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Original Research

Community structure of planktonic copepods in Hendijan harbor (NW Persian Gulf)

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ABSTRACT:

The qualitative and quantitative dynamics of the copepod community in Hendijan harbor was studied through zooplankton samples collected seasonally in summer 2010 (July- August), autumn 2010 (October), winter 2011 (December-February) and spring 2011(April). The copepods community was represented by 27 species, belonging to calanoida (16 species), cyclopoida (5 species), Poecilostomatoida (3 species) and harpacticoida (3 species). The highest abundance of copepods was in summer (14402±3352 Ind/m^3) while the lowest was in winter (852±155 ind/m^3). Of the adult forms, *Acartiella faoensis* was the most abundant species, forming 19% of the total copepods, followed by *Paracalanus parvus* (17%), *Corycaeus andrewsi* (13%) and *Clausocalanus arcuicornis* (8%). Most of copepod species displayed distinct seasonal occurrence relative to environmental conditions. The spearman's correlation revealed that temperature and salinity were the most important factor controlling the size of copepods density in Hendijan harbor. The cluster analysis demonstrated different types of association between copepods species. The highest value of Shannon's diversity index, Margalef index and Pielou's evenness was noticed in summer. These results revealed that the summer is different from other seasons of the year and in this season the ecological situation is better and more stable than other seasons in Hendijan shores waters.

Keywords:

Acartiella faoensis, Hendijan harbor, Copepod community.

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INTRODUCTION

Zooplanktons are dominated over the rest of the organisms in the sea and they have an important role in energy transfer in the marine ecosystem (Severini *et al.,* 2009). Planktonic copepods comprehend the largest and abundant group of zooplankton in marine environments forming around 60-80% of zooplankton, numerically (Conway 2005; Castro and Huber 2003; EL-Din and AL -Khayat 2001). Copepods are the most widespread and diverse component in the ocean and they are found at all depth in every marine, brackish and freshwater environment (Brusca and Brusca 2003). These organisms have a key role in the marine food webs with representing a main link between the phytoplankton (primary producers) and the various economically important fishes and serve as secondary producers in marine ecosystems (Turner, 2004). They are also consumed by other animals of higher trophic levels such as macrozooplanktons and planktivorous fishes. In addition, copepods play an important role in energy cycling in the ocean (Frangoulis *et al.,* 2005). Therefore, community structure of planktonic copepods may also directly affect the local fisheries.

Little information is available on planktonic copepods (Michel and Herring, 1984; AL-Khabbaz and Fahmi 1994) and total zooplanktons (Nilsaz *et al*., 2005, Falahi *et al*., 2003; ROPME, 2004) in the Persian Gulf. Hendijan harbor is one of the major fishing grounds in the Northwestern Persian gulf along the coast of Iran (ROPME, 1999). Although, copepods are very important for the recruitment of fishery resources, our knowledge about the seasonal fluctuation of community structure of copepods in this area is lacking. The present study attempted to examine the seasonal variations of species composition, density and diversity of copepods under the influence of environmental factors in Hendijan harbor, where fishery activities are high but information on planktonic copepods is limited.

MATERIALS AND METHODS

The study area is located in Hendijan harbor in the Northwestern Persian Gulf along the coast of Iran

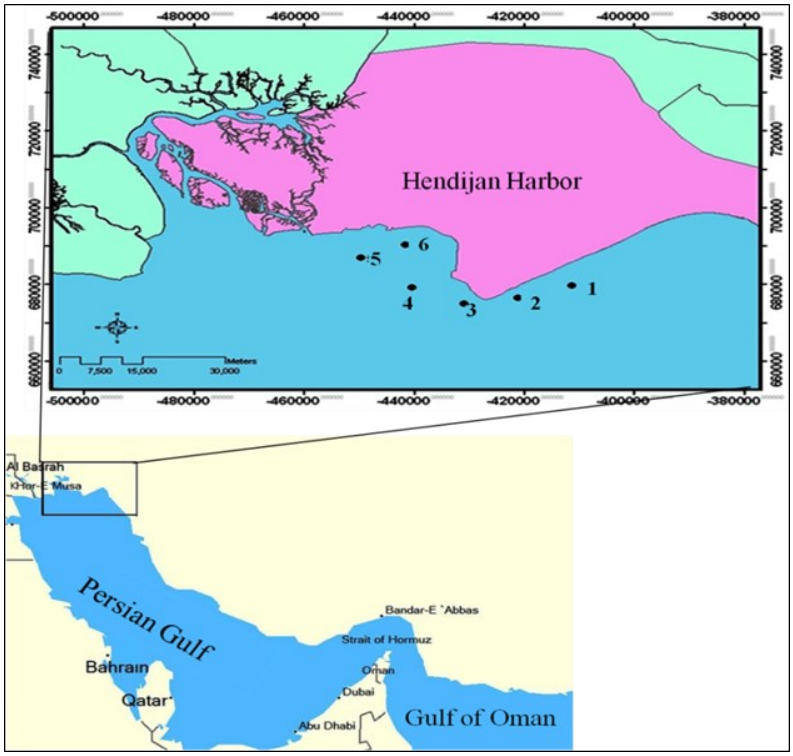

Figure 1. Sampling stations in the Hendijan harbor (NW Persian Gulf)

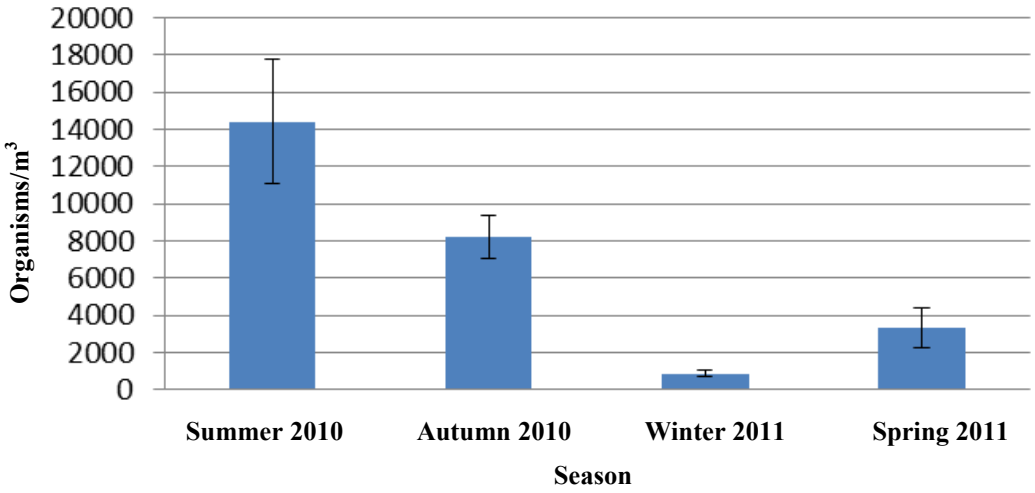

Figure 2. Seasonal average of copepod density in Hendijan harbor (2010-2011)

(Khuzestan province) and it is located between 30º 15´ N and 49º 43´ E. Six sampling stations were setup in the study area (Figure 1). Water depth of the stations was approximately 6-8 m. Zooplankton samples were collected during four oceanography cruises: summer 2010 (July- August), autumn 2010 (October), winter 2011 (December-February) and spring 2011 (April) by oblique plankton tows (45 cm diameter and 100-µm mesh nets). A digital flow meter was used to measure the filtered water volume. Most of the sampling was done in the afternoon. Surface temperature, salinity and dissolved oxygen were measured at each station. Collected samples were immediately transferred to one-liter bottles and preserved in 5% buffered formalin. In the laboratory, copepods were sorted from the other zooplanktons and identified to the lowest taxa possible by using standard keys (Conway *et al.*, 2003; Al-Yamani *et al.*, 2011). Abundance of copepod species was determined and density of them was expressed as the number of individual/m^3 of seawater. The Shannon's diversity index, Margalef index and Pielou's evenness were calculated only for the adult copepods. One-way analysis of variance (ANOVA) was used to examine the spatial and temporal differences between months in all hydrographic variables, copepod density, and diversity. Spearman's correlation coefficient was calculated to characterize the relation between the population dynamics of copepods and the ecological conditions. Cluster analysis was also done to follow up the associations between the copepod species.

RESULTS

The average monthly water temperature fluctuated between 16.30º C in winter and 31.22º C in summer. Mean salinity varied from 40.59% in winter to 50.81% in autumn. The highest average dissolved oxygen value of 6.86 mg/L was recorded in spring, while the lowest (avg. 4.89mg/L) occurred in summer.

Table 1. Seasonal changes in water parameters in Hendijan harbor (NW Persian Gulf)

S. No	Parameters	Summer 2010	Autumn 2010	Winter 2011	Spring 2011
1	Temperature (°C)	31.22±0.51	24.01±0.78	16.30±0.15	23.55±0.09
2	Salinity (%0)	45.74±0.92	50.81±0.83	40.59±0.41	44.11±0.31
3	Dissolved oxygen (mg/l)	4.89±0.05	5.04±0.01	5.67±0.5	6.86±0.06
4	pH	8.33±0.17	8.20±0.81	8.29±0.24	8.22±0.32

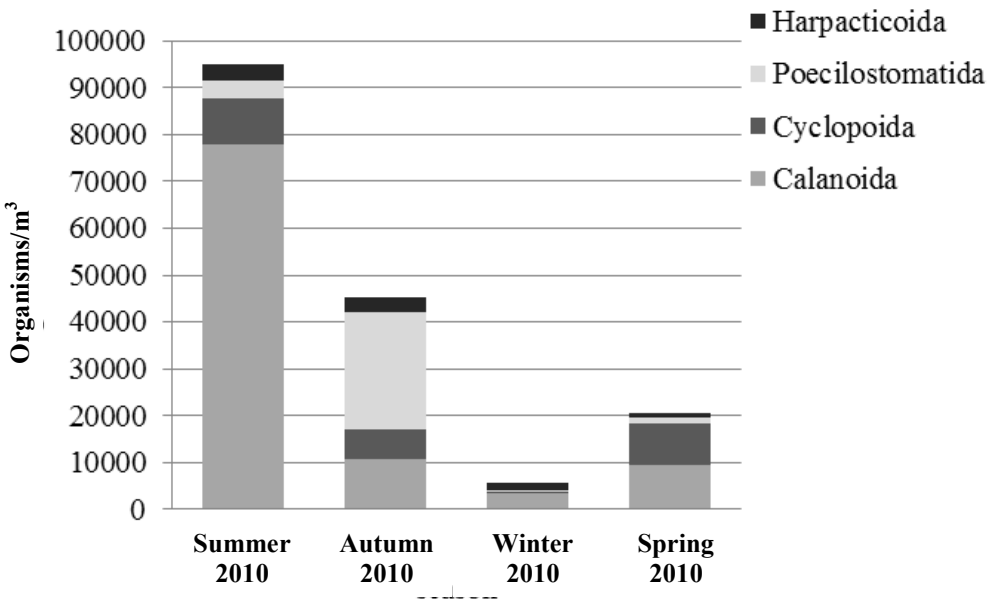

Figure 3. Seasonal count of adult assemblages of the major copepod groups in Hendijan harbor (2010-2011)

diversified (16 species) than Cyclopodis, Harpacticoids and Poecilostomatoids (with 5, 3 and 3 species respectively). While Calanoids constituted 66% of the total copepods, Harpacticoids (4%), Cyclopoids and Poecilostomatoids demonstrated similar percentages.

Since the Calanoids were the most abundant adult copepods, its abundance cycle followed that of the total copepods, being high in summer 2010. In contrast, Poecilostomatids displayed one distinctive peak in autumn and then decreased continuously over the year. For both Cyclopoids and Harpacticoids, the highest count were observed in early summer (Figure 3).

Among the copepod species found in Hendijan harbor, 4 species were responsible for the numerical density of adult Calanoids; namely *Acartiella faoensis*, *Paracalanus parvus, Corycaeus andrewsi* and *Clausocalanos arcuicornis. A. faoensis* was observed just in summer and it showed the highest density of adult copepods and comprised 19% of adult copepods through the year. *P. parvus* was the second dominant species and it was observed all sampling months with distinctive pick in summer. *C. andrewsi* was the single dominant Poecilostomatid species in the harbor over the year due to a large peak in autumn. *C. arcuicornis* was the forth dominant species and it existed on all sampling months. This species showed the most abundance in summer. Spearman's correlation showed that, both temperature and salinity had clear effect on the copepod abundance ($P < 0.05$, Table 3).

The cluster analysis for the seasonal average count of most abundant adult species indicated limited association between the copepod species in Hendijan harbor. Relatively high similarity (97.7) was observed between *Acrocalanus gracilis* and *C. arcuicornis*, in addition to *P. parvus*, which occurred in the same subcluster. These two species displayed similar patterns of monthly variations, attaining their highest count in summer. Low similarity appeared between *A. faoensis* and *Sapphirina nigromaculata*, which was observed only in summer. All other species showed independent clusters, since each demonstrated its own seasonal distribution pattern (Figure 4).

The copepods diversity index experienced little monthly variations, with high values during spring and summer, and low values in autumn and winter (Table 3).

According to monthly variations in Margalef index, the number of species tended to show significant

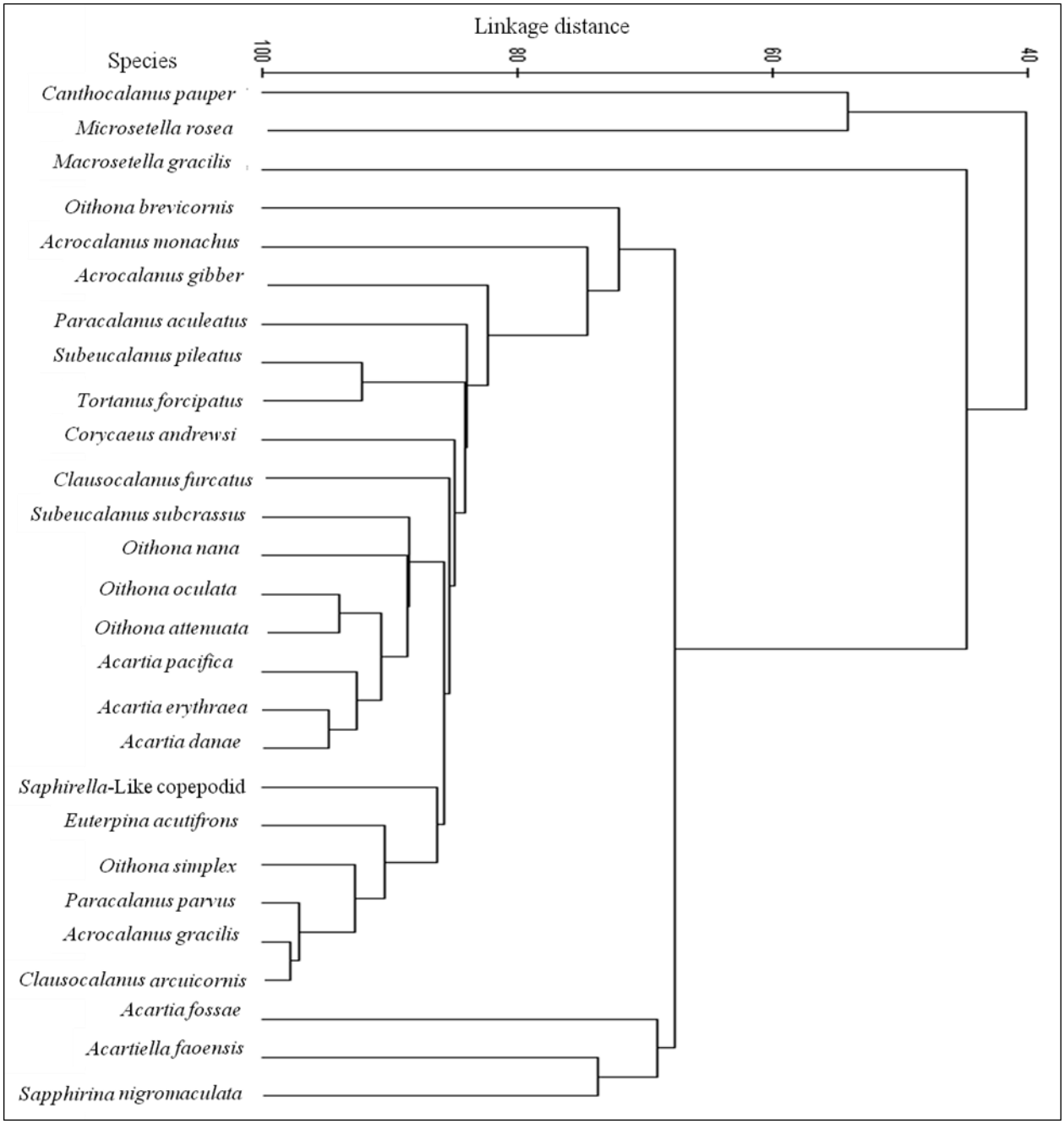

Figure 4. Cluster analysis for copepod species in Hendijan harbor

The pH values demonstrated narrow variation over the year. (Table 1). One way ANOVA did not show any significant difference among the stations over the sampling period.

Copepods were represented by 27 species belonging to 15 genera and 13 families (Table 2). The monthly number of species showed high variations between a maximum of 24 species in summer and a minimum of 14 species in winter. 6 species were found during all sampling period and well distributed throughout the Hendijan harbor.

In this study, the highest abundance of adult copepods was observed in summer (14402±3352 ind/ m^3) and the lowest in winter (852±155 ind/m^3). There are significant differences in density of copepods over the year (Figure 2).

Table 2. Abundance of copepod species (ind. m^{-3}) in Hendijan harbor (Summer 2010 – Spring 2011)

S. No	Species	Summer	Autumn	Winter	Spring
1	*Acartiella faoensis*	27078	0	0	0
2	*Acartia erythraea*	1874	141	0	191
3	*Acartia ohtsukai*	4444	871	0	324
4	*Acartia danae*	1236	34	0	166
5	*Acartia fossae*	2647	253	0	0
6	*Paracalanus parvus*	15392	4961	1248	3900
7	*Paracalanus aculeatus*	2728	400	107	0
8	*Acrocalanus gibber*	2375	28	0	0
9	*Acrocalanus monachus*	164	0	0	0
10	*Acrocalanus gracilis*	8180	1434	685	2136
11	*Clausocalanus arcuicornis*	8521	1213	1346	2334
12	*Clausocalanus furcatus*	2020	0	25	348
13	*Subeucalanus subcrassus*	767	463	0	30
14	*Subeucalanus pileatus*	170	79	0	0
15	*Tortanus forcipatus*	181	819	0	0
16	*Canthocalanus pauper*	0	0	64	0
17	*Oithona oculata*	1456	493	19	134
18	*Oithona attenuata*	2672	1868	19	469
19	*Oithona nana*	2289	516	283	6516
20	*Oithona simplex*	3573	3448	18	1822
21	*Oithona brevicornis*	90	0	0	0
22	*Corycaeus andrewsi*	335	22526	185	969
23	*Saphirella*-Like copepodid	3014	2680	144	75
24	*Sapphirina nigromaculata*	262	0	0	0
25	*Euterpina acutifrons*	3561	3099	1244	1146
26	*Macrosetella gracilis*	0	58	0	0
27	*Microsetella rosea*	0	0	126	0

The adult assemblages of the copepod groups dominated the copepods count (40%), nauplii comprised (36%) of the whole planktonic copepods and copepodids occupied the third order of abundance (24%). Among copepods, Calanoids were more differences among months and it was maximum in summer (1.51±0.07) and minimum in winter (0.4±0.01). The Shannon-Wiener index ranged from (1.12±0.11) in winter to (2.29±0.08) in summer. The highest average of Pielou's evenness value (0.92±0.08) was recorded in summer, while the lowest (0.69±0.1) occurred in October (Table 4). The results of ANOVA indicated significant differences among seasons in each index ($P < 0.05$) but no among stations.

DISCUSSION

The first objective of this study was to document the composition of planktonic copepods in Hendijan harbor. In this study 27 species were identified. Among copepods, four species *A. faoensis*,

Table 3. Spearman's correlation between ecological parameter and total copepods in Hendijan harbor (2010-2011) (Correlation is significant at P< 0.05)

S. No		Copepods
1	Copepods	1.00
2	Temperature (°C)	0.65*
3	Salinity (%0)	0.61*
4	Dissolved oxygen (mg/l)	0.38
5	pH	0.19

P. parvus, *C. arcuicornis* and *C. andrewsi* formed the bulk of the adult copepods count in Hendijan harbor. These species were the major component of zooplankton abundance in NW Persian Gulf (Michel and Herring 1984; AL-Khabbaz and Fahmi 1994; Al-yamani *et al.,* 2011). *A. faoensis* was observed just in summer 2010. This species was reported only from NW Persian Gulf (Khalaf, 1991; Khalaf, 2007; Ali *et al*., 2009) and it looks, this species is indigenous from this region which needs more investigation in this matter.

P. parvus recorded high abundance in summer. This species is a cosmopolitan, euryhaline and eurythermal species and it was highly abundant in the warm season and it can exist in all months (Abdel-Aziz 2007; Rong *et al*., 2002).

C. andrewsi showed the highest number in autumn with the highest of salinity (50.81 %0) and was the dominant species in this season. *C. andrewsi* is the common species in the superhaline area (Thompson ,1991).

C. arcuicornis was fourth dominant and its high abundance was observed in summer and it also showed the highest abundance in winter among the other calanoids. Generally, *C. arcuicornis* was highly abundant in warm months in most tropical-subtropical seas (Peralba and Mazzocchi, 2004). Genus *Clausocalanus* adapted to low level of phytoplanktons and they can feed wide range of foods in sea and they can increase in cold month (winter) when the amount of phytoplanktons decrease (Cornils *et al*., 2007).

The second aim of this investigation was to understand seasonal variations of copepods density in Hendijan harbor. The highest abundance of copepods, were observed in summer while increase in temperature was noted. The lowest abundance of copepods was recorded in winter. Other studies have been conducted on planktonic copepods in the Persian Gulf showed the same results (Michel and Herring, 1984)

In many environments, abundance and spawning frequency of copepods was affected by temperature and food supply (Niehoff, 2007). Generally, in warm seasons with increase in water temperature and phytoplankton and micro-zooplankton volume, abundance of copepods increase (Madhu *et al*., 2007) and several studies in Hendijan harbor have shown the most abundance of phytoplanktons and high level of nutrients in the summer (Nilsaz, 2005; Alizadeh, 2010).

The highest count of larval stages of copepods in Hendijan harbor was reported during the summer, indicating the important role of high temperature in promoting the egg production and development. The presence of copepod nauplii and copepodides as persistent component of zooplankton in Hendijan harbor indicated the continuous reproduction of copepods all over the year. It appeared that the breeding of different copepod species was influenced not only by temperature but also by other environmental factors, particularly

Table 4. Shannon index, Pielou's evenness, and Margalef index for copepods community in Hendijan harbor

S. No		Summer	Autumn	Winter	Spring
1	Shannon index	2.29±0.08	1.73±0.07	1.12±0.11	1.61±0.13
2	Pielou's evenness	0.92±0.01	0.69±0.03	0.82±0.05	0.76±0.01
3	Margalef	1.51±0.07	1.25±0.04	0.4±0.01	0.82±0.09

salinity and food availability. It is important to mention that the high density of nauplii and copepodides in Hendijan harbor reflects the high potential production of copepods.

The third objective of this study was to examine diversity of planktonic copepods in Hendijan harbor. Mean of Shannon diversity index was (1.69±0.06) over the year and the mean of Margalef species richness was (0.98±0.05) which indicated rich good biodiversity in Hendijan harbor. The highest value of these indexes was measured in summer and the lowest was in the cold months (winter). Mean of Pielou's evenness index was (0.75±0.02) all over the year; while, maximum value of this index was recorded in summer and the minimum of this index was in autumn. The high values of diversity indexes in the summer may be attributed to the high number of the copepod species (24 species) and to the count of total copepods. The low diversity index in autumn and winter could be attributed to the low total count and to the dominance of a few species.

The results revealed that the summer is different from other seasons of the year and in this season the ecological situation is better and more stable than other seasons in Hendijan shores waters which is in accordance to the other studies in the neretic waters of Indian oceans (Prabhahar *et al*., 2011; Abdel-Aziz *et al*., 2007).

CONCLUSION

The results of this investigation indicated that the rate of biodiversity in Hendijan harbor, is fairly good and it showed the relative stability of the environment. Hendijan harbor is one of richest ecosystems in the Northwestern Persian Gulf and study of copepods indicated secondary production and related indices in describing the ecological status of coastal waters of Hendijan harbor play an important role in efficient management and good protection of this area.

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