Article

Epifaunal assemblage on morphologically distinct intertidal seaweeds of Kodiyaghat (South Andaman), India

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Abstract
Benthic macroalgae termed seaweed occupy coastal environments primarily on rocky intertidal areas. However, it has significant role by adding spatial complexity to the substratum and alter accessibility to other faunal and floral community. The studies of potential benefits of seaweeds have encouraged extensively yielding industrial, medicinal, pharmaceutical and cosmetic products. The present study deals with the quantitative distribution of epifaunal community associated with seaweeds of South Andaman and the influence of conspicuous morphology of seaweed on the assemblage of epifauna were compared. *Galaxura* sp. and *Halimeda tuna* supported higher faunal density than other seaweeds, with the respective mean density of 139.2 and 104.5 nos. per 100g of algal wet weight. *Sargassum duplicatum* held the lowest epifaunal density. *Arthropoda* was the major group found in this study, dominated by the *Amphipoda* (35.1%), *Mysida* (19.4%) and *Isopoda* (2.8%) followed by *Annelida* (20.1%) and *Mollusca* (12%). The result indicated that the distribution and abundance of epifauna differ based on the structural morphology among macroalgal species which forms suitable habitat for these organisms. The present study suggests that the sediment retention capacity of weeds might play an important role on the assemblage of epifaunal community.

Keywords Andaman Islands; epifauna; seaweed; *Galaxura* sp.; *Halimeda tuna*; sedimentation; India.

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1 Introduction

Algae are the primary producers of ocean and form the base of marine food chain (Sridhar et al., 2006; Saravanakumar et al., 2008). They include unicellular phytoplankton (Folkowski and Knoll, 2007; Paerl and Justić, 2011) to the giant multicellular macrophytes (Castro and Huber, 2003). Seaweed as a benthic primary producer (Kaladharan and Kandan, 1997; Charpy-Roubaud and Sournia, 1990; Howarth and Marino, 2006; van Dam et al., 2008) occupy significant role in many coastal environment particularly on rocky intertidal areas. Since they need a substratum for attachment, the rocky intertidal areas are more favorable for seaweed growth (Mantri, 2005). Generally, in such habitats the most limiting factor for benthic organisms is space (Dayton, 1971). Also, they subject to traumatic effects of high light intensity, temperature, desiccation and wave action. In such stressful environment some marine organisms can act as foundation species, thereby, mounting the substrate heterogeneity by increase the area available for settlement and provide refuges against predators and unfavorable environmental conditions (Monteiro et al., 2002). The community structure of most benthic marine systems are reliant on the physical structure provided by foundation species such as kelps (Graham, 2004), mangroves (Ellison et al., 1996), and seagrass patches (Jayabarathi et al., 2012). They harbor diverse assemblages of associated fauna (Bracken et al., 2007). Marine macroalgae serve as both primary space holder for benthic communities which competes for resources such as space, as well as secondary substratum, acting as a biological structure providing suitable habitat for the abundant and diverse organisms. Though, the potential resources of seaweeds in the Andaman and Nicobar Islands were established (Gopinathan and Panigrahy, 1983; Jagtap, 1992), the reports on the epifaunal organisms of macrophytes are lacking from Andaman Islands and recently received attention (Jayabarathi et al., 2012). In view of the fact the animal community structure has been believed to be governed by plant diversity (Parker et al., 2001). The present study emphasizes the influence of seaweed morphology in the assemblage of epifauna and their qualitative and quantitative distribution associated with seaweed.

2 Materials and Methods

This study was carried out in the intertidal region of Kodiyaghat (11°31.699’N, 92°43.432’E), South Andaman at low tide during the month of January and February (2011). This area is a rocky shore with numerous tidal pools, corals, seagrass patches and is mostly invaded by seaweeds (Fig. 1). Among which five morphologically different seaweeds were selected for the study. Seaweeds were randomly selected and each alga including the holdfast was gently cut from the substratum with a scraper and immediately transferred into a plastic bag filled with formalin (5%) to irritate the epifauna and cause them to release their grip. Replicate samples of seaweed were collected. In laboratory, each algal host was washed separately in a bucket containing freshwater and the epifauna was sieved through one mm (ASTM No.18) sieve. This procedure was carried out twice for each alga. The process removes over 99% of individuals and then the algae searched thoroughly under hand lens for any leftover animals. After washing, the seaweeds were blotted with paper to remove the water and allowed to dry in room for one hour and its wet weight was measured (Taylor and Cole, 1994). The epifauna retained on the sieve were collected and preserved with 4% formalin. The specimens were identified using standard literatures (Rao, 1987; Kaliaperumal et al., 1995; Dhargalkar and Kavlekar, 2004; Ponce et al., 1992; Fauchald, 1977; Fauvel, 1953; Barnard and Karaman, 1991; Brusca and Iverson, 1985; Rao, 2003). Their density was expressed as nos. per 100 g algal wet weight. One way Analysis of Varience (ANOVA) was used to access difference in abundance of epifaunal taxon for each seaweeds. The community composition on seaweeds examined based on Bray-Curtis similarity. For ANOVA and cluster analysis statistical package of PAST (PAleontological STatistics, Hammer et al., 2001) was used.

3 Results

Seaweeds adapt a variety of structure and show conspicuous difference in morphology. The intertidal rocky shores of Kodiyaghat region are invaded by many types of seaweed among which five different seaweeds were identified such as *Halimeda tuna*, *Padina gymnospora*, *Turbinaria ornata*, *Galaxaura* sp. and *Sargassum duplicatum*. Analysis of epifauana resulted that the seaweeds supported a mean abundance of 424.5 individuals. The abounding of epifauna include taxonomic groups like *Amphipoda* (35.1%), *Polychaeta* (20.1%), *Mysida* (19.4%), *Mollusca* (12%), *Brachyura* (5.1%), *Isopoda* (2.8%), *Pycnogonida* (2.4%) followed by other fauna such as *Echinodermata* (1.6%), *Nemertea* (0.7%) and *Sipuncula*(0.4%) were (Fig. 2). The mean density and composition of epifauna per 100g of each weed are given in the Table 1 and Fig. 3 respectively.

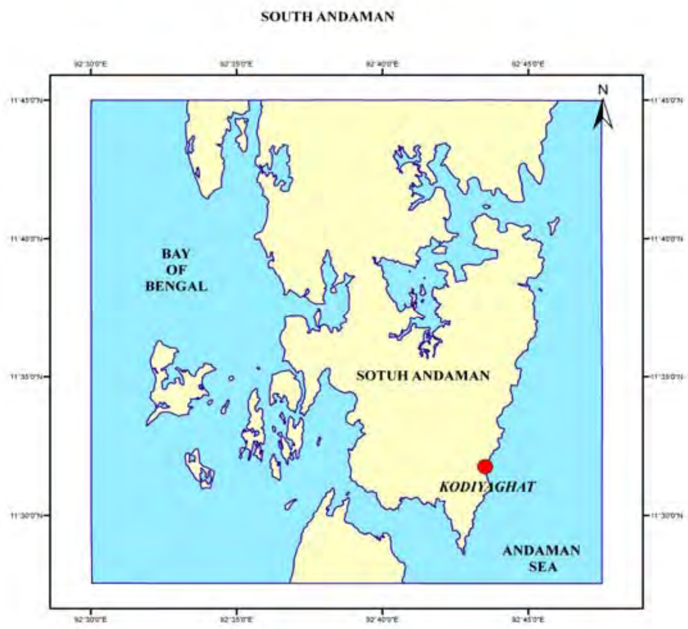

Fig. 1 Map showing the study area.

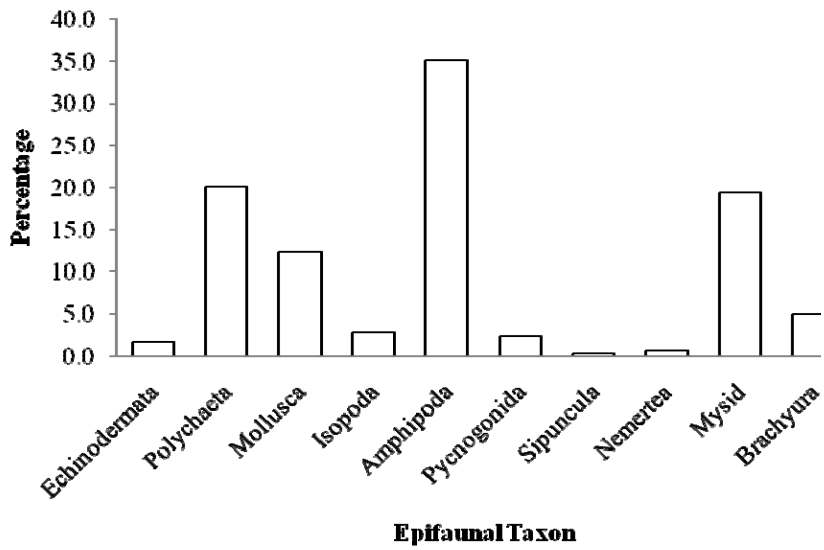

Fig. 2 Percentage composition of total epifaunal taxon.

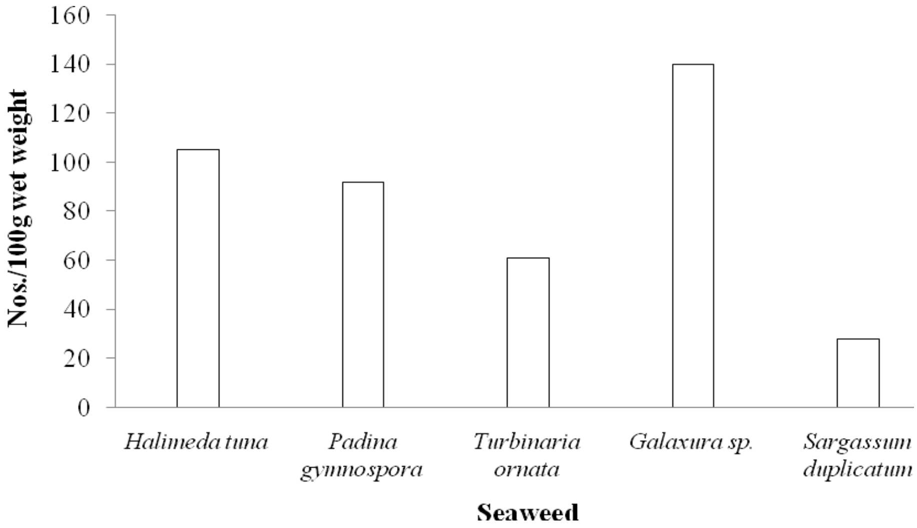

Fig. 3 Mean density of epifauna on seaweed species.

Table 1 Mean and Standard Deviation [mean±SD] of epifaunal assemlage on seaweeds.

No.	Epifaunal Taxa/Seaweed	*Halimeda tuna*	*Padina gymnospora*	*Turbinaria ornata*	*Galaxura sp.*	*Sargassum duplicatum*
1	*Echinodermata*	7±5.7	-	-	-	-
2	*Polychaeta*	31.5±4.9	22.5±4.9	8.5±6.4	20±1.4	3±2.8
3	*Gastropoda*	22.5±10.6	8.5±2.1	10±2.8	5.5±0.7	6±2.8
4	*Isopoda*	2±1.4	2±0	5±5.7	0.5±0.7	2.5±0.7
5	*Amphipoda*	18.5±0.7	29.5±6.4	27.5±24.7	67±1.4	6.5±0.7
6	*Pycnogonida*	10±5.7	-	-	-	-
7	*Sipuncula*	1.5±2.1	-	-	-	-
8	*Nemertea*	2±1.4	-	-	1±1.4	-
9	*Mysida*	3±0.0	20±4.2	7±1.4	43±2.8	9.5±0.7
10	*Brachyura*	6.5±2.1	9±1.4	3±4.2	2.5±3.5	0.5±0.7
	Total	104.5±34.6	91.5±19.1	61±45.3	139.2±12.0	28±8.5

- : No Occurrence

Out of all five seaweeds, *Galaxura* sp. and *Halimeda tuna* supported higher faunal density, with respective mean density of 139.2 ± 12.0 and 104.5 ± 34.6 nos./100 g of algae wet weight [mean ± SD] (Table 1). *Sargassum duplicatum* upheld lowest epifaunal density. Significant difference in the epifaunal composition between algae was found ($p<0.05$ One-way ANOVA). Bray-Curtis similarity for abundance of fauna on each weed showed that seaweeds such as *Galaxaura* sp., *Halimeda tuna* and *Padina gymnospora* with more associated fauna formed a cluster. Whereas, other two seaweeds such as *Sargassum duplicatum* and *Turbinaria ornate* with low number of associated fauna formed a separate cluster (Fig. 4). *Galaxaura* sp. has calcified branches regular to irregular and calcification absent at nodes. They are cylindrical profusely branched bearing short acute alternate branches. The animals belonging to 7 major groups were found to be associated with the *Galaxaura*. Amphipods were found to be 67 ± 1.4 per 100 g weed, which contributed half of the total bulk of faunal density. *Mysida* and *Polychaeta* were next dominating groups with density of 43 ± 2.8 and 20 ± 1.4 per 100g respectively. Isopoda (0.5/100g) encountered very less in contrast to other seaweeds. *Halimeda tuna* is characterized by a thallus consisting of numerous segments with deposits of calcium carbonate. Hence, they are known as calcareous green alga. It is one of the main sediment forming organisms on most reefs which supported diversified fauna with high density. Among the associated fauna, *Polychaeta* (31.5 ± 4.9) constituted maximum density, followed by *Gastropoda*, *Amphipoda* and *Pycnogonida* with 22.5 ± 10.6, 18.5 ± 0.7 and 10 ± 5.7 per 100g respectively. Few taxa such as *Echinodermata*, *Sipuncula* and *Nemertea* (*Baseodiscus* sp.) were found to be present only on *Halimeda tuna*. Among the echinoderms species such as *Echinometra* sp. and *Ophiothrix* sp. were conspicuous. The broad leathery *Padina gymnospora* harbors an average total of 91.5 ± 19.1 individuals per 100g among which *Amphipoda*, *Polychaeta* and *Mysida* were dominant taxa. *Padina gymnospora* harbor abundant amphipods (29.5/100g) followed by *Turbinaria ornata* (27.5/100g). *Turbinaria ornata* are characteristically cone shaped, generously branched and are attached to the substratum by branching heptera. In *Turbinaria ornata g*astropods (10/100g) were second dominant followed by *Polychaeta* (8.5/100 g). *Sargassum duplicatum* harbor least number of organisms when compared with the all other seaweeds (Fig. 3). An average total of 28 ± 8.5 per 100 g of algae were found of which mysids, amphipods and isopods showed abundance.

Table 2 Index of faunal assemblage on macroalgae from previous studies.

Sl. no.	Author	Area	Macroalgae	Composition of Epifauna
1.	Present study	South Andaman, India	*Halimeda tuna*, *Padina gymnospora*, *Galaxaura sp.*, *Turbinaria ornate* and *Sargassum duplicatum*	An average total of 424.5 individuals encountered with abundance order of *Amphipoda* (35.1%), *Polychaeta* (20.1%), *Mysida* (19.4%) and *Mollusca* (12%) *Galaxaura* sp. harboured abundant fauna.
2.	Cacabelos et al. (2010)	Galician coast, NW Spain	*Laminaria ochroleuca* and *Sargassum muticum*	*Laminaria ochroleuca* (80% of the total number of individuals) polychaetes and gastropods were the dominant groups. *Sargassum muticum* (70%) amphipods and isopods were dominant groups.
3.	Bracken et al. (2007)	Northern California, USA	*Cladophora columbiana*	Seven different animal phyla with dominant amphipods, polychaete, and insect larvae (179 .7 individuals/g).
4.	Schmidt and Scheibling (2006)	Nova Scotia, Canada	*Codium fragile* ssp. *tomentosoides*, *Laminaria longicruris* and *L. digitata*	*Codium* (amphipods and harpacticoid copepods were abundant) *Laminaria* (greater density of gastropods and asteroids).
5.	Taylor and Cole (1994)	Northeastern New Zealand	Brown Seaweed (Phaeophyceae) *Carpophyllum plumosum* var. *capillifolium and Cystophora retroflexa*	Amphipods and isopods were the most abundant animals (2000 individuals per algal wet weight).
6.	Sarma and Ganapathi (1968)	Visakhapatnam, India	*Ulva fasciata*, *Sargassum sp.*, *Chaetomorpha antennina*, *Caulerpa taxifolia*, *C. racemosa*, *Dictyota dichotoma*, *Padina tetrastromatica*, *Hypnea musciformis*, *Gracilaria corticata*, *Amphiroa fragilissima* and *Liagora erecta*	Seaweed harbour enormous micro and macro fauna with diverse group of *Mollusca*, *Foraminifera*, *Polychaeta*, *Nematoda*, *Amphipoda* and *Isopoda*.

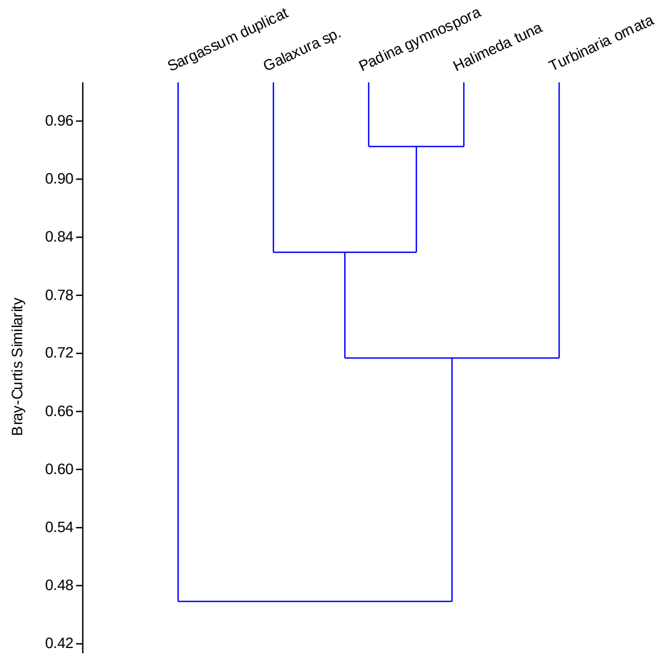

Fig. 4 Dendrogram of Cluster analysis of seaweeds based on epifaunal composition.

4 Discussion and Conclusions

Seaweeds in India are abundant along the southeastern and northwestern coast (Rao and Mantri, 2006). They are well known for their chemical properties and nutritional values. They have been successfully utilized by many countries of world as food, fodder, fertilizer, protein, iodine, vitamins and antibiotics. They are only source for the production of phycocolloids such as agar, carrageenan and sodium alginate. However, in India, seaweeds are exploited exclusively for the production of agar and sodium alginate (Kaliaperumal and Kalimuthu, 1997). Although, the study area is dominated by different types of macroalgae, there is no information available on Seaweed epifauna from South Andaman. Hence, present study was undertaken to gain information about epifauna and its abundance in relation with the structured morphology of different seaweeds.

In this study, seven phyla associated with the seaweeds namely *Arthropoda*, *Annelida*, *Mollusca*, *Echinodermata*, *Nemertea*, *Sipuncula* and *Pycnogonida* have been recorded. The arthropods were major groups, represented by the amphipod families *Ampithoidae* (*Ampithoe* sp.) and *Ischyroceridae* and Isopod genera comprised *Cirolana* sp., *Excirolana* sp., *Sphaeroma* sp., *Exosphaeroma* sp. and *Paracerceis* sp. followed by *Annelida* consisted *Nereis* sp., *Syllis* sp. and *Serpulidae* and Molluscan families such as *Littorinidae*, *Cerithiidae*, *Epitoniidae*, *Buccinidae*, *Columbellidae*, *Potamididae*, *Neritidae* and *Mitridae.* The epifauna found in this study was similar to earlier reports (Sarma and Ganapathi, 1972; Taylor and Cole, 1994; Cacabelos et al., 2010; Roberts and Poore, 2005; Bracken et al., 2007; Schmidt and Scheibling, 2006). In general, these reports also showed frequent occurrence of few groups such *Amphipoda*, *Isopoda*, *Polychaeta* and *Mollusca* in seaweeds (Table 2).

The study showed that a stronger impact of morphology of seaweed on the epifaunal taxa. *Galaxura* sp. supported maximum density of epifauna whereas the diversity was greater in *Halimeda tuna* than other weeds which indicated that the shape and structural complexity of macroalgae are important factors in determining the abundance of different taxa which provides suitable habitat for the organism. *Galaxaura* sp. with numerous cylindrical branches supported maximum number of Amphipoda. The present study indicated that habitat selection by epifauna is determined by structural and morphological characteristics of the algal species, rather than the amount of habitable area available for colonization (Schmidt and Scheibling, 2006). The isopods and amphipods with powerful grasping appendages could hold firmly on the cylindrical filaments of weeds (Sarma and Ganapathi, 1972; Caine, 1977). Though the cylindrically branched *Galaxura* harbor abundant amphipods, the isopods were least in the present study. Whereas finely structured *Halimeda tuna* holds large sediments (Castro and Huber, 2003) provides suitable habitat for diversified fauna with high density and supported sediment dwelling polychaetes in maximum. The coarse and rough nature of *Padina gymnospora* with its flat, fan shaped physiology of the thallus and with little sediment may be suitable for colonisation of *Amphipoda* and *Polychaeta* (Sarma and Ganapathi, 1972). Finely structured algae support more animals than coarsely structured seaweeds and epifauna are not host specifc (Taylor and Cole, 1994). Patchy landscapes maintain high species diversity and should necessarily be considered as favorable habitat (Roberts and Poore, 2005). *Sargassum duplicatum* supported least density of epifauna which may be due to its coarse structure and generously branched structure of plant. They grow on the exposed rock surface where very little sediment gets collected in the plant, could be the reason for the low abundance of fauna when compared with other weeds. Seaweeds may influence the assemblage of associated epifauna either directly, as hosts, or indirectly by modifying the biological and physical environment. The diverse assemblage of invertebrates plays a major role in mediating the growth of seaweeds by utilizing the nitrogen excreted by invertebrate taxa living within its filaments (Bracken et al., 2007).

The epifaunal assemblages associated with *Laminaria ochroleuca* and *Sagassum muticum* differed, but only differences in epifaunal densities were likely to be related to the structure of algae since all other variables did not clearly differ between the two algae (Cacabelos et al., 2010). But, in this study *Halimeda* sp. which holds lot of sediments on the thallus provided a suitable habitat for diversified fauna. The composition and density of phytal fauna is influenced by many factors of which one of the important factors is sediment retention capacity of the alga as observed in this study has been reported earlier (Sarma and Ganapathi, 1972). It shows that the structure of algae influences on epifauna in many ways including availability of food, refuge from predators, and protection from wave action, habitat formation and adverse environmental condition. The quality and quantity of epiphytic load may also play an important role by increasing the structural complexity of the habitat. Although structure might play an important role, other factors need to be taken into account. Apart from all these uses it act as a ecosystem basement (food chain) and marine habitat by support diverse assemblages of associated epifauna that provide tropic links between primary producers and predatory fishes. Consequently, understanding the role of seaweed dominated habitat is necessary and it should not be destroyed through human activities like harvesting of seaweeds from their natural habitats, coastal developments, recreational activities and beach cleaning activities can deplete valuable seaweeds from the coast.

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