

Community Structure of the Honeycomb Worm *Neosabellaria clandestinus* From a Biogenic Reef of Gujarat Coast, India

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ABSTRACT

This communication reports the community structure of *Neosabellaria clandestinus* on Sarkeshwar coast at the mouth of Gulf of Khambhat in Kathiawar Peninsula, Gujarat (20° 50' N, 71° 19' E). The coast has a sandy intertidal zone with rocky outcrops. The landscape of tidal flat supports both the *Ulva* sp. bed and *N. clandestinus* assemblage for biogenic reef formation. We examined the distribution pattern of the newly developing biogenic reef and associated species, the spatio-temporal variations in the cover of the area, and the species composition of the community associated with reef stages. Field observations and random quadrat method were used for a year from September 2013 to August 2014. The results indicated that the honeycomb worm, *N. clandestinus* created, maintained, and modified or destroyed the large biogenic reefs which constitute diversity hotspots on the tidal flats. Results revealed that *N. clandestinus* was the dominant macro-benthos competing for space with the dominant alga *Ulva* sp. for the biogenic reef formation in the middle intertidal zone. The study revealed that the biogenic reef building followed an annual cycle during which the well-established reef was partly destroyed in some peripheral areas. These areas again passed through the re-establishment process but encountered fierce competition from other benthic communities. The degraded reef stages has more complex assemblage compared to ball-shaped stage and platform stage.

Key Words: Habitat Ecology; Biogenic Reef; Sabellariid Worm; Species Composition; Gulf of Khambhat

INTRODUCTION

The tube-building polychaetes of family Sabellariidae form massive biogenic reefs. The biogenic reefs play key functional roles in ecosystems by stabilizing substrates and trapping sediments, providing a diversity of microhabitats that attract macrofauna or increasing available space for new species to colonize (Gruet 1982, Done 1995, Bianchi 2001, Bayers et al. 2006). Sabellariid reefs have been studied on the coast of South America (Lana and Bremec 1994), Brazil (Lana and Gruet 1989), Great Britain and Ireland (Mettam 1992, Bamber and Irving 1997), Portugal (Dias and Paula 2001), and the Northern coasts of France (Volvelle 1963, Gruet and Boudier 1997, Dubois et al. 2006), Mediterranean coast of France

(Bellan 1964), Spain (Porrás et al. 1996) and Italy (Sparla et al. 1992, Gambi et al. 1996, La Porta et al. 2006). Associated fauna of biogenic reef has been studied on the coasts of South America (Fausto-Filho et al. 1970), Spain and Portugal (Porrás et al. 1996), and western America (Posey et al. 1984) and France (Gruet 1970, 1971, 1972). More recently Dubois et al. (2002) have provided detailed analysis of the associated fauna of *Sabellaria alveolata* reefs. Diversity, distribution patterns and associated fauna of the Sabellariid reefs from the Indian coasts have been reported by Achary (1969, 1974). His study was based on observations and collections at southern and south-western sub tidal regions of India. However, no such reports are available for *Neosabellaria clandestinus* from world database as well

as the vast coastline of India. Therefore, we studied the biogenic reef of *N. clandestinus* (Menon and Sareen 1966a,b, Day 1973, Kirtley 1994) for its associated species diversity, their composition, distribution, habitat and sand particle preference, temporal variations in the vertical zonation and the percent cover of the seaweed and *Neosabellaria* assemblages in the intertidal zone at Sarkeshwar coast of Gujarat state.

THE STUDY AREA

Sarkeshwar (20° 50' N, 71° 19' E) coast is located on the Kathiawar Peninsular coastline on the outer rim of the Gulf of Khambhat (Figure 1). Gulf of Khambhat has semi-diurnal tide system where the reefs are exposed twice a day and its hydrodynamics force and periodic aeration help a successful cementation of the newly built

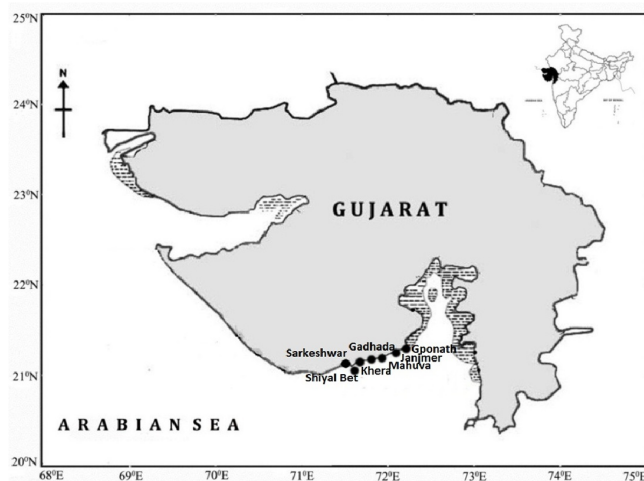


Figure 1. Map showing the study site and local distribution along the outer rim of Gulf.

tubes into a reef (Dubois et al. 2002). The Gulf area provides turbulence of turbid water for the supply of sand particles which form substratum for attachment. Under these conditions massive aggregation of this worm occurs as the worms settle down and form a massive biogenic reef (Hartman 1944). The seawater temperature of this area varies seasonally with minimum in winter (20 °C to 27 °C) and maximum during summer (29 °C to 33 °C) (Vaghela et al. 2010). The turbidity of the seawater is high during summer and monsoon seasons and slightly decreases during winter (Bhadja and

Kundu 2012). Residual circulation of Gulf of Khambhat is generally high but the biogenic reefs are situated on the outer rim of the Gulf and thus, circulation of water is not high compared to the deeper areas of the Gulf (Vaghela et al. 2010).

METHODS

Habitat survey and biodiversity assessments were made during the lowest tide period along the Gulf coastline. Samples were collected every month from July 2013 to August 2014 on sandy-rocky coast, which is about 3 km long. The vertical intertidal zone of about 70-90 m is exposed during the low tide. The main biotic assemblages and zones were identified, their extent measured, and the upper and lower limit of each zone were measured. The encountered macrofauna and flora were identified in situ whenever possible. In case of taxonomic uncertainty, the voucher specimen was collected and identified in the laboratory with the help of authentic keys and a checklist was prepared. The structure, size and components of biogenic reef tubes were studied by microscopy. The spatio-temporal variation in distribution pattern and percent cover of area within the vertical zonation of biogenic reef and algal bed along the intertidal zone were studied by laying nine 50 x 50 cm quadrats (Misra 1968).

RESULTS AND DISCUSSION

Biogenic Reef of *N. clandestinus*

N. clandestinus, also known as the honeycomb worm, is a reef building polychaete (Figure 2A) which lives in self-made small tube constructed by cementing coarse sand, silt and broken shell materials. The tubes are arranged in close proximity and have a distinctive honeycomb like appearance (Figure 2B). There were three reef stages: degraded reef stage i.e., older established reef (Figure 2C), ball shaped structures stage i.e. developed reef (Figure 2E) and platform stage i.e. developing reef (Figure 2D). All were found on flat rocky substratum, bare pointer rock puddle, boulder rock, platform rock, of intertidal zone which get exposed during low tides.

Degraded reef: The degraded reef was uneven, about 78 m long and 30-45 m wide. It was made up of millions of overlapping tubes of the polychaete *N. clandestinus*

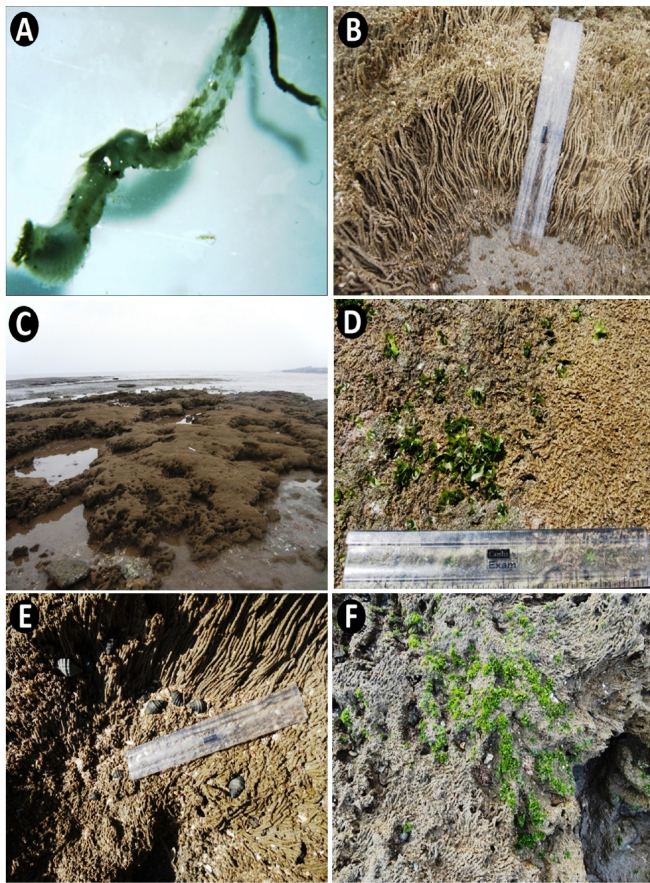


Figure 2. A. *Neosabellaria clandestinus*, B. Tube orientation by *N. clandestinus*, C. Degraded reef stage, D. Platform reef stage, E. Ball shaped reef stage, F. Reef associated fauna

(Figure 2B). About 80-180 tubes were observed in 0.10 m² area. Each tube was irregularly shaped, about 10-26 cm long and 0.8-1.6 cm thick, and the lower part of the tubes were narrower than the upper part. In the degraded reef, *N. clandestinus* preferred 3-50 mm sized bioclastic coarse sand and particles for construction of the tubes. The tubes were pale brown or whitish in color depending on the type of sand particles used by the animals. The surface of the reef was also uneven in shape which forms small pools or crevices like structures within the reef that provide structural habitat for other benthic fauna like polychaetes, zoanthids, slugs, molluscs, hermit crabs etc. Six species of seaweed were also recorded in study area and amongst them, *Ulva lactuca* and *Ulva fasciata* were common on the reef and in the surrounding areas (Table 4).

Ball shaped and Platform reefs: Ball-shaped and platform stages were found spreading around the main

degraded reef towards middle intertidal zone indicating the reef building process of *N. clandestinus* on the tidal flat over time. However, the successful progress of platform stage was observed only on the flat rocky substratum of the middle littoral zone and developed as a ball shaped stage after succession (Figure 2E). The new developing ball shaped reefs were about 0.2-5 m long and 0.3-2.0 m wide and were arranged in series along the tidal flat. The preferred sand particle size was around 0.2-3 mm which was smaller than the particle used in main reef by these animals. The mean length of tubes in these colonies was 3-6 cm and the tubes overlapped with each other instead of their vertical growth. This may be due to the absence of the support of nearby full grown tubes, which are easily available in the degraded reef. There were about 250-320 tubes in 0.10 m² reef area. Microscopic observations of the colony revealed that the constructed tubes were joined together by bio-mineralized cement consisting of coarse sand forming 1.2-1.8 m thick honeycomb like structures. The colour of the tube varied with the colour of sand grains used to make the structure. The animals which form ball shaped and platform colonies in the developing reefs preferred much smaller (0.3- 1.2 mm) sized particles. On the other hand, many platform and ball shaped colonies were destroyed by the tidal wave action and competition with *Ulva* bed which was already settled on the rocky substratum. The primary requirement like food and availability of reef building material for the new developing colony was sufficient on the flat rocky substratum of middle inter-tidal zone which was already covered by degraded reef. Moreover, the animals faced stiff competition from growing seaweeds like *U. fasciata* and *U. lactuca* for available space. During field observations, competition was also observed between community members for space, especially at the edge of developing colony where suitable substratum was no longer available. In these areas the animals were more coiled with each other on the side where the reef was broken.

Distribution Patterns of Biogenic Reef

The degraded reef was observed in spatial clusters where the distribution pattern and size exhibited spatio-temporal variations in the middle intertidal zone. The ball shaped and platform reef were found uneven, randomly distributed in the middle intertidal zone. In the upper and lower intertidal zone, no settled colony was observed. Platform and ball shaped reefs did not prefer the sandy substratum, pools and paddles and substrate

that remained submersed during low tide for building up the biogenic reef. The settlement of new developing colony was seen on the bare rocks for short period of time and later degraded by wave action.

Percent Cover of Assemblages

The percent cover of the biogenic reef of *N. clandestinus* was increased from August 2013 to December 2013 and declined thereafter until July 2014 (Figure 3). The maximum area covered was 35.11 % in winter season

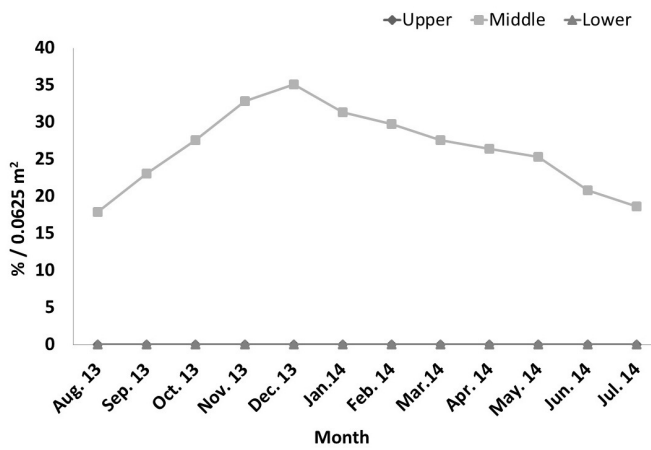


Figure 3. Percent cover of *N. clandestinus* assemblage. The species was not observed in upper and lower littoral zones.

and minimum in the post-monsoon season. The area covered by the *Ulva* bed also increased from August 2013 to December 2014 and declined thereafter. The maximum area covered by *Ulva* sp. was 66.42 % during winter season and the minimum was 20.5 % in the post monsoon season (Figure 4). It has been reported earlier that a short spawning period every year in July initiates each new generation (Wilson 1971). This explains the observed increase in the population of *N. clandestinus* during August. Further, the variation in the cover of the new developing colony in winter season may be due to the competition of both the communities for space during winter season when few *Ulva* sp. were growing abundantly in the middle intertidal zone (Figure 4). During the monsoon season the area covered by biogenic reef was minimum, possibly due to the tidal activity that degrades the biogenic reef, mainly ball shaped structures. The biogenic reef building followed an annual cycling process where the existing well-established reef was partly destroyed at some peripheral areas which again pass through the re-establishment process but experience fierce competition from the other benthic communities.

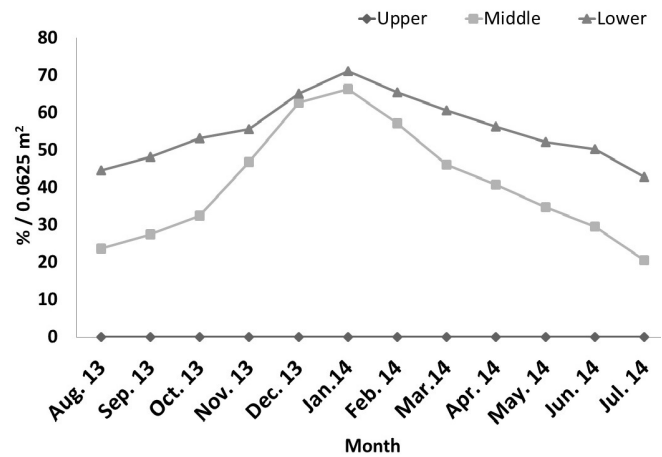


Figure 4. Percent cover of *Ulva* sp. bed. The species was not observed in upper littoral zones.

Community Structure of the Reef

N. clandestinus was dominant faunal species in the intertidal zone of the study area and was associated with a large number of other fauna (Figure 3F). Several prominent floral and faunal groups were found to be associated with the reefs (Tables 1, 2 and 3). They include eleven gastropod species (*Gibbula magus*, *Tectus niloticus*, *Trochus radiates* *Uvanilla buschii*, *Astralium semicostatum*, *Turbo intercostalis*, *Clypeomorus bifasciata*, *Cerithium scabridum*, *Cerithium columna*, *Cerithidea cingulata*, *Cellana karachiensis*), sea slug *Onchidium* sp., hermit crab species (*Clibanarius* sp. and *Pagurus* sp.), *Chiton* sp., polychaetes *Nereis* sp. and flat fish (*Pleuronectes* sp.) (Table 1). The associated floral diversity included *U. lectuca*, *U. faciata*, *Enteromorpha clathrata*, *Padina gymnospora*, *Gracilaria corticata* and *Ceramium rubrum* (Table 4). In case of ball-shaped colony, the associated fauna were *G. swainsonii*, *T. niloticus*, *Trochus radiatus*, *U. buschii*, *A. semicostatum*, *T. intercostalis*, *C. bifasciata*, *C. scabridum*, *C. cingulata*, *C. karachiensis*, *Clibanarius* sp., *Pagurus* sp. and *Nereis* sp. (Table 2). Among them *Astralium semicostatum*, *T. intercostalis*, *Clibanarius* sp. and *Pagurus* sp. were moderately associated during the winter season. *C. karachiensis*, *Clibanarius* sp. were moderately in association with platform stage while, *T. niloticus*, *T. radiatus*, *U. buschii*, *A. semicostatum*, *T. intercostalis*, *C. bifasciata*, *C. scabridum*, *Pagurus* sp. and *Chiton* sp. were rarely observed (Table 3). The species composition of stagnant degraded reef stage was more diverse than other reef stages. The gastropods, hermit crabs, polychaete and sea slug were observed in abundance.

Table 1. Reef associated faunal diversity. Species names are updated as per WoRMS (Nov. 2016).

Species	Aug 2013	Sep	Oct	Nov	Dec	Jan 2014	Feb	Mar	Apr	May	Jun	Jul
<i>Gibbula</i> sp.(Linnaeus, 1758)	-	-	+	+	+	+	-	-	-	-	-	-
<i>Tectus niloticus</i> (Linnaeus, 1767)	+	+	+	+	+	+	+	+	+	+	-	-
<i>Trochus radiatus</i> (Gmelin, 1791)	+	+	+	+	+	+	+	+	+	+	+	+
<i>Uvanilla buschii</i> (Philippi, 1844)	+	+	+	+	+	+	+	+	+	+	+	+
<i>Astrarium semicostatum</i> (Kiener, 1850)	-	+	++	+++	+++	+++	+	+	+	+	+	+
<i>Turbo intercostalis</i> (Menke, 1846)	+	+	++	++	++	++	++	+	+	+	+	+
<i>Clypeomorus bifasciata</i> (Sowerby II, 1855)	-	-	-	+	+	+	-	-	-	-	-	-
<i>Cerithium scabridum</i> (Philippi, 1848)	-	-	-	++	++	++	-	-	-	-	-	-
<i>Cerithium columna</i> (Sowerby I, 1834)	-	-	-	-	-	+	+	-	-	-	-	-
<i>Cerithidea cingulate</i> accepted as <i>Pirenella cingulata</i> (Gmelin, 1791)	-	-	-	-	+	+	-	-	-	-	-	-
<i>Cellana karachiensis</i> (Winckworth, 1930)	-	-	+	+	+	+	+	+	-	-	-	-
<i>Clibanarius</i> sp. (Dana, 1852)	++	++	++	+++	+++	+++	+++	++	+	+	+	+
<i>Pagurus</i> sp. (Fabricius, 1775)	++	++	++	++	++	++	++	+	+	+	+	+
<i>Pleuronectes</i> sp. (Linnaeus, 1758)	+	++	++	++	++	++	+	+	-	-	-	-
<i>Chiton</i> sp. (Linnaeus, 1758)	-	-	-	-	+	+	+	+	-	-	-	-
<i>Nereis</i> sp. (Linnaeus, 1758)	+	+	+	++	++	++	+	+	+	+	+	+
<i>Onchidium</i> sp. (Buchanan, 1800)	-	+	+	++	++	++	++	+	-	-	-	-

+ Rare, ++ Moderate, +++ Abundant, - Absent.

Table 2. Ball shaped reef associated faunal diversity. Species names are updated as per WoRMS (Nov. 2016).

Species	Aug 2013	Sep	Oct	Nov	Dec	Jan2014	Feb	Mar	Apr	May	Jul	Jul
<i>Gibbula</i> sp. (Linnaeus, 1758)	-	-	-	+	+	+	+	-	-	-	-	-
<i>Tectus niloticus</i> (Linnaeus, 1767)	-	-	-	-	+	+	+	-	-	-	-	-
<i>Trochus radiatus</i> (Gmelin, 1791)	-	-	-	-	+	+	+	+	-	-	-	-
<i>Uvanilla buschii</i> (Philippi, 1844)	-	-	-	-	+	+	+	+	+	-	-	-
<i>Astrarium semicostatum</i> (Kiener, 1850)	-	+	-	-	++	+++	+	++	-	-	+	+
<i>Turbo intercostalis</i> (Menke, 1846)	+	-	+	+	++	+	++	+	-	+	-	-
<i>Clypeomorus bifasciata</i> (Sowerby II, 1855)	-	-	-	+	+	+	-	-	-	-	-	-
<i>Cerithium scabridum</i> (Philippi, 1848)	-	-	-	+	++	+	-	-	-	-	-	-
<i>Cerithium columna</i> (Sowerby I, 1834)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cerithidea cingulate</i> accepted as <i>Pirenella cingulata</i> (Gmelin, 1791)	-	-	-	-	+	+	-	-	-	-	-	-
<i>Cellana karachiensis</i> (Winckworth, 1930)	-	-	-	-	+	-	+	-	-	-	-	-
<i>Clibanarius</i> sp. (Dana, 1852)	-	-	+	+	+	++	++	+	+	+	+	+
<i>Pagurus</i> sp. (Fabricius, 1775)	+	-	+	+	+	+	++	+	+	+	+	+
<i>Pleuronectes</i> sp. (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Chiton</i> sp. (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nereis</i> sp. (Linnaeus, 1758)	-	-	-	-	+	+	+	-	-	-	-	-
<i>Onchidium</i> sp. (Buchanan, 1800)	-	-	-	-	-	-	-	-	-	-	-	-

+ Rare, ++ Moderate, +++ Abundant, - Absent.

Table 3. Platform reef associated prominent faunal diversity. Species names are updated as per WoRMS (Nov. 2016).

Species	Aug 2013	Sep	Oct	Nov	Dec	Jan2014	Feb	Mar	Apr	May	Jun	Jul
<i>Gibbula</i> sp.(Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tectus niloticus</i> (Linnaeus, 1767)	-	-	-	-	+	+	+	-	-	-	-	-
<i>Trochus radiatus</i> (Gmelin, 1791)	-	-	-	-	+	+	+	+	-	-	-	-
<i>Uvanilla buschii</i> (Philippi, 1844)	-	-	-	-	+	+	+	-	-	-	-	-
<i>Astrarium semicostatum</i> (Kiener, 1850)	-	+	-	-	++	+	+	+	-	-	-	-
<i>Turbo intercostalis</i> (Menke, 1846)	-	-	-	-	+	++	+	-	-	-	-	-
<i>Clypeomorus bifasciata</i> (Sowerby II, 1855)	-	-	-	-	+	+	-	-	-	-	-	-
<i>Cerithiumscabridum</i> (Philippi, 1848)	-	-	-	-	+	+	-	-	-	-	-	-
<i>Cerithiumcolumna</i> (Sowerby I, 1834)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cerithidea cingulate</i> accepted as <i>Pirenella cingulata</i> (Gmelin, 1791)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cellana karachiensis</i> (Winckworth, 1930)	-	+	-	+	++	++	++	-	+	+	-	-
<i>Clibanarius</i> sp. (Dana, 1852)	-	-	+	-	++	+	++	+	++	-	-	-
<i>Pagurus</i> sp. (Fabricius, 1775)	+	-	-	-	+	+	+	-	+	-	-	-
<i>Pleuronectes</i> sp. (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Chiton</i> sp. (Linnaeus, 1758)	-	+	+	-	+	++	++	++	+	+	-	-
<i>Nereis</i> sp. (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-
<i>Onchidium</i> sp. (Buchanan, 1800)	-	-	-	-	-	-	-	-	-	-	-	-

+ Rare, ++ Moderate, +++ Abundant, - Absent.

Table 4. Reef associated floral diversity. Species names are updated as per WoRMS (Nov. 2016).

Species	Aug 2013	Sep	Oct	Nov	Dec	Jan2014	Feb	Mar	Apr	May	Jun	Jul
<i>Ulva fasciata</i> (Delile, 1813)	+	+	+	+	++	++	+	+	-	-	-	-
<i>Ulva lactuca</i> (Linnaeus, 1753)	+	++	++	+++	+++	+++	++	++	++	++	+	+
<i>Enteromorpha clathrata</i> (Greville, 1830)	-	-	-	+	+	+	-	-	-	-	-	-
<i>Padina gymnospora</i> (Sander, 1871)	-	-	-	+	+	+	-	-	-	-	-	-
<i>Gracilaria corticata</i> (J. Agardh, 1852)	-	-	-	-	+	+	+	-	-	-	-	-
<i>Ceramium rubrum</i> (C. Agardh, 1811)	-	+	+	++	+++	+++	++	++	+	+	+	+

+ Rare; ++ Moderate; +++ Abundant.

Gastropods were rarely observed in ball shaped colonies while, patellogastropods were moderately associated with platform stage in winter season due to the seaweed growth. *U. fasciata* and *U. lectuca* were the most abundant species among all associated floral species of biogenic reef that offer tough competition to new developing colony for space.

Degraded reefs provided a stable structural habitat for benthic fauna while ball-shaped structures and platform stage were in competition with seaweeds and other encrusting assemblage for space. Species richness of the associated fauna was much higher than that of the

surrounding area of exposure zone mostly concerned with reef surface. Species observed varied according to the substratum. The number of species was high but very few species were prominent with reef stages in all months. These biogenic reefs offered large number of micro-habitats like small pools and puddles created by uneven arrangements of the tubes within the reef. Dubois (2002) reported that in the *S. alveolata* reef on the French coast, polychaetes were dominant and principal component in terms of the number of species and individuals compared with other associated fauna such as mollusca, insects, crustacea, echinodermata,

anthozoa, nemertea, and sipuncula. In the Gulf of Mannar (India), *Sabellaria pictinata* reef associated fauna was dominated by hermit crabs, hydroids (*Sertularians* sp.), octocoral (*Telesto* sp.), sea anemone (*Actinias* sp.), polychaete (*Plerusa* sp.) and corals (*Montipora informis*) while *Hyatella cribriformis* was abundantly associated with *Sabellaria floridensis* (Achary 1969).

CONCLUSIONS

Reef-building polychaete *N. clandestinus* was acting as an ecosystem engineer by physically creating, modifying and maintaining the reef habitats. From the present report it is concluded that the stagnant degraded reef stage had diverse and unique species composition than ball and platform shaped stages. This is because of the availability of more microhabitats that provided more structural habitats or space, and food availability. Developing stages changes the shapes and sizes which decreased the available space and microhabitats leading to less diversity compare to complex and degraded reef assemblage.

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