

**Full Length Research Paper****Distribution and Diversity of Intertidal Macrofauna of Bandar Lengeh Coast: An Area in South of Iran**Fozieh Barkhori Mahni¹, Alireza Salarzadeh¹, and Keyvan Ejlali Khanghah²¹ Department of Fishery, Bandar Abbas Branch, Islamic Azad University, Bandar Abbas, Iran.² Department of Aquaculture, Persian Gulf and Oman Sea Ecology Research Institute.**Corresponding author: Alireza S.***Abstract**

This contribution presents the abundance and diversity of macrofauna in the pristine intertidal regions of Bandar Lengeh coast (South of Iran) during August 2013 to January 2014. The width of the beach is 15-30m, which alternates according to the tidal height. Environmental parameters like salinity, nutrients, conductivity and total dissolved salts analyzed exhibited significant correlation with macrofauna that dwells in the habitat. Gastropods (45.54%), polychaetes (10%), and annelids (43.4%) dominated in the present study. The monthly variations in abundance were displayed by dominant faunal species in various stations but did not show any seasonal variations except that of *Emerita holthuisi*, which was observed only in Feb-May and Jun-Sep months. Analysis of community indices showed monthly variations in species diversity. The peak mean species diversity was observed in station 1 in May, 2013 and Station 2 in December, 2013 and January, 2014. The spatial distribution of some organisms were not even in the study area. The sparse distribution, low richness and higher dominance of organisms were the characteristic feature of community structure. Assessing the correlation of water quality parameters to the fauna residing in study area BEST (Bio-Env + Stepwise) analysis was done and salinity showed more significance towards fauna. The highest correlation has been showed by barnacles and gastropods (0.825). The present study discussed the interaction of organisms in the selected habitat with environmental factors prevailing there along with the diversity and abundance.

Keywords: Bandar Lengeh; Intertidal macrofauna; Distribution; Diversity**Introduction**

The study of abundance of life in each ecosystem is a cognizance to everyone that how an ecosystem is performing. Intertidal zone are such fascinating ecosystems which have been pulled towards scientific community since many years. The intertidal, sometimes called the littoral zone, is defined as the part of the seafloor that lies between the highest high and lowest low tides (Castro and Huber, 2005). Being out of water and exposed to air establishes a unique nature to this environment. Intertidal zones especially the South West coast of India are harbor of distinct and specific organisms. The subsistence of intertidal habitat is almost by definition due to tides (Carefoot and Simpson, 1977, Kenchington, 1990), which are the outcome of confounded gravitational effects of the sun and moon of the oceans. Both flora and fauna found in between the intertidal zones experiencing the tidal movements, which influences the life of inhabitants there. The intertidal organisms are more prone to climate changing like sea level rise and temperature fluctuations, rainfall etc. It affects the abundance and distribution of organisms.

The distributions of organisms in the intertidal zones usually occupy only specific zones. The upper limit (high tide zone to mid tide zone) of intertidal organisms seems to be set by abiotic environmental factors like extreme temperature, prolonged exposure to air, less feeding time. In general abiotic factors set the boundaries to the range of a species within an environmental gradient (Beukema and Flach, 1995). But generally the lower limit of intertidal zone is controlled by the biological factors especially predation and competition.

The coastline of Bandar Lengeh is 90km long and endures several alterations in the near shore processes. The coast of Bandar Lengeh embraces a great variety of shores according to the coastal geography and form of the substrate. Sandy beaches are very dynamic environment. Wave, wind action, grain size and tide amplitude is the most important factors in their physical characterization (Nybakken, 1993). The intertidal macrofaunal studies have been great interest to the researchers during the mid of the 20th century. Between 1920s and 1980s shore studies were at its peak. Studies on soft shores were made by Dahl, 1952, Morton and Miller, 1968, Stephenson and Stephenson, 1972, Dayton, 1971, Menge, 1976, Peterson, 1977. In 1983 two researchers McLachlan and Brown have studied about the patchiness of sandy beach macrofauna. By following this Thrush, 1991, Morrissey et al., 1992 have been studied about the distribution and abundance of organisms including soft sediment macrofaunal patchiness.

In recent times several studies have been fashioned by the researchers to investigate community structure and diversity of the intertidal zones (Dutta et al., 2010; Singh Gohil and Kundu, 2012). In Bandar lengeh as a coastal state of Iran an approach to the study on intertidal zones and their diversity has been exhibiting a declining trend. Limited studies have been accomplished in various beaches of Bandar lengeh (Travallion et al., 1970; Philip, 1970). It would be a point of interest to explore new intertidal zones along the coast of Bandar lengeh. This as a purpose in mind, a pioneer study was undertaken on a sandy beach situated in the northern part of Bandar lengeh along the South of Iran.

Materials & Methods

Study area

Bandar lengeh beach (Long. $54^{\circ} 30' 23''$ E, Lat. $26^{\circ} 18' 35''$ N) is an exposed beach with less intense wave action. Continuous stretch of straight beach with lesser steeper profiles offers the area a unique impression (Figure 1). Two stations were selected for the study. On both stations sandy characters are predominate. But at station 2 mixed type of sediment composition is persists. Fine sand adhering with scattered laterite rock formation gives the beach a unique appearance. The beach boards an array of macrofauna. Before assaying the abiding macrofauna, the reconnaissance of environmental factors were carried out.

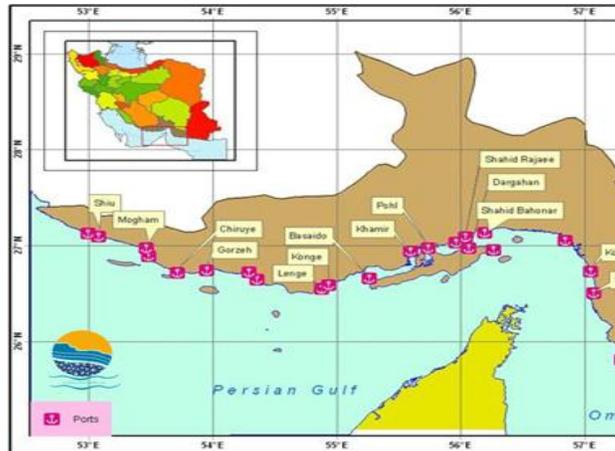


Fig 1: Map showing location of study area

Sampling methods

The intertidal zones of Bandar lengeh beach was monitored from 2013 August to January 2014. Low tide time has chosen to sample the area. Two localities at 500m apart were selected for intensive sampling. A 15-30m transect was established from above the drift line to below the swash line with four regularly marked stations. At the précised stations a metal quadrat of 25×25 cm area were sited and the sediment within the quadrat were collected and sieved through 0.5mm mesh sieve (Anastasios Elftheriou and Alasdair McIntyre, 2005). The retained organisms in the sieve were preserved in 5% buffered formalin and conveyed to the lab for sorting. The organisms present in the sediment were sorted out, preserved and identified.

In addition to the faunal component the measurement of water and sediment samples from the picked zones were also collected to analyze different physico chemical parameters. Temperature of the sediment was measured by using a centigrade thermometer. Dissolved oxygen was estimated according to Winkler's method (Grasshoff et al., 1983). Salinity was measured by using a Systronics water analyzer (Model No. 317; accuracy ± 0.01) calibrated with std. seawater (APHA, 2005). Conductivity was recorded by Systronics digital potentiometer (Model No.318). Turbidity, pH, and TDS were measured by using Systronics water analyser (Model No.317) Tidal heights were estimated from predicted tide tables. Long shore currents were measured by releasing a plastic bottle top to the water and determined the time for it to travel one meter. Three consecutive readings were taken.

Analysis of data

Diversity indices were computed according to Shannon-Wiener diversity (H') and Pielou's evenness index (J') by using PRIMER Vs. 6.0 (Clarke and Gorley, 2006). Statistical analysis like BEST (Bio-Env + Stepwise) analysis for finding out the combination patterns that best explains the biological data. The BEST analysis gives the 'best' match between the multivariate among-sample patterns of an assemblage and that from environmental variables associated with those samples (Clarke and Gorley, 2006). Draftsman scatter plot were also done to find out interaction between organisms.

Results

Environmental factors

The important environmental characteristics were as follows: Tides are semi diurnal type with maximum tidal amplitude of 1.3m and a minimum of 0.01m. The speed of the long shore current varied from 0.023m/s – 0.034m/s. Among water quality parameters temperature, pH, and salinity of sand varied from 25-34 $^{\circ}$ c, 25.5-32 $^{\circ}$ c, 7-8.31, 6.48-8.32 and 34-43ppt, 33-45ppt at station 1and2 respectively. The particle size showed dominance of sandy grains. The percentage of sand varied from 37.4-99.2%.

Distribution and abundance of macro fauna

Thirty four species of macro invertebrates were obtained from the stations during sampling. Among the identified samples, gastropods, tanaids, and polychaetes formed the dominant organisms in order of faunal composition. The number of tanaids (43.4%) was highest at all months at station1 when compared to other groups whereas in station 2, gastropods (45.54%) were dominant. The obtained species and their abundance from high to low water mark are given in Table 1. The distribution of organisms from high tide to low tide marks was almost consistent throughout the sampling. Around high tide zone of the studied sites were characterized with burrows of ocyopde crabs. The amphipod (*Pontocrates altamarinus*) occurred in a zone around mean high water at the time of the collection and the sea star, *Astropectan irregularis* was spotted at about these tidal levels at both the stations.

Table 1. Counts of Macrofauna from high tide to low tide

Species	Station 1	Station 2	Qua1		Qua2		Qua3		Qua4	
			St1	St2	St	St2	St	St2	St	St2
POLYCHAETES										
<i>Scolecopsis squamata</i>	23	46	7	5	1	11	6	7	7	23
<i>Glycera longipinnis</i>	5	4	2	1	1	1	1	2	1	
<i>Paranoides</i> sp.	1	-	1	-	-	-	-	-	-	-
<i>Prionospio ehlersi</i>	11	3	-	3	-	-	11	-	-	-
<i>Prionospio</i> sp.	3	29	-	28	-	-	3	-	-	1
<i>Glycera</i> sp.	4	-	1	-	1	-	2	-	-	-
<i>Prionospio sexoculata?</i>	1	4	-	4	-	-	1	-	-	-
<i>Owenis</i> sp.	1	-	-	-	-	-	1	-	-	-
<i>Spio filicornis</i>	1	-	-	-	1	-	-	-	-	-
<i>Nereis</i> sp.	2	-	2	-	2	-	-	-	-	-
<i>Nereis willeyi</i>	-	2	-	2	-	-	-	-	-	-
<i>Prionospio cirrobranchita</i>	-	1	-	1	-	-	-	-	-	-
<i>Prionospio pinnata</i>	-	6	-	-	-	6	-	-	-	-
<i>Prionospio saldanha</i>	-	1	-	-	-	1	-	-	-	-
CRABS										
<i>Ocyopde</i> sp.	2	12	1	-	1	6	-	1	-	5
Juvenile of Ocyopde crab	23	7	6	-	7	-	5	4	5	3
Megalopa of Ocyopde crab	3	17	-	-	2	3	1	-	-	14
Megalopa of <i>Emerita holthuissi</i>	19	83	-	-	-	11	19	52	-	20
Megalopa of <i>Emerita talpoida?</i>	-	16	-	-	-	-	-	14	-	2
ISOPODS										
<i>Eurydice peraticis</i>	45	14	15	7	20	5	10	1	-	1
<i>Sphaeromopsis</i> sp.	-	2	-	2	-	-	-	-	-	-
AMPHIPODS										
<i>Pontocrates altamarinus</i>	12	68	-	-	-	-	1	50	11	18
TANAIDS										
<i>Tanzanapseudes</i> sp.	203	72	56	26	52	23	71	3	24	20
HERMIT CRABS										
<i>Diogene</i> sp.	-	65	-	15	-	30	-	-	-	20
MYSIDS										
	12	16	-	-	-	-	8	16	4	-
ECHINODERM										
<i>Astropecten irregularis</i>	4	2	-	-	1	-	2	1	1	1
<i>Psammechinus milaris</i>	-	10	-	-	-	-	-	2	-	8
MOLLUSCS										
<i>Donax</i> sp.	1	-	-	-	-	-	1	-	-	-
<i>Nassarius</i> sp.	4	8	-	-	-	-	2	8	2	-

<i>Turricula</i> sp.	-	4	-	-	-	-	-	2	-	2
<i>Littorina</i> sp.	-	161	-	161	-	-	-	-	-	-
<i>Turbo</i> sp.	-	30	-	12	-	18	-	-	-	-
<i>Patella</i> sp.	-	3	-	2	-	1	-	-	-	-
<i>Natica genuosa</i>	-	4	-	-	-	4	-	-	-	-
<i>Cymasium</i> sp.	-	10	-	-	-	10	-	-	-	-
<i>Bufo</i> sp.	-	8	-	-	-	8	-	-	-	-

Note: X-species present, Qua-Quadrate, Qua 1-High tide zone, Qua 2 & 3- Mid tide zone, Qua 4- Low tide zone

On the rocky fragments of high tide zone, gastropods especially *Littorina* sp. was abundant at station 2. The mid region of the intertidal zone was characterized by several polychaete worms, commonly *Scolelepis (Scolelepis) squamata* at both the stations, whose distribution extends down into the surf zone. Mid tide region was blessed with different kinds of macrofauna, *Donax* sp., mole crab larvae, and other crustaceans, like mysids etc. Low tide region was dominated by echinoderms, polychaetes and some gastropods like *Turricula* and *Nassarius* sp.

Macrofaunal diversity based on diversity indices

Spatially community indices varied from month to month at any given station. Species diversity varied from month to month at both the stations. Highest species diversity was observed in May, 2013 at station 1. As shown in the Figure 2, October shows zero values in diversity indices. This clearly enlightens the interruption of sampling due to heavy rain in that month. None of the organisms were obtained except dead shells and broken pieces of organisms.

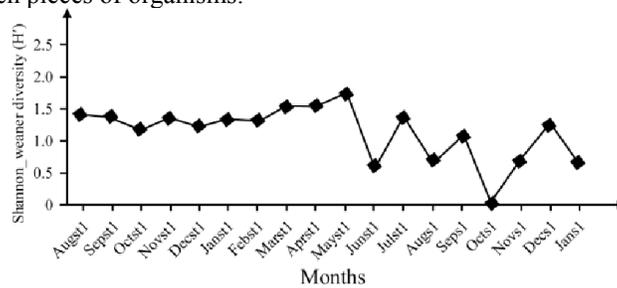


Fig 2. Monthly variations of macrofaunal diversity at station 1, Bandar lengheh beach

The low species diversity in the month of June 2013 at station 1 was mainly due to the abundance of larvae of *Emerita holthuisi* (Figure 2). This may be due to high reproductive periodicity of organism during this month. At station 2, in Bandar lengheh beach the highest species diversity was observed in December, 2013 and January 2014 (Figure 3). Species diversity is interrelated with relative species abundance in a community (Whittaker, 1965; Hulbert, 1971). The abundance of tanaid and polychaete species in the study area clearly showed the probability of less species diversity of that area.

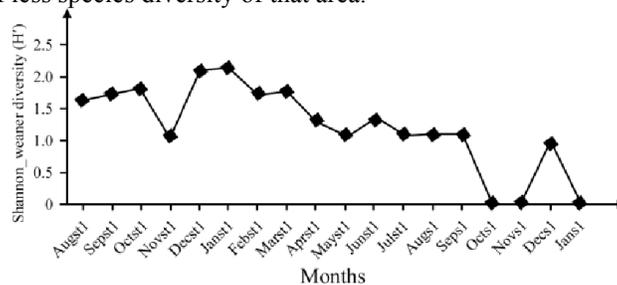


Fig 3. Monthly variations of macrofaunal diversity at station 2, Bandar lengheh beach

One or few species dominating a community shows low evenness while those that have more even distribution have a high evenness. The species evenness observed in the Bandar lengheh beach agrees with the statement (Figure 4 & 5). The distribution of organisms was not even in monthly observations. The overall community shows low species evenness.

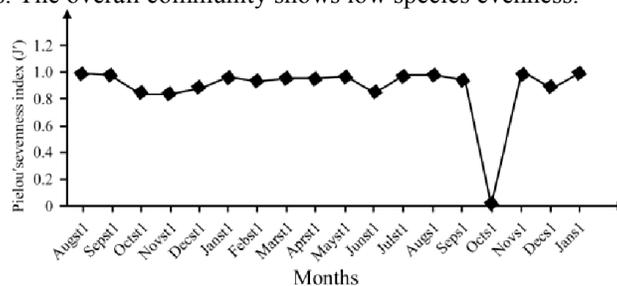


Fig 4. Monthly variations of species evenness at station 1

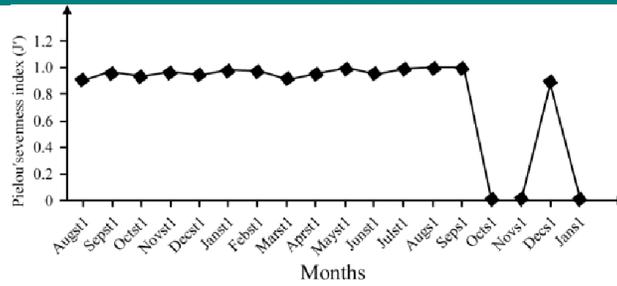


Fig 5. Monthly variations of species evenness at station 2

Faunal interactions based on statistical analysis

BEST analysis was carried out to check the influence of water quality parameters on total groups collected from the beach on monthly basis. The results showed that the BEST correlation coefficient (Rho) for total groups from Bandar lengh beach was 0.139 (Figure 6, Table 2). The variables are environmental parameters and the selected variables for each parameter have been displayed according to their SI No. (Table 2).

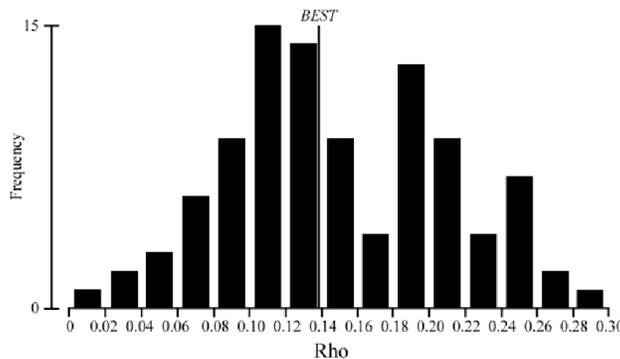


Fig 6. Histogram showing the BEST results of total groups (Rho 0.139)

Table 2. BEST results for total groups

S No.	Variables	Variables selected	Best correlation values (rho)
1	Temperature	3,6,11,12	0.139
2	pH	6,9,11	0.136
3	Salinity	3,6,9,11	0.133
4	Carbon di oxide	6,11,12	0.133
5	Dissolved Oxygen	6,9,11,12	0.131
6	Conductivity	3,6,9,11,12	0.127
7	TDS	3,6,11	0.121
8	Turbidity	3,11,12	0.108
9	Phosphate	3,6,7,11,12	0.108
10	Silicate	6,11	0.107
11	Nitrate	3,6,7,9,11,12	0.102
12	Nitrite	3,6,7,9,11	0.102

According to the BEST results, among the twelve water quality parameters were analyzed from the study area, six (salinity, nitrate, nitrite, conductivity, total dissolved salts) showed significant correlations with the fauna (Figure 7 & Table 2). The highest significance has been shown by salinity.

The dynamics of an ecosystem has been determined by the interactions between and within the communities. The significant correlation has been showed by some groups. Barnacles and gastropods showed high significance (0.825) followed by bivalves and gastropods (0.660), mysids and amphipods (0.599), tanaids and polychaetes (0.517).

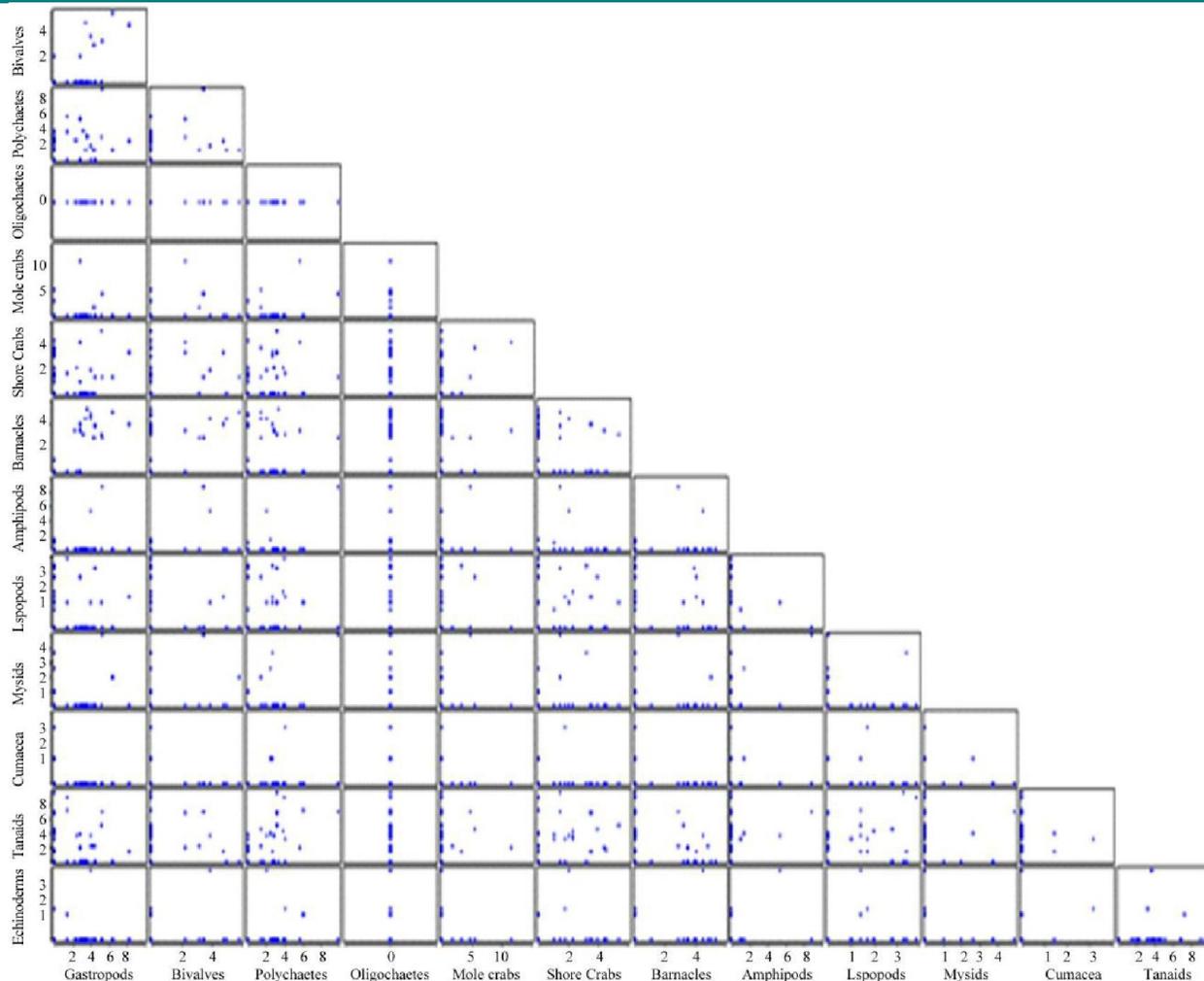


Fig 7. Draftsman plot showing correlations between faunal groups for all the stations

Discussion

Abundance and Influence of environmental gradients on macrofauna

The life and living in these zones are big challenges to the animals here. They are persistently facing fluctuating salinity, drying out by wind and sunlight, predators, strong currents that carry them back to the sea and changing weather conditions. Sedimentation, light, moisture, and temperature variations are also common.

As a first study on that beach, this reveals that the beach system supports high abundance of two or three species which has led to less species richness as well as low species evenness. The abundance of tanaids found almost all the months. Other organisms observed to be polychaetes (*Scolecipis (Scolecipis) squamata*) and gastropods formed the dominant group of organisms. Communities with a large number of species that are evenly distributed are the most diverse and communities with less species that are dominated by one or few species are least diverse. Some studies revealed that sandy beach ecosystems wherein species evenness and diversity are influenced by the population dynamics of numerically abundant species. (Holland and Polgar, 1978; Dexter, 1984). The present study agrees with this statement. Among groups polychaetes (14 species were observed from two stations) and gastropods (9 species) have shown high species richness but the overall community showed lesser species. Sandy beach macrofauna is controlled by interaction between different factors (Sivadas et al., 2012). They could be abiotic and biotic factors.

According to Bortone (2005), the salinity range of *Scolecipis squamata* was 25-40ppt. In this study also the range of salinity at station1 was 34-43ppt (the abundance of *Scolecipis* species is more in station 1). *S. squamata* is known to tolerate oscillations in salinity (Rizzo and Amaral, 2001). This could be one of the reasons for the abundance of species in that area. The results of BEST analysis clearly illustrates that salinity has high significant correlation with fauna that resides there. Except for other fauna, only mole crabs have the direct correlation with tidal heights. Being tidal migrants as tide advances it goes up to the beach and as tide recedes it follows the tide towards lower depths. Variations of abundance of dominant faunal species were significantly different in various stations (polychaetes at station1 and gastropods at station 2) but they did not show any differences between seasons except larvae of mole crabs (*E. holthuisi*).

Fauna in relationship with environmental variables: A statistical approach

Different statistical analysis clearly showed the similarities and significance of organisms that live there. From the BEST (Bio-Env + Stepwise) analysis it was inferred that salinity, nitrate, nitrite, conductivity, phosphate and TDS were the best matching variables for total groups on monthly basis. The present study reveals that water temperature and dissolved oxygen are not at all a limiting factor for the organisms in the area. But the present study showed that gastropods were present in almost all seasons. The interactions between some organisms were shown in Draftsman plot (between barnacles and gastropods). In a harsh environment like intertidal zone the interaction between organisms and environment variables is a must for the healthy survival of the organisms. These may be for feeding, shelter, or to escape from predators.

Diversity values are influenced by the values of evenness and total number of species. The dominance of two or three species affected the diversity of the beach system. The observations on abiotic and biotic factors clearly show that they directly or indirectly influence the organisms that persist there. In a heterogeneous habitat such as intertidal region the abundance and diversity of organism changes continuously according to the abiotic, biotic and climatic conditions that persists there (Harkantra and Parulekar, 1985). Being a dynamic system the beach environment is changing continuously. Anthropogenic activities also fasten the habitat destruction. A proper assessment of composition of organisms and the environmental properties of the beach is necessary for future management and protection of whole beach ecosystem.

Conclusion

Results of the present study indicated that there were no significant spatial variations in the species diversity of major macrofaunal phyla. This is possibly due to the fact that the shores studied are situated along the same continuous coastline and share common coast characteristics. Significant temporal variations in the faunal diversity of few phyla were observed indicating that the varying environmental factors do have a cumulative influence on the distribution pattern of the benthic organisms.

Acknowledgements

Authors are thankful Mr. Mortazavi, the dear chief and Mr. Deghani the deputy of persian gulf and oman sea ecology research institute that this research was performed at this institution, and also we acknowledge Mrs. M. Moezi that helped us so much for providing necessary facilities.

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