ROTIFERS AS INDICATORS OF LAND-BASED EFFLUENTS IN THE MEDITERRANEAN COASTAL WATERS OF EGYPT.

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ABSTRACT

The species composition, abundance, and distribution of rotifers were sudied in several parts along the Egyptian Mediterranean coast, particularly those exposed to variable sorts of discharged inland waters. These areas include from east to west the swash zone between El-Maadiya City and Rosetta mouth of the River Nile, Boughaz El-Maadiya, Abu Qir Bay, and both Western and Dekhaila Harbours of Alexandria.

The results were discussed in relation to water circulation patterns in the areas of study. Significant regional variations were recorded in the species composition and density of the rotifer community, as well as their role in the total zooplankton. The distribution of rotifer species appeared to be tightly related to the variability in volume and dispersion of the discharged waters. Several species of fresh and low brackish water origins were found at high salinity (up to 39.2%^{0}), referring them as hydrological or ecological indicators.

Each of the studied areas was characterized by its own dominant species, but some of these species were observed as dominant in the whole region. Rotifers in the study region were most productive during the warm period from late spring to early autumn.

INTRODUCTION

Rotifers are usually of the main components of freshwater zooplankton (Hutchinson, 1967), but they occur frequently in the coastal seawater, particularly those exposed to land based effluents. The distribution of rotifers in the coastal seawaters reflects the extension of these effluents in the sea, and the existing species may serve as hydrological indicators. The Egyptian coasts of the Mediterranean sea receive fresh and brackish waters from both Nile branches (Rosetta and Damietta) and all the coastal lagoons (Mariut, Edku, Borollus and Manzalah). These waters are mostly loaded by variable quantities and qualities of agricultural, domestic and/or industrial wastes, and could be considered as the main sources of rotifers to the coastal seawater.

The species composition, abundance and ecology of rotifers were studied in different areas of the Egyptian Mediterranean coasts (Zaghloul,1976; El-Zawawy, 1980; Helal, 1981; Gharib, 1983; Aboul-Ezz *et al.*, 1990; Aboul-Ezz, 1994; Hussein, 1997a,b; Abdel-Aziz, 1997, 2000a,b & 2001; Gharib and Soliman, 1998; Soliman and Gharib, 1998). Many of these studies were based on one or two sampled stations in nearshore areas, and involved little information about rotifers.

The objective of the present paper is to study the community structure, abundance and role of rotifers in several parts along the Egyptian Mediterranean coast and their distribution relative to the water circulation and volume of the discharged inland waters based on samples collected monthly throughout a complete year. It is also aimed to assign the rotifer species which could serve as hydrological indicators in the coastal waters.

MATERIAL AND METHODS

Zooplankton samples were collected weekly from the area of Boughaz El- Maadiya(April-October 1997), monthly from Abu Qir Bay and Dekhaila Harbour (April 1998-March 1999), the Western Harbour (April 1999-March 2000) and the swash zone between El-Maadiya City and Rosetta mouth of the River Nile (November 1999-October 2000) (Fig.1).

The collection of samples were carried out by vertical hauls, using a zooplankton net with 55 μm mesh size and 30 cm mouth diameter, from the bottom to the surface or from the upper 10m according to the depth at each station. In the swash zone, the samples were collected by filtering a hundred litres of seawater from the beaches of Maadiya, Edku and Rosetta Cities. The standing crop of rotifers was estimated as ind./m^3

RESULTS AND DISCUSSION

Although they are widely distributed and highly diversified in the Egyptian inland waters (a total of 160 spp.), rotifers are represented by moderately low numbers of species (10- 42 spp.) in the Egyptian Mediterranean coastal waters.

Variations of the environmental conditions (Table 1) in these waters were reflected on the species composition, abundance and biogeographical distribution of rotifers, particularly the wide range of salinity variations, which is mainly caused by the discharged waste waters to each area.

The abundance and distribution of rotifers are affected pronouncedly by water temperature, salinity, and quantitative and qualitative food supply (Schmidt-Araya, 1991). They are the major component of zooplankton, especially in eutrophic waters (Arora, 1966 and Guergues, 1993). The present study revealed that abundance and distribution of rotifers in the coastal seawaters are controlled by salinity variations and abundance of this group in the discharged waters. As shown in Table 2 and Figure 2, Dekhaila Harbour contained the lowest density, while Abu Qir Bay Harboured rotifers about 68 times that in Dekhaila Harbour and 3 times that in the Western Harbour. Such regional differences are related to the volume of the discharged waters and their dispersion pattern in each area.

Abu Qir Bay receives the greatest volume of freshwater from Rosetta branch of the River Nile (up to $2080x10^6$ m^3/month) in winter, Lake Edku through Boughaz El-Maadiya (up to $195x10^6m^3$/month) in summer and mixed industrial, domestic and agricultural waste waters through El-Tabia Pumping station (up to $54x10^6m^3$/month) in summer. This coincides with the high summer stock of rotifers found in the bay during the present study.El-Rayis *et al.* (1993) reported that the dispersion pattern of the freshwater in Abu Qir Bay is governed mainly by the prevailing winds, extending more seawards during the calm season (spring) and the S-SE winds in winter, eastwards in summer due the NW winds and westwards in autumn due to the èffect of N-NE winds. These authors suggest that the water quality at different locations in Abu Qir Bay was subjected to changes from time to time, depending partly and sometimes mainly on the direction of the dispersed freshwater in the bay which was tied with the wind direction.

The swash zone of the southeastern Abu Qir Bay is affected by freshwater from Lake Edku at the west and the Nile Rosetta Branch at the east. The effect of both freshwater sources was found to be variable seasonally, since the River Nile is the major source of fresh water to Abu Qir Bay in winter and lake Edku is the major one in summer (El-Gindy *et al.*, 1988). The dispersion of freshwater from both sources in the bay and along the swash zone is governed by the water circulation system, where a nearshore anticlockwise eddy was found near Rosetta headland associated with a long shore current moving from EL-Maadiya outlet to the east (El-Gindy *et al.* 1988). This may explain the high species richness and density of rotifer in Edku and Rosetta beaches than at Maadia, because in Rosetta the rotifer community includes those species entering the area from Rosetta branch and those which may be transferred by long shore current from Lake Edku.

El-Dekhaila Harbour is affected indirectly by the freshwater discharged to Mex Bay through Umum Drain ($198x10^6m^3$/month), but the effect on the Western Harbour comes directly from El-Noubaria Canal ($2.7x10^6m^3$/month) and indirectly from Umum Drain. The water circulation in the western Harbour is governed by a surface inward current (0-5 m) and a subsurface (5-10 m) outward current. The direction of both currents varied seasonally (Farag, 1982) causing the exchange of the whole water of the Harbour with the open sea in Mex Bay (Flushing time) within about 30 days (El-Gindy, 1986 and Hassan and Saad, 1996). This leads to continuous changes in the rotifers assemblages as well as other zooplankters in the Western Harbour.

The present study revealed that seasonal abundance of rotifers in different coastal areas was affected largely by their densities in the adjacent freshwater basins. For example the high density of rotifers in Abu Qir Bay was associated with their abundance in Lake Edku (Table 2). Regardless to salinity effect, the warm period (May-August) at a temperature range of 20 -31.5°C was the most productive for rotifers in all the studied waters (Fig. 3). This is contradicted with Guergues (1993), who stated that rotifers increase in species richness and abundance in organically polluted and cold waters. The temporal abundance of rotifers in the several Egyptian coastal waters showed peaks in different seasons (Table 3). Such patterns may be referred to species composition and thermal affinity of the existing species.

Similar to other planktonic groups, the bulk of rotifers was always caused by few species, with more or less different dominance patterns in the different areas. As shown in Table 2 and Figures 4-6, *Brachionus calyciflorus* was the predominant species in Boughaz El-Maadiya followed by *B.* plicatilis, B. *angularis* and *Polyarthra vulgaris*. In Abu Qir Bay, the dominant species were *Synchaeta okai* and *S. pectinata*, while in the Western Harbour and Swash zone, *S. okai* was the dominant one. It is to be noted that all the recorded species in the coastal waters are fresh or brackish water forms except *S. grimpei, S. vorex* and *Trichocerca marina* which exist in both brackish and sea waters, confirming the effect of freshwater effluents on the structure and abundance of rotifers in the coastal areas.

The effect of waste waters on rotifer community was also observed in the offshore waters. Hussein (1997b) recorded three species off Alexandria coast, namely *Brachionus calyciflorus, B. angularis* and *Synchaeta oblonga*. During the present study, several species were found in Abu Qir Bay at relatively large distance from the shore, some of which sustained relatively high count such as *S. okai, S. pectinata* and *S. grimpei.*

The existance of several rotifer species at salinity up to 39.2%° indicates that they could be considered as indicators of the freshwater dispersion in the sea, or hydrological indicators. In Abu Qir Bay, the indicator species were *Anuraeopsis fissa, Ascomorpha saltans, Asplenchna priodonta, B. angularis, B. calyciflorus, B. plicatilis, Colurella adriatica, Keratella cochlearis, K. hiemalis, K. quadrata, P. vulgaris, S. okai, S. pectinata, T. cylindrica, Tripleuchlanis plicata*. Nearby El-Tabia Pumping Station, four species were considered as industrial-domestic indicators, namely *Eothinia elongatus, Lepadella patella, S. tremula, Wigrella* sp. In Mex Bay, there were 6 hydrological rotifer indicators, including *Asplenchna priodonta, B. plicatilis, Colurella adriatica, K. cochlearis, S. oblonga, T. cylindrica*. On the other hand, three marine species were also found to reflect the flux of the offshore water to the coastal areas, comprising *S. grimpei. S. vorex and T. marina.*

Variability of the water quality in the coastal waters is a chracteristic feature, resulting from the received variably qualitative and quantitative discharged inland waters. On the long term, these variations were reflected on the abundance and composition of zooplankton in general and rotifers in particular (Table 3). In the Eastern Harbour of Alexandria, rotifers formed 9 % of the total zooplankton in 1976-77 against 37.1% in 1986-87. In Mex Bay, several water masses were distinguished in 1995, with markedly different densities of rotifers, constituting totally 79.9 % of zooplankton, while in 1996, they formed only 11% of the Bay zooplankton. The present study revealed abnormally small contribution in Dekhaila Harbour and in the Western Harbour, (0.5% and 7.2% respectively).

The ecological studies of rotifers in different world regions indicated that some rotifers have the ability to exist in polluted waters and are considered as pollution indicators, like *Brachionus* spp., *Polyarthra* spp., *Monostyla* spp. (Klimowicz, 1961), or serve as indicators of trophic nature of environment (Arora, 1966). The presence of *Brachionus* spp., *Keratella cochlearis* and *Filinia* spp. in any water body is an indicator of eutrophy (Pejler, 1957), while *Anuraeopsis fissa, Cephalodella gibba* and *Filinia longiseta* were considered among pollution indicators (EL-Bassat, 1995). All the species mentioned above were found in the Egyptian coastal waters during the present study, which are classified as highly eutrophic and polluted waters.

In conclusion, the abundance and distribution of rotifers in the coastal sea waters are related to the salinity variations and the abundance of this group in the discharged waters, as well as other ecological conditions like water temperature, transparency, dissolved oxygen and the phytoplankton stock. This was reflected on the contribution of rotifers in the total zooplankton in each area. The water circulation pattern in each area played significant role in the extension of rotifers seawards, which was clearly observed in the variation of the indicator species found in the different areas.

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Table 1. Ecological conditions surrounding rotifers in different Egyptian coastal areas .

	D.H.	W.H.	AQ	M.D.	S.Z.
Temp.	15 - 29	15 - 28	17 - 31.5	19.5 - 27	15 - 33
Secchi disc (cm)	45 - 270	30 - 300	64 - 280	40 - 100	
Salinity	17.3 - 39.2	26.3 - 40.7	24.8 - 37.9	0.9 - 35.7	30.7-36.5
Dissolved oxygen(mg/l)	1.9 - 8.3	0.9 - 9.6	2.0 - 6.8	1.9 - 5.9	
Chlorophyll-a (mg/m^3)	2.5 - 1324	1.9 -219.4	2.1 - 52.6	10.8 -124.7	1.5-116.8
No. of rotifer species	10	11	20	42	12
Total rotifers (ind./m^3)	104	1929	6936	41334	4625
Total zoopl. (ind./m^3)	22640	26728	90083	86473	33927

D.H.= Dekhaila Harbour, W.H.= Western Harbour, AQ. = Southwestern Abu Qir Bay, M.D.= Boughaz EL-Maadiya, S.Z.= Swash Zone of southeastern Abu Qir Bay.

Table 2- Total average count of Rotifers (ind./m^3) in different coastal sea waters from Rosetta to Dekhaila.

	D.H	W.H	AQ	MD	SZ
Anuraeopsis fissa	0	0	4	313	6
Ascomorpha saltans	0	23	0	6	6
Asplenchna priodonta	0.1	0.6	103	1334	111
Brachionus angularis	0.5	0	8	2710	22
B. bidentata	0	0	0	4	0
B. budapestinensis	1.1	0	0	180	0
B. calyciflorus	0.2	0	2	22227	0
B. falcatus	0	0	0	3	0
B. plicatilis	5	3	1	6308	161
B. quadridentata	0	0	0	0.3	0
B. urceolaris	0	0	0	1045	0
Cephalodella gibba	0	0	0	30	0
C. megallocephala	0	0	0	74	0
Chromogaster sp.	0	0	0	1	0
Colurella adriatica	1	1	0.1	16	0
C. obtusa	0	0	0	4	0
Conchilus sp.	0	0	0	0.1	0
Dipleuchlanis sp.	0	0	0	3	0
Eothinia elongatus	0	0	0.1	0	0
Filinia longiseta	0	0	0	209	0
F. opoliensis	0	0	0	11	0
Harringia rousseleti	0	0	0	8	0
Kellicottia longispina	0	0	0	1	0
Keratella cochlearis	0.1	0.1	7	9	6
K. hiemalis	0	0	17	0	67
K. quadrata	0	0.1	0.2	17	0
K. valga	0	0	0	16	6
Lecane depressa	0	0	0	2	0
L. luna	0	0	0	5	0
L. ohioensis	0	0	0	3	0
Lepadella ovalis	0	0	0	3	0
Lepadella patella	0	0	0.8	0	0
Monostyla bulla	0	0	0	16	0
M. closterocera	0	0	0	3	0
M. lunaris	0	0	0	2	0
M. quadridentata	0	0	0	30	0
Polyarthra vulgaris	0	0	2	2392	0
Rotaria neptunia	0	0	0	0.1	0
Scaridium sp.	0	0	0	0.1	0
Synchaeta grimpei	0	110	738	0	167
S. oblonga	14	277	0	59	0
S. okai	0	1317	4214	193	3170
S. pectinata	0	180	1215	1834	56
S. tremula	0	0	460	0	0
S. vorex	82	0	3.3	0	0
Trichocerca cylindrica	0.2	17	0	25	877
Trichocerca marina	0	0	160	0	0
Trichotria tetractis	0	0	0	180	0
Tripleuchlanis plicata	0	0	0.2	58	0
Wigrella sp.	0	0	0.1	0	0
Total average	104	1929	6936	41335	4625

Table 3 - Contribution of rotifers (%) to total zooplankton In different aquatic localities in Egypt.

Locality	Sampling date	%	Sp. No.	Seasonal peaks	Reference
Port Said	1992- 93	14.3	12	winter and summer	Aboul-Ezz, 1994
Rosetta Estuary	1972-73	37.1	11	summer and autumn	Zghloul, 1976
Rosetta Estuary	1987-89	73	28	autumn	Soliman, 1994
Damietta Eastuary	1978-79	67.7	15	spring, summer and autumn	Helal, 1981
Swash zone	1999-2000	13.7	12	spring, summer and autumn	Present study
Boughaz El-Maadiya	1997	47.8	42	spring and summer	Present Study
Abu Qir Bay	1998-1999	7.7	20	spring and summer	Present study
Eastem Harbour	1976-77	9	—	winter and summer	El-Zawawy, 1980
Eastem Harbour	1986-87	37.1	6	winter and summer	Aboul-Ezz et al., 1990
Dekhalla Harbour	1998-99	0.5	10	summer and autumn	Present study
Westem Harbour	1999-2000	7.2	11	summer and autumn	Present study
Alexandria coast	1991	2.7	15	spring and summer	Abdel-Aziz, 1997
Mex Bay	1995	79.9	28	winter and summer	Soliman & Gharib, 1998
Mex Bay	1996	11	11	summer	Hussein, 1997a

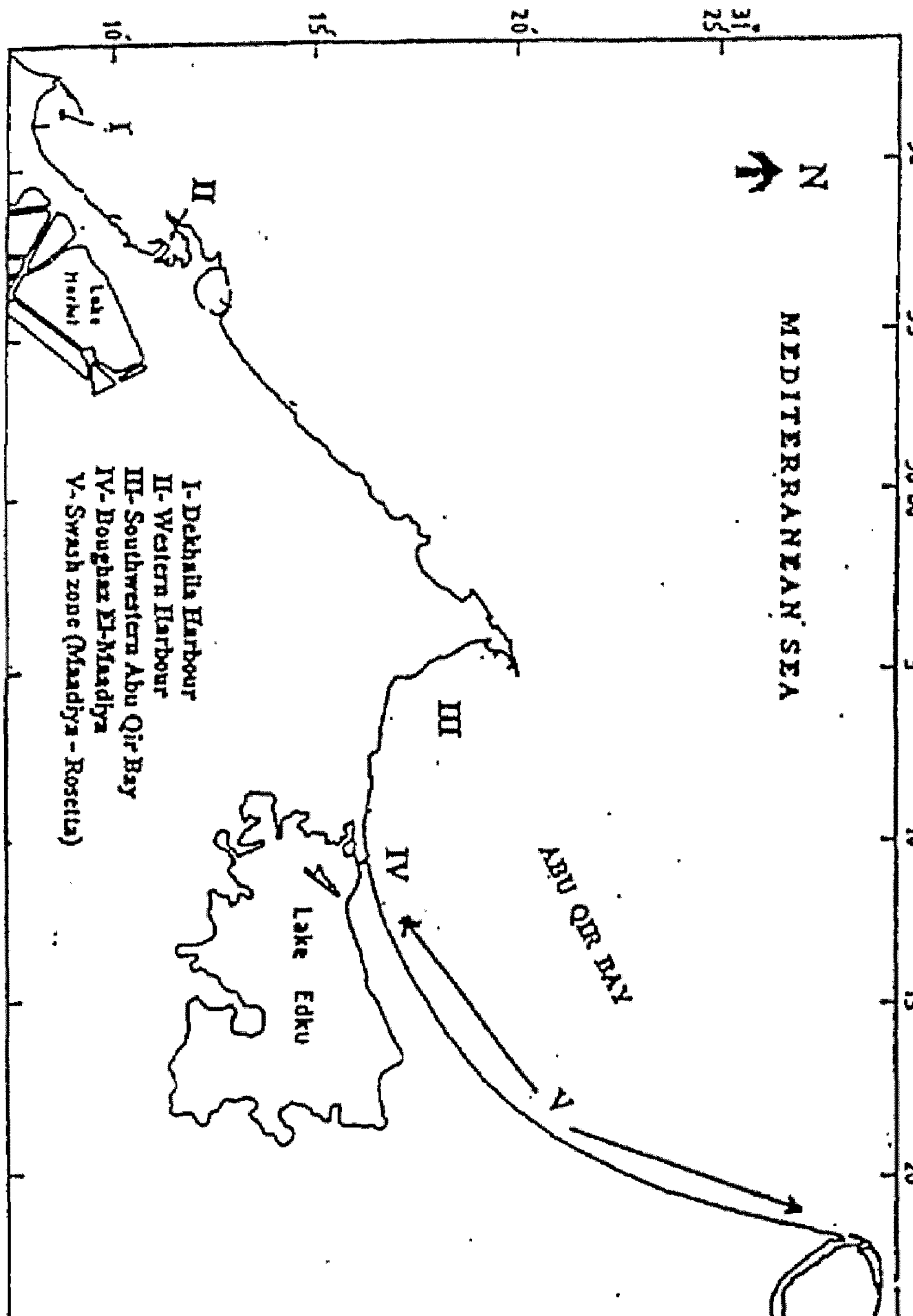

Fig. 1- The investigated area including the studied sites.

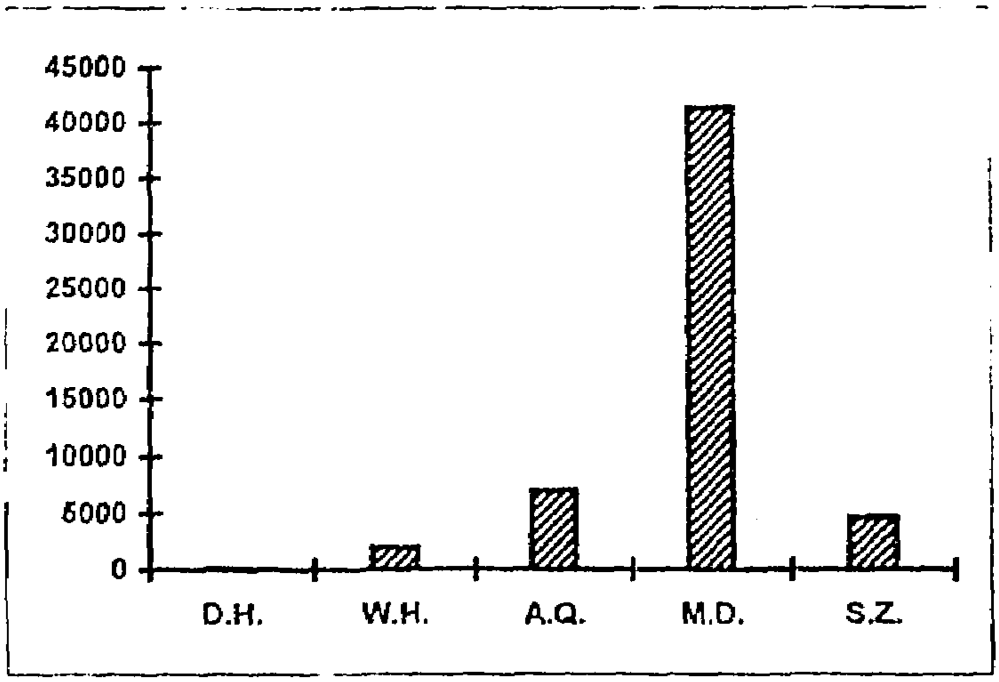

Fig. 2- Average abundance of rotifers (ind./m^3) in the study areas.

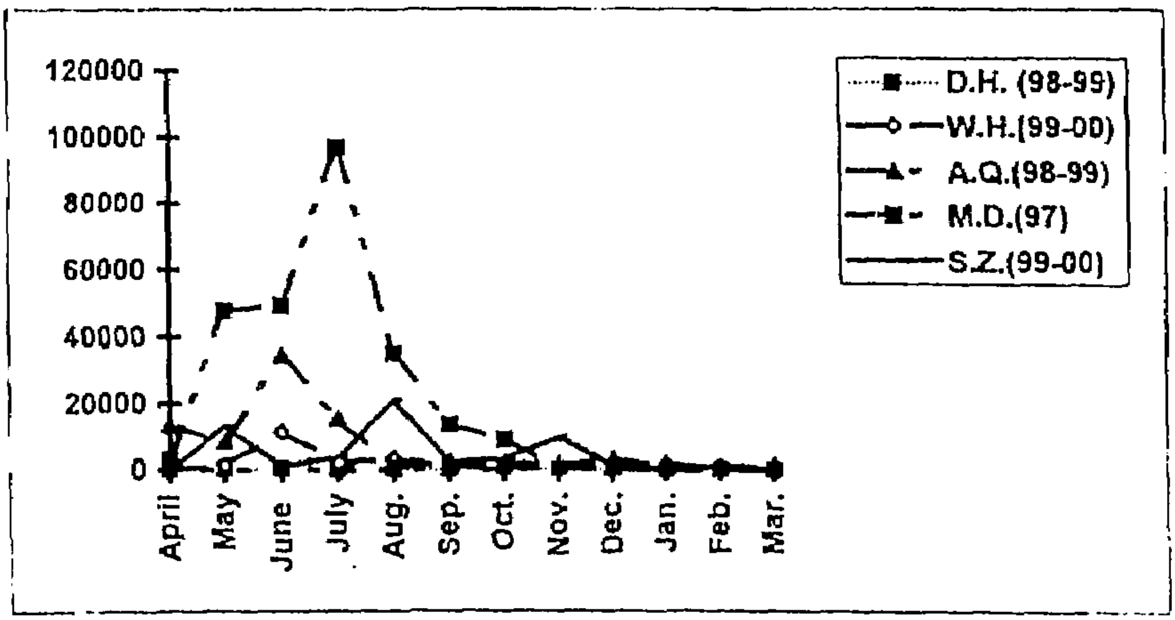

Fig. 3 -Monthly abundance of rotifers (ind./m^3) in different areas.

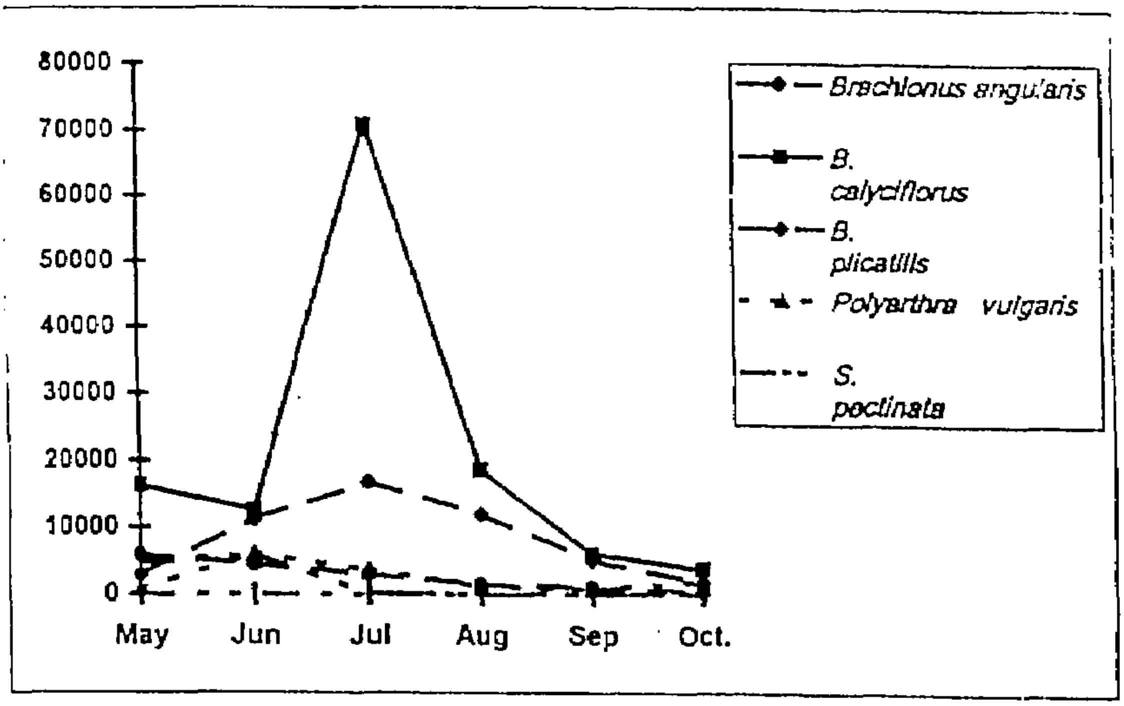

Fig.4- Monthly abundance (ind./m^3) of dominant rotifers in Boughaz El-Maadiya.

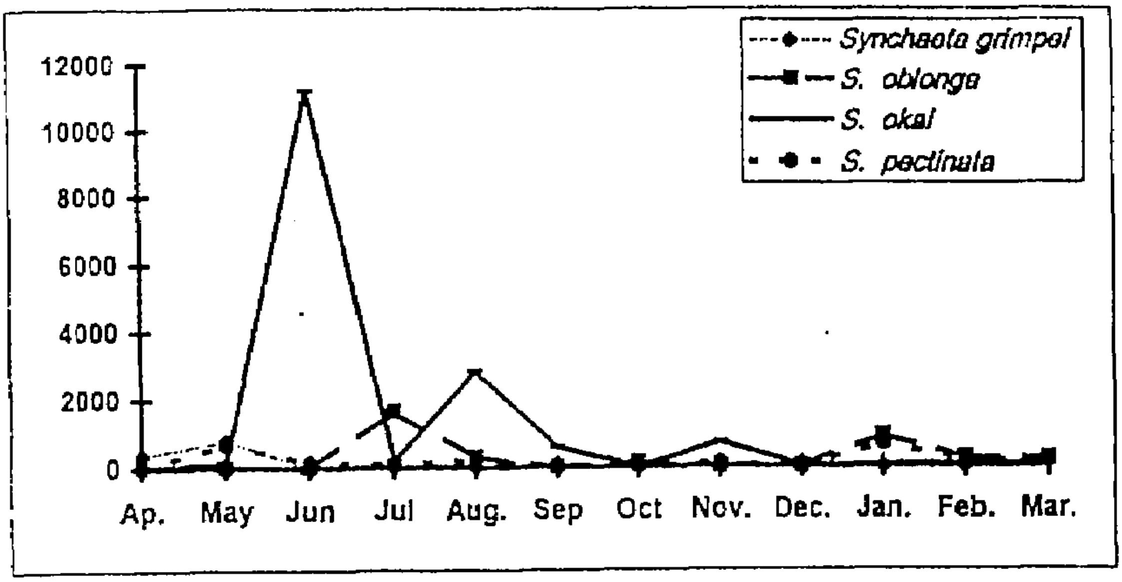

Fig. 5- Monthly abundance (ind./m^3) of dominant rotifers in Abu Qir Bay.

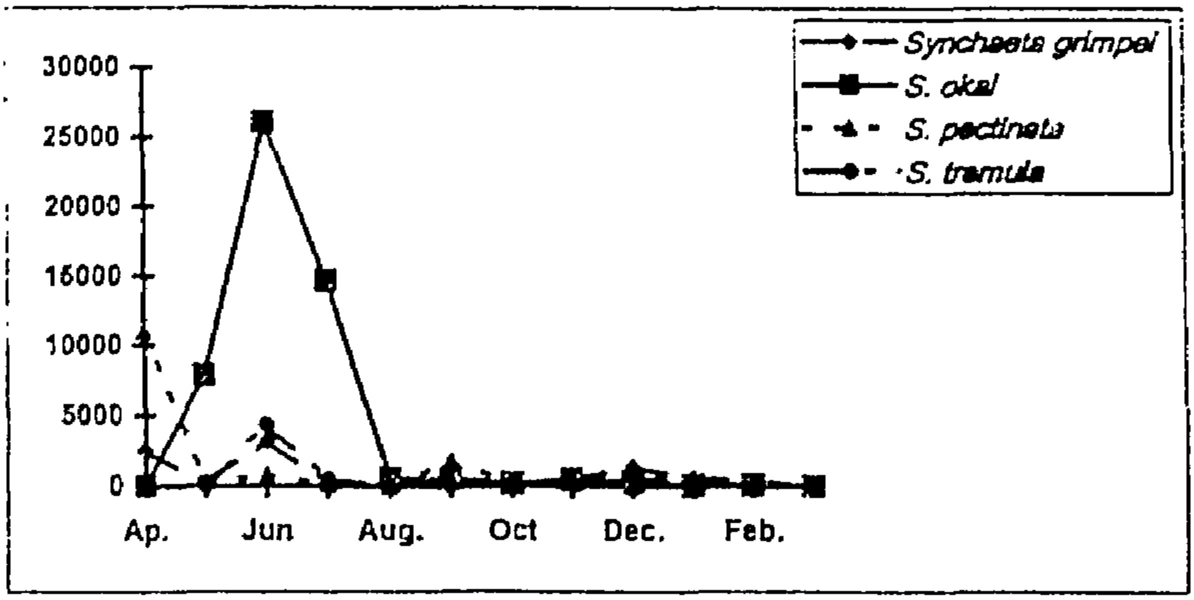

Fig. 6- Monthly abundance (ind./m^3) of dominant rotifers in the Western Harbour.