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Diversity and distribution of deep sea Bryozoa from Andaman waters

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Abstract

In Andaman waters, the phylum bryozoa was understudied. Considering the geographical and related maritime aspects, an extensive study on marine bryozoa is most needed in this island waters. Aiming to find out the distribution and diversity of the deep-sea bryozoan of Andaman waters, a study was carried out in the seven sites of the Indian Exclusive Economic Zone (EEZ) of Andaman Sea. The samples were dredged using sampling gears, during the scientific cruise of FORV Sagar Sampada along Andaman Islands on November, 2017. The investigation was yielded eighteen Cheilostome bryozoan species. A total of 18 species belonging to 11 genera of 10 families coming under 7 super families and 1 suborder of Cheilostomes were listed out from the study. Out of this result, 15 species are first reports from the Indian EEZ. This study has also occupied the paucity of the study of distribution and diversity of deep sea bryozoan from Andaman Islands, after nine decades.

Keywords: Bryozoa; Cheilostomes; Deep Sea; Andaman waters.

1. Introduction

Bryozoans are small, aquatic organisms that form habitually colonial structure by the interconnected individuals. The colonies were usually found as a moss like attachment on the surfaces and hence those colonies observed were called as moss (*bryo*) animals (*zoa*) by early observers (Bock *et al.,* 2018). Bryozoans are sometimes called sea mats, as they were found as flat encrusting forms on boulders and rocks. Erect, cord like forms are often named as lace corals. They have worldwide occurrence from tropical to polar zones, from marine to fresh water, and from intertidal to abyssal zones. In older British literatures, Phylum Bryozoa was well known as Polyzoa. Afterward, in the nineteenth century, it was divided in to

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Ectoprocta and Endoprocta (Nitsche, 1869). Then, the elevation of both classes into phylum status was done by Hyman (1959). Now, the term Phylum Bryozoa is widespread instead of Polyzoa and Ectoprocta and this standard terminology was recognized by the researchers of the International Bryozoology Association (Soule *et al.,* 1995).

More than 6300 living species and 15000 fossil species have been described (Bock *et al*., 2018) all over the world. In India, an aggregate of 258 species coming under, 63 families of Gymnolaemates have been listed by many researchers till date. This diversity status was much less than what could be predictable from such a large aquatic territory that consists of the coral lagoons of Lakadives Islands and Andaman and Nicobar. Fatefully, for such a vast region of the world, the bryozoans from the Indian waters were comparatively poorly identified. Though, the Indian researchers and marine scientists, particularly in the perspective of marine biofouling, have contributed some striking series of reports from the eastern and western coastal waters (Menon and Menon, 2006, Soja and Menon, 2008). Similarly, the bryozoans of deep-sea basins have been notably unexplored. Earlier, the innovative research on bryozoa was by Hincks (1884, 1887) narrating 13 species from the Indian EEZ and nearby waters. Thornely (1905) described and listed 116 species and no figures of species were published other than those described and listed. Thornely (1907) had worked on the specimens collected during the voyage of R.I.M.S. Investigator, reserved in the Indian Museum. She incorporated 81 species to that report, amongst 4 were new to science. The works of Robertson (1921) on the Bryozoa from the Bay of Bengal and other eastern waters and listing of 95 species were significant effort.

Andaman and Nicobar cover 30% of Indian EEZ with rich repositories of biodiversity and endemicity. However, the bryozoan reports from Andaman and Nicobar were below 18%, due to its remoteness and lack of research (Shrinivaasu *et al*., 2015). The available literatures on Andaman bryozoans were limited, (Thornely, 1905; Thornely, 1907; Robertson, 1921). Thornely (1905, 1907) had covered offshore waters of Passage Island, Cinque Island, Table Island, Marshel Passage, and Sentinel Island and reported 27 different species from the dredge samples. Robertson (1921) had explored the offshore waters of Port Blair and reported 19 different species of bryozoan from Andaman waters during Siboga Expedition. Taylor *et al*. (2015) reported 23 species including 12 Anascan and 11 Ascophoran bryozoan species from the Penang and Langkawi Islands of Malaysian territory in the Andaman waters. Nearly two decades into the 21st century, only two papers on Andaman bryozoans were published. Naufal and Jayaraj (2018), and Naufal *et al*. (2018) have studied the intertidal bryozoans from Andaman Waters. The poor publication rate was largely attributed to very few trained bryozoan taxonomists. Notwithstanding, the actual diversity is still underestimated owing to differences in survey efforts in relation to different geographical areas and biotopes. The present study targets the distribution and diversity of deep sea bryozoan from the Andaman waters, which can act as a baseline for further investigation.

2. Materials and methods

The deep sea samples of Andaman waters were collected from offshore waters of Port

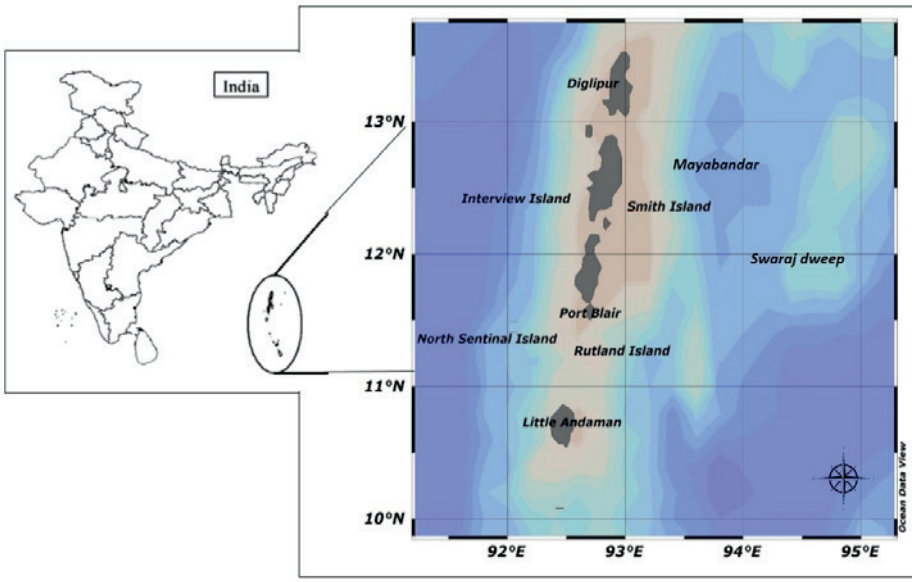

Figure 1. The deep sea study locations

Table 1. The details of Deep bottom study locations

	Station name	Date of collection	Latitude	Longitude	Bottom depth (m)
1.	Port Blair	24/11/2017	11°41'94" N'	92°46'46" E'	73
2.	Swaraj Dweep	24/11/2017	12°01'82" N'	92°91'71" E'	325
3.	Mayabundar	26/11/ 2017	12°30'57" N'	93°04'70" E'	400
4.	Diglipur	27/11/2017	13°29'83" N'	92°38'22" E'	302
5.	North Sentinels	28/11/2017	11°29'97" N'	92°10'69" E'	614
6.	Interview	28/11/2017	12°30'14" N'	92°19'86" E'	629
7.	Little Andaman	22/11/2017	10°12'39" N'	92°39'37" E'	673

Blair, Swaraj Dweep (Havelock Island), Mayabandar, Diglipur, Interview Island, North Sentinel Island, and Little Andaman (Figure1), during the FORV Sagar Sampada Cruise #367, Leg – II, along the Indian Exclusive Economic Zone of Andaman Sea, between 22 November 2017 and 28 November, 2017. The details of coordinates and depths of sampling locations are given in Table 1. The sampling gears used were bottom trawls, grab, and dredge. Well-encrusted colonies on the shell, gravel, or stones were washed in fresh water and dried. The individual colonies were scrapped out and sorted using a surgical blade. Some of the rocks and dead shells were broken. Each specimen was clearly labelled with the station name and date of collection. Whole colonies were scraped out from the substratum to enable later examination of the colony from wherever it was possible. Field observations of the natural appearance, habitat depth and substratum type were noted down.

The systematic identification and classification were done based on Bock *et al*. (2018) and the World Register of Marine Species (WoRMS). Though, some of the conflicted species were resolved using the literature The Global Biodiversity Information Facility (GBIF) which provides free access to biodiversity data (http://www.gbif.org/).

For the diversity analysis, the three levels put forwarded by Whittaker (1972): alpha, beta, and gamma diversity, were applied. The study locations were considered as habitat units and the identified species richness was given as alpha diversity. Alpha diversity is the number of species reported from a study site or within a community, in which both mean values or total number of species can be used. It is also considered that alpha diversity is equal to total species exist over a limited time, during which the species number does not change. The chances for change in the species number at a specific site vary based on the arrival of new species, emigration, and local extension of some species. Beta diversity is the rate of change in the number of species between two types of communities in two sites or two landscapes. In other words, beta diversity gives the quantitative value of diversity of communities along environmental gradients. Gamma diversity is the total number of species recorded for the group of sites or communities that make up a landscape. The enumeration of Gamma diversity gives the species richness over a large ecological region (Jost, 2010).

The inter-station comparison was done for deriving the beta diversity and the sum total of all species richness was taken as an estimate of gamma diversity.

3. Results and Discussion

A total of 18 species belonging to 11 genera of 10 families coming under 7 super families and 1 suborders of order Cheilostomes were identified from the collections of deep sea investigation from the Andaman waters. The occurrence list of deep bottom bryozoan from Andaman waters were given in Table 2. Out of 18 species, *Adeonellopsis distoma and Margaretta longicollis* were reported from two sites. Whereas *Psammocleidochasma* sp., *Characodoma latisinuatum, Characodoma excubans, Adeonella* sp., *Buskea* sp. were identified only from one stations each. Maximum number of species were identified from Little Andaman. While Port Blair and North Sentinel Islands were contributed 7 species each. Similarly, 6 species were identified from Mayabandar. Swaraj Dweep, Diglipur and Interview Islands were contributed 5 species each. The genus *Characodoma* was identified from only Little Andaman. The genus *Adeonellopsis* was not reported from Diglipur and Little Andaman. Among the 18 identified species, *Antropora granulifera* was previously reported from West Coast of India (Table 3). Likewise, *Drepanophora incisor* was identified from both west coast and east coast of India. None of the species identified in the present study was reported from the waters of Lakadives waters.

On a comparative basis, 317 named bryozoan species were known at the Great Barrier Reef from published literature (Gordon and Bock, 2008). About 500 species were known from the smaller Mediterranean Sea area (2.5 million km^2) (Rosso, 2003; Koçak and Önen, 2014). Nearly 1000 bryozoan species were known from the larger, more-temperate New Zealand EEZ (4.2 million km^2) and up to 1200 species

in total were expected (Gordon *et al*., 2009). While considering the different marine zones of Indian EEZ, the most number of collections were reported from the West coast, followed by East Coast, Andaman Islands, and Lakshadweep Islands. The same trend was seen in the listing of Shrinivasu *et al*. (2015). Comparing with the world wide estimated number of living bryozoans (i.e., 6300), the present updated list of bryozoan from the Indian waters with 323 species will form only 5.1%.

While considering the western part of Bay of Bengal, the major collections were from the coastal waters of West Bengal, Orissa, and Andhra Pradesh. Gordon *et al*. (2007) pointed out that, after synonym corrections of these data and ignoring taxa of equivocal status, such as species which were not illustrated or poorly so, and uncertain biogeographical data, only about 44 marine bryozoans so far known from the northern Bay of Bengal. The bryozoan research gap in Andaman Island was in its extreme since last nine decades after the Siboga expedition results published by Robertson (1921). The dominant genera in their study were *Scrupocellaria* and *Crisia* which were not at all reported in the present study. Out of species belonging to 11 genera of 10 families coming fewer than 7 super families and 1 suborders of order Cheilostomes listed out from the Andaman waters, fourteen bryozoans were identified up to species level. Considering the distribution of the deep bottom bryozoans listed in the present study, none of the deep sea species of the present study was reported from the Lakshadweep waters. But two species were reported from the west coast. They were *Antropora granulifera* and *Drepanophora incisor* (Menon and Menon, 2006). Similarly, *Antropora granulifera* was also reported from east coast of India. Except these two species, remaining 15 species were first report from Indian waters.

The common species which was reported in recent study and previous reports from the coastal waters of Port Blair during various global expeditions was *Adeonellopsis distoma,* (Thornely 1905; Thornely 1907; Robertson 1921). Except this species, all the 17 species listed in this study were first report from Andaman waters. Correspondingly 4 genera namely *Adeonellopsis, Crepidacantha, Margaretta, Puellina,* reported in the present study and the previous studies from Andaman were common. Ten species listed in this study namely *Adeonellopsis subsulcata, Buskea* sp*., Characodoma excubans, Characodoma rotundum, Crepidacantha longiseta, Margaretta longicollis, Puellina decipiens,* were first report to Indian Ocean region. They were reported from various parts of the world including the Great Barrier Reef (Ryland and Hayward 1992), Brazil (Almeida *et al*., 2015), Mediterranean Sea (Harmelin 2014), and Japan (Dick and Grischenko 2017). The global occurrence of *Psammocleidochasma* sp*.,* and *Drepanophora incisor* species were reported only from Red Sea (Ostrovsky *et al*., 2011), and Indonesia (Di Martino and Taylor 2018). The species *Antropora granulifera,* which was found from other areas of Indian water (Menon and Menon 2006), as well as Indian Ocean (Ostrovsky *et al*., 2011), and other oceans (Ryland and Hayward 1992) were expressing their cosmopolitism behavior.

The earlier form of classification of Cheilostome bryozoa was by considering two sub orders called Anasca and Ascophora (Levinsen 1909) which was based on nature of the frontal body wall of the autozooid. The same system was followed in the earlier works from the Indian waters

like Menon and Menon (2006), Shrinivasu *et al*., (2015). Gordon (1984) reviewed various schemes used for classification of cheilostomes until the early 1980s. He conservatively retained the two-suborder arrangement of Anasca and Ascophora, clustering families into superfamilies within these suborders. Accordingly, Bock and Gordon (2013) abandoned the use of Ascophora and Ascophoran infraorders as formal taxa. The Bryozoan classification used in the present study is based on the evolving synthesis which was compiled by Bock *et al*., (2018) and Bock and Gordon (2013). The same was given in the Bryozoa Home Page (www.bryozoa.net) and used in the World Register of Marine Species (WoRMS). This classification pattern recognizes seven suborders, in which genera and families were grouped into various super families.

Table 2. The occurrence of bryozoan species from the Deep bottom zone (+ - presence, 0 – absence)

Species	Port Blair	Swaraj Deep	Mayabundar	Diglipur	Interview	N. Sentinal	Little Andaman
Adeonellopsis subsulcata	+	+	+	0	0	+	0
Adeonella sp.	+	0	0	0	0	0	0
Adeonellopsis distoma	+	+	+	0	+	+	0
Antropora granulifera	+	0	+	0	+	0	+
Buskea sp.	0	0	+	0	0	0	0
Characodoma excubans	0	0	0	0	0	0	+
Characodoma latisinuatum	0	0	0	0	0	0	+
Characodoma rotundum	0	0	0	0	0	+	+
Characodoma sp.	0	0	0	0	0	+	+
Cosciniopsis lonchaea	0	0	0	+	0	0	+
Crepidacantha longiseta	0	0	0	+	0	0	+
Drepanophora corrugata	0	0	0	+	0	0	0
Drepanophora incisor	+	0	+	0	0	+	+
Plesiocleidochasma laterale	0	0	0	+	+	+	0
Plesiocleidochasma normani	0	0	0	+	+	0	0
Puellina decipiens	+	+	0	0	0	0	0
Psammocleidochasma sp.	0	+	0	0	0	0	0
Margaretta longicollis	+	+	+	0	+	+	0
Total	7	5	6	5	5	7	8

Table 3. The comparative list of deepsea bryozoa species of Andaman waters with the earlier report of same species from other regions of Indian EEZ (+ - presence, 0 – absence).

	EC	WC	LDI
CLASS GYMNOLAEMATA (Allman, 1856)			
ORDER Cheilostomata (Busk, 1852)			
SUBORDER Flustrina (Smitt, 1868)			
Superfamily Calloporoidea (Norman, 1903)			
Family - Antroporidae (Vigneaux, 1914)			
Antropora granulifera (Hincks, 1880)	0	+	0
Super family Cribrilinoidea (Hincks, 1879)			
Family - Cribrilinidae (Hincks. 1879)			
Puellina decipiens	0	0	0
Super family Adeonoidea (Busk, 1884)			
Family - Adeonidae (Busk. 1884)			
Adeonellopsis distoma (Busk, 1858)	0	0	0
Adeonellopsis subsulcata	0	0	0
Adeonella sp	0	0	0
Superfamily Lepralielloidea (Vigneaux, 1949)			
Family - Lepraliellidae (Vigneaux, 1949)			
Drepanophora incisor (Thornely, 1905)	+	+	0
Drepanophora corrugata	0	0	0
Super family Schizoporelloidea (Jullien, 1882)			
Family Margarettidae (Harmer, 1957)			
Margaretta longicollis	0	0	0
Family Gigantoporidae			
Cosciniopsis lonchaea	0	0	0
Superfamily Mamilloporoidea (Canu and Bassler, 1927)			
Family Crepidacanthidae (Levinsen, 1909)			
Crepidacantha longiseta	0	0	0
Family Cleidochasmatidae			
Characodoma latisinuatum	0	0	0
Characodoma rotundum	0	0	0
Characodoma excubans	0	0	0
Characodoma sp.	0	0	0
Family Celleporidae (Johnston, 1838)			
Buskea sp.	0	0	0
Family Phidoloporidae			
Psammocleidochasma sp.	0	0	0
Plesiocleidochasma normani	0	0	0
Plesiocleidochasma laterale	0	0	0

3.1. Diversity Indices

The biodiversity of the collected species at different spatial scales was enumerated with Whittaker's alpha, beta and gamma diversity. The indication of alpha value is the diversity of the species of the ecosystem, within a specific habitat. The overall alpha diversity indicates that all the stations have value of 5 or more (Table 4). The alpha diversity (α value) was more for Little Andaman (8) and less for North Island, Diglipur and Swaraj Deep (5). The beta diversity (β Value) reflects the degree of change in diversity of a species between as well as within the habitats. The beta diversity values for Diglipur and Little Andaman were high. This indicates the exclusivity in species richness when related to other zones. The gamma diversity of refers to the value of total diversity for the various ecosystems within an area. The gamma diversity of Deep bottom sites was 18. High beta values indicate uniqueness in species richness when compared to other zones. The Beta diversity value provides the extent of the difference in species composition either between two or more local accumulations or among local and regional accumulations. In the available level of regional species richness, as beta diversity increases, individual localities differ more markedly from one another (Koleff *et al*., 2003). Alpha, beta, and gamma diversities are among the fundamental descriptive variables of ecology and conservation biology. The results from the present analysis indicate that similar studies have to be carried out from other marine ecosystems along the Andaman Waters, so that it becomes benchmark information for studying impacts on biodiversity.

These finding have increased the conviction that many other species could occur in this island ecosystem which indicated high potential biodiversity in the long stretch of Andaman and Nicobar Archipelago, necessitating continued research are essential. Discovery of true diversity of bryozoans around Andaman Islands and their distributional pattern will need much more research, with strong specimen collection, by sophisticated techniques and diving to get reef and subtidal species, because benthic diversity assessments maybe used to identify potential sites for marine conservation or marine protection (Rouse *et al.,* 2014). As benthic data layers improve through increased sampling effort, particularly in unstudied areas, greater understanding into the relationship between the physical environment, diversity, and spatial distribution patterns of benthic fauna will be gained (Rouse *et al.,* 2014). Assessment of the biodiversity and its conservation, particularly at marine protected zone of Andaman Islands are among the early recommendations for India. This study provides an example of the application of methods to assess spatial patterns in benthic diversity and serves as a baseline for long-term monitoring of changes in biodiversity in this poorly studied Phylum.

Conclusion

Our survey of the literature showed that despite of the available research history and a rather substantial number of published papers, the knowledge about bryozoan diversity of the Indian EEZ is very incomplete. This is partially because a majority of the studies were done in pre-SEM times and species identifications require thorough re-examination using SEM. Hence the discovery of true diversity of bryozoans of Indian EEZ, especially, around Andaman Islands and their distributional

Table 4. Alpha, beta and gamma diversity values for Deep Sea Bryozoan species

	β Value							α Value
	Port Blair	Swaraj Deep	Mayabundar	Diglipur	Interview Island	North Sentinal	Little Andaman	
Port Blair		2	5	12	6	7	11	7
Swaraj Deep			5	11	6	5	9	5
Mayabundar				10	5	4	10	6
Diglipur					7	10	12	5
Interview Island						7	9	5
North Sentinel							8	7
Little Andaman								8
γValue				18				

pattern will need much more research, with strong specimen collection, by sophisticated techniques and diving to get reef and subtidal species.

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