International Journal of Zoology Studies
ISSN: 2455-7269
Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 3; Issue 1; January 2018; Page No. 145-153

Molluscan biodiversity (phytal fauna) of Thondi coast in Palk Bay, Southeast coast of India

[*1] Mohamed Meeran, [2] Abdul Khadar Jailani, [3] Kalyanasundaram Dhinamala, [4] Rajasingh Raveen, [5] Subramanian Arivoli, [6] Samuel Tennyson

[1] Department of Zoology, Hajee Karutha Rowther Howdia College, Uthamapalayam, Theni, Tamil Nadu, India
[2] Department of Chemistry, Hajee Karutha Rowther Howdia College, Uthamapalayam, Theni, Tamil Nadu, India
[3, 4, 6] Department of Zoology, Madras Christian College, Chennai, Tamil Nadu, India
[5] Department of Zoology, Thiruvalluvar University, Vellore, Tamil Nadu, India

Abstract
The Thondi coast of Palk Bay is one among the biospheres which is biologically rich and rated among the highly productive regions of the world. Its diversity is considered globally significant. However, the diversity of this area is poorly documented, especially that of molluscans associated with the seaweeds and sea grasses occurring here in great profusion. In the present investigation, eleven different seaweeds and four species of seagrasses were recorded; the highest molluscan species with its percentage contribution in both seaweeds and seagrasses were recorded as *Cerithedia cingulata* (49.40%), *Umbonium vestiarium* (16.09%), *Bullia belangeri* (14.05%), *Nassarius comptus* (1.98%) and *Babylonia zeylanica* (1.46%).

Keywords: seaweeds, seagrasses, molluscan biodiversity, phytal fauna, thondi coast

1. Introduction

Convention on Biological Diversity (CBD) defined biodiversity as the variability among the living organisms from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part. This includes diversity within species, between species and within ecosystems [1]. Among the various groups of organisms having rich diversity, molluscan species is one which includes organisms which live on, in, or near the seabed, also known as the benthic zone. They live in or near marine sedimentary environments, from tidal pools along the foreshore, out to the continental shelf and then down to the abyssal depths. Among benthos, the molluscans qualify most of the following requirement of an ideal indicator organism [2].
In the benthic environment, seaweeds and seagrass beds constitute important niches. Seaweed zones and seagrass beds are the conspicuous and widespread biotopes in the shallow marine environment. The faunal association with the plant communities have been receiving greater attention from various parts of the world only in recent years. The fauna associated with seaweeds and seagrasses are mainly to fulfil their needs, with regard to food, habitat, protection from predators, tidal currents and waves, and availability of oxygen for respiration [3]. Seaweeds enhances biodiversity. Many organisms restrict their movements to the vicinity of shelter and thus submerged vegetation can influence the distribution of marine organisms [4]. Macroalgae may provide shelter as well as profitable foraging sites for invertebrate feeders and omnivores, which predate on the associated epifauna [5].
Seagrasses act as "nurseries" and provide abundant shelter from predators and enhanced food supplies for juvenile finfish and shellfish; and direct grazing of seagrasses is of little importance in coastal food webs. These familiar paradigms concerning plant-animal interactions in seagrass meadows have recently been reassessed [5]. The relationship between habitat and fauna has been of long-standing interest in a variety of aquatic environments including seagrass beds [5]. A great deal of information is available on the molluscan species associated with seaweeds and sea grasses of temperate waters. A study of seaweeds and sea grasses in Thondi coast which form an ecological niche to diverse phytal fauna assumes significance from view point of protecting biodiversity here. Hence, this investigation will definitely add valid information to the present knowledge on the ecology and productivity of benthic ecosystem of Thondi coast, Palk Bay, Southeast coast of India.

2. Materials and methods

The present investigation was carried out in five different stations, *viz.*, Station 1: Vattanam (Lat. 9˚43’58.80”N; Long. 79˚00’59.58”E), Station 2: Thondi harbour (Lat. 9˚44’39.51”N; Long. 79˚01’23.89”E), Station 3: Back waters (Lat. 9˚43’53.35”N; Long. 79˚00’56.13”E), Station 4: Nambuthalai (Lat. 9˚40’57.08”N; Long. 78˚56’39.07”E) and Station 5: Soliyakudi (Lat. 9˚35’30.34”N; Long. 78˚55’42.25”E) located in the Thondi coastal waters, Palk Bay, Southeast coast of India (Figure 1) from January 2007 to December 2007 during the lowest neap tide periods. Seaweeds and seagrasses samples were collected from the intertidal region of Thondi coast. After hand picking, the weeds and grasses were washed thoroughly in fresh water a couple of times to remove the associated molluscan fauna. At the time of collection, the plants were detached with roots, rhizomes and leaves. In each station, five benthic samples were collected on a monthly basis. To estimate the abundance of seaweeds, seagrasses and their associated molluscan faunal components, a wooden quadrat ($1x1m^2$) was thrown at random on the seagrass beds and seaweeds. The seaweeds and seagrasses present within the quadrat were collected very carefully for separating the fauna associated with them. After collection, the samples were emptied onto a plastic tray [6, 7].

Prior to sampling, water samples were collected for estimating the water quality parameters, *viz*., temperature (˚C), salinity (ppt), Dissolved Oxygen (DO) (mL/L), alkalinity (mg/L) and pH. Temperature was measured using a standard celsius thermometer with accuracy of ±0.5˚C by standard method of FAO [8] and pH was recorded using an Elico LI 10 pH pen. Biological Oxygen Demand (BOD) (mg/L) and Chemical Oxygen Demand (COD) (mg/L) were estimated using the methods described by Strickland and Parsons [9]. The water lying above the seaweed and seagrass environment was collected in a plastic container and used for estimating the physical and chemical characteristics of the water. The sediment samples were shade dried and kept in sealed polythene bags for further analysis. The composition of sediment was assessed following the pipette method as proposed by Krumbein and Pettijohn [10]. The shade dried samples were passed through successive sieves of mesh sizes (2, 0.2, 0.02 and 0.002mm) in order to grade them in to coarse sand, silt, clay and fine sand respectively.

Sedimentary copper, iron, manganese and zinc were estimated following the standard methods of Watling [11]. The sediment samples were oven dried at 110˚C for 24 hours and was ground with the help of a pestle and mortar. These samples were digested with concentrated perchloric acid and nitric acid (1:3). The supernatant was analysed using the Inductively Coupled Plasma-Mass Spectrophotometer (ICP-MS) and the values were expressed in µg/g. The benthic fauna were separated following the procedures of Sarma and Ganapati [12] and identified. Data was pooled and subjected to further statistical analyses.

3. Results and discussion

The phytal-faunal association of the marine environment differed substantially both in density and species composition. This might be due to the influence of water bodies differing in origin, turbidity, temperature, salinity and differences in sediment granulometry. These factors show a continuous and irregular pattern of change making the marine environment unstable and unpredictable. Despite this, marine bodies are hospitable to benthic communities, which are able to cope with this harsh environment. The seaweeds recorded during the present study were *Ulva lactuca, Ulva reticulata, Grateloupia lithophila, Enteromorpha compressa, Enteromorpha intestinalis, Chaetomorpha linum, Chaetomorpha aerea, Hypnea musciformis, Hypnea valentiae* and *Gracillaria verrucosa* besides the seagrasses *viz*., *Halophila beccari*, *Halophila ovalis*, *Halodule pinnifolia* and *Cymodocea serrulata*. *Cerithedia cingulata* was found to be most abundant molluscan species constituting of the total number of organisms collected. *Umbonium vestiarium* came next followed by *Bullia belangeri*, *Nassarius comptus*, *Tectus mauritianus, Nassarius stolatus, Thais tissoti*, *Pyrene scripta, Tibia curta*, *Polinices pesoelephanti*, *Epitonium lamellosum, Anadara indica* and *Lucina eduntula*.

3.1 Physicochemical parameters

Rainfall in India is largely influenced by two monsoons, *viz*., southwest and northeast. Thondi experiences higher rainfall during the northeast monsoon [13] and the total rainfall recorded during the study period was 764.8mm. Higher rainfall during the monsoon season is in agreement with the observations made by earlier workers [14, 15]. In the present study, the average temperature of water remained around 30˚C in samples collected from all stations with a range of 29.1 to 31.3˚C (Figure 2A). Thus, the range of water temperature noticed in the study area was found to be highly conducive for the better survival and growth of aquatic organisms including invertebrates. In the coastal waters of east coast of peninsular India, the highest water temperature has been reported to occur during the summer months [16-18].

Satheesh and Wesley [19] reported that the seaweeds and seagrasses, being benthic forms are important indicators of quality of coastal waters reflecting temporal changes. These organisms directly integrate with the water column properties and respond to different kinds of environmental stresses. The most frequently cited abiotic factor controlling the distribution of seaweeds and seagrasses is the temperature and many workers have emphasized the importance of water temperature [20-24]. In the present study, several species of seaweeds and seagrasses were observed to occur in plenty during months of elevated water temperature. The major variable in marine environment is salinity and it varies in relation to season, river runoff, proximity to the coast and depth. Marine animals occurring in the near shore waters have to adapt themselves to variations in salinity. Thus, salinity is considered to be one of the basic and prime factors among the environmental variables in the marine environment. Salinity in the study area varied from 13.18 to 34.96ppt (Figure 2A) and are in agreement with reports of Ketchum [25], Jayaraman [26], Sulochana and Muniyandi [13] and Mohammed *et al*. [27] in different coastal habitats.

DO is known to function as an index of the balance existing between photosynthetic production of oxygen and utilization by community respiration. In the present study, DO concentration was low during summer and high during premonsoon months (Figure 2A). Humidity influences the evaporation rate, which in turn affects the salinity [13] in Palk Bay. The trend noticed in the present study is in conformity with the findings of Ketchum [25]. pH remained alkaline throughout the study period and varied from a minimum value of 7.8 during summer season to the maximum of 8.2 during premonsoon (Figure 2) in comparison to the average pH values in the Palk Bay (7.9) reported by Sulochana and Muniyandi [13], Krishnamurthy and Jeyaseelan [20] and Dwivedi and Varshney [22].

3.2 Heavy metals and sediment composition

Trace metals form an important abiotic component of marine ecosystem. These metals may associate with the sediment particles either by adsorption or by complexation, forming particle structure, and gradually sink with sediment or they may get released when mixed with sea water due to altered physicochemical environment [28]. These metals are persistent pollutants and are discharged constantly through industrial, municipal, domestic and agricultural effluents into the coastal environs in substantial amount. The possibility of these heavy metals affecting the non-target organism needs to be emphasized [29]. Trace metals are associated with colloidal and fine matter in suspension which resulted in lower concentration in sediment. Similar downstream minimum was observed by Palanichamy and Balasubramanian [30] in Palk Bay, who observed a twofold decrease and justified this kind of decrease mainly due to the draining of elements with the oxides of iron and manganese from the mouth region of the river to the sea by wave action.

With respect to the concentration of copper, significant seasonal fluctuations were noticed in all the stations and values differed significantly between the stations. The high concentration factors has been considered as the basis for their use as biological indicators of metal pollution and for taxonomical identification of the concentrating organisms and similar kind of observation was made by Mary *et al.* [31] at Tuticorin coast. As per other metals, the distribution of zinc marked significant seasonal variations and the values also significantly varied between the stations. In the case of manganese, significant seasonal fluctuations were noticed in its concentrations, and the values observed in the present study (Figure 2B) are in harmony with the observation of Mary *et al*. [31].

In many aquatic systems, nature of the substratum plays a significant role in the distribution and abundance of phytal faunal assemblages. In the present study, the sediment composition revealed differences in percentage of sand, silt and clay fractions. While the sand content varied significantly between the seasons, silt and clay contents varied only in relation to stations (Figure 2C).

3.3 Phytal fauna

As many as 76 species of macrofauna (molluscans) were identified from all the five stations. Gastropods were found to be the largest component in the collections with 42 species (55%). The abundance varied from 45 to 1974 individuals per square metre. The abundance was more in Station 1 when compared to other stations. The abundance varied in relation to season and was low during monsoon and high during the dry seasons. The total number of species estimated by various extrapolators varied from 76 to 89 species. Among the top 10 species, *Cerithedia cingulata* was found to be the most abundant species constituting 49.4% of the total number of organisms collected. *Umbonium vestiarium* followed next with 16.09% contribution accompanied by *Bullia belangeri* (14.05%) and *Nassarius comptus* (1.98%) (Figure 2D). All the other species contributed less than 1% of the total.

3.4 Diversity indices

In the present study, a marked seasonal variation in the Shannon diversity was noticed with the maximum diversity during the dry months of the year and less during the monsoon period. Such observations were reported by researchers [32] which is attributed to less human interference and undisturbed nature of the habitat besides availability of thick vegetation year round in particular *Enteromorpha compressa*, whereas in Stations 4 and 5, anthropogenic disturbances occurred and consequently vegetative cover was also less. BVSTEP was used to find out the most influential species. The routine indicated 14 out of the 76 species to be influential with a rank correlation value of 0.842 (Table 1). The diversity, richness and evenness were higher in Station 1 when compared to other Stations. The Shannon-Weiner diversity (H'log^2) varied in relation to season and also in relation to station within the range of 2.267 to 4.046 (Figure 3A). The Margalef's richness value (d) was in the range of 1.984 to 5.570 (Figure 3B) and Pielou's evenness (J') in the range of 0.847 to 0.974 (Figure 3C). The dominance index (D) behaved opposite to that of the diversity values and was in the range of 0.042 to 0.161. The dominance plot drawn for all the seasons also vouched safe for the above fact that the diversity was higher in Station 1 when compared to other Stations (Figure 4). The number of species recorded from various species of seaweeds and seagrasses varied from 25 to 68 (Table 2; Figure 5). The maximum number of species was recorded in the seaweed, *Enteromorpha compressa* and minimum in *Chaetomorpha aereae*. In seagrasses, it was in the range of 35 species for *Halophila ovalis* and 32 species for both *Halophila beccari* and *Cymodocea serrulata*.

The maximum diversity H'log^2 (6.021) was observed in *Enteromorpha compressa* and the minimum value (4.785) in *Grateloupia lithophila*. In seaweeds, the range was 6.021 to 4.785, whereas in seagrasses it was 4.934 (*Halophila ovalis*) to 4.786 (*Halophila beccari*). The maximum value of richness (d) (14.084) was observed in *Enteromorpha compressa* and the minimum (6.573) in *Chaetomorpha aereae*. In seagrasses, the range was 8.314 (*Halophila ovalis*) to 7.767 (*Halophila beccari*). The maximum value of (J') was (0.989) observed in *Enteromorpha compressa* and the minimum value (0.957) in *Halophila beccari* and in seaweeds, the range was 0.989 (*Enteromorpha compressa*) to 0.974 (*Chaetomorpha aereae*) and in seagrasses it was 0.966 (*Cymodocea serrulata*) to 0.957 (*Halophila beccari*). The maximum value of dominance (D) was observed in *Halophila beccari* (0.025) and the minimum in *Enteromorpha compressa* (0.007). In seaweeds, the range was 0.023 (*Chaetomorpha aereae*) to 0.007 (*Enteromorpha compressa*) whereas in seagrasses it was 0.025 (*Halophila beccari*) to 0.022 (*Cymodocea serrulata*). The maximum number of species and diversity found in *Enteromorpha compressa* could be due to its wide prevalence in the study area besides its availability throughout the year.

In the Caswell neutral model used to compare the observed diversity, with the expected, the V values varied in seaweeds from 12.535 (*Enteromorpha intestinalis*) to 1.559 (*Grateleupia lithophila*). In seagrasses, it was in the range of 6.335 (*Cymodocea serrulata)* to 1.827 (*Halophila beccari*). All showed that the observed diversity was more than expected (Table 2). Cluster analysis was employed to analyse the similarity between the Stations during various seasons. The Bray-Curtis similarity calculated varied from 3.51 to 78.31%. The minimum similarity was noticed between Stations 2 and 1 and the maximum among samples collected in Station 2. The cluster analysis showed 22 groups. In most instances, a particular station of one month got fused with the same station of another month. In few instances, a station formed a group with the nearby station only and not with a station lying apart. This showed gradual changes in species composition from Station 1 to Station 5. The Bray-Curtis similarity calculated for molluscan associated with 11 species of seaweeds and four species of seagrasses varied from 55.15 to 85.58% (Figure 6A).

The dendrogram derived showed three groups of which two groups were formed by seaweeds and one by seagrasses. The macrofauna associated with seagrasses *Halophila ovalis* and *Cymodocea serrulata* joined together to form the first group at 85.58% similarity. Macrofauna associated with seaweeds *Ulva reticulata* and *Gracilaria edulis* formed the second group at 84.13%. The third group was formed by macrofauna association with seaweeds *Ulva lactuca* and *Hypnea musciformis* at 78.26% similarity. The large group formed by macrofauna (molluscan) associated with seagrasses was quite distinct in the dendrogram (Figure 6B) and also in Multi Dimensional Scaling (MDS). The stress value (0.12) of MDS clearly showed the goodness of fit (Figure 7A & 7D). The dominance plot for the macrofauna associated with the seaweeds and seagrasses were drawn as such and *Enteromorpha compressa* showed maximum diversity and *Cymodocea serrulata* the minimum. Dominance Diversity Index Scaling (DOMDIS) test was done to compare the significant differences between the distances of the curves (seaweeds and seagrasses) (Figure 7B). Analysis of similarities (ANOSIM) showed the R value to range between -0.08 and +0.16. However, the global R value (0.147) was not statistically significant (26.8%) (Figure 7C). In Similarity percentage (SIMPER), analysis was done to study the assemblage of macrofaunal molluscan species associated with the seaweeds and seagrasses, and the average similarity among species of seaweeds was 70.05% and among seagrasses it was 80.87%. The average dissimilarity in the assemblage of molluscans between seaweeds and seagrasses was 33.56% (Table 3). The assemblage of molluscans with respect to seaweeds were *Cerithedia cingulata, Umbonium vestiarium, Bullia belangeri, Nassarius comptus* and *Babylonia zeylanica*. The molluscan assemblage of seagrasses were *Umbonium vestiarium, Bullia belangeri, Prionospio pinnata, Tectus fenestratus* and *Eunice indica*.

Among the 11 species of seaweeds and four species of seagrasses studied, *Enteromorpha compressa* was observed to support the highest abundance of phytal fauna and highest diversity. Available literature show marked variation in phytal fauna. Sarma and Ganapati [12] reported that the phytal fauna associated with *Gracilaria corticata* was mostly of molluscs and foraminiferans. In the present study, gastropods and bivalves occurred abundantly in order. Changes in phytal fauna associated with seaweeds appeared to be a common phenomenon in tropical waters with marked seasonal variations. Notably, *Hypnea musciformis* and *Gracillaria verrucosa* have been reported to support higher number of associated animals due to their branched and bushy nature [33]. Weiser [34] also reported that the composition and density of phytal fauna varied from alga to alga depending on the shape and its ecological distribution on the shore. Sarma and Ganapati [12] reported that the association of phytal fauna with seaweeds depended on the morphology of the algae. Species of *Chaetomorpha* are usually filamentous, whereas *Enteromorpha compressa* has foliaceous structure and *Gracilaria* species a cushion-like structure. Warwick [35] also commented that variation in faunal abundance among the algae could be related to the texture and coarseness of the algae. Thus structure-wise, *Hypnea musciformis* and *Gracillaria verrucosa* could be expected to support higher population density of phytal fauna than the other green algae. However, in the present study *Enteromorpha compressa* occupied the first rank with respect to the population density and diversity of molluscan phytal fauna. The reason could be its wide prevalence in the study area besides its availability throughout the year. This sporadic occurrence of this species throughout all the stations have also been responsible for comparatively lower annual mean population of molluscan phytal fauna recorded in *Enteromorpha compressa*.

Another important observation made in the present study was that molluscs contributed the highest percentage of phytal fauna in all the 11 seaweeds and four seagrasses occurring in all the five stations. However, the least contributing species varied markedly among the 11 seaweeds and four seagrasses investigated. Gastropods found to be associated with the seaweeds are scavengers or detritus feeders and few were algivores. Joseph [36], Barkman [37], Fuse [38] and Yogamoorthy [33] reported that gastropods seemed to prefer macroalgae for depositing their eggs to avoid predation of them and destruction by other physical factors. Sarma and Ganapati [12] reported that phytal fauna associated with *Grateloupia corticata* occurring in Visakhapatnam coast was mostly molluscs. Joseph [36] reported the abundance of *Modiolus striatus* on marine seaweeds occurring in Rameswaram port. The association of *Musculus strigatus* with *Caulerpa taxifolia* and *Caulerpa racemosa* was reported by Sarma and Ganapati [12] at Visakhapatnam.

In the marine environment, few habitats have been identified as rich in biodiversity. These habitats include mangroves, corals, seaweeds, seagrasses and rocks. While molluscan biodiversity associated with all the other habitats have been covered extensively, the same was not true with respect to seaweeds and seagrasses in the present study, thereby provoking biodiversity investigations to be undertaken in all the seaweed and seagrass rich areas on a priority basis. The entire area occupied by the above plants in the Palk Bay has to be covered to create a database on phytal fauna of Palk Bay. Such information will go a long way in evolving strategies for protection of biodiversity and conservation of resources.

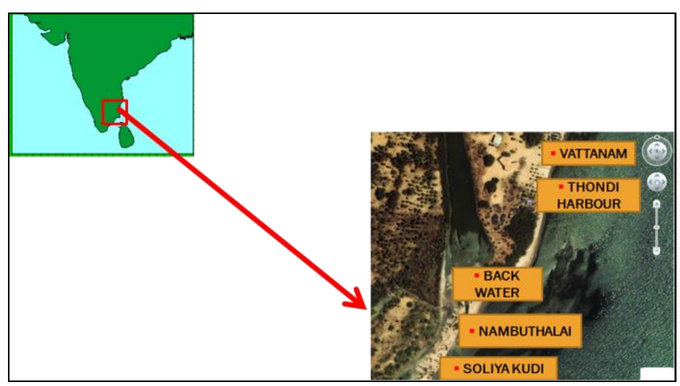

Fig 1: Study area

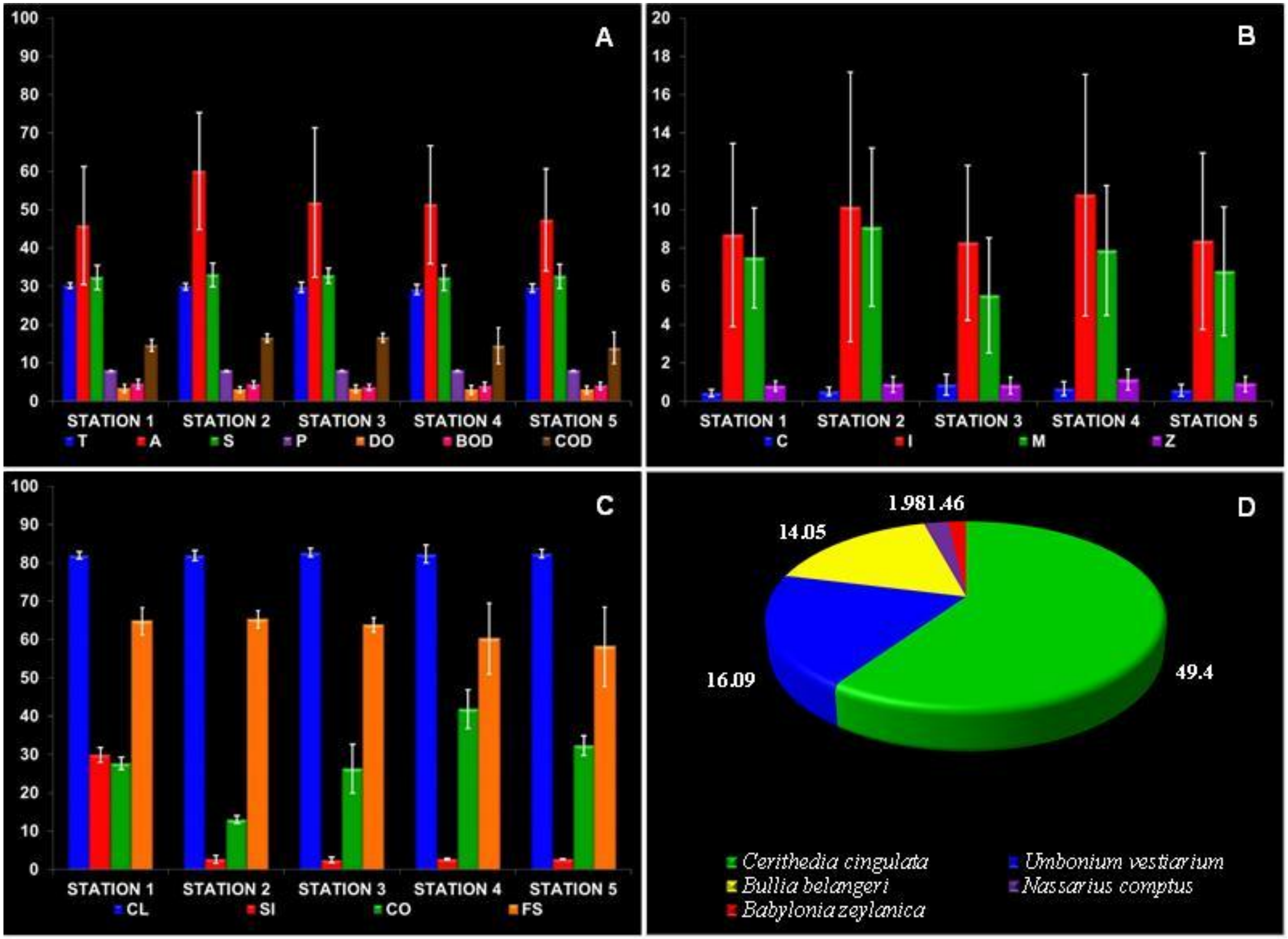

Fig 2: Parameters of five stations of Thondi coast.

A: Physicochemical = T: Temperature; A: Alkalinity; S: Salinity; P: pH; DO: Dissolved oxygen; BOD: Biological oxygen demand; and COD: Chemical oxygen demand.

B: Heavy metal = C: Copper; I: Iron; M: Manganese; and Z: Zinc.

C: Sediment composition = CL: Clay; SI: Silt; CO: Coarse; and FS: Fine sand.

D: Dominant species with contribution.

Table 1: BVSTEP

S. No.	Name of species	Group
1.	*Tectus mauritianus*	Gastropod
2.	*Nassarius stolatus*	
3.	*Thais tissoti*	
4.	*Pyrene scripta*	
5.	*Tibia curta*	
6.	*Polinices pesoelephanti*	
7.	*Epitonium lamellosum*	
8.	*Anadara indica*	Bivalve
9.	*Lucina eduntula*	

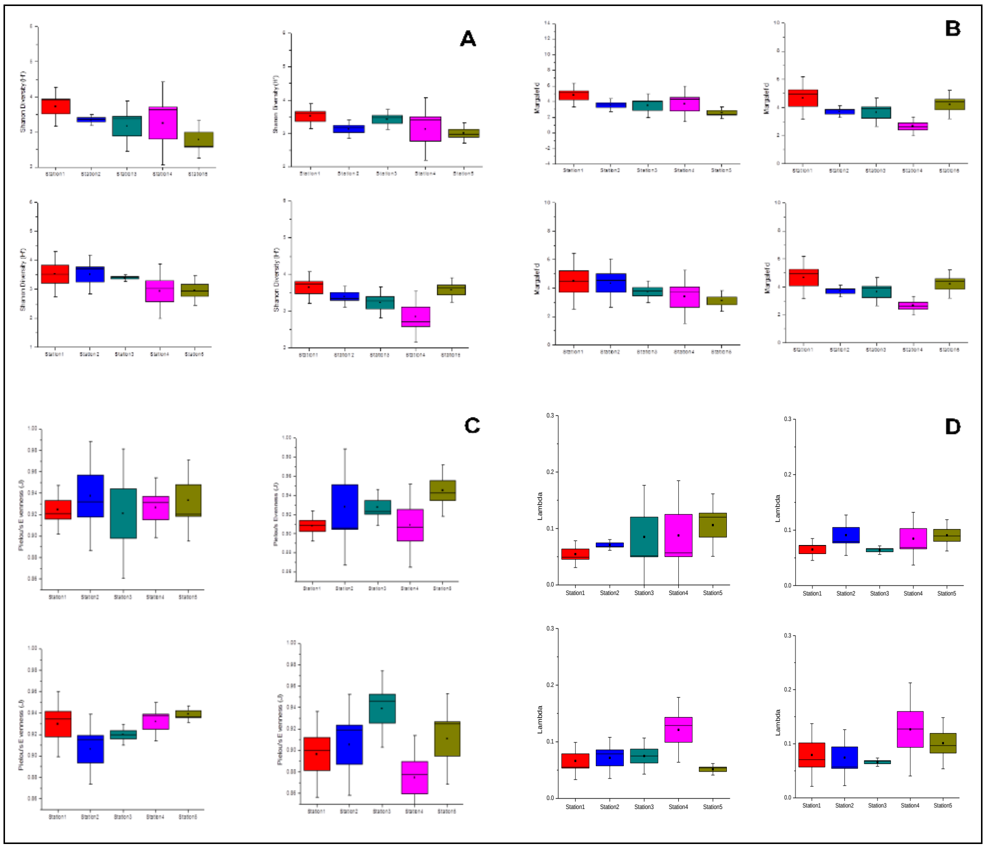

Fig 3: A: Shannon diversity (H′); **B**: Margalef richness (d); **C**: Pielou's eveness (J); and **D**: Lambda

Table 2: Diversity of associated macro fauna (molluscans) in seaweed and seagrasses

Species	S	d (marg)	J' (piol)	H' (log2) (s)	Lambda'	V (N.D.)
Enteromorpha compressa	68	14.084	0.989	6.021	0.007	4.687
Enteromorpha intestinalis	30	7.670	0.977	4.798	0.017	12.535
Chaetomorpha aerea	25	6.573	0.974	4.527	0.023	3.768
Chaetomorpha linum	37	9.124	0.980	5.107	0.013	9.783
Ulva lactuca	33	8.209	0.981	4.951	0.015	5.767
Ulva reticulata	39	9.382	0.985	5.206	0.012	8.338
Grateloupia lithophila	30	7.705	0.975	4.785	0.018	1.558
Hypnea valentiae	35	8.629	0.980	5.028	0.014	4.179
Hypnea musciformis	31	7.873	0.978	4.846	0.016	5.390
Gracillaria verrucosa	36	8.889	0.977	5.053	0.014	10.444
Gracillaria edulis	35	8.708	0.981	5.032	0.013	16.468
Halophila beccari	32	7.767	0.957	4.786	0.025	1.827
Halophila ovalis	35	8.314	0.962	4.934	0.022	4.728
Halodule pinnifolia	33	7.967	0.958	4.837	0.024	4.371
Cymodocea serrulata	32	7.794	0.966	4.832	0.022	6.335

S: Diversity indices; d (marg): Margalef richness; J' (piol): Pielou's eveness; H' (log2) (s): Shanon diversity; V (N.D.): V statistics

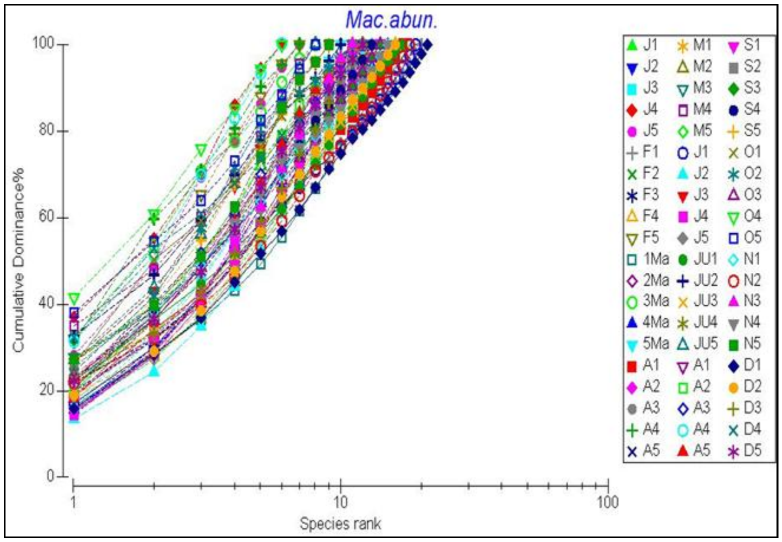

Fig 4: Over all k-dominance plot

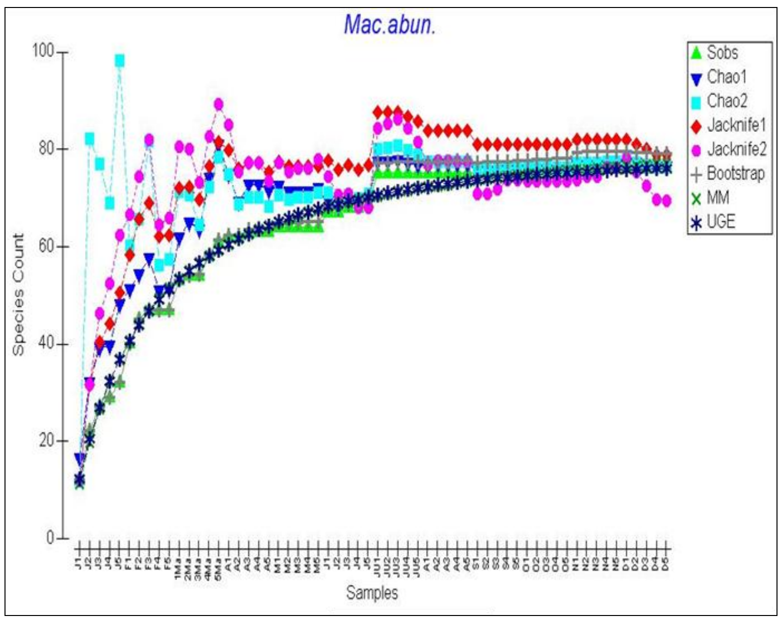

Fig 5: Species estimators

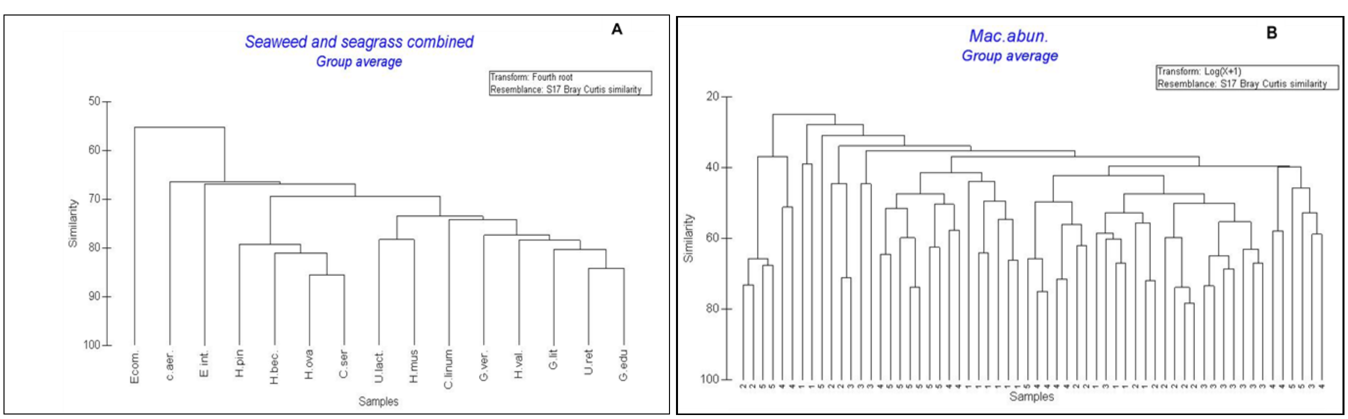

Fig 6: A: Multivariate analysis - Cluster analysis; and **B**: Dendrogram of hierarchial clustering

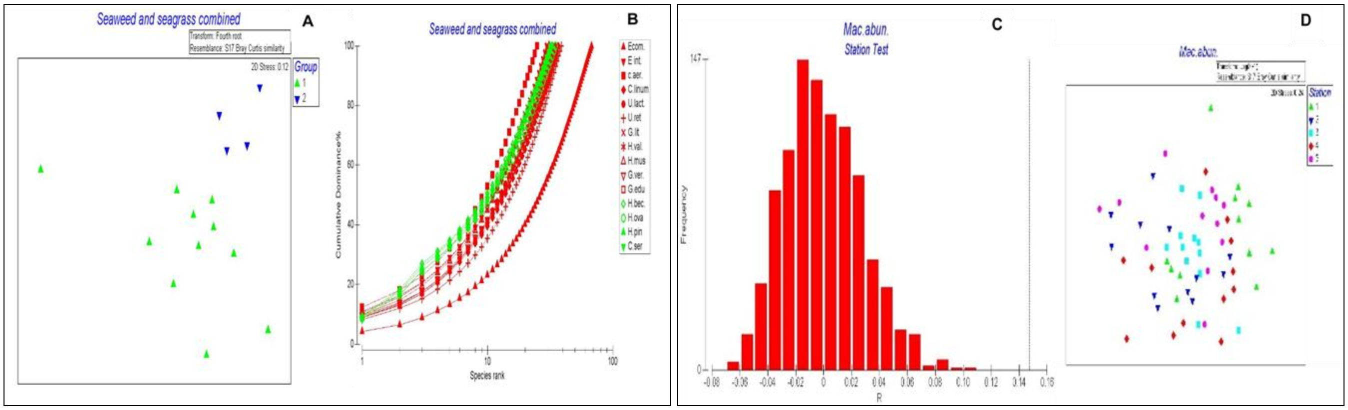

Fig 7: A: MDS; **B**: DOMDIS; **C**: ANOSIM; and **D**: MDS ordinations for the molluscs

Table 3: SIMPER

Species	AA (G1)	AA (G2)	AD	D/SD	CO (%)	CU (%)
Umbonium vestiarium	0.00	4.86	4.52	7.42	13.48	13.48
Bullia belangeri	0.00	4.70	4.37	7.01	13.03	26.51
Nassarius comptus	1.71	2.10	0.72	1.15	2.14	28.65
Trochus pustulosus	0.97	1.51	0.66	0.99	1.98	38.93
Babylonia zeylanica	1.58	1.93	0.65	0.98	1.93	40.87
Pyrene flava	0.75	0.30	0.65	1.11	1.93	42.80
Prionospio pinnata	0.70	1.10	0.62	1.32	1.85	44.64
Tectus fenestratus	0.79	1.37	0.61	1.03	1.81	50.10
Nassaria coramendalica	0.52	0.60	0.59	1.08	1.75	51.85

G1: Group 1 (seaweeds); G2: Group 2 (seagrasses); AA: Average abundance; AD: Average dissimilarity (33.56); D: Dissimilarity; SD: Standard Deviation; CO: Contribution; CU: Cumulative

4. References

1. Rao CG. The interstitial fauna in the intertidal sands of Andaman and Nicobar islands. Journal of the Marine Biological Association of India. 1998; 17(2):116-128.
2. Reish DJ. Benthic invertebrates as indicators of marine pollution: 35 years of study. Proceedings of IEEE Oceans' 86th Conference, China. 1986, 23-25.
3. Ansari ZA. Benthic macro and meiofauna of seagrass *Thalassia hemprichii*, bed at Minicoy, Lakshadweep. Indian Journal of Marine Science. 1984; 13:126-127.
4. Orth J, Larkum AWD, Duarte CM. Seagrass biology: A treatise. CRC Press, Boca Raton, 1996.
5. Bologna PAX, Heck Jr. KL. Macrofaunal associations with seagrass epiphytes. Relative importance of trophic and structural characteristics. Journal of Experimental Marine Biology and Ecology. 1998; 242(1):21-39.
6. Shanmugam A, Rajagopal S, Nazeer AR. A monograph on the common bivalves of Parangipettai coast. Annamalai University, India. 1997.
7. Rajagopal SS, Khan A, Srinivasan M, Shanmugam A. A monograph on the gastropods of Parangipettai coast. Annamalai University, India. 1998, 38.
8. FAO. Manual of methods in aquatic environment measurement and monitoring of water pollution. FAO Fisheries Technical Papers. 1975, 137-238.
9. Strickland JDH, Parsons TR. A practical hand book of seawater analysis. 2nd edition. Fisheries Research Board of Canada Bulletin. 1972; 157:310.
10. Krumbein WC, Pettijohn FJ. Manual of sedimentary petrography. Appleton Century Crofts, New York. 1938, 549.
11. Watling RJ. A manual of methods for use in the Southern African Marine Pollution Monitoring Programme. South Africa Journal of National Sciences Program Report. 1981; 44:82.
12. Sarma ALN, Ganapati PN. Faunal associations of algae in the intertidal region of Visakhapatnam. Proceedings of the Indian Natural Science Academy, Part B. 1972; 38(5-6):380-396.
13. Sulochana B, Muniyandi K. Hydrographic parameters off Gulf of Mannar and Palk Bay during a year of abnormal rainfall. Journal of the Marine Biological Association of India. 2005; 47(2):198-200.
14. Ramamoorthy. A preliminary study of the hydrography and fauna of Vellar estuary. Indo-Pacific Fish Council Symposium. 1954, 9.
15. Seshadri B. Preliminary studies in the hydrobiology and biology of the Vellar estuary. M.Sc., Dissertation, Annamalai University, India. 1955.
16. Santhanam R. Hydrobiological studies in Porto Novo waters: Ecology of the phytoplankton in different biotopes. Ph.D. Thesis, Annamalai University, India. 1976.
17. Ramadhas V. Studies on phytoplankton nutrients and some trace elements in Porto Novo waters. Ph.D. Thesis, Annamalai University, India. 1977.

18. Veerabahu C. Environmental characteristics of Tuticorin coastal waters (South India), Ph.D. Thesis, Manonmaniam Sundaranar University, India. 2000.
19. Satheesh S, Wesley SG. Settlement pattern of seaweeds on suspended test panels in Kudankulam coastal waters. Seaweed Research Utilization. 2007; 29(1&2):15-21.
20. Krishnamurthy K, Jeyaseelan PMJ. The Pitchavaram mangrove India ecosystem. Proceedings of the Indian National Science Academy. 1980; 46(1):48-53.
21. Kasinathan R, Shanmugam A. Molluscan fauna of Pitchavaram mangroves. The mangroves: Proceedings of the National Symposium on Biological Utilization and Conservation of Mangroves. 1985, 11-18.
22. Dwivedi SN, Varshney PK. Intertidal macrobenthic fauna of deteriorated mangrove ecosystem off Seven Banglows, Bombay. Geobios. 1986; 13:112-117.
23. Kumar SR. Animal sediment interactions with respect to the distribution pattern of polychaetous annelids in the mangrove ecosystem of Cochin backwater. Journal of Zoological Society of Kerala. 1995; 5(1&2):43-48.
24. Kumar V, Manivannan V. Benthic foraminiferal responses to bottom water characteristics in the Palk Bay off Rameswaram, Southeast coast of India. Indian Journal of Marine Science. 2001; 30:173-179.
25. Ketchum BH. The exchange of fresh water and salt water in tidal estuaries. Journal of Marine Research Utilization. 1951; 10:19-38.
26. Jayaraman R. Seasonal variations in alkalinity, dissolved oxygen and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam. Indian Journal of Fisheries. 1954; 1(1&2):345-364.
27. Mohammed G, Nasser AKV, Haneefakoya CN. Domestic waste and its impact on production of *Caulerpa racemosa* Forssk. Weber v. Bosse at Minicoy island, Lakshadweep. Seaweed Research. 2007; 21(1&2):73-77.
28. Athalye RP, Gokhale KS. Study of selected trace metals in the sediments of Thane creek near Thane city-antagonistic behaviour of zinc and copper. Mahasagar. 1989; 22:185-191.
29. Selvakumar S, Haridasan TM. Toxic effects of heavy metals copper, zinc, cadmium and mercury on the zoeal development of sesarminid crab *Nanosesarma batavicum*. Journal of Environmental Biology. 2000; 21(2):105-109.
30. Palanichamy S, Balasubramanian T. Distribution of calcium and magnesium in the Vellar estuary. Mahasagar Bulletin of the National Institute of Oceanography. 1989; 22(1):1-11.
31. Mary PC, Bai KV, Phoebe MM. Distribution of trace metals in red algae, sea water and sediment of Tuticorin coast. Seaweed Research. Utilization. 2003; 25(1&2):63-68.
32. Mondal N, Lyla PS, Khan AS. Biodiversity and seasonal variation of macro-benthic in faunal community in the inshore water of Parangipettai coast. Environmental Monitoring and Assessment. 2009; 163(1-4):67-79.
33. Yogamoorthy A. Studies on the seaweeds of Vellar estuary and adjacent from the southeast coast of India. Ph.D. Thesis, Annamalai University, India. 1982.
34. Weiser W. Investigation on the micro fauna inhabiting seaweeds on rocky coasts. Journal of the Marine Biological Association of the United Kingdom. 1952; 31:145-147.
35. Warwick RM. The structure and seasonal fluctuations of phytal marine nematode associations on the Isles of Scillys. In: Biology of benthic organisms by Keegan BF. 11th European Symposium on Marine Biology. Galway, P.O. Cerdigh and Boaden. Eds. 1977, 23-42.
36. Joseph MM. Ecological studies on the fauna associated with economic seaweeds of South India I. Species composition, feeding habits and interrelationship. Seaweed Research Utilization. 1978; 3:8-25.
37. Barkman JJ. On the distribution and ecology of *Littorina obtusa* L. and its sub specific units. Archives Néerlandaises de Zoologie. 1955; 11:22-80.
38. Fuse SI. The animal community in the *Zostera* belt. Physiological Ecology. 1962; 11:123.