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DISTRIBUTION AND NUMERICAL ABUNDANCE OF THE COPEPOD COMMUNITY ALONG THE COASTAL WATERS OF QATAR (ARABIAN GULF)

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Key words: Copepoda, distribution, abundance, Qatar, Arabian Gulf

ABSTRACT

The copepod distribution and abundance were studied along the Exclusive Economic Zone (EEZ) of Qatar during October, December 1994 and April 1995. The copepod population (including their copepodite stages) was numerically dominating the zooplankton community contributing about 76% of the total community with an average of 1896 Ind./m^3. Higher standing stocks were associated with low salinity high chlorophyll a bearing waters. High peak of the copepod population was observed during December 1994 (av. 3,522 Ind./m^3). No significant major differences in copepod abundance appeared between October 1994 (av. 1,115 Ind./m^3) and April 1995 (av. 1,050 Ind./m^3). Fifty-one species belongs to 24 genera of copepods were identified. The most abundant copepod genera were Oithona spp. (15.6%), Paracalanus spp. (14.5%), Euterpina acutifrons (13.8%) and Oncaea spp. (10.7%). The same genera were recorded in all seasons reflecting their capability of tolerating temperature (<20°C - >30°C) changes.

INTRODUCTION

Zooplankton plays a major role in the marine food chain leading to the production of organisms of economical value such as shrimp and fish.

As copepods dominate the marine zooplankton community, often contributing over 70% of the total zooplankton counts in nearshore habitats; variations in their composition and abundance are a valid indication of ecological succession, breeding, periodicity as well as environmental conditions. Numerous investigations from different geographic locations have emphasized the importance of copepods in ecological studies (Houde & Lovdal, 1982; Chisholm & Roff, 1990; Ramaiah & Nair, 1997 and Rios-Jara, 1998).

The Arabian Gulf is a rich habitat for different species of marine flora and fauna. Considerable research papers are available on the distribution and abundance of the Zooplankton community in the Gulf waters for the pre-spill period of the second Gulf War (Frontier, 1963; Kimor, 1973; Yamazi, 1974; Basson ***et al.***, 1977; Jacob & Zabra, 1979; Gibson ***et al.***, 1980; Halim, 1984; Michel ***et al.***, 1986; Fahmi ***et al.***, 1987; Al-Yamani, 1989; Sheppard ***et al.***, 1992). For the post- spill period, Al-Yamani ***et al.*** (1993) and Al- Aidaroos (1993) reported on the plankton distribution during spring (April and May, 1992) as part of the Mt. Mitchell 100 days Gulf cruise studies. Al-Yamani ***et al.*** (1998) and Al- Khabbaz and Fahmi (1998) studied the distribution of zooplankton and the copepod community in the ROPME Sea Area for samples collected from the R/V Umitaka Maru cruises once during December 1993 and December 1994, respectively.

Concerning the coastal environment off Qatar, studies on the total zooplankton community are few. Yamazi (1974) included information on the surface zooplankton in waters offshore of Qatar. Dorgham & Hussein (1991) studied the hydrography and plankton distribution of the Doha Harbor, Qatar. Hussein (1992) gave a comprehensive list of zooplankton species and percentage abundance of each group observed during 1984 for Qatari waters. Gobashy ***et al.*** (1994) studied the zooplankton community in Qatari waters. On the other hand, Dorgham and Hussien (1997) described the seasonal dynamics of the numerical abundance and species composition in relation to the prevailing physico-chemical conditions in Doha Harbor.

The present study was therefore undertaken with a view to provide more information on species composition, abundance, spatial and temporal variations and diversity of copepods during three seasons; autumn, winter and spring of 1994-1995 in relation to the prevailing environmental conditions. Such information would be helpful in the future monitoring of the ecology of this ecosystem.

MATERIAL AND METHODS

Twenty four stations, representing six sectors (namely; 100 - 600) each comprising 4 stations, perpendicular to the coast, covering the northern and eastern Qatari marine areas using *the RV "Mukhtabar Al-Bihar"* of the University of Qatar. They were monitored during three seasons October 1994 (Autumn), December 1994 (Winter) and April 1995 (Spring) (Fig. 1). This area lies between Lat. 25° 00'-26° 51'N and Long. 51° 10' – 52° 30'E. The water depth of the area lies between 10 and 60 m. Zooplankton samples were collected vertically by zooplankton net of 0.5m mouth diameter having a mesh size of 190 µm. The collected samples were preserved in 5% buffered formalin solution. Most copepod taxa were enumerated in triplicate and identified to species level by the following key: Rose (1933); Newell (1979); Yamaji (1986). Todd and Laverack (1991). The standing stock of zooplankton community was calculated as their total number of copepods per cubic meter.

Physicochemical oceanographic variables such as water temperature, salinity, pH, dissolved oxygen (DO) were measured for the water samples collected from the same sites, using a YSI Water Quality Logger. Samples for chlorophyll a were collected, filtered onboard using 0.45µm membrane filters, extracted using 90% acetone and measured spectrophotometrically using the method described by Strickland & Parsons (1972).

RESULTS AND DISCUSSION

Physico-Chemical parameters

Along the Exclusive Economic Zone (EEZ) of Qatar, surface water temperatures varied between 29.0 and 30.5 °C, 19.9 and 24.3 °C and 22.9 and 25.0°C during October 1994, December 1994 and April 1995, respectively.

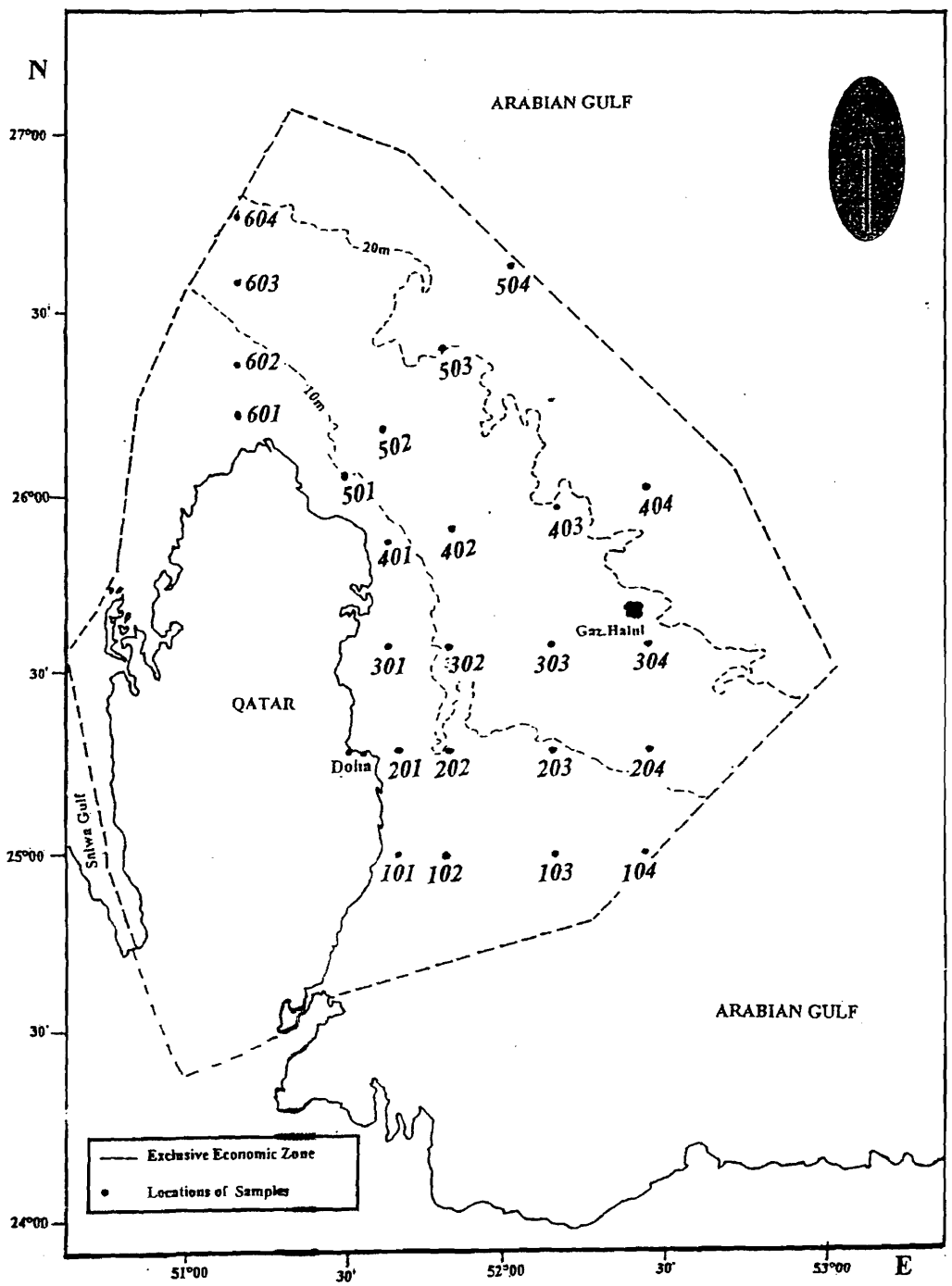

Fig. (1): The Exclusive Economic Zone of Qatar, showing the sampling locations.

During summer the maximum recorded water temperatures approaches 34.0 °C (Al-Ansari, 1998). Thermal stratification appeared clearly at the offshore locations when the station depth exceeded 40m The amplitude of temperature difference between surface and bottom approached sometimes 6°C. This amplitude decreased in April 1995 where the difference did not exceed 2°C while in December 1994 it was completely absent where vertical mixing masked the appearance of any vertical stratification.

Dissolved oxygen was high during December 1994 and April 1995 with an average of 6.39 to 6.2 mg/l, respectively. Lower values were observed during October 1994, with an average of 5.22 mg/l. Variations in pH values were not significant ranging between 8.14 and 8.32.

As a part of the Gulf, the area generally sustains high salinity fluctuating between 39 and 42 psu. Salinity variations along the EEZ of Qatar are governed by water circulation in the area. The water current entering the Gulf from Hormuz, in an anticlockwise rotation pattern, deflected to some degree by the Qatar peninsula. This current is characterized by relatively low salinity (38.4 psu). Highly saline water (average 57 psu) from Salwa Bay west of Qatar are derived from the northern area, diluted upon mixing with the anticlockwise gyre water derived from Hormuz leading to salinity of 42.7 psu at the nearshore stations of sector 600. The inshore stations of sectors 400 and 500 are still affected by this current showing salinities between 40 and 41 psu. However, the offshore waters of these sectors still retain the gyre water characteristics on the surface (salinity 39.6 – 39.8 psu) The mid region is characterized by salinities similar to the rest of the Gulf (between 40-41 psu) while the southern region located away from the gyre effect retains high salinities lying between 44.6 and 45.2 psu.

Chlorophyll *a*

The average chlorophyll a for the EEZ of Qatar is 0.21 µg/l, ranking it as an oligotrophic ecosystem (Al-Ansari, 1998). Chlorophyll a values >1 µg/l were only intermittently recorded at the nearshore areas of the southeastern coast. The nearshore northern and northeastern areas sustained low chlorophyll a levels fluctuating between 0.1 and 0.48 µg/l. On the other hand, the offshore locations impacted by the low salinity anticlockwise current (sectors 500 and 600) are characterized by high nutrient levels (Abdel-Moati & Kureishy, 1997) and consequently high chlorophyll a biomass (range 0.41-0.76 µg/l) specially

during December 1994. Except the high chlorophyll a levels observed during winter (December 1994), variations between different locations during October 1994 and April 1995 and even between the two seasons were not significant. Comparable results were observed by Al-Khabbaz & Fahmi (1998) for chlorophyll a concentration off northern Qatar during December 1994 i.e. range 0.34-1.05 µg/l.

Copepod population

The spatial and temporal distribution of total copepods sampled along the EEZ of Qatar appeared in Table 1. Despite the distinctive drop in the copepod densities at the two offshore stations of sectors 300 & 400 with an average of 859 Ind./m^3 and 1639 Ind./m^3 , respectively (Table 1 and Fig. 2a-c), no clear inshore / offshore trend existed along the different sectors allover the study period. Sector 200 showed the highest density of copepods (average 3813 Ind./m^3) situated opposite to the Capital Doha harbored the highest densities of copepoda during the study period relative to the whole area (Table 1). The area receives a continuous flow of excess brackish water loaded with nutrients lowering the salinity sometimes to about 28.4 psu during high flow (Al-Ansari, 1998). The maximum copepod density was recorded at station 202 (8,513 Ind./m^3) during December 1994 (Table 1 and Fig. 2b). The offshore waters of sectors 500 and 600 affected by the anticlockwise low salinity, high chlorophyll bearing current, were generally characterized by an increase in the total numbers of copepods especially during December 1994. Station 303 contributed the lowest copepod counts allover the period of study (av. 398 Ind./m^3) due to minimum values of copepod density (148 Ind./m^3) during April 1995 (Table 1 and Fig. 2c). The offshore stations of these sectors are continuously subjected to formation water disposal from Halul Island, the largest offshore oil facility of Qatar.

Generally speaking, sector 2 contributed the highest counts of copepoda during the three seasons; while, the lowest attained in sector 3 (Table 3). This is due to the high nutrient content of sector 2 sampled opposite to Doha Harbor (Abdel-Moati and Kureishy, 1997).

Regarding the seasonal variations, the main peak of copepod abundance was recorded in December 1994 (av. 3,522 Ind./m^3) whereas October 1994 and April 1995 harbored the lowest densities (av. 1,115 and 1,050 Ind./m^3, respectively) (Table 1). On the other hand, the blooming of copepods during)

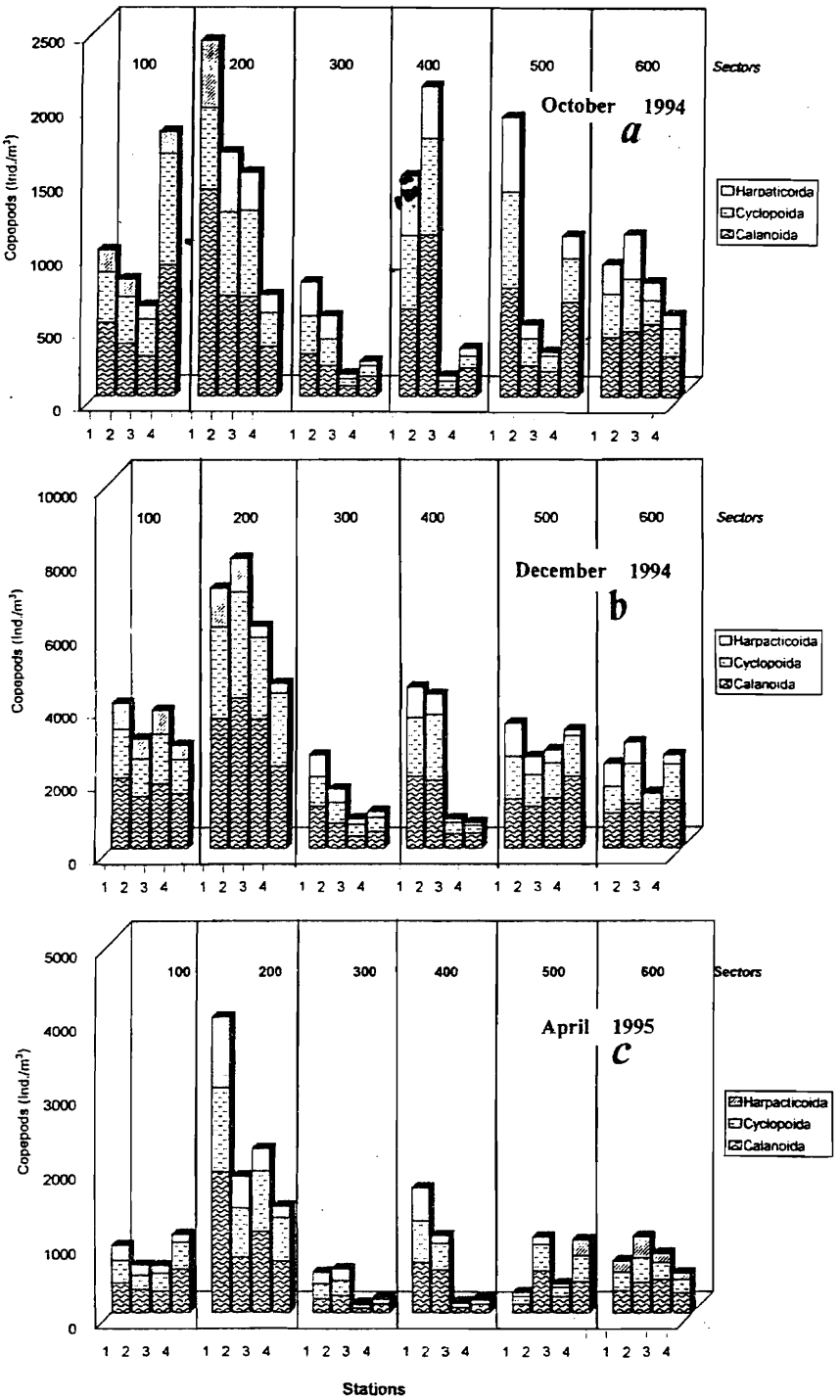

Fig. (2): Relative abundance of copepod orders alont the EEZ of Qatar.

Table (1): Spatial and temporal distribution of total Copepoda along the EEZ of Qatar.

Sector	Months / Stations	October 1994 T.C.*	Av.	December 1994 T.C.	Av.	April 1995 T.C.	Av.	Mean T.C.	Mean Of Sectors
1	101	1190		4258		1003		2164	
	102	922	**1197**	3314	**3665**	724	**897**	1677	**1920**
	103	691		3916		721		1799	
	104	1987		2951		1140		2039	
2	201	2761		8132		4256		5070	
	202	2101	**1842**	8513	**7048**	2002	**2548**	4205	**3813**
	203	1672		6536		2383		3547	
	204	834		4912		1552		2429	
3	301	882		2832		590		1451	
	302	623	**492**	1918	**1675**	648	**409**	1063	**859**
	303	181		865		148		398	
	304	284		1038		250		524	
4	401	1702		5247		1926		2958	
	402	2298	**1138**	4864	**2920**	1114	**860**	2739	**1639**
	403	192		835		182		403	
	404	361		796		218		458	
5	501	2109		3940		297		2115	
	502	582	**1099**	2789	**3277**	1106	**736**	1492	**1704**
	503	379		2926		472		1259	
	504	1326		3454		1070		1950	
6	601	969		2694		807		1490	
	602	1264	**921**	3186	**2544**	1160	**844**	1870	**1436**
	603	854		1682		830		1122	
	604	597		2614		579		1263	
Mean		**1115**		**3522**		**1050**		**1896**	

*T.C. = Total Copepoda

December 1994 was accompanied by an increase of chlorophyll a concentration in addition to the highest development of zooplankton during winter season (Fig. 3a-c). The relationships between the copepod distribution and chlorophyll a during October 1994 and April 1995 (Fig. 3a & 3c) was not detected as in December 1994 (Fig. 3b) due to the lowering chlorophyll a values.

The Gulf, including Qatari waters, apparently follows the Indian Ocean in the seasonal frequency of zooplankton and copepod population. Panikkar and Rao (1973) stated that during winter Monsoon a great development of zooplankton and copepod communities occurs. The plankton productivity of Kuwaiti and Qatari coastal waters were studied by Michel ***et al.*** (1986) and Ghobashy ***et al.*** (1994) showing two peaks in summer and winter and the copepod peak in winter.

Previous studies in the Arabian Gulf especially along the Kuwaiti and Qatari waters (Table 2) indicated that copepods are the most numerous zooplankton groups in the coastal waters. These observations agreed with the present study, whereas predominance of copepods including their copepodite stages was 1,896 Ind./m^3 constituting about 76% of total the zooplankton community. The copepod/zooplankton percentage lied between 50-85% when using zooplankton nets having mesh size between 100-120 µm (Table 2).

Table (2): Percentage frequency and number of species for the copepod community in the Arabian Gulf and coastal waters off Qatar.

Copepoda (% Composition)	No. of species	Net size (µm)	Reference
52.4%	30	330µm	Yamazi (1974)
74%	49	110µm	Michel *et al.* (1986)
22.08%	-	335µm	Al-Yamani et al. (1993)
83%	-	100µm	Fahmi *et al.* (1987)
35.4%	57	55µm	Hussein (1992)
10.6-35.3%	-	55µm*	Ghobashy *et al.* (1994)
80%	-	120µm**	
66%	-	100µm	Al-Khabbaz & Fahmi (1998)
51.7	-	100µm	Al-Yamani *et al.* (1998)
76	51	120µm	Present study

*Samples collected 1984-1986

**Samples collected Decemb 1993

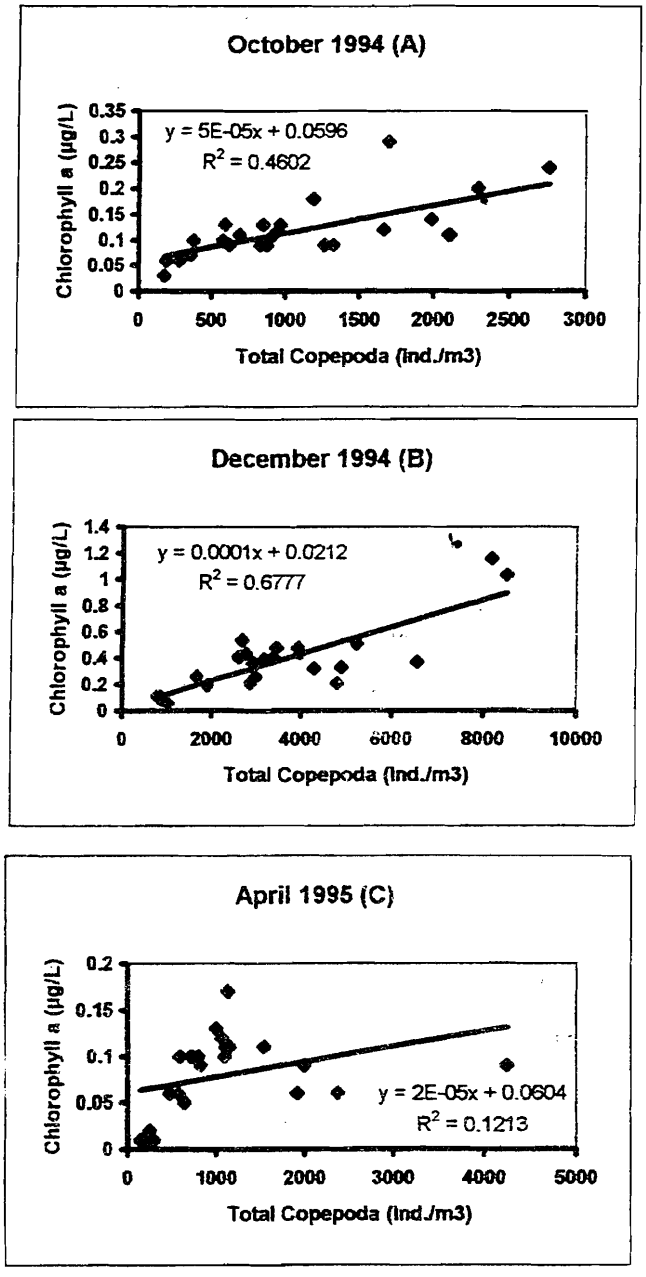

Fig. (3): Relationship between chlorophylla and total copepoda along the EEZ of Qatar.

Al-Khabbaz and Fahmi (1998) studied the distribution of copepods along an inshore/offshore sector off the northeastern coast of Qatar, extending to Iran from 4 stations. The mean numbers of total copepods averaged 4,633 Ind./m^3 ranging between 1,689-8,444 Ind./m^3, during December 1994. The same authors mentioned that the copepod densities varied between 568 and 2,828 Ind./m^3, 8 and 788 Ind./m^3 and 3,199 and 12,192 Ind./m^3 for Saudi Arabia Bahrain and U.A.E. Gulf waters, respectively.

In the present study, the copepod population was represented by fifty-one species belonging to 24 genera from the three orders Calanoida (35). Cyclopoida (11) and Harpacticoida (5) (Table 3 and Appendix 1). The percentage frequency of Calanoida to copepod population during the three seasons was 42.2% in October 1994, 44.5% in December1994 and 43.1% in April 1995. ***Paracalanus*** spp. was the most abundant genus among Calanoid copepods constituting about 14.5% of the total copepod, followed by ***Acartia*** spp. (av. 5.3%) and ***Temora*** spp. (av. 5.1%) (Table 3). Similar species were observed in Doha Harbor (Dorgham and Hussein, 1991 and 1997).

Cyclopoida was representing the second most abundant group among the copepod assemblage forming 28.8%, 32.7% and 30.6% of the total copepods for the three seasons, respectively (Table 3). The dominant Cyclopoid genera were ***Oithona*** spp. (av. 15.6%) of the total copepods. These values are in agreement with the studies of Dorgham and Hussien (1997) who recorded the predominance of this species inside Doha Harbor constituting 24-59% of the total copepod population. On the other hand, ***Oncaea*** spp. Was represented by 10.7% of the total copepods (Table 3).

In the study area, Harpacticoid copepods maintained relatively constant densities with the exception of December 1994 (av. 13.0%) of the total copepods. Harpacticioda is represented mainly by ***Euterpina acutifrons*** (av 13.8%) (Table 3). Dorgham and Hussien (1997) observed this species throughout the zooplankton of Doha Harbor, constitute 2.3-17% of the total copepods. Generally, Harpacticoids increased in the inshore stations while Calanoids showed high tendency to increase at the offshore stations (Fig. 2a- c)

Along the western Arabian Gulf south of Kuwaiti waters, Michel ***et al*** (1986) stated that Cyclopoid abundance approximated that of Calanoid

Appendix 1. Copepods species list for the EEZ of Qatar

Order : Calanoida

Acartia bispinosa
A. clausi
A. discaudata
A. negligens
Acrocalanus gibber
A. gracilis
Calanopia elliptica
C. minor
Candacia bispinosa
C. bradyi
Centropages furcatus
C. orsinii
C. violaceus
Clausocalanus arcuicornis
C. furcatus
Eucalanus crassus
E. mucronatus
E. subcrassus
Euchaeta concinna
E. marina
Erytemora affinis
Labidocera acuta
L. kroyeri
Paracalanus aculeatus
P. crassirostris
P. parvus
Pontella longipedata
P. spinicauda
Rhincalanus cornutus
R. nasutus
Temora discaudata
T. turbinata
Tortanus forcipatus
Undinula darwini
U. vulgaris

Order : Cyclopoida

Corycaeus clausi
C. limbatus
C. speciosus
C. venustus
Oithona nana
O. plumifera
O. similis
Oncaea conifera
O. venusta
Sapphirina angusta
S. nigromaculata

Order: Harpacticoida

Clytemnestra scutellata
Euterpina acutifrons
Macrosetella gracilis
Microsetella norvegica
M. rosea

Table 3. Temporal distribution of Copepod genera along the EEZ of Qatar.

Genera	October 1994		December 1994		April 1995	
	Ind./m^3	%	Ind./m^3	%	Ind./m^3	%
Acartia spp.	69	6.2	209	5.9	39	3.7
Acrocalanus spp.	4	0.4	65	1.8	18	1.7
Calanopia spp.	52	4.7	123	3.5	75	7.1
Candacia spp.	5	0.4	18	0.5	4	0.4
Centropages spp.	24	2.2	65	1.8	32	3.0
Clausocalanus spp.	32	2.9	50	1.4	30	2.9
Eucalanus spp.	11	1.0	15	0.4	8	0.8
Euchaeta sp.	1	0.1	1	0.03	0	0
Eurytemora sp.	0	0	3	0.1	0	0
Labidocera spp.	26	2.3	80	2.3	27	2.6
Paracalanus spp.	135	12.1	680	19.3	126	12.0
Pontella spp.	2	0.2	2	0.1	7	0.7
Rhincalanus spp.	1	0.1	0	0	0	0
Temora spp.	58	5.2	190	5.4	50	4.8
Tortanus sp.	1	0.1	3	0.1	0	0
Undinulla sp.	48	4.3	62	1.8	36	3.4
Total Calanoidae	**469**	**42.2**	**1566**	**44.5**	**452**	**43.1**
Corycaeus spp.	24	2.2	191	5.4	43	4.1
Oithona spp.	155	13.9	563	16.0	179	17.0
Oncaea spp.	131	11.7	387	11.0	99	9.4
Sapphirina spp.	11	1.0	9	0.3	1	0.1
Total Cyclopoida	**321**	**28.8**	**1150**	**32.7**	**322**	**30.6**
Clytemenestra sp.	7	0.6	11	0.3	1	0.1
Euterpina sp.	156	14.0	413	11.7	165	15.7
Macrosetella sp.	4	0.4	9	0.3	5	0.5
Microsetella spp.	21	1.9	23	0.7	9	0.9
Total Harpacticoida	**188**	**16.9**	**456**	**13.0**	**180**	**17.2**
Copepodite stages	137	12.2	350	9.9	96	9.1
T. Copepod (Ind./m^3)	**1115**		**3522**		**1050**	
Diversity	**23**		**23**		**20**	

population. During December 1993, samples collected from ROPME Sea Area were examined by Al-Yamani *et al.* (1998). They observed that Calanoids composed 49% of the total copepod population followed by Cyclopoids (46%) and Harpacticoids (5%). During December 1994, Al-Khabbaz & Fahmi (1998) observed that Calanoid copepods were the dominant group constituting 42.5% followed by Cyclopoids 40% and Harpacticoids 9.6%.

In the present study, Calanoids dominated the copepod community throughout the three seasons with an average of 829 Ind./m^3 (43%) followed by Cyclopoids (598 Ind./m^3, 31.5%) and Harpacticoids (275 Ind./m^3, 14.5%) of the total copepod population (Fig. 4). Twenty-three copepod genera were recorded during October and December 1994 while only 20 genera were observed in April 1995. Hussein (1992) recorded 29 genera (for the samples of 1984) along the Qatari coast, while 24 genera were identified by Al-Khabbaz & Fahmi (1998) from the NE of Qatar, indicating the decline in diversity during 10 years

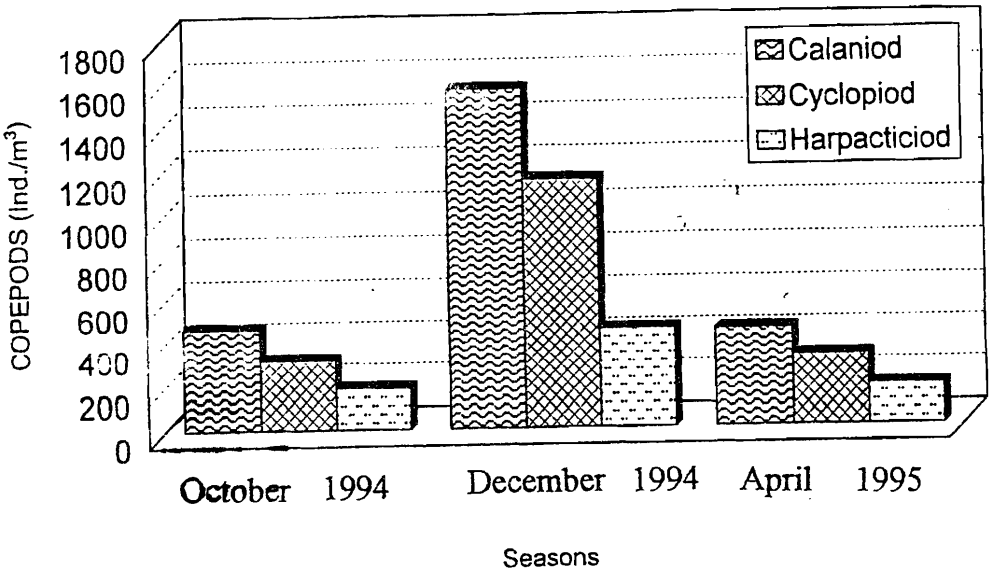

Fig. (4): Seasonal mean total abundance of copepod groups along the EEZ of Qatar.

due to the increased development, trading and man-made activities at the nearshore environments.

During the entire study, the copepod community was numerically dominated by ***Oithona*** spp. (av. 299 Ind./m^3), ***Euterpina acutifrons*** (av. 245 Ind./m^3), ***Oncaea*** spp. (av. 206 Ind./m^3), ***Paracalanus aculeatus*** (av. 200 Ind./m^3), ***Temora discaudata*** (av. 71 Ind./m^3) and ***Acartia negligens*** (av. 63 Ind./m^3). Along the western Arabian Gulf South of Kuwait waters, Michel ***et al.*** (1986) listed the following most abundant species during November 1979: ***Paracalanus crassirostris*** (3,985 Ind./m^3), ***Oithona*** spp. (2,350 Ind./m^3), ***Oncaea*** spp. (1970 Ind./m^3), ***Paracalanus aculeatus*** (668 Ind./m^3), ***Corycaeus*** spp. (259 Ind./m^3), ***Euterpina acutifrons*** (173 Ind./m^3) and ***Microsetella rosea*** (18 Ind./m^3). Along the sector sampled north of Qatar, Al-Khabbaz and Fahmi (1998) recorded ***Oncaea*** spp. (2,195 Ind./m3), ***Oithona*** spp. (1,689 Ind./m3) and ***Calanopia*** sp. (1,126/m3). The most abundant species recorded by Al-Yamani ***et al.*** (1998) at the NE coast of Qatar were ***Oithona*** spp., ***Paracalanus*** spp., ***Oncaea*** spp., ***Corycaeus*** spp. and ***Euterpina acutifrons.***

Meanwhile, for 1984 samples, Hussein (1992) reported that ***Oithona nana***, ***Acartia clausi***, ***Paracalanus parvus***, ***Labidocera acutifrons***, ***Euterpina acutifrons***, ***Temora discaudata***, ***Acartia negligens*** and ***Oncaea conifera*** form the greater bulk of the copepod population in the Qatari waters. Although, the species listed appeared similar to the present study, differences existed in terms of species numerical dominance. This is probably due to inter-annual variabilities of physico-chemical characteristics of coastal Gulf environments.

Temperature and salinity seem to be the important factors influencing the abundance of the dominant species (Dorgham and Hussien, 1997). Despite the limited variations in salinity values i.e. 38.4 - 45.2 psu observed during this study, higher densities of copepods were associated with low salinity waters i.e. nearshore waters off the Capital Doha and the offshore waters of sectors 500 and 600. The low salinity bearing waters are characterized by increased nutrients levels and available food (chlorophyll a biomass) which indicate that copepod spatial distribution is highly related to food availability. Meanwhile, although this study covered wide range of water temperature (19.9 to 30.5°C), the same genera were almost recorded in all seasons with variable magnitudes. This indicates that most of the recorded copepods are capable of tolerating seasonal changes in water temperature. Except during summer (Al-Ansari,

1998), there is evidence from temperature and salinity profiles that the water column during the three seasons was thoroughly mixed and nutrients appeared to be available, inspite of the low concentrations, at all times, even during minimum plankton production.

Despite the exposure of the southeastern marine area of Qatar to intermittent oil spills originating from oil loading and unloading activities through mooring buoys as well as ballast water disposal from oil tankers, the copepod population in this area did not show significant low numerical abundance. This could be related to the presence of available food (chlorophyll a) from one hand (range 0.13-0.52 µg/L) or those copepods are adapted to survive at low levels of petroleum hydrocarbons. This finding is in agreement with other investigations that took place in the area after the Gulf War oil spill (Al-Yamani ***et al.***, 1993 and Ghobashy ***et al.***, 1994).

Since the area is currently subjected to rapid industrial development during the last 5 years, future studies should be concentrated on the impact of the chemical, biological and thermal pollution on secondary productivity, which is the base for the continuing growth of fisheries.

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