Community composition and diversity of zooplankton in the northwest Persian Gulf

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Abstract

Survey on zooplankton composition was studied during June 2015 to March 2016, by selecting six stations along the coastal waters of Bushehr (the Northwest Persian Gulf). Twenty four zooplankton taxa were identified, and the different zooplankton groups represented twenty-one families. Copepoda was recorded with the most abundance (53.30 %) followed by Malacostraca (32.87 %), which in turn was followed by Sagittoidea (7.44 %) and Appendicularia (6.39%). A major peak of 189.34 N/m^3 was observed in February-2016 with 53.25% contribution from Copepoda. Among Copepoda, *Labidocera* sp. was the major contributor to this peak. Appendicularia was the comparatively less represented group, being chiefly represented by *Oikopleura dioica*. *Labidocera* sp., *Oithona plumifera* which were common in most of the stations. This common distribution were observed for Malacostraca, namely *Lucifer hanseni (*mysis I), *Upogebia* sp. (zoea I), *Parthenope* sp., *Ilyoplax frater(zoea VI)*, for Sagittoidea, namely *Sagitta enflata, Sagitta neglecta* and for Appendicularia, namely *Oikopleura dioica*. The mean Shannon's diversity index (H') and evenness were 1.36±0.43 and, 0.68±1.17, respectively. The highest Margalef's index was recorded in station-6 (2.72±1.32) and the lowest in station-2 (1.98±0.89). According to non-significant differences between temporal and spatial zooplankton density and Shannon's index, from an ecological point of view, it seems the study area is unique and the zooplankton composition is homogenous.

Keywords: Zooplankton, Density, Diversity, Persian Gulf.

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Introduction

The Persian Gulf, located in a subtropical region, is a semi-enclosed marginal sea with a mean depth of 36 m, separated from the Oman Sea by the narrow Strait of Hormuz (Sheppard, *et al*., 1992). It is located in a region between latitudes of 24º and 31ºN and longitudes of 48º and 56ºE. Fishery is an important economic activity in the region and the second only one is the oil industry (Carpenter, *et al*., 1997).

The Bushehr coastal area has occupied 905 km of the northern coastline of the Persian Gulf, with different ecosystems including creeks, estuaries, and different types of beaches, such as sandy, muddy, and rocky. Coastal regions of Bushehr are ecologically sensitive areas.

Zooplankton is the first consumer of the marine ecosystem. They have an important role in linking the primary producers (phytoplankton) and higher trophic levels (Raymount, 1980; Timofeev, 2000; Sakhaie et al., 2011). Zooplankton provides an important food source for larval stages of fishes and invertebrates especially in marine coastal ecosystems. Marine coastal ecosystems are zooplankton rich and they are among the most productive environments in the world. The species diversity and community structure of the zooplankton are necessary to assess the potential fishery resources.

Climate change and anthropogenic exploitation play a crucial role in zooplankton community and coastal ecosystems (Fromentin and Planque, 1996; Beaugrand *et al*., 2002; Möllmann *et al*., 2003; Chiba *et al*., 2006; Bagheri *et al*., 2017). Zooplankton species distribution shows wide spatiotemporal variations due to the different - hydrographical factors in coastal ecosystems (Baliarsingh *et al.*, 2014). Their community composition, richness and diversity also serve as good indicators of ecosystem health (Baliarsingh *et al.*, 2014). Research on zooplankton in the Persian Gulf has been done by Mohsenzadeh *et al.*(2016) and ROPME (2010).

The present research was done to complete the information on zooplankton diversity in Bushehr coastal waters and in order to understand the factors influencing zooplankton density.

Materials and methods

This study was carried out in coastal waters adjacent to and to the north west of the Persian Gulf. Six sampling stations were set up four in creeks, Ramleh, Dubbeh, Shif and Lashkary, one in Farakeh river-estuary and one in the coastal waters of the sea. A series of 7 bimonthly samples were collected from Jun 2015 to March 2016 (Fig.1, Table 1).

Samples were collected using plankton net of 60 cm in diameter with mesh size of 100μm, attached to flow-meter. The collected samples were preserved in 5% buffered formalin. The net hauls were carried out obliquely at variable depths (1-2m) at the different sampling stations.

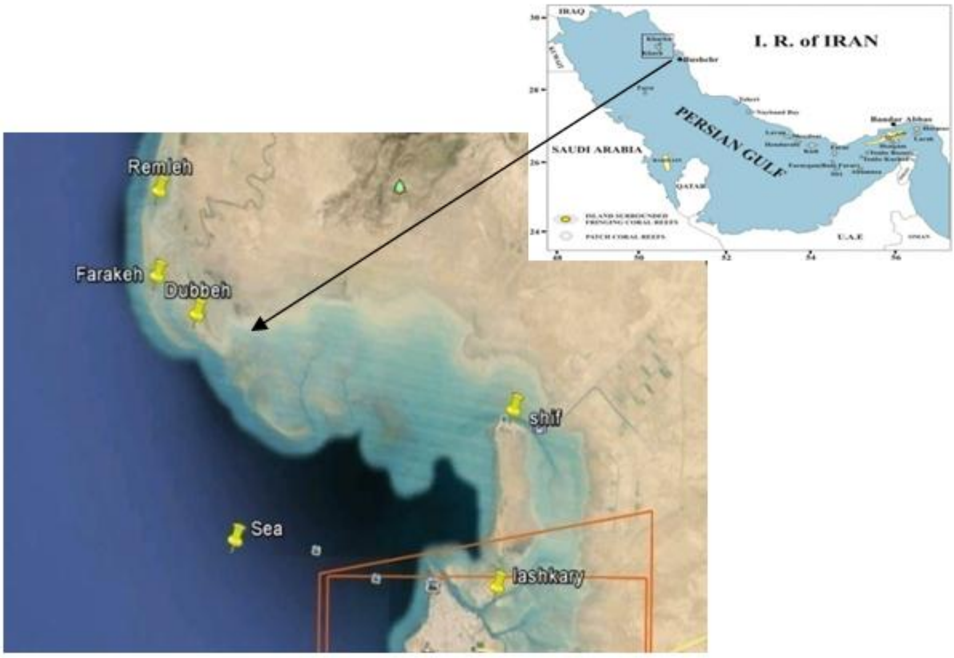

Figure 1:The sampling stations along the Bushehr Coastline - Northwest of the Persian Gulf.

Table 1: The position of sampling stations on the Bushehr Coastline - Northern Part of the Persian Gulf .

Station No.	Stations	Longitude	Latitude	Ecosystem type
1	Shif	N 29° 04.117´	E 050° 51.130´	Creek
2	Lashkary	N 28° 58.948´	E 050° 51.947´	Creek
3	Ramleh	N 29° 10.702´	E 050°38.792´	Creek
4	Farakeh	N 29° 08.865´	E 050° 38.838´	Creek-Estuary
5	Dubbeh	N 29° 06.613´	E 050° 40.294´	Creek
6	Sea station	N 29° 16. 371´	E 050° 42.501 ´	-

Zooplankton were counted and identified to the lowest possible taxonomic level by using different zooplankton identification keys (Newell and Newell, 1977; Barnes, 1978; Omori and Ikeda, 1984; Al-Yamani *et al*., 2011).

For estimation of density, the samples were gently shaken to make a homogenous distribution of different zooplankton components inside the sample, and a sub-sample of 5 mL was transferred into a counting chamber (Bogorov chamber) using a plunger pipette 20 (ROPME, 2010). All zooplankton samples were counted to the species level and the counting was repeated in three replicates. The abundance was expressed as number of organisms/m^3 (ROPME, 2010). The statistical bio- indices are calculated as follows: (Margalef, 1960; Shannon and Weaver, 1963; Pielou, 1966).

In comparing density of zooplankton, as the data did not conform to normality and the variances were not homogeneous, the non-parametric Kruskal-Wallis tests were used. For finding significant differences in Shannon index, we applied the one way analysis of variance (ANOVA). All analyses were done on SPSS software version 19.

Results

21 families of zooplankton were identified, including 22 genera and 24 species. The four most common families, arranged in order of decreasing abundance, were Pontellidae, Ocypodidae, Oikopleuridae and Sagittidae. Zooplankton from nine common families occurred in six stations (Pontellidae, Oithonidae, Mysidae, Luciferidae, Upogebiidae, Parthenopidae, Ocypodidae, Sagittidae, Oikopleuridae). All zooplankton genera of the different groups were represented by 1-2 species. Several species occurred at the most station, like the copepods *Labidocera* sp., *Oithona plumifera*, from Malacostraca *Lucifer hanseni* (mysis I), *Upogebia* sp. (zoea I), *Parthenope* sp., *Ilyoplax frater* (zoea VI), from Sagittoidea, *Sagitta enflata*, *Sagitta neglecta* and from Appendicularia, *Oikopleura dioica* .

The total number of zooplankton species varied between a minimum of 17 species at stations 1 and 6 and a maximum of 23 species at station 2. Whereas Malacostracan crustacean were the most diversified group (8- 15 species) and they could be considered as the keystone which affects the total number of zooplankton species over the whole areas (Table 2, Fig. 2).

The population density in the present study ranged from 4.41 to 189.34 N/m^3. Bimonthly total abundance of zooplankton varied considerably. A significantly ($p<0.05$) higher abundance of zooplankton was found in mid-winter, and late summer. A major peak abundance of 189.34 N/m^3 occurred in February with contribution of 53.25% for Copepods, and another peak in September, while the lowest abundance was recorded in June (4.41%). Copepoda was recorded as the highest in number of abundance (53.30%) followed by Malacostraca (32.87%), which in turn was followed by Sagittoidea (7.44%) and Appendicularia (6.39%) (Fig. 3).

Table 2: Occurrence/absence of zooplankton species at different stations (2015-2016)

Species\Group	1	2	3	4	5	6
Temora turbinata	-	+	-	+	+	+
Labidocera sp.	+	+	+	+	+	+
Acartia fossae	-	+	+	+	+	+
Tortanus barbatus	-	+	+	+	+	+
Oithona brevicornis	-	-	+	+	+	-
Oithona plumifera	+	+	+	+	+	+
Corycaeus lubbocki	+	-	+	-	-	-
Mysid shrimp *Rhopalophthalmus* sp.	+	+	+	+	+	+

Table 2 (continued):

Species\Group	1	2	3	4	5	6
Penaeus semisulcatus, protozoea III.	-	+	+	+	+	-
Lucifer hanseni, mysis I.	+	+	+	+	+	+
Lysmata sp. zoea IV.	-	+	-	-	-	-
Callianassa spp. zoea I.	+	+	-	+	+	-
Upogebia sp. zoea I	+	+	+	-	+	+
Pachycheles sp. zoea I.	-	+	-	-	+	-
Dardanus sp. zoea I.	+	+	+	+	+	-
Paguristes sp. zoea I.	-	+	-	+	+	-
Pagurus sp. zoea III	-	+	-	+	-	-
Ebalia sp.	+	-	-	-	+	+
Parthenope sp.	+	+	+	+	+	+
Ilyoplax frater, zoea VI.	+	+	+	+	+	+
Sagitta enflata	+	+	+	+	+	+
Sagitta neglecta	+	+	+	+	+	+
Oikopleura dioica	+	+	+	+	+	+
Appendicularia sicula	+	+	-	-	-	+

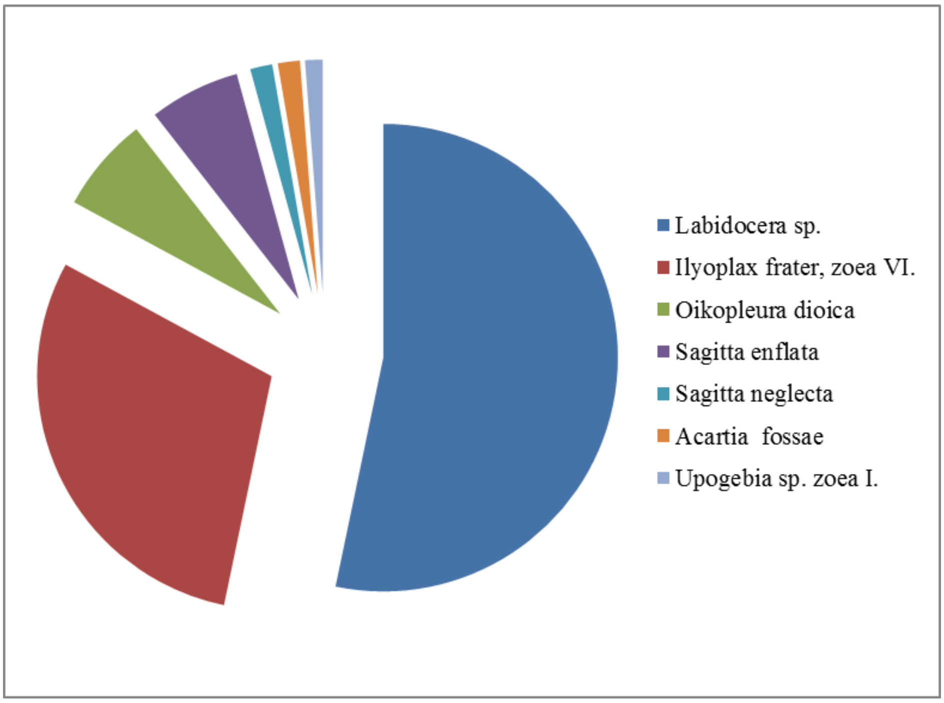

Figure 2: The percentage of the zooplankton groups with major abundance (>1%).

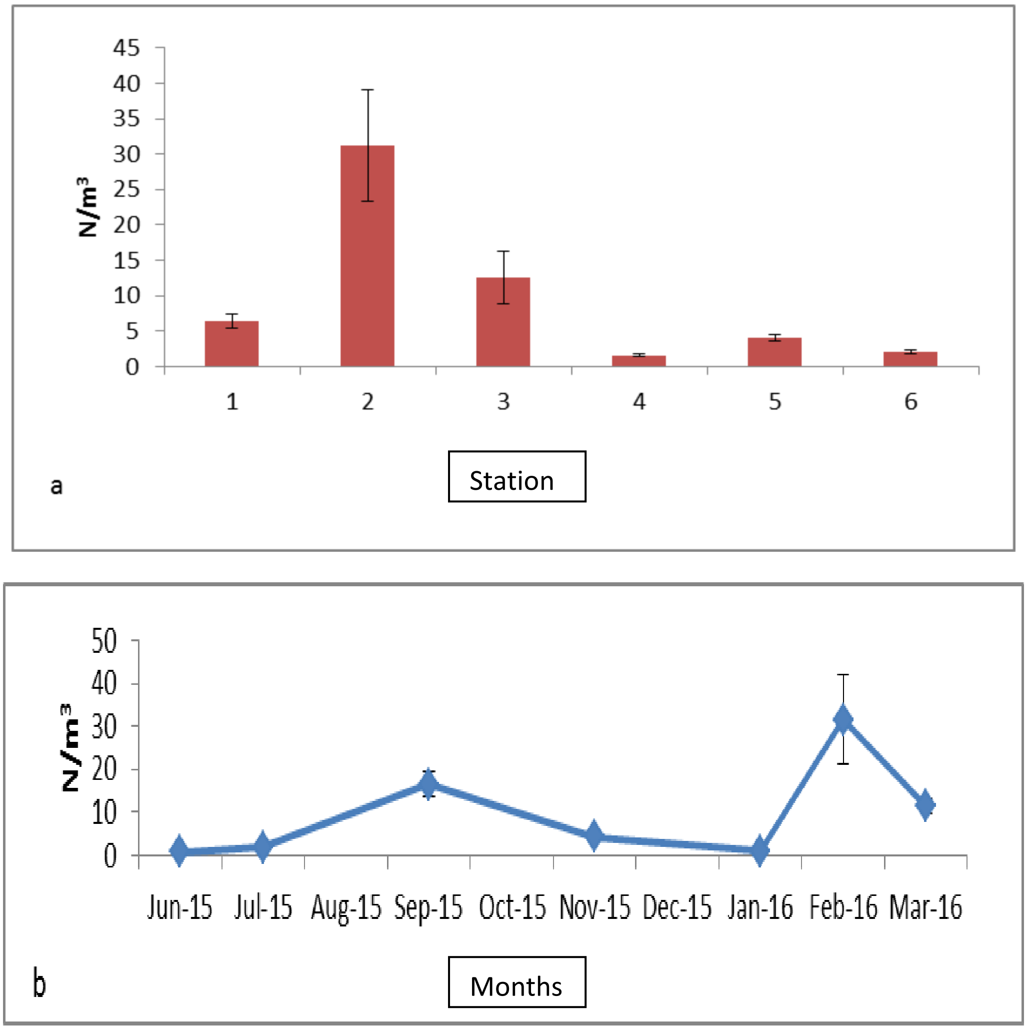

Figure 3: Spatial (a) and temporal (b) distribution of zooplankton (2015-2016) (Mean±SE).

The density of Copepoda showed well marked spatial variation and it ranged from 4.77N/m^3 in station-6 to 309.11N/m^3 in station-2. The Copepods were found to be represented by 7 species belonging to 6 families and 2 orders, Calanoida and Cyclopoida, each order represented by 4 and 3 species, respectively. Calanoida contributed to up to 73% and cyclopoida to up to 27% of the total copepods. Among Calanoida, the species *Labidocera* sp. was dominant in all stations (maximum in station 1). Malacostraca were found to be represented by 15 species belonging to 12 families and 2 orders. Mysida and Decapoda were represented by 1 and 14 species, respectively. Mysida contributed to 1.28 % and Decapoda to 98.72 % of the total Malacostraca (Fig. 4**)**.

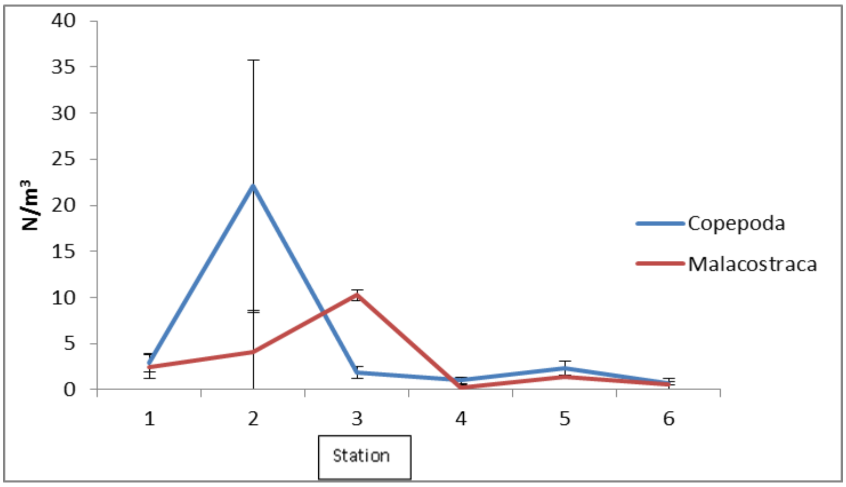

Figure 4: Spatial distribution of Copepoda and Malacostraca in the Northwest Persian Gulf (2015-2016) (mean±SE).

Brachyuran zoea occurred throughout the year, but had maximum abundance (40% of total zooplankton) in March during the dry season. They were represented by the family Ocypodidae. Appendicularia were found to be represented by 2 species belonging to 2 families. Appendicularia was the comparatively less represented group (25.82 N/m^3), being chiefly represented by *Oikopleura dioica* (Fig. 5**)**.

Overall, the greater number of species in terms of richness index (23), also the highest abundance (218.12 N/m^3) was observed in station 2, but in station 4, 20 taxa were recorded with the lowest abundance (11.19 N/m^3).

The Shannon's diversity index (H') was found to be the highest at station-6 (1.59±0.24) and the lowest in station 2 (1.17±0.47). Evenness ranged between 0.55±0.19 for station-2 and 0.83±0.09 for station 6 during the study period. Margalef's index was found to be the highest (2.72±1.32) in station 6 and the lowest (1.98±0.89) in station 2 (Table 3). Despite all these differences, there were no significant differences between density and Shannon's index temporally and spatially (p>0.05).

Table 3: Zooplankton community structure at different stations (2015-2016).

Station	**Number of taxa (S)**	**Shannon's diversity index (H')**	**Evenness Index (J')**	**Margalef's richness index (d)**
1	17	1.27 ±0.35	0.67±0.16	2.26±1.28
2	23	1.17±0.47	0.55±0.19	1.98±0.89
3	18	1.25±0.50	0.63± 0.26	2.39±1.46
4	20	1.31±0.51	0.66±0.24	2.06 ±0.89
5	22	1.59 ±0.39	0.73±0.16	2.68 ±1.31
6	17	1.59±0.24	0.83±0.09	2.72±1.32

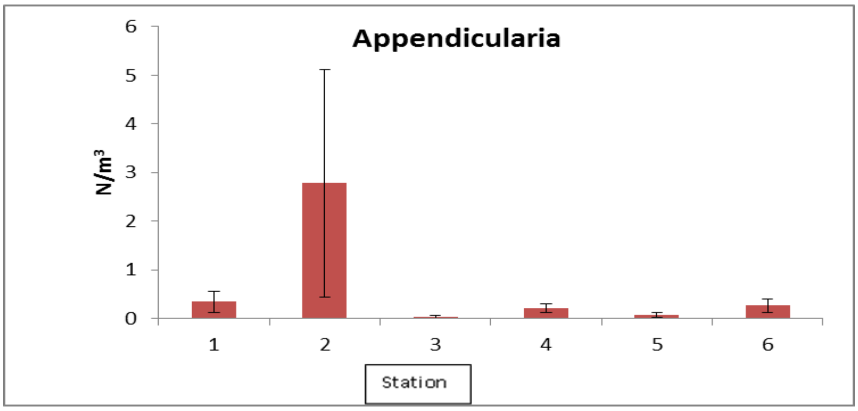

Figure 5: Spatial distribution of Appendicularia (mean±SE) in the northwest Persian Gulf (2015-2016).

Discussion

Several studies have shown that the levels of diversity for zooplankton, particularly those of the copepods, were usually low in coastal zones. Generally, for marine ecosystems with high levels of ecological stress low diversity and high dominance values are common, so the diversity index is a suitable criterion for health assessment (Velmurugan, *et al*., 2014).

In this study, zooplankton population was represented by copepods, malacostraca, chaetognatha and appendicularians. Copepods and Malacostraca were present in all sites and two peaks in zooplankton density were observed in February and September. While the first peak was mainly due to copepods, the second peak was constituted by malacostraca. Copepoda was the most diversified group over the whole area in both the inner RSA (ROPME Sea Area) and Oman Sea (Winter 2006) and they could be considered as the keystone which affects the total number of zooplankton species over the whole area with the different groups, including: nauplii, copepoda, adult calanoids, cyclopoids and harpacticoids. On the other hand, calanoids appeared as the major component of adult copepods in the inner RSA, while they dominated (53.1 – 66.0%) in the inner RSA and Oman Sea. Cyclopoids was recorded with the highest percentage (50.0- 62.6 %) in the inner RSA and predominated (52.6%) in some station of Oman Sea (ROPME, 2010).

Mohsenizadeh *et al.* (2016) reported the variation of zooplankton in the Naiband Bay related to the seasonal cycle of rainfall and recorded Cyclopoida was dominant (24%) in Copepoda group. A major peak of abundance was observed in winter and spring 2015.

Also, the results suggested that mesozooplankton taxa were not uniformly distributed in stations. It seems that zooplankton diversity was inversely related to abundance, which was highest at February in station 2 and

September in station 3. Two dominant species, *Labidocera* sp. and *Ilyoplax frater* showed an almost burst of development from an apparent absence to numerical dominance of community within a short period. This fluctuation of zooplankton density is closely related to the nature of shallow environments of creeks and estuaries (Camatti *et al*., 2008). Also in these unstable ecosystems a rapid modification of community would be common in response to environmental stress (Christou, 1998). Conversely the highest diversity was observed in 6 sites which showed that the individuals in the community were distributed more equitably and this might be due to the better and stable environment of the sea station. A similar pattern was revealed for the oceanic and coastal zooplankton of the northeast coast of India (Rakhesh *et al*., 2006).

The most interesting result is the inverse correlation between the Shannon's index and evenness and the total zooplankton abundance. It means that the lower amount of evenness shows that the abundance of zooplankton groups were not homogenous and some of them were dominant while the lowest Shannon's index indicates that these sampling areas are effected by stress being in a coastal zone and at shallow depths. An explanation is entered in the text as well. A similar trend was determined for pelagic zooplankton of the coastal waters of Malvan (D´Costa and Pie, 2012). To explain this trend it would be assumed that with a reduction of the total amount of zooplankton, the relative amount of the biotope (water mass) that species can exploit increases, leading to a reduction of interspecific competition. Under conditions of sufficient resources for each species, most likely evenness in their abundance occurs (Tackx *et al.*, 2005).

The relative low diversity (~1.5), low evenness, high dominance indices and the narrow range in variations of species richness (1.9 -2.7) in the creeks and estuarine and marine ecosystems of Bushehr could be due to the relatively homogenous but hard and unstable hydrographic conditions. The dry climatic condition is responsible for lower diversity and average taxonomic distinctness (Beaugrand *et al*., 2002). It has been hypothesized that a decrease in average taxonomic distinctness may be related to either an increase in environmental constraints which act as habitat filters or to a local heterogeneity loss not allowing the survival of only some closely related species with particular common biological attributes (Marques *et al*., 2007).

Generally, for marine ecosystems with high levels of ecological stress, low diversity and high dominance values are common, so the diversity index is a suitable criterion for health assessment.

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