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Benthic Macrofaunal Assemblage in the Arid Zone Mangroves of Gulf of Kachchh – Gujarat

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Abstract The total benthic macrofauna consisting of 62 species in 5 groups, viz. crustaceans (18), gastropods (17), bivalves (16), polychaetes (9) and fishes (2), was recorded in western Kachchh mangroves near Gujarat. The population densities of benthic macrofauna ranged from 424 to 2393 ind.m^{-2}, the diversity ranged from 1.84 to 2.45 bits $ind.^{-1}$, the richness varied between 0.82 and 0.98, and the evenness varied between 0.64 and 0.81. Two maximum diversity values were recorded during winter and summer. The salinity ranged from 34 to 44, temperature varied between 17 and 37 ℃, and the acidity ranged from 7 to 8.9.

Key words mangroves; Gulf of Kachchh; macrofauna

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1 Introduction

Mangrove is the habitat of very rich faunal, which is comparable with tropical evergreen forest and coral reef. In spite of mangrove-rich faunal, there used to be a general belief that animals are of minor significance in the mangrove environment. It is only recently that the distribution, abundance and importance of mangrove fauna were realized well (Parulekar, 1994). The muddy or sandy sediment of mangrove forest acts as the home of a variety of epibenthic, infaunal and meiofaunal invertebrates (Kumar, 1995). Composition of these communities and their importance varies enormously from one habitat to another depending upon the sediment characteristics of the mangroves. The macro epifaunal communities such as crustaceans and molluscs constitute a major component of all mangrove faunal assemblages. Similarly, it is recognized that faunal assemblages influence the function of mangrove ecosystem in various ways. For example, birds' rookeries enrich mangrove sediment with phosphates (Onuf *et al*., 1997). Crabs are known to feed on mangrove leaves and change the topography of the mangrove floor by burrowing (Warren and Underwood, 1986). They are also significant agent of mangrove leaf degradation to detrital-sized particle and play a significant role in maintaining the steady state of the mangrove ecosystem while enhancing its biological productivity (Malley, 1978). Realizing the importance of this interaction, a lot of work on the mangroves of east and west coasts of India has been carried out on the ecology of mangrove macrofauna (Ali *et al*., 1983; Maruthamuthu *et al*., 1985; Ansari *et al*., 1986; Sinha *et al*., 1986; Kasinathan and Shanmugam, 1986; Rambabu *et al*., 1987; Patra *et al*., 1988 and 1990; Kondalrao and Ramanamurthy, 1988; Devi and Venugopal, 1989; Das and Dev Roy, 1989; Chakraborty *et al*., 1992; Balasubramanian, 1994; Santhakumarn and Sawant, 1994; Kumar and Antony, 1994; and Kumar, 1995, 1997 and 2001). These studies pertaining to the distribution of macrofauna are found deficient in the western Kachchh mangroves of Gujarat. Hence, the present investigation attempted to gain an insight into the species distribution, composition and density of the mangrove-associated macrofauna of Kachchh coast. It would also help us to gain a holistic view of the mangrove ecosystem.

2 Materials and Methods

Rainfall data was obtained from Meteorological Department at Bhuj, Kachchh Gujarat. The environmental parameters such as temperature, salinity, dissolved oxygen and pH were analysed following the methods of Strickland and Parsons (1972). The sites were selected based on their proximities to open sea and their levels of anthropogenic pressure. The three selected sites, namely, Site 1 Jakhau – (Babber Creek) (68.36ºN, 23.30ºE), Site 2 Sangi – (Kharo Creek) (68.31ºN, 23.17ºE) and Site 3 Medi – (Sinthodi Creek) (68.29ºN, 23.27ºE) (Fig.1) were chosen with 5 km distances between each other. These three creek sites in the fringe of mangrove varied in microclimatic niche. Species present on the substratum and

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vegetation in the intertidal belt of the vegetated area were recorded in a quadrant measuring 1m^2. Crab burrow density was recorded in 3 randomly placed one-square-meter quadrates following the method of Jones (1984). Crabs and other fauna were collected during low tide, and then were preserved in 5% neutralized formalin. The collected specimens were identified following the works of Rathburn (1930), Chhapgar (1957), Crane (1975), Williams (1984) and Sethuramalingam and Ajmalkhan (1991). For the sake of interpreting the data, a calendar year was divided into 3 main seasons, viz. Winter (November - February), Summer (March - June) and Monsoon (July - October).

The general survey involved the collection of various species of crabs from the creek and the estimation of the density of crabs by randomly counting crabs either active on the substrate enclosed within the quadrant or staying in burrows. Further, samples of fauna were collected from the same study area using a Peterson grab. The grab was found to cover a sampling area of 0.08 m^2. Immediately after collection, the sediment was gently passed through a 0.5 mm mesh and the animals retained by the sieve were preserved in 5% neutralized formalin and stained with Rose Bengal solution for easy spotting. The identified samples were expressed as ind m^{-2}. Biodiversity indices such as species diversity, richness and evenness were calculated following the standard formulae (Shannon and Weaver, 1949; Gleason, 1922 and Pielou, 1966).

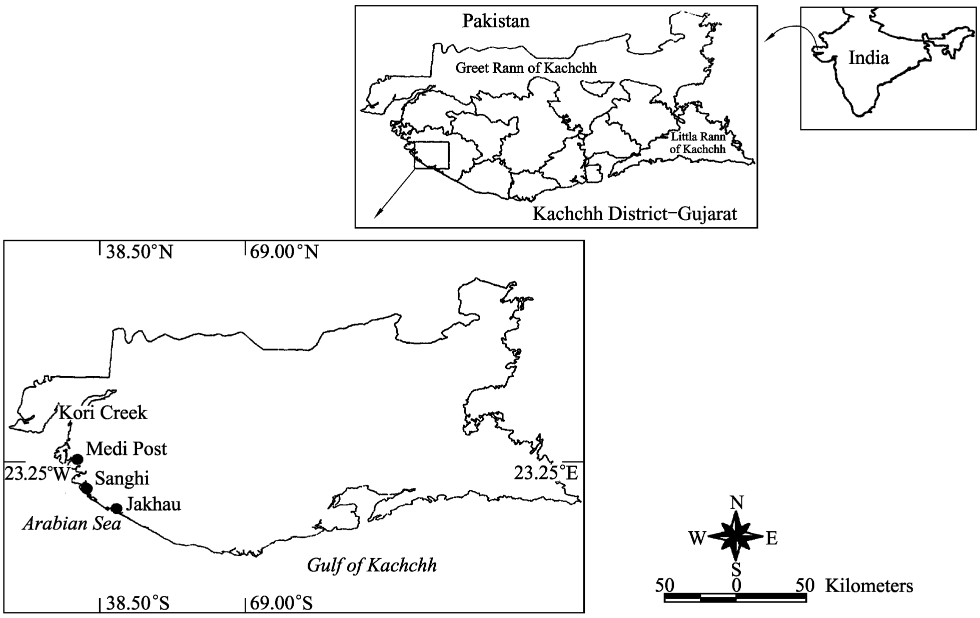

Fig.1 Map showing the study area.

Statistical Analysis Correlation coefficients (r) were calculated for benthic faunal density and physicochemical parameters, ANOVA tests were made for hydrobiological parameters in relation to stations. All these statistical analyses were performed using SPSS statistical software (Ver. 11.5 for Windows, SPSS, Chicago, IL, USA).

3 Results

The water temperature ranged from 17℃ to 37 ℃ (Fig.2). The salinity varied from 34 to 44 (Fig.3). The acidity fluctuated monthly between pH 7.0 and pH 8.9 (Fig.4). The dissolved oxygen concentrations ranged from 3.42 to 5.85 mL L^{-1} (Fig.5). The maximum value was recorded in winter and minimum in monsoon season. In total, 62 species were recorded from all the three stations, which covered crustaceans (18), gastropods (17), bivalves (16), polychaetes (9) and fishes (2). At Station 3, the highest number of species was recorded. Totally, 54 species were identified. The lists of species are given in Table 1. The

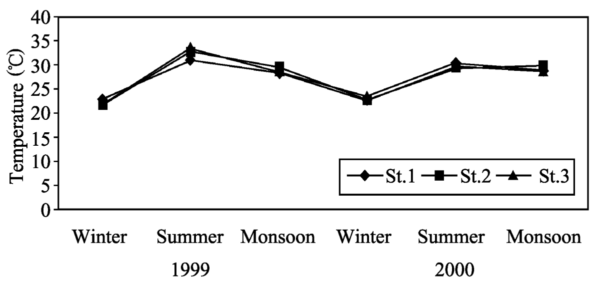

Fig.2 Seasonal variations of temperature recorded from stations 1, 2 and 3.

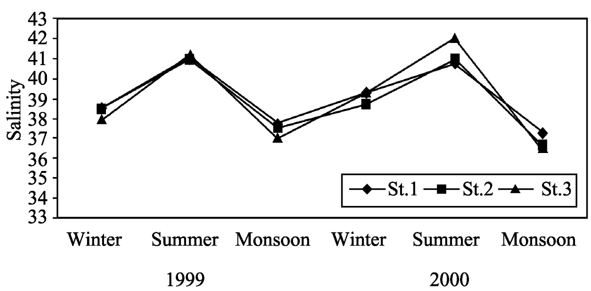

Fig.3 Seasonal variations of salinity recorded from stations 1, 2 and 3.

percentage composition of crustaceans varied between 5.8% and 18%; polychaetes ranged from 37% to 69.8%; gastropods varied between 16.6% and 48.2%; bivalves varied from 1.3% to 3.1% and gobiid (mudskippers) varied from 0.3 to 0.6% at all three stations. The benthic macro faunal density (ind. m^{-2}) ranges were 486-1190, 424 -1577 and 424-2393 at stations 1, 2 and 3, respectively (Fig.6). The highest was recorded in early winter.

The diversity values varied from station to station, ranging from 1.84 to 2.45. Generally, the diversity value was high in winter and low in monsoon and summer (Table 2). In the present study, benthic population was positively correlated with all physico-chemical parameters, and correlations with benthic density, diversity, richness and evenness were significant ($P<0.05$) at all the three stations.

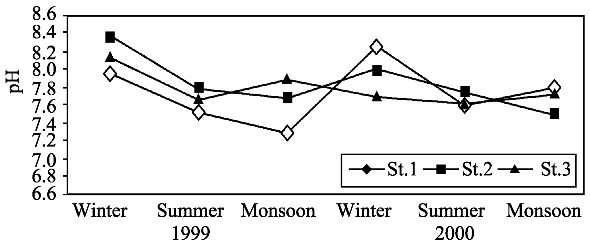

Fig.4 Seasonal variations of pH recorded from stations 1, 2 and 3.

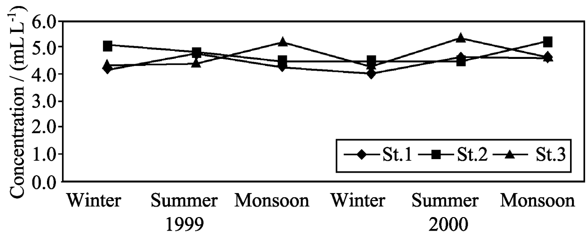

Fig.5 Seasonal variations of dissolved oxygen recorded from stations 1, 2 and 3.

Table 1 Checklist of benthic fauna recorded at stations 1, 2 and 3

	Crustaceans	Station 1	Station 2	Station 3		Crustaceans	Station 1	Station 2	Station 3
1	*Eriopisa* sp.	+	+	+	33	*Telescopium telescopium*	+	+	+
2	*Balanus amphitrite*	+	+	+	34	*Thais buffo*	+	+	+
3	*Balanus* sp.	+	–	–	35	*Turritella acutangula*	–	+	+
4	*Clibanarius longitarsus*	+	–	+		**Bivalves**			
5	*Dotilla myctiroides*	+	+	+	36	*Anadara granosa*	–	+	+
6	*Thalassina anomala*	+	+	+	37	*Arca* sp.	–	+	–
7	*Metapograpsus messor*	+	+	+	38	Bivalve spat	+	+	+
8	*M. maculatus*	+	+	+	39	*Crassostrea madrassensis*	–	–	+
9	*Macrophthalmus depressus*	+	+	+	40	*Dosinia* sp.	+	–	+
10	*Nanosesarma minutum*	–	+	+	41	*Gafrarium* sp.	+	+	+
11	*Neoepisesarma mederi*	+	+	–	42	*Dosinia trigona*	+	+	+
12	*Ocypode macrocera*	+	+	+	43	*Mactra mera*	+	+	+
13	*Scylla serrata*	–	+	+	44	*M. luzonica*	–	+	+
14	*Sesarma brockii*	+	+	+	45	*Saccostrea cucullata*	+	+	+
15	*S. plicatum*	+	+	+	46	*Saccostrea* sp.	+	–	+
16	*Uca acuta*	–	–	+	47	*Pholas orientalis*	+	+	–
17	*U. dussumieri*	+	+	+	48	*Paphia* sp.	–	+	+
18	*U. lactea annulipes*	+	+	–	49	*Solen lamarkii*	–	+	+
	Gastropods				50	*S. truncatus*	+	–	–
19	*Assiminea brevicula*	+	+	+	51	*Tellina* sp.	+	+	+
20	*Cerithidea cingulata*	–	+	+		**Polychaetes**			
21	*C. fluviatilis*	+	+	+	52	*Diapatra neopolitana*	+	+	+
22	*C. obtuse*	–	+	+	53	*Eunice* sp.	+	+	+
23	*Littorina scabra*	+	+	+	54	*Glycera alba*	+	+	+
24	*Melampus singaporensis*	+	+	+	55	*Lumbriconereis latreilli*	+	+	+
25	*Nassa striata*	+	–	–	56	*Marphysa stragulum*	+	+	+
26	*Nassarius stolatus*	–	+	+	57	*Nereis* sp.	+	+	+
27	*N. taenia*	–	+	–	58	*Perinereis cavifrons*	–	+	+
28	*Natica tigrina*	+	+	+	59	*Pulliella armata*	+	+	+
29	*Nerita articulata*	+	–	+	60	*Thalehasapia tenuis*	+	+	+
30	*Nerita* sp.	+	+	+		**Fishes**			
31	*Onchidium verruculatum*	+	+	+	61	*Boleophthalmus* sp.	+	+	+
32	*Pythia plicata*	–	+	+	62	*Periophthalmus* sp.	+	+	+

Notes: – Absence; + Presence

The polychaetes, *viz*. *Diapatra neopolitana*, *Glycera alba*, *Perinereis cavifrons*, *Pulliela armata*, *Thalehasapia tenuis* and *Nereis* sp. were observed throughout the year. These species are found to be euryhaline forms except *Glycera alba* and *Diapatra neopolitana* which are stenohaline in nature. The influence of environmental parameters, especially salinity, on the distribution of benthic organisms has been reported for Cochin backwaters (Antony and Kuttyamma, 1985; Devi and Venugopal, 1989 and Kumar and Antony, 1994). Molluscs group was the second dominant next to polychaetes. In the mangrove environment, molluscan forms, especially gastropods, occur in high abundance; they form an ecologically very intimate group of associates in the mangrove ecosystem. In the present study, *Assiminea brevicula*, *Cerithidia cngulata*, *Melambus singaporensis*, *Onchidium verruculatum*, *Telescopium telescopium*, *Littorina scabra* and *Nassarius stolatus* were found to be common. Among the molluscan forms, bivalves were next to gastropods in abundance, which were represented by *Solen lamarckii*, *S. truncates*, *Gafrarium* sp. *Pholas orientalis*, *Crossostrea madrassensis* at all stations. Crustaceans formed the third dominant group at all three stations, which was represented by *Ocypode macrocera*, *Sesarma brockii*, *Uca acuata*, *U. dussumieri*, *U. lactuea*, *Balanus amphitrite* and *Nanasesarma minutum*.

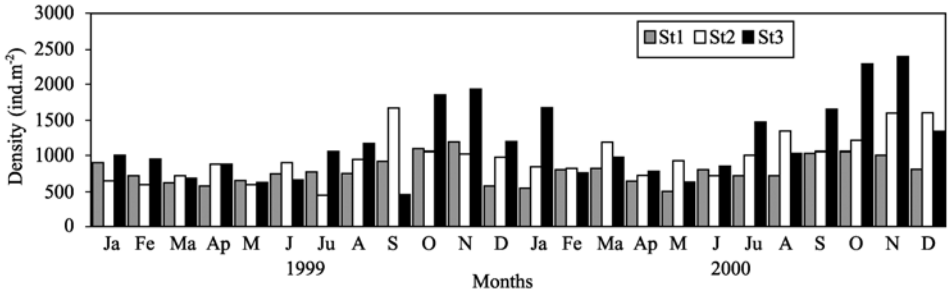

Fig.6 Benthic macrofaunal density during 1999 to 2000 at stations 1, 2 and 3.

Table 2 Benthic species diversities, richnesses and evennesses at stations 1, 2 and 3 during 1999 to 2000

Parameter	Year	Station 1			Station 2			Station 3		
		Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon
Diversity	1999	2.08	2.00	2.03	2.26	2.44	1.86	2.45	2.19	2.04
	2000	2.02	1.90	1.84	2.27	2.25	2.24	2.36	2.17	2.00
Richness	1999	0.92	0.90	0.82	0.95	0.92	0.85	0.96	0.89	0.85
	2000	0.96	0.896	0.856	0.98	0.91	0.85	0.98	0.88	0.87
Evenness	1999	0.72	0.75	0.73	0.75	0.81	0.75	0.75	0.79	0.71
	2000	0.72	0.69	0.64	0.72	0.73	0.72	0.74	0.72	0.64

4 Discussion

In Gujarat, particularly in Kachchh district, monsoon is predicted by the hot dry weather prevailing in the months of March - June. The rain sets in over most of the Gujarat between late June and September. October and November constitute the early winter. It does not rain in October (GUIDE, 1999). The months of December, January and February are practically rainless. Kachchh district experiences typical ‘Monsoon climate’ with rainy season confined to the four months from mid June to September (GUIDE, 2000). The surface water temperature ranged from 17 ℃ to 37 ℃. There was a steady increase in temperature from March to June, which peaked in May and very low temperature of 17°C was recorded in winter. All stations showed a similar trend with similar seasonal variations. Generally, surface water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mixing up with ebb and flow from adjoining neritic waters. In the present study, summer peaks and monsoonal troughs in air and water temperatures were similar to those reported in the western coast of India (Desai, 1992 and Arthur, 2000). The salinity acts as a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation influences the fauna most likely in the intertidal zone (Gibson, 1982). In the present study, salinity at all the sites was high in summer and low in the monsoon season. Higher values in summer could be attributed to faster evaporation in the study area. Though perennial rivers are absent, the run off due to rains during the monsoon season could reduce the salinity. Thus, the variation of salinity at study sites is probably due to freshwater run off entering the creek systems as reported by Vijayalaksmi *et al.* (1993) for the Gulf of Kachchh and Saisastry and Chandramohan (1990) for the Godavari estuary. In the present investigation, dissolved oxygen was high in monsoon season at all sites, which might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing. Relatively lower values were in winter, which could be mainly due to reduced agitation and turbulence of the coastal and creek waters. De Souza and Gupta (1986) and Zingde *et al.* (1987) have attributed seasonal variation of dissolved oxygen mainly to the freshwater influx and ferriginous impact of sediments. It is well known that the temperature and salinity affect the dissolution of oxygen (Vijayakumar *et al.*, 2000). Hydrogen ion concentration (pH) in surface waters remained alkaline at all sites throughout the studying period with the maximum value in summer and winter seasons and the minimum in monsoon. Generally, fluctuation in pH values during different seasons of the year are attributed to factors like removal of CO_2 by photosynthesis through bicorbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter (Ragothaman and Patil, 1995; Upadhyay, 1988).

Benthic macrofaunal community is characterized by temporal and spatial changes in the population. The benthic invertebrates were found to have a linkage with fishes through food web (Bell, 1979). In the present study, macrofaunal distribution pattern seems to be fully governed by the physico chemical and hydro-biological characteristics of the environment. Intertidal fauna at the studying area have to cope with harsh environmental conditions marked by high salinity, increased evaporation, wide seasonal temperature fluctuations and different tidal amplitudes. These unique physicochemical factors exert a strong influence on faunal assemblages subjected to such situations. The erratic rainfall pattern and the resultant land runoff of the arid climate of Kachchh imposed wide temporal changes in the salinity. Likewise, temperature fluctuation was also extreme; it ranged from 1 ℃ to 48 ℃, resembling a subtropical climatic regime. This complex interaction of limiting factors renders the intertidal habitat of the studying area stressful. Thus, it is evident from the study that the physico-chemical factors, rather than the biological factors, have much influence on the faunal assemblages. However, fluctuations in the population size and density of the component species of the intertidal macrofauna were moderately pronounced, barring season-related reproductive and recruitment changes. This is possibly due to the inherent adaptations of this faunal component to the prevailing milieu.

Species composition of the benthic macrofauna in the present observation showed dominance in the order of polychaetes, crustaceans, molluscs (gastropods and bivalves) and fishes as was observed earlier by Ansari *et al.* (1986), Mohammed (1995) and Kumar (2001). In the present study, the macro benthic faunal density ranged from 424 ind.m^{-2} to 2393 ind.m^{-2} at all stations. This density was higher than the macrobenthic faunal densities reported by Parulekar and Waugh (1975) in the Zuari eatuary (50 to 1437 ind.m^{-2}) and by Parulekar and Ansari (1981) in the Andaman seas (80 to 998 ind.m^{-2}). It is comparable also with that reported by Harikantra *et al.* (1980), 50 to 3715 ind.m^{-2}, in the shelf region along the west coast of India. However, the density we observed is lower than 1253 to 5723 ind.m^{-2} reported in northwestern Arabian Sea shelf by Parulekar and Waugh (1975) and Salzwedal *et al*. (1985) in the northern sea.

In the present study, higher density values were recorded in winter. This could be due to low temperature and turbidity coupled with stable environment of this season. In the west coast, post monsoon seasons (Nov.-Feb.) were registered by high macrofaunal density in the studies made by Ansari *et al*. (1986), Kumar and Antony (1994), GUIDE (2000) and Kumar (1995, 2001). In the present observation, low population density recorded in monsoon was apparently due to the effect of heavy rainfall. Similar to this, Seshappa (1953) reported a 'severe decline' in the shallow water macrobenthos during the southwest monsoon and the decrease was attributed to lowered salinity. This observation coincides with the previous findings of Kumar and Antony (1994) and Kumar (2001). Untawale and Parulekar (1976) reported the dominance of polychaetes in the mangrove fauna and the smaller number of molluscs in the silty clay substratum. The soft substrate of mangrove constituted by clay and silt generally favors the abundance of tube dwellers such as polychaetes, but it has an adverse effect on diggers and burrowing animals, especially bivalves. The dominance of polychaetes is also due to firm substrate provided by roots and dense canopy of the mangroves which provide protection against desiccation, which enabled polychaetes to flourish since they are more opportunistic in their potential to colonize stressed habitats (Divakaran *et al*., 1981; Mishra and Choudhury, 1985). High vegetation cover with good canopy index of the present study sites favours colonization of polychaetes at all stations. Polycheates in general are endowed with greater potential to colonize habitats marked by extreme physico-chemical conditions (Pearson and Rosenberg, 1978). The above mentioned adaptable nature of polychaetes may be a plausible reason for their dominance in the species composition and for their abundance observed in the present investigation. The crustaceans in mangrove environment were observed earlier by Matilal *et al.* (1986) and De (1998) in Sundarban mangrove. Crabs in mangrove habitat showed distinct distributional pattern related to substratum characteristics, salinity, degree of tidal inundation and wave exposure in the present study. Substrate characteristics were found to be the most important factor influencing the distribution and abundance of brachyuran crabs in Sundarbans and Cochin backwater mangroves (Chakraborthy and Choudhury, 1992; Kumar, 1995). In light of these studies, crabs are also known to prefer leaves of certain mangrove species, which in turn influences their distribution. Camillieri (1989) reported that leaves of *A. marina* are the most preferred over other mangrove leaves by sesarmid crabs. Further, it is established that vegetation structure, soil properties, seaward gradient, tidal inundation, availability of food and microhabitat such as root and stem crevices are some of the factors that influence the distribution and abundance of crabs. In the present study canopy cover was dense that provided a preferred microhabitat to the crabs, especially *Seasarma* sp. and *Macropthalmus* sp. Besides crabs, other crustaceans such as mud lobster, *Thalassina anomala*, were found in association with dense *Avicennia marina* canopy patch in regions where the substratum remained water-logged. The gobiidae fishes, *Periophthalmus* sp. and *Boleophthalmus* sp., were conspicuous in such areas of mangroves where mud is semifluid. These groups were dominant at all three stations. Dominance of gobiid in such loose substratum in close association with mangroves has earlier been reported by Kumar (1995) in Cochin backwaters.

Species diversity is a simple and useful measure of a biological system. Sanders (1968) and Redding and Cory (1975) found high level of agreement between species diversity and the nature of the environment and hence regarded the measure of species diversity as an ecologically powerful tool. Moreover, Pearson and Rosenberg (1978) proposed that the use of diversity indices is advantageous for the description of faunas at different stages in the succession. Sanders (1968) postulated that the species diversity is mainly controlled by the fluctuations in the environment that lead to less diversity. Species diversity in the present study registered a wide fluctuation between 1.84 and 2.45 with stations and seasons, evidencing the dynamic nature of the mangrove habitat under investigation. The pattern of lower species diversity in monsoon and higher diversity values in winter recorded at the studying sites is in conformity with the earlier observations of Vellar (Chandran, 1987) and Coleroon estuary (Devi, 1994). Shillbeer and Tapp (1989) stated that the mangrove environment is far more dynamic than the marine environment. Hence, a wider range of temporal variation in the diversity of the benthos as recorded in the study area of mangrove environment could be naturally expected. In the present study, richnesses of benthic macrofauna were the maximum in winter and summer. Similar observation was reported by (Kumar, 1995) in Cochin backwaters and in the east coast in Sundarban mangrove by Parulekar *et al.* (1980). The low richness recorded in this study in southwest monsoon might be due to the freshwater flow which induced low saline conditions, which in turn affected the distribution of benthos, particularly the polychaetes. Maximum diversity and richness recorded in winter at the study sites might be due to stable environmental factors, such as salinity, which play a most important role in faunal distribution.

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