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ECOLOGY OF EPIFAUNA ON *BRYOPSIS PLUMOSA* (HUDSON) *C. AGARDH* (1823) IN MULLUR COAST, KERALA

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Abstract: The rocky intertidal seaweed microhabitats effectively serve as shelters from desiccation or predation for motile inhabitants. Macro algae are important habitat forming organisms in the rocky coasts and enhance biodiversity. The present study aims at comparing the seasonal variations of the epifaunal assemblages and diversity of fauna on the distichously branched green algae *Bryopsis plumosa* (Hudson) C. Agardh (1823) in relation to water quality along the Mullur coast (8°22' N Lat. and 77° 00' E Long.). Physico chemical parameters such as pH, dissolved oxygen, salinity and nutrients such as nitrite- nitrogen, nitrate- nitrogen, phosphate-phosphorous and silicate- silicon were analysed. Algae were collected using 25 cm^2 area quadrant and the associated organisms were sorted out and preserved in 10% formalin solution. The quantitative data was expressed in terms of number of animals per 100g wet weight of algae. A total of 19650 macro faunal specimens were sorted and examined (36.04% molluscs, 33.57% arthropods, 16.77% annelids, 13.06% aschelminthes and 0.56% echinoderms). Gastropods were the dominant group in *Bryopsis plumosa* followed by amphipods. Juveniles of gastropods (size <0.5 cm) and sea cucumbers (size <1 cm) were represented as epifauna. Maximum number of associated organism was recorded during November (4462) and lowest in December (267). Sea cucumber, *sabella* and *Cellana* were found occasionally. Correlation of epifauna was explained on the basis of natural differences in seawater pH (r= -0.06), salinity(r= -0.05), dissolved oxygen(r= 0.0009), phosphate- phosphorous(r= 0.8), nitrite- nitrogen(r= 0.7), nitrate- nitrogen(r= 0.8) and silicate- silicon(r= 0.4) etc. The Shannon index of diversity (H') was also calculated for the faunal community. H' was greater in monsoon (1.641) than other seasons. This study demonstrated that this macroalgae supports diversified epifaunal assemblages and enhance the biodiversity as a micro habitat.

Key words: Rocky shore, Green algae, Associated fauna, Biocoenosis, Micro habitat

INTRODUCTION

The intertidal zone is one of the world's most diverse environments, biologically and physically. Animals are constantly making choices in response to their environment, whether those choices are related to food, habitat or reproduction (Meadows and Campbell, 1972; Hughes, 1990 and Alcock, 1998). Marine macroalgae serve as both primary space holders in communities, competing for resources such as space, as well as a secondary substratum, acting as biological habitat structure (Colman, 1940; Jones and Andrew, 1992; Chemello and Milazzo, 2002 and Wikstrom and Kautsky, 2004) and providing suitable habitat for abundant and diverse organisms (Viejo, 1999; Jones and Thornber, 2010). The marine plant- animal relationship has had a much shorter history and far or less investigation has been performed (Parsons, 1980).

This association may be due to several biological factors such as life cycles, algal structure (McCoy and Bell, 1991; Gee and Warwick, 1994; Taylor, 1998; Chemello and Milazzo, 2002; Jones and Thornber, 2010), habitat complexity (Schreider *et al.*, 2003), chemical defences (Edmunds, 1974; Hay *et al.,* 1987; 1988; Cronin and Hay, 1996; Lali, 1996; Sotka and Hay, 2002 and Wernberg *et al.*, 2004) or physical factors (e.g. wave exposure or tidal height) (Underwood, 1984; Smith, 1993; Chemello and Milazzo, 2002; Schreider *et al.*, 2003 and Cacabelos *et al.*, 2010a). In this context, quality and quantity of epiphytic load may play an important role by increasing the structural complexity of the habitat, determining habitat preferences (Schneider and Mann, 1991; Smith, 1993; Attrill *et al.*, 2000 and Schreider *et al.*, 2003), and providing additional new resources (i.e. food, habitat) for invertebrates. Plant species diversity and composition affects marine epifaunal assemblages (Parker *et al.*, 2001). Roberts and Poore, (2004) carried out a work on the effects of habitat configuration on the colonisation of epifauna in a marine algal bed. Though the distribution of littoral organisms is influenced by tidal levels, exposure to wave action and the general littoral environment, Wieser (1952) and Sarma and Ganapati (1972) concluded that the most significant factor for epifauna is the micro-environment offered by the seaweed. Many of the studies focused on the composition of phytal macrofaunal assemblages (Colman 1940 and Dommasnes, 1969). Only scattered reports on the epifaunal assemblages on seaweeds were recorded in India (Sarma and Ganapati, 1972; Joseph, 1978a; 1978b; 1978c; James *et al.*, 1986; Padmakumar and Sindhu, 2005; Ranjitham *et al.,* 2008*;* Satheesh and Wesley, 2006; Jansi and Ramadhas, 2009; Manilal *et al.* 2010; Joshi *et al.* 2011 and Sugathan *et al.* 2012). In Kerala work on littoral seaweed epifauna has been neglected and the seaweed microhabitat is only briefly mentioned in the studies of (Amritha Kumari, 1992; Sobha and Nair, 1992; Lali, 1996; Leena and Prabha Devi, 2004; Sheeja and Padmakumar, 2010).

MATERIAL AND METHODS

The samples were monthly collected from August 2011 to July 2012. The main objectives of the study were to analyse the hydrological parameters and the comparative study of seaweed associated fauna from the intertidal zones of Mullur coast (8°22' N Latitude and 77°E Longitude).

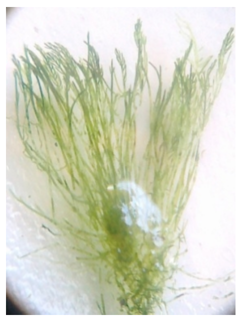
Water samples were collected from the surface for physico-chemical analysis. Salinity was recorded using Ecoscan Salt 6 Salinity meter. The Hydrogen Ion Concentration was determined using Cyber pH-14 L pH Meter. The oxygen concentration was determined by Winkler's Titration Method. Dissolved nutrients i.e. Nitrite-Nitrogen (NO2--N), Nitrate-Nitrogen (NO3--N), Phosphate-Phosphorous (PO43--P) and Silicate-Silicon (SiO32--Si) were estimated by Calorimetric Methods using Systronics 167 Spectrophotometer and PC based Double Beam Spectrophotometer 2202 at appropriate wave lengths, following the standard method described by Grasshoff *et al.*, (1976).

For quantitative and qualitative analysis, the algal samples were collected from intertidal rocky areas. Seaweeds were collected from each station at random during low tide. The method of Sarma and Ganapathi (1972) was followed. A quadrant of 25 cm2 area was placed over the intertidal rock covered by seaweeds and all the vegetation inside the frame was taken and transferred immediately into a polythene bag and the samples were brought to the laboratory. The algae were later kept in separate polythene basins containing filtered seawater. Then the samples were fixed in 10% formaldehyde solutions. Vigorous shaking in formalin solution dislodges most of the clinging animals. Small portion of the sample was taken into a Petri dish and carefully examined for every frond under a stereo dissection microscope with strong incident illumination. The animal groups were sorted, counted and preserved. The quantitative data was expressed in terms of number of animals per unit wet weight of algae. PAST software is used for the diversity assessment.

RESULTS AND DISCUSSION

Monthly variations in the physico-chemical parameters of water are presented in Table 1. In Mullur coast surface water pH varied from 7.79 (January) to 8.39 (June). This is well within the pH range of normal seawater (7.5 to 8.5) mentioned by Pinnet (1992). The average pH value for the entire study period was 8.03. Studies conducted by Mukhopadhyay *et al.* (2003) in West Bengal reported a pH range between 7.5 and 8.5 at different seasons. pH showed negative correlation (r = -0.0608) with seaweed epifauna during the study period. Fluctuations in dissolved oxygen, salinity etc also influences the pH (Anirudhan, 1988). The Dissolved oxygen concentration ranged from 6.56 mg/l in March to 9.44 mg/l in May & July. The annual mean was 8.05 mg/l. Salinity was fluctuated between 30.75 psu (July) and 32.10 psu (September). The mean salinity obtained for the entire study period was 31.21 psu. During the study period dissolved oxygen showed negative correlation (r = -0.0501) and salinity showed positive correlation (r = 0.0009) with seaweed epifauna.

The phosphate-phosphorus levels showed highest values in June (0.54 µg/l) and minimum (0.15 µg/l) in March. Annual mean phosphate-phosphorus value was found to be 0.32 µg/l. The lowest nitrite-nitrogen level (0.003 µg/l) was found during February and comparatively higher value found during the monsoon months (0.20 µg/l). The nitrate-nitrogen concentration fluctuated between a low value 0.03 µg/l in January to 0.35 µg.at/l during June.The concentration of silicate varied from 0.40 µg/l in July and 1.05 µg/l in October & November. Higher value found during the post monsoon season (1.00 µg/l). Nutrients showed significant positive correlation with seaweed epifaunal assemblages (0.801, 0.698, 0.783, 0.384).



Kingdom	:	Plantae
Phylum	:	Chlorophyta
Class	:	Bryopsidophyceae
Order	:	Bryopsidales
Family	:	Udoteaceae
Genus	:	*Bryopsis*
Species	:	*Bryopsis plumosa* (Hudson) C. Agardh

Bryopsis is usually epilithic and bright green in colour. Thallus broadly spreading (2–3 cm high) with several to numerous axes and is arising from a branched rhizoidal basal system. *Axes* essentially distichously branched, less so below, with lower laterals elongating progressively towards the base and often themselves becoming pinnate, clustered simple, fronds bearing pinnae most commonly in two rows growing from the margins of the axes; growth of the pinnae restricted to the upper portions. *Bryopsis plumosa* is economically used as human food, animal feed and as manure.

Epifauna

Macrophytes are important primary producers along coasts worldwide, serving as habitat or functioning as ecological engineering species. Seaweed, kelp and sea grasses form small patches or larger vegetation beds which support epiphytic algae and animals, as well as a variety of associated mobile animals, including meiofauna, macrofauna and fish (Christie *et al.*, 2009). Epifaunal organisms belonging to five different groups were sorted out (brittle stars, sea cucumbers, sea spiders, amphipods, isopods, nematodes, pin worms, segmented worms, polychaetes, *sabella*, gastropods, slug, *Cellana*, bivalves and chiton) from the collected algal samples and the number of each groups associated were noted (Table 2).

Table 1. Monthly variation in physico-chemical parameters of Mullur coast from August 2011 to July 2012

Month	pH	DO ($mg.l^{-1}$)	Salinity	Phosphate-Phosphorus (µg/l)	Nitrite-nitrogen (µg/l)	Nitrate-nitrogen (µg/l)	Silicate-silicon (µg/l)
August	8.12	6.88	31.10	0.42	0.17	0.18	0.81
September	8.00	8.48	32.10	0.29	0.16	0.21	0.92
October	7.92	7.52	32.00	0.39	0.11	0.15	1.05
November	8.11	8.00	31.20	0.36	0.11	0.25	1.05
December	8.15	8.64	30.80	0.30	0.11	0.10	0.97
January	7.79	7.52	31.25	0.34	0.01	0.03	0.60
February	7.82	6.88	31.20	0.23	0.003	0.19	0.46
March	7.82	6.56	30.85	0.15	0.01	0.25	0.62
April	7.91	8.48	31.05	0.18	0.03	0.26	0.72
May	8.11	9.44	31.05	0.16	0.08	0.26	0.66
June	8.39	8.80	31.15	0.54	0.28	0.35	0.46
July	8.18	9.44	30.75	0.53	0.27	0.30	0.40
Average	**8.03**	**8.05**	**31.21**	**0.32**	**0.11**	**0.21**	**0.73**

Table 2. Monthly variations in epifaunal assemblages on *Bryopsis plumosa* from Mullur coast (No. of organism/100gm wet wt. of algae) during August 2011 to July 2012

Months	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Brittle star	-	15	61	-	-	-	-	-	-	-	17	-
Sea cucumber	-	-	17	-	-	-	-	-	-	-	-	-
Sea spider	-	7	35	-	-	-	18	-	-	-	-	-
amphipods	26	15	1183	923	107	1000	754	200	46	33	356	19
Isopods	17	44	87	769	13		18	462	93	58	314	-
Nematodes	94	712	-	462	13	500	211	62		133	153	176
Pinworms	-	-	-	-	-	-	-	-	-	50	-	-
Segmented worms	-	-	-	-	-	-	-	-	-	-	93	-
polychaetes	51	545	-	538	80	286	404	138	-	600	534	9
Sabella	-	-	-	-	-	-	-	-	-	-	17	-
Gastropods	43	392	1817	1615	27	357	982	446	444	83	-	83
Slug	-	-	-	-	-	-	-	-	-	67	-	-
Bivalves	103	36	130	154	13	-	35	46	9	-	110	37
Chiton	-	-	-	-	-	-	-	15	-	-	17	-
Cellana	-	-	-	-	13	-	-	-	-	8	-	-
Total	**333**	**1766**	**3330**	**4462**	**267**	**2143**	**2421**	**1369**	**593**	**1033**	**1610**	**324**

Table 3. Percentage occurrence of epifaunal assemblages on *Bryopsis plumosa* from Mullur coast during August 2011 to July 2012

Months	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Brittle star	-	0.85	1.83	-	-	-	-	-	-	-	1.06	-
Sea cucumber	-	-	0.51	-	-	-	-	-	-	-	-	-
Sea spider	-	0.40	1.05	-	-	-	0.74	-	-	-	-	-
Amphipods	7.81	0.85	35.53	20.69	40.07	46.66	31.14	14.61	7.76	3.19	22.11	5.86
Isopods	5.11	2.49	2.61	17.23	4.87	-	0.74	33.75	15.68	5.61	19.50	-
Nematodes	28.23	40.32	-	10.35	4.87	23.33	8.72	4.53	-	12.88	9.50	54.32
Pinworms	-	-	-	-	-	-	-	-	-	4.84	-	-
Segmented worms	-	-	-	-	-	-	-	-	-	-	5.78	-
Polychaetes	15.32	30.86	-	12.06	29.96	13.35	16.69	10.08	-	58.08	33.17	2.78
Sabella	-	-	-	-	-	-	-	-	-	-	1.06	-
Gastropods	12.91	22.20	54.56	36.19	10.14	16.66	40.56	32.58	74.87	8.03	-	25.62
Slug	-	-	-	-	-	-	-	-	-	6.49	-	-
Bivalves	30.93	2.04	3.90	3.45	4.87	-	1.45	3.36	1.52	-	6.83	11.42
Chiton	-	-	-	-	-	-	-	1.10	-	-	1.06	-
Cellana	-	-	-	-	4.87	-	-	-	-	0.77	-	-

During the study period Mullur coast showed 19650 epifaunal organisms on *Bryopsis plumosa*. The highest organisms reported was molluscs (36.04 %) followed by arthropods (33.57 %). Amphipods reported throughout the study period with maximum percentage occurrence during the month of January (46.66%) (Table 3). Many studies reported that amphipods are the major epifauna on the seaweed (Duffy, 1990; Duffy and Hay 1991 a&b; Schreider *et al.*, 2003; Christie and Kraufvelin, 2004; Leite *et al.*, 2007; Jacobucci *et al.*, 2008 and Guerra-Garcya *et al.*, 2009a;). Among molluscs, gastropods were the dominant group and among arthropods, amphipods were the most abundant organisms followed by isopods. Epifauna showed higher density during post-monsoon periods. Amphipods, isopods, nematodes, polychaetes, gastropods and bivalves were recorded throughout the seasons (Table 4). Gastropods and amphipods occupied most part of the epifauna during these months, even though diversity was high during monsoon months (Table 5). During March isopods were high with low concentration of dissolved oxygen and phosphate phosphorous. Seaweed dwelling isopods are often abundant components of the macrophytic habitat (Salemaa 1987; Schaffelke *et al.*, 1995; Merilaita

Table 4. Seasonal occurrence of epifaunal assemblages on *Bryopsis plumosa* from Mullur coast during August 2011 to July 2012

Phylum	Months	Pre-monsoon	Monsoon	Post-monsoon
Echinoderms	Brittle star	-	17	76
	Sea cucumber	-	-	17
Arthropods	Sea spider	18	-	52
	Amphipods	2000	434	2228
	Isopods	573	389	913
Aschelminthes	Nematodes	773	556	1187
	Pinworms	-	50	-
Annelida	Segmented worms	-	93	-
	Polychaetes	828	1194	1163
	Sabella	-	17	-
Molluscs	Gastropods	2229	209	3851
	Slug	-	67	-
	Bivalves	90	250	333
	Chiton	15	17	-
	Cellana	-	8	-
	Total	**6526**	**3300**	**9825**

Table 5. Biodiversity indices of epifaunal assemblages on *Bryopsis plumosa* from Mullur coast during August 2011 to July 2012

Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Total No. of Epifauna	334	1766	3330	4461	266	2143	2422	1369	592	1032	1611	324
Dominance_D	0.223	0.308	0.427	0.230	0.272	0.318	0.297	0.255	0.593	0.372	0.214	0.378
Simpson_1-D	0.777	0.692	0.573	0.770	0.728	0.682	0.703	0.745	0.407	0.628	0.786	0.622
Shannon_H	1.621	1.337	1.068	1.603	1.550	1.263	1.375	1.548	0.769	1.416	1.734	1.194
Evenness_e^H/S	0.843	0.476	0.416	0.828	0.673	0.884	0.565	0.672	0.539	0.515	0.629	0.660

and Jormalainen 1997; Merilaita and Jormalainen, 2000; Jormalainen *et al.,* 2001 and Guerra-Garcia *et al.*, 2009b). Sarma, 1972; Ronald, 2003 and Veena *et al.*, 2008 investigated the habits of numerous sea spiders as phytal fauna. In the present study the pycnogonids (sea spiders) were reported in three months (September, October and February). Gastropods were abundant in the epifauna and present throughout the year except for June. Minute opisthobranchs, gastropods and bivalves were reported during the study period as epifauna. Bishop and Bishop (1973) and Beckley, 1982, working on the association between molluscs and marine plants, commented on the small size of epifaunal molluscs. Juvenile brown mussels *Perna indica* were found in the epifauna of *B. plumosa* during August and it appears that primary settlement of these bivalves occurs on littoral seaweeds on Mullur coast (Beckley 1979). Taylor and Cole, 1994 reported the high density of bivalve spat above 0.1 mm size as epifauna.Sea cucumber and Sabella were the least abundant animals in the epifauna (Fig. 1). In general nematodes were also abundant at the site than the isopods. Polychaetes constitute 96.66% of the annelid. Tube-living sabellids were also found. Colman (1939), Glynn (1965) and Bennett (1971) have recorded the association of marine oligochaetes with seaweeds whilst Chapman (1955), Morton and Miller (1968), Hicks (1971) and Sarma and Ganapati (1972) have documented the abundance of syllids in seaweed epifauna. A feature of seaweed

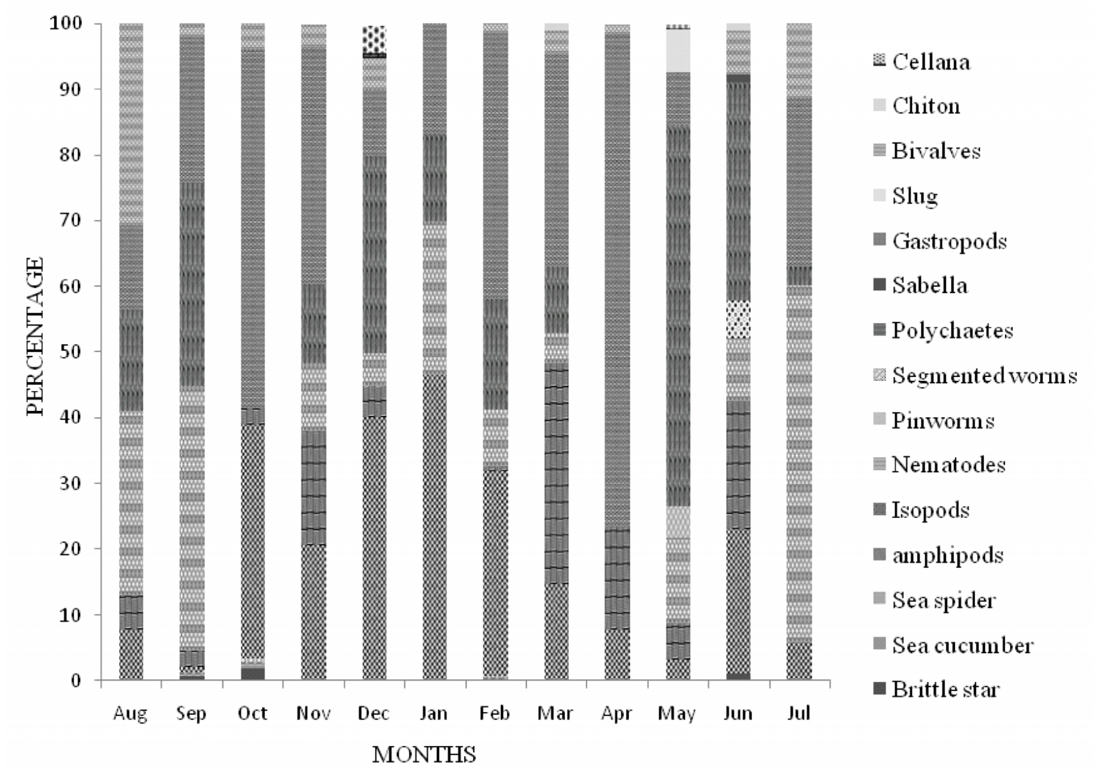


Fig. 1. Occurrence of epifaunal assemblages on Bryopsis plumosa from Mullur coast during August 2011 to July 2012

epifauna community structure which became apparent in the present study was the abundance of early life-stages of animals, for example, Juvenile stage of brittle stars, sea cucumbers, isopods, amphipods, gastropods and bivalves constituted the epifauna of *B. plumosa* on Mullur coast. Seaweeds appear to be important nursery areas for littoral animals and consideration should be given to this when planning and implementing commercial exploitation of seaweed resources. It is suggested that, seaweed habitats should protect from anthropological activities to enhance biodiversity.

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