EGYPTIAN JOURNAL OF AQUATIC RESEARCH ISSN: 1687-4285
VOL. 33 NO. 1, 2007: 144-162

QUALITATIVE AND QUANTITATIVE STUDY OF COPEPODS IN DAMIETTA HARBOR, EGYPT

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Keywords: Copepods structure- Damietta Harbor- Copepods abundance- environmental conditions.

ABSTRACT

The qualitative and quantitative dynamics of the copepod community in Damietta Harbor was studied through zooplankton samples collected monthly from May 2003 to April 2004. The copepods community was represented by 21 species, belonging to calanoids (9 species), cyclopoids (5 species) and harpacticoids (7 species). A few species appeared to be persistent, while the majority of copepods were recorded either intermittently or rarely. The abundance of copepods showed wide range of variations ($7x10^3$ - 175 $x10^3$ organisms/ m^3), and the annual cycle of the standing stock displayed bimodal peaks in June and August-September. The nauplii and copepodides constituted the bulk of copepods count (71.6% and 12.3% respectively). Of the adult forms, *Oithona nana* was the most abundant species, forming 8.1% of the total copepods, followed by *Euterpina acutifrons* (3.8%) and *Paracalanus parvus* (2.5%). Most of copepod species displayed distinct seasonal occurrence relative to environmental conditions. The stepwise regression analysis based on the annual average revealed that temperature was the most important factor controlling the size of standing stock of copepods in Damietta Harbor, while on seasonal bases, Chlorophyll *a*, pH and salinity seem to play a role in the copepods abundance. The cluster analysis demonstrated different types of association between copepods species, while Shannon-Weaver Diversity Index reflects relatively pronounced changes in biodiversity of the copepods community.

1. INTRODUCTION

Of all the marine zooplankton copepods are probably the most familiar, since with few exceptions they are the dominant constituent of the plankton in every sea area, comprising about 70% of the plankton fauna and rank as the world's most abundant metazoans (Raymont, 1983). The importance of copepods is raised from being one of the major consumers of the primary producers of the organic matter (phytoplankton) and essential food materials for plankton feeding fishes and other aquatic animals. They are important component of zooplankton communities in the neritic regions of the Mediterranean Sea, where a limited number of species account for the bulk of abundance and biomass during most of the year (Scotto di Carlo and Ianora, 1983).

Many studies have been conducted on planktonic copepods in the Egyptian coasts of the Mediterranean Sea, particularly in the neritic waters (Nour El Din, 1993; Hussein, 1977; 1997a, b; Abdel-Aziz, 1997; 2000a, b; 2001a, b; 2002; 2004; Gharib and Soliman, 1998; Soliman and Gharib, 1998; Abdel-Aziz and Dorgham, 1999; 2002; Abdel-Aziz and Aboul-Ezz, 2003).

Since it was constructed in 1987, Damietta Harbor has attracted no attention for ecological and biological studies, although it lies under stress of different maritime activities, the wastes of imported and exported materials and fresh water discharge from the Damietta Branch of the River Nile. These conditions necessitate the study of the hydrography and zooplankton community in the harbor, as a first step to establish data base on the harbor's ecosystem. The hydrography of the Harbor was studied and published in a separate paper by Ghobashi *et al*. (2006). The present study aims at following the monthly qualitative and quantitative dynamics of copepods in the harbor over a complete year cycle relative to the existing hydrographic conditions. It is considered as the first intensive work done so far on any of the zooplankton components in Damietta Harbor.

2. MATERIALS AND METHODS

2.1. The Study area

Damietta Harbor is a shallow semi-closed basin with a maximum depth of 15 meter, lies on the Egyptian Mediterranean coast at Latitude 31° 28˜ N and longitude 31° 45˜ E (Fig. 1). It is far from the coast by 1.3 km and connected to the sea by a navigational canal of about 300m width. The harbor is connected also to the Damietta Branch of the River Nile through a narrow canal (Barge Canal), which was planned to be used for the riverine transport of the imported and exported goods. The harbor comprises the main basin and two quadrangle extensions from the southeastern side, all of which are surrounded by 24 quays for various maritime processes. The activities in the harbor include export of agricultural crops, animal fodder, chemical fertilizers, manufactured and raw cement (clinker), natural gas, textiles, cotton and flax fibers. Also, many imported materials are received at the harbor, such as grains, food oil, manufactured fish powder, fruits, frozen fish and meat, wheat flour, cement, wood manufactured, and raw iron. It is to be noted that the infrastructure of the harbor is still completing at present, which may affect on the ecosystem of the harbor in the future.

Several exported and imported materials are stored in great heaps on quays before packing. Some of these materials such as grains, fertilizers and flour reach to the harbor water, causing increase of the nutrient levels, while others like cement, clinker and raw iron lead to variation of water quality when dissolved in the harbor water.

2.2. Samples collection

The present study was conducted monthly from May 2003 to April 2004 at seven stations, representing different ecological entities in the harbor. Station I lies at the opening of the navigational canal to the harbor (Boughaz), station II at the connection between the Barge Canal and the navigational channel , station III in the Barge basin, which is affected directly by Nile water , and stations from IV to VII are distributed inside the main basin of the harbor (Fig 1).

Zooplankton samples were collected between 9.00-11.00 AM by vertical hauls from the bottom to the surface at each station, using plankton net with 44 cm mouth diameter and 55µm mesh size and they were then preserved in 5 % buffered formalin solution. For the taxonomic survey of copepods, the samples were examined under a binocular research microscope (A. Kruss Hamburg MBL 2000). The identification was undertaken to the species level, following Rose (1933), Farran (1948), Farran and Vervoort (1951), Tregouboff and Rose (1957), Newell and Newell (1979), Malt (1983), Todd and Laverack (1991).

To estimate the copepods standing crop, the sample was gently shaken and a sub-sample of 5 ml was transferred to a counting chamber (Bogorov chamber), where all copepod species and larvae were counted. The standing crop was calculated from the mean counts of three replicates of 5ml and estimated as organisms per cubic meter. The data were subjected to statistical treatment to find 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 and other zooplankton species.

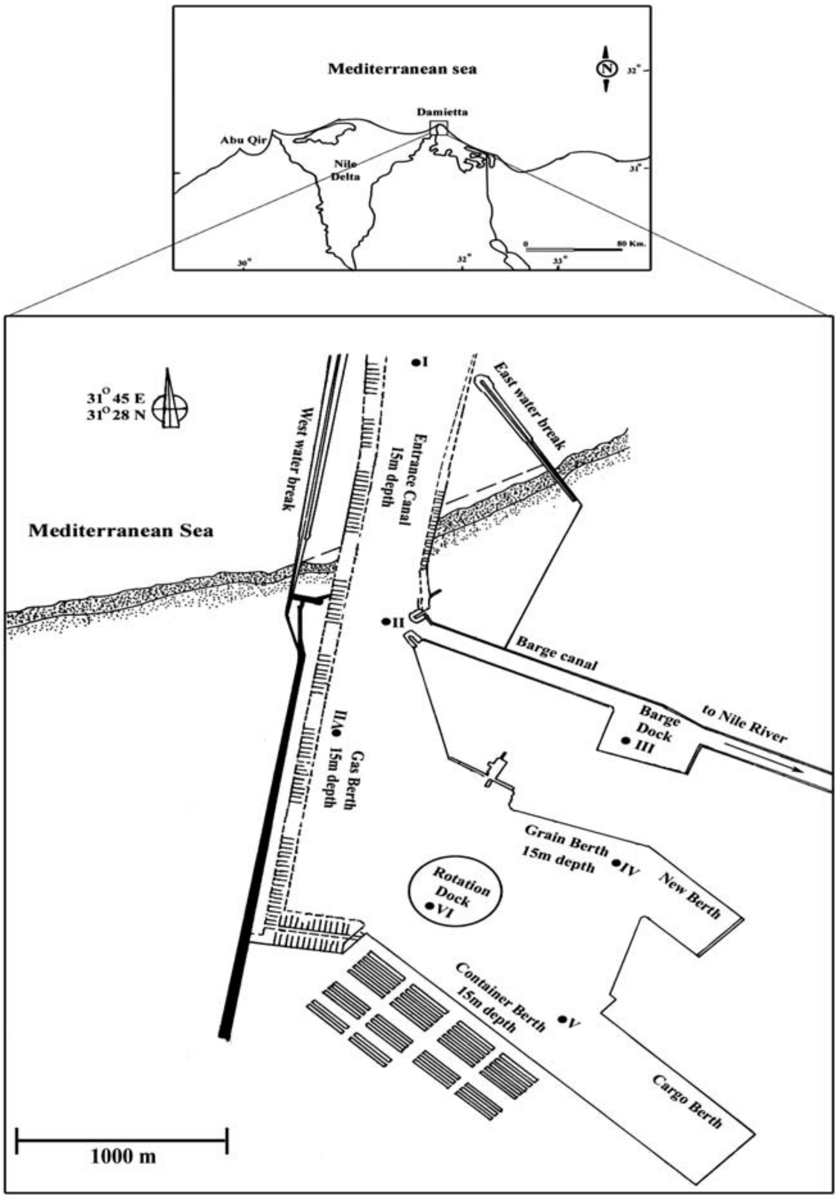

Fig. (1): Map of Damietta Harbor and position of sampling stations

3. RESULTS

The hydrographic conditions of the Damietta Harbor were studied parallel to the present study and have been published in a separate paper by El-Ghobashi *et al.* (2006). As shown in table 1, the surface water temperature in Damietta Harbor displayed the classical range of variations experienced on the Egyptian Mediterranean coast, while surface salinity showed relatively wide changes over the year, but it was mostly lower (<37%o) than in other Egyptian coastal waters which are not exposed to terrestrial discharges. The harbor' water appeared to be low transparent, with Secchi disc readings less than 2 meter over the year round, coincided with intensive phytoplankton growth, which is indicated from pronouncedly the high chlorophyll *a* concentrations. The pH values demonstrated narrow variation may be relative to analogous changes in the concentrations of the dissolved oxygen that reflected well aeration conditions in the harbor.

Copepods were represented by 21 species in Damietta Harbor, comprising 6 freshwater species and 15 marine species. The monthly number of species showed small variations between a maximum of 13 species in September and January, and a minimum of 8 species in October (Fig.2). One third of the recorded species were found all seasons and well distributed throughout the harbor, 7 species appeared for two to three successive seasons and 7 species appeared once a year (Table 2).

The copepods diversity index experienced little monthly variations, with high values during spring and summer, and low values in autumn and early winter (Fig. 2).

In terms of the numerical density, the copepods constituted the bulk of zooplankton in Damietta Harbor (68.3%), having an annual average of $56x10^3$organisms/m^3. They displayed the greatest role in August (84.6%), September (80.7%) and January (84.2%) and the smallest one (14.4%) in March. Although copepods count was the lowest during the period from November to May they were mostly the predominant component of zooplankton (Fig. 3). Over the harbor, the contribution of copepods was pronouncedly different; varying from 55.8% at station I to 72.6% at station V.

Nauplii dominated the copepods count (71.6%), and copepodides occupied the second order of abundance (12.4%). The adult assemblages of the copepod groups (calanoids, cyclopoids and harpacticoids) provided different roles in both the number of species and the standing crop in Damietta Harbor. The calanoids and harpacticoids were relatively more diversified (9 and 7 species respectively) than cyclopoids (5 species). However, cyclopoids could establish more healthy populations (annual average: 5746 organisms/m^3) than did both calanoids (annual average: 1642 organisms/m^3) and harpacticoids (annual average: 1674 organisms/m^3). While cyclopoids constituted 10.3% of the total copepods, calanoids and harpacticoids demonstrated approximately similar percentages (2.9% and 3% respectively). Since the cyclopoids were the most abundant adult copepods, its abundance cycle followed that of the total copepods, being high from June to October and in April (Fig. 4). In contrast, both calanoids and harpacticoids displayed one distinctive peak in June, and then decreased continuously over the year (Fig. 4). On the spatial scale, the adult cyclopoids attained the highest crop at station III, and the lowest one at station I, while the crops were approximately close at the other stations (Fig. 5). The calanoids sustained markedly high count at station VII compared to other stations, which harbored slightly different numbers with the lowest one at station IV. For harpacticoids, the highest count was observed at station II, and the lowest at station IV, while the other stations were inhabited by close numerical densities (Fig. 5).

Among the twenty one copepod species found in the harbor, three species only were responsible for the numerical density of adult copepods; namely *Oithona nana*, *Euterpina acutifrons* and *Paracalanus parvus*. The abundance cycles as well as the spatial distribution of these species were typically similar to those of the group, to which they belong, indicating their sharing the production of nauplii and copepodides in June, but in different percents relative to the count of each species. In other months, the cyclopoid *O.nana* appeared to be the main producer of larval stages during the period from July to October 2003 and April 2004, while *E. acutifrons* was the main producer in December.

Oithona nana was the most abundant persistent copepod, forming 59.2% of the adult copepods count. It attained high counts from June to October 2003 and in April 2004 at a temperature range of 21.5-32.3°C and salinity of 33.2-39.4%o, while the peaks were recorded in June, September and April at widely different temperatures (27.5, 29.7 and 21.5°C) and salinities (36.9%o, 34.4%o and 33.2%o respectively).

The stepwise multiple regression analysis of annual average data revealed that, chlorophyll *a*, temperature, salinity, DO and pH were the effective factors controlling the abundance of *O.nana* (r = 0.781, p = 0.02) and the annual average density of the species could be calculated from the following model:

O. nana = 84974.3 + 419.46 chlorophyll *a* + 699.6 temperature − 1202.6 salinity − 1216 DO − 5886.5 pH.

On seasonal basis, temperature seems to be a common factor affecting the growth of *O. nana* over the year, but other factors like chlorophyll *a*, transparency, dissolved oxygen and salinity showed seasonal effects, as illustrated in following equations, which are used to compute the seasonal average count of the species:

In spring = 54876.6 − 119.9 transparency + 1365.5 temperature − 1315.3 salinity − 1555.9 DO, (r = 0.883, p = 0.009).

In summer = no correlation.

In autumn = − 32138 + 458.98 chlorophyll *a* + 1234.9 temperature, (r = 0.898, p = 0.003).

In winter = −8778 + 383.9 temperature − 385.14 chlorophyll *a* + 100.68 salinity, (r = 0.796, p = 0.014).

The harpacticoid *E.acutifrons* was the second dominant species, constituting 18.4% of the adults with a distinctive peak in June and small one in December. The June peak coincided with a temperature of 27.5°C and a salinity of 36.9%o, while December peak occurred at 17.5°C and 36.5%o. The stepwise analysis of the annual average reported that, temperature and pH were the controlling factors and the annual average of the standing stock of the species can be calculated from the following model:

E. acutifrons = 18563.14 + 161 temperature − 2597.47 pH, (r = 0.42, p = 0.01).

On seasonal basis, temperature had a clear permanent effect on the abundance of this species during three seasons, but pH or chlorophyll *a* displayed effect for one season only. The seasonal average size of the standing stock of *E. acutifrons* is to be computed as follows:

In spring = 6039.68 − 673.52 pH, (r = 0.545, p = 0.01).

In summer = 46879.8 − 1465.81 temperature + 117.4 chlorophyll *a,* (r = 0.89, p = 0.038).

In autumn = − 3983.4 + 179.71temperature, (r = 0.657, p = 0.001).

In winter = −8409.84 + 551.7 temperature, (r = 0.715, p = 0.0001)

Paracalanus parvus was the single dominant calanoid species in the harbor over the year, forming 15.6% of the adult copepods due to a large peak in June at a temperature of 27.5°C and salinity of 36.9%o. As revealed from the stepwise multiple regression analysis based on annual average, temperature, chlorophyll *a* and pH appeared to be the most effective factors on the abundance of *P. parvus*. The annual average abundance of this species is computed as follows:

P. parvus = 7975.36 + 106.32 temperature + 49.11 chlorophyll *a* − 1250.5 pH, (r = 0.596, p = 0.025).

However, regression analysis indicated different seasonal responses of this species to the environmental factors, and the average standing stock in the different seasons can be computed from the following equations:

In spring = 10530.79 − 1243 pH, (r = 0.739, p = 0.0001).

In summer = 11311.58 + 171.3 chlorophyll *a* − 359.3 temperature, (r = 0.769, p = 0.026).

In autumn = − 21660.3 + 138.95 temperature + 2343.8 pH, (r = 0.802, p = 0.016).

In winter = no correlation.

Acartia clausi was among the perennial species but usually in small numbers (1.8% of adult copepods), attaining the highest contribution in May.

The cluster analysis for the monthly average count of most abundant adult species and larval stages indicates limited association between the copepod species in Damietta Harbor.

Relatively high similarity (58%) was observed between *Acartia latisetosa* and *Centropages kroyeri*, in addition to *Acartia granii*, which occurred in the same subcluster. These three species displayed similar patterns of monthly variations, attaining their highest count in spring and summer. Low similarity appeared between *Acartia clausi* and *Paracalanus parvus,* which showed the same peak in June and comparatively low counts most of the year round. All other species showed independent clusters, since each demonstrated its own monthlydistributional pattern (Fig. 6).

Table (1): The annual average of hydrographic parameters and chlorophyll *a* at different stations in the Damietta Harbor (May 2003 to April 2004).

St.	Water temp (°C)	Secchi depth (cm)	Salinity (‰)	pH	DO (mg /l)	Chlorophyll *a* (µg /l)
I	23.4	154.6	36.9	8	7.86	6.64
II	23.4	167.5	35.7	8	8.5	11.6
III	23.5	159.8	33.8	8	8.9	17.8
IV	24.1	192.5	36	7.96	8	6.7
V	23.8	172.9	36	7.9	7.8	7.4

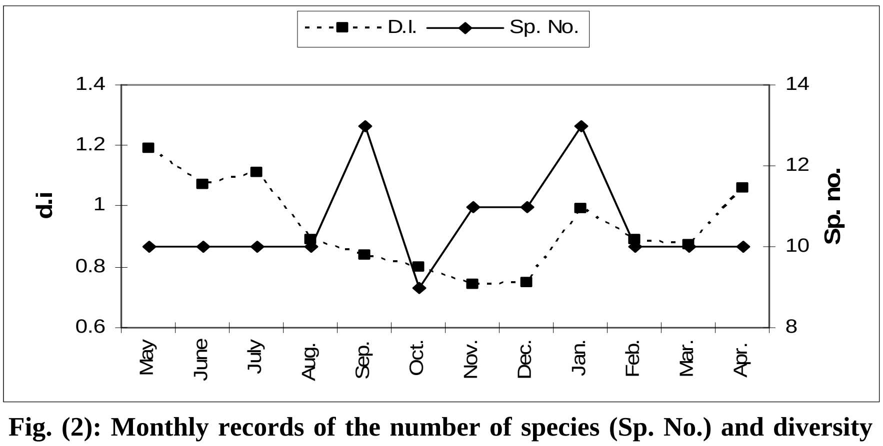

Fig. (2): Monthly records of the number of species (Sp. No.) and diversity index (D.I.) of copepods in Damietta Harbor (May 2003- April 2004).

Table (2): Frequency and duration of occurrence of copepod species in Damietta Harbor (May2003 – April 2004) (FW = Freshwater species).

Copepod species	Frequancy	Months
Calanoida		
Acartia clausi (Giesbr.)	70	12
Acartia discaudata(Giesbr.)	4	2
Acartia grani (G.O.Sars)	47	11
Acartia latisetosa (Kricz.)	22	7
Centropages kroyeri(Giesbr.)		
Eucalanus attenuatus (Dana)	1	1
Paracalanus parvus (Claus)	83	12
Paracalanus pygmaeus (Claus)	1	1
Temora stylifera (Dana)	1	1
Cyclopoida		
Acanthocyclops americanus March **(FW)**	1	1
Ergasilus sieboldi (Nordmann)	43	10
Oithona nana (Giesbr.)	84	12
Oithona plumifera (Baird)	81	12
Clytemnestra scutellata(Dana)	17	4
Diacyclops bicuspidatus odessanus (Claus) **(FW)**	3	1
Harpacticoida		
Euterpina acutifrons (Claus)	84	12
Microsetella rosea (Dana)	8	7
Nitocra lacustris (Schmankewitsch) **(FW)**	14	5
Schizopera clandestine (Klie.)**(FW)**	1	1
Onychocamptus mohammed (Blanch&Rich.) **(FW)**	18	4
Siphonostomatoida		
Caligus rapax(Mine&Edward)	1	1
Nauplii larvae	84	12
Copepodite stages	84	12

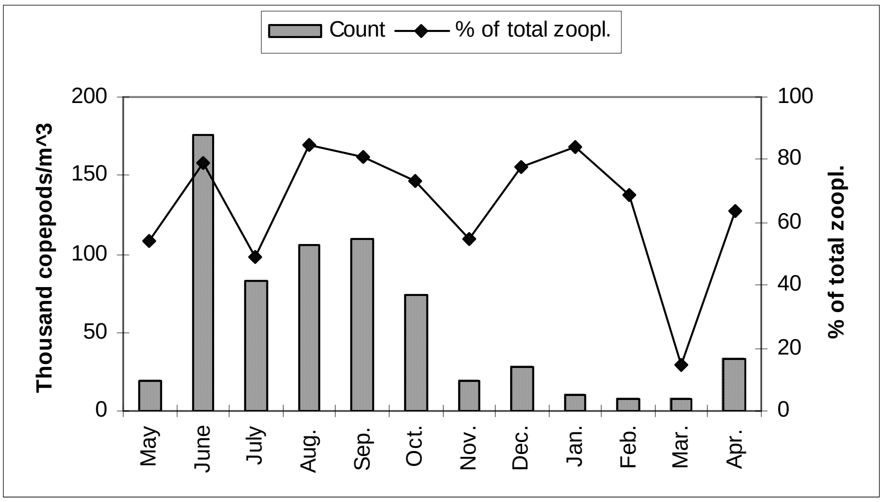

Fig. (3): Monthly count and relative abundance of total copepods in Damietta Harbor (May 2003-April 2004).

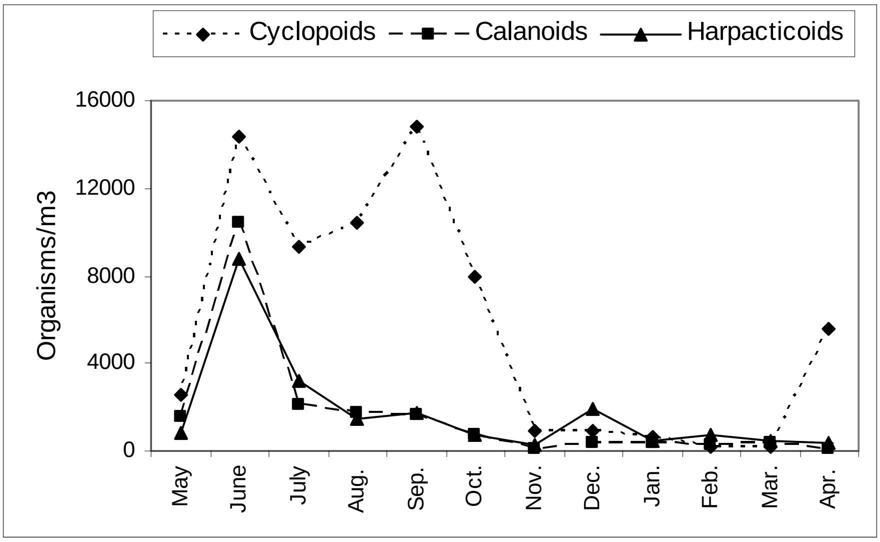

Fig. (4): Monthly count of adult assemblages of the major copepod groups in Damietta Harbor (May 2003 – April 2004).

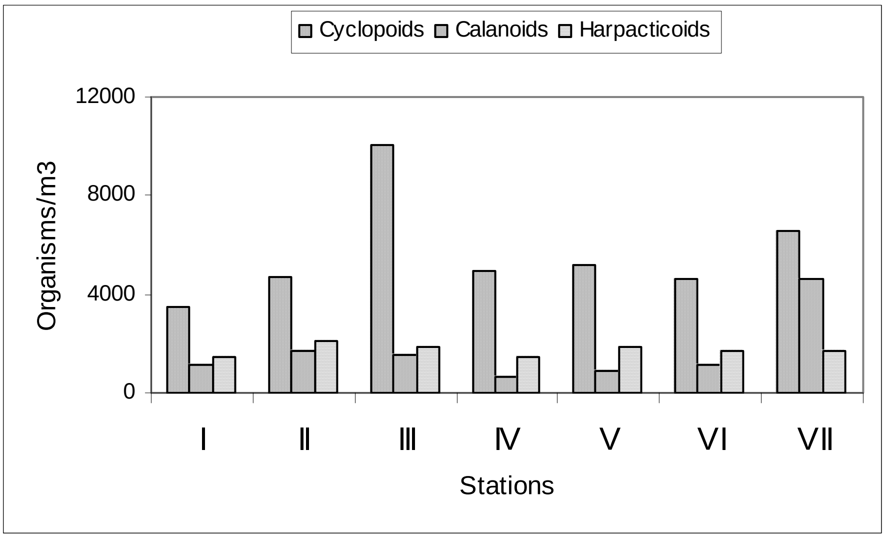

Fig. (5): Spatial distribution of adult assemblages (annual average) of the major copepod groups in Damietta Harbor (May 2003 – April 2004).

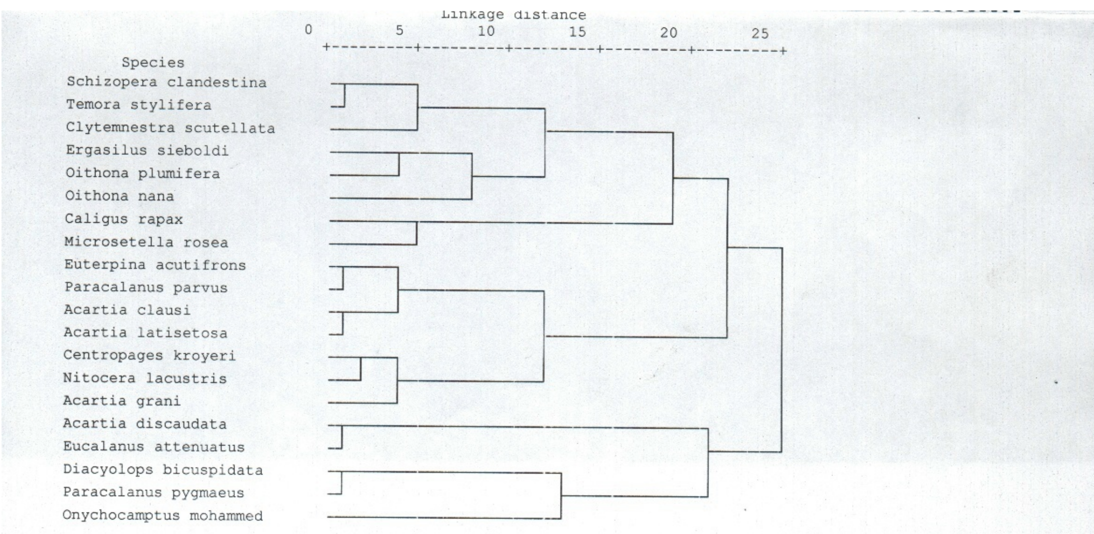

Fig 6- Cluster analysis for copepod species in Damietta Harbor

4. DISCUSSION

The present study revealed that the diversity of copepod community in Damietta Harbor was low (21 species), comprised only 7 persistent species, while the rest of species occurred either seasonally or rarely. Although the connection between the harbor and the open sea is supposed to be a way of increasing the number of copepod species in the harbor, the continuous variability of salinity and maritime activities may retard such increase, and consequently the number of copepod species showed very limited variations (9 – 13 species) over the year. Even the wide temperature variations did not affect the diversity of copepods, whereas their markedly high standing stock in September at 29.7°C and the extremely low stock in January at 16°C were associated with the same number of species (13 species). The low diversity of copepod community appeared to be a characteristic feature of several small basins on the Egyptian Mediterranean coast, particularly those receiving land-based effluents (Abdel- Aziz and Dorgham, 2002 and Abdel-Aziz, 2004).

Although 6 freshwater species were identified in Damietta harbor some of them were very rare, like *Acanthocyclops americanus, Diacyclops bicuspidatus,* and *Schizopera clandestina*, but others were frequently reported either in winter and early spring (*Onychocamptus mohammed*) or in spring and summer (*Nitocra lacustris*). One parasitic species, *Ergasilus sieboldi* was reported among the persistent free living copepods in the harbor, sometimes in high counts, while another parasitic species *Caliga rapax* appeared occasionally with a few specimens.

In addition to the great count of the larval stages, only three species, *Oithona nana, E. acutifrons*, and *P. parvus,* formed the bulk of the adult copepods count in Damietta Harbor. These species are the major component of zooplankton abundance along the Egyptian Mediterranean coast (Abdel-Aziz and Dorgham, 2002; Abdel-Aziz, 2004). *O. nana* is cosmopolitan, widely distributed in estuaries, coastal and oceanic waters and it seems to prefer deeper shelf and coastal waters, and *Euterpina acutifrons* is a neritic temperate marine form usually found in continental shelf and in brackish coastal waters. It is known as euryhaline form (Rocha and Botelho, 1998). *P. parvus* is a cosmopolitan species with variable ecological affinities, being recorded in both oceanic and neritic zones thermophilic and epiplanktonic(Montu and Goleden, 1998).

The diversity index of copepod community in Damietta Harbor displayed relatively narrow monthly variations (0.74 – 1.19 nats). Margalef (1978) recorded diversity index of 1-2.5 nats for the actively growing coastal populations. The low values of diversity index in the study area, which is considered as a coastal area, may be attributed to the low number of copepod species (9-13 species), the high number of dominant species (4-7 species) and/or to the count of total copepods. Significant correlation was found between the diversity index and copepod count ($r = -0.3625$, $p = 0.001$). The low diversity index in winter could be attributed to the low total count, whereas those in summer may be related to the dominance of a few species irrespective of the abnormally high standing crop. The high diversity in May was related to the high count of *Acartia granii* and *Centropages kroyeri*, in June to the abundance of *P. parvus* and *A. clausi*, while in July the high diversity index was accompanied by high counts of *C. kroyeri*, *O. plumifera* and *Ergasilus sieboldi*. On the other hand, the low diversity index in September coincided with the dominance of *O. nana* and *O. plumifera*, while in the period October – December the low diversity may be attributed to the absolute dominance of copepod nauplii. The diversity index is a suitable criteria for water quality (Balloch, *et al.,* 1976; Gharib and Dorgham, 2006), and the value of diversity index is related to the disturbance of environment (Levinton, 1982). According to these observations and the low values of its diversity index, Damietta Harbor may be considered as disturbed environment. However, diversity index has a clear relation with the degree of dominance, species richness and total standing crop (Gharib and Dorgham, 2006).

Regardless of the predominance of nauplii and copepodides, which formed together 84% of total copepods, the adult assemblages of the three groups (calanoids, cyclopoids and harpacticoids) demonstrated different densities compared to the open sea areas. Calanoids usually outnumber the other groups in species and density, but small cyclopoids can be exceeding plentiful and more diverse in warmer seas (Raymont, 1983). In the present study, cyclopoids were less diversified (5 species) and exceedingly abundant than both calanoids (9 species) and harpacticoids (7 species). The numerical density of the three groups ranked: 3.5 cyclopoids: 1 calanoids: 1.1 harpacticoids. This ranking appeared to be common in many coastal waters but with different values; Michel *et al*. (1986) found the respective ratio 5:3:1 in Kuwait water of the Arabian Gulf, while Dorgham and Hussein (1997) reported 5.5:1.7:1 in Doha Harbor on the Arabian Gulf. The dominance of cyclopoids in aquatic area is reported as indication of eutrophication (Waller *et al*., 2002 and Abdel-Mawla, 2004). The observations of these authors are in clear agreement with the findings in Damietta Harbor, where cyclopoids were the most abundant copepod group, and the high concentration of chlorophyll *a* over the year indicates the eutrophication in the harbor.

The pronounced dominance of the nauplii and copepodides appeared to be a common phenomenon in small bays along the Egyptian Mediterranean Coast, especially those having similar conditions to those of Damietta Harbor. The nauplii occupied 57.3% - 65.4% and copepodides formed 3.7% - 7.1% of total copepods and 17.3% - 27.4, 1.0% - 2.7% of total zooplankton respectively in the Dekhaila Harbor, the Western Harbor, and the Eastern Harbor of Alexandria (Abdel-Aziz, 2000a; 2002; 2004). The highest count of larval stages of copepods in Damietta Harbor was reported during the warm period, indicating the role of high temperature in promoting the egg production and development. This agrees with Makino and Ban (2000), who reported that water temperature causes more rapid development and higher egg production while increased food density causes more rapid development, larger body size and higher egg production. Fernández de Puelles *et al*. (2004) found copepods as the dominant zooplankton group in many coastal waters, and he attributed this to abundance of suitable food, besides their high sensitivity to warm temperature.

The presence of copepod nauplii and copepodides as persistent component of zooplankton in Damietta Harbor indicates the continuous reproduction of copepods all the year round. Such reproduction is hightly related to several species, which differ in their breeding seasons and number of broods over the year. It is most probable that the bulk of nauplii and copepodides are produced by the dominant species according to the following order, *O. nana*, *E. acutifrons* and *P.parvus* which formed 59.2%, 18.4% and 15.6% of the adult copepods respectively. *O. plumifera* and *A. clausi* took also a part in the production of larval stages but to a pronouncedly less extent as they constituted 3.3% and 1.8% of the total adult copepods. The spawning period of different zooplankton species precede their maximum abundance and the numbers of breedings are usually related to numbers of peaks (Dorgham and Hussein, 1997). Accordingly, the abundance cycles of the three dominant adult species in Damietta Harbor suppose that *O. nana* produced 3-4 generations/year, *E.acutifrons* three generations and *P. parvus* one or two generations. Dowidar and El-Maghraby (1970a) expected 5 generations for the three species in the southeastern Mediterranean Sea, Abdel-Aziz (2000a) reported 2-3 generations in Dekhaila Harbor (Alexandria). In Doha Harbor (Arabian Gulf), Dorgham and Hussein (1991) recorded three generations for *O. nana* and two generations for *E. acutifrons* and *P. parvus*, but El-Sherbiny (1997) reported 2-3 generations for cyclopoids and 3-4 generations for calanoids in Sharm El-Sheikh (Red Sea). In general, the breeding of many copepods may continue all the year round but varies in intensity in response to temperature variations and the spawning regimes of the various species (Dorgham and Hussein, 1997). Further, the occurrence of early stages of copepods almost throughout the year in the warm seas implies that breeding is continuous in those warm waters (Raymont, 1983). It appeared that the breeding of different copepod species is influenced not only by temperature but also by other ecological factors, particularly the food availability and salinity. It is worth to mention that the pronouncedly high count of nauplii and copepodides in Damietta Harbor reflects the high potential production of copepods.

Although no significant correlation was reported between total copepods and salinity in Damietta Harbor, some dominant species displayed weak significant correlation with salinity (Table 4). However, the abundance of total copepods displayed inverse monthly relationship with salinity over the year, except the direct relationship in November, January and February (Fig. 7a & b). Since nauplii and copepodides were the major component of copepod standing stock they demonstrated similar monthly relationship with salinity to that of total copepods, but the dominant adult species showed either inverse or direct relationship with salinity throughout the year (Fig. 7). Such patterns may be related to the response of each species to salinity variation.

On the other hand, chlorophyll *a* showed direct monthly relationship with the salinity that may serve as a good indication of nutrient enrichment to the harbor through the freshwater discharge. This deduction is confirmed by the pronouncedly high biomass of phytoplankton in Damietta Harbor all the year round (annual average of chlorophyll *a*: 5.53 – 15.21 µg/l). Furthermore, the highest chlorophyll *a* was reported at station III which sustained the lowest salinity (annual average: 33.8‰), while the lowest chlorophyll *a* appeared at station I with the highest salinity (annual average: 36.93‰). Accordingly, the low salinity water in the barge canal is supposed to be richer in nutrient than the higher salinity water in the navigational canal and the main basin of the harbor, as indicated from of chlorophyll a (EL-Ghobashi *et al*., 2006). The high copepod abundant was associated with high phytoplankton biomass at the low salinity areas in the harbor, and both groups i.e. copepods and phytoplankton biomass were significantly correlated (Table 3). Similar observations were reported by Mazzocchi and Ribera d'Alcalá (1995).

The stepwise multiple regression analysis revealed that temperature was the common factor controlling copepods abundance in the harbor, and their standing crop can be estimated as follow:

Copepods count = − 121085.8 + 7440.6 Temperature, (r = 0.616, p = 0.0001).

However, on seasonal bases, more detailed picture is given about the controlling factors of copepods abundance in Damietta Harbor. The following models defined the factors affecting copepod growth in different seasons and show how to calculate their standing stock seasonally:

In spring = 292584.9 – 633 transparency + 7176.8 temperature – 6908.9 salinity – 7971.8 DO, (r = 0.883, p = 0.012).

In summer = no correlation.

In autumn = – 234768.9 + 14828 temp. – 486.4 transparency, (r = 0.742, p = 0.0001).

In winter = – 119448+7901.6 temp, (r = 0.742, p= 0.035).

Table (3): Pearson's correlation between ecological parameters and total copepods in Damietta Harbor (May 2003 – April 2004) (Correlation is significant at P< 0.01).**

	copepods
copepods	1.00
Temp. °C	0.616**
Salinity%o	0.105
Trans. cm	0.196
pH	-0.036
DO (mg/l)	-0.021
Chl *a* (µg/l)	0.434**

Table (4): Correlation coefficients between different ecological parameters and the dominant copepod species in. Damietta Harbor (May 2003 – April 2004).

Zooplankton taxa	Temp.	Salinity	DO	pH	Chl. *a*	Trans.
Acartia clausi	-.320**	-.162	.108	-.342**	-.197	.207
Euterpina acutifrons	.435**	.168	-.112	-.255**	.245*	-.015
Oithona nana	.825**	.265*	-.053	.049	.569**	.277*
Oithona plumifera	.739**	.232*	-.026	-.043	.473**	.154
Paracalanus parvus	.689**	.322**	.064	-.173	.435**	.185

(marked correlations * are significant at p<0.05 and ** at p<0.01)

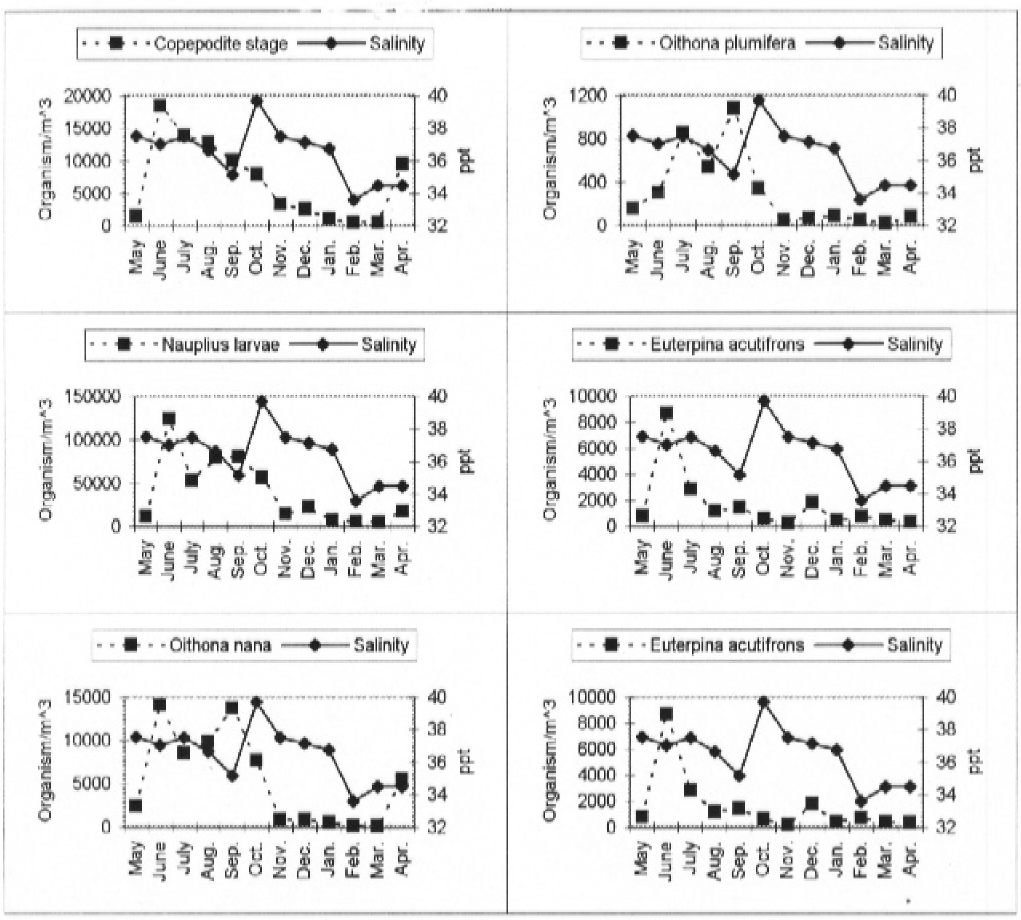

Fig. (7): Monthly distribution of larval stages and dominant copepod species in Damietta Harbor (May2003-April 2004).

In addition, the simple Pearson's correlation indicate that, both temperature and chlorophyll *a* had clear effect on the abundance of the dominant zooplankton species, while salinity and pH showed effect on some dominant species, as demonstrated from the significant correlations (Table 4).

Compared with other bays on the Egyptian Mediterranean coast, the copepod community in Damietta Harbor seems to be more diversified with denser population than many of them (Table 5). This may be related to slightly better conditions in Damietta Harbor, since there are no direct discharges of industrial and domestic wastes into the harbor so far. These conditions may encourage the reproduction of copepods in Damietta Harbor rather than in other areas, whereas their larval stages attained the greatest relative abundance than in most of the coastal areas off the Mediterranean Coast of Egypt.

The existence of some copepod species in Damietta Harbor was of particular interest.The cyclopoids *Ergasilus sieboldi* is a worldwide freshwater parasite, occurring in very large numbers on gills of many fishes. Abdelhalim (1990) recorded over 13,400 individuals of this species on the gills of a single host fish in British freshwaters. It is not host-specific and can infect a majority of fishes in many regions of the world (Piasecki *et al*., 2004). The occurrence of this species in the plankton of Damietta Harbor indicates that it is found on the gills of some local fishes and could leave the fishes to the water. Also *Caligus rapax* is an ectoparasite on gill chamber of many fish species of family Mugilidae in the Egyptian Mediterranean waters (Abu-Samak, 2004). It may leave the host and retain the power of swimming.

Eucalanus attenuatus is an oceanic epi- and bathypelagic species, widely distributed in tropical Atlantic, Indian and Pacific oceans, Mediterranean and Red Seas, and Suez Canal. The occurrence of the species in the Damietta Harbor may indicate its penetration either from from the Red Sea through the Suez Canal or from the offshore Mediterranean waters.

The calanoid copepod *Acartia discaudata* is well known in the Eastern and the Northern Mediterranean (Lakkis and Zeidane, 1990, Uysal *et al*., 2002). The occurrence of this species in Damietta Harbor is considered the first record to the Egyptian Mediterranean waters. It may be transferred to the study area either by currents or through the ship ballast water.

Table (5): The number of species and numerical density of copepods in different Egyptian coastal waters.

Area	Sp.no.	Annual average Organisms/m^3	Maximum Organisms/m^3	Nauplii Larvae %	Reference
Dekhaila Harbor	16	5977	10940 (May)	30.5-83.6	Abdel-Aziz, 2000a
Western Harbor	13	12434	25929 (December)	52.5 – 73.3	Abdel-Aziz, 2002
Eastern Harbor	13	15735	34311 (August)	52.6 – 81.1	Abdel-Aziz, 2004
Abu Qir Bay	23	48082	122843 (February)	57.3 – 79.2	Abdel-Aziz, 2001a
Damietta Harbor	21	56024	175780 (June)	73.1 – 93.2	Present study

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