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Research Article

Analyses of macro benthic fauna in rocky habitats along the coast of Bushehr, Persian Gulf, Iran

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Abstract

The present study considers community variability and structure at taxa-groups of macro-fauna. Sampling was carried out in three seasons at three zones in intertidal rocky shores of Bushehr, Persian Gulf. In this study, 1936 individuals belonging to 66 species were collected. These are classified into 12 groups. The mollusks were abundant in all three sites in winter and also low zone in all seasons. In contrast, Portunid crabs and Polychaets were the lowest abundant groups. All zones in three stations were occupied by mollusks and were dominated by *Planaxis sulcatus* and hence the community is named "*P. sulcatus* ". Due to habitat diversity, the most abundant decapod groups were xanthoid and porcelanid crabs.

Keywords: Biodiversity, Rocky shore, Persian Gulf, Iran

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Introduction

The marine areas around the world are threatened by human activities (Halpem *et al*., 2008). The coastal areas of Bushehr Province, Persian Gulf, Iran, are not exempt and affected by activities including construction of oil platforms such as south and north Parses and Emam-Hassan port in vicinity of the Khark Island, the main oil port of Iran. In the eastern part of province, the Nayband Marine Coastal Natural Park is located which was studied recently by Badri (2007) and had been identified 8 species of echinodermata in Khark and Karkho islands and Nayband Bay, Ashja-Ardalan *et al.* (2011)

Ashja-Ardalan *et al*.(2011) had been identified 97 species of mollusks, nine species of crabs and 6 species of Echinodermata, and Kohan *et al*. (2012) studied gastropods and reported community of *Planaxis sulcatus*. The other studies on Bushehr coastal waters include Sharifipour *et al*. (2005) on evaluation of ecological susceptibility, Vazirizadeh *et al*. (1997) on benthos from Bushehr intertidal zone, Azizi (2007) on biodiversity and identified 57 species of bivalvia in Khark and Karkho islands and Nayband Bay, and Savari *et al*. (2010) on Decapods, Vazirizadeh *et al*. (2011) on faunal community as an indicator of sewage pollution, Aarebi *et al*. (2012), Boulder type to be influenced by pollutions and Bandar-Rostami very polluted, Vazirizadeh *et al.* (2012) studied ecological assessments of mollusks and found out community of *P. sulcatus* and reported high diversity in Nayband Bay. Nourinezhad *et al.* (2013) emphasized on macro-fauna, Naderloo *et al*. (2013), on hermit crabs, Dabbagh *et al*. (2012), on first record of *Holothuria scabra*, Farsi (2013) on biodiversity of Inter- and subtidal macrobenthic assemblages, Shahdadi *et al.* (2014) considered current status of intertidal barnacle in Persian Gulf and Gulf of Oman, Aghajanpour *et al.* (2015) on combining biological and geomorphological data in order to identify the biotopes and Nateghi-Shahrokni *et al*. (2016) on echinoderm fauna. Overall, Intertidal rocky shores are considered as biodiversity hotspots (Naderloo *et al*., 2013) some of which are threatened by major developments and anthropogenic born pollutants interacting with these vulnerable ecosystems. Macro-faunal community composition is a valuable index for biotope comparison. The previous studies were mostly devoted to taxonomy and ecology, and therefore there was a need for current knowledge about population variability and habitat diversity. The shoreline of Bushehr province comprised of several typical intertidal habitats including rocky, muddy, sandy, and rocky/sand. These habitats are home to variety species. Therefore, the aims of this study were to demonstrate distribution of benthic macro-fauna in different intertidal levels from high tide to low tide zone and habitat diversity using community structure.

Sampling methods

The present study was carried out in three intertidal locations at Bushehr

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Province, Persian Gulf, Iran in three seasons including winter and summer 2014, and spring 2015. These were selected based on substrate types. From east to west, these are Shirinu; N 27˚ 37' 10.5", E 52˚ 28' 48.5", Bandar-Amerie; N 28˚ 30' 11.6", E 51˚ 05' 41.9" and Bonak; N 29˚ 43' 53.4", E 50˚ 19' 47.7" (Fig. 1).

Sampling locations

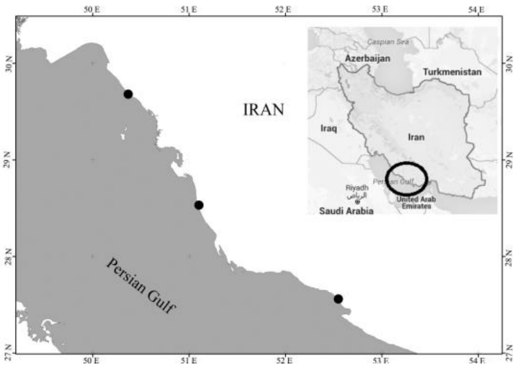

Figure 1: Sampling locations in Bushehr province, Iran.

Samplings were carried out at the lowest low water~~s~~ levels of the spring tides. The tide tables were obtained from official site of Easy Tide (www.1ukho.gov.uk/easytide). The Physical properties of the localities were similar, comprising bedrock, boulder and cobble with little or no sediment on substrate.

Sampling

In each location, samples were collected from upper, mid and lower intertidal zones using three random quadrates 0.25 m^2 at each zone perpendicular to the coastline. In quadrates, all taxa including mobile, encrusting and hidden in rock crevices were collected. Samples were first separated and then transferred to the laboratory. Finally, specimens were identified to the lowest possible taxonomic level and their abundances were recorded. The use key for identification of: Molluska (Bosch *et al.*, 1995) and the others species identified by Naderloo and Nateghi-Shahrokni. Geographical positions were recorded by hand-held GPS (GPSMAP® 78_S).

Statistical analyses

The univariate and multivariate analyses were carried out using SPSS (v.18) and PRIMER 5, respectively. The multivariate analyses include Multidimensional Scaling (MDS), K-dominance curves, cluster SIMPER analysis. Normality was tested using the Shapiro-Wilk's test. Comparisons of observed frequency were considered none significantly differen~~t~~ces at a level of p>0.05 and therefore analysis was carried out by nonparametric test. The discriminant analysis was applied to consider species compositions between three locations. The SIMPER and ANOSIM routines were applied within the PRIMER v5.0 software package (Clarke and Gorley, 2001) to investigate community variability and structure in taxa-groups and order levels. Macro-faunal communities assessment based on dis-similarities were evaluated using multidimensional scaling (MDS) and analyses of similarity. In both analyses, Bray-Curtis similarity indices were calculated.

Due to scarcity and lesser abundances of some species, using variable analysis, associated taxa were recognized and pulled together (Table

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1). This resulted in revealing to 12 groups, which is used for community structure evaluations.

Based on frequency distribution of taxa group on each zones per locations, the partial frequency of groups are illustrated.

Result

This study revealed that the intertidal zone at Bushehr province considered a rich fauna. In total, 1936 individuals from 216 quadrates (0.25 m ^{2}) covering 54 m^2 of benthic macro-fauna have been recorded. The results have been classified into 12 groups consist of 66 species (Table 1).

Table 1: 12 taxa groups recorded in each location during three different seasons in 2014-2015.

Season	Station *	zone	Anaemons -Sponges	Mollusks	Polychaeta	Barnacles	Alpheid shrimp	Xanthoid crabs	Porcellanid crabs	Portunid crabs
Winter	1	High		*						
Summer	1	High		*				*		
Spring	1	High		*				*	*	
Winter	1	Mid		*			*		*	
Summer	1	Mid		*				*		
Spring	1	Mid		*				*	*	*
Winter	1	Low	*	*			*	*	*	
Summer	1	Low	*	*		*		*		
Spring	1	Low		*						
Winter	2	High		*						
Summer	2	High		*	*			*		
Spring	2	High		*						
Winter	2	Mid		*		*			*	
Summer	2	Mid		*				*		
Spring	2	Mid		*				*	*	*
Winter	2	Low		*						
Summer	2	Low		*			*	*		
Spring	2	Low	*	*				*		
Winter	3	High		*		*				
Summer	3	High		*		*		*		
Spring	3	High		*						
Winter	3	Mid		*						
Summer	3	Mid	*	*		*		*		
Spring	3	Mid	*	*		*		*		
Winter	3	Low		*						
Summer	3	Low	*	*	*	*		*		
Spring	3	Low	*	*		*		*	*	

Table 1 continued:

Season	Station *	zone	Grapsid crabs	Other crabs	Other Crustaceans	Echinoderms
Winter	1	High				
Summer	1	High		*		
Spring	1	High			*	
Winter	1	Mid				*
Summer	1	Mid		*	*	*
Spring	1	Mid				
Winter	1	Low		*	*	*
Summer	1	Low				*
Spring	1	Low				
Winter	2	High	*			
Summer	2	High			*	
Spring	2	High				
Winter	2	Mid				
Summer	2	Mid				
Spring	2	Mid	*		*	
Winter	2	Low				
Summer	2	Low				
Spring	2	Low		*		*
Winter	3	High		*		
Summer	3	High				
Spring	3	High	*			
Winter	3	Mid				
Summer	3	Mid		*		
Spring	3	Mid		*	*	*
Winter	3	Low				
Summer	3	Low		*		
Spring	3	Low		*		*

* 1. Shirinu, 2. Bandar-Amerie, 3. Bonak

We observed, based on presence and absence of taxa at 12 groups, that the mollusks are abundant in three sites in all seasons and Portunid crabs and Polychaets are the least abundant groups. The dominancy of taxa groups were as follows:

Mollusks >Xanthoid crabs > other crabs >Barnacle>Porcellanid crabs, Anemones/Sponges, Echinoderms >Peracarid>Grapsid crabs, Alpheid shrimps>Portunid crabs>Polychaeta.

In total, 66 species are recorded in all seasons and localities. The species composition for the groups is shown as the presence and absence of species. This includes 44 species of mollusks (bivalves, gastropods and chitons). Others presented as echinoderms and major crustaceans. Anemones and sponges were considered as one group because of low density and their habitat similarity.

Due to habitat diversity, crabs were divided into five groups including: Xanthoid, Portunid, Grapsid and others including less abundant ones and Porcellanids (Anomurans). The most abundant groups were Xanthoid and Porcelanid crabs.

In the winter, mollusks were dominant at the high Zone and Echinoderms at the Low and Mid Zones. In the summer, mollusks, Cirripedia (Barnacle) and other Crustacean (Xanthoid crabs) were dominant at the all zones. In the spring, mollusks and

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Xanthoid crabs were dominant at the each zone (Table 1).

In the Shirinu, mollusks were dominant at three zones. In the Bandar-Amerie, mollusks and Xanthoid crabs were dominant at all zones. In Bonak, mollusks were dominant at the high zone. At the mid zone and low zone, from abundance point of view, anthoid crabs, mollusks, barnacles and anemones were dominant and are arranged in the following taxa-groups dominancy order using table 1: mollusks>xanthoid crabs>barnacles >anemones -sponges

In the winter, at Shirinu, more taxa groups were found with relativly higher abundances. At Bandar-Amerie, the most abundant group was mollusks while others groups were less abundant. In Bonak, the most abundant taxa groups were mollusks (13%) while others were less abundant (alpheid shrimp, 2.3% and echinoderm 3%) (Fig. 2).

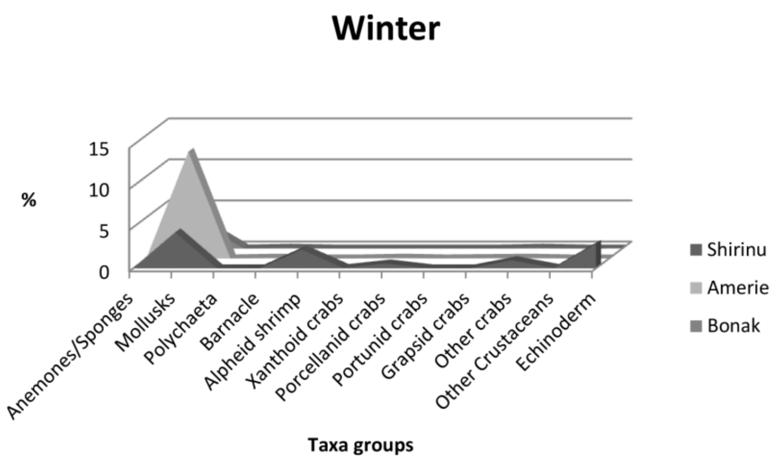

Figure 2: Abundances of taxa groups in winter 2014 for three localities.

In the summer, in Shirinu, mollusks and Xanthoid crabs were abundant. Bandar-Amerie was similar to Shirinu based on taxa group abundance. In Bonak, more taxa groups were found with relatively higher abundances. The ~~a~~Alpheid shrimp abundance was different and more than other stations (e. g. mollusks, 7.4% , barnacle,4.5%) (Fig. 3).

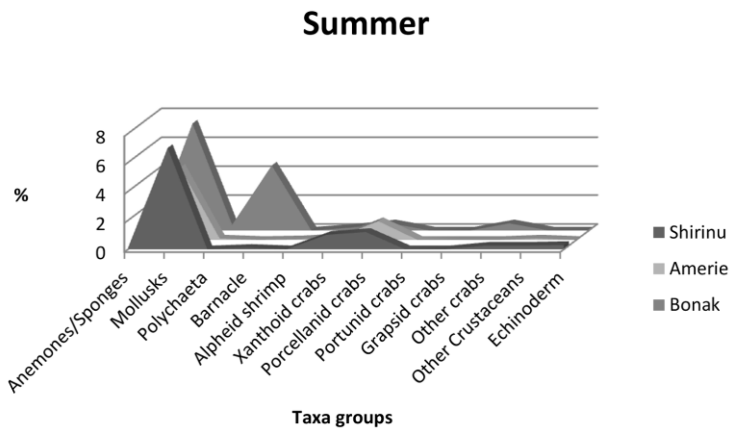

Figure 3: Abundances of taxa groups in summer 2014 for three localities.

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Results of frequency distribution (Fig. 4) show significant abundances of taxa groups in Bonak.

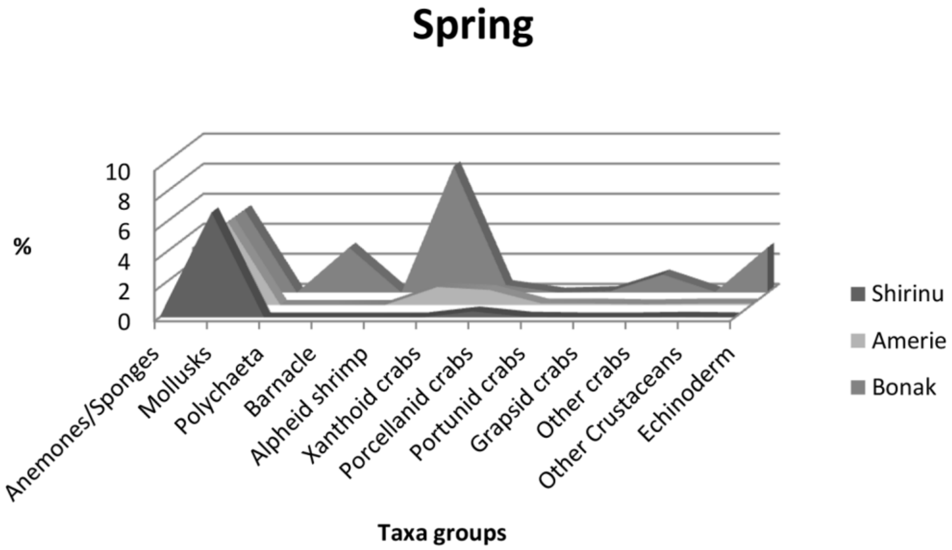

Figure 4: Abundances of taxa groups in spring 2015 for three localities.

In Bonak, six groups were found with relatively higher abundances. These are mollusks, Xanthoid, other crabs, ~~a~~Alpheid shrimp, echinoderms and Anemone-Sponge group. The Xanthoid crabs were the most abundant group (Fig. 4) in spring (8.4%) and mollusks placed in close frequency (7%).

Result of MDS, based on 12 taxa group's abundance data, showed that samples collected in summer were partially separated but in the other seasons presented overlapping and stress level indicating close similarities (Fig. 5).

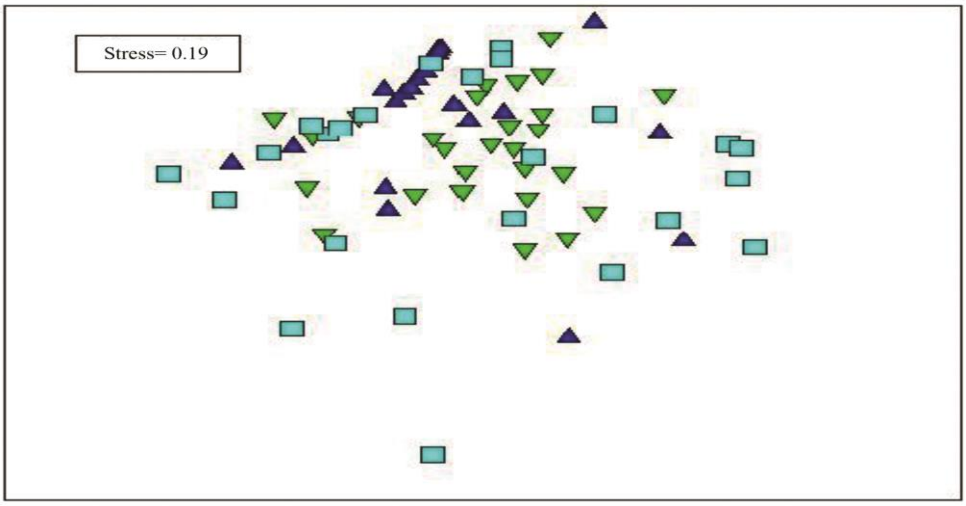

Figure 5: MDS ordination of seasons using abundance of taxa groups. ▲, Winter; ■, Summer; ▼, Spring

Table 2: One-way ANOSIM results (global and pair-wise comparison between levels of each factor) for each of factor of the factors considered (999 random possible permutations from a large number possible).

Tests (factors)	Global R	R Statistic	Significance level%
Substrate type	0.123	0.1	
boulder- cobble		0.003	33.5
boulder- bedrock		0.157	0.1
cobble- bedrock		0.213	0.1
Intertidal zone	0.03	7.6	
High- Mid		0.02	17.7
High –Low		0.088	0.7
Mid -Low		-0.021	77.9
Season	0.106	0.1	
Winter- Summer		0.107	0.2
Winter – Spring		0.103	0.2
Summer -Spring		0.116	0.2

In Table 2, results of ANOSIM tests performed to the square-root transformed data matrix considering separately three summarized factors. The results are showing high differences in substrate type have been observed in bedrock. While boulder and cobble showed this differences for community composition. For some seasons, factor plotted in Fig. 1, the level winter is equivalently different from summer and spring (R-values of the same magnitude). These results show that there were significant differences between two levels, high and low zones.

Table 3 shows the two-way crossed ANOSIM results for the two factors “substrate type” and “season” at each levels. These results show that bedrock is an important substrate type due to high diversity and also there have been significant differences between this habitat and others. Assuming substrate type as the main discriminating factor of samples here, separate analyses were performed for each level.

Table 3: Two-way crossed ANOSIM results (global and pair-wise comparison between levels of each factor) for factors considered substrate type and season of the zone intertidal factor (999 random possible permutations from a large number possible).

Tests (factors)	Global R	R Statistic	Significance level%
substrate type	0.268	0.1	
boulder- cobble		0.087	2.7
boulder- bedrock		0.288	0.1
cobble- bedrock		0.441	0.1
Season	0.239	0.1	
Winter- Summer		0.298	0.1
Winter – Spring		0.224	0.1
Summer -Spring		0.235	0.2

The SIMPER procedure for taxa abundance contributions showed that there are no main differences in three seasons (Table 4).

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Table 4: SIMPER analysis of taxa-groups contribution (%) for each group at each season according to abundances during the study period.

Taxa groups	Contribution%			Taxa groups	Contribution%		
	winter	summer	Spring		winter	summer	Spring
Mollusks	97	86.6	78	Xanthoid crabs			11
Barnacle				Porcellanid crabs		4.7	4.7
Other Crustaceans				Portunid crabs			
Polychaeta				Grapsid crabs			
Alpheid shrimp				Echinoderm			
Other crabs				Anemones/Sponges			

Also the SIMPER procedure showed differences related to substrate type in three sites. In the cobble dominated shore (Bandar-Ameri), similarity was 44 but the other substrate types presented some overlapping indicating similarities most probably due to close abundances of mollusks. While, in the substrate dominated with boulder (Shirinu) this value was 90.6 (Table 5).

Table 5: SIMPER analysis of taxa- groups contribution (%) for each group at each substrate type according to abundance during the study period.

Taxa groups	Contribution%			Contribution%		
	Boulder Shirinu	Cobble Amerie	Bedrock Bonak	High zone	Mid zone	Low zone
Mollusks	90.6	92	75	96.7	86	84.8
Barnacle			14.8			
Other Crustaceans						
Polychaeta						
Alpheid shrimp						
Other crabs						
Xanthoid crabs						4
Porcellanid crabs				4.7		3
Portunid crabs						
Grapsid crabs						
Echinoderm						
Anemones/Sponges						

There are dissimilarities in abundances among localities (Shirinu and Bonak) of the present study, which was %69. This value was 67.78 for three zones mostly between low and mid levels.

The K-dominance curves on taxa group abundances for two studied levels showed that the dominance was higher in the winter level (Fig. 6) and also it was higher in the high-shore level (Fig. 7). The differences in cumulative dominance among regions (mid and low zones) were not so strong (Fig. 7). The differences in cumulative dominance among stations showed that this value dominated in Bandar-Amerie (Fig. 8).

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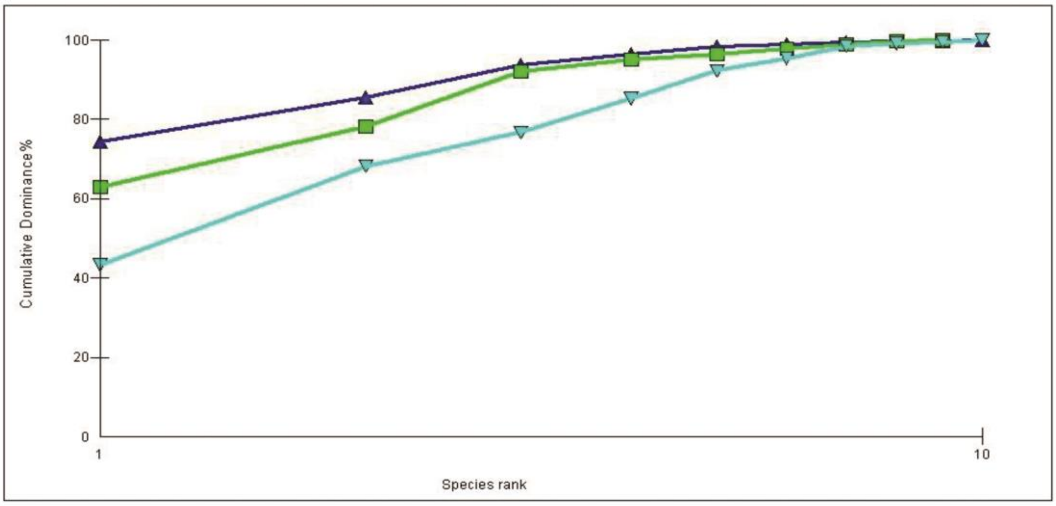

Figure 6: Cumulative dominance for season levels. Season:▲, Winter; ■, Summer; ▼, Spring.

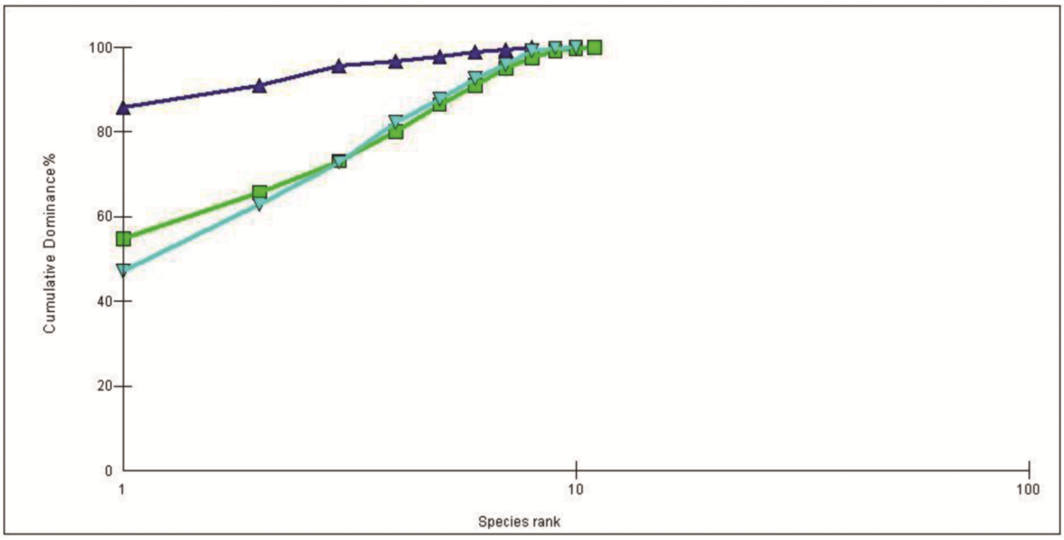

Figure 7: Cumulative dominance for zone levels. Zone:▲, High; ■, Mid; ▼, Low.

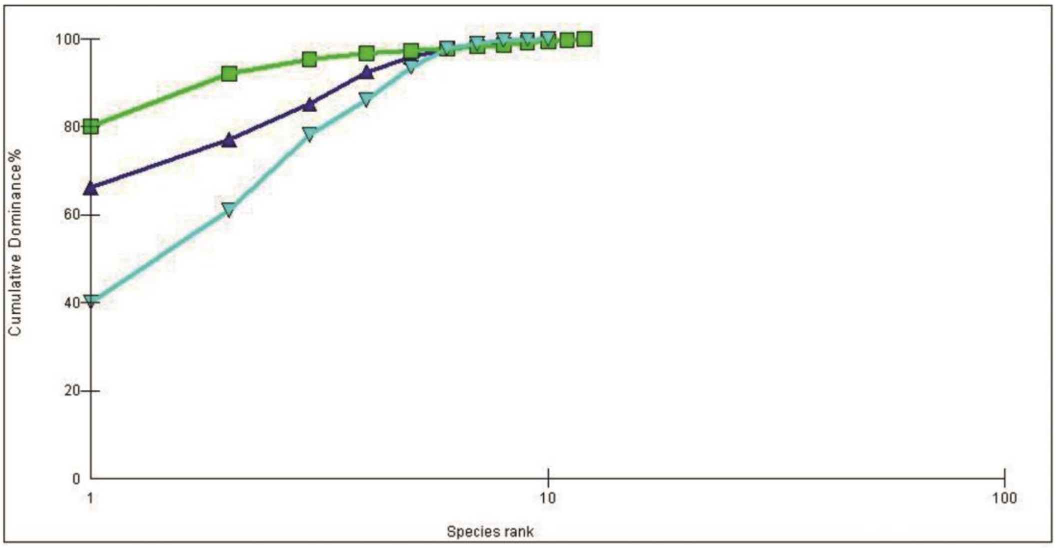

Figure 8: Cumulative dominance for stations: ▲; Shirinu, ■ ; Bandar-Amerie; ▼;Bonak.

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The studied community was included 12 macro-faunal groups. The total recorded number was 1936 individual in three locations. The maximum abundance were in winter=538, summer=602 and spring=796.

Based on data (Table 8) the frequency percentages were categorized into 12 groups (Table 6).

Table 6: Taxa group seasonal dominancy (%) (based on Bouderesque 1971, quoted by Albano *et al.*, 2009). Categories: abundant (x> 15 %), common (5% <x ≤15%), occasional (1% <x ≤ 5%), scarce (x≤ 1%).

Taxa groups	Winter (%)	Summer (%)	Spring (%)
Anemones-Sponges	scarce (0.05)	scarce (0.3)	occasional (3.5)
Mollusks	abundant (20)	abundant (20)	abundant (18)
Polychaeta	scarce (0)	scarce (0.5)	scarce (0)
Barnacle	scarce (0.2)	occasional (5)	occasional (3)
Alpheid shrimp	occasional (2.3)	scarce (0.05)	scarce (0)
Xanthoid crabs	scarce (0.05)	occasional (1.4)	common (10)
Porcellanid crabs	scarce (0.6)	occasional (3)	occasional (2)
Portunid crabs	scarce (0)	scarce (0)	scarce (0.1)
Grapsid crabs	scarce (0.05)	scarce (0)	scarce (0.2)
Other crabs	scarce (1)	scarce (1)	occasional (1.3)
Other Crustaceans	scarce (0.05)	scarce (0.4)	scarce (0.25)
Echinoderm	occasional (3)	scarce (0.3)	occasional (3.5)

Among taxa groups, mollusks have been found in all sites in different seasons with relatively higher frequencies. The Xanthoid crabs have been common in spring and scarce in winter. The others taxa were scarce or occasionally found in seasons.

Table 7: Species locational dominancy (%) (based on Bouderesque 1971, quoted by Albano *et al.*, 2009). Categories: abundant (x>15 %), common (5% <x ≤15%), occasional (1% <x ≤ 5%), scarce (x≤ 1%).

Mollusks	Shirinu (%)	Amerie (%)	Bonak (%)
Planaxis sulcatus	common (13)	abundant (19)	occasional (5)
Nerita albicilla	occasional (4)	scarce (1)	occasional (1.5)
Lunella coronate	scarce (1)	occasional (5)	scarce (1)
Xanthoida			
Epixaltnus frontalis	scarce (0.5)	occasional (4)	abundant (70)

Among species, *P. sulcatus* (mollusks) in Bandar-Amerie has been found with relatively higher frequency than Shirinu and considered as common species. *Epixanthus frontalis* (Xanthoida) found with relatively higher frequency in Bonak (%).

Based on analysis of data presented in Table 8, three locations and three zones were compared. Among 12 taxa groups in three stations, significant differences were observed in echinoderm and anemones/sponges group ($0.007 \le p \le 0.009$). The high difference was observed between Shirinu and Bandar-Amerie ($0.04 \le p \le 0.07$).

The evident significant differences at three zones were in other crabs and anemones/sponges group ($0.01 \le p \le 0.04$). In Mid-Low zones the

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most significant differences between groups were observed (0.002≤*p*≤ 0.02).

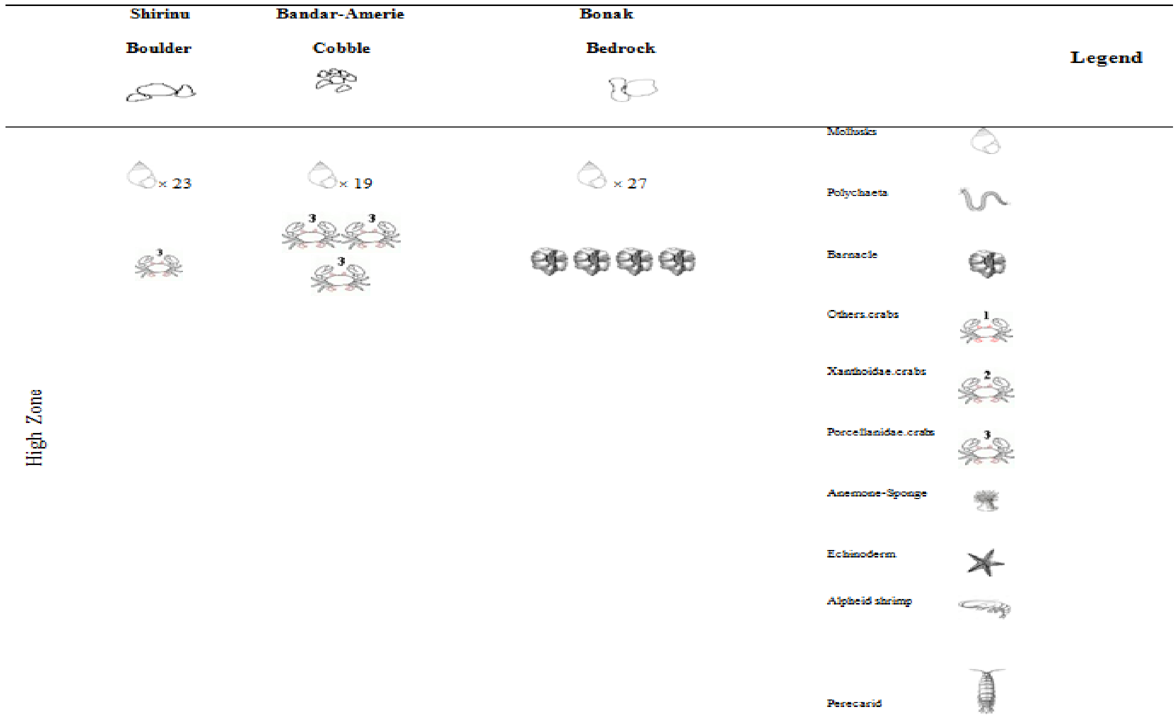
Kruskal-Wallis analysis among 12 taxa groups in three seasons showed significant differences in polychaetes, barnacle, Xanthoid crabs and Porcellanid crabs (0.03≤*p*≤0.028). The most significant differences were observed in Winter- Summer for four groups including polychaetes, barnacles, Xanthoid and Porcellanid crabs (0.04≤*p*≤0.008), while only polychaetes were found to be different among spring-summer (*p*=0.04).

Table 8: Frequency of taxa groups per zone.

station	Zone	Anemones-Sponges	Mollusks	Polychaeta	Barnacle	Alpheid shrimp	Xanthoid crabs	Porcellani dcrabs	Portunid crabs	Grapsid crabs	Other crabs	Other Crustaceans	Echinoderm
	High	0	117	0	0	0	1	7	0	0	3	1	0
Shirinu	Mid	0	143	0	0	15	1	12	1	0	2	5	16
	Low	4	96	0	2	29	18	20	0	0	14	1	49
	High	0	99	2	0	0	3	15	0	1	0	3	0
Amerie	Mid	0	130	0	2	0	8	25	2	2	2	3	0
	Low	2	213	0	0	1	16	7	0	0	1	0	2
	High	0	136	0	20	0	1	0	0	2	2	0	0
Bonak	Mid	26	48	0	42	0	54	0	0	0	20	1	25
	Low	43	124	7	85	0	112	18	0	0	14	0	40

The schematic vertical distribution of taxa grouping patterns is presented (Table 8), based on proportional dominance on the three zones of the different locations, in Bushehr province.

Table 9: Diagram of macro-fauna in three zones at three stations. Combined proportionalrepresentative of taxa group. Each sketch represents about five individual based on data in table 8. The frequency of mollusks ( ) multiplied by numbers shows number of comprising five individuals.



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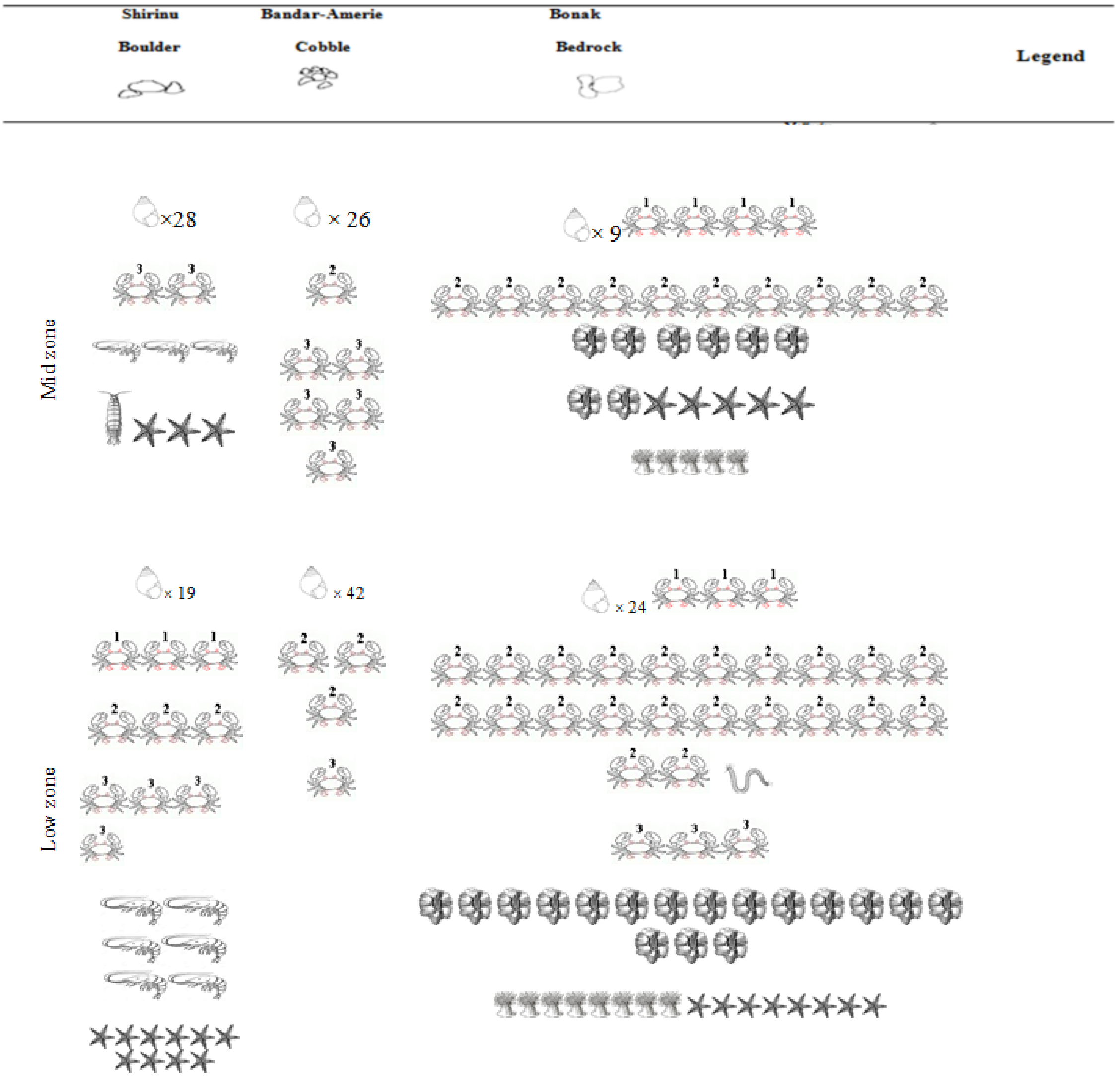

We selected the dominant groups and defined dominant species based on species' abundance to evaluate the community. Mollusks are the most common forms per locality while polychaetes have been found with low abundance. All zones in three stations occupied by mollusks and were dominated by *P. sulcatus.* Many Xanthoid and Porcelanid crabs are present and *Leptodius exeratus* (13%) and *Petrolisthes rufescens* (69%) were the abundant species, respectively.

Among these groups, some species were dominant. The most abundant mollusks were belonging to *P. sulcatus* (38%), *Lunella coronate* (7.5%), *Nerita albicilla* (6%), *Osilinus kotschyi* (6%) and others (42.5%).

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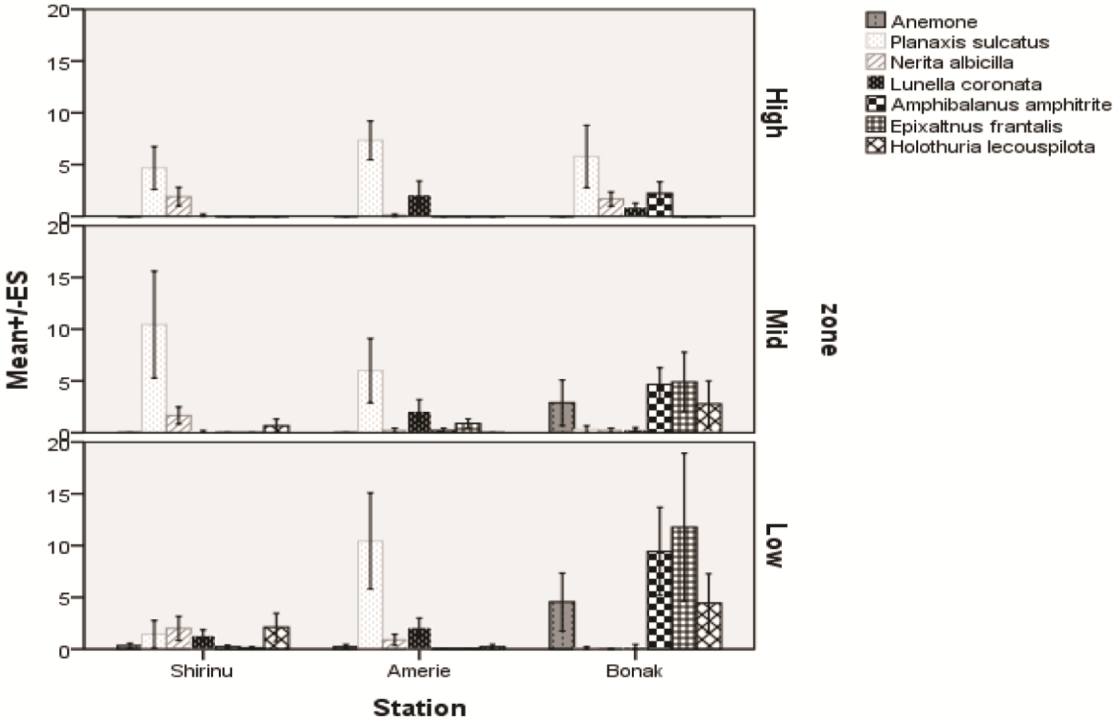

Figure 9: The mean (+/-SE) dominant species group number in high, mid and low zones for three localities. Mean based on three replicate quadrates.

In Fig. 9, the mean dominant species are shown for three zones. Among mollusks, *P. sulcatus*, *Lunella coronate* and *Nerita albicilla* were dominant species.

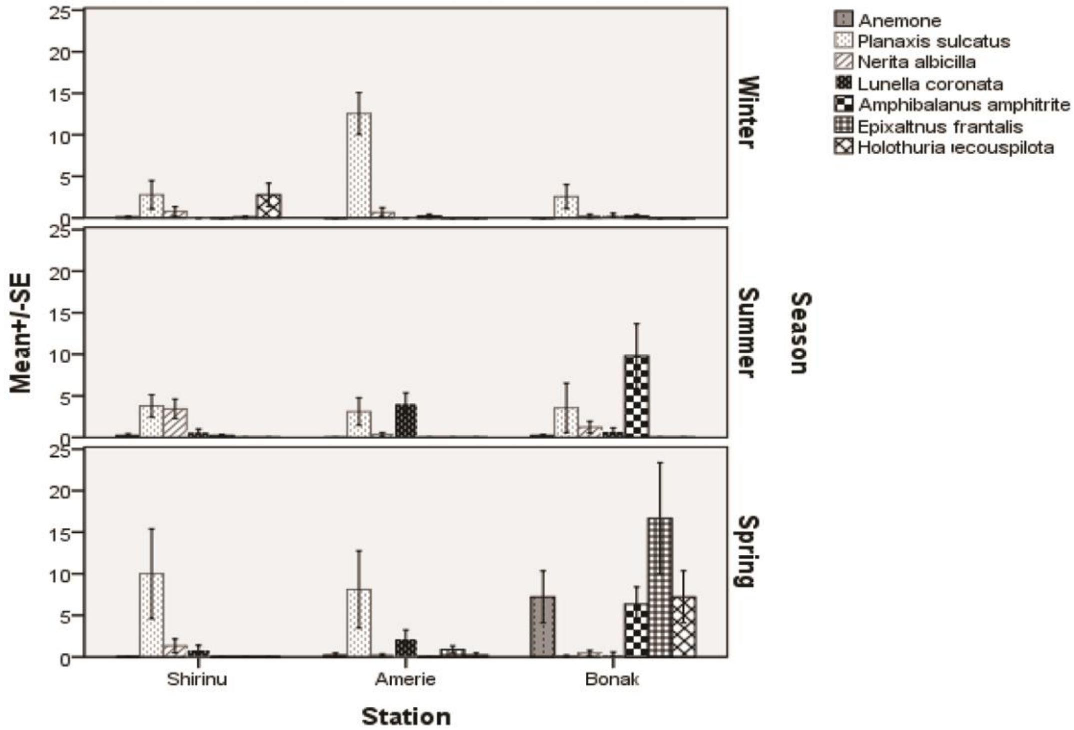

Figure 10: The mean (+/-SE) dominant species in three seasons and three localities. Mean based on three replicate quadrates.

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In echinoderms, the sea cucumber, *Holothuria lecouspilota* was dominant species.

According to data presented in Table 9, total mean numbers of mollusk in the winter were slightly higher than the other seasons. The total individuals of *P. sulcatus* in the winter were higher than the summer, and spring, showed the highest abundance whiles this value for *Nerita albicilla* and *Lunella coronate* in the winter were lower than the summer. Also in the echinoderms and Alpheid shrimp taxa groups, total individuals in the winter were higher than the summer. The individuals of *H. leucospilota* were abundant in winter. The Porcellanid crabs group was found mostly in winter. The others groups in the summer were abundant than the winter. Among the Porcellanid crabs, *P. rufescens* were almost found in the summer, only one individual was found in the winter.

In the spring, Xanthoid, Porcellanid, Portunid and Grapsid crabs, echinoderms, Anemones-Spognes groups, and other crabs show total individuals higher than the two others seasons. The total number of individuals of *P. sulcatus* represents the first major dominant species in all localities. The individuals of *E. frontalis* and *H. leucospilota* were found mostly in the spring.

Discussion

In this section we will discuss first, taxa groups are compared per stations, second total numbers of individuals in community and also species are demonstrated for each season and third, dominant species and community structure is evaluated per seasons and station.

Our previous knowledge and data, as stated in introduction, are mostly limited to faunistic studies. The present study is a survey on grouping of taxa based on abundances in intertidal zones of rocky shores.

In these localities, absence/presence data per seasons was considered to evaluate richness and total abundance in the communities. Here, due to impractical comparison of individual taxa at species level, variations among taxa group and distribution of benthic macro-fauna in different intertidal levels and seasons on rocky shores at Bushehr province intertidal zones have been considered. These types of habitats and biotope pattern has been studied less and need to be assessed to comparable substrate in the other shores from the Persian Gulf and the world (see introduction). Also, the type of shore and season seems to affect the species abundance. The diversity pattern is common in many rocky shores (Raffaelli and Hawkins, 1996; Underwood, 1997).

The variations in diversities and abundances are affected by local features of the studied shores (Cardoso *et al.*, 2011). Results of several studies in different shores indicate that some morphodynamics have affects on the coastal macrofaunal patterns (Reichert *et al.*, 2008; Van Colen *et al.*, 2009; Cardoso *et al.*, 2011). In Brazil, Cardoso *et al.* (2011) noted effects of morphodynamics such as grain size, wave height on abundance and

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biodiversity of mollusks, which were more than the values in the sheltered shores. They noticed crustaceans were dominant on exposed shores.

In current study, common taxa groups in intertidal shores of Bushehr province such as Porifera, Cnidaria, Polychaeta, Mollusca, Arthropoda and Echinodermata have been considered. The analysis of assemblages of three localities can be explained by relationship between morphodynamics (substrate types or grain size) and population of macrofauna (Cardoso *et al.*, 2011).

The substrate type in Shirinu was boulder dominated and 49 species were recorded (in nine replicated 50×50 centimeters quadrate), while Bandar-Amerie was mainly cobble by 39 species. In Bonak differentiable bedrock were recorded with 39 species (Personal observation N.A). The Rocky stations bearing crevices and rock pool provide better living opportunity for taxa. In similar study by Azizi (2007), 57 bivalve species were identified in the Nayband Bay. Later, in Khark and Kharku Islands, Badri (2007) identified eight species of Echinoderms. Ashja-Ardalan *et al*. (2011) identified 97 species of mollusks, nine species of crabs and six species of Echinoderms at Shirinu, one of the localities at present study.

In this study, in total 1936 individuals of benthic macro-fauna were recorded and, based on their common characteristics and functions, have been classified into 12 groups. Mollusks were more abundant taxa group. It seems that high values in terms of abundance of certain groups belong to gastropods, which here comprised of 48% of total community in different biotic substrate. The results of other studies in the region in different years (Emam, 2005; Azizi, 2007; Badri, 2007; Ashja-Ardalan *et al*., 2011; Vazirizadeh *et al*., 2011; Kohan *et al*., 2012; Vazirzadeh *et al*., 2012; Fahimi, 2013; Aghajanpour *et al*., 2015; Farsi, 2013) shows fluctuations in species composition.

Also, in a case study by Vazirizadeh *et al*. (2011), 41 species of mollusks were recorded and gastropods were found to be dominant group. In their study, continuous and intensive competition was observed in rocky stations. In another study by Kohan *et al*. (2012), 87 species were identified in seven rocky-sand stations, 37 species found in one station and rich diversity in different habitats of Bushehr province was recorded. Nourinezhad *et al*. (2013) collected 29 species in Bushehr province and accordingly Asalouyeh was found as one of the habitats with a rich diversity.

There are differences between communities in high, mid and low zones. In this study, zonal pattern of community structure is considered. In Bonak lower zone, many crevices in bedrock were occupied by anemones mostly *Diadumene* sp. Whereas, intertidal flat in Bonak mid shore, were at tidal flow regularly and this provide suitable habitat in mid and low zones for filter feeders such common barnacle species, *Amphibalanus amphitrite*.

Based on all taxa evaluations, mollusks are the most contributed in three

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seasons (N=1124). We observed high number of species and individual richness within community in three locations when data pulled together from three seasons.

In similar study, Ashja-Ardalan *et al*. (2011) showed consistency of mollusks in four stations rocky-sand shores comprised of 65% mollusks in winter-spring.

In this survey, the most occurrences of mollusks were 13% in winter. Mollusks can survive at low temperature even if the body water gets frozen up to 70% (Raffaelli and Hawkins, 1996). The rate of water in low slope face and algae in surface area helps to increase tolerance on flow and ebb tides. Also seaweed area on rock and sand retain water for food and mollusk attachment.

In winter, mollusks in Shirinu were with similar value compare to Bonak (N<100) while in Bandar-Amerie these were more abundant (N>200).

Mollusks in summer and spring were observed with nearly similar frequency in three stations. Xanthoid crabs were more abundant in spring and showed the highest value in Bonak. In Bonak, similar to spring, more individuals of Barnacle, *A. amphitrite* was recorded in summer. While in winter there was no record of this species possibly due to cold winter and its effects of intertidal community at low tide. Porcellanid contributed with high frequency in summer and spring but appeared in lower abundance in summer.

When the three seasons in various localities have been compared, the Shirinu showed more significant differences in summer and winter. While in Bandar-Amerie and Bonak significant differences have observed in spring. In a study by Ghiasnejad *et al*. (2008), autumn was recorded with high abundance of mollusks; substrate type and suitable attachment area on rocks which were important factors to support higher diversity. While Savari *et al*. (2010) observed decreased diversity and abundance of decapods in the Bushehr city coast. They demonstrated that even if the substrate was similar, high temperature was important on diversity status. The high biodiversity on the rocky shores seems to be due to the substrate stability and this is more stable in tropical regions (Savari *et al.*, 2010).

As stated by Raffaelli and Hawkins (1996) the association between temperature and respiration in gastropods are complex and depends on food availability. It seems water movement in tidal flow is an important factor in accessibility to food in gastropod communities. In the study by Amini-Yekta *et al.* (2013), winter was recorded with the high abundance of mollusks species, results of the current survey also showed that winter was of high value for mollusks probably due to decrease in tidal regime in March and September.

While gastropods formed large part of mollusks (84%), some factors supported their distinct abundance in winter. These are aggregated on rock surfaces during winter for foraging, sunbathing and breeding. The wave action and the time in which these are out of water and also behavioral

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variations have influences on the spatial patterns in gastropods.

In the winter, mollusks show the high value in Bandar Amerie. Possibly, the cobble coverage of the substrate in this locality provides enough suitable habitats by providing the stone surfaces and spaces among stones as temperature tolerable microhabitats. While in Bonak, substrate is less divers and hence showing lesser diversity. The other two localities provide more habitat diversity to accommodate rich macro-fauna.

The results of one-way Analysis of Similarity (ANOSIM) test showed significant differences between seasons that are shown by Multidimensional Scaling (MDS) plot. Overall using pulled data, winter had low diversity and a trend level in low temperature while in spring higher diversity was observed (Fig. 4). In Figs. (2-4) the same results has been observed and probably higher diversity in spring depend on temperature, food availability and the breeding season in which more individuals are looking for appropriate mate.

In three locations, 66 species of macro-fauna (Table 1) have been identified, from which *P. sulcatus* was the most abundant of mollusk taxa groups (Tables 2, 5). Vazirizadeh *et al*. (2012) reported the high contribution of mollusks. It seems, the high diversity of gastropods is due to effective biological adaption and foraging behavior. The most important appears to be temperature because, too many *P. sulcatus* individuals have been observed resting on stone and rocks. According to Rao and Sundaram (1972), these were active in the afternoon. Comparatively, Bonak was different from individuals species abundance point of view, as species diversity and richness are possibly linked to substrate type which was bedrock comprised of tidal pool and many crevices (Fig. 4). In mobile animals such as gastropods, the pedal attachment and mucus secretion allows firm attachment while water is at flow and ebb at stationary tidal phase (Raffaelli and Hawkins, 1996).

In the present study, crabs were categorized into five groups. The Grapsid crabs were grazer and the other predators. The Xanthoid crabs were dominant groups regarding common factors such as zone and slope face. The comparison of three zones revealed differences at high and low intertidal zones for echinoderms, crustacean (Xanthoid crabs) and anemones/sponges groups (Fig. 6). Biotic and abiotic factors such as water flow, substrate type, and human economic activities in some localities on rocky shores, can attribute to observation of these differences. Effects of human activities, which were observed in Bandar-Amerie and adjacent breakwater, could have influences on cobble substrates community.

In Fig. 8, dominancy of *P. sulcatus* at high zone is shown while among mid and low zones there are no differences. The results of SIMPER analysis agree with those of Kruskal-Wallis test, considerable dissimilarity value between three zones were in mid-low zones (67.78). Also, as shown in Fig. 8,

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the greatest dissimilarity in values between stations has observed in Shirinu and Bonak (69).

We observed aggregation of *P. sulcatus* on open surface of boulders in Shirinu between cobbles in Bandar-Amerie. Intact open bedrock in Bonak and strong temperature affect the abundance of *P. sulcatus* and the individuals were stayed in rock pool to avoid heat. Total abundance of 12 taxa groups was the highest in the spring and the lowest in winter (Fig. 4).

Recruitment for large number of *P. sulcatus* requires the water movement for feeding in the summer- winter transition (Denley and Underwood, 1979). This species has also been found at more sheltered region (Denny, 1988; Denley and Underwood, 1979; Leung, 2012) and its world distribution is in the northwest Pacific and Indian Ocean (Hong Kong, Thailand, Australia, the Red sea, India, the Suez Canal and the Philippines). *P. sulcatus* is common species and mostly was found in different seasons and zones at the Bandar-Amerie. These are more abundant in winter than the summer (Leung, 2012). In winter, this dominancy was reported by high value of mollusks abundance in the Hong Kong. While in India and Japan this dominancy is reported in spring and summer (Leung, 2012). Results of the present study show that *P. sulcatus* are the most abundant species and observed significant difference in winter, while Leung (2012) found no variations between seasons, tidal condition and times of day (p>0.05).

Ghiasnejad *et al*. (2008), reported 29 species of gastropods from intertidal zone ~~at~~ in Qeshm Island and *P. sulcatus* was one of the abundant species.

P. sulcatus with frequency of more than 800 individuals per m^2 was reported in autumn (Ashja-Ardalan *et al.*, 2011). Aarebi *et al*. (2012) showed there was significant difference in winter, summer and spring of macro-fauna in polluted sediments. Also, Kohan *et al*. (2012) recorded the highest gastropod species in the eastern Bushehr and demonstrated that *P. sulcatus* is the dominant species. In Shirinu, Farsi (2013) observed 17 species of mollusks. According to Kohan *et al*. (2012) gastropods could be attributing as a variable to show the similarity of substrate and as these are of high value because of adaption efficiently to fluctuating environmental factors. Differences between zones such as the time spent under seawater or being out of water were real element for variability in species richness. The average density of Xanthoid crabs shows these were more abundant group after mollusks. Badri (2007) and Ashja-Ardalan *et al.* (2011) reported same echinoderms species in Shirinu.

Fahimi (2013) studied intertidal xanthoid crabs in Hormoz Island, *L. exetratus* and *E. frontalis* were found to be the dominant species with higher abundance in summer. Present study reports Xanthoid crabs as dominant group abundant in spring. Two species namely, *P. rufescens* (Anomura) and *L. exetratus* (Xantoid) were recorded as dominant species.

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The coastal crustaceans include both littoral and supralittoral species (Defeo and McLachlan, 2013). These results confirm Defoe's opinion, as echinoderms exist in mid and low zones. The echinoderms were abundant in winter in Shirinu and spring in Bonak.

Barnacle individuals were collected at high more than the mid and low zones in the summer in Bonak and *Amphibalanus amphitrite* was dominant species. Shahdadi *et al*. (2014) reported nearly similar results. High mortality observed in barnacles could be due to flood run off, 2014 in the region and also cold winter affecting the out of water barnacles at low tide.

Since echinoderms, Xanthoid crabs and anemones need the areas with water movement for their feeding, this is probably the reason for their aggregation in the low zone and consequently there are significant differences between abundances in high and low zones.

Also, Aghajanpour *et al.* (2015), using Costal and Marine Classification Standard (CMECS), have found dominant species and defined bedrock substrate including bedrocks, crevices, cobbles and tide pools in the eastern coast of Bushehr province. In their study, seven substrate subgroups, five microhabitats in rock substrate and nine biotic groups were identified.

Future studies needed in these coastal areas to examine temporal changes, environmental parameters and industrial activities and their effects on macro-fauna. Macro-fauna absence/presence and abundance of species at intertidal sandy beach is a pattern observed due to physical features (McLachlan *et al*., 2007). According to different aforementioned report from shores at different longitude and latitude, no similar patterns for species abundance and composition are expected. Ecological features including tide time /range, beach exposure, slope, sand size, breakwater and wave power, gas or oil sources and tar balls, and season changes have marked effects on the organisms and level zones (see McLachlan *et al*., 2007; Defeo *et al.*, 2009).

In conclusion, present study identified macro-fauna diversity and dominant species in the three zones, seasons at three localities. In total, 66 species were categorized in 12 taxa groups. Mollusks were the most contributed in three seasons. The spring was observed to serve the highest entire diversity possibly due to higher productivity and breeding season. Among 66 species, only one gastropod was dominant species and accordingly the assemblage named "*P. sulcatus* community". These results are important in finding any possible patterns in taxa group zonal distribution. Human and economical activities in this area have influences on the community structure and the species composition alteration, which deserve further survey.

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