



# Systematics, zoogeography and affinity of boring sponges infesting the brown mussel, *Perna indica* Kuriakose and Nair from the southwest coast of India

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## Abstract

A study on the boring sponges infesting the brown mussel population of the southwest coast of India was initiated in 1998, and bored shells collected from five major mussel fishing centres along the coast were analysed on a regular basis. It could be seen that out of 5,600 shells examined during 1998-2000 period, 997 shells were found infested with boring sponges registering an overall incidence of 17.8%, and this, when compared with 3-8 % noticed in natural molluscan beds was too high. The total number of boring sponge species recorded from mussel is nine, and these fall under two families and four genera, the most speciose genus being *Cliona* with five species. The Enayam centre accounted for all the nine species, and the two new infiltrants, *Pione margaritifera* and *C. lobata* formed a common factor with high specific incidence (%) in all the centres surveyed. Out of three conventional species, only two viz. *Cliona celata* and *Pione vastifica* were present in all the centres surveyed with subdued activity and lower incidence %. *Pione carpenteri*, the third conventional species, could be collected only from Enayam and Kadiyapatnam. *Cliothisa hancocki*, *Thoosa armata* and *Siphonodictyon minutum* were present only at Enayam and were new records to brown mussel. Another species, *Alectona wallichii*, is also recorded from Enayam. During the present study it could be ascertained that *P. vastifica*, a conventional boring species of molluscs, has succeeded in colonizing the estuarine realms of Ashtamudi Lake, Kollam due to its euryhaline nature, and hence form a

major threat to any molluscan culture farm along this estuary in future. Systematics, description, distribution of all the nine species along with illustrations are given in this paper.

**Keywords:** Brown mussel, dreadful sponge pests, southwest coast, India

## Introduction

Many species of sponges are capable of boring into shells of molluscs causing considerable damage to molluscs. The species information of boring sponges is scanty. Thomas (1975) studied the distribution of boring sponges in the estuarine environment. Thomas and Thanapathi (1980) recorded the infestation of *Pione vastifica* in an ancient window pane oyster bed in Goa. The pearl oyster culture rafts at Tuticorin were infested with two conventional species, *P. vastifica* and *Cliona celata* till 1981. But in 1987 *Pione margaritifera* could also be identified from the Tuticorin pearl culture rafts (Dharmaraj et

*al.*, 1987). Thomas (1979) has described the various families, genera and species of boring sponges present in Indian seas.

Among the commercially important molluscan species distributed along the southwest coast of India, the brown mussel, *Perna indica* Kuriakose and Nair, is the only species which occur in fishable magnitude in various centres of this coast. Previous studies made along the coast (Thomas *et al.*, 1983, 1993) have shown that the brown mussel population along this coast is worst affected by boring sponges, and two pest species have even migrated to tended stocks of mussel kept on culture rafts at Vizhinjam Bay around 1980. Sunil (2002) studied the after effects of the two new migrants to these culture rafts and their subsequent spreading to molluscan beds in and around Vizhinjam, competing with various conventional boring species. The present paper deals only with the systematics of boring sponges infesting the brown mussel population of the southwest coast of India

## Material and methods

### Study area

Six major landing centres were selected for the present study *viz.* Vizhinjam (Stn. 1), Mulloor (Stn. 2), Enayam (Stn. 3), Colachel (Stn. 4), Kadiyapatnam (Stn. 5) and Kanyakumari (Stn. 6). Map of study area is the same as given by Sunil and Thomas (2012). The collection from Kanyakumari (Stn. 6) was discontinued later due to erratic nature of mussel landings.

### Sampling

A sample of 100 mussels was collected at random from each centre from different units once or twice every month. Total length of each specimen was recorded and bored shells were separated from the sample. The outer surface of the shell (mainly the umbo proper) was examined to know the nature of pores, their size, colour of papillae and whether the papillae are expanded or contracted in fresh condition. The inner sides of the shell were examined in case of advanced boring to ascertain whether the papillae have established contact with the soft parts of the mantle or not.

The methods suggested by Old (1941), Thomas (1972, 1979), Schonberg (1999, 2000) were followed for preparing spicules and for bioerosion studies. Length and width of each category of spicules were calculated for ten spicules at random, and measurements were recorded in mm. A uniform pattern, length  $\times$  width is given for each category of spicules. For making permanent slides, Euparal and DPX were used.

## Results

### Classification

**Phylum:** Porifera Grant, 1836

**Class:** Demospongiae Sollas, 1885

**Order:** Haplosclerida Topsent, 1928

**Family:** Phloeodictyidae Carter, 1882

**Genus:** *Siphonodictyon* Bergquist, 1965

1. *Siphonodictyon minutum* (Thomas, 1973)

**Order:** *Clionaida*, Morrow & Cárdenas, 2015

**Family:** *Clionaidae* d'Orbigny, 1851

**Genus:** *Cliona* Grant, 1826

2. *Cliona celata* Grant, 1826

3. *Pione vastifica* Hancock, 1849

4. *Cliona lobata* Hancock, 1849

5. *Pione carpenteri* Hancock, 1867

6. *Pione margaritifera* (Dendy, 1905)

**Genus:** *Cliothosa* Topsent, 1905

7. *Cliothosa hancocki* (Topsent, 1888)

**Order:** Tetractinellida, Marshall, 1876

**Family:** Thoosidae Cockerell, 1925

**Genus:** *Thoosa* Hancock, 1849

8. *Thoosa armata* Topsent, 1888

**Family:** Alecetonidae Rosell

**Genus:** *Alectona* Carter, 1879

9. *Alectona wallichii* (Carter, 1874)

General classification adopted here is that of de Laubenfels (1936) and for Alecetonidae of Rutzler (2002).

### 1. *Siphonodictyon minutum* Bergquist, 1965

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

**Material** : Five brown mussel shells.

**Locality** : Enayam (Stn. 3)

**Depth** : Mussel beds, 5-8 m.

**Colour** : Not recorded in living condition; papillae light brown when dry.

**Consistency** : Papillae papery when dry, oxeas strewn irregularly and collapse when taken out of water, not contractile.

**Description:** Openings at the outer surface confined to the umbo part only, these openings may vary in diameter from 0.1 to 0.6 mm; larger openings lodge excurrent papillae and smaller, the incurrent papillae; excurrent papillae with single and incurrent with many openings at the extremities.

Chambers formed inside the shell by the activity of sponge are usually in one tier and occupy the middle layers of the shell. These chambers are irregular in outline, 1-1.8 mm in maximum diameter. The 'sponge mass' inside the chamber produce branches (upto three numbers in some) and these branches, after a distance of 1-1.5 mm, form another chamber. The canals through which these branches pass to the adjacent chamber is called 'inter-chamberal canals'. The interior of chambers and inter chamberal canals have an etched out appearance under high magnification. The etchings, in this species, when compared with those of *Cliona* spp. are not so sharp and distinct.

**Spicules:** Oxeas. Younger forms are uniformly curved, but well developed forms are slightly angulated at the centre; tips gradually and sharply pointed; size, 0.06-0.134 mm x 0.002-0.006 mm. (Fig. 1A, I)

**Distribution:** A widely distributed pest of shell/coral in the Indian seas; it is here recorded from brown mussel shell.

## 2. *Cliona celata* Grant, 1826

**Synonymy** : *Cliona celata* Thomas 1973, p. 60, pl. 3, fig.10.  
**Material** : 41 bored mussel shells.  
**Locality** : Stations 1-5  
**Depth** : Mussel beds, 5-8 M.  
**Colour** : Papillae green to golden yellow or even red in living condition; 'sponge mass' inside the cavities often red or colourless; green, red or yellow colour oozes out when preserved in alcohol indicating the presence of symbiotic algae inside the sponge.

**Description:** The umbo part of the shell is usually infested first and then the branches of sponge spread towards the marginal parts of the shell by a 'canal and chamber' system of proliferation, which is specific to boring sponges.

Surface of the shell is perforated by circular to oval openings with a diameter varying from 0.037-1.0 mm. Smaller openings (0.03-0.28 mm diameter) lodge incurrent papillae while larger

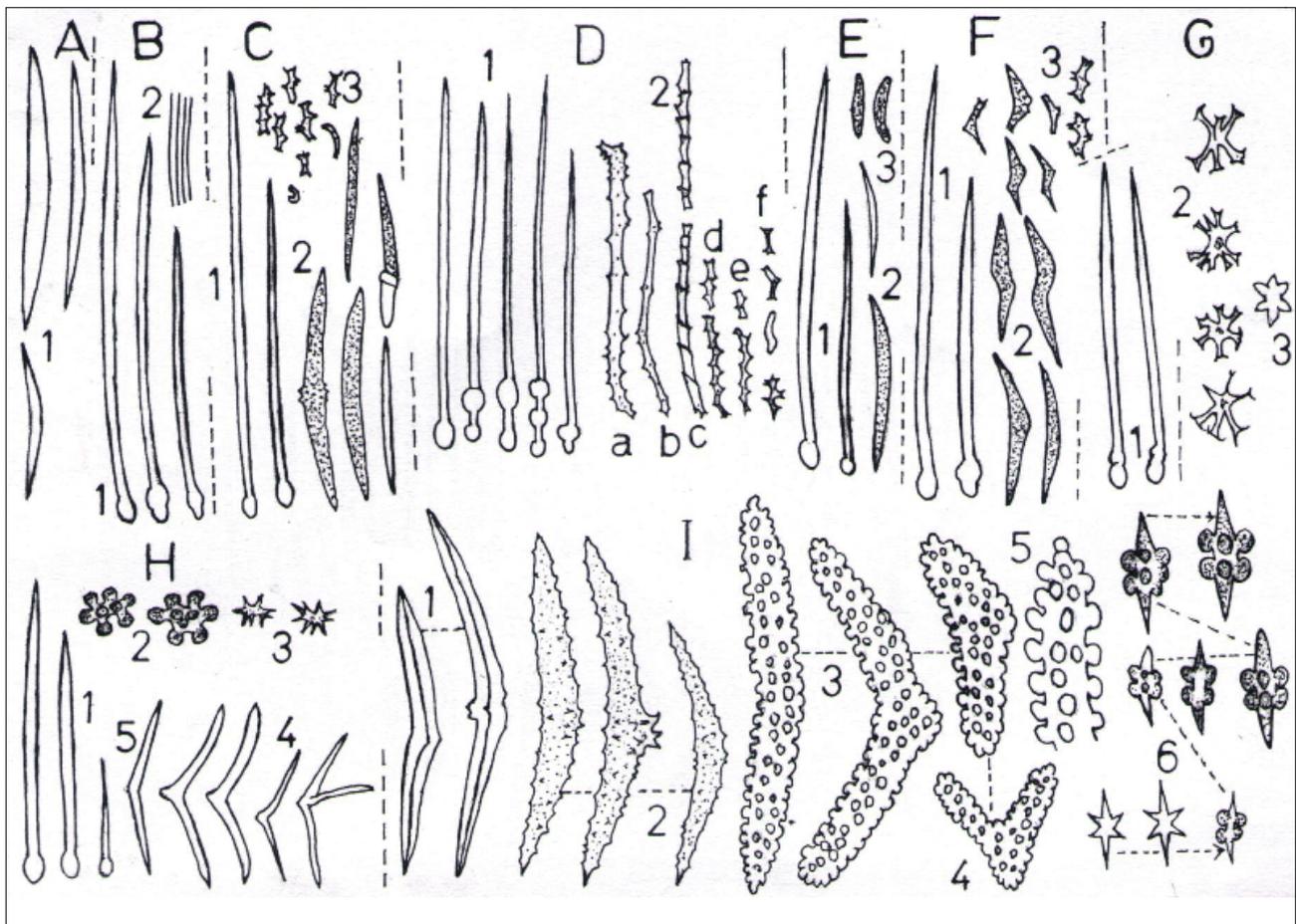


Fig.1. Spicules of species A-I

(0.038-1.0 mm diameter), the excurrent papillae. In living condition the papillae may project out of the shell surface to a height of 4 mm, but when taken out of water they contract and remain flush with the surface. Incurrent papillae may have several smaller openings at their extremities while the excurrent papillae with solitary opening. Both these papillae are provided with a 'crown' of tylostyles projecting out in a 'brush-like' pattern protecting the papillar tip. These brush-like spicules rub against the mantle epithelium producing lysis and many other pathological manifestations to the host in living condition.

The skeletal arrangement of the 'sponge mass' inside chambers is irregular whereas on papillae it is often parallel to the long axis towards the base, slanting at the middle part and 'brush-like' at extremities.

The inner wall of the chambers, inter chamberal canals and papillar canals may provide an 'etched out' or 'frothy' appearance when viewed under high magnification and this condition is specific to boring sponges. Each such etched out 'pit' may represent the area from which a 'microchip' had been removed by the boring activity of sponge and the maximum diameter of a pit may vary from 0.02 -0.07 mm. Boring is effected in a chamber-canal pattern.

**Spicules:** Tylostyles: Smooth and slightly curved at the base, tip sharply pointed, head oblong or trilobed; size, 0.08 -0.29 mm x 0.002 - 0.013 mm (length x width). (Fig. 1B, 1)

**Oxeas:** Hair-like and very rare; size, 0.08 -0.14 mm. (Fig. 1B, 2)

**Spirasters.** Not seen in any of the specimens examined.

**Remarks:** Only alpha stage is seen in the Indian seas.

**Distribution:** Cosmopolitan, widely distributed in the Indian seas, present in all stations surveyed.

### 3. *Pione vastifica* Hancock, 1849

**Synonymy** : *Cliona vastifica* Thomas 1973, p.61, pl. 3, fig.11.

**Material** : 364 sponge infested brown mussel shells.

**Locality** : Stations 1-5

**Depth** : Mussel beds, 5-8 M

**Colour** : Papillae yellow when alive; 'sponge mass' inside shell light yellow.

**Description:** The umbo part of the shell is infested first and from this part the branches spread towards the marginal zones of the shell almost in a straight line often branching dichotomously in the same line forming chambers at regular

intervals. From each such chamber two papillae are formed and they pierce the upper or lower surfaces of the shell, and of these, one may be excurrent and the other incurrent papillae: the larger (dia. 0.37-0.75 mm) and smaller (dia. 0.07-0.037 mm) lodge excurrent and incurrent papillae respectively.

The chambers formed inside the shell are in two or three tiers at the thicker umbo part of the shell, but only in one tier in thinner parts (margins). The chambers formed inside the shell are oval with a diameter varying from 0.5- 1.5 mm and inter-chamberal canals from 0.1 -0.2 mm. The interior of chambers, inter chamberal canals and papillar canals show a pitted appearance under high magnification. These pits or cavities represent an area from which a microchip has been removed by the boring activity of the sponge, and the diameter of these pits may vary from 0.016-0.07 mm.

**Spicules-Tylostyles:** Straight or slightly curved; sharply pointed; size 0.13 to 0.29 x 0.001 to 0.006 mm (Fig. 1C. 1).

**Oxeas:** Microspined partly granulated or even smooth, swelling may or may not be present at the middle; sharply pointed or even stylote at tips; size, 0.04 to 0.14 x 0.002 to 0.007 mm (Fig.1C. 2)

**Spirasters:** Usually with 2-5 angulations, spines prominent at angles only, rarely microspined all over. Smaller forms with 2-3 angulations and may be spiny, granulated or even smooth; size, 0.006 to 0.016 x 0.001 to 0.002 mm. (Fig. 1C, 3)

**Remarks:** It is a common boring sponge in the Indian Seas and has even migrated to the estuaries due to its low salinity tolerance (Thomas, 1975, Sunil, 2002).

**Distribution:** It is a cosmopolitan species and was present in all the stations presently investigated. It could be collected from Ashtamudi Lake, Kollam by Sunil (2002).

### 4. *Cliona lobata* Hancock, 1849

**Synonymy** : *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.

**Material** : 443 infested brown mussel shells.

**Locality** : Stations 1-5

**Depth** : Mussel beds, 5-8 M.

**Colour** : Papillae bright red or yellow when alive.

**Description:** Openings made by the sponge are concentrated more at umbo proper initially, but later spread to marginal parts of the shells; branches formed are in a linear and reticulate pattern as in *P. vastifica* (vide supra). In advanced stages the

papillae may open to the interior piercing the nacreous layer and establish contact with the soft mantle tissue creating much irritation or even colour change to the mantle epithelium of the mussel. Surface of the shell with two types of openings, smaller (dia. 0.037- 0.22 mm) lodges incurrent papillae and larger (dia. 0.11 - 0.47 mm) lodges excurrent papillae. These papillae, in life, may project out of the surface to a height of 2-4 mm and have a crown of tylostyles at their tips. Excurrent papillae have only one opening while incurrent, with several openings at their tips. When live shell is taken out of water, these papillae may contract and remain flush with the surface of the shell. The chambers formed inside the shell by the activity of the sponge are irregular in shape and vary from 0.8 - 1.8 mm in diameter but only in one tier in thinner marginal zones of the shell. The interior of chambers, inter chamberal canals and papillar canals have an etched out appearance and these etchings have a diameter of 0.029 - 0.076 mm, each pit represents the area from which a microchip has been removed through boring activity of the sponge.

**Spicules-Tylostyles:** Straight with pointed tips, head spherical; oblong and rarely with additional swellings near the head; size, 0.1 to 0.211 x 0.002 to 0.006 mm, head with a diameter of 0.002 - 0.006 mm. Younger spicules may be sinuous or setose (Fig. 1 D, 1).

**Spirasters:** Examination of specimens from different stations revealed the presence of 6 different, geometrically distinct, spiraster types and in no single specimen all these different types could be located (Fig. 1D, 2): They are:

- long and robust forms with rarely distributed spine; size, 0.127 x 0.004 mm (length x width) (Fig. 1 D 2a).
- long and slender forms, which are sparsely and spirally spined; size, 0.12 x 0.001 mm. (Fig.1 D. 2b).
- long and robust forms which are closely and spirally spined; size upto 0.1 x 0.002 mm. (Fig.1 D. 2c),
- long zig zag type with spines arranged spirally; size upto 0.05 x 0.001 mm (Fig. 1 D. 2d).
- long, zig zag type with spines arranged at angles only; size upto 0.05 x 0.001 mm (Fig.1 D 2e.) and
- small zig zag, curved and angulated forms or straight with spines at both ends; size upto 0.01 x 0.001 mm (Fig.1 D2 f).

**Remarks:** It is a dreadful oyster pest of the Atlantic. Burton (1937) recorded it from Gulf of Mannar but no specimen of this could be collected from the Indian seas. In 1980, this species appeared in the molluscan culture rafts at Vizhinjam, and now it is wide spread in the southwest coast of India as a pest of both natural and tended stocks of molluscs. It was present in all stations surveyed by Sunil (2002).

**Distribution:** Atlantic and Indo Pacific.

### 5. *Pione carpenteri* Hancock, 1867

**Synonymy** : *Cliona carpenteri* Hancock, 1867, p.241, pl.8, fig. 4. *Cliothisa carpenteri* de Laubmfels, 1936, p.156

**Material** : 10 infested mussel shells.

**Locality** : Enayam and Kadiyapatnam

**Depth** : Mussel beds, 5 -8 M

**Colour** : Papillae pale yellow when alive

**Description:** The umbo region of the shell is infested first, openings seen at the outer part of the shell are circular to oval in outline, diameter may vary from 0.37 -0.56 mm, larger openings lodge excurrent and smaller, the incurrent papillae. Tip of these papillae may bear a crown of spicules and they protect the excurrent openings (single) or incurrent openings (many). Papillae are highly contractile and when extended may have a height varying from 2-4 mm. Chambers formed inside the shell by boring activity are in 2-3 tiers in thicker umbo part, while in thinner marginal zones, they may be in one tier and occupy the middle layers of the shell. These chambers may be irregular or angulated in outline with a diameter varying from 1-2 mm.

The interior of chambers, inter-chamberal canals and papillar canals have an etched out appearance under high magnification and each etching may represent an area from which a microchip has been removed by the activity of boring. Each etching may have diameter of 0.025-0.072 mm.

**Spicules-Tylostyles:** Straight or slightly curved, tips sharply pointed, head globular or irregular; size, 0.144 to 0.261 x 0.004 to 0.006 mm (Fig. 1 E, 1).

**Oxeas:** Entirely spined, granulated or smooth rarely; size, 0.046 to 0.113 x 0.003 to 0.006 mm (Fig. 1 E, 2).

**Bacilliform spicules:** Straight, fusiform or slightly curved at the middle, may be microspined, granulated or even smooth, size, 0.012 to 0.020 x 0.002 mm (Fig. 1 E, 3).

**Distribution:** Atlantic and Indo-Pacific. This species could be collected only from two stations surveyed by Sunil kumar (2002).

### 6. *Pione margaritifera* (Dendy 1905)

**Synonymy** : *Cliona margaritifera* Dendy, 1905, p.128, pl.5, fig. 9.

**Material** : 123 infested mussel shells

**Locality** : Stations 1-5

**Depth** : Mussel beds, 5 and 8 M.

**Colour** : Papillae pale yellow in living condition.

**Description:** Openings made at the surface of the shell are much crowded at umbo part. The diameter of these openings may vary from 0.037 to 0.8 mm, those openings with larger diameter accommodate the excurrent papillae while the smaller ones, the incurrent papillae. These papillae, in life, may project out of the surface to a height of 3-5 mm, but when disturbed may contract into respective openings and remain flush with the surface. Excurrent papillae are provided with a single opening and incurrent papillae with several openings. The summit of papilla is protected with a crown of tylostyles arranged in brush-like pattern. Excurrent openings may be detected in contracted condition also.

Chambers formed inside the shell may be in 2-3 tiers in umbo part, but always in one tier at the marginal, thinner parts of the shell, branches originating from umbo region may be in straight line initially, but may branch dichotomously at irregular intervals and these branchlets run almost in a straight line producing chambers at regular intervals as in *P. vastifica* (*vide supra*). Papillae originating from these chambers pierce the nacreous layer of the shell and come into contact with the mantle epithelium producing discoloration to the mantle tissue. Chambers formed inside the shell may be circular to oval in outline with a diameter varying from 1 to 3 mm. The interior of chambers, inter-chamberal canals and papillar canals present an etched out appearance under high magnification as in any species of *Cliona* and these concavities may have a diameter varying from 0.037- 0.075 mm.

**Spicules-Tylostyles:** Straight or slightly curved and sharply pointed, head globular, oblong or even trilobed; size, 0.11 to 0.22 x 0.003 to 0.006 mm, head 0.004 to 0.008 mm in diameter (Fig. 1 F, 1).

**Oxeas:** Uniformly curved, centrally angulated or even Z-shaped, may be spiny, granulated or even smooth, spines prominent at central part; size. 0.063 x 0.003 to 0.006 mm in diameter (Fig. 1 F, 2).

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**Spirasters:** Typical spirasters with 2 -6 angulations, spines prominent at angles only; size, 0.02 -0.06 x 0.002-0.004 mm. (Fig. 1 F, 3).

**Remarks:** This species was first reported from Sri Lanka as a pest which caused wide spread depletion of pearl oyster beds in the Gulf of Mannar (Dendy, 1905). But in subsequent surveys made from the Gulf of Mannar, this species could not be collected. Later, in 1980, it reappeared in the cultivated stocks of molluscs (pearl oysters and mussel) at Vizhinjam after a long lapse of about 75 years. Since then it migrated

to almost all molluscan beds of the south west coast of India and also to Tuticorin culture rafts (for pearl oysters). For further details on the spreading pattern in different molluscan beds see Thomas *et al.* (1993).

**Distribution:** Indo-Australian

### 7. *Cliothisa hancocki* (Topsent, 1888)

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

**Material** : Four infested mussel shells

**Locality** : Enayam

**Depth** : Mussel beds, 5 - 8 M.

**Colour** : Papillae and sponge mass inside chambers dark yellow when alive.

**Description:** Surface of mussel shell (mainly the umbo part) with openings varying in diameter from 0.05 -0.415 mm. The larger ones lodge excurrent papillae while the smaller, the incurrent papillae. Excurrent papillae, when contract, form a ridge-like rim at the surface of the shell and an opening, one per papilla, is found at the summit of the rim even in contracted condition. The incurrent papillae, when contract, form a mat-like structure at the surface of the shell.

The chambers formed inside the shell by the boring activity of sponge are irregular in older parts, but chambers, inter-chamberal canals and papillar canals are well defined at actively growing parts of the branch. Well defined chambers formed inside mussel shell may come up to 1.5 mm in diameter, but in thicker shells of rock oyster the diameter of chambers may come up to 6 mm. The interior of chambers, inter-chamberal canals and papillar canals presents an etched out appearance as in any species of *Cliona*. The diameter of these etchings may vary from 0.037-0.063 mm and are well defined only at new chipping sites.

**Spicules-Tylostyles:** Straight, or slightly curved, head round to oval, sometimes with additional swelling near the head, size 0.21 to 0.44 x 0.01 to 0.021 mm, head 0.006 to 0.021 mm in diameter (Fig. 1 G, 1).

**Slender amphisters:** Rays long and with recurved terminal hooks; size, 0.028 mm when well developed (Fig. 1 G, 2).

**Nodular amphisters:** Rays conical, rarely seen, size up to 0.016 mm (Fig. 1 G, 3).

**Remarks:** It is here recorded as a pest of brown mussel.

**Distribution:** Mediterranean Sea, Red Sea, Indian Ocean and Western Pacific.

### 8. *Thoosa armata* Topsent 1888

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

**Material** : One mussel shell

**Locality** : Enayam

**Depth** : Mussel beds, 5 - 8 M.

**Colour** : Papillae pale yellow when alive.

**Description:** Only three openings could be located at the umbo part of the shell, and they vary in diameter from 0.5 -1 mm. Papillae retractile and form a cup-like structure when contracted; the diameter of these cups may vary from 0.03 to 3.5 mm. The entire surface of these cups is ornamented with tylostyles projecting radially or in a slanting manner.

Chambers formed inside the umbo are in one tier and the diameter may vary from 0.3 - 0.4 mm. The interior of chambers, inter chamberal canals and papillar canals have an etched out appearance as in any species of *Cliona*. The diameter of these etchings (pits) may vary from 0.025-0.04 mm, their edges are not sharp.

**Spicules-Tylostyles:** Straight or slightly curved, shaft widest at central part, head well developed and globular in most; size, 0.126 to 0.21 x 0.004 to 0.008 mm, head up to 0.008 mm in diameter.(Fig. 1 H,1). (tuberculated), 4. Tuberculated diact with an additional arm at the centre, 5. Tip of spicule enlarged to show the arrangement of tubercles, 6. Amphiasers (8 growth forms are shown).

**Amphiasers:** Rays in two sets, capitate and microspined, size, 0.021 x 0.016 mm. (Fig. 1 H, 2).

Amphiasers with lanceolate rays. Not present in the specimen examined.

Amphiasers with long rays, only early stages were present, size, 0.016 x 0.012 mm. (Fig. 1 H, 3).

**Oxyasters:** Centrum small, reduction of rays common, rays long, deflected and abruptly pointed, rays may show a reduction in their number; those with two rays are common, and those with three rays are rare, size 0.06 to 0.17 mm, width of a ray upto 0.003 mm. (Fig. 1 H, 4).

**Oxeas:** Rare, often with a small swelling at the centre, rays sharply pointed; size, 0.12 to 0.15 mm, width 0.002 mm average. (Fig. 1 H, 5).

**Remark:** This is the first record of the species from a mussel shell.

**Distribution:** Tropical Atlantic, Red Sea and Indian Ocean.

### 9. *Alectona wallichii* (Carter, 1874)

**Synonymy** : *Alectona wallichii* Bavestrello *et al.*, 1998 p.63, fig. 3 A-G

**Material** : Two infested mussel shells

**Locality** : Enayam

**Depth** : Mussel beds, 5 - 8 M.

**Colour** : Papillae pale brown when dry.

**Description:** Only umbo part is infested in both shells, papillar opening two numbers in one and four in the other shell, contracted in both and the diameter of the openings found at the surface of shell, 0.5 – 1 mm.

Since the area of the shell attacked by sponge was too inconspicuous the entire umbo part was used for extracting the spicules, hence only spicular details are furnished here.

**Spicules:** Diacts (smooth). Oxea- like form with a 'kink' at the centre in most, rays wavy in outline and asymmetrical in some, axial canal may or may not be prominent; size, 0.126-0.26 x 0.016 mm (maximum) (Fig. 1 I,1).

Diacts (Robust). Partly or entirely spined (Fig. 1 I, 2), or tuberculated (Fig. 1 I, 3), tubercles mushroom- shaped and often supported by a distinct stalk, some such spicules may have an additional arm at the centre; size, 0.23-0.35 x 0.004 mm (maximum) (Fig. 1 I,4) tubercles up to 0.008 mm in diameter (Fig. 1 I, 5)

Amphiasers. Shaft fusiform or pointed, microspined partly or fully, with two median verticles composed of microspined out growths, usually 4 in number. Younger forms with conical rays; size, when well developed, 0.016-0.042 mm (Fig. 11, 6)

**Remarks:** Various species of *Alectona* and their global distribution and substratum preference were described by Sunil Kumar and Thomas (2012). Considering its capacity to destroy calcium carbonate, it is proposed here to undertake a long- term monitoring on the spreading pattern of this species in the Indian seas.

**Distribution:** Agulhas Bank (Cape of Good Hope) Seychelles, Western Pacific, Mediterranean Sea and Indian seas.

### *Zoogeography and affinity of the mussel boring sponges of the southwest coast of India*

The various zoogeographic regions selected by Thomas (1987) for assessing the zoogeography and affinity of Indian sponges were followed here also. The area with which the present fauna shows maximum affinity is the Australian region, six

species are common to both these regions. The next two regions, viz. Atlantic and Pacific Oceans have five species each common with the present area. Affinity with regions like Red Sea and Mediterranean Sea is equally expressed with four species each, though the presence of *A. wallichii* in the Mediterranean Sea is still controversial. Finally, *C. celata* is a cosmopolitan species and could be collected from all centres surveyed here.

## Discussion

The presently recorded 9 species may be classified under four different heads 1. infiltrants of 1980 period viz. *Cliona lobata* and *P. margaritifera*, 2. conventional species of natural beds like *S. minutum*, *C. celata*, *P. vastifica* and *C. carpenteri*, 3. species common to coral reefs and molluscan beds, other than that of mussels, like *C. hancocki* and *T. radiata* and 4. recent infiltrant viz. *A. wallichii*.

The sudden invasion of the two species falling under the first category to the molluscan culture rafts at Vizhinjam, around 1980, and their subsequent spreading to the nearby natural molluscan beds and coral reefs were traced out and the details were published subsequently (Thomas *et al.*, 1983). A follow up was made during 1983-1987 period by Thomas *et al.* (1993) to assess the spreading pattern, incidence etc., of these two new infiltrants to other molluscan beds of the south west coast of India and their interaction with conventional species present in various molluscan beds/corals. It could be seen that these species migrate rather quickly to other beds and as a result there was a sudden spurt in the incidence either through their own activity or through triggering the activity of conventional species in the respective beds. The initial hike in the incidence (%) was due to the excessive activity of the above two species (*C. lobata* and *P. margaritifera*) but their incidence (%) gradually subsided in various natural beds and reached a level close to that seen prior to the invasion of these two species. But such a regulatory trend was not at all discernible in the culture systems indicating that the ecological equilibrium which is at play in nature is no longer in operation in man-made culture systems. In culture systems at Vizhinjam the incidence of these two species (*C. lobata* and *P. margaritifera*) together contributed to 70% clearly suppressing the activity of all conventional species put together (Thomas *et al.*, 1993).

The present study conducted during 1998-2000 may be taken as a follow-up from the same area, after a lapse of 20 years from the date of entry of these two dreadful pests (*C. lobata* and *P. margaritifera*) at Vizhinjam molluscan culture rafts in 1980.

It could be seen during the present study that 9 species of boring sponges infest the brown mussel population of this coast and out of these 4 species are new records to the brown mussel population. The Enayam centre accounted for all the 9 species recorded here, and hence it could be reckoned as a centre of rich boring sponge diversity and considering the route taken by *A. wallichii* to gain entry into the Indian molluscan beds, the centre Enayam may be adjudged as a 'gateway' of boring sponge migration to Indian seas.

Another important finding emerged during the present study is the wide distribution of *P. vastifica*, a euryhaline species, in the Ashtamudi Lake, Kollam. This species accounted for about 18 % of the boring sponge infestation in brown mussel, and no other species of boring sponges could be recorded from this Lake. A similar condition could be recorded from both Zuari and Mondovi Estuaries of Goa (Thomas, 1975). These findings, hence, denote that molluscan population in our estuaries is under severe threat of boring sponge infestation.

The frequency of occurrence of boring sponge species in any molluscan bed may vary from time to time as any one or more species may at any time, can cause an outburst creating severe havoc in any molluscan bed or coral reef and then disappear into a period of quiescence while some others may continue to exhibit moderate incidence without causing any deleterious effect (Thomas, *et al.*, 1979). Hence a continuous monitoring of all such species, both from the marine and estuarine realms, is essential on a long term basis

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