on either end of the shaft at a short distance from the tips. Size, 0.041-0.08 mm and shaft, 0.006-0.013 mm. (3) Oxyasters. With only 2 rays attached to a small rudimentary centrum.

Distribution: Bay of Bengal.

19. *DELECTONA HIGGINI* (Carter)

(Fig. 5, G)

Alectona higgini Carter, 1880, p. 58, pl. 5, fig. 25.

Delectona higgini de Laubenfels, 1936, p. 156.

Host: Calareous alga.

Description: Cavities formed inside the alga about 4 mm in diameter. Three type of spicules are present. (1) Rhabds. With subspherical and partly annulated swellings. Size about 0.02-0.082 x 0.006-0.01 mm. (2) Toxiform oxeas. Very slender and hair like. Size about 0.05 mm. (3) Asters. With rays arranged in two whorls. Rays microspined and with capitate endings. Size about 0.02 x 0.016 mm.

Distribution: Ceylon.

20. *DOTONA PULCHELLA* Carter

(Fig. 5, F)

Dotona pulchella Carter, 1880, p. 57, pl. 5, fig. 24. Topsent, 1904, p. 108, pl. 12, fig. 2.

Host: Calcareous algae and corals.

Description: Cavities made are 3-5 mm in diameter, and are interconnected by narrow canals.

Spicules: (1) Styles. Slender, Smooth. Size 0.08-0.1 x 0.002 mm. (2) Spirasters. Shaft cylindrical, curved. Heads microspined. Shaft with spirally arranged micro-Spined ridge running throughout the entire length. Size, 0.11-0.12 x 0.006 mm. (3) Spirasters. Shaft straight, with central whorl of spines, and tips with diverging spines. Size, 0.006-0.008 x 0.002-0.003 mm.

This species was found infesting *Melobesia* from the Gulf of Mannar (Carter 1880) and Corals from Azores (Topsent 1904).

Distribution: Indian Ocean, Atlantic Ocean.

21. *THOOCE SOCIALS* (Carter)

(Fig. 2, D)

Thoosa socialis Carter, 1880, p. 56, pl. 5, fig. 23.

Thooce socialis de Laubenfels, 1936, p. 156.

Host: Calcareous algae.

Description: Spicules two types. (1) Amphiaster, with shaft bearing 10 globular microspined projections on either end and two whorls consisting of 4 branches each at a short distance from the middle part. These microspined projections, by their enlargement, may even obscure the shaft in advanced stages. Size, when well developed, 0.032 x 0.020 mm. (2) Discs. Circular, compressed; rough and microspined. Size, 0.020 x 0.016 mm.

Distribution: Ceylon.

22. *THOOSA HANCOCKI* Topsent

(Fig. 1, P)

Thoosa hancocki Topsent, 1888, p. 81, pl. 7, fig. 12. Annandale, 1915A, p. 21 (Synonymy)

Host: Coral and shells.

Description: Three types of spicules are seen (1) Tylostyles. Shafts straight, head spherical. Size, 0.36-0.45 x 0.020 mm. (2) Nodular amphiasters. Size, 0.010 x 0.004 mm. Nodular amphiasters may be totally absent in some specimens.

This species was originally recorded from Indian Ocean from the shells of *Tridacna*. It is a common pest of coral in Java and also in Maldives.

Distribution: Indian Ocean, Australian region, Mediterranean Sea, Red Sea.

23. *THOOSA ARMATA* Topsent

(Fig. 2, A; Fig. 3, B)

Thoosa armata Topsent, 1888, p. 81, pl. 7, fig. 9. Thomas 1973, p. 62, pl. 3, fig. 12, pl.5, fig. 5. (Synonymy)

Host: Coral and shells.

Description: Cavities found inside the substratum irregular, 1-2 mm in larger diameter. The interconnections long.

Spicules: (1) Tylostyles. Straight, head globular. Size, 0.24 x 0.002 mm. (2) Nodular amphiasters. Rays in two sets; each ray with a microspined head. As a result of extra thickening in advanced stages, these may look like spheres. Well developed forms measure 0.012 x 0.008-0.021 x 0.016 (0.018 x 0.015 mm). (3) Slender amphiasters. Body slender, rays capitate. Size, 0.033-0.050 (0.042 mm). (4) Oxyasters. Centrum small, rays long and abruptly pointed. Reduction of rays quite common. When well developed, size about 0.067-0.117 (0.10 mm) x 0.003 mm. (5) Oxeas. With a swelling in the centre. Size 0.160 x 0.002 mm.

Distribution: Atlantic Ocean, Red Sea, Indian Ocean.

24. *THOOSA FISCHERI* Topsent

(Fig. 2, B)

Thoosa fischeri Topsent, 1891, p. 582, pl. 22, fig. 16 a-h.

Host: Shell

Description: Five types of spicules are met with. (1) Tylostyles. Size, 0.150-0.400 x 0.008 mm. (2) Nodular amphiaslers. Shape as in those of *T. armata*. (3) Ordinary amphiasters. (4) Oxyasters. Shape as in those of *T. armata*. (5) Corpuscles. Irregular, size, 0.018 x 0.012 x 0.006 mm.

Distribution: Ceylon.

25. *THOOSA INVESTIGATORIS* Annandale

(Fig. 2, C)

Thoosa investigatoris Annadale, 1915A, p. 18, pl. 1, figs. 5, 6. Tex fig 3..

Host: Shell

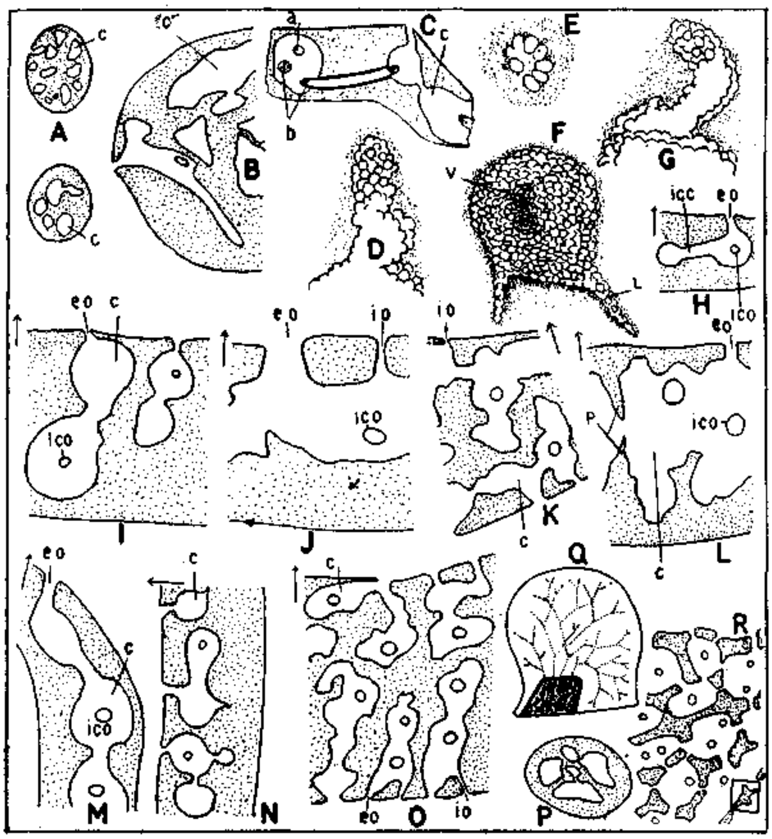

FIG. 3. (Arrow indicates the outer surface of the shell/coral. a. Openings without perforations. b. Openings with perforation. c. Chambers, e o. Excurrent openings, i o. Incurrent openings, i c o. Inter chamberal openings, i c c. Inter chamberal canals). A. *Aka minuta* Cross section of coral branch showing the cavities made inside the coral. B. *Thoosa armata.* Coral infested by this sponge. C. *Aka diagonoxea.* Section of the coral showing the structure of chambers formed inside. Two types of inter chamberal openings - perforated or not - are found to open into a chamber. *D. Aka minuta.* Detailed structure of the chamber formed inside the coral. The pattern of etching is quite similar to that found among the species of *Cliona.* E. Initial etchings made by the larva of Clionid sponge on the surface of a shell (after Goreau and Hartman, 1963). F. Spreading of boring sponge inside the substratum. Cross section of a chamber Branches are formed the mass inside the chamber which after a short distance produce another chamber. In this figure four branches are present, two growing vertically down wards (marked V) and two growing sideways (marked L). Etched out appearance is prominent evrywhere G. Pattern of boring exhibited by *Cliona celata* inside *Placenta placenta* shell. H-L. Various degrees of damage caused to *Xancus pyrum* by *C. celata.* H and I. Chambers at their early stage of development. They are less crowded and confined to the peripheral part of the shell. J and L. Advanced stages of attack. Chambers increase in dimensions and units laterally forming a continuous cavity traversed occasionally by 'pillars' connecting the less bored outer layers of the shell. (p - Pillar like remnants of the middle layers). M. Shell of *Lambis lambis* bored by *Cliona celata* initial stage of boring. N. *Cliona vastifica* inside the shell of *Xancus pyrum* initial stage. O. *C. vastifica* inside *X. pyrum* - chambers ramify the entire thickness of shell. P. *Cliona ensifera* boring inside the branch of a coral (*Pocillopora damicornis*). Q. *C. vastifica* boring into pearl yster shell. Note the linear and reticulate pattern of boring. Surface layer of the shell is removed partly to show the crowded nature of chambers formed inside. R. Part of the shell (marked in Fig. Q) enlarged to show the details of chambers.

Description: Papillae 2 types; incurrent and mixed which are 0.4 and 1 mm in diameter respectively.

Chambers not clearly differentiated, but often flattened and irregular. Whole structure, fragile and delicate. In papillae the tylostyles lie paralled to the surface and convergent with a chitinoid protection at the tips. Papillae are protected by a dense ring of tylostyles.

Spicules: (1) Tylostyles. Straight or slightly curved, head rounded or trilobed. Size, 0.34 x 0.002 mm. (2) Nodular amphiasters. Nodules spherical and covered with straight spines; terminal nodules large. Size, 0.036 x 0.016 mm. (3) Smooth amphiasters. Branches straight and with terminal hooks. Size, 0.016 x 0.024 mm.
Distribution: Ceylon.

26. *SPIRASTRELLA CUSPIDIFERA* (Lamarck)

(Fig. 1, F; Fig. 4, M)

Spirastrella cuspidifera Thomas, 1973, p. 48, pl. 2, fig. 20, pl. 8 (Synonymy)
Host: Coral.

Description: Sponge boring in the initial stage. Cavities formed are in vertical line; maximum diameter of the chamber, 0.5 mm. Papillae formed are digitate to conical, bearing 5-6 excurrent canals inside. In advanced stages the bases of papillae may unite and form a compact mass. Oscules terminal, sphinctrate and slit-like. Pores in groups, diameter up to 0.04 mm. Colour yellowish gray when alive. Texture tough but compressible when fresh.

Skeleton of papillae consists of vague bundles of tylostyles running up along the interior and curving out to the periphery and in the surface form brushes of smaller spicules. Microscleres abundant at the outer part.

Spicules: Tylostyles. Straight or slightly curved; head oval or irregular. Size, 0.115-0.667 (0.511 mm) x 0.003-0.017 (0.012 mm). (2) Spirasters. Two types. a) Slender forms with spines or tubercles arranged spirally or even straight. Size, 0.008-0.068 x 0.001-0.002 mm. b) Robust forms with two bends, spines long and spirally arranged or rarely smooth. Size up to 0.038 x 0.006 mm.
Distribution: Red Sea, Indian Ocean, Australian Region, Pacific Ocean.

27. *SPIRASTRELLA INCONSTANS* (Dendy)

(Fig. 1, J; Fig. 4, K)

Spirastrella inconstans Thomas, 1973, p. 49, pl. 2, fig. 21, pl. 8, fig. 6 (Synonymy).

Host: Coral.

Description: Overgrowth on the substratum may be globose, meandrine, or digitate in shape. The mass found inside the substrutum never form ramifications inside; and the number of papillae communicating to the exterior may be

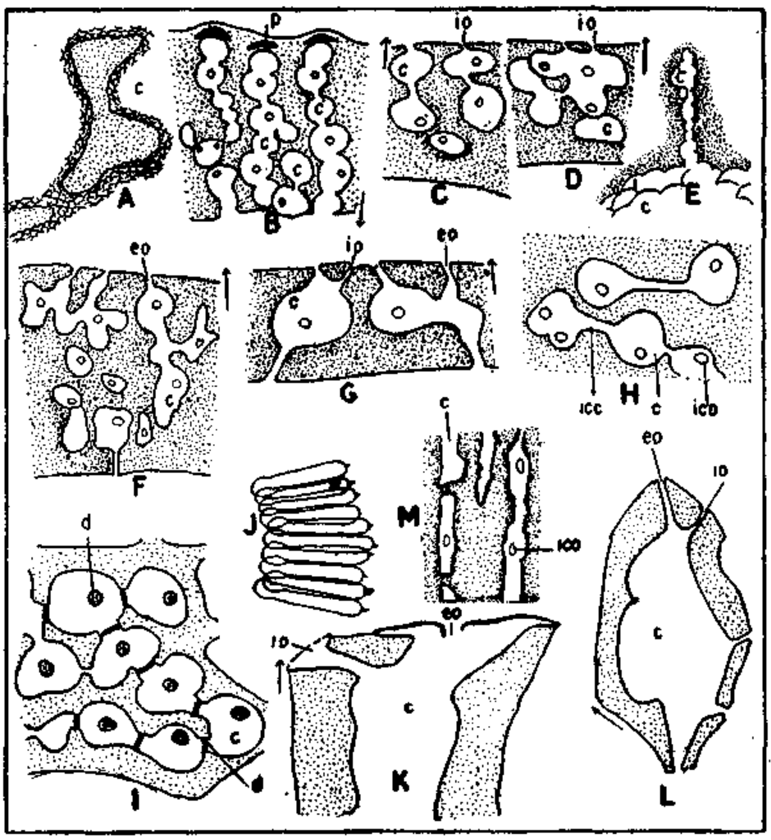

FIG. 4. (Arrows indicate the outer surface of shell/coral. c. Chambers, d. Diaphragm, e o. Excurrent openings, i c c. Inter chamberal connectives, i c o. Inter chamberal openings, i o. Incurrent openings, p. Pigment) A. Area marked in Fig. 3 R enlarged to show the etched out appearance. B. *Cliona vastifica* in *Chama* shell. The contact of sponge with the soft parts of the mollusc is prevented by secreting nacreus layer or ordinary lime in between. Pigment deposition (marked-p) is noted wherever such repairs take place. This may cause nodular outgrowths or undulations in the inner part of the shell. C. *C. carpenteri* boring into X. pyrum - initial stage. D. *C. carpenteri* boring into *X. pyrum* - advanced stage. E. *C. carpenteri*. Showing the branches formed from a chambed. Note the etched out appearance. F. *C. orientalis* inside *Crassostrea* sp. G. *C. annulifera* inside *Rapana bulbosa*. H. *Halina plicata*. Section of the coral showing the boring pattern. I. *C. mucronata* in *Chama* shell. J. *C. mucronata*. Part of the inter chamberal diaphragm enlarged to show the arrangement of mucronate spicules. K. *Spirastrella inconstans*. Section of coral showing the irregular cavities formed inside. L. *S. aurivilli*. Section of coral showing the irregular chambers. M. *S. cuspidirefa*. Section of coral with details of chambers formed inside.

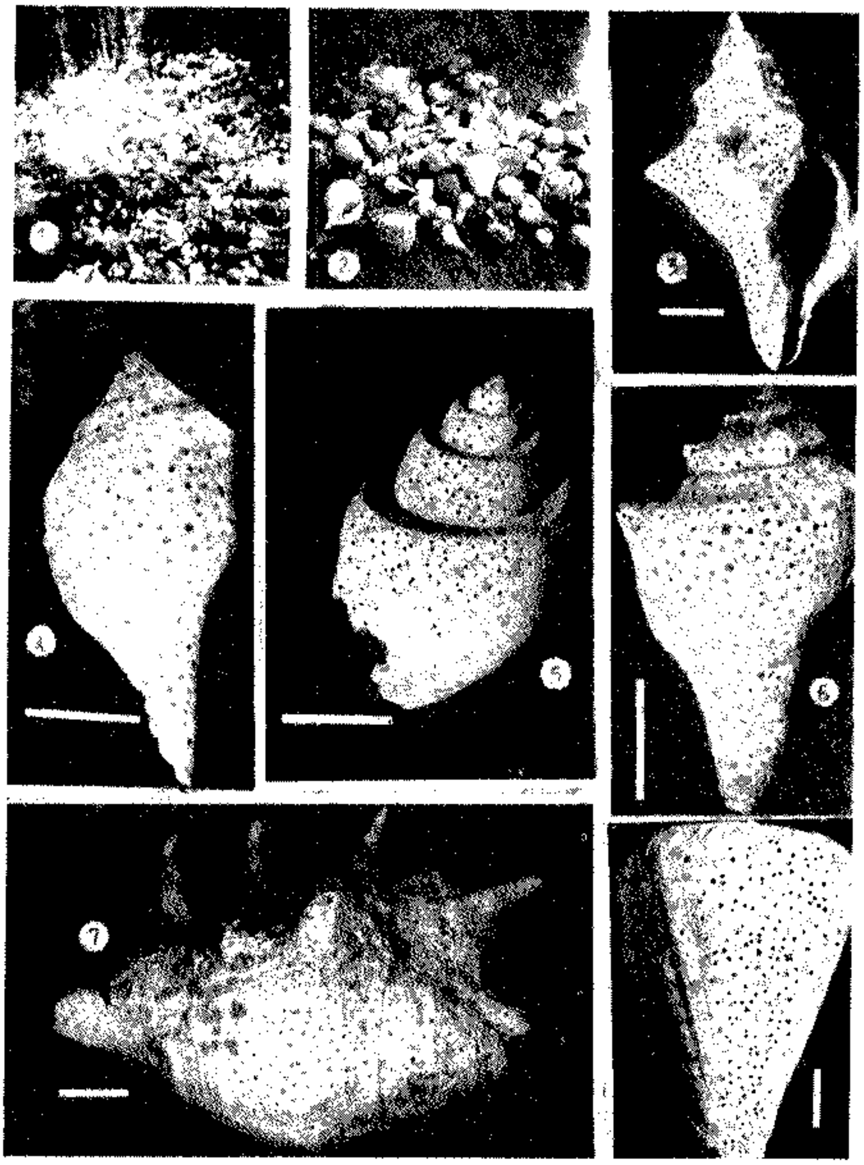

PLATE I 1. Discarded shells found in the Jamalia Chank Industries at Kelakarai. 2. A representative collection of bored shells. 3. *Fasciolaria trepezium* bored by *Cliona vastifica*. 4. *Xancus pyrum* bored by *C. celata*. 5. *Babylonia spirata* bored by *C. celata*. 6. *Hemifusus* sp. bored by *C. celata*. 7. *Lambis lambis* bored by *C. celata*. 8. *Conus* sp. bored by *C. celata*. (Inset scale in all the figures: 2 cm)

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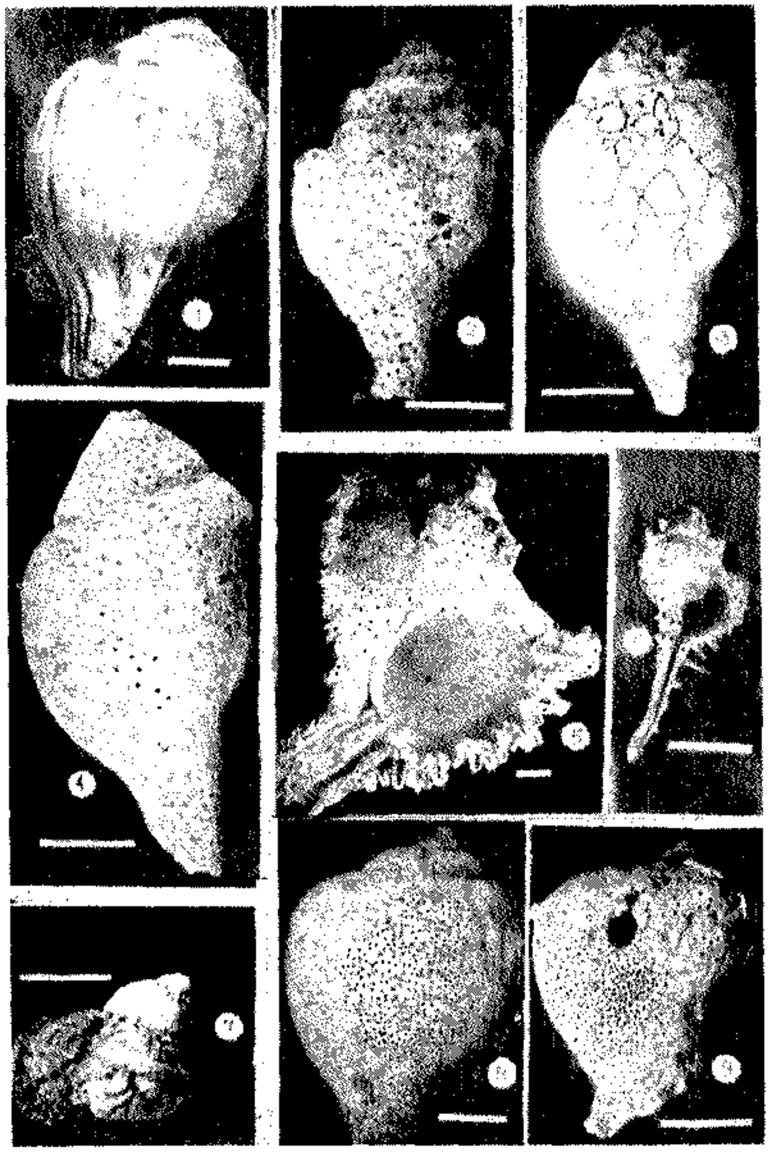

PLATE II 1. *Xancus pyrum* bored by *C. carpenteri* (advanced stage). 2. *Hemifusus* sp. bored by *C. celata*. 3. *Xancus pyrum* bored by *C. vastifica*. 4. *Xancus pyrum* bored by *C. celata*. 5 & 6. *Murex* sp. bored by *C. celata*. 7. *Turbo intercostalis* bored by *C. carpenteri*. 8. *Xancus pyrum* bored by *C. carpenteri*. 9. *Rapana bulbosa* bored by *C. annulifera*; the upper portion lodges *C. celata*

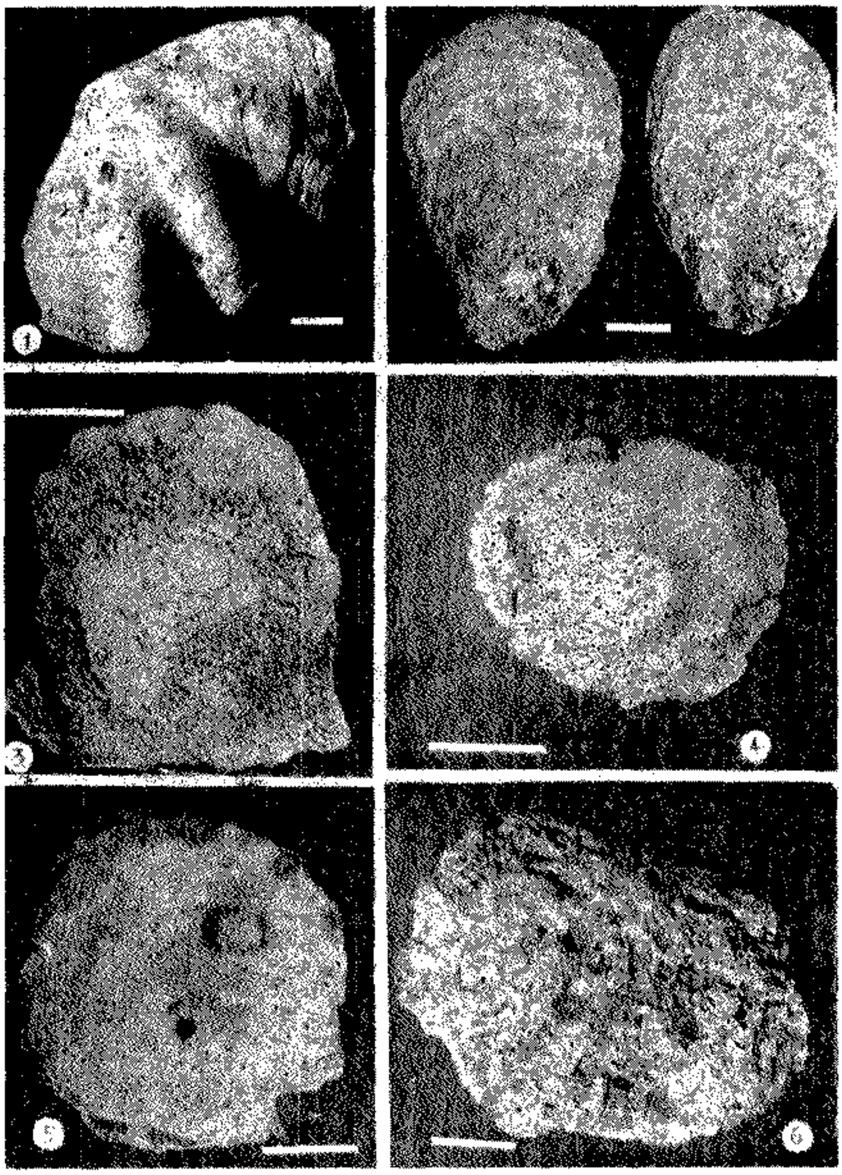

PLATE III 1. *Tridacna* sp. bored by *C. celata*. 2. *Crassostrea madrasensis* bored by *C. carpenteri* (left) and *C. vastifica* (right). 3. *Pinctada anomioides* bored by *C. celata*. 4. *Crassostrea madrasensis* bored by *C. celata*. 5. *Crassostrea cucullata* bored by *C. celata*. 6. *Crassostrea madrasensis* bored by *Aka minuta*.

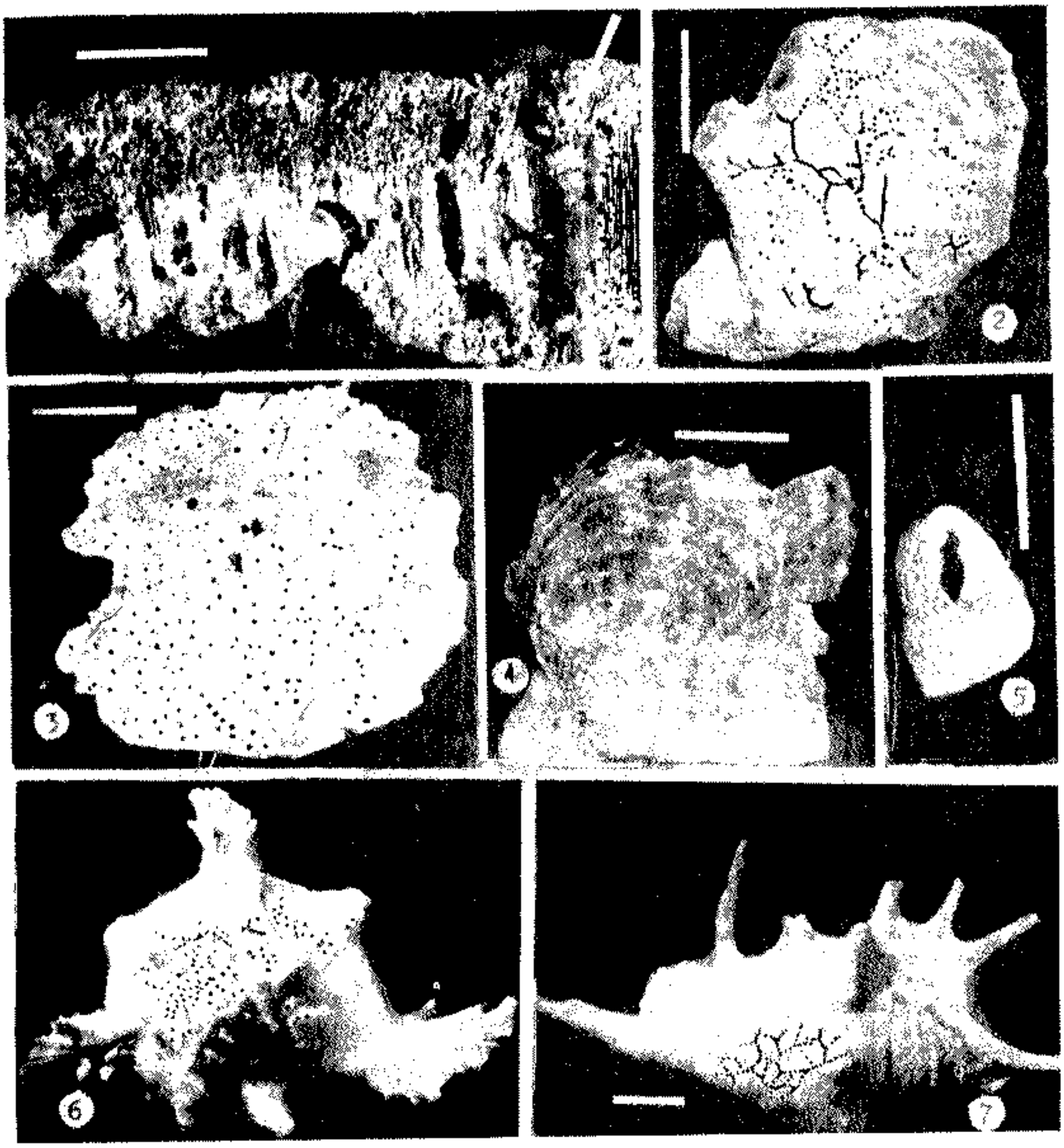

PLATE IV 1. Coral rock infested by *C. orientalis* (area marked by arrow lodges *Amphinopsis excavans*). 2. *Pinctada* sp. bored by *C. vastifica*. 3. *Placenta placenta* bored by *C. celata*. 4. *Pinctada* sp. bored by *C. celata*. 5. *Euchelus asper* bored by *C. celata*. 6. *Murex ramosus* bored by *C. celata*. 7. *Lambis* sp. bored by *C. vastifica*

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limited in number. The incurrent and excurrent openings may be found on the same or on different papillae. Oscules 2-10 mm in diameter; oval circular or even slit-like. Pores minute, up to 0.2 mm in diameter.

Spicules: (1) Tylostyles. Straight or slightly curved; smaller forms located in the surface. Size, 0.110-0.681 (0.525 mm) x0.003-0.024 (0.019 mm). (2) Spirasters. Rarely represented with 2-5 bends. Size, 0.008-0.035 x 0.002 mm.

Distribution: Red Sea, Indian Ocean, Australian Region, Pacific Ocean.

28. *SPIRASTERELLA AURIVILLI* Lindgren

(Fig. 1, O; Fig. 4, L)

Spirasterella aurivilli Lindgren, 1897, p. 484.

Spirasterella aurivilli Thomas, 1972, p. 340, pl. 1. figs. 4-4C (Synonymy)

Cliona aurivilli de Laubenfels, 1936, p. 154.

Host: Coral.

Description: Cavities formed inside the coral may come up to 4 x 6 x 5 cm in size. Papillae about 1-4 mm in diameter; often flush with the surface or slightly projecting. Incurrent papillae usually flush with the surface and bear 2-6 openings whereas the excurrent papillae, only one. The papillae are tough, thick walled, with an inner vertical layer, a central irregular layer and a brush like dermal layer of spicules. The spicules inside the chambers are irregularly arranged. Colour, when alive, pinkish red.

Spicules: (1) Tylostyles. Two types are noted (a) larger form, contributing the bulk. Straight or slightly curved. Head spherical, irregular or trilobed; diameter, 0.002 mm. Size, 0.500-0.690 (0.611 mm) x 0.014-0.045 (0.028 mm). In this form the greatest width is noted in the distal half. (b) Smaller forms of the dermal region. Size, 0.211-0.510 (0.321 mm) x 0.006-0.017 (0.012 mm). (2) Spirasters. Slender, with long and sometimes bifid spines. Size, when well formed, 0.061 x 0.003 mm.

This species is quite abundant in the Gulf of Mannar and Palk Bay just below the low tide level along with *Cliona celata* Grant.

Distribution: Indian Ocean, Australian region, Pacific Ocean.

29. *JASPIS PENETRANS* (Carter)

(Fig. 1, H)

Jaspis penetrans Thomas, 1973, p. 64, pl. 3, fig. 14 (Synonymy)

Host: Coral.

Description: Chambers irregular. Skeleton consist of large oxeas scattered irregularly intermingled with microxeas.

Spicules: (1) Oxeas. Gradually and sharply pointed. Average size, 0.47 x 0.010 mm (2) Microxeas. Uniformly curved or slightly angulated. Average size, 0.063 x 0.004 mm. (3) Oxyasters. Centrum insignificant, and with 6 micro-spined rays, Diameter, 0.012 mm average.

Distribution: Indian Ocean.

30. *JASPIS INVESTIGATRIX* (Annandale)

(Fig. 2, E)

Coppatias investigatrix Annandale, 1915, p. 460, pl. 34, figs. 1, 2.

Host: Shell.

Description: Sponge inside the chamber is irregularly oval. Growth is effected by minute, blunt, finger like processes arising from oval masses.

Spicules: (1) Oxeas. Spindle shaped; with or without errect spines near the extremities. Size, 0.098-0.205 mm. (2) Oxyasters. Rays often 6 in number. Tips of the ray sharply or gradually pointed and with erect spines. Diameter, 0.0126-0.025 mm. (3) Spherasters. Rays may or may not bear spines at extremities. Diameter, 0.010-0.012 mm.

This species was collected off Ceylon at a depth of 703 fathoms (Annandale 1915).

31. *HALINA PLICATA* (Schmidt)

(Fig. 2, G; Fig. 4, H)

Halina plicata Thomas, 1973, p. 83, pl. 4, fig. 7, pl. 5. figs. 8, 11 (Synonymy)

Host: Coral.

Description: Cavities 1-3 mm in diameter, circular or oval in outline. Conical branches are given off from the mass inside the chamber and these branches form new chambers.

Spicules: Diachotriaenes. Shaft conical. Measurements are: Shaft, 0.157 x 0.025 mm. Protoclad, 0.021 x 0.029 mm. Deuteroclad, 0.126 x 0.025 mm. Chord, 0.315 mm. Smaller spicules, measuring to about 0.088 mm chord length, are also seen. Calthrops are rarely noted. (2) Streptasters. Shaft straight, spines at both ends and with two or more whorls at the middle portion. Size, 0.008-0.14 x 0.002 mm.

Distribution: Mediterranean Sea, Indian Ocean, Australian Region.

32. *SAMUS ANONYMA* Gray

(Fig. 2, F)

Samus anonyma Thomas, 1973, p. 85, pl. 4, fig. 9 (Synonymy)

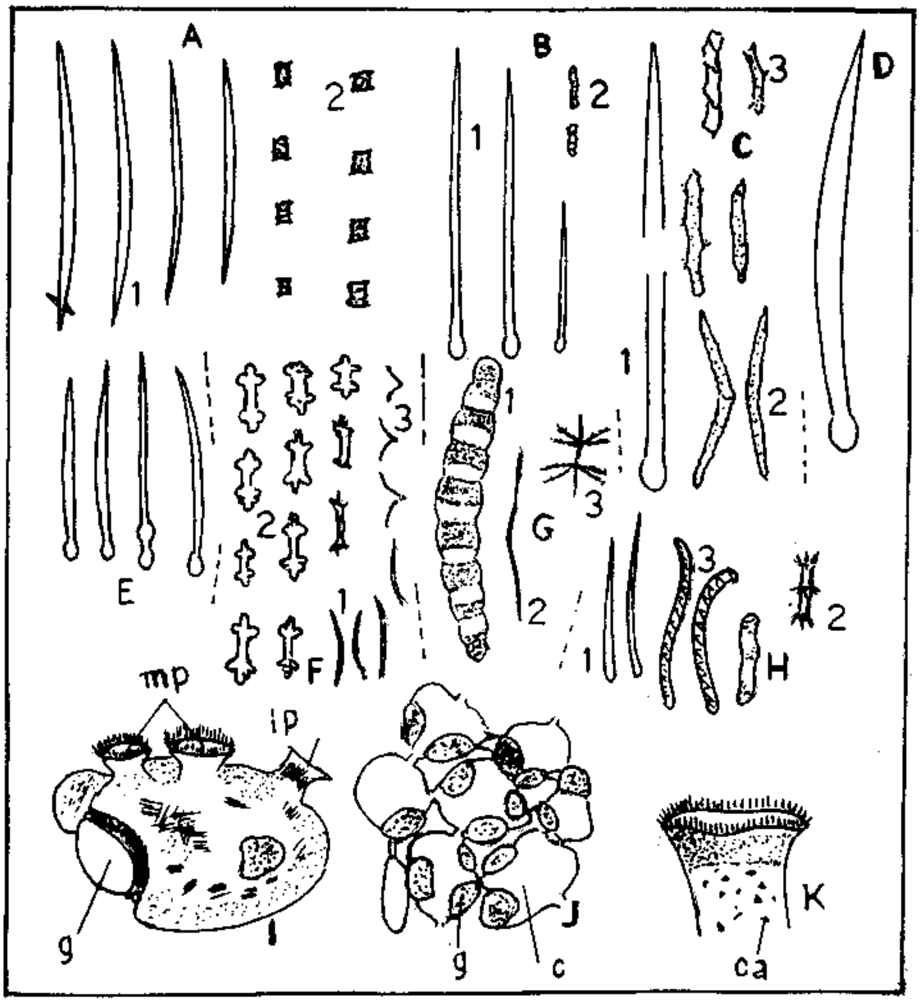

FIG. 5. A. *Donotella acustella.* 1) Oxeas, 2. Streptasters B. *Cliona indica.* 1) Tylostyles, 2. Spirasters. C. *C. margaritifera.* 1. Tylostyle, 2. Acanthoxeas, 3. Spirasters. D. *C. quadrata.* Tylostyle, E. *C. kempi.* Tylostyle, F. *Annandalea laeviaster.* 1. Oxea, 2. Amphiasters, 3. Oxyasters. G. *Delectona higgini.* 1. Rhabd, 2. Toxiform Oxea, 3. Aster. H. *Dotona pulchella.* 1. Styles, 2. Spiraster, 3. Spiraster with cylindrical shaft. I. *Cliona annulifera.* Mass inside the chamber showing poriferous papillae (i p), mixed papillae (m p) and gemmule (g). J. *Cliona annulifera.* Chambers showing the position and arrangement of gemmules. K. *C. annulifera.* Mixed papilla enlarged to show the Calcareons particles attached to it (c a).

Host: Coral.

Description: Details regarding the morphology of this species is lacking. It was not possible to get a specimen *in situ* in coral. Spicules were seen intermingled with the spicules of *Cliona spp.*

Spicules: (1) Amphitriaene. Protoclad, 0.021 x 0.012, denteroclad, 0.033 x 0.008 mm. Size, 0.050-0.132 mm (2) Sigmas. C-shaped, chord length, 0.008-0.010 mm.

Distribution: Atlantic Ocean, Indian Ocean, Australian region, Pacific Ocean.

DISTRIBUTION OF THE SPECIES

	A.O	M	R	I	A	P	E*
1. *Amorphinopsis excavans* Carter	—	—	—	x	x	—	—
2. *Aka diagonoxea* Thomas	—	—	—	x	—	—	—
3. *Aka minuta* Thomas	—	—	—	x	—	—	—
4. *Donotella acustella* (Annandale)	—	—	—	x	—	—	—
5. *Cliona celata* Grant	x	x	x	x	x	x	Arc
6. *C. vastifica* Hancock	x	x	x	x	x	x	—
7. *C. lobata* Hancock	x	—	—	x	—	x	—
8. *C. quadrata* Hancock	x	x	—	x	—	—	—
9. *C. viridis* (Schmidt)	x	x	x	x	x	x	—
10. *C. carpenteri* Hancock	x	—	—	x	x	x	—
11. *C. mucronata* Sollas	—	—	—	x	x	—	—
12. *C. ensifera* Sollas	—	—	—	x	—	—	—
13. *C. indica* Topsent	—	—	—	x	—	—	—
14. *C. orientalis* Thiele	—	—	x	x	x	—	—
15. *C. margaritifera* Dendy	—	—	—	x	x	—	—
16. *C. annulifera* Annandale	—	—	—	x	—	—	—
17. *C. kempi* Annandale	—	—	—	x	—	—	—
18. *Annandalea laeviaster* (Annandale)	—	—	—	x	—	—	—
19. *Delectona higgini* (Carter)	—	—	—	x	—	—	—
20. *Dotona pulchella* Carter	x	—	—	x	—	—	—
21. *Thooce socialis* (Carter)	—	—	—	x	—	—	—
22. *Thoosa hancocki* Topsent	—	x	x	x	x	—	—
23. *T. armata* Topsent	x	—	x	x	—	—	—
24. *T. fischeri* Topsent	—	—	—	x	—	—	—
25. *T. investigatoris* Annandale	—	—	—	x	—	—	—
26. *Spirastrella cuspidifera* (Lamarck)	—	—	x	x	x	x	—
27. *S. inconstans* (Dendy)	—	—	x	x	x	x	—
28. *S. aurivilli* Lindgren	—	—	—	x	x	x	—
29. *Jaspis penetrans* (Carter)	—	—	—	x	—	—	—
30. *J. investigatrix* (Annandale)	—	—	—	x	—	—	—
31. *Halina plicata* (Schmidt)	—	x	—	x	x	—	—
32. *Samus anonyma* Gray	x	—	—	x	x	x	—

* A.O. Atlantic Ocean, M. Mediterranean Sea, R. Red Sea, I. Indian Ocean, A. Australian Region, P. Pecific Ocean. E. Elsewhere. Arc. Arctic, x = present, — = Absent.

Of the 32 species of boring sponges known from the Indian Seas, 11 species (*Spirastrella cuspidifera, Cliona celata, C. vastifica, C. lobata, C. viridis, C. carpenteri, C. quadrata, Thoosa hancocki, T. armata, Halina plicata,* and *Samus anonyma*) have very wide distribution. *Amorphinopsis excavans, Cliona* *mucronata* and *C. margaritifera* are distributed widely in Indo-Australian Region and *Cliona orientalis* from Red Sea to Australia. *Dotona pulchella* is known both from Atlantic and Indian Oceans. The rest of the species are known only from the Indian Ocean or its adjacent seas. Species like *Jaspis penetrans, Cliona ensifera* and *Aka minuta* are distributed widely in the Indian Ocean whereas *Cliona indica, Thoosa fischeri, Jaspis investigatrix* and *Thoosa investigatoris* are known only from the type locality, Ceylon. *Thooce socialis, Delectona higgini* and *Aka diagonoxea* are known from the Gulf of Mannar and *Cliona kempi* from Andamans. *Donotella acustella* is reported from Orissa and Madras coasts and is found commonly in the shells of *Ostrea spp. Cliona annulifera* and *Jaspis investigatrix* were collected from a depth of 703 fathoms off Ceylon by R.I.M.S. 'Investigator' and *Annandalea laeviaster* from Morgui Archipelago.

The greatest depth at which the species of *Cliona* is found to occur in Indian Seas is 703 fathoms.

Reproduction and Growth

Reproduction in sponges is effected in two different ways - sexual and asexual.

Sexual reproduction: Ova and spermatozoa are produced as in other animals, and after fertilization the eggs develops into microscopic larvae which swim at the surface of the water. This stage may last for 2-3 days and afterwards they return to the bottom in search of suitable substratum. Upon settling, the larvae get flattened and immediately begin to excavate into the substratum. According to Warburton (1958) a large boring sponge may spawn several hundred thousand eggs during a summer. These larvae can spread in water causing wide spread infestation in the marine environment.

TABLE 1. *Breeding season of Clionids*

Author and year	*Locality.*	*Species*	*Period*
Grant 1826	Scotland	*C. celata*	March & April
Topsent 1900	Channel Coast, France	*C. celata*	Sept. & Oct.
Topsent 1900	English Channel	*C. vastifica*	Sept. & Oct.
Nassanov 1883	Black Sea	*C. vastifica*	June & July
Tuzet 1930	Banylus-Sur Mer	*C. viridis*	July to Sept.
Volz 1939	Revignoe	*Thoosa hancoki*	April
Hartman 1958	Milford Harbour	*C. celata*	Aug. to Oct.
Old 1942	Chesapeake Bay	Species not specified	Aug.

Asexual reproduction: Asexual reproduction by means of buds is more wide spred among boring sponges. A typical example is *Spirastrella inconstans* (Dendy), in which as the first step the tips of the excurrent papillae, which are seen in the form of finger like structures outside the substratum, may obtain a globular shape followed by the closure of the oscules and incurrent canals. These globular bodies may enlarge developing a construction in between. After obtaining full shape these bodies may get nipped off from the parent body and form new colonies. Such bodies are seen floating in water during November-May period in large numbers in the Gulf of Mannar and Palk Bay. More or less the same mode of bud formation is noticed in *S. cuspidifera* also, but not so frequent as in the former. Hartman (1958) observed another type of asexual reproduction in *C. vastifica*. Linear bulbous expansions are produced by certain undifferentiated papillae on the shell during the summer. These 'bulbs' get nipped off and establish new colonies.

Gemmules are found to occur in the deep sea forms like *C. annulifera* and *Thoosa investigatoris*. In the former the gemmules lie at the perirphery of the lower part of the chamber and are lenticular in shape with greatest diameter of 0.56 mm. These gemmules are protected by horizontally arranged microscleres which differ considerably from that of the general choanosome. In *Thoosa investigatoris*, the gemmules are spherical with a diameter of 0.374 mm and fully occupy a separate chamber. Asexually produced gemmules can swim in water with the help of cilia and can form new colonies on suitable substratum.

According to Warburton (1958) the sponge may simply grow across the border between two shells if they are in close contact. In places where the shells live in greater concentration this method of infestation may prove very effective in the spreading up of boring sponges.

It is a general fact that all animals grow rapidly when they are young and small, and slowly when they are older and larger. But this is not the case with sponges. It has a growth rate that is constant in relation to its age and size. Thus a young mollusc when infected with a sponge may not show noticeable damage since the shell is in a rapidly growing phase. After attaining sufficient maturity, the growth in the case of shell slows down but that of the sponge goes on in a relatively faster rate. According to Warburton (1958) this is the reason for not showing extensive damage in the case of young oysters.

After the free swimming stage the larvae settle down on suitable substratum. On settling they assume an incrusting shape and start boring into the substratum by chipping off elliptical particles from the surface of the shell. The larvae thus gaining access into the shell chip off calcium carbonate particles liberally and form an initial chamber inside the shell. Warburton (1958) studied the machanism of boring by using calcite crystals. Under the phase contrast microscope, he could see two types of cells at the site of boring. The first type of cells were provided with a "remarkable network of thread - like interconnections and pseudopodia, often 50 microns or more long. These surrounded the areas reminiscent in shape of the calcite particles excavated by the sponges, or of the lines etched on calcite crystals." Other cells showed "broad filmy expansion, only 2 or 3 microns thick."

Spreading inside the substratum is effected in the same way. First from the mass inside the chamber certain conical branches are formed (Fig. 3, E, F). These branches excavate conical cavities inside the shells, the interior of which possesses the same etched out appearance as that of a chamber with a difference that the etchings are smaller when compared to those inside the chamber. Shell particles, thus removed, are hemispherical or semicircular in outline, and may vary from 0.2-0.5 mm in diameter; but subject to considerable variation from shell to shell. These particles are expelled out through the oscules continuously when alive.

Several theories have been put forward in the past to explain this phenomenon. Hancock (1867) and Fischer (1868) considered that boring is by mechanical means, by the aid of spicules. But this theory is abandoned thoroughly for Nassanow (1833), Old (1942), and Warburton (1958) have shown that the larvae of Clionid even before the development of spicules can chip off calcareous particles. Nassanow (1883), Cotte ,1902), Vosmaer (1933) and Warburton (1958) suggested that such chips are removed by the dissolution of calcarcous material at the point of contact of cytoplasmic processes of the cell and the substratum. But no evidence has been obtained showing an increase in the dissolved calcium in the water in which they have been cultured. Old (1942) Warburton (1958), and Topsent (1888) have stated that the boring is effected purely by machanical means by the contractability of the sponge cells and not by chemical action for two reasons. First, the conchiolin is removed in the form of chips possessing regular shape and secondly, the sponge cells in contact with the substratum differ in size from the chips removed. However, a chemical action involved in the boring has not been convincingly prooved.

The protoplasmic processes put forward by the sponge cells are uniformly seen in all boring sponges, but whether they remove the particles which have been cut off by some other means or actually engaged in cutting and removing the particles is not well known.

Damage Caused to the Shell

In the initial stage of infestation the presence of the boring sponge is very difficult to recognise, whereas in advanced stages, when riddling become extensive, shells turn brittle and are liable to crumble under slight pressure. The papillae, both excurrent and incurrent, increase tremendously in number at the outer surface. The possibility of the sponge 'tissue' coming into contact with the soft parts of the mollusc is seen only in cases of old, heavy infestation. But in most cases, the measures adopted by the mollusc prevent such a contact with the soft parts by secreting conchiolin in between the shell and the soft parts. de Laubenfels (1947) pointed out a serious drain in oyster's energy due to the extra strain of secreting additional conchiolin to prevent the contact of the sponge with the soft tissue. Galstoff (1964) found out that when deposition of shell material is delayed due to the adverse conditions, "the sponge makes direct contact with the mantle and produce lysis of the epithelium and underlying connective tissue. Dark pigmented pustules form exactly opposite the holes in the shell. The tissue of the oysters is flabby and mantle is easily detached from the shell surface." These dark spots are, according to Warburton (1958), concentrations of blood cells. Warburton found out that in summer the oysters patch up holes made in the inner surface by sponge with conchiolin and later with limy shell whereas in autumn and early spring the oysters are unable to repair the shell, and this is the reason why the oysters fished out from cold waters in late autumn, winter or early spring often bear small holes in the inner surface of the shell.

Damage caused to the hinge machanism:

The hinge machanism in bivales is a protective device from their enemies and hence the proper functioning of the hinge machanism plays a vital role in the welfare of the organism. The sponge, by making blisters or openings at or near the adductor attachment area or hinge may affect their effective functioning; and such oysters may die or fall prey to their enemies.

The magnitude of damage caused by boring sponges cannot be detected by external examination, since they leave the surface layers of the shell untouched except for the holes through which the incurrent and excurrent papillae project out. The tunnels produced by the sponges are confined chiefly to the middle layers of the shell. In advanced stages it is often seen that the central layer may be eroded to the maximum, leaving the two surface layers (inner and outer) interconnected by some pillar like structures (Fig. 3, 4-L). Such shells are liable to break off by slightest pressure and hence are often discarded by curio manufacturers.

It is very difficult to say which part of the shell is affected more. But it is generally seen that the thickest part is damaged more intensively. The reason is that a thick column of calcium carbonate provides more space for a dense proliferation. In bivalves, especially in pearl oysters, the umbo region is infested first, the ramification gradually spread to the periphery of the shell. In *Crassostrea* species, the attached valve is the prime target though free valves also are affected in some cases. The spire area of the gastropod species like *Xancus pyrum*, *Lambis lambis*, are more heavily infested. In corals often the dead parts are infected more intensively, and the living branches when infected may exhibit stunted growth.

Structure and Composition of the Boring Sponges in Indian Seas

Species of *Cliona* are very difficult to be identified in the field by the naked eye since the tunnels made by different species assume different sizes and shapes in different shells. Hence microscopic examination of the different catagories of spicules, their measurements etc. become highly essential. It is usually seen that in *Cliona celata* the holes made on shell are large and are wide apart when compared with those of *C. vastifica* when they infest the same species of mollusc. But by naked eye it is very difficult to differentiate species like *Cliona vastifica C. carpenteri, C. lobata, C. orientalis* and *C. annulifera* since all of them have tunnels more or less of the same shape and size.

In a sample of 200 shells taken at random from a total of 2000 shells, the various species of mollusc infested with sponges are given in the following table:

Mollusc	*Nos. infested*
Xancus pyrum	153
Crassostrea madrasensis	8
Lambis lambis	7
Hemifusus cochlidium	6
Turbo intercostalis	5
Murex virgineus var. *ponderosa*	3
Arca inaequivalvis	3
Murex ramosus	2
Placuna placenta	1
Rapana bulbosa	1
Murux virgineus	1
Babylonia spirata	1
Fasciolaria trapezium	1
Pinctada fucata	1
Conus sp.	1
Murex sp.	1
Strombus sp.	1
Tonna dolium	1
Crassostrea cucullata	1
Bivalve shell (Highly erroded)	1
Lambis chiagra	1

Incidence of boring sponges in the above sample of 200 shells are:

Cliona celata	129
C. vastifica	53
C. carpenteri	8
Doubtful *	11
C. orientalis	1
C. annulifera	1
Aka minuta	1
Total	24**

* Spicules were washed away completely.

** Multiple infestation noted in 4 shells.

Pests of Xancus pyrum:

Sacred chank (*X. pyrum*) is widely distributed in Indian Seas. Several varities have been described; but here no attempt is made to differentiate the varieties. The different species of *Cliona* infesting the shells of *X. pyrum*, and their percentage of incidence are given in the following table. In a random sample of 200 shells, 153 were of *X. pyrum*.

C. celata	101	65.161
C. vastifica	41	26.451
C. carpenteri	5	3.225
Doubtful	8	5.163
	155*	

* Multiple infection in 2 shells.

Inorder to study whether there is any difference in the size of shells infested by those three species of *Cliona*, the various shells examined were arranged under the following size groups (in cm).

Group I 2-3.9 cm diameter
Group II 4-5 9 cm diameter
Group III 6-7.9 cm diameter
Group IV 8-9.9 cm diameter
Group V 10-11.9 cm diameter
Group VI 12-13.9 cm diameter

Further details are given in the following table:

	Gp. I	Gp. II	Gp. III	Gp. IV	Gp. V	Gp.VI
C. celata	1	7	58	31	4	Nil
C. vastifica	Nil	1	20	20	Nil	Nil
C. carpenteri	Nil	2	2	1	Nil	Nil
Doubtful	Nil	5	3	1	Nil	Nil
Total	1	15	83	52	4	Nil = 155

It is evident from the above table that *C. celata* infestation is more in shells coming under group III. Shells of Group IV constitute the second largest size group in the order of abundance. But as far as *C. vastifica* is concerned the size group III and IV are equally infested. Shells of group II and III are infested equally in the case of *C. carpenteri*.

In the Chank beds of Gulf of Mannar, Palk Bay and Nagapatanam, *C. celata* predominates and *C. vastifica* plays only a secondary role. But this condition changes considerably in Andaman beds, where the incidence of *C. vastifica* is considerably more.

Pearl oysters:

Though several species of the genus *Pinctada* Roding are reported from Indian waters, the most valued species for natural pearl is *P. fucata* (Gould) (= *P. vulgaris* Schumacher). This species forms extensive beds extending form Kelakarai to Cape Comorin along the south east Coast of India. It is abundant in Ceylon also.

Hornell (1904) recorded sponge as a common enemy of Pearl Oyster of Ceylon. He found that the sponges can cause damage to the Pearl Oyster in the following lines.

a) Shells become brittle when the intensity of boring is too high. b) Insertion scar of the adductor muscle becomes tuberculated and diseased. c) Boring may affect the nacre production of the epidermal layer. d) Subepidermal tissue becomes thin and diseased when the inroads become extensive.

Hornell (1904) pointed out that *Cliona margaritifera* Dendy, is a common pest of Pearl Oyster in Ceylon beds. Neither Hornell nor Dendy (1905) could record other species of *Cliona* in the Pearl Banks of the Gulf of Mannar than the one mentioned above.

During the present investigation 400 shells of *Pinctada fucata* were examined. It is found that out of 400 shells examined about 34 (8.5%) were infested with different species of *Cliona*. Of these 34 shells, 18 were infested by *C. vastifica*, and 12, by *C. celata*. In 4 shells spicules were not found since they were in a badly eroded condition. No specimens of *C. margaritifera* were obtained during the present survey.

It is observed that *C. celata* affect the thickest part of the shell and may even penetrate to the nacreous layer. Blister like growth of nacreous layer is observed in may cases and in some a dark pigment (Fig. 4, B) is also noted at the tip of such blisters. In advanced stages such blisters became highly crowded. Galleries formed by *Cliona vestifica* inside the pearl oyster shell are in linear and reticulate pattern and in most cases the ramification may reach up to the edge of the shell.

Shells of another species of oyster, *P. anomioides* (Ruve), found rarely in this area are also infested with *C. celata*.

Edible oysters

Several species of edible oysters are represented in Indian waters. Species like *Crassostrea madrasensis*. Preasdon. *C. gryphoides* (Newton and smith), *C. cucullata* (Born) and *C. discoides* (Gould) form extensive fishable beds along the Indian coasts.

Both living and semifossilised shells were utilized for the present study. In living shells it is noted that the fixed valve is infested first, and thence to the free valve by contact. The contact of sponge with the soft parts of the mollusc is effectively prevented by rapid secretion of conchiolion in between. Blister formations are not seen in *Crassostrea* species, instead the interior becomes undulated and uneven where the chambers are richly concentrated.

The different species of sponges collected from edible oysters were: *C. celata, C. vastifica, C. carpenteri,* and *Aka minuta.*

C. celata is seen both in *C. madrasensis* and *C. cucullata* alike, whereas *C. vastifica* is common only in the former. Another species, *C. carpenteri,* is met with only in *C. cucullata* and *Aka minuta* in *C. madrasensis*. Annandale (1915) recorded another species, *Donotella acustella* from *C. cucullata,* from a depth of 15-30 fathom off the coast of Orissa, and according to him this species is apparently very common in Orissa coast.

The uneven surface pattern afforded by the shell of *Crassostrea* spp. may attract the larvae and this may be the reason for the heavy incidence of boring sponges in *Crassostrea* species.

Turbo intercostalis:

This edible gastropod is also infested by a good number of sponges. The different species, in their order of abundance, are: *Cliona carpenteri. C. vastifica, C. celata.*

It is seen that both the surfaces of the shell are punctured alike by the incurrent and excurrent papillae.

Lambis lambis:

Cliona celata and *C. vastifica* are found commonly.

Fesciolaria trapezium

Only *Cliona vastifica* is found.

Murex ramosus:

Cliona celata is the only species found infesting.

Murex virgineus:

Both *Cliona celata* and *C. vastifica* are found.

Arca inaequivalvis:

Only subfossilised shells were collected and most of them were infected with *C. celata*.

Hemifusus cochlidium:

Only *Cliona celata* is found.

The occurrence of 32 species of boring sponges in the Indian Seas shows that this area is quite suitable for the growth of boring sponges. But all the 32 species mentioned above are not distributed with equal abundance, and some of them are known only through the type discription. Hartman (1958), while discussing the distribution of *Cliona celata* and *C. vastifica*, came to the conclusion that "the overall ranges are practically coextensive' and according to him in the warmer regions of the world, *C. vastifica* is more common than *C. celata*. *Cliona vastifica* in the Indian Waters prefers the molluscan shells; and in coral reefs it is scarcely found. According to Annandale (1915) *C. vastifica* is very common in the littoral zones of Indian Seas; and may even spread to the brackish water. Annandale reported *Cliona vastifica* from Chilka Lake in Orissa, from the Ganjam District of Madras presidency, from Adayar river at Madras and also from the Ennur Backwater in the same district. He also reported that in Persian Gulf it is common and apparently distructive to the Pearl shells. Hartman (1958) found that *C. celata* is the dominant species in oyster beds of temporate regions; but in Indian oyster beds *C. vastifica* is the most dominant species.

During the present survey it is noted that both *Cliona celata* and *C. vastifica* are coextensive in Indian seas; but the former is rather widely distributed in shells and corals. *Cliona vastifica*, though abundant in shells, assumes only a secondary position and in coral reefs it plays only a minor role. But this is, by far, the most successful species in the estuarine realms.

The salinity and temperature tolerances of *Cliona celata* and *C. vastifica* have been studied by Hartman (1958) and he came to the following conclusions.

Both *Cliona celata* and *C. vastifica* are capable of functioning noramlly in salinities lower (20‰) than they are likely to meet in the offshore waters.

Tolerance of Clionids to low salinities is inversely related to temperature.

Cliona vastifica is more tolerant of exposure to low salinities than *C. celata*. Population of *C. vastifica* have invaded the brackish water in a number of regions and have undergone paralled morphological changes in each region. In American Atlantic coast alone three populations which merit specific rank are apparently existing.

Control of Boring Sponges

Several control measures have been adopted in the past with little success. According to Warburton (1958) a perfect system of sponge control should check the settling of larvae and also at the same time prevent the spreading of the sponge from shell to shell by way of contact. In natural beds it is very difficult to prevent the settling of the larvae. According to Warburton (1958) a practical control system should have the following procedures.

A. *Removing spongy shells*

This is essential because reinfestation of new shells through spongy shells already existing in the grounds is possible.

B. *Killing the sponges*

a) By soaking in freshwater

Topsent (1900) and de Laubenfels (1947) suggested that soaking the oysters 'briefly' in fresh water will kill the sponge. Hartman (1958) experimentally proved that at temperature near 23°C a period of exposure to fresh water between 1 and 2 hrs. would kill the sponge; another point noted in this is that restitution bodies would arise and regeneration may ensure.

b) Killing by chemicals.

Soaking the oysters for an hour in potassium permanganate solution (1 pound permanganate in 25 gallons of seawater) or in formaldehyde (1 gallon commercial formalin in 10 gallons of seawater).

c) Exposure on beaches.

Oysters may be placed in sloping beaches for few weeks. But care should be taken since too much exposure may kill or stunt the growth of the oysters.

d) Floating the oysters in creeks.

Freshwater available in creeks during certain period may effectively kill the sponges. Use of dead shell as cultch in the grounds may be avoided and instead Hartman (1958) suggested a non calcarous cultch to decrease their incidence.

Coating the cultch shell with black varnish also may protect them from boring sponges (Orton 1937).

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