Epifaunal Assemblages on Morphologically Distinct Seaweeds of the Intertidal Zone, South Andaman

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Abstract

The present study was conducted in the intertidal zone of the South Andaman Islands. The study was carried out during the dry season of the Islands from January to April 2017 and addressed on the morphologically distinct seaweeds and the variation in the diversity of associated meiofauna. Three morphologically distinct seaweeds were selected and investigated. The study determined a total of five major meiofauna genera. Out of all the three seaweeds, *Padina* sp. and *Halimeda* sp. supported higher faunal density while *Liagora* sp. upheld the lowest epifaunal density. The study attributes to the morphological impacts on the epifaunal diversity which indicates the susceptibility of seaweed as potential epifaunal habitat.

Key words: Seaweed, morphologically distinct, intertidal zone, meiofauna, Andaman Islands

Introduction

Seaweeds are one of the most important living resources of the oceans and also are important as food for human beings, as feed for animals, fertilizers for plants, and as a source of chemicals and drugs. Certain other organisms live on and utilize the oxygen produced by seaweeds (Castro and Huber, 2003). Generally, in rocky intertidal habitats, one of the most limiting resources for benthic organisms is space (Dayton, 1971). The community structures of the most benthic marine system are dependent on the physical structure provided by the organisms. Many foundation species harbor diverse assemblages of associated organisms (Bracken *et al.*, 2007). Epifaunal abundances and species composition can be strongly influenced by host plant architecture.

Despite the importance of structural complexity being generally recognized, studies about this issue are scarce because it is difficult to separate the effects of the structural complexity from those of the available habitat. However some finely structured seaweeds support more meiofauna (Taylor and Cole, 1994, Christie *et al.*, 2009). Higher habitat complexity is thought to increase the number of niches available for colonization thus reducing competition, and providing a larger surface area for interception and colonization, coupled with this, higher complexity habitats have a high sediment trapping potential.

Materials and Methodology

Study Station

The Andaman and Nicobar Islands are present in the Bay of Bengal forming an acute chain of 585 islands and extending for about 850 km between 6° to 14° N latitude and 92° to 94° E longitude. The productive waters of the Bay of Bengal extend on the eastern side whereas on the western side the oligotrophic water of the Andaman Sea is present.
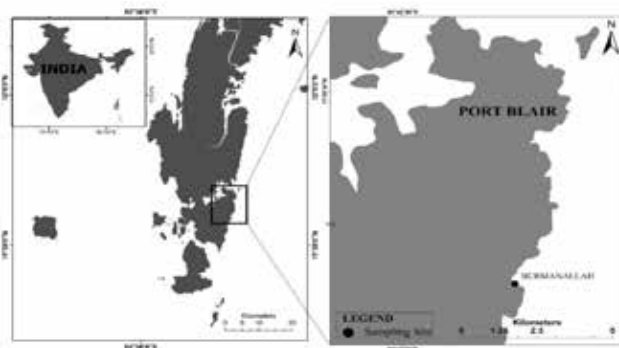

Fig. 1. Map showing the study area

Station description

The intertidal rocky shores of Burmanallah (South East Andaman; 11°33′835′′ N, 092°44′069′′E) region are invaded by many types of seaweed. Burmanallah was chosen as the study station. Station (Burmanallah) has a rocky shore with numerous tidal pools, corals, and sea grass patches and is mostly invaded by natural, healthy seaweeds which are mostly unaffected by human activities. A pilot study was carried out to study and observe the presence of seaweed in the intertidal zone and after thorough observation, the sampling site was selected. The sampling area lies approximately 80 m from the highest high tide mark in the intertidal zone of the sampling station. Monthly sampling was done during the study period

Seaweed selection

Among these, three morphologically different seaweeds such as *Halimeda* sp., *Padina* sp., and *Liagora* sp. were selected for the present study. *Halimeda* sp. is characterized by a thallus consisting of numerous segments with deposits of calcium carbonate. *Padina* sp. is small, flat and fan-shaped, and the apical margin of the thallus is rolled inward. Each blade is calcified, forming a *fan-shaped* cluster. *Liagora* sp. has a mucilaginous body with calcareous deposits.
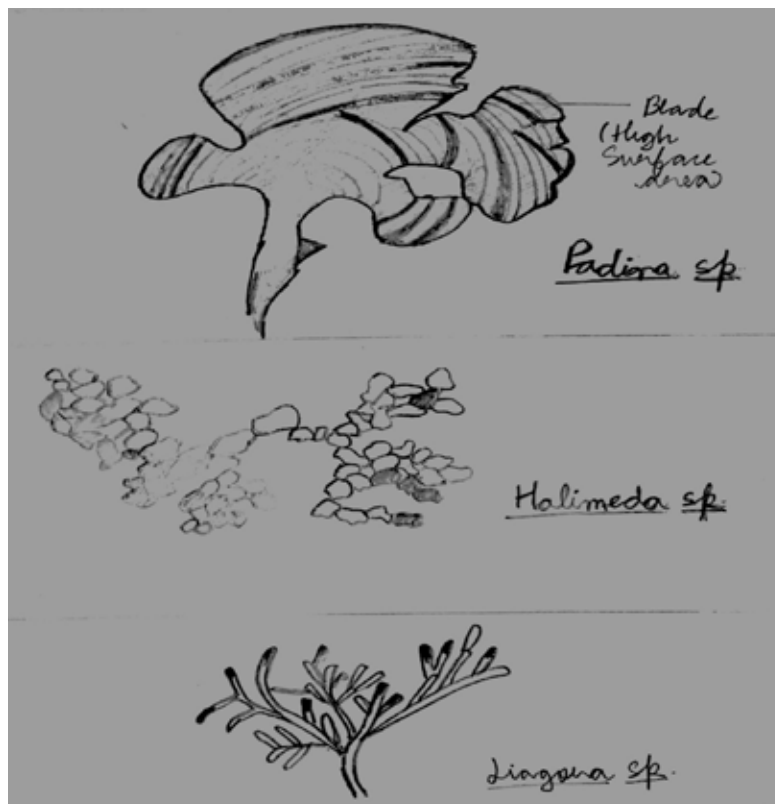

Fig. 2. Structural and morphological variation in seaweeds *Padina* sp., *Halimeda* sp. and *Liagora* sp. respectively (hand-drawn sketch) in the study area

Morphological studies

The surface area was recorded and compared by using oil for morphological distinction. Only one station was selected to maintain parameters like geographical variation and wave action to be constant. The duration of this study was 60 days, through the months of January, February and March' 2017. A random area was selected from the region of the sampling station around the mid-tide mark (around 80m from the highest high-tide mark).

Algal and meiofauna collection

Random sampling method was opted to do the sampling. Plastic pouches were cinched-off just above the holdfasts and then the algae were scraped off from above the holdfast so that each pouch contained a single algal thallus and associated meiofauna; pouching was executed quickly and with minimal handling to avoid scaring or losing meiofauna and then taken to the laboratory for further sorting and analysis. Seaweeds were randomly selected and each alga excluding the holdfast was gently cut from the substratum with a scraper and immediately transferred into a plastic pouch filled with seawater.
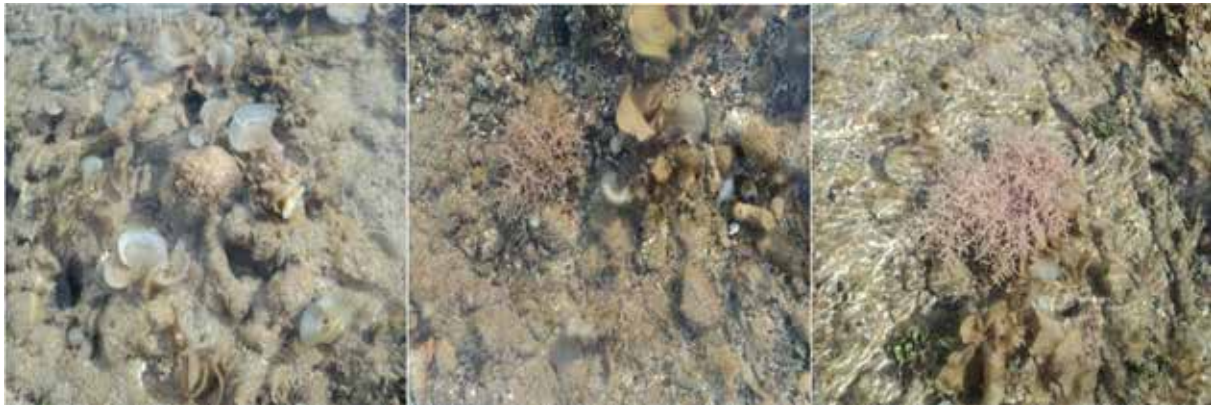
Padina sp.   *Halimeda* sp.   *Liagora* sp.

Fig. 3. Three different seaweeds in the sampling site.

Laboratory Analysis

In the laboratory, each algal host was washed separately in a bucket containing freshwater and the epifauna was sieved through 850 µm (ASTM 20) and 63 µm (ASTM 230) sieves. This process removes over 99% of individuals and then the algae searched thoroughly under a hand lens for any leftover animals and were removed by using a fine brush. The epifauna retained on the sieve were collected and preserved with 4% formalin. The specimens were identified by using standard literature (Rao, 1987; Kaliaperumal et al., 1997; Dhargalkar and Kavlekar, 2004; Fauchald, 1977; Rao, 2000) and meiofauna by using stereo microscope (Nikon SMZ1500) and Phase contrast microscope (OLYMPUS BX41) for calculation of meiofaunal abundance and diversity.

Surface area of three different seaweeds

Preparation of seaweeds for estimation of surface area

Seaweeds were washed with fresh water and the epifauna was removed from the surface. The seaweeds were then allowed to air dry for more than 24 hours at room temperature. Then seaweeds were weighed in the laboratory and then soaked in oil of low viscosity (Mustard Oil). The excess oil was allowed to drip out until the dropping of oil stopped. Then the seaweeds were weighed again having oil on them. The amount of oil absorbed by the surface, would give an estimation of the surface area.

Halimeda sp.   **Padina** sp.   **Liagora** sp.

Fig. 4. Morphologically distinct seaweed for analysis of surface area in Laboratory

Results

Physico-chemical parameters:

Water temperature ranged from 27.5°C-38°C. The maximum temperature was recorded during March 17(38°C) and the minimum in January 17(27.5°C). Maximum salinity was recorded during February'16(37 PSU) and minimum during March'17(PSU)

Surface Area of the Seaweeds

Table 1. Estimation of surface area in the three seaweeds in the study area

Ratio	January	February	March
Halimeda sp.	1.59	1.81	1.58
Padina sp.	3.14	3.56	3.10
Liagora sp.	1.25	1.48	0.00

Epifaunal composition

Analysis of three samples from three morphologically distinct seaweeds resulted that there is a difference in the seaweed-related epifauna but most of the epifauna have a weak relationship with their host plant.Out of all the three seaweeds, the epifauna was abundant in *Halimeda* sp. with an average of 201 nos. epifauna (total=603nos.).

The samples of seaweedspecieswere collected from the same sites at three different times to test whether the variability of epifaunal assemblages was consistent over space and time. Results suggest that stability and morphology of the habitat played an important role in shaping the structure of epifaunal assemblages. This study also showed that *Padina* sp. and *Halimeda* sp. offered a suitable habitat for many epifaunae. In the present study, *Halimeda* sp. exhibited a high concentration of meiofauna of which the copepods, nematodes and polychaetes were in abundance. In the case of other seaweed like *Padina* sp. it was noticed that the polychaetes are nil or very less while high concentrations of nematodes and copepods andother crustaceans were also noted. The seaweeds such as *Halimeda* sp. and *Padina* sp. exhibited almost the same proportion of copepods and nematodes throughout the study period. While the seaweed *Liagora*sp. exhibited high numbers of copepods and very low or nil abundance of polychaetes and nematodes.

Out of all the three seaweeds, *Padina* sp. and *Halimeda* sp. supported higher faunal density; *Liagora* sp. upheld the lowest epifaunal density. Bray-Curtis similarity for the abundance of fauna on each seaweed showed that *Padina* sp. and *Halimeda* sp. with more associated fauna formed a cluster(85% similarity). Whereas, other seaweed such as *Liagora* sp. with low number of associated fauna formed a separate cluster. The meiofauna belonging to 5 major groups were found to be associated with the *Halimeda* sp. Similarly, the Multi-Dimensional Scaling (MDS) showed the similarity between the three different seaweeds in relation to the associated fauna with 51 % similarity among the three seaweeds and 85% similarity among *Halimeda* sp. and *Padina* sp.The Bray-Curtis similarity

index, down-weighs the importance of highly abundant species, allowing not only the mid-range but also the rarer species to exert some influence on the calculation of similarity.

There was a significant positive correlation between the epiphytic abundance of *Halimeda* sp. and *Padina* sp., although correlation values were low. *Liagora*sp. and *Halimeda sp.* showed a strong positive correlation but a very weak negative correlation in *Liagora* sp. and *Padina* sp (Table 3), further correlation values were higher in *Halimeda* sp. (r =-0.88) with temperature r =0.83 with salinity but weak relationship with surface area r =0.20) than in *Padina* sp. (water temperature r =0.20, Salinity r =-0.29 but a strong surface area relationship r = -0.86). *Liagora* sp. on the other hand had strong negative correlation with temperature r =-0.98 and a strong positive correlation with salinity r =0.96 and further strong positive correlation with the surface area r = 0.98.

Table 2. Meiofauna abundance in seaweeds during the study period

January	Abundance						
Sample	**Copepods**	**Other crustaceans**	**Nematodes**	**Polychaetes**	**Foraminiferans**	**Others**	**Total**
Padina sp.	62	17	31	7	35	29	181
Liagora sp.	52	3	7	3	12	6	83
Halimeda sp.	64	13	35	46	41	25	224

February	Abundance						
Sample	**Copepods**	**Other crustaceans**	**Nematodes**	**Polychaetes**	**Foraminiferans**	**Others**	**Total**
Padina sp.	78	10	30	37	32	19	206
Liagora sp.	46	2	5	5	16	6	80
Halimeda sp.	64	13	35	46	41	25	224

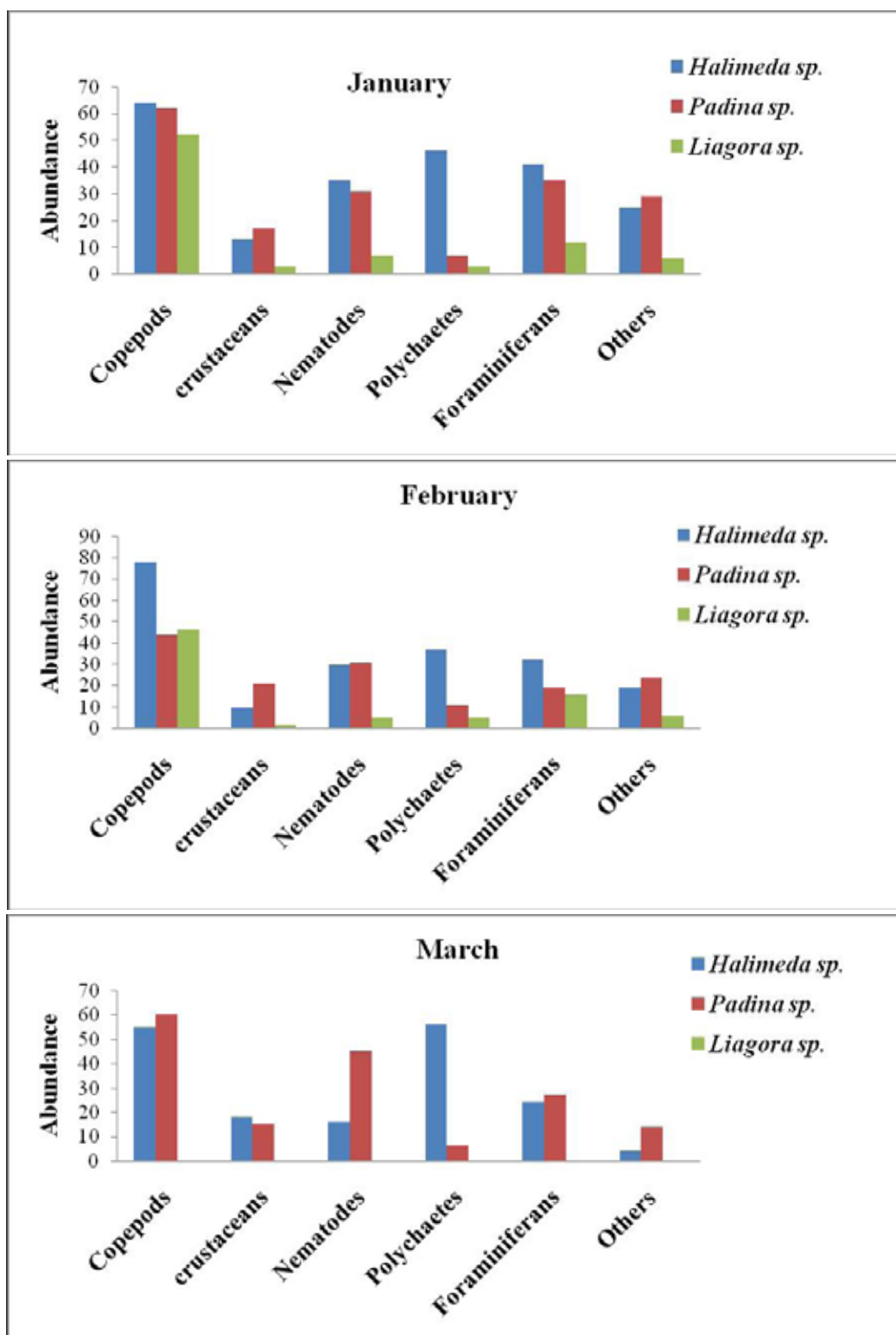| March	Abundance						
Sample	**Copepods**	**Other crustaceans**	**Nematodes**	**Polychaetes**	**Foraminiferans**	**Others**	**Total**
Padina sp.	60	15	45	6	27	14	167
Liagora sp.	0	0	0	0	0	0	0
Halimeda sp.	55	18	16	56	24	4	173

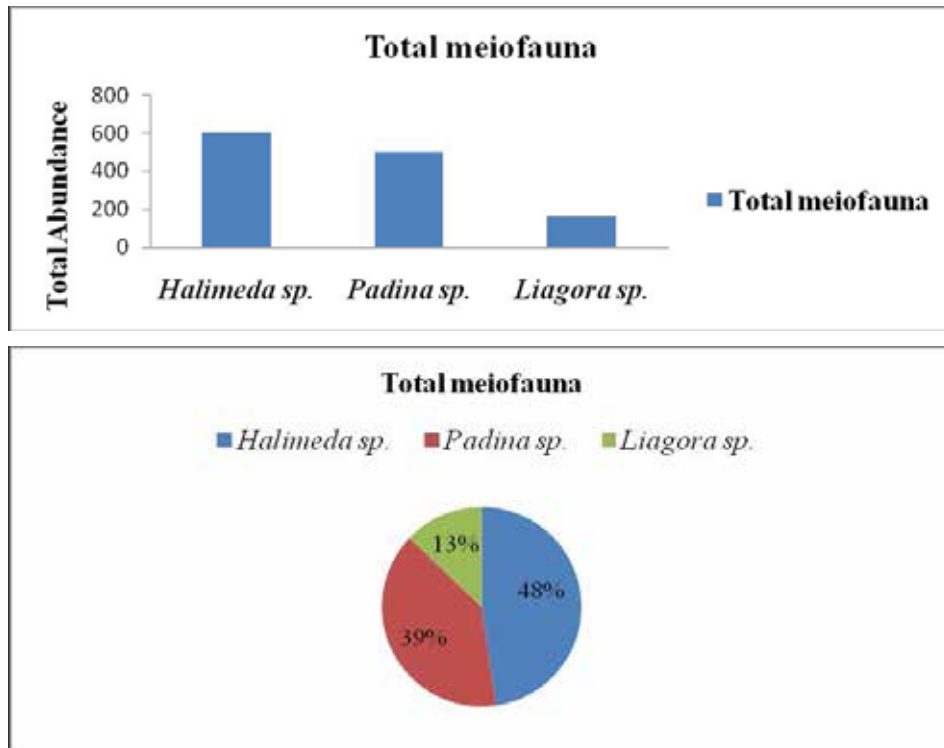**Fig. 5. Monthly variation of meiofauna abundance in the seaweeds**

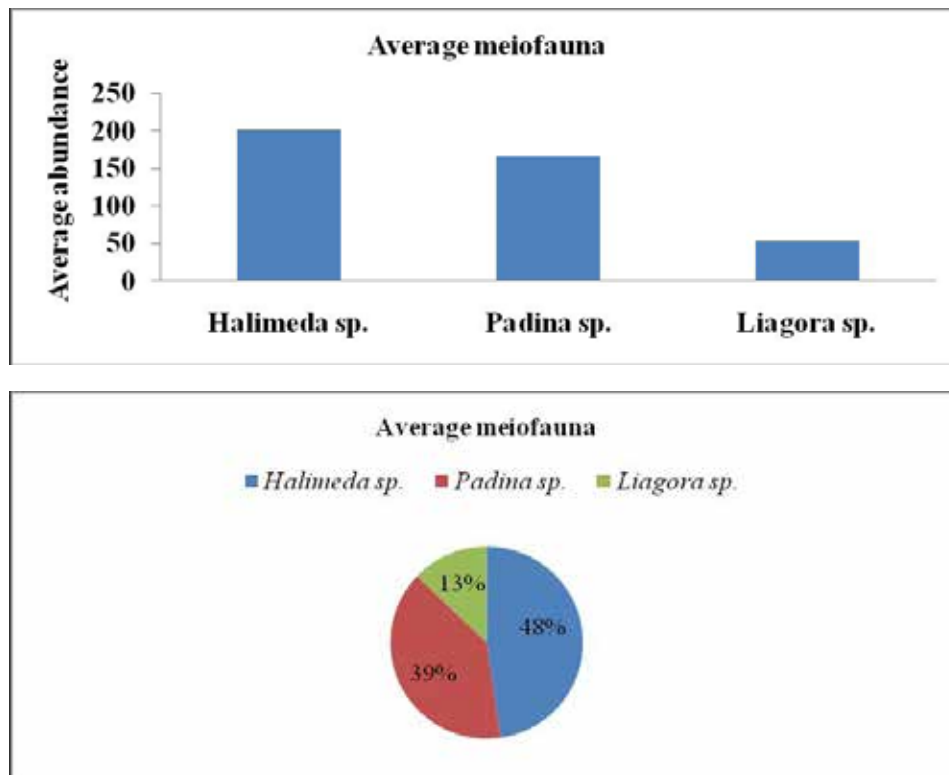**Fig. 6. Percentage of meiofauna in the different seaweeds**

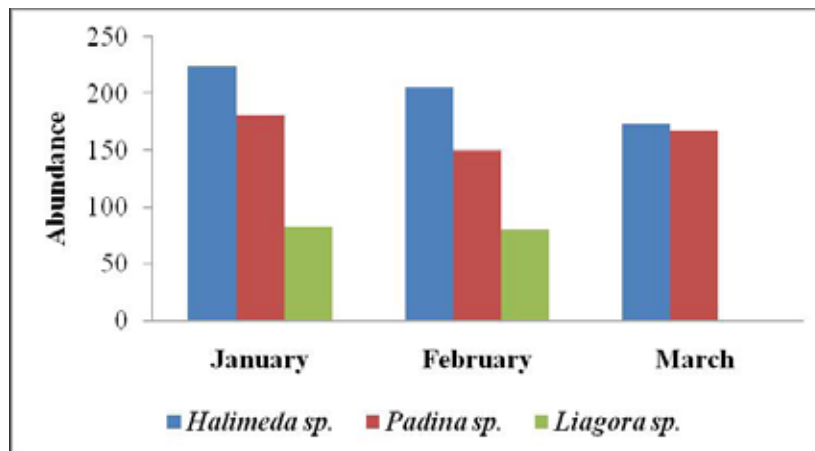**Fig. 7. Average meiofauna in the different seaweeds**

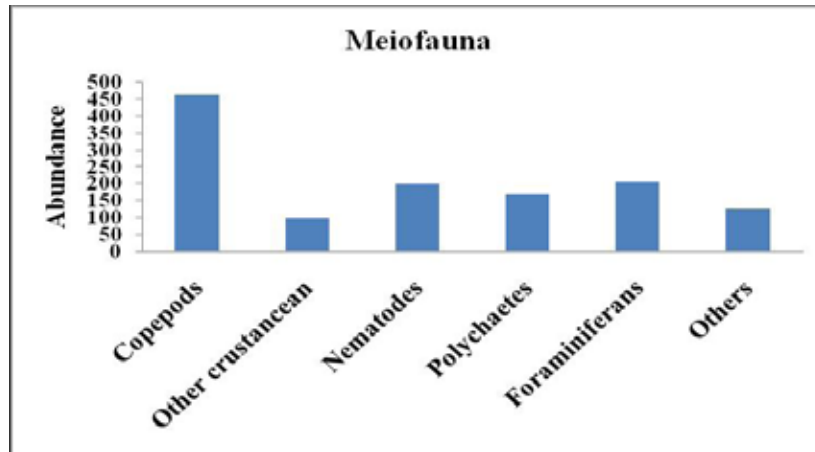**Fig. 8. Monthly variation of mean abundance of different seaweeds**

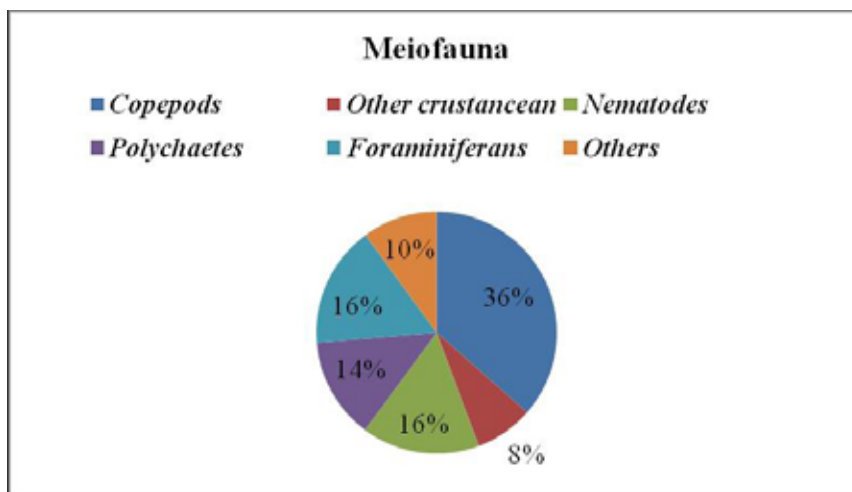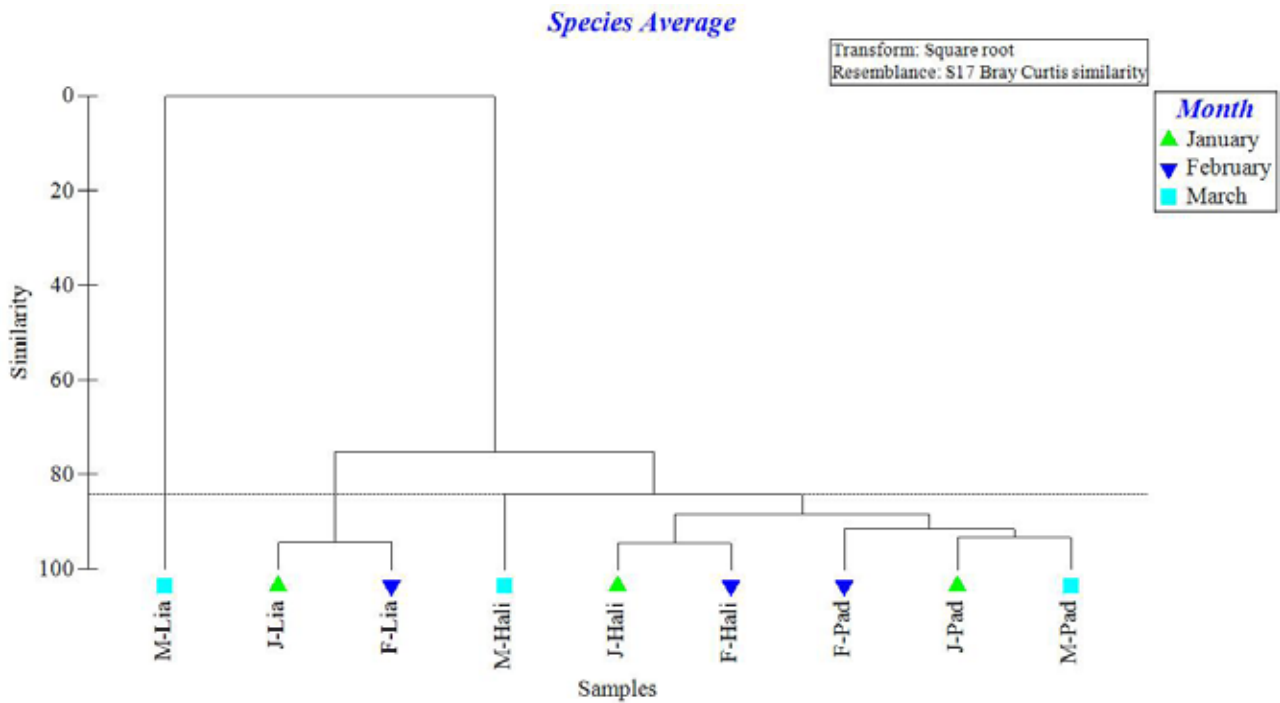**Fig. 9. Overall total abundance of associated meiofauna in the study area**

Fig. 10. Overall percentage of associated meiofauna in the study area

Hali=*Halimeda sp*., Lia=*Liagora sp.*, Pad=*Padina sp*.

Fig. 11. Bray-Curtis similarity showing the formation of groups among the seaweeds in the study area

Fig. 12. Multidimensional Scaling showing the relationship of seaweeds in terms of meiofaunal abundance

Table 3. Correlation between temperature (°C), salinity (PSU), surface area, and the different seaweeds

	Water Temperature (°C)	Salinity (‰)	H-SA	P-SA	L-SA	Halimeda sp.	Padina sp.	Liagora sp.
Water Temperature (°C)	1							
Salinity (‰)	-1.00	1.00						
H-SA	-0.65	0.72	1.00					
P-SA	-0.68	0.74	1.00	1.00				
L-SA	-1.00	1.00	0.65	0.68	1.00			
Halimeda sp.	-0.88	0.83	0.20	0.24	0.88	1.00		
Padina sp.	0.20	-0.29	-0.88	-0.86	-0.20	0.30	1.00	
Liagora sp.	-0.98	0.96	0.50	0.54	0.98	0.95	-0.02	1

SA=Surface area,

H = *Halimeda* sp., P =*Padina* sp., L =*Liagora* sp.

Discussion

An ample abundance of Copepods (36%) was recorded and other crustaceans were meager in the study. Earlier reports show positive relationships between the abundance of associated fauna and clump size of the seaweed (Stoner and Greening, 1984). Similar observation was found in the present study. Although preference of the associated fauna appears highly variable, it is clear that the faunal species composition is strongly influenced by the size and composition of the clumps of seaweed. The finely structured seaweed such as *Halimeda* sp. holds large sediments (Castro and Huber, 2003) and provides suitable habitat for diversified fauna with high density and supported sediment-dwelling polychaetes in maxima. Whereas the coarse and rough nature of *Padina* sp. with its flat, fan-shaped physiology of the thallus and with little sediment,support the colonization of *Amphipod* and *Polychaeta* (Sarma and Ganapathi, 1968) but the polychaetes in this study were found to be weakly associated with this seaweed. Finely structured algae support more animals than coarsely structured seaweeds and epifauna are not host-specific (Taylor and Cole, 1994). But in this study, the finely structured *Liagora* sp. which is mucilaginous and has calcareous deposits on it didn't support more organisms. Isolated and scattered distribution was found for *Liagora* sp. in this area which

maintained low diversity. *Halimeda* sp. showed patchy distribution with sediment deposition supported high species diversity. In the intertidal zone where problems of desiccation, and high illumination persist the patchy distribution of different seaweed should necessarily be considered as favorable habitat (Roberts and Poore, 2005).

Seaweed epifaunal composition may also be blurred due to the obligate opportunistic nature of a lot of the associated macrofaunal species. The survival of some of these species such as flying insects that were blown offshore and landed on the floating seaweeds, and juvenile fish that need shelter from larger predators depends on the food, shelter, and attachment space offered by the seaweeds. The seaweed-associated fauna, therefore, takes advantage of the presence of all alternative habitats in the intertidal environment, regardless of the seaweed composition.

There is documentation that different macrophytes support different assemblages of mobile epifauna (Cacabelos et al., 2010 and references therein), and this may be due to several biological factors such as life cycles, algal structure, presence of algal epiphytes (Dawes et al., 1998), habitat complexity (Buschbaum et al., 2006), chemical defenses, or physical factors (e.g., wave

exposure or tidal height). But in our short-duration study, morphological variation and their surface area among the seaweeds could be the key factors for supporting the epifaunal assemblages.

The vivid composition of copepods, amphipods, polychaetes, gastropods, foraminifera and shrimp and the meager quantity of isopods, mollusks, bivalves recorded in this study area could be due to their appendages/ setae which help them to hold the seaweeds blades. *Halimeda* sp. exhibited high concentrations of meiofauna such as copepods, nematodes, and polychaetes. In the case of other seaweed, i.e. *Padina* sp. it was noticed that the polychaetes are nil or very less and showed a high concentration of nematodes and copepods so also other crustaceans. The seaweed i.e. *Halimeda* sp. and *Padina* sp. exhibited almost similar concentrations of copepods and nematodes during the study period. Further, the seaweed *Liagora* sp. exhibited high numbers of copepods and a very low number of polychaetes and nematodes.

Copepods were the most abundant group in the three habitats accounting for 36% of the total meiofauna. Nematodes and foraminiferans (16% each) were the second most abundant group followed bypolychaetes and other crustaceans with 14% and 10%, respectively. Cluster Analysis revealed no significant differences between seaweed habitats for a number of species whereas, the number of individuals and diversity varied across the habitats, inconsistently over time and at the study site. In general, the number of individuals was larger in *Halimeda* sp. compared to the other two macroalgae showing a peak of abundance in the morphologically different seaweeds.

Based on these results it has been concluded that wherever there is a substrate for colonization there is a scope for species heterogeneity. Similarly, the meiofauna availability suggests that the conditions are almost favorable for the development of the community on the entire rocky coast with seaweed environment. The associated seaweed epifauna found in this work is similar to other works carried out in India (Sarma and Ganpathi, 1968) and elsewhere like New Zealand (Taylor and Cole, 1994), Spain (Cacabelos et al., 2010), Australia (Roberts and Poore, 2005) California (Bracken et al., 2007) and Canada (Schmidt and Scheibling, 2006). Habitat selection

by epifauna is determined by structural and morphological characteristics of the algal species, rather than the amount of habitable/surface area available as found in this study for colonization (Schmidt and Scheibling, 2006) as suggested earlier was observed in this study.

Finely structured algae support more animals than coarsely structured seaweeds and epifauna are not host-specific (Taylor and Cole, 1994) but it was not so in the present study. Diverse assemblages of invertebrates play a major role in mediating the growth of seaweeds (foundation species) by utilizing nitrogen excreted by the invertebrate taxa living within its filaments (Bracken et al., 2007).

With numerous complex branches stacked like the coins, *Halimeda* sp. supported the maximum number of meiofauna. Finely structured *Halimeda* sp. forms large sediments (Castro and Huber, 2003) and supported sediment-dwelling polychaetes in maxima. But in the case of *Liagora* sp. the plant is very small and the surface area of the thallus is mucilaginous and with calcareous deposits which may not be useful for the attachment and thereby a considerable decrease in number of epifauna was found even though it is finely structured. The coarse and rough nature of *Padina* sp. with its flat, fan-shaped physiology of the thallus and with little sediment was found to be suitable for colonization of Amphipoda and Polychaeta (Sarma and Ganpathi, 1968) but it was not so in this study.

Halimeda sp. which retains a lot of sediments on the thallus provided a suitable habitat for diversified fauna in this study. It showed that the structure of algae influences epifauna in many ways including the availability of food, refuge from predators, protection from wave action, habitat formation, and adverse environmental conditions. The quality and quantity of epiphytic load also play an important role in increasing the structural complexity of the habitat. Although the structure of seaweed might play an important role, other factors need to be taken into consideration and further investigation is necessary.

The composition and density of epifauna are influenced by many factors of which one of the important factors is the sediment retention capacity of the alga as

observed in this study has been reported earlier (Sarma and Ganapathi, 1968). The epifauna assemblage as found in this study has been reported earlier (Sarma and Ganapathi, 1968; Taylor and Cole, 1994; Cacabelos et al., 2010; Roberts and Poore, 2005; Bracken et al., 2007; Schmidt and Scheibling, 2006). Despite the low specificity of the epifaunal assemblages by the host plant, the abundance and distribution of animals among the seaweeds suggest the presence of certain mechanisms of host selection, which are probably different for each species and even for each developmental stage within a species. The morphology and complexity of macroalgae might also be important factors in shaping the structure of these assemblages and determining the habitat choice (Schmidt and Scheibling, 2006; Cacabelos et al., 2010). Since the availability of different species at different times of the year, the dominance of particular species may vary according to seasonal changes.

Summary and conclusion

The main objective of this study was to assess the importance of the morphologically distinct seaweed species in structuring the species composition, density, and diversity of the seaweed-associated macro and meiofauna. Comparing the overall study area it has been found that the seaweed *Halimeda* sp. and *Padina* sp. supported more number of related epifauna than the *Liagora* sp. The degree of host-plant specificity will, moreover, determine the local impact of the invasion of the epifaunal assemblages. Moreover, finely structured seaweeds support fewer animals than coarsely structured seaweeds. The assemblages of epifauna were distinct for different seaweed, but the individual epifaunal taxa were generally not strongly host-specific, with most occurring on more than one algal species. It was observed that most of the epifauna have a weak relationship with their host plant

References

Allan S. & Greening, H. (1984). Geographic variation in the macro fauna associated of pelagic Sargassum and some Biogeography implications. Mar. Eco. Prog. Ser. 20:184-192.

Bracken, M.E.S., Dorantes, C.A.G. & Stachowicz, J.J. (2007). Whole community mutualism: Associated invertebrates facilitate a dominant habitat-forming seaweed. Ecology 88(9):2211-2219.

Buschbaum, C., Chapman, A. & Saier, B. (2006). How an introduced seaweed can affect epibiota diversity in different coastal systems. Mar. Biol. 148:743-754.

Cacabelos, E., Olabarria, C., Incera, M. & Troncoso, J.S. (2010). Effects of habitat structure and tidal height on epifaunal assemblages associated with macroalgae. Estuar. Coast. Shelf Sci. 89:43-52.

Castro, P. & Huber, M.E. (2003). Marine Biology. The McGraw Hill Companies, 4th ed. pp. 96-114.

Dayton, P.K. (1971). Competition, disturbance and community organization: The provision and subsequent utilization of space in rocky intertidal community. Ecol. Monogr. 41:351-389.

Dhargalkar, V.K. & Kavlekar, D.P. (2004). *Seaweeds: A field Manual*, X.N. Verlecar and V. Rathod, Eds. NIO, Dona Paula, Goa.

Fauchald, K. (1977). The Polychaete Worms Definitions and Keys to the Orders, Families and Genera. Natural History Museum of Los Angeles County, Science Series 28:1-88.

Kaliaperumal, N. & Kalimuthu, S. (1997). Seaweeds and its potential exploitation in India. Seaweed Res. Utiln. 19(1&2):33-40.

Krishnamurthy, V. & Untawale, A.G. (1985). Marine Plants. Seaweed Resource Utilization. Assoc. Madras. pp. 1-344.

Rao, U.M. (2000). Some Marine Algae from Andaman and Nicobar Island. Phykos. 39:85–99.

Rao, U.M. (1987). Key for identification of Economically Important Seaweeds, Seaweed Research and Utilization in India. CMFRI Bulletin 41:19-25.

Roberts, D.A. & Poore, A.G.B. (2005). Habitat configuration affects colonization of epifauna in marine algal bed. Biol. Conserv. 127:18-26.

Sarma, A.L.N. & Ganpathi, P.N. (1968). Faunal association of algae in the intertidal region of Visakhapatnam. Department of Zoology, Andhra University.

Schmidt, A.L. & Scheibling, R.E. (2006). A comparison of epifauna and epiphytes on native kelps *(Laminaria* sp.) and an invasive alga *(Codiim fragile* ssp. *Tomentosoides)* in Nova Scotia, Canada, Bot. Mar. 49:315-330.

Taylor, R.B. & Cle, R.G. (1994). Mobile epifauna on subtidal brown seaweeds in northeastern New Zealand, Mar. Ecol. Prog. Ser. 115:271-282.

Untawale, A.G. & Agadi, V.V. (1981). Distribution of marine algae in the littoral zone of Karnataka coast. In: *Marine Plants*, Krishnamurthy, V. and Untawale, A.G., Eds. Seaweed Resource Utilization Association, Madras, India, pp. 35-42..