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Preliminary Study on Protozoan Community in Damietta Harbor, Egypt

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Abstract: The dynamics of protozoan community in Damietta Harbor was studied monthly from May 2003 to April 2004. The results showed that protozoa was the second important zooplankton group (26.3%) after copepods, represented by tintinnids (37 species) and foraminiferans (22 species). Tintinnids Appeared to be the predominant protozoans (99.7%) over the year, with an annual average count of 21.5x 10^3 organisms /m^3 and three clear abundance peaks during July October and March. *Amphorellopsis acuta* was the key species among tintinnids, forming 31.3% followed by *Leprotintinnus nordgvisti* (15%), *Favella serrata* (10.9%) and *Stenosemella ventricosa* (10.6%). Regardless of their high diversity, foraminiferans occurred in markedly low counts (annual average: 55 organisms/ m^3) with a small peak in June. *Discorbis florida* and *Loxostomim plaitum* were the most common species of this group. Temperature and chlorophyll *a* were the most important environmental factors controlling the abundance of tintinnids at Damietta Harbor. However, the dominant tintinnid species exhibited different responses to environmental conditions. Shannon - Weaver Diversity Index reflects relatively pronounced changes in biodiversity of the tintinnids.

Key wards: Protozoan community · Damietta harbor · Tintinnids · Foraminifera · Environmental conditions

INTRODUCTION

Protozoa are prominent component of marine zooplankton, particularly ciliates (tintinnids) [1] making a significant contribution to the biological economy of the sea, particularly at lower trophic levels [2] as well as in biological and non-biological activities in the marine habitat [3]. Tintinnids have received little concern in the Egyptian Mediterranean waters [4].

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 and fresh water discharge from the Damietta Branch of the River Nile. Therefore, the present study is a preliminary comprehensive one dealing with the hydrography and some biological characteristics of the Damietta Harbor. It aimed at following the spatial and temporal dynamics of protozoan community in relation to the existing hydrographic conditions.

MATERIAL AND METHODS

The Study Area: Damietta Harbor lies on the Egyptian Mediterranean coast at Latitude 31° 28˜ N and longitude 31°45˜ E (Fig. 1). It is a shallow semi-closed basin with a maximum depth of 15 meter, displace by 1.3 km from the coast, connected to the sea by a navigational canal of about 300m width and to the Damietta Branch of the River Nile through a narrow canal. The harbor comprised the main basin and two quadrangle extensions from the southern 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 through the harbor, such as grains, food oil, manufactured fish powder, fruits, frozen fish and meat, wheat flour, manufactured iron, cement, wood and raw iron.

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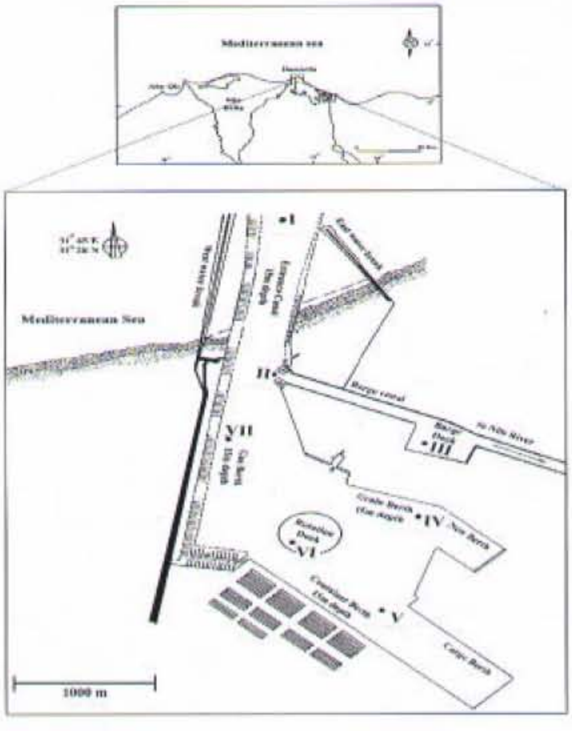

Fig. 1: Map of Damietta Harbor and position of sampling stations

Samples Collection: Sampling was carried out monthly from May 2003 to April 2004 at seven stations (Fig. 1). Station I lies at the connection between the open sea and 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 lie in the main basin of the harbor.

Zooplankton samples were collected by vertical hauls, using plankton net with 44 cm mouth diameter and 55 μm mesh size. The samples were preserved in 5% formalin and examined under a binocular research microscope (A.Kruss Hamburg MBL 2000) for protozoan species identification [5-11].

To estimate the protozoans standing crop three 5 ml aliquots of each sample were counted in a Bogorov chamber, the crop was calculated from the mean values of the three counts and expressed as organisms per cubic meter. The data were subjected to statistical analysis to find the possible interrelations between the dynamics of tintinnids population and the ecological conditions.

RESULTTS

Protozoans in Damietta Harbor were represented by 37 tintinnid species and 22 foraminiferans (Table 1).

Tintinnids abundance experienced wide variations (902 - 73504 organisms m^{-3}), reporting three seasonal peaks (Fig. 3). A pronouncedly high peak occurred in July and two small peaks in October and March, meanwhile winter months showed the lowest abundance. A few species were responsible for the major bulk of tintinnids counts in the harbor, namely, *Amphorellopsis acuta* (31.3 %), *Leprotintinnus nordgvisti* (15%), *Favella serrata* (10.9%) and *Stenosemella ventricosa* (10.6%). Other species displayed relatively active contribution, like *Stenosemella nivalis* (4.6%), *Metacylis mediterranea* (3.4%), *Favella ehrenbergi* (3%), *Stenosemella steinii* (3%) and *Tintinnopsis cylindrica* (2.9%). The dominant species showed different abundance cycles. The maximum count of *Amphorellopsis acuta* coincided with the peak of total tintinnids in July. *Leprotintinnus nordgvisti* showed a peak in June, while *Favella serrata* sustained the highest count during the peak of March. On the other hand, *Stenosemella ventricosa* reported two small peaks in June and April. Regardless to their small roles in total tintinnids, the codominant species demonstrated pronouncedly high counts at certain times during the years. *Favella ehrenbergi* displayed two peaks during

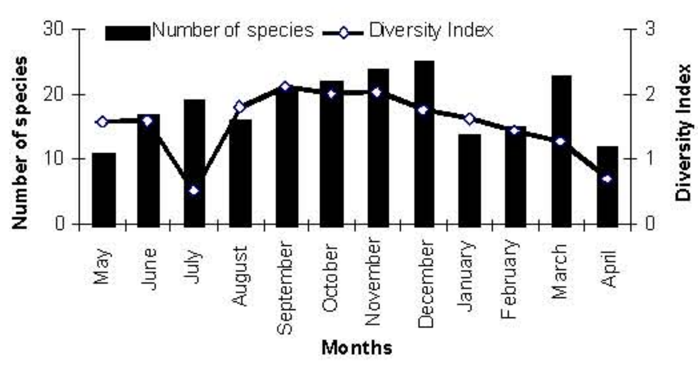

Fig. 2: Monthly variation of species numbers and diversity index of tintinnids in Damietta Harbor (2003- April 2004)

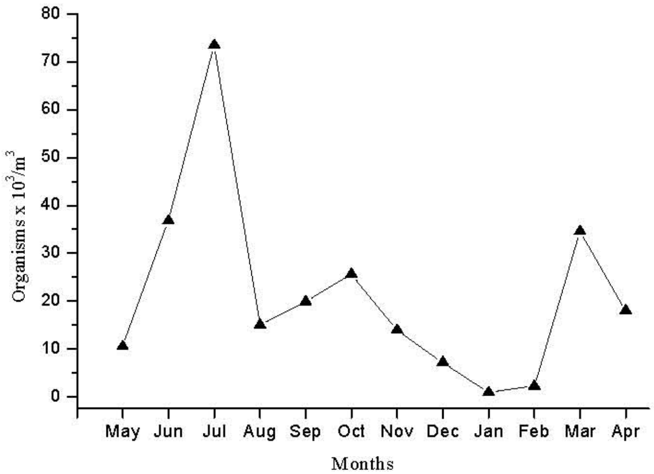

Fig. 3: Monthly abundance of tintinnids in Damietta Harbor (May 2003- April 2004)

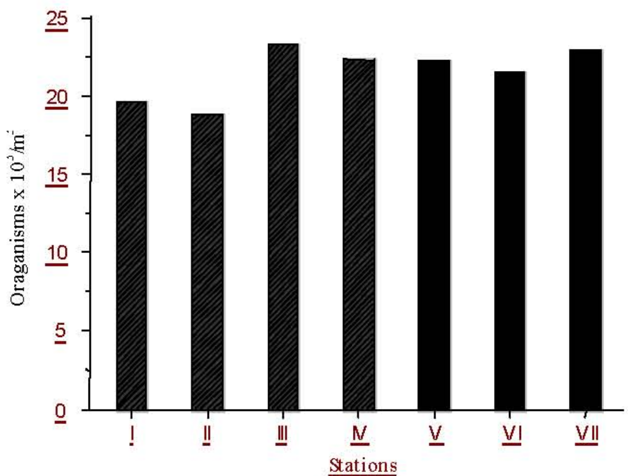

Fig. 4: Spatial distribution of tintinnids in Damietta Harbor (May 2003- April 2004)

Table 1: Frequency of occurrence of potozoan components with time in Damietta Harbor (May2003 – April 2004)

Foraminiferans	
Adelosina elegans (Williamson)	*Laticarinia sp.*
Ammonia beccarii (Linne)	*Loxostomum plaitum* (Carsey)
Bolivina sp.	*Nodosaria* sp.
Chilostomella sp.	*Nonion boueanum* (d'Orbig.)
Discorbis floridana (Cushman)	*Quinqueloculina laevigata* (d'Orbig.)
Discorbis orbicularis (Terquem)	*Quinqueloculina limbata* (d'Orbig.)
Discorbis sp.	*Quinqueloculina seminulum* (Linn.)
Eponides repandus (Fich. and Moll)	*Quinqueloculina striata* (d'Orbig.)
Globigerina inflata (d'Orbig.)	*Spiroloculina depressa* (d'Orbig.)
Globigerinoides ruber (d'Orb.)	*Spirillina vivipara* (Ehr.)
Globorotalia truncatuloides (d'Orb.)	*Trochaminia sp*
Tintinnids	
Amphorellopsis acuta (Kof.andCamp.)	*Rhabdonella spiralis* (Fol.)
Codonella aspera (Kof.andCamp.)	*Stenosemella nivalis* (Meun.)

Table 1: Continued

Codonella galea (Haeck.)	*Stenosemella steini* (Jorg.)
Codonella sp.	*Stenosemella ventricosa* (Clap.and Lachm.)
Codonaria sp.	*Tintinnopsis aperta* (Brand.)
Codonellopsis bulbulus (Meun.)	*Tintinnopsis baltica* (Brand.)
Codonellopsis morchella (Cl.)	*Tintinnopsis beroidea* (Entz)
Coxliella ampla (Jorg.)	*Tintinnopsis büetschlii* (Dad.)
Coxliella annulata (Dad.)	*Tintinnopsis campanula* (Ehr.)
Coxliella decipiens (Jorg.) .	*Tintinnopsis compressa* (Dad.)
Eutintinnus lusus -undae (Entz)	*Tintinnopsis corniger* (Hada.)
Eutintinnus macilentus (Jorg.)	*Tintinnopsis cylindrica* (Dad.)
Favella adriatica (Imhof.andBdt.)	*Tintinnopsis lobiancoi* (Dad.)
*Favella ehrenbergii (*Clap.and Lahm.)	*Tintinnopsis mortensenii* (Schmidt.)
Favella markusovszkyi (Dad.)	*Tintinnopsis nana* (Lohm.)
Favella serrata (Mob.)	*Tintinnopsis radix* (Imhof.)
Helicostomella subulata (Ehr.)	*Tintinnopsis tocantinensis* (Kof. and Camp)
Leprotintinnus nordgvisti (Brand.)	*Tintinnopsis tubulosa* (Levand.)
Metacylis mediterranean (Mereschk.)	

June and March, *Metacylis mediterranea* in October, *Stenosemella nivalis* during December, June and April, *Stenosemella steinii* during August and *Tintinnopsis cylindrical during* May.

Throughout the harbor, tintinnids abundance demonstrated relatively small variations between stations (Fig. 4), the highest counts were reported at stations III and VII and the lowest counts at stations I and II.

Foraminiferans: Were represented monthly by 1 to 5 species, except that (16 species) during December. Stations VI and VII were inhabited by low numer of species (5 and 4 species respectively) as compared to those found at stations III and IV (18 and 17 species respectively). They were usually found in markedly low counts, with an annual average of 55 organisms/ m^{-3}, and monthly average between one and 64 organisms m^{-3}, except the relatively high peak in June, and completely disappearance at most stations during winter.

Small differences were accounted between stations, where the count of foraminiferns was less than 40 organisms/m^3 except at station III (170 organisms/m^3). *Discorbis floridana* and *Loxostomum plaitum* were the most common species of this group.

DISCUSSION

The present study revealed that protozoa was the second abundant zooplankton group in Damietta Harbor after copepods and predominated by tintinnids (99.7%). It constitutes an important link between ultra-and nanoplankton and the higher trophic levels [12], as they feeding on such particles not effectively grazed by larger zooplankton and subsequently serving as readily assimilated prey for larger zooplankton [2,13].

Tintinnids contributed significantly to the biological economy of the sea, particularly at lower trophic levels [2] and in biological and non-biological activities in the sea [3]. The role of tintinnids in seawater differs widely in the different habitats [14] and they have a greatly variable contribution to the zooplankton stock, particularly in the surface layer [15]. The great role of tintinnids in the marine habitats is attributed mainly to their rapid regeneration, which enable them to establish dense populations at suitable conditions [16].

The assemblages of tintinnids are the major herbivore microzooplankton and effective grazers [17] particularly on nanozooplankton [18] such as bacteria, small flagellates, coccolithophorides and dinoflagellates [19]. They are also considered as primary agents of nutrient regeneration [20] and of major importance in sustaining nitrogen supply for primary production in some coastal waters and open sea [21]. Specific excretion rates of ammonia by tintinnids are one to two orders of magnitude higher than rates of macrozooplankton [22]. However, the effective role of tintinnids in nutrient recycling is supposed to be related to their active grazing on phytoplankton, which is the main user of inorganic matter [15].

The distribution and abundance of tintinnids are affected by several factors including biological factors such as food supply [23, 24], predation and the prevalinig physico-chemical conditions, particularly temperature, salinity and dissolved oxygen [25 - 27].

In Damietta Harbor, the abundance of tintinnids was the highest in summer and autumn at a temperature range of 27-33°C. The preference of tintinnids to high temperature seems to be common in many marine coastal and estuarine waters. This may be attributed to the fact that many tintinnids grow better at higher temperature and chlorophyll *a* concentrations, which both are often considered as the most important factors to increase the growth rate.

The low temperature and chlorophyll *a* concentrations drastically affect the life cycles of many tintinnids and consequently they severely affect the abundance and growth rate of these animals [28, 29]. This explains the low standing crop of tintinnids in Damietta Harbor during winter and spring, when the temperature and chlorophyll *a* attained the lowest values over the year. The significant positive correlation between tintinnids and each of temperature, chlorophyll *a* and transparency (Table 2) supports the crucial effect of these ecological factors on the tintinnids abundance in Damietta Harbor.Further, the stepwise multiple regression analysis reported temperature as the effective factor on tintinnids during spring ($r = 0.566$, $p = 0.008$) and winter ($r = 0.837$, $P = 0.000$), while no correlations during summer and autumn were found.

The dominant genera of tintinnids in Damietta Harbor (i.e. *Amphorellopsis, Stenosemella, Favella, Leprotintinnus and Tintinnopsis*).

From the regression analysis and the simple correlations (Table 2) it is clear that, temperature, pH, salinity and phytoplankton biomass seems to be factors governing the counts of dominant tintinnid species in Damietta harbor. This was partially in agreement with Verity [3], Dorgham and. Abdel-Aziz [15] and Kimor and Golandsky [30], but contradict with Graziano[31]. However, abundances can shift rapidly in response to environmental changes, but with variable time lags and the diversity of tintinnids can shift rapidly and unpredictably with a given factor such as predation. In a slow growing community of tintinnids, copepod predation decreased diversity relative to changes in communities without copepods, while in a community highly dominated by rapidly growing tintinnid species, copepod predation increased diversity [32]. In Damietta Harbor, predation by copepods and other carnivorous zooplankters could be considered as a factor reducing tintinnid diversity and abundance, as indicated from the significant correlations between tintinnids and each of copepods, rotifers and cirriped larvae (Table 3). The latter two groups comprises some carnivorous or omnivorous assemblages which may predate tintinnid species. Vay, *et al.* [33] reported nauplii 5-6 of cirriped larvae as omnivores.

The distribution of tininnids with time in Damietta Harbour reported the occurrence of about 38% of the recorded species were persistent all the year round, indicating their tolerance to the seasonal ecological changes. This reflects a degree of stability of the zooplankton community in Damietta Harbor. These observations are supported by Bakker, [34]who found that the sheltered environment gives aquatic organisms the opportunity to persist for longer period in the preferred zone. The other species appeared in the harbour for short duration or occasionally, indicating their preference to certain seasonal environmental conditions or they are allochthonous species. As shown in Table 4, 11 of tintinnids species and 10 of foraminiferans in Damietta Harbor have never been recorded along the Egyptian Coast.

Of the new recorded titinnids in Damietta Harbour *T. aperta* and *T. mortensenii* were recorded in the Suez Canal [35], while *T. tocantinensis* and *T. tubulosa* in Suez Canal and Red sea [35, 36]. This indicates the migration of these species to the study area through the Suez Canal. *T. mortensenii* have been reported in the Northern Mediterranean, off Italy, as an invasing species through the ballast waters of ships comes from the Indian Harbors[37]. Furthermore, *A. acuta* found in neritic waters and Indian estuaries [38, 39] *S. steini* in the Mediterranean sea [40] and the Indian Ocean [39] *T. corniger* in the Atlantic Ocean [41] and Northern Mediterranean [42] *T. baltica* in the Atlantic Ocean [43, 44] Baltic Sea, North Sea and Mediterranean Sea [7]. All these species are supposed to be transported to the Damietta Harbour either by currents from other parts of the Mediterranean or with ships ballast water.

The low diversity of tintinnids in Damietta Harbor compared to the offshore waters appeared to be related to some extent to a type of pollution in the harbor. This is partially agree with Moraitou Apostopoulou [45] who observed that partial pollution by sewage produce more zooplankton abundance and low diversity. Eutrophication in the harbor may be also another factor reducing the diversity of both groups.

The tintinnids of Damietta Harbor were less diversified than some other Egyptian Mediterranean waters, while more diversified than some inshore areas (Table 5).

Table 2: Pearson's correlation of ecological parameters, total copepods and total tintinnids from data collected in Damietta Harbor (May 2003 – April 2004).

	Tintinnids	Temp. (°C)	Salinity (%)	Trans. Cm	pH	DO (mg/l)	Chl *a* (µg/l)
Copepods	0.397**						
Temp. °C	0.427**	1.00					
Salinity %	0.166	0.30**	1.00				
Trans. Cm	0.244*	0.39**	0.21	1.00			
pH	0.086	0.12	-0.47**	0.018	1.00		
DO (mg/l)	-.001	0.13	-0.47**	-0.15	0.52**	1.00	
Chl *a* (µg/l)	0.262*	0.49**	-0.073	0.031	0.33**	0.43**	1.00

Significant correlations * at P<0.05 and ** at P<0.01

Table 3: Pearson's correlation between the different groups of zooplankton in Damietta Harbor (May 2003 – April 2004)

	Tintinnids
Copepods	0.397**
Rotifers	0.279*
Cirripedes larvae	0.298**

Significant correlations * at P<0.05 and ** at P<0.01

Table 4: New records of Protozoan species in the Egyptian Mediterranean Coasts.

Foraminiferans	Tintinnids
Bolivina sp.	*Amphorellopsis acuta* (kof.andCamp.)
Chilostomella sp.	*Codonella sp.*
Discorbis floridana (Cushman)	*Codonellopsis bulbulus* (Meun.)
Discorbis orbicularis (Terquem)	*Coxliella sp*
Discorbis sp.	*Stenosemella steini* (Jorg.)
Nodosaria sp.	*Tintinnopsis aperta* (Brand.)
Quinqueloculina laevigata (d'Orbig.)	*Tintinnopsis baltica* (Brand.)
Quinqueloculina limbata (d'Orbig.)	*Tintinnopsis corniger* (Hada.)
Spiroloculina depressa (d'Oorbig.)	*Tintinnopsis mortensenii* (Schmidt.)
Trochaminia sp.	*Tintinnopsis tocantinensis* (Kof. and Camp.)
	Tintinnopsis tubulosa (Levand.)

Table 5: Number of tintinnids species in different areas of Egyptian Mediterranean waters

Area	Year	Tintinnids	Reference
Off Alexandria Coast	1961-63	99	[46]
Off Alexandria Coast	1996	11	[47]
Alexandria Coast	1991	31	[48]
Mex Bay	1996	13	[49]
Mex Bay	1982-83	46	[50]
Dekhaila Harbor	1998-99	29	[51]
Abu-Qir Bay	1999-2000	23	[52]
Western Harbor	1999-2000	40	[53]
Eastern Harbor	1999-2000	28	[54]
Damietta Harbor	2003-2004	37	Present study

The diversity index of tintinnids in Damietta Harbor showed a wide range of variations (0.9 - 2.6), the values during spring (1.93) and autumn (1.89) were slightly higher than during winter (1.71) and summer (1.64). The low winter diversity could be due to the low total count, while those during summer may be related to the dominance of a few species. The variation range of diversity index in Damietta Harbor is similar to that (1-2.5) reported by Margalef [55] for the coastal zooplankton.

According to Levinton [56], the value of diversity index is related to the disturbance of environment, whereas three stages could be identified relative to succession. He stated that the newly disturbed environment has low species richness, high dominance and hence low diversity (Stage I). With further succession, species richness increases but, dominance may still be high due to the competitive superiority of a few species (Stage 2), in latter successional stage diversity index increases (Stage III). Accordingly, the values of diversity of zooplankton in Damietta Harbor may proposed that stage I appeared to be the dominant most of the year round, since zooplankton community characterized by low diversity, low species richness and low evenness.

In conclusion, the protozoan community in Damietta Harbour was represented by tintinnids (37 species) and foraminiferans (22 species). In term of numerical abundance tintinnids appeared to the predominant over the year, displaying three peaks during July, October and March. Of the recorded species, 11 tintinnids and 10 foraminiferans were not known previously in the Egyptian Mediterranean waters, indicating their tranferrance either from the Red sea or from other parts of the Mediterranean.

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