JJBS

Volume 3, Number 4, December 2010
ISSN 1995-6673
Pages 153 - 164

Jordan Journal of Biological Sciences

Seasonal Variation of Copepoda in Chabahar Bay-Gulf of Oman

Neda Fazeli [a], Hamid Rezai Marnani [b], Saeed Sanjani [b], Rasool Zare [a], Simin Dehghan[a] and Najme Jahani [a]

[a] *Khorramshahr University of Marine Science, Department of Biology, Khorramshahr, Iran*

[b] *Iranian National Center of Oceanography (INCO)*

.

Abstract

Zooplankton was collected with vertical plankton tows using 100 µm mesh nets during August to November 2007 and February to May 2008 from five stations through the Chabahar Bay. Totally, 75 copepods species were identified. Post-monsoon was characterized by the highest numerous of copepod species and diversity. Pre-monsoon showed the lowest number of copepod species and diversity index. The results showed that seasonal variation of chlorophyll-a concentration associated phosphate concentration is a major factor controlling abundance of copepod after a time lag. Abundance of copepod was significantly higher during the pre-monsoon as compared to other seasons.

الملخص

جمعت الهوائم الحيوانية خلال الفترة (أب الى تشرين الثاني 2007 و شباط الى ايار 2008) من خمسة مواقع في خليج شهبهار. تم تحديد 75 نوعا من المججافيات. اظهرت النتائج تميزا لظهور المجدافيات بعد هطول الامطار الموسمية و كذالك اقل ظهورا قبل هبوب الرياح الموسمية. الاختلاف الجوهري للمجدافيات كان واضحا خلال فترة ما قبل هبوب الرياح الموسمية مقارنة بالمواسم الاخرى. اظهرة النتائج ان التغيرات الفصلية لظهور المجدافيات ارتبط ارتباطا وثيقا بتراكيز اليخضور و الفوسفات.

Keywords: Copepoda, Abundance, Diversity, Monsoon, Chabahar Bay, Species richness.

1. Introduction

Chabahar Bay is a sub-tropical and semi-enclosed bay with high biological production, providing an ideal breeding ground for many economically important fishes and shell fishes (Fazeli, 2008). Information on the marine zooplankton of the Chabahar Bay is scanty, except for the projects of Sanjarani, 2007 and Zareei, 1994, who worked in the Goater Bay. Further, many projects existed at Oman Sea such as Seraji, 2007.

The ecological importance of zooplankton, especially its main component such as copepods, in the pelagic food webs of the world's oceans has long been recognized. These organisms often constitute a significant component of the plankton community in many marine environments (Relevante *et al.,* 1985; Burkill *et al.*, 1987; Al-Najjar, 2002); and play a central role in the transfer of nutrients and energy through the marine food webs (Poulet and Williams, 1991; Williams *et al.,* 1994; Kiorboe, 1997) and have an important role in the trophy food web (Thiriot, 1978). Copepods support energy transfer between primary producers (phytoplankton) and the final consumer of highly valuable fish and crustacean species (Faure, 1951). Despite abundant evidence of the importance of zooplankton in marine pelagic food webs, little is known about their density, composition, stratification and distribution in Chabahar Bay. The main objective of the present study is to examine the composition of the main planktonic taxes, temporal and spatial variation of the abundance and distribution of copepods and the impact of environmental factors on copepod's abundance.

2. 2. Materials and Methods

2.1. Study Area

Chabahar Bay is a small semi-enclosed bay on the southeastern coasts of Iran (from 25° 17' 45"N- 60° 37' 45" E). This Bay is connected to the Indian Ocean by the Oman Sea. The Bay surface area is 290 km^2 with 14 km wide located between of Chabahar and Konarak (Fig.1). The average depth of this Bay is 12 m (ranges from 8-22m).

* Corresponding author. n_fazeli200@yahoo.com.

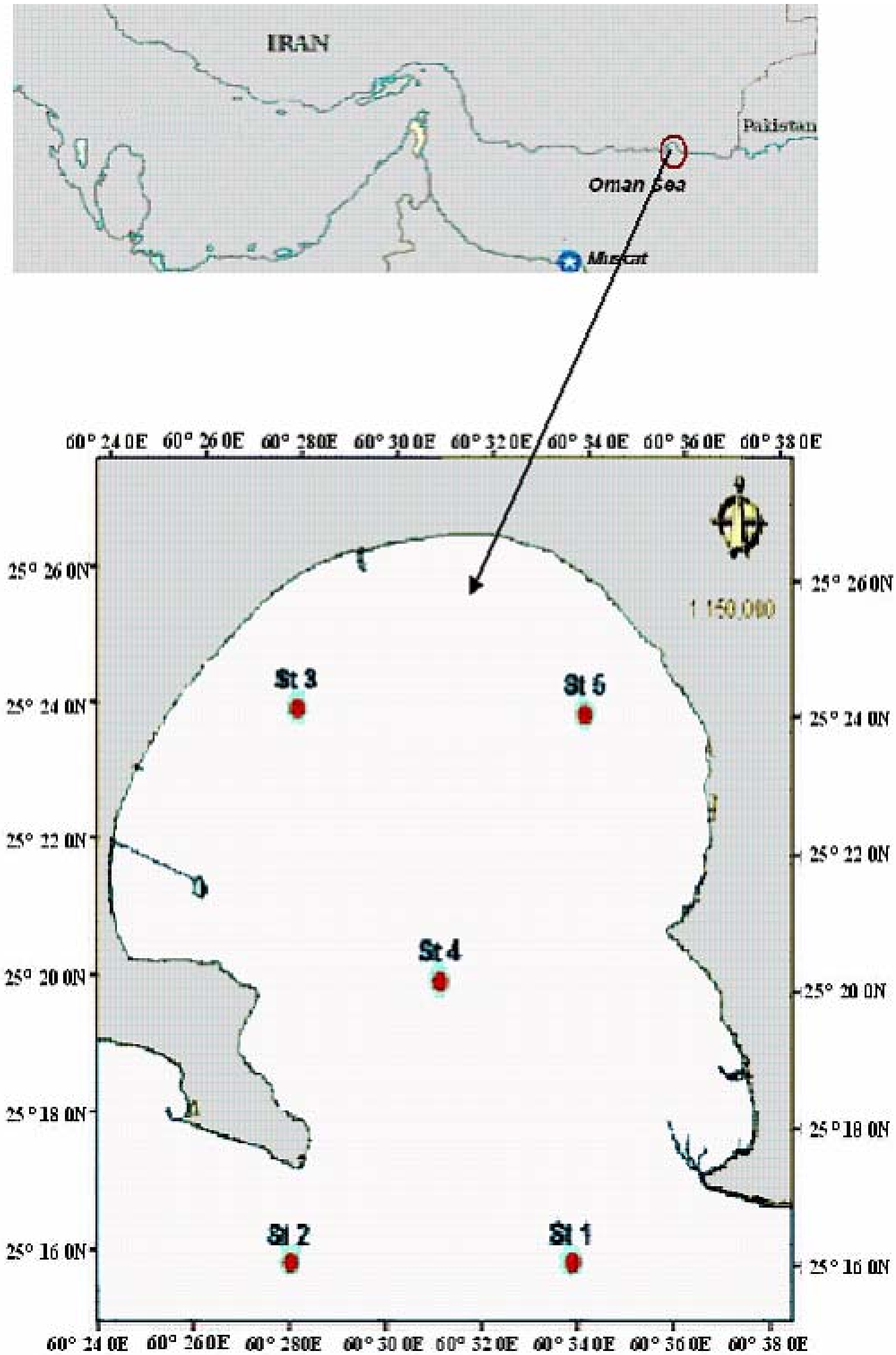

Figure 1. Sampling stations in the Chabahar Bay-Oman Sea

2.2. Sampling

Four sampling cruises were carried out in August 2007 (SW-monsoon), November 2007 (post-monsoon), February 2008 (NE-monsoon), and May 2008 (pre-monsoon). Five stations were investigated throughout the Chabahar Bay. Two stations (St. 1 and 2) were located far from shore waters with 22 m depth, another two stations were near the shore with 6m depth (St. 3 and 5) and the final station (St. 4) was located in the middle of the bay with 12m depth. Zooplankton was collected by using 100-µm mesh nets equipped with Hydrobios flow meter, from near the bottom to the surface at each station where physico-chemical variables were determined. The samples were preserved immediately in 4-5% formalin, bufferered to a pH of 8 with sodim tetraborate (borax). Organisms were identified to groups and copepods to species level (whenever possible) and counted. Density was expressed as individuals per m^{-3} (individual. m^{-3}).Only adult copepods were counted (Somoue *et al.,* 2005).

2.3. Data Analysis

Species diversity was calculated using Shannon–Weaver diversity index (Shannon–Weaver, 1963) and Species richness (Margalef, 1968). The data were further subjected to hierarchical cluster and multidimensional scaling (MDS) analyses to identify the similarity between stations based on composition of copepod species that were calculated as Braye Curtis similarity index using PRIMER (Clarke and Warwick, 1994).

3. Results

3.1. Environmental variables

The mean of water temperature varied from (20.53 ± 0.20°C) in NE-monsoon to (29.92 ± 0.05°C) in SW-monsoon. The mean of salinity ranged from (36.7 ± 0.06 Psu) in SW-monsoon to (36.91Psu) in pre-monsoon (Fig.2b). The minimum and maximum values of chlorophyll-*a* concentrations were noticed (0.77 ± 0.08 mg. m^{-3}) in SW-monsoon to (1.84 ± 0.92 mg. m^{-3}) in NE-monsoon (Fig.2c). The average of dissolved oxygen (DO) ranged from 5.66 ± 0.05 ml.l^{-1} in SW-monsoon to 8.80 ± 0.03 ml.l^{-1} in NE-monsoon (Fig.2d).

Pre-monsoon season showed the maximum Silicate (SiO_4) concentration (av. 0.031 ± 0.006 mg. m^{-3}) whereas it was minimum during the NE-monsoon (av.0.017 ± 0.05 mg. m^{-3}) (Fig. 2e). The variation of nitrate (NO_3) was (av. 0.026 ± 0.004 mg. m^{-3}) in pre-monsoon (av; 0.002 ± 0.0002 mg. m^{-3}) in post-monsoon (Fig. 2f). Minimum and maximum values of phosphate (PO_4) were from 0.015 ± 0.006 mg. m^{-3} during the NE-monsoon season to 0.008 ± 0.002 mg. m^{-3} during the SW-monsoon season (Fig. 2g).

3.2. Copepoda abundance and composition

Copepods were the dominant group during four seasons, reaching 69.73% (1253.57 ± 302.65 ind. m^{-3}) during pre-monsoon, 67.02% (613.30 ± 326.35 ind.m^{-3}) during SW-monsoon, 62.58% (594.12 ± 54.11 ind. m^{-3}) during post-monsoon and 47.38% (904.17 ± 161.7 ind. m^{-3}) in NE-monsoon (Fig 3; Fig 4). Copepod abundance increased significantly ($p<0.05$) during pre-monsoon than other seasons. There were significant spatial differences during SW-monsoon, post-monsoon and NE-monsoon ($p<0.05$).

3.3. Community structure

Totally, 75 copepod species including 5 orders, 19 families, and 21 genera were identified during four cruises in Chabahar Bay. Some species were observed only in one season with lowest abundance (less than 25 ind. m^{-3}) (Table1) such as '*Saphirina gastric aphirina nigromoculata* (at station 2) *Lucicutia flavicormis*, *Lucicutia gaussae* (at stations 1 and 3) and one species from Monstrilloida (at station 1) that only occurred during post-monsoon. *Oithona fallax, Paracanadica truncate,Euchatea marina* were observed at station 1(only during NE-monsoon). *Bestiolina similis*, *Delius nudus* just appeared during pre-monsoon (at station 2). *Euterpina acotifrons*, *Macrosetella gracilis* and *Microsetella rosea* were observed highest (44.87% from total copepoda) in pre-monsoon. *Temora turbinate* were greater during pre-monsoon (7.94%) and NE-monsoon (12.06%). Moreover, Psododiaptomidae species increased remarkably during NE-monsoon (7.57%) and were rare in other seasons. Results of cluster analyses based on copepod abundance revealed the presence of 2 main groups (groups *I* and *II*) during each season (Fig 5).

4. Discussion:

Zooplankton abundance in Chabahar Bay follows a cycle related to the monsoonal winds. In Chabahar bay, climatic changes and other environmental variables due to monsoonal winds play a key role in zooplankton community (Fazeli, 2008).

Nutrient enrichment is a key factor regulating temporal variations in zooplankton (mostly copepods) in coastal environments (Garcia and Lopez, 1989). Further, phytoplankton is a source of nourishment of herbivorous copepods (Tan *et al.,* 2004), but in present study there was not positive correlation between chlorophyll-a concentration and copepods abundance. According to (Tranter, 1973) there was a time lag between phytoplankton bloom and the increase of zooplankton. Our results showed chlorophyll-a concentration increased with phosphate concentration ($p<0.01$) (Table 2). Domestic sewage and industrial effluents noticed around the bay may also be responsible for increase of nutrients (mostly phosphate) and chlorophyll-a concentration consequently. This fact suggests that an earlier increase of phytoplankton must have favored such an increase in copepod and that the early bloom of phytoplankton may have used up the phosphate in this area.

Baars (1998) noticed during the SW- monsoon, that upwelling occurs in almost the entire western Arabian Sea, giving high primary productivity and vast diatom blooms, especially off Oman. This contrast with our result is because these areas are greatly affected by monsoonal winds and zooplankton densities were highest in the upwelling seasons, but upwelling was not reported in Chabahar Bay (Wilson, 2000).

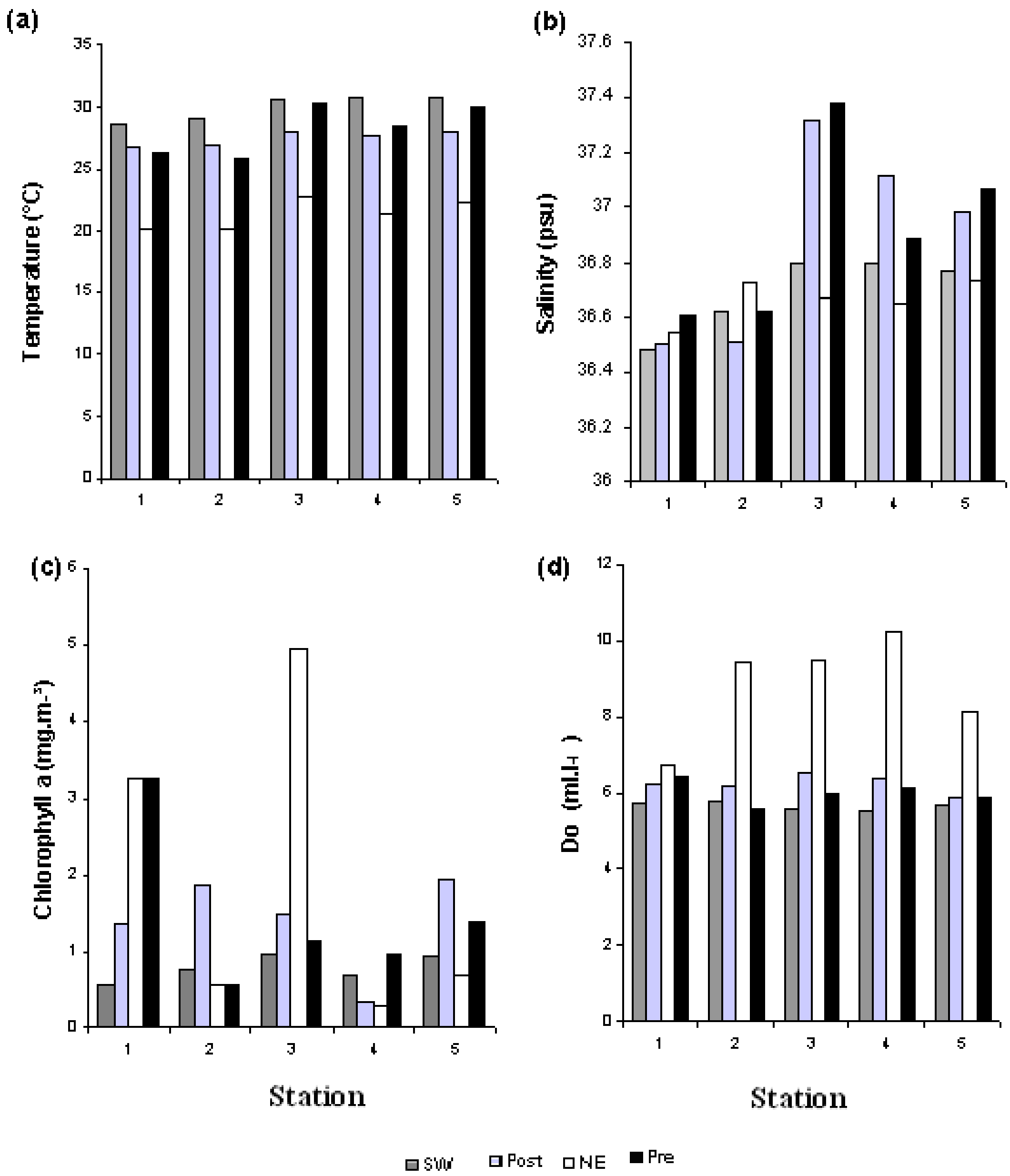

Figure 2. a, b, c, d, Distribution of major physico-chemical variables during monsoonal seasons (x axis as stations and Y axis as physico-chemical variables).

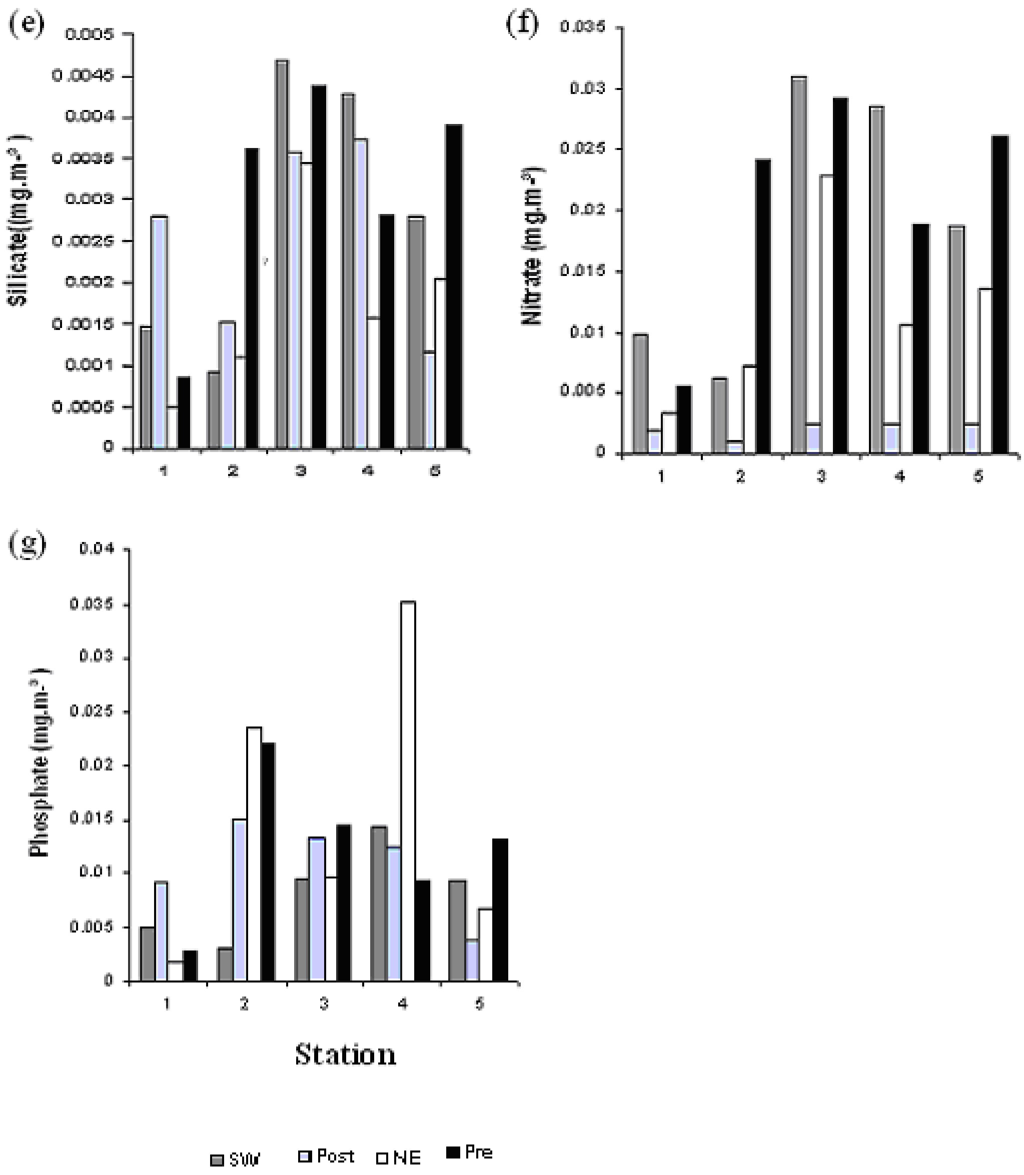

Figure 2. e, f, g, Distribution of major physico-chemical variables during monsoonal seasons (x axis as stations and Y axis as physico-chemical variables).

Since, there was no correlation between copepoda abundance and temperature-salinity, we conclude that the abundance of copepoda does not have any relationship with these parameters in Chabahar bay, while in some tropical embayments and estuaries in India, accelerate of zooplankton production during the periods of high salinity was documented by (Baidya and Choudhury, 1984; Tiwari and Nair 1993) and high temperature by (Li *et al.,* 2008).

Copepod diversity and richness were related to copepod abundance inversely. Species richness was enhanced towards the far from the shore and middle stations of the bay (Table 3). This is because organisms living in near shore waters seem to be adapted to the qualification and unable to thrive in offshore area (Faure, 1951). Increase of diversity and richness indices in far from shore communities is common in Indian Ocean (Madhupratap, 1986). This trend was observed in waters of Africa by (Okemwa, 1990) in Tudor Bay, (Mwaluma, 1997) in Kenya, (Osore, 1992; Osore, 1994) in Gazi Bay and (James *et al.,* 2003) in Media creek. In India, in the Bay of Bengal and Cochin backwaters, the similar trend were reported by (Pillai *et al.,* 1973; Nair *et al.* 1981; Tiwari and Vijayyalakshmi, 1993), who attributed this high diversity to the calmer, more stable oceanic waters.

In this study *Oithona nana* had much abundance through the year. This species is a euryhaline and euryterm species in tropical water (Nishida, 1985). Most abundance of copepod species during the pre-monsoon belongs to Harpacticoida in particular *Macrosetlla gracilis* ‹ *Microsetella rosea* ‹*Euterpina acutifrons* and Corycaeus *andrewsi.*

In conclusion, chlorophyll-*a* concentration appear to be the important factor leading to increase of copepod

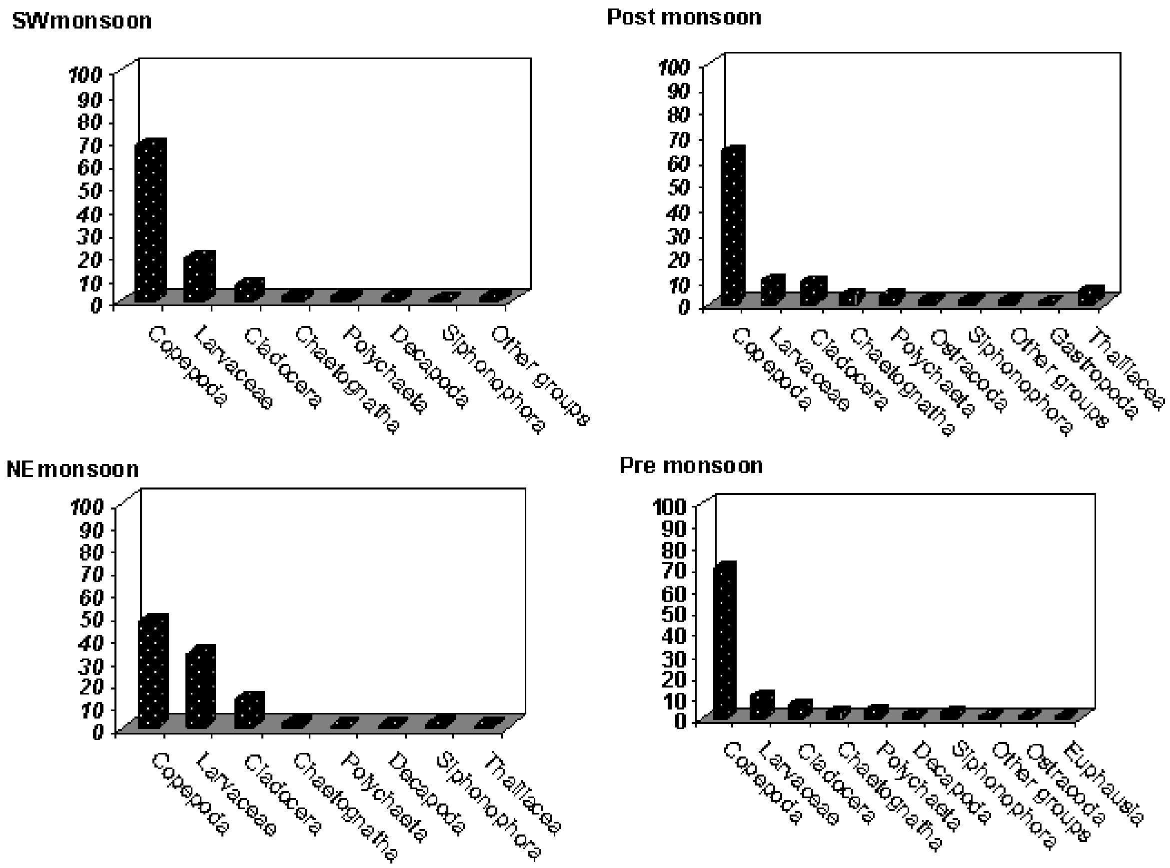

Figure 3. Percentage of zooplankton groups (%) during monsoonal seasons in Chabahar Bay.

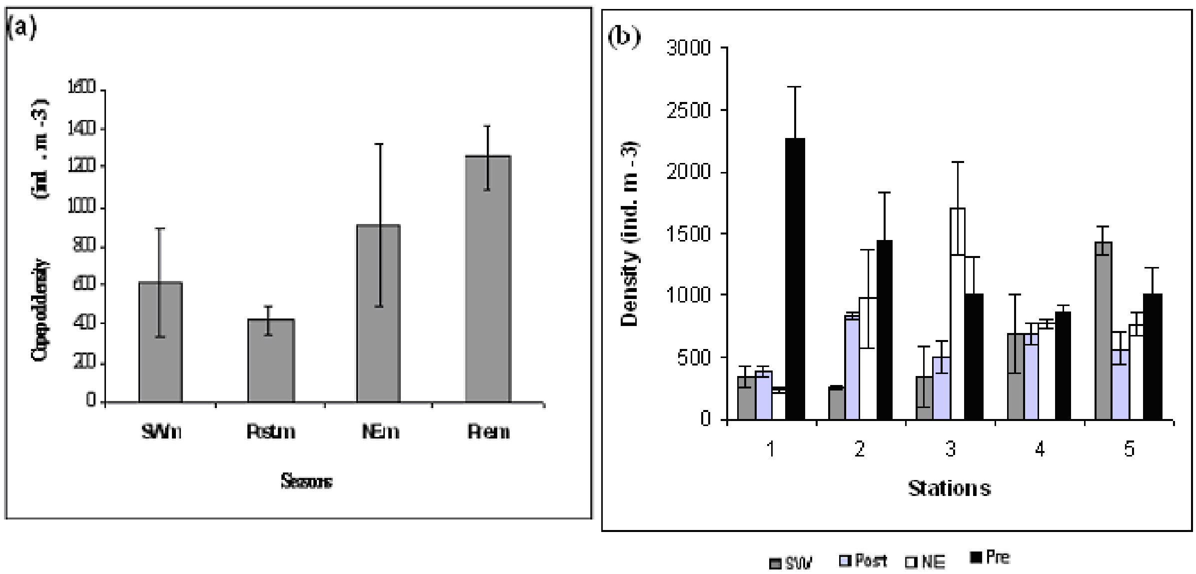

Figure 4. Seasonal (a) and spatial (b) distribution of copepoda during monsoonal seasons in Chabahar Bay.

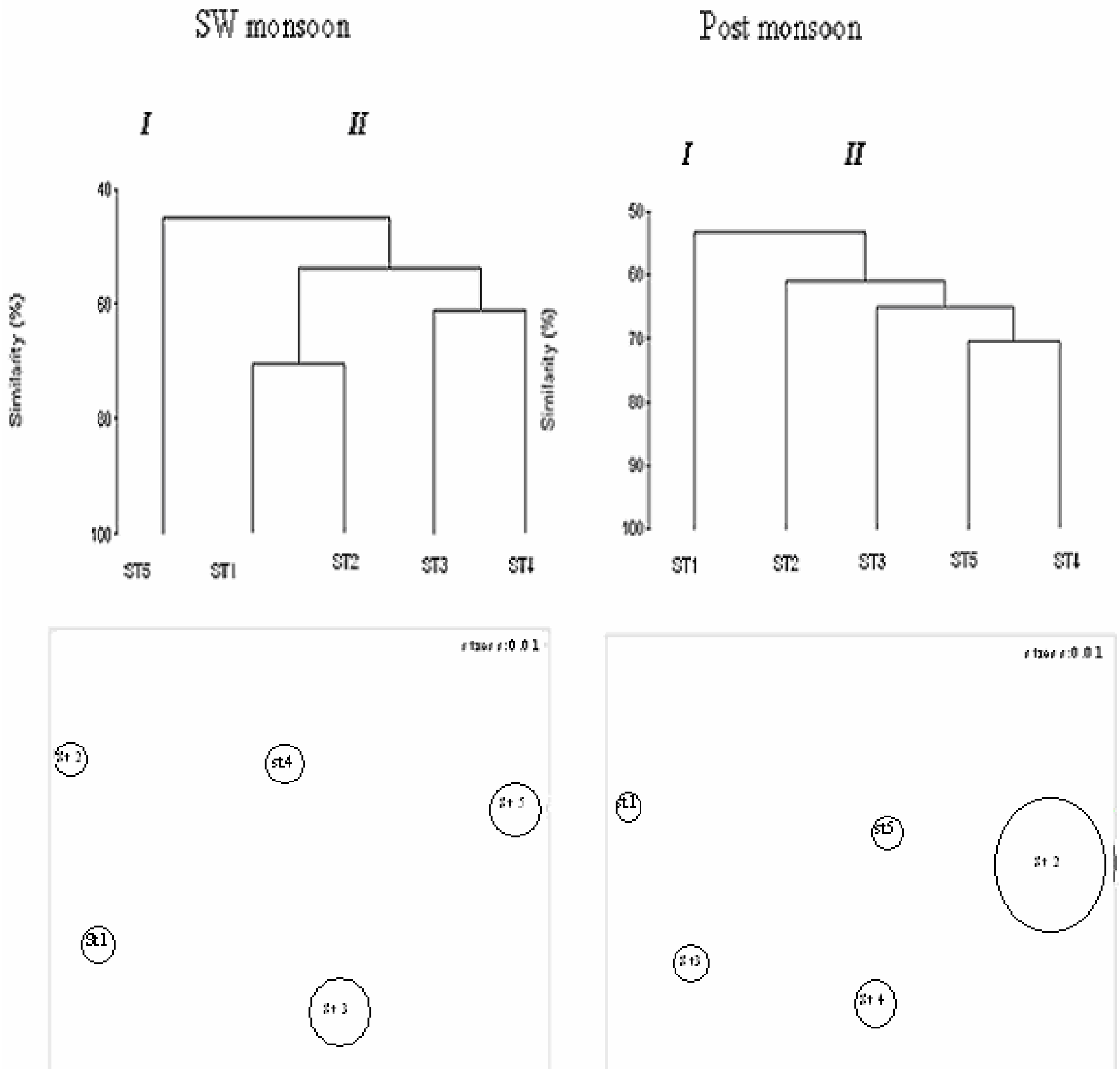

Figure 5. Cluster and MDS analyses showing similarity of stations during monsoonal seasons based on copepod composition in Chabahar Bay.

*Figure 5 continues in the next page.

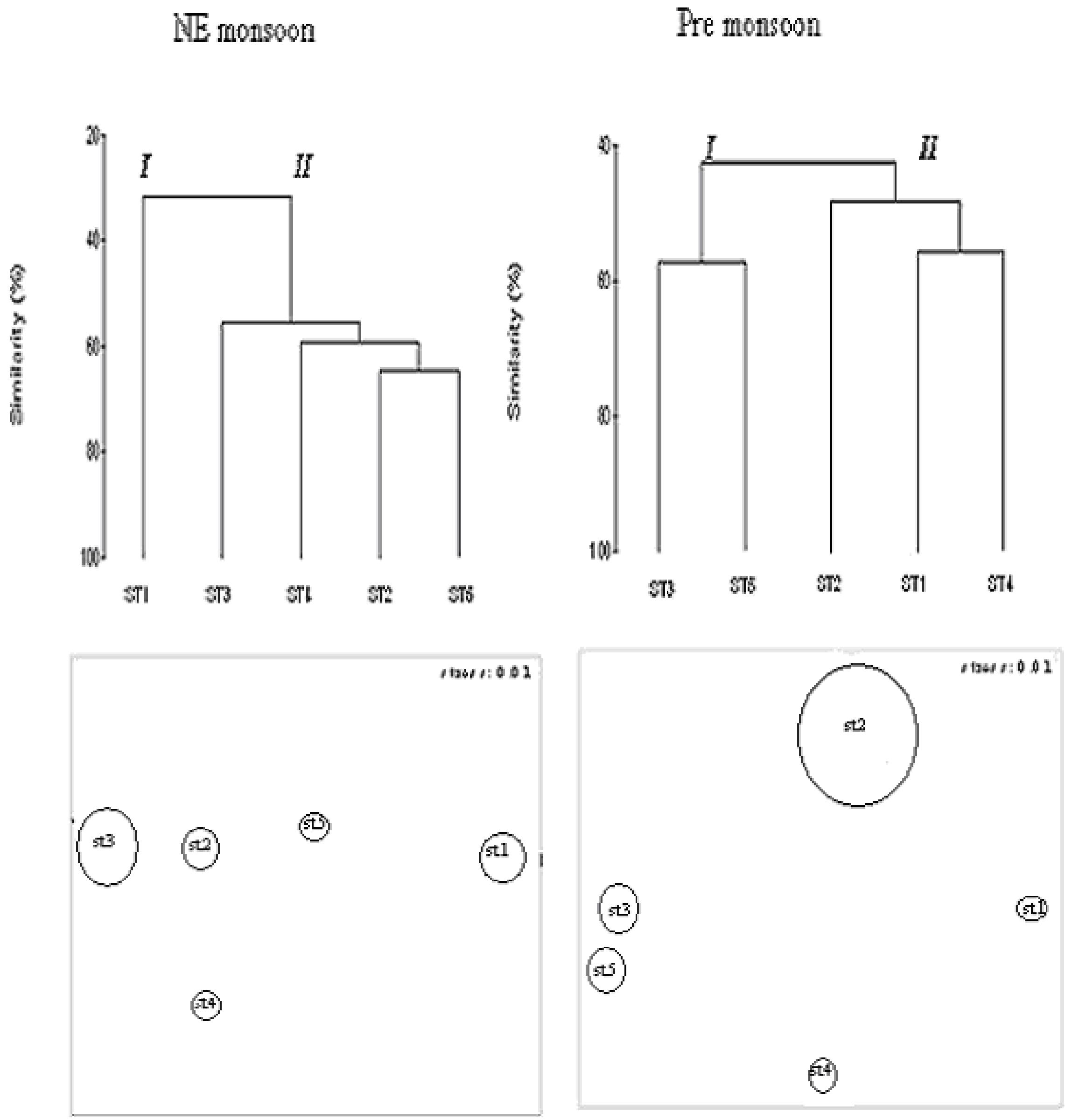

Figure 5. Cluster and MDS analyses showing similarity of stations during monsoonal seasons based on copepod composition in Chabahar Bay.

Table 1. Abundance of copepod species (ind. m^{-3}) in monsoonal seasons in Chabahar Bay.

Species	SW .m	post. m	NE. m	pre.m
Paracalanus crassirostris	1125.62	2830. 62	255 .24	548.34
P.elegans	2782.11	4162.53	1558.07	516.59
P.aculatus	56.1676	1701.56	160	47.418
P.denudatus	579.69	540.17	165	-
P.parvus	189.02	140.55	125	87.129
*P.*sp	600.52	1350.36	-	288.60
Acrocalanus longicornis	1230.81	339.7	222.22	-
A.gracilis	2152.94	61.54	630.48	-
A.gibber	2479.67	187.59	246.96	-
A.monochus	1374.52	87.90	316.75	259.74
*A.*sp	1219.27	541.49	525.71	412.67
T. desicaudata	89.43	1584.75	40	-
T.turbinata	677.3	5698.92	9291.32	5717.78
T.stylifera	-	299.07	-	-
Eucalanus subcrassus	221.32	626.23	1004.45	-
E. morcantus	-	210.12	-	-
E.sp	87	-	31.75	-
E. crassus	231.25	133.25	31.75	-
E. attenuatus	41.03	-	40	-
E.monochus	85.10	49.84	-	-
E. pileatus	44.07	-	-	-
E. halinus	44.07	-	-	-
Acartia pasifica	644.97	-	-	-
A.erythraea	47.60	-	-	-
A.sp	187.56	277.50	111.11	225.11
A. longirenis	205.66	389.75	236.11	-
Clausocalanus furcatus	-	-	430.58	-
C. gracilis	-	110.42		-
C. minor	-	-	766.96	-
C.sp	600.52	-	285	-
Calocalanus styliremis	45.30	42.60	-	-
C. plumulosus	-	63.06	31.75	-
C.pavo	47.60	55		
Pseudodiptomus sp	136.03	-	4994.04	299.32
P.marinus	-	-	589.21	-
Centropages furcatus	-	-	713.22	-
C. tenuremis	690.54	384.41	9441.95	839
Labidocera sp	27518.82	84.49	375.24	-
Pontellina	-	90. 115	-	-
Paracanadica truncata	-	-	191/11	-
Lucicutia sp	-	-	31/75	-
L. *flavicormis*	-	20.51	-	-
L. *gaussae*	-	22.04	-	-
Bestiulina similis	-	-	-	130
Delius nudus	-	-	-	127
Euchata marina	-	-	31.75	-

Oithona oculata	1952.91	1742.31	1558.78	1619.05
O. attenuata	3600.99	2762.99	1891.85	965.99
O.nana	3551.84	5254.90	10203.44	6323.23
O. bremicornis	336.41	2496.91	3761.27	1238.10
O.simplex	1343.38	5624.04	750.95	761.90
O. rigida	3883.92	1913.12	1284.20	1111.11
O.plumifera	45.35	1058.42	591.11	894.66
O. sp	5270.54	5911.14	5735.79	7163.06
O.fallax	-	-	31.75	-
Corycaus pacificus	194.72	311.33	166.98	-
C. andrewsi	1005.18	659.05	1528.07	5125.54
C. asiaticus	321.52	279.52	236.11	1910.13
C. erythraeus	90.52	2013	267.86	-
C. sp	725.13	390.30	166.96	285.71
C. affinis	-	243.68	125	331.07
C. dahli	-	384.77	361.11	-
C. speciosus	-	65.86	220.24	-
Oncea media	608.28	3626.43	2907.78	-
O. venusta	703	1860.83	634.20	259.74
O. clevei	417.74	1174.20	160	-
O. minuta	44.07	670.01	-	387.72
Sapphirina sp	-	-	331.35	-
S. gastrica	-	44.35	-	-
S. nigromoculata	-	45.35	-	-
Clytemnestra scutellata	-	123.08	1227.88	704.81
Macrosetlla gracilis	302.14	2375.38	753.49	14286.96
Microsetella rosea	172.92	280.86	366.96	8116.86
Euterpina acutifrons	4058.41	8791.82	4831.53	10440.73
Monstrilloida	-	105.17	-	-

Table 2. Pearson correlation of major environmental parameters and copepoda density

Variables	Chl-*a*	Temperature	Salinity	DO	SiO3	NO3	PO4
Copepod density	0.05	-0.26	-0.08	0.20	-	-	-
Chl- *a*	1.00	-0.38	0.06	0.33	0.05	0.05	0.93**

(‘*’ significant at 0.05 level; ‘**’ significant at 0.01 level).

Table 3. Diversity index (H') and species richness (D) of Copepoda in monsoonal seasons.

Stations	SW .m	post .m	NE .m	pre. m
1	3.09 (4.10)	3.03 (4.59)	2.89 (4.39)	2.52 (1.65)
2	3.41 (4.11)	3.34 (4.23)	2.67 (2.40)	2.47 (1.90)
3	2.40 (1.35)	2.62 (2.99)	2.19 (1.44)	1.96 (1.57)
4	2.73 (3.13)	2.85 (3.58)	2.88 (2.97)	2.14 (1.84)
5	1.15 (1.71)	2.33 (1.79)	2.54 (2.55)	1.93 (1.04)
Mean	2.55 (2.88)	2.83 (3.43)	2.63 (2.75)	2.20 (1.60)
Number species	50	58	57	33

abundance (after a time lag) and associated phosphate concentrations during pre-monsoon.

Acknowledgements

We wish to thank Dr. Irina Prusova for guide and Iranian National Center of Oceanography for the encouragement and support. The study was supported by Khorramshahr University of Marine Science.

References

Al-Najjar T Badran M and Zibdeh M. 2002. Seasonal cycle of surface zooplankton biomass in relation to the chlorophyll a in the Gulf of Aqaba, Red Sea. Abhath Al-Yarmouk Basic Sci. Eng. **12 (1)**: 109-118.

Baars MA. 1998. Zooplankton biomass in the upper 200 m in and outside the seasonal upwelling areas of the Western Arabian Sea Pelagic. Proceedings of the 2nd International Conference Final-report-of-SCOR. Noordwijkerhout, Netherlands.

Baidya AU and Choudhury A. 1984. Distribution and abundance of zooplankton in a tidal creek of Sagar Island, Sundarbans, West Bengal. Envir. Ecol. 2: No. 4.

Burkill PH Mantoura RFC Llewellyn CA and Owens NJP. 1987. Microzooplankton grazing and selectivity of phytoplankton in coastal waters. Mar. Biol. **93**:581-590.

Clarke KR and Warwick RM. 1994. Changes in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth Marine Laboratory, Plymouth.

Faure ML.1951. Le zooplankton de la zone coterie du Maroc Anne 1950. Conseil International pour l' Exploration de la Mer. Annale Bio. **8**: 66-68.

Fazeli N. 2008. Ecological studies on zooplankton from the Chabahar Bay with special reference to copepods (MSc. thesis). Khorramshahr (Iran): Khorramshahr University of Marine Science.

Garcia JR and Lopez JM. 1989. Seasonal patterns of phytoplankton productivity, zooplankton abundance and hydrological conditions in Laguna Joyuda, Puerto Rico. In: Ros J D, editor. **Topics in Marine Biology**. Scientia Marina. Academic Press, pp. 625-631.

James M Melckzedeck O Joseph K and Peter W. 2003. Composition, Abundance and Seasonality of Zooplankton in Mida Creek. West. Indian. Ocean. **2**:147–155.

Kiorboe T. 1997. Population regulation and role of mesozooplankton in shaping marine pelagic food webs. Hydrobiol. **363**: 13-27.

Li CT Ram K Hans UD Qing CC and Jiang SH. 2008. Monsoon-Driven Succession of Copepod Assemblages in Coastal Waters of the Northeastern Taiwan Strait. Zool. Stud .**47**: 46-60.

Madhupratap M. 1986. Zooplankton standing stocked diversity along an oceanic track in the western Indian Ocean. Mahasagar. Nat. Inst. Ocean.**16**: 463–467.

Margalef DR. 1968. **Perspectives in Ecological Theory**. The University of Chicago: Chicago Press, USA.

Mwaluma JM. 1997. Distribution and abundance of zooplankton off the Kenya coast during the monsoons (MSc. thesis). Nairobi (Kenya): University of Nairobi.

Nair SRS Nair V Achuthankutty CT and Madhupratap M. 1981. Zooplankton composition and diversity in Western Bay of Bengal. J. Plankton Res. **3**: 493–507.

Nishida S.1985. Taxonomy and distribution of the family Oithonidae (Copepods, Cyclopedia) in the pacific and Indian Oceans. Ocean Res. Inst. Univ. Tokyo. Japan, 20:167.

Osore MK. 1992. A note on zooplankton distribution and diversity in a tropical mangrove creek system, Gazi, Kenya. Hydrobiol. **247**: 119–120.

Osore MK. 1994. A study of Gazi Bay and the adjacent waters: community structure and seasonal variation (MSc thesis) Vrije (Belgic): Vrije University.

Okemwa EN. 1990. A study of the pelagic copepods in a tropical marine creek, Tudor, Mombasa, Kenya with a special reference to their community structure, biomass and productivity (PhD thesis). Vrije (Belgic): Vrije University.

Paffenhofer GA and Stearns DE. 1988. Why is Acartia tonsa (copepoda) restricted to near shore environment? Mar. Ecol. Prog. Ser. **42**: 33-38.

Pillai P Qasim SZ and Kesavan N. 1973. Copepod component of zooplankton in a tropical estuary. Indian J. Mar. Sci. 2: 38-46.

Poulet SA and Williams R. 1991. Characteristics and properties of copepods affecting the recruitment of fish larvae. Plankton Soc. Japan. Special. **7**: 271-290.

Relevante N Gilmartin M and Smodlaka N. 1985. The effects of Po River induced eutrophication on the distribution and community structure of ciliated protozoan and micro metazoan populations in the northern Adriatic Sea. J. Plankton Res. **7**: 461-471.

Seraji F. 1995. Distribution and abundance of plankton population at Hormozgan estuaries. Proceedings of the 2nd marine conference. University of Shahid Chmran. Ahvaz, Iran.

Sanjarani E. 2007. Seasonal variation of zooplankton from the strait of Hormoz to Goater Bay (MSc thesis).Bandar abbas (Iran): Azad University of Bandar Abbs.

Shannon CE and Weaver W. 1963. **The Mathematical Theory of Communication**. University of Illinois Press, Urbana, USA.

Somoue L Elkhiatil N Ramdani M Hoai TL Ettahirio O Berraho A and Chi TD. 2005. Abundance and structure of copepod communities along the Atlantic coast of southern Morocco. Acta. Adri. **46**: 63-76.

Tan Y Huang L Chen Q and Huang X. 2004. Seasonal variation in zooplankton composition and grazing impact on phytoplankton standing stock in the Pearl River estuary, China. Continent. Shelf Res. **24**:1949-1968.

Thiriot A. 1978. Zooplankton communities in the West African upwelling area. In: Boje R and Tomzak M., editors. **Upwelling Ecosystems**. New York. pp. 32-61.

Tiwari RL and Vijayyalakshmi RN. 1993. Zooplankton composition in Dharamtar creek adjoining Bombay harbors. Indian J. Mar. Sci. **22**: 63–69.

Tranter D. 1973. Seasonal studies of a pelagic ecosystem (meridian 110° E). In: B. Zeitzschel, editors. **The Biology of the Indian Ocean**. University of California, Institute of Marine Sciences, Santa Cruz, CA 96063, ETATS-UNIS, pp. 487-520.

Williams R Conway DV and Hunt HG. 1994. The role of copepods in the planktonic ecosystems of mixed and stratified waters of the European shelf seas. Hydroboil. **292**: 521-530.

Zareei A. 1994. The case study of Hydrology and Hydrobiology of the Goatr strait. Proceedings of the 2nd marine conference. University of Shahid Chmran. Ahvaz, Iran.