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ECOLOGICAL STUDY ON THE ZOOPLANKTON COMMUNITY IN BARDAWIL LAGOON, EGYPT

SUMMARY

Distribution, seasonal dynamics, community structure and standing crop of zooplankton were studied in Bardawil lagoon during 2002-2003. A total of 58 zooplankton taxa were recorded from a total of 12 sampling sites. Copepoda were the most abundant, contributing 69.9% of the total zooplankton numbers. Zooplankton reached the highest density during summer at station X (198,500 ind. m^{-3}). Protists (23 species), made up 10.3% of total zooplankton. Winter was the season characterized by the highest standing crop. The dominant and common zooplankton species in 1985, *Tintinnopsis lobiancoi* (Ciliophora) and *Acartia clausi* (Copepoda) were replaced by *T. tocantinensis* (Ciliophora) and *Oithona nana* (Copepoda); moreover, 21 zooplankters were newly recorded. Few species occurred all-over the lagoon: *Oithona nana*, *Centropages ponticus* and *Euterpina acutifrons* (Copepoda), *Tintinnopsis tocantinensis* (Ciliophora) and *Limacina inflata* (Pteropoda), while the others were highly confined to restricted areas.

RIASSUNTO

La laguna di Bardawil è una depressione costiera naturale ipersalina a causa dell'elevata evaporazione dell'acqua soprattutto nel periodo estivo. È situata ad 1-3 m sotto il livello del mare, lungo le coste del Mediterraneo nella regione del Sinai. Si estende per circa 90 Km in lunghezza ed ha una larghezza massima di 22 Km, una profondità massima di 3,6 m e comunica con il mare attraverso due aperture.

La laguna è considerata la risorsa naturale ecologicamente ed economicamente più importante della regione. Dal 1995 la composizione biologica della laguna è cambiata, perciò lo studio delle comunità zooplanctoniche è importante perché contribuisce alla conoscenza dell'ecologia della laguna e quindi ad una solida base per la sua gestione.

I campioni di zooplancton sono stati raccolti in 12 stazioni (2002-2003) mediante trascinamento verticale di un retino a maglie di 55 µm e conservati in formalina al 4%. In laboratorio è stata effettuata un'analisi qualitativa e quantitativa mediante un microscopio binoculare.

I risultati sono stati trattati statisticamente. In tutto sono stati rinvenuti 58 taxa zooplanctonici, appartenenti a 9 gruppi principali. Le zone più densamente popolate sono risultate essere la stazione II e X, mentre quelle a più bassa densità la XII e la III. È stata registrata anche una considerevole variazione stagionale: primavera ed estate sono state le stagioni con una maggiore abbondanza di organismi. I copepodi sono la componente principale della comunità zooplanctonica (69,9%) e sono rappresentati da 12 specie. La specie dominante è *Oithona nana*, mentre *Acartia clausi* compare solamente in inverno ed in primavera. *Centropages ponticus* è una specie esclusivamente estiva ed *Euterpina acutifrons* è una specie perenne. La presenza di nauplii e copepoditi durante tutto l'anno in percentuale superiore rispetto agli adulti, indica una continua attività riproduttiva dei copepodi.

Gruppi ben rappresentati sono anche i protozoi, gli pteropodi e il meroplancton.

La Cluster Analysis ha messo in evidenza una forte similarità tra le stazioni IX e X.

È stata utilizzata la CCA (Canonical Corrispondence Analysis) per relazionare le specie zooplanctoniche con le variabili ambientali e ciò ha rivelato che la salinità, la temperatura dell'acqua e l'ammonio sono i fattori più importanti che influenzano la struttura di comunità nella laguna di Baldawil.

In condizione di eutrofizzazione il numero di specie zooplanctoniche decresce gradualmente e generalmente la comunità è semplificata con poche specie che tollerano un'alta variabilità ambientale ed esplodono demograficamente in condizioni di cibo favorevoli.

Le specie dominanti nel 1985, *Tintinnopsis lobiancoi* e *Acartia clausi* sono state rimpiazzate da *Tintinnopsis tocantinensis* e *Oithona nana*; inoltre sono stati trovati 21 taxa nuovi rispetto al passato.

Il cambiamento della struttura della comunità zooplanctonica potrebbe essere una delle cause principali della diminuzione delle specie ittiche economicamente più importanti.

INTRODUCTION

Lagoons are among the most productive aquatic ecosystems, which for thousands of years have been exploited by man (LASSERRE, 1979). Bardawil lagoon is a shallow natural depression (1-3 m below mean sea level) separated from the Mediterranean Sea by a narrow arc-shaped sedimentary bar of about 90 km length, with a maximum width of 2 km. Bardawil lagoon, particularly at Zaranik area (the eastern region) has been described as a wetland of a major international importance for migrating water birds passing through the eastern Mediterranean region, where wetlands are scarce (MEININGER and ATTA, 1990; VARTY *et al.,* 1990). The lagoon is considered the main ecological and economic natural resource of North Sinai region. A recent estimate of fish and crustaceans production amounts to 2801 ton (GAFRD, 2001), composed of 35.8% mullets, 21.2% shrimps, 18.6% crabs, 8% sea bream, 5.1 sole, 2.4% sea bass and 9.4% miscellaneous.

The characteristics of catch composition in Bardawil lagoon have greatly changed since 1995, when the contribution of the most economic species (sea bream and sea bass) dropped sharply. On the contrary, other species as crabs and shrimps have attained a noticeable contribution in the catch (EL-GANAINY *et al.,* 2002). The study of zooplankton communities seems to be useful for the evaluation of the lagoon ecology and contributes a solid base for its management.

Several studies have been carried out on the abundance, distribution and biomass estimation of zooplankton in the Egyptian Mediterranean Sea (EL-MAGHRABY, 1964; DOWIDAR and EL-MAGHRABY, 1970; 1973; HUSSEIN 1977; 1997; EL-ZAWAWY, 1980; DOWIDAR, 1981; NOUR EL-DIN, 1987; ABOU-ZEID, 1990; ABDEL AZIZ, 1997; HUSSEIN and ABDEL AZIZ, 1997; ABDEL AZIZ and DORGHAM, 2002), despite the importance of zooplankton in lagoon food chain, extremely poor is the knowledge of the distribution and standing crop of zooplankton of Bardawil Lagoon. KIMOR (1975) carried out a preliminary study on the plankton of Bardawil hyper saline lagoon. IBRAHIM *et al.*, (1987) included zooplankton in their studies on fishery and management of the lagoon. FOUDA *et al*. (1985) listed 87 zooplankton species in Bardawil lagoon and mentioned that some species occur over a relatively wide range of habitats, while others were confined to certain localities. They added that zooplankton populations were poor in variety of species, compared to phytoplankton. So, the main objective of the present study is to investigate the biodiversity, species composition, standing crop and seasonal variation of zooplankton community in Bardawil lagoon after the detection of a considerable change in the species composition of fish catch during the last decade.

MATERIALS AND METHODS

Study site

Lake Bardawil is a hyper-saline lagoon located along the Mediterranean shore of the Sinai Region. The lagoon extends for about 90 km length and has a maximal

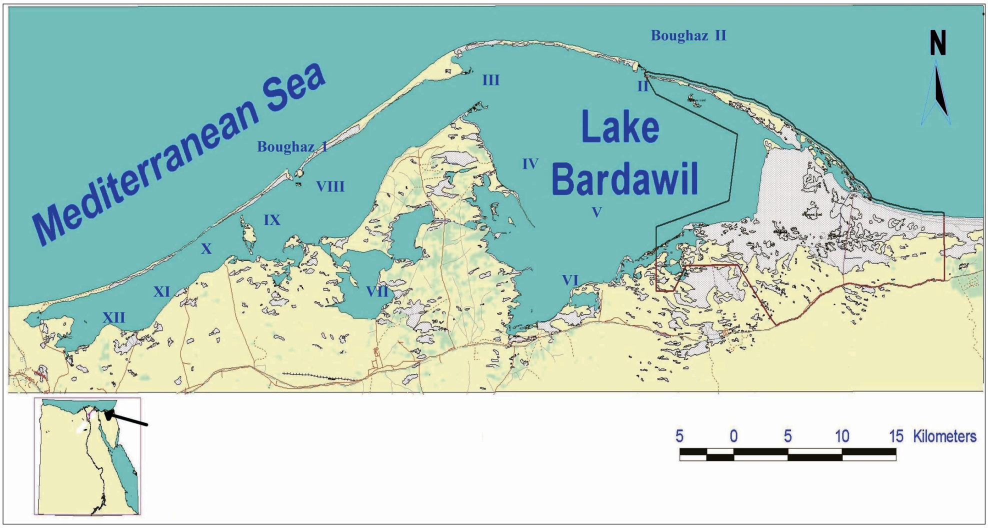

Fig. 1 - Map of the northern side of Egypt showing the location of Bardawil Lagoon and the selected stations.

width of 22 km. The flooded area is approximately 65,000 hectares between longitudes 32° 40' to 33° 30' E and latitude 31° 03' to 31° 14' N (Fig 1). Bardawil lagoon is extremely shallow; the water depth ranges between 0.5 and 3,6 m. Three openings (Boughaz) connect the lagoon with the sea. Two of these are man-made (the western Boughaz I and the Middle Eastern Boughaz II), while the third one is natural (eastern Boughaz III at Zaranik protectorate). The whole water supply of the lagoon comes from the Mediterranean Sea which flows constantly through these three openings.

Bardawil lagoon is subjected to excessive water evaporation, particularly in summer that led to a progressive increase in water salinity. Surface water temperature ranged between 19.2 °C at station VIII in winter and 29.8 °C at station VI in summer. Station VIII (Infront to Boughaze I) was the deepest, varied in depth from 3.05 to 3.6 m. The other sites had a depth varied from 0.8 to 1.7 m. The secchi-depth reached the bottom at most sites on most or all occasions, except for site VIII, where it fluctuated from 0.9 m in winter to 3 m in summer. pH was always on the alkaline side and varied from 8 to 8.79. Dissolved Oxygen was lowest, 5.2 mg/l at site XII in spring, while the highest value of 8.8 mg/l occurred at site V in summer (IBRAHIM *et al*., 1987; ANONYMOUS, 2000; ABDEL-SATAR, 2005). The measured values of salinity fluctuated from a minimum of 41.1 ‰ at station II in autumn to a maximum of 78.8 ‰ at stations VII and XII in summer. Generally the bicarbonate values were high in autumn (≈ 211-267 μg l^{-1}), while the lowest values detected in spring (≈106-211 μg l^{-1}). The concentrations of nitrate were fluctuated between 9 μg l^{-1} at station IV in autumn and 43.8 μg l^{-1} at station V in summer. The highest value of orthophosphate, 54.2 μg l^{-1} was recorded at station VI in spring, while the lowest, 3.06 μg l^{-1} occurred at station VII in summer. Ammonia was generally high in spring and summer in compared with autumn and winter (ABDEL-SATAR, 2005).

Sample collection

Zooplankton samples for quantitative analysis were collected seasonally during 2002-2003. 12 stations were selected to represent different areas of the lake (Fig. 1, Table I). Integrated samples were collected by vertical towing a 55 μm mesh size net. The net was lowered to the bottom and hauled vertically to the surface at a uniform speed. In addition, qualitative samples were taken from each station. Samples were preserved immediately after collection in 4 % formalin solution. In the laboratory, samples were made up to a standard volume (120 ml). Sub-samples (1-3 ml) were used for enumeration by aid of binocular microscope. The major groups of zooplankton (Protozoa, Copepoda, Cladocera, Meroplankton) were submitted to detailed analysis. Zooplankton species were identified according to the literature of TREGOUBOFF and ROSE (1957), NEWELL and NEWELL (1977), NISHIDA (1985) and BRADFORD-GRIEVE (1994; 1999).

Table I - Location of selected stations (longitude and latitude)

Station	Location	Station	Location
I	31° 09' 18 N 33° 19' 25 E	VII	31° 05' 35 N 32° 59' 18 E
II	31° 12' 27 N 33° 15' 43 E	VIII	31° 08' 11 N 32° 55' 75 E
III	31° 11' 78 N 33° 06' 24 E	IX	31° 06' 12 N 32° 53' 30 E
IV	31° 08' 96 N 33° 07' 92 E	X	31° 05' 67 N 32° 51' 18 E
V	31° 04' 50 N 33° 10' 13 E	XI	31° 04' 20 N 32° 48' 36 E
VI	31° 05' 81 N 33° 13' 65 E	XII	31° 03' 51 N 32° 46' 75 E

Statistical treatment of data

We computed Shannon-Winner diversity, Species richness, Evenness and similarity index. The correlation between some environmental variables and zooplankton assemblage was calculated using SPSS program. Canonical Correspondence Analysis (CCA) was performed to assess the influence of environmental factors on the distribution and community assemblage of zooplankton. CCA is a direct gradient analysis technique where the ordination axes are constrained to be linear combinations of environmental factors. The environmental variables included in the analysis were: DO, BOD. COD, NO_2, NO_3, NH_3, Urea, TP, Mg, Ca, SO_4, K, Na, Cl, pH, CO_3 and HCO_3.

RESULTS AND DISCUSSION

A total of 58 zooplankton taxa belonging to 9 main groups (Protozoa, Copepoda, Cladocera, Rotifera, Cnidaria, Pteropoda, Chaetognatha, Appendicularia and Meroplankton) were recorded during the present study (Table 2). A mutual increase and decrease in zooplankton density were noticeable from one station to another. Station X and II maintained the highest crops with an average 137,938 and 120,375 ind. m^{-3} respectively, while the lowest crops of 71,063 and 75,125 ind. m^{-3} occurred at stations XII and III respectively. In contrast to the present study, FOUDA *et al.*, (1985) recorded the highest density of plankton at Raabah station (St XII). Regarding seasonal variation, Spring and summer were the seasons of highest abundance of these organisms, with average of 134,958 and 185,333 ind. m^{-3}, respectively, while a severe depletion in zooplankton density were occurred in winter and autumn (Fig. 2).

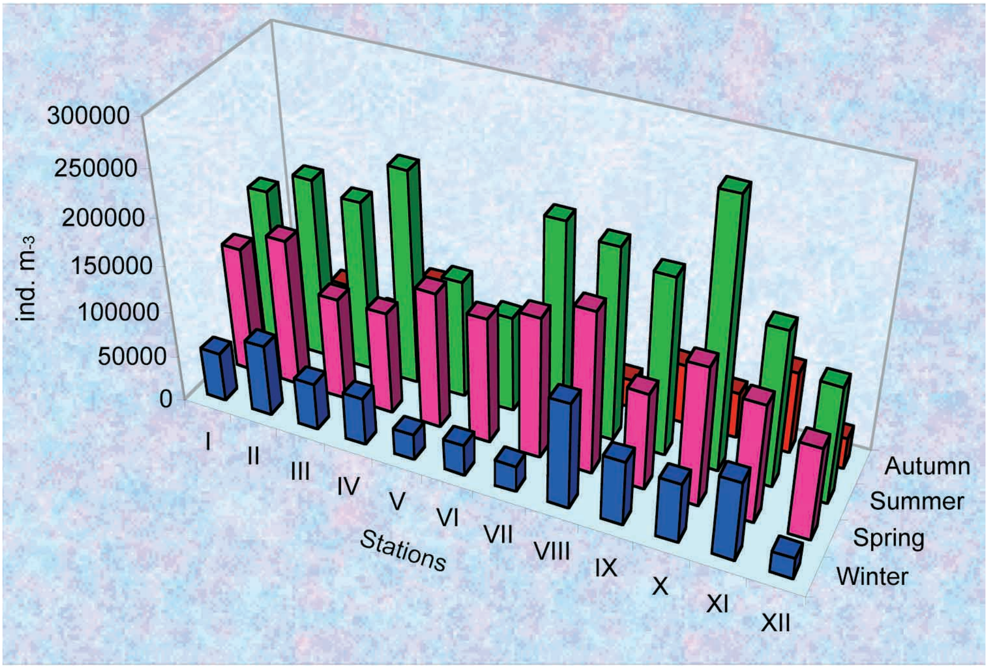

Fig. 2 - Distribution and seasonal variation of total zooplankton.

Copepoda

Copepoda attained the highest density, with relative average of 69.9% of the total zooplankton (range, 51.2-74.1%) (Fig. 3). Summer showed the highest density (av. 137,333 ind. m^{-3}), with a maximum peak of 198,500 ind. m^{-3} at station X.

	1985	2002	present status
Protozoa			
Ciliophora spp.#		*	R
Codonella agalea Haeckel	*	*	R
Codonella amphorella Biedermann	*	*	R
Codonella aspera Kofoid & Campbell	*	*	MC
Cyttarocylis plagiostoma	*	*	VR
Dictyocysta minor Jörgensen	*		
Dictyocysta obtusa Jörgensen	*	*	VR
Epiplocylis acuminata (Daday) Jörgensen #		*	VR
Favella ehrenbergi (Clap & Lach.) Jörgensen#		*	R
Favella serrata (Möbius) Jörgensen	*	*	C
Helicostomella subulata (Ehr.)	*	*	R
Leprotintinnus bottnicus (Narolqvist) Jörgensen#	*	*	R
Metacylis mereschkowskii Kofoid & Campbell	*		
Petalotricha major Jörgensen #		*	VR
Ptychocylis minor Jörgensen #		*	VR
Rhobdonella elegans Jörgensen	*	*	VR
Stenosemella nivalis (Meunier) Kofoid & Campbell	*	*	R
Tintinnidium neapolitanum Daday	*		
Tintinnopsis campanula (Ehr.) Daday	*	*	R
Tintinnopsis cylindrica Daday	*	*	MC
Tintinnopsis lobiancoi Daday	*	*	R
Tintinnopsis nucula (Fol) Brandt	*	*	MC
Tintinnopsis beroidea Stein	*	*	MC
Tintinnopsis tocantinensis Kofoid & Campbell #		*	C
Undella sp.	*	*	VR
Foraminifera			
Globigerina bulloides d'Orbigny	*		
Orbilina universa d'Orbigny		*	VR
Copepoda			
Nauplius larvae	_	*	C
Cyclopoid copepodid	_	*	C
Calanoid copepodid	_	*	C
Harpacticoid copepodid	_	*	MC
Lucicutia flavicornis Claus	*		
Lucicutia ovalis Giesbrecht	*		
Temora longicornis Müller	*		
Acartia clausii Giesbrecht	*	*	MC
Paracartia latisetosa (Kricz.) #		*	R
Calanus finmarchisus Gunnerus	*		
Eurytemora hirunoloides Nordqvist	*	*	VR
Paracalanus parvus Claus #		*	R
Centropages ponticus Karavaev #		*	C
Sapphirina opalina Dana	*		
Sapphirina angusta Dana	*		
Parapontella brevicornis Lubbock	*		
Parapontella sp	*		
Oithona nana Giesbrecht #		*	C
Oithona plumifera Baird #		*	MC
Corycaeus clausi F. Dahl	*		
Isias clavipes Boeck	*		
Euterpina acutiforns Dana	*	*	C
Microsetella norvegica Boeck	*	*	R
Amallothrix auropecten Giesbrecht	*		
Echinocomptus spp.	*		
Canuella sp. #		*	VR
Harpacticus littoralis Sars #		*	R
Metis jousseaumei Richard #		*	VR
Cladocera			
Bosmina maritima Müller	*		
Evadne spinifera Müller	*	*	R
Evadne tergestina Claus #		*	R
Podon polyphemoides Leuckart #		*	VR
Rotifera			
Synchaeta calva Ruttner-Kolosko	*	*	MC
Synchaeta sp #	_	*	R
Cnidaria			
Rhizostoma pulmo Merci.	*	*	VR
Obelia spp #	_	*	R
Cotylorhiza tuberculata Agassiz	*	_	
Pteropoda			
Limacina inflata d'Orbigny	*	*	R
Cheatognatha			
Sagitta setosa Müller #	_	*	C
Appendiculariae			
Oikopleura longicauda Vogt #	_	*	R
Meroplankton			
Polycheate larvae	*	*	C
Cirripedia larvae	*	*	MC
Mollusca larvae	*	*	C
Echinodermata larvae	*	*	VR
Ostracoda spp	*	*	R
Chironomus larvae	_	*	VR
Mysis sp	_	*	VR
Osteichthyes eggs	_	*	VR
Nematoda	*	*	VR

C: Common Species
MC: Moderate Common Species
VR: Very Rare species
R: Rare Species
1985: After Fouda et al., 1985
2002 Present study
#: new recorded species

Table 2 - Check list of zooplankton taxa recorded in Lake Bardawil during different time periods (1985-2002).

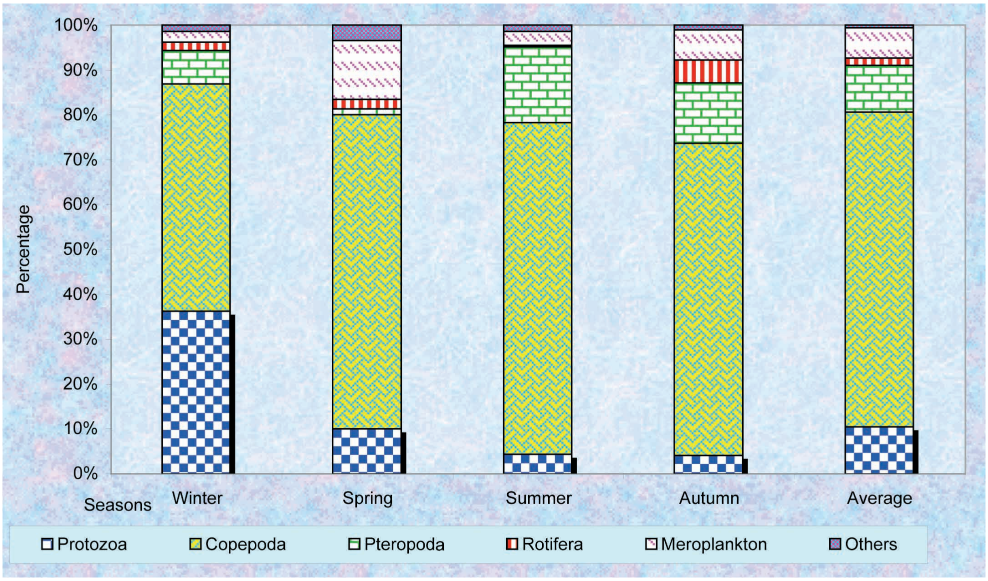

Fig. 3 - The percentage frequency of different zooplankton groups.

Winter showed the lowest density (av. 29,083 ind. m^{-3}) (Fig. 4). 12 copepod species were identified. FOUDA *et al.* (1985) previously recorded 16 species, dominated mainly by *Acartia clausi.* The present study showed that *Oithona nana* is the most common and dominant copepod. *A. clausi* occurred only during winter and spring. Nauplii and copepodids proved to be the most common forms, being about 72.7% and 14.9% of total copepod density, while adult stages contributed 12.4% only (Fig. 4). The presence of copepod juveniles (nauplii and copepodids) all year round indicates the continuous reproduction of copepods (RAYMONT, 1983). Nauplii and copepodid stages were the major component of copepod in the whole Egyptian Mediterranean and Red Seas (DOWIDAR and EL-MAGHARBY, 1970; HUSSEIN, 1977; ABDEL RAHMAN, 1997; EL-SHERBINY, 1997). Five broods representing five generation over the year were expected for *Oithona nana*, *Euterpina acutifrons* and *Paracalanus parvus* (common species in Bardawil lagoon) in the S-E Mediterranean (DOWIDAR and EL-MAGHRABY, 1970). *Oithona nana*, the numerically dominant copepod, contributed 59.1% of total adult copepod (range 26.2 - 77.6%). *O. nana* exhibited a clear peak in summer (avr. 14,583 ind. m^{-3}) and persisted with numbers ranging between 1,000 and 7,000 ind. m^{-3} during the rest of the year. Station X maintained the highest density (Fig. 4). *O. nana* is common, not only in the open sea but also in estuaries and enclosed Bays in the tropical and subtropical regions (GRICE, 1960; NISHIDA, 1985). *Acartia clausi* was recorded only during winter and spring. Station X had

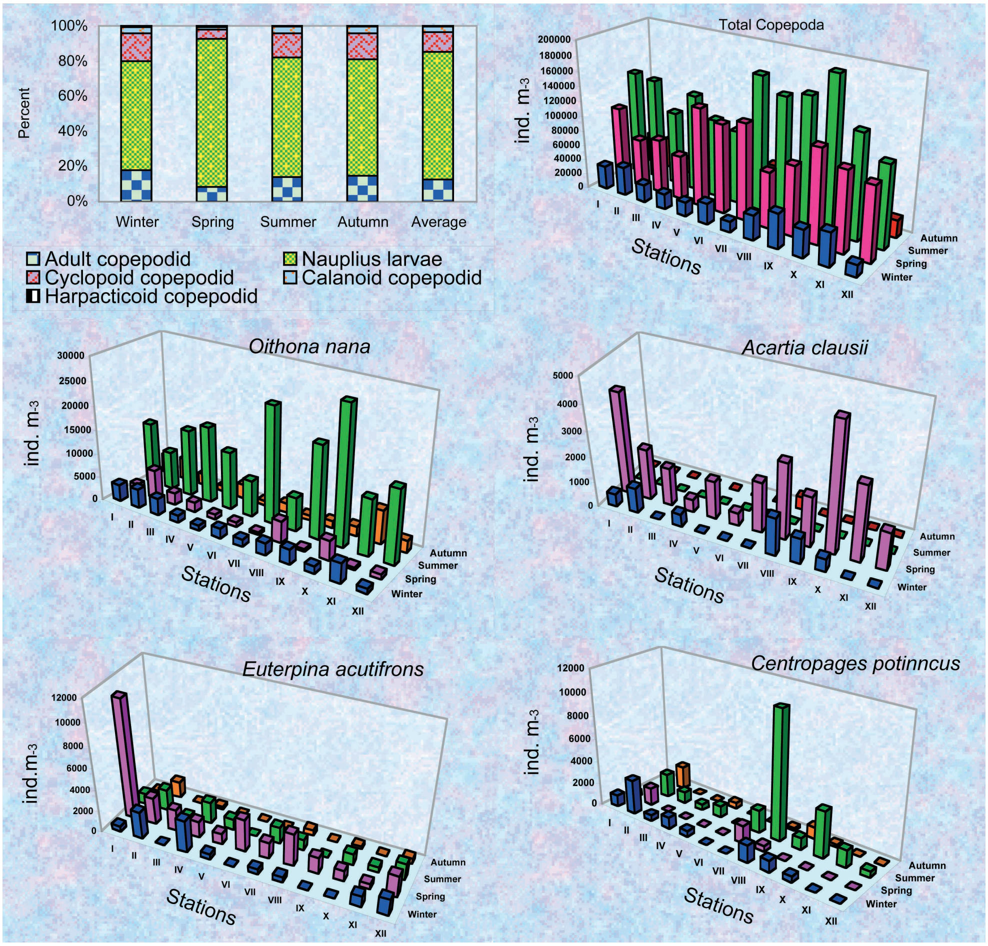

Fig. 4 - Community composition, distribution and seasonal variation of total Copepoda and most common copepod species.

the highest density (5,000 ind. m^{-3}) in spring (Fig. 4). *A. clausi* is Atlanto-Mediterranean, anti-lessepian migrant (FOX, 1927), mostly common in the entire Ponto-Mediterranean province (BELMONTE and POTENZA, 2001). NOUR EL-DIN (2001) mentioned that *A. clausi* disappeared at some areas of Bardawil lagoon with salinity above 48‰. During present study, *A. clausi* totally disappeared during summer and autumn.

Centropages ponticus is the only summer species, (av. 2,042 ind. m^{-3}), with a pronounced peak of 11,000 ind. m^{-3} at station VIII (Fig. 4). *C. ponticus* is a neritic species and previously recorded in Suez Canal and Eastern Mediterranean (ABDEL RAHMAN, 1993; SEI *et al.*, 1996). *Euterpina acutifrons* is a perennial species, made up 12.4% (range 4.9 - 31.9%) of total adult copepod. In contrast to the upper mentioned copepod species, *E. acutifrons* peaked in spring, with a maximum of 11,000 ind. m^{-3} at station I (Fig. 3). The species was practically absent in autumn.

Protozoa

23 species were recorded, contributing 10.3% (range 4 - 36.4%) of total zooplankton density, with average abundance of 11,052 cells m^{-3}. The highest density was recorded in winter, with a peak of 77,000 cells m^{-3} at station VIII (Fig. 5), while the minimum was in autumn. *Tintinnopsis tocantinensis* and *Favella serrata* (both Ciliofora) were the most common protozoan species. FOUDA *et al*. (1985) recorded 21 protozoan species dominated mainly by *Tintinnopsis lobiancoi* (Table 2).

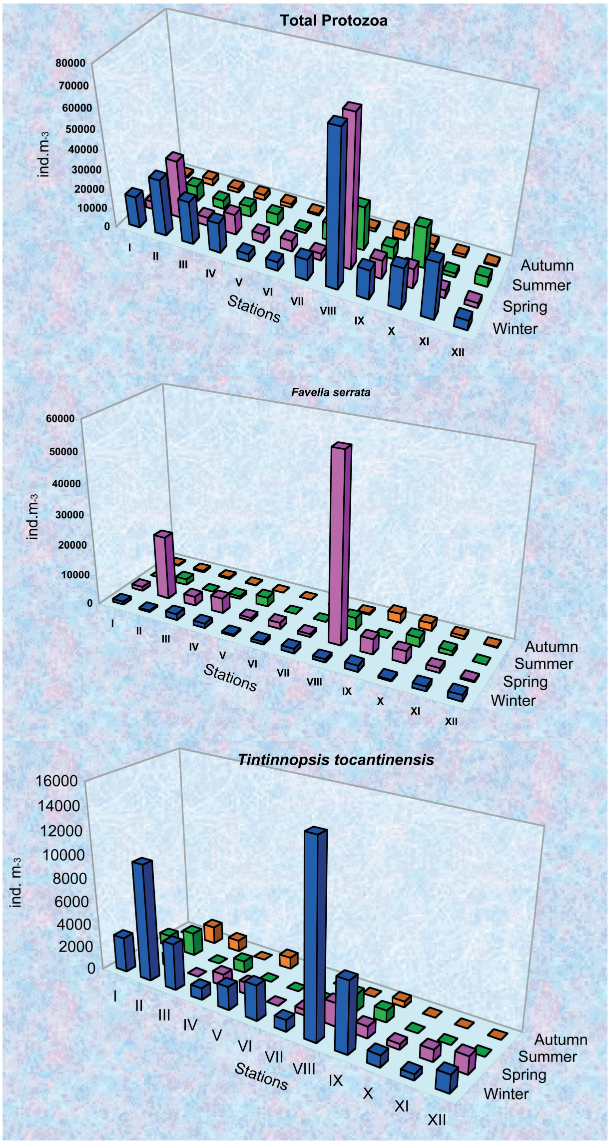

Fig. 5 - Distribution and seasonal variation of total Protozoa and most common protozoan species.

Favella serrata contributed with about 27.1 % to the total Protozoa density, with an average of 2,995 cells m^{-3} (range 250 -60,000 cells m^{-3}). Spatially, there is a numerical increase tendency towards station VIII, with showed the peak of 60,000 ind. m^{-3} in spring (Fig. 5).

Tintinnopsis tocantinensis represented 13.1% of total protozoan population density. Its highest standing crop (4,083 cells m^{-3} ; range 1,000 - 16,000 cells m^{-3}) occurred in winter (Fig. 5). ABDEL RAHMAN (1997), and EL-SEREHY *et al*. (2000) respectively recorded this species at Suez Gulf of Red Sea and Suez Canal.

Pteropoda

Pteropoda were represented mainly by *Limacina inflata*, which made up 10.3% of total zooplankton density. It was highly represented in spring with two peaks of 77,000 and 85,000 ind. m^{-3} at stations III and IV, respectively (Fig. 6). Lowest density was recorded in winter. HUSSEIN (1977; 1997) recorded a remarkable peak of this species in autumn in Mediterranean waters of Egypt, while NOUR EL-DIN (1987), and DORGHAM and HUSSEIN (1997) recorded the peak during summer in east Mediterranean and Doha harbor.

Meroplankton

Meroplankton made up 7.6% of total zooplankton density. The maximum standing crop occurred in spring with a peak of 61,000 ind. m^{-3} at station II (Fig. 6). Mollusca and Polychaeta larvae were the most common among stations and seasons, while others showed sporadic. The distribution of these larvae is shown in Fig. 6.

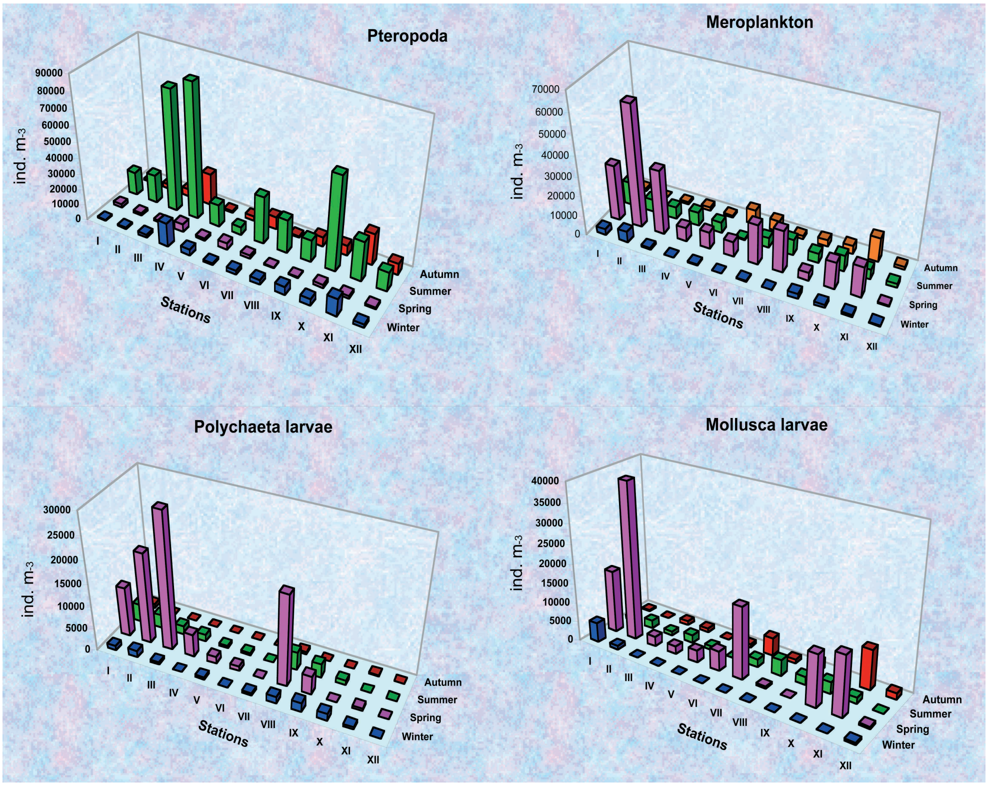

Fig. 6 - Distribution and seasonal variation of Pteropoda and meroplankton (Polychaeta and Mollusca larvae).

Species richness and other diversity indices:

Regarding spatial distribution, the highest species number (40) was found at station II, while station XII had the lowest (20). Stations II and VIII showed the highest evenness (0.67, and 0,67) and diversity (2.47, 0.84 and 2.36, 0.82) (Table 3).

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Species	31	40	29	36	27	26	31	33	31	29	30	20
Richness	2.60	3.35	2.44	3.00	2.28	2.22	2.57	2.72	2.59	2.37	2.48	1.70
Evenness	0.55	0.67	0.60	0.56	0.49	0.41	0.47	0.67	0.50	0.57	0.51	0.45
Shannon diversity	1.90	2.47	2.01	2.01	1.60	1.33	1.62	2.36	1.72	1.92	1.72	1.35
Simpson diversity	0.66	0.84	0.78	0.76	0.60	0.49	0.61	0.82	0.64	0.72	0.67	0.55

Table 3 - Diversity measures of the zooplankton (spatial distribution).

Station VI sustained the lowest evenness (0.41), and diversity values (1.33, and 0.49). Cluster analysis of zooplankton measures revealed three groups of stations: II, VIII; V, VI, XII and the others. The highest similarity (80.1) occurred between station IX and station X within the third group (Fig. 7). On a seasonal basis, spring maintained the highest species number (42), while autumn had the lowest (31).

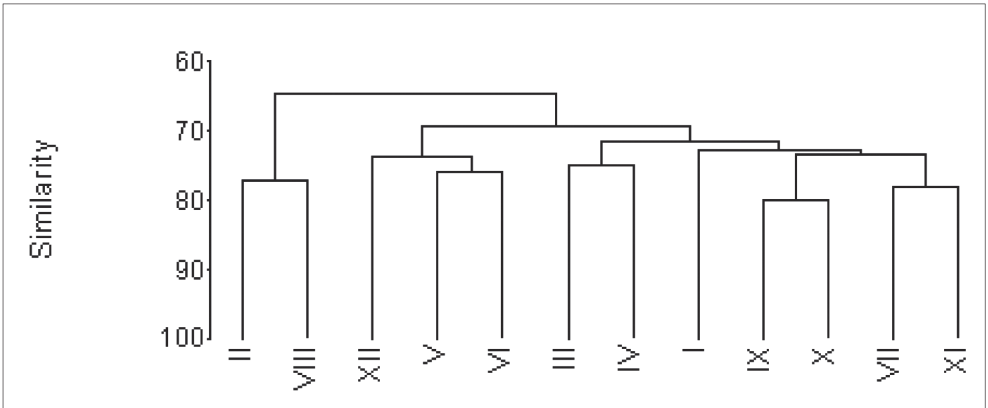

Fig. 7 - Clustering of the Bardawil Lagoon stations according to their zooplankton fauna.

The highest evenness (0.7) and diversity (2.6, and 0.86) were recorded in winter, while the lowest (0.47; 1.73 and 0.69) occurred in summer (Table 4). Canonical correspondence analysis was used to summarized the relationships between the most common zooplankton groups or species (Fig. 8, A and B) and environmental variables. CCA revealed that salinity, water temperature and ammonium were the most important factors affecting zooplankton structure in Bardawil Lagoon. The ordination by dominant groups shows a negative correlation between Rotifera, Protozoa and water temperature, ammonia & salinity. Pteropoda were highly

	Winter	Spring	Summer	Autumn
Species	**41**	**42**	**37**	**31**
Richness	**3.65**	**3.47**	**3.30**	**2.78**
Evenness	**0.70**	**0.47**	**0.47**	**0.55**
Shannon diversity index	**2.60**	**1.74**	**1.73**	**1.89**
Simpson diversity index	**0.86**	**0.62**	**0.69**	**0.73**

Table 4 - Diversity measures of the zooplankton (seasonal).

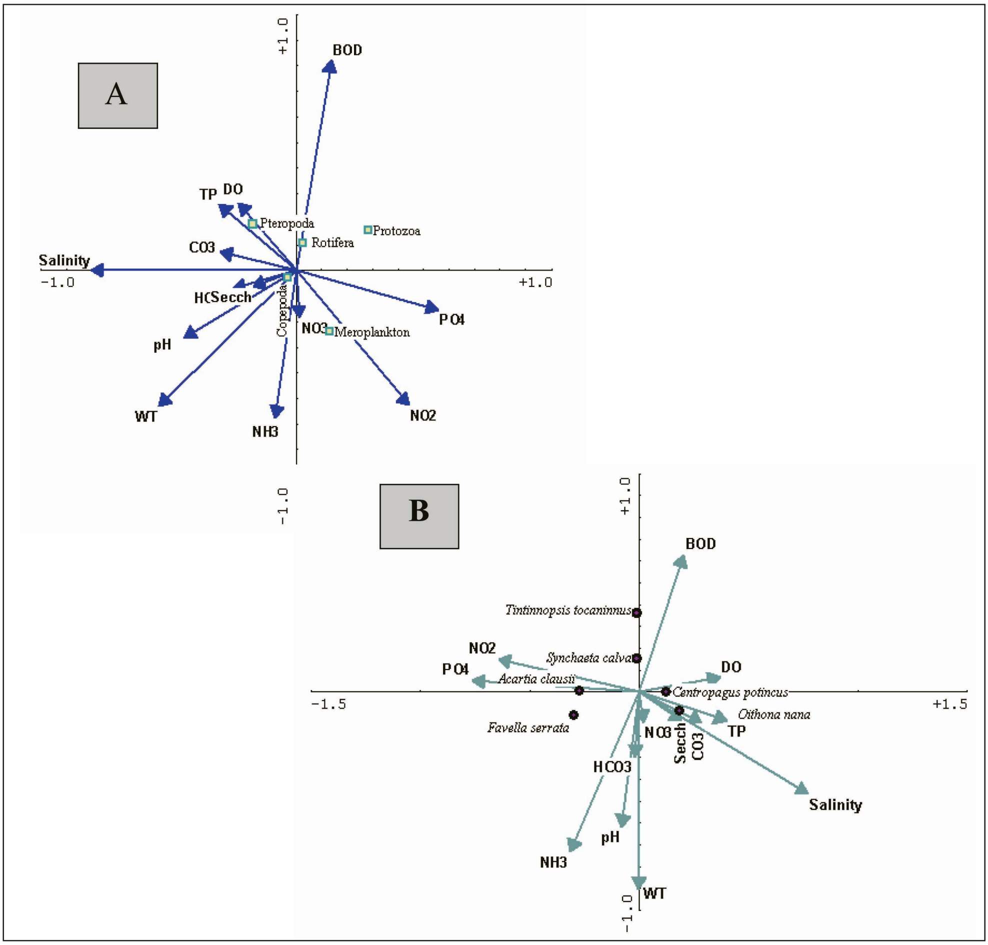

Fig. 8 - CCA ordination plot of axis I and axis II relating variations in the distribution of zooplankton groups or species to environmental variables. The joint plot of groups A (quadrate) and species B (circle), and the environmental arrows is a biplot that approximate the weighted average of each group or species with respect to each of the environmental variables. The abbreviations used for Physical &chemical variables are: WT = Water temperature, NH3 = Ammonium, HCO3 = Bicarbonate, CO3 = Carbonate, Secch = Secchi-depth, NO3= Nitrate, NO2 = Nitrite, DO = Dissolved Oxygen, BOD = Biological Oxygen Deman, PO4= Orthophosphate and TP = Total phosphorus.

associated with total phosphorus and dissolves oxygen, while Copepoda can withstand all of a biotic variables. The ordination by dominant species was more informative. *Tintinnopsis tocantinensis*, *Synchaeta calva*, *Acartia clausi* and *Favella serrata* were negatively correlated with most of abiotic factors (salinity, water temperature, ammonia and biological oxygen demand, in particular). *Oithona nana* and *Centropages ponticus* were highly associated with salinity and dissolved oxygen, respectively.

In conditions of increasing eutrophication, the number of zooplankton species gradually decreased and generally the faunistic assemblage is simplified (SIOKOU-FRANGOU *et al.*, 1998). The low species richness under eutrophication conditions and the abundance of few species in a particular biotope result from their tolerance of the environmental variability and their capability for optimum exploitation of food resources. This variable tolerance results from special physiological adaptations of the organisms (GAUDY, 1984). There is an obvious increase in nitrate and soluble phosphate from 0.04 - 0.16 mg/l and 0.009 - 0.42 mg/l in 1988 (SILIEM, 1989) to 1.1 - 5.8 mg/l and 0.02 - 0.89 mg/l in 1999 (ANONYMOUS, 2000). Progressive increase in nutrient salts proved to be inversely correlated with zooplankton diversity and may led to changes within zooplankton community structure. The dominant species in 1985 (*Tintinnopsis lobiancoi* and *Acartia clausi* were replaced by *Tintinnopsis tocantinensis* and *Oithona nana*. The first two species are quit bigger than the second this may indicate stressed situation and /or confined water. Moreover, 21 zooplankton species were found for the first time in the lagoon. Few zooplankters occurred all over the whole area of the lagoon, such as *Oithona nana*, *Centropages ponticus* and *Euterpina acutifrons* (Copepoda) and *Tintinnopsis tocantinensis* (Protozoa) as well as *Limacina inflata* (Pteropdoda), while others were highly confined to restricted areas.

The total mullet catchs showed general negative trends in spite of general increase in fishing effort. The total mullet catchs reached 1,011 tons in 1994 contributing 67.3% of total lagoon production. The percentage gradually decreased to 43.9% in 1995 and 32.9% in 1999. The production of the most economic important fish species (*Sparus aurata*) sharply decreased from 1,105 ton in 1962-1966 to 252 and 223 tons during 2000 and 2001, respectively (EL-GANAINY and YASSIEN, 2002). The changes in zooplankton community structure may be one of main reasons.

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