



## Diversity and distribution of shallow water sponges (Porifera) in the coastal waters from Enayam to Kollam, south-west coast of India

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### ABSTRACT

Underwater surveys were conducted in the shallow coastal waters extending from Enayam to Kollam, southern India, covering six study locations viz., Enayam, Adimalathura, Vizhinjam, Varkala, Odayam and Paravoor to record the diversity of sponges. A total of 24 species of sponges were identified during the study which belonged to 20 genera, 14 families and 6 orders. Maximum species diversity was recorded at Enayam (11 species), followed by an equal number of species at Vizhinjam and Adimalathura (10 species). Five species of sponges were recorded at Odayam while three species were recorded at Varkala and only one at Paravur. Shannon diversity was high at Enayam, Vizhinjam and Adimalathura and the dominance plot also showed rich diversity of sponges in these three stations. The cluster results using Bray Curtis similarity Index indicated two clusters: stations Enayam, Vizhinjam and Adimalathura showed one cluster indicating similarity of species in these stations, while the stations Varkala, Odayam and Paravoor showed another cluster. The present study has indicated that the stations Enayam, Vizhinjam and Adimalathura are rich in diversity and abundance of sponges, compared to Varkala, Odayam and Paravoor.

Keywords: Distribution, Diversity, Marine sponges, Southern India

### Introduction

The sponges are important components of coral reefs having both ecological and commercial significance. Their biomass and ecological tolerance frequently exceed that of the reef-building corals (Reutzler, 1978). The sponges are the oldest parazoans still extant and their continued existence in vast numbers is closely linked to the apparent adaptability to changes in environmental characteristics and competing biota (Bergquist, 1978; Muller, 2003). They are also known to be effective filter-feeders, having an ability to filter four to five times their own volume every minute (Allen, 2000). Some of the sponge species are capable of bio-eroding as well as consolidating reef structures (Hooper, 2000).

The sponges are in great commercial demand as some of them are good sources of bath sponges for cosmetic industry. They have become the focus of biochemical studies due to the presence of novel compounds and bioactive secondary metabolites which might turn out to

be a cure for many diseases, including cancer (Longakit *et al.*, 2005). Some sponges like *Aplysina fulva* and *Mycale microsigmatosa* have been found to have potential to prevent marine biofouling (Pierera *et al.*, 2002).

The knowledge on sponge biodiversity is still largely incomplete and to date 8517 valid species of sponges are enlisted in the World Porifera Database (Van Soest *et al.*, 2014); however, it is believed that there could be more species. The coral reef areas in Indian waters are rich in sponge fauna and there have been several works to unravel the sponge diversity from the reef areas. A total of 486 species of marine sponges have so far been described from the Indian waters (Thomas, 1998).

Intensive field surveys in the hitherto unexplored areas may result in the discovery of many new species that were not reported earlier. The present study was therefore aimed at to identify the sponges found distributed in the shallow waters from Enayam to Paravur; an unexplored patchy coral reef area of southern India.

## Materials and methods

Underwater surveys were conducted by SCUBA diving in six different study locations *viz.*, Enayam, Adimalathura, Vizhinjam, Varkala, Odayam and Paravoor (Fig. 1), where patchy coral growths are present. The surveys were conducted in shallow waters in depth ranging from 10 to 30 m. Table 1 shows the six sampling stations and their locations.

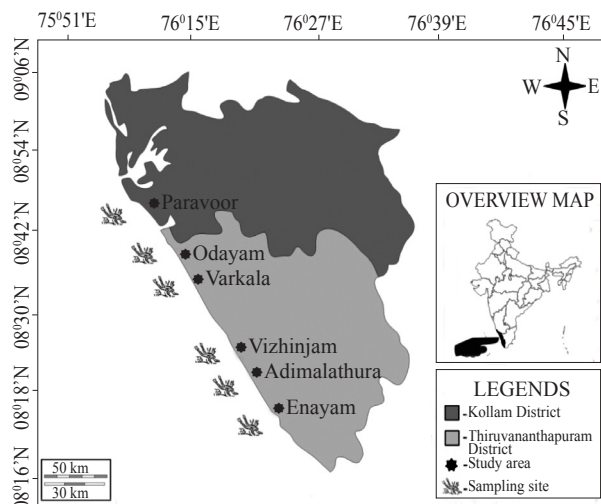


Fig. 1. Map showing the study stations

Surveys were carried out in all the study stations to record the diversity of sponges along the reef. The sponge samples collected were coded for later identification in the laboratory and the number of each species collected were recorded. Underwater photographs of the reef area and the associated sponge fauna were also taken. The samples were brought to the laboratory in clean polythene bags; one sample per bag. The specimens were photographed immediately after they were brought to the laboratory.

The morphological characteristics of each specimen including size, shape, colour, texture, total length, breadth and oscule diameter were noted. The specimens were then individually preserved in 90% alcohol for identification to the species level. For identification, samples from different portions of the sponge specimen were carefully removed using a fine razor blade and digested separately using concentrated nitric acid for extraction of sclerites. The sclerites were microscopically examined and measured using Image Analysis Software (Scopephoto-Catcam). The specimens were identified following the taxonomic keys described by de Laubenfels (1936; 1948).

The biodiversity indices were calculated using PRIMER (v6). The diversity of sponges was calculated following Shannon-Weiner Index ( $H'$ ) and Pielou's Evenness Index ( $J'$ ). The diversity of sponges between stations was compared by drawing the dominance plot.

The variations in sponge community structure between the stations were examined using hierarchical cluster analysis.

## Results and discussion

A total of 24 species of sponges were identified which belonged to 20 genera, 14 families and 6 orders (Table 2). At Enayam, Vizhinjam and Adimalathura, many of the recorded species were found attached to the brown mussel, *Perna indica* (Fig. 2). The total number of sponge species recorded during the present study is far less when compared to the sponges distributed in the Gulf of Mannar and Palk Bay region (319 species), Andaman & Nicobar islands (95 species) and Lakshadweep islands (91 species) as shown in the works of Venkataraman and Wafar (2005) and Thomas (1989). This could be due to the fact that the reefs are only patchy in the region extending from Enayam to Kollam and moreover, further intensive studies at different depths in this stretch may help to add more species to the present list.



(a) *Sigmadocia carnosa*



(b) *Callyspongia fibrosa*

Fig. 2. Underwater photographs showing sponges attached to the mussel bed at Adimalathura

Table 1. Six study stations and their respective locations

| Station No. | Location     | Position    |              | Remarks  |
|-------------|--------------|-------------|--------------|--|
|             |              | °N Latitude | °E Longitude |  |
| 1.          | Enayam       | 08°12'      | 77°10'       | Reefs with abundant brown mussel population; many sponges were found attached to the brown mussels |
| 2.          | Vizhinjam    | 08°22'      | 77°65'       | Reefs with abundant brown mussel population; many sponges were found attached to the brown mussels |
| 3.          | Adimalathura | 08°21'      | 77°00'       | Reefs with abundant brown mussel population; many sponges were found attached to the brown mussels |
| 4.          | Varkala      | 08°44'      | 76°41'       | Sparse small patches of corals   |
| 5.          | Odayam       | 08°44'      | 76°41'       | Sparse small patches of corals   |
| 6.          | Paravoor     | 08°48'      | 76°38'       | Sparse small patches of corals   |

Table 2. Synoptic list of sponge species recorded from Enayam to Kollam

| Classification  |   |
|---|---|
| Phylum Porifera Grant   | Family Ophlitaspongiidae de Laubenfels                  |
| Class Demospongiae Sollas   | Genus <i>Clathria</i> Schmidt                           |
| Order KERATOSIDA Grant  | <b>13. <i>Clathria frondifera</i></b> (Bowerbank)       |
| Family Spongiidae Gray  | <b>14. <i>Clathria procera</i></b> (Ridley)             |
| Genus <i>Ircinia</i> Nardo  | Genus <i>Mycale</i> Gray                                |
| <b>1. <i>Ircinia fusca</i></b> (Carter)                                   | <b>15. <i>Mycale mytilorum</i></b> Annandale            |
| Genus <i>Spongia</i> Linnaeus   | Genus <i>Zygomycale</i> Topsent                         |
| <b>2. <i>Spongia</i> sp.</b>  | <b>16. <i>Zygomycale parishii</i></b> (Bowerbank)       |
| Order HAPLOSCLERIDA Topsent   | Family Microcionidae Henteschel                         |
| Family Adocidae de Laubenfels   | Genus <i>Aulenella</i> Burton & Rao                     |
| Genus <i>Sigmadocia</i> de Laubenfels                                     | <b>17. <i>Aulenella foraminifera</i></b> (Burton & Rao) |
| <b>3. <i>Sigmadocia carnosus</i></b> (Dendy)                              | Order HALICHONDRIDA Gray                                |
| Genus <i>Toxadocia</i> de Laubenfels                                      | Family Axinellidae Carter                               |
| <b>4. <i>Toxadocia toxius</i></b> (Topsent)                               | Genus <i>Axinella</i> Schmidt                           |
| Genus <i>Petrosia</i> Vosmaer   | <b>18. <i>Axinella donnani</i></b> (Bowerbank)          |
| <b>5. <i>Petrosia similis</i></b> Ridley and Dendy                        | Family Halichondridae Gray                              |
| Family Callyspongiidae de Laubenfels                                      | Genus <i>Trachyopsis</i> Dendy                          |
| Genus <i>Callyspongia</i> Duchassaing and Michelotti                      | <b>19. <i>Trachyopsis halichondroides</i></b> Dendy     |
| <b>6. <i>Callyspongia diffusa</i></b> (Ridley)                            | Order HADROMERIDA Topsent                               |
| <b>7. <i>Callyspongia fibrosa</i></b> (Ridley and Dendy)                  | Family Clionidae Gray                                   |
| <b>8. <i>Callyspongia reticulata</i> var. <i>salomonensis</i></b> (Dendy) | Genus <i>Cliona</i> Grant                               |
| Order POECILOSCLERIDA Topsent   | <b>20. <i>Cliona celata</i></b> Grant                   |
| Family Plocamiidae  | <b>21. <i>Cliona vastifica</i></b> Hancock              |
| Genus <i>Plocamilla</i> Topsent   | Family Suberitidae Schmidt                              |
| <b>9. <i>Plocamilla mannarensis</i></b> (Carter)                          | Genus <i>Pseudosuberites</i> Topsent                    |
| Family Myxillidae Dendy   | <b>22. <i>Pseudosuberites andrewsi</i></b> Kirkpatrick  |
| Genus <i>Myxilla</i> Schmidt  | Order EPIPOLASIDA de Laubenfels                         |
| <b>10. <i>Myxilla arenaria</i></b> Dendy                                  | Family Jaspidae de Laubenfels                           |
| Family Raspailiidae Henteschel  | Genus <i>Prostylyssa</i> Topsent                        |
| Genus <i>Aulospongia</i> Norman   | <b>23. <i>Prostylyssa foetida</i></b> (Dendy)           |
| <b>11. <i>Aulospongia tubulatus</i></b> (Bowerbank)                       | Family Sollasellidae Lendefeld                          |
| Genus <i>Endectyon</i> Topsent  | Genus <i>Epipolasis</i> de Laubenfels                   |
| <b>12. <i>Endectyon fruticosa</i></b> (Dendy)                             | <b>24. <i>Epipolasis topsenti</i></b> (Dendy)           |

### Structure, composition and distribution of sponges

The percentage distribution (by order) of sponges identified from the study locales (Fig. 3) showed that the Order Poecilosclerida had the highest species composition (37.5%), followed by Haplosclerida (25.0%) and Hadromerida (12.5%). The Order Keratosida, Halichondrida and Epipolasis had a composition of 8.33% species in each.

At Enayam, both Poecilosclerids and Haplosclerids contributed 36.4% each to the total number of species

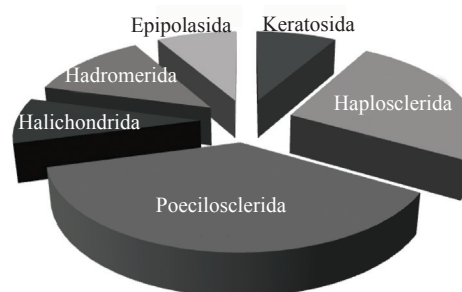


Fig. 3. Percentage distribution of sponge species in different orders

recorded from this station. The species belonging to Hadromerida comprised of 18.2% while Keratosida was represented by 9.1% of the species at Enayam. At Vizhinjam, species belonging to Haplosclerida constituted 50%, followed by Poecilosclerida (30%), while Hadromerida and Keratosida constituted 10% each. At Adimalathura, 50% of the species belonged to Poecilosclerida, while 40% belonged to Haplosclerida and 10% of the species belonged to Keratosida. At Varkala, of the three species recorded, two belonged to Poecilosclerida (66.7%) and one species belonged to Halichondrida (33.3%). Forty percent of the species recorded at Odayam belonged to Halichondrida and another 40% belonged to Epipolasisida, while 20% of the species belonged to Poecilosclerida. The only species recorded from Paravoor belonged to Halichondrida (Table 3).

Table 4 shows the distribution and species richness of sponges in six stations. Maximum species diversity

was recorded at Enayam (11 species), followed by an equal number of species at Vizhinjam and Adimalathura (10 species). Five species of sponges were recorded at Odayam while three species were recorded at Varkala and only one at Paravoor. The stations Enayam, Vizhinjam and Adimalathura are characterised by patches of corals, rocky stretches and mussel beds which would probably be assisting in easy settlement of the larval forms and better colonisation of sponges. The reef patches are comparatively less at Odayam, Varkala and Paravoor which might be the reason for the poor diversity of sponge fauna. Also, light and wave action may play an important role affecting sponge distribution in these zones. Wave stress may limit the colonisation and growth of sponges by creating substrate instability, high turbidity and turbulence (Diaz *et al.*, 1985). Also, turbulence due to wave action would substantially decrease with depth (Schmahl, 1985) which would give a better opportunity to colonise. However, influence of depth on the diversity

Table 3. Species composition of sponges of different orders in different study stations

| Order           | Stations  |           |              |           |         |          |
|-----------------|-----------|-----------|--------------|-----------|---------|----------|
|                 | Enayam    | Vizhinjam | Adimalathura | Varkala   | Odayam  | Paravoor |
| Poecilosclerida | 4 (36.4%) | 3 (30%)   | 5 (50%)      | 2 (66.7%) | 1 (20%) | -        |
| Haplosclerida   | 4 (36.4%) | 5 (50%)   | 4 (40%)      | -         | -       | -        |
| Hadromerida     | 2 (18.2%) | 1 (10%)   | -            | -         | -       | -        |
| Keratosida      | 1 (9.1%)  | 1 (10%)   | 1 (10%)      | -         | -       | -        |
| Halichondrida   | -         | -         | -            | 1 (33.3%) | 2 (40%) | 1 (100%) |
| Epipolasisida   | -         | -         | -            | -         | 2 (40%) | -        |
| Total           | 11        | 10        | 10           | 3         | 5       | 1        |

Table 4. Distribution of sponges in the study area

| Sl. No. | Species   | Enayam | Vizhinjam | Adimalathura | Varkala | Odayam | Paravoor |
|---------|---|--------|-----------|--------------|---------|--------|----------|
| 1       | <i>Ircinia fusca</i>                                    | +      | -         | +            | -       | -      | -        |
| 2       | <i>Spongia</i> sp.                                      | -      | +         | -            | -       | -      | -        |
| 3       | <i>Sigmatocia carnosa</i>                               | +      | +         | +            | -       | -      | -        |
| 4       | <i>Toxadocia toxius</i>                                 | -      | +         | -            | -       | -      | -        |
| 5       | <i>Petrosia similis</i>                                 | +      | +         | -            | -       | -      | -        |
| 6       | <i>Callyspongia diffusa</i>                             | -      | -         | +            | -       | -      | -        |
| 7       | <i>Callyspongia fibrosa</i>                             | +      | +         | +            | -       | -      | -        |
| 8       | <i>Callyspongia reticulata</i> var. <i>salomonensis</i> | +      | +         | +            | -       | -      | -        |
| 9       | <i>Plocamilla mannarensis</i>                           | -      | +         | -            | -       | -      | -        |
| 10      | <i>Myxilla arenaria</i>                                 | -      | +         | +            | -       | -      | -        |
| 11      | <i>Aulospongia tubulatus</i>                            | -      | +         | -            | +       | +      | -        |
| 12      | <i>Endectyon fruticosa</i>                              | -      | -         | -            | +       | -      | -        |
| 13      | <i>Clathria frondifera</i>                              | +      | -         | +            | -       | -      | -        |
| 14      | <i>Clathria procera</i>                                 | -      | -         | +            | -       | -      | -        |
| 15      | <i>Mycale mytilorum</i>                                 | +      | -         | +            | -       | -      | -        |
| 16      | <i>Zygomycala parishii</i>                              | +      | -         | +            | -       | -      | -        |
| 17      | <i>Aulenella foraminifera</i>                           | +      | -         | -            | -       | -      | -        |
| 18      | <i>Axinella donnani</i>                                 | -      | -         | -            | +       | +      | +        |
| 19      | <i>Trachyopsis halichondroides</i>                      | -      | -         | -            | -       | +      | -        |
| 20      | <i>Cliona celata</i>                                    | -      | +         | -            | -       | -      | -        |
| 21      | <i>Cliona vastifica</i>                                 | +      | -         | -            | -       | -      | -        |
| 22      | <i>Pseudosuberites andrewsi</i>                         | +      | -         | -            | -       | -      | -        |
| 23      | <i>Prostylyssa foetida</i>                              | -      | -         | -            | -       | +      | -        |
| 24      | <i>Epipolasis topsenti</i>                              | -      | -         | -            | -       | +      | -        |
| Total   |   | 11     | 10        | 10           | 3       | 5      | 1        |

and distribution of sponges were not studied during the present investigation.

Of the twenty four species recorded during the study, no species was found to represent in all of the six study stations (Table 4). Only five species (21%) viz., *Sigmatocia carnososa*, *Callyspongia fibrosa*, *C. reticulata* var. *salomonensis*, *Aulospongos tubulatus* and *Axinella donnani* were found to occur in three of the six stations studied. Six species viz., *Ircinia fusca*, *Petrosia similis*, *Myxilla arenaria*, *Clathria frondifera*, *Mycale mytilorum* and *Zygomyscale parishii* (25%) were present in two of the six stations. The remaining thirteen species (54%) were present only in one station and these include *Spongia* sp., *Toxadocia toxius*, *Callyspongia diffusa*, *Plocamilla mannarensis*, *Endectyon fruticosum*, *Clathria procera*, *Aulenella foraminifera*, *Trachyopsis halichondroides*, *Cliona celata*, *C. vastifica*, *Pseudosuberites andrewsi*, *Prostylyssa foetida* and *Epipolasis topsenti*. Raymundo and Harper (1995) in their study of sponges in Central Visayas (Philippines) recorded 53% of the 85 sponges only from one site. Longakit *et al.* (2005) also recorded a higher percentage (67% of the 33 sponges) of sponges recorded only from one study station in Cebu, Philippines. However, there are no previous reports available on the distribution of sponges from Enayam to Paravoor for corroboration.

The diversity indices are given in Table 5. With respect to the number of species and their abundance, Shannon diversity was high at Enayam, Vizhinjam and Adimalathura. The dominance plot (Fig. 4) also proves the rich diversity of sponges at Enayam, Vizhinjam and Adimalathura when compared to Varkala, Odayam and Paravoor.

The cluster results using Bray Curtis similarity Index is shown in Fig. 5 wherein, two major groupings were observed. The stations Enayam, Vizhinjam and Adimalathura showed one cluster indicating similarity of species in these stations, while the stations Varkala, Odayam and Paravoor showed another cluster, which could be due to the reason that these stations are far away from Enayam, Vizhinjam and Adimalathura. This indicated that the distance from the stations could be the reason for the formation of two distinct clusters.

Table 5. Univariate diversity indices of sponges of different locations

| Sample       | S  | N  | d     | J'     | H'(log2) | 1-Lambda' |
|--------------|----|----|-------|--------|----------|-----------|
| Enayam       | 11 | 16 | 3.611 | 0.977  | 3.38     | 0.9578    |
| Vizhinjam    | 10 | 14 | 3.449 | 0.973  | 3.232    | 0.9568    |
| Adimalathura | 10 | 18 | 3.102 | 0.9635 | 3.201    | 0.9335    |
| Varkala      | 3  | 3  | 1.82  | 1      | 1.585    | 1         |
| Odayam       | 5  | 5  | 2.485 | 1      | 2.322    | 1         |
| Paravur      | 1  | 1  | ****  | ****   | 0        | ****      |

S = Total species; N = Total individuals; J' = Pielou's evenness; H' = Shannon diversity; 1-Lambda' = Simpson diversity

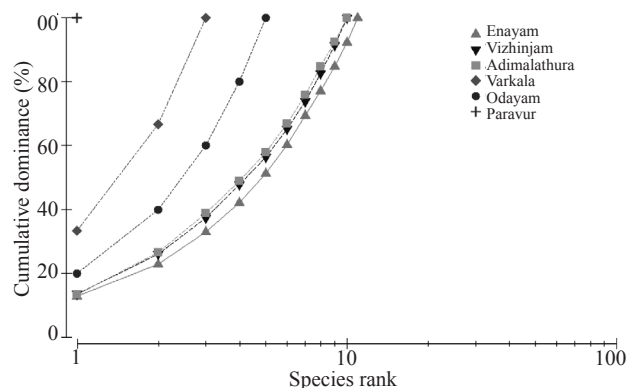


Fig. 4. Dominance plot for sponges in different study stations

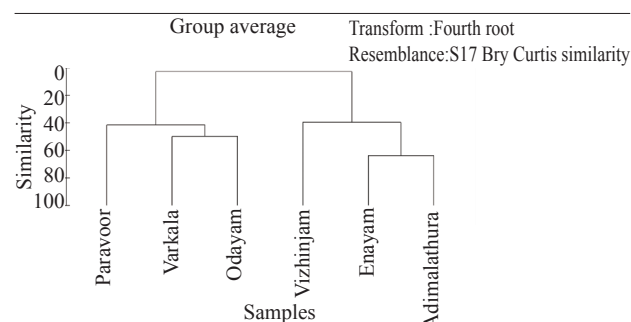


Fig. 5. Cluster analysis of different sampling stations from Enayam to Paravoor

The present study has indicated that the stations Enayam, Vizhinjam and Adimalathura are rich in diversity of sponges when compared to Varkala, Odayam and Paravoor. Although five species were recorded from Odayam, their occurrence during the survey was only once. However, depth-wise exploration in these regions would throw more light on their distribution, composition and diversity.

The coastal stretch of the south-west coast of India, especially from Kollam to Kanyakumari, is mostly rocky and affords a congenial habitat for the larvae of sedentary organisms to settle and flourish. Crevices of rocks, surfaces of cliffs, rocky outcrops in the intertidal zone as well as beds of brown mussel, which are in plenty in this area provide a rich abode for massive, encrusting and boring sponges.

Both massive and encrusting sponges are richly distributed along the coast. The former type, after its initial encrusting phase grows to massive, lamellar, tubular or even clathrous form in advanced stages weighing 2-4 kg or even more, while the latter type retain the initial encrusting morphology throughout life time. These encrusting species usually prefer the under surfaces of rocks away from direct sunlight. To collect such specimens, one has to scrape the substratum with a scalpel and the quantity, thus obtained, will also be too meager, say, 1-4 g at the most. Bioactivity investigators in India are now following 'macromethod' wherein a minimum of

0.5-1 kg of sponge material is a must for running the various experiments. So the encrusting fraction of our sponge fauna is left untouched by bioactivity workers in India. In order to plug this lacuna, it is advisable to switch on to 'micromethod' which is in vogue in foreign countries, so that even 0.5 g of encrusting sponge material may be made use of. By adopting this method, it is possible to double our activities in the field of bioactivity investigations.

Surveys carried by the third author (P. A. Thomas) and also by various research teams under the 'Drugs from the Sea' Project of MoEN/MoEF, New Delhi, could collect sponge samples from the south-west coast of India from 1990 onwards. These samples together with those collected by the same author (P. A. Thomas) from the intertidal and raft-cultured molluscs (pearl oysters and mussel) at Vizhinjam Bay helped much in a systematic appraisal of the encrusting and boring species occurring in this area totaling to 105 species. These include both massive and encrusting species with a ratio of 1:1. The sponge fauna of this area shows considerable similarity with that of the Gulf of Mannar. It is hoped that more and more species may emerge from this area when statistically designed surveys are made in future.

The main constraint noted with regard to collection of sponges by commercial divers is that they collect only massive specimens which are visible to the naked eye from a distance and both encrusting and boring species are totally ignored. Such collections, hence, are only selective sampling and not a qualitative collection of the sponge fauna of any area.

Considering the richness of sponge species (105 nos.) along this coast, institutions situated in Kerala and Tamil Nadu with 'drug from the sea' mandate should take up this work with much determination and enthusiasm. It is a long and arduous task from the discovery of a new active compound to the release of the same as a 'drug' in the market and besides a lot of money and expertise are required for this. If all the activities connected with drug production are brought under one roof, we may expect speedy results.

In view of the ecological and pharmacological importance of sponge taxa, it is imperative to conduct surveys and investigations to understand the distribution and abundance of various species in our waters. The explorations would also help to unravel species of sponges hitherto unknown to science.

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Date of Receipt : 16.08.2013

Date of Acceptance : 11.03.2014