EGYPTIAN JOURNAL OF AQUATIC RESEARCH 1687-4285
VOL. 31 NO. 2, 2005: 239-252

ZOOPLANKTON STRUCTURE IN LAKE EDKU AND ADJACENT WATERS (EGYPT)

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Keyword: Zooplankton, Lake Edku, diversity.

ABSTRACT

Zooplankton community structure and its diversity index in relation to the most important hydrographic conditions at Lake Edku, Sea, Boughaz and Drains were investigated during the period from June 1995 to April 1996. Results showed that a total of 80 species were identified comprising 26 Rotifera, 23 Protozoa, 16 Copepoda, 4 Cladocera, 4 Ostracoda, free living nematodes, meroplanktonic larvae of Cirripeds, insects, Polychaetes , decapods and veliger of molluscs. Protozoa was the most important group in Sea sector mainly represented by *Favella serrata*. Rotifera was the predominant group at the other three sectors where *Brachionus calyciflorus*, *B. plicatilis* and *B. angularis* were common. The zooplankton density showed a remarkable increase as compared with the previous records and the study indicates high level of eutrophication in lake sector. The diversity index showed wide variations at the different sectors. The highest diversity was at Boughaz and the lowest at lake sectors analogous to the number of species. A series of stepwise regression equations describing the dependence of zooplankton standing stock, its main groups on changes of the most abiotic prevailing conditions are given and discussed.

INTRODUCTION

Lake Edku is a shallow inland water basin with an average depth of 1m. Limnologically it belonges to the open-Lake system. The western extremity of the lake is directly connected through a short channel, Boughaz El-Maadiya, to Abu Qir Bay which is a semicircular shallow embayment with an average depth of about 10m. This bay receives; considerable amounts of waste waters through El-Tabia pumping station (1850 x 10^3 m^3/day, Shriadah and Tayel, 1992), lake water through Boughaz El-Maadiya and fresh water of the River Nile through the Rosetta branch. The eastern part of the lake receives large quantities of drainage water released from the agricultural land of the Behera province via three main drains.

Several years ago Lake Edku was classified among oligotrophic lakes (Salah 1960, 1961 and Soliman 1983). Recently due to high input of nutrient rich effluents from drains the lake became eutrophic (Abdel-Aziz and Dorgham 1999 and Gharib 1999). This condition was manifested by extensive growth of the macrophyte *Phragmites communis* (L.) and *Typha australis* (Schumt & Thoron).

Nowadays, the Lake Edku map exposed to many changes such as, tourist Edku beach 7 km east of Boughaz El-Maadiya had been constructed few years before (Gharib & Soliman 1998) and more than 30% of the lake's area were isolated and converted to fish farms.

Many studies were conducted on the hydrology, chemical and biological characteristics of Lake Edku and Abu Qir Bay (Gharib 1983, Soliman 1983, Gharib and

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Soliman 1998, Gharib 1999 and Siam and Ghobrial 1999).

The principle objective of this study was to follow up the changes occurring in the zooplankton density, species composition and its estimated diversity in Sea, Boughaz, Lake and Drains sectors in relation to environmental conditions.

MATERIAL AND METHODS

The zooplankton samples were collected monthly from June 1995 to April 1996 at selected eight stations, in four sectors; Sea, Boughaz, Lake and Drains (Fig.1). The samples were preserved immediately by 4% neutral formalin solution. The standing stock was estimated from average counts of three 5 ml aliquots and expressed as number of individual per cubic meter. Identification of zooplankton species was done following, Sars (1926), Pennak (1978), Tregouboff & Rose (1957), Edmondson (1959), Berzins (1960) and AL-Hussaini and Demian (1982). The diversity index (H`) was calculated according to Shannon and Weaver (1963). Stepwise multiple regression equation at confidence limit 95% are performed using the statistical computer program (NCSS) by Hintze (1993).

The physical and chemical conditions of the investigated area were described in detail at the same time and stations by Gharib and Soliman (1998).

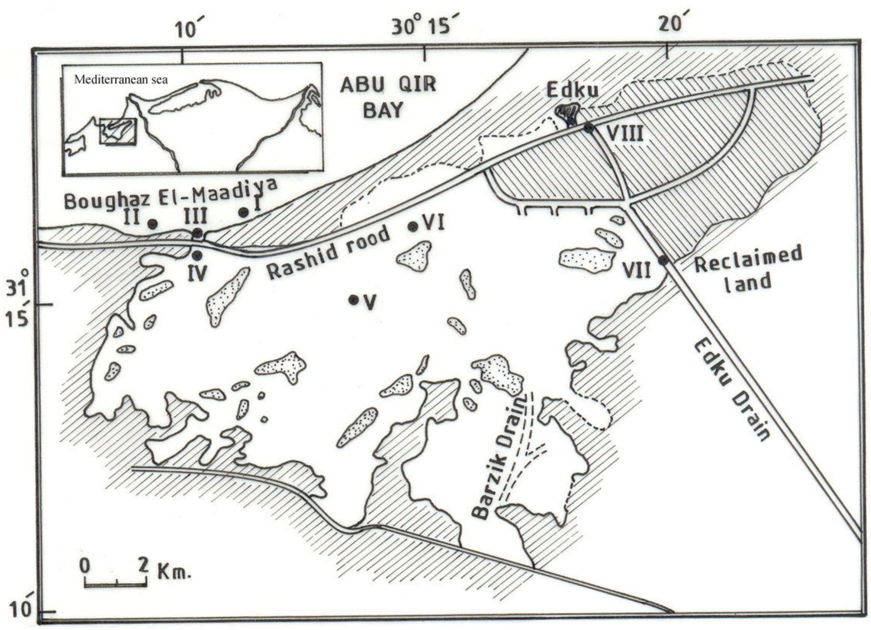

Fig. (1): The location map of sampling stations in Lake Edku.

RESULTS AND DISCUSSION

Species composition

A total of 80 species were recorded in the whole area including in the main groups namely; 26 Rotifera, 23 Protozoa, 16 Copepoda, 4 Cladocera, 4 Ostracoda besides, free living nematodes, meroplanktonic larvae of cirripeds , insects , polychaetes , decapods and veligers of molluscs . The frequency of appearance for different species revealed that 5 species were specific to the sea, 2 to Boughaz, 4 to the lake and 5 to Drains sectors. Otherwise, 15 species (9 rotifers, 3 protozoan, 1 ostracod, polychaete larvae and nematode) were common to the whole area and others were present only in 2 or 3 sectors . The greatest majority of the recorded species (68 species) showed seasonal occurrence. However 6 rotifers, 4 protozoans and 2 copepods were perennial. Among these perennial species, *Globigerina inflata* (16.5%) and *Favella serrata* (21%) were restricted to the sea sector where *Brachinous calyciflorus, B. Plicatilis* and *B. angularis* were common in the other sectors. Also *Centropyxis aculeata* was like wise in Drains (13.2%).

Magnitudes of zooplankton abundance in this study are much higher than that of previous works as mentioned by Gharib (1983) and Soliman (1983) (Table 1). Also, the species composition showed different pattern of dominance. According to Gharib (1983), the protozoan *Acanthocystis* sp. and *Glaucoma scintillans* were dominant in the sea sector, while *Brachionus plicatilis* and *Mesodinium acarus* were dominant in Boughaz sector. In Lake sector, *Monostyla bulla* and *M. closterocerca* dominated the population while, *Vorticella* sp. and *Astramoeba radiosa* were dominant in Drains sector (Soliman 1983). These species were minor constituents or absent in the present study.

Spatial distribution of zooplankton

The average standing stock of zooplankton at the sea sector being 0.17×10^6 organisms m^{-3}, also at Boughaz sector the density approximately attained close average to the sea sector (0.18×10^6 organisms m^{-3}). The zooplankton population increased rapidly towards the lake sector (Fig. 2) with average of 2.7×10^6 organisms m^{-3}, while Drains sector characterized by scarcity of zooplankton (average 0.06×10^6 organisms m^{-3}). The abundance and distribution of zooplankton were clearly affected by the chlorosity of the habitat. Rotifera was the most diversified group at the lake sector represented by 24 species. It comprised the major portion of the total population forming 92.2% to the total counts (Table 1). This percentage decreased to 63.4% at the drains sector (21 species) and 61.57% at Boughaz sector (15 species). At the sea sector, rotifers were minor components (7.92%) with low number of species (8 species) corresponding to the disappearance of several fresh water forms which can not withstand high chlorosity. Rotifera occurred frequently in the coastal waters particularly those exposed to land based effluents and their distribution reflect the dispersion of the fresh water in the sea (Abdel Aziz and Dorgham 2001). Protozoa dominated at the sea sector (60.53% to the total density) particularly at the eastern part. Pierce and Tuner (1992) claimed that protozoan organisms are the dominant component of the microzooplankton in marine waters. The relative importance of Protozoa decreased from Boughaz sector (7%) to the lake sector (0.1%) while at Drains sector reached 20.38% (Table 1). Copepods were frequently recorded at the lake sector constituted 7.18% to the total zooplankton increased towards the Boughaz sector (17.06%) and Drains sector (11.32%). At the sea sector, ostracods were secondary prominent forming 14.17% sharing with Copepoda (11.89%) while at the other sectors ostracods were of minor occurrence.

Table (1): The average number of the different of zooplankton groups, their percentage frequencies during 1976-1977 (Gharib, 1983 and Soliman 1983) and 1995-1996 (the present work) in four sectors.

Years	1976 - 1977								1995 - 1996							
Sector	Sea		Boughaz		Lake		Drains		Sea		Boughaz		Lake		Drains	
Groups	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%	org. m^{-3}	%
Rotifera	1801	2.1	7457	27.49	33997	56.00	8061	33.30	13695	7.92	108800	61.57	2454509	92.14	38236	63.43
Protozoa	53647	61.76	12603	46.48	5850	9.60	12672	52.30	104686	60.53	12409	7.02	2650	0.10	12286	20.38
Copepoda	29616	34.1	6144	22.69	19350	31.90	2730	11.30	20564	11.89	30155	17.06	191332	7.18	6823	11.32
Cladocera	22	0.03	54	0.20	656	1.10	580	2.40	564	0.33	7805	4.42	8327	0.31	1150	1.91
Ostracoda	0	0	0	0.00	0	0.00	0	0.00	24500	14.17	11795	6.67	4386	0.16	941	1.56
Cirripedia	537	0.62	380	1.40	0	0.00	0	0.00	932	0.53	3122	1.77	0	0.00	0	0.00
Nematoda	174	0.15	271	1.00	381	0.60	103	0.40	1577	0.91	1309	0.74	2564	0.10	587	0.97
Other forms	1076	1.29	203	0.74	490	0.80	72	0.30	6423	3.72	1323	0.75	255	0.01	259	0.43
Total	86873	100.05	27112	100.00	60724	100.00	24218	100.00	172941	100.00	176718	100.00	2664023	100.00	60282	100.00

Monthly fluctuations (Figs. 3and 4)

Sea sector

Sea sector was characterized by chlorosity ranged between 6.94 and 21.76 gm Cl l^{-1} while dissolved oxygen, oxidizable organic matter, dissolved phosphate, ammonium and silicate attained low values (Table 2). The zooplankton community comprised fresh, brackish and marine species. The dominant protozoan species, *Favella serrata* was leading in October forming 67.1% to the total density in this month. Bears *et al.* (1980) mentioned that tintinnid constitutes a major fraction of any microzooplankton communities. Protozoan ciliates decreased to the minimum during June may be due to the increase of ammonium concentration as predicted by Mageed *et al.* (2002) during an experiment in the aquatic laboratory. *Globigerina inflata* appeared frequently throughout the sampling period with the dominance during December (37.8%) and April (32.6%). *Ammonia beccarii* appeared all the year round except summer months with a peak in January (41.8%). The ostracod *Conchaecia obtusa* was restricted to the cold period from December to April (temperature ranged between 16 and 23.05^{o}C) with a high percentage of 60% during March (high chlorosity 21.1 gm Cl l^{-1}).

Boughaz sector

This sector was characterized by chlorosity varying from 0.53 to 13.97 gm Cl l^{-1}. A pronounced increase in the standing stock was observed during December. *Brachionus calyciflorus* was the dominant species formed 44% to the total count and it was highly recorded from November to February while completely disappeared during spring months (Fig. 4). It was followed by *B. angularis* which was highly recorded from November to January with the predominance during March (53% of the community). *B. plicatilis* was frequently recorded all the year round. *Keratella valga* appeared once during December with 13.5% of the community. Gharib 1983 declaird that *B. calycilforus* was completely absent at Boughaz during 1976-1977 while Abdel Aziz and Dorgham (2001) recorded that *B. calyciflorus* was the predominant species followed by *B. plicatilis* and *B. angularis* at the same sector during 1997. A greater cumulative dominance of fresh water species indicate that the influence of land drainage water is stronger than marine, this is probably related at least in part to important fresh water input by drains which flows from east to west along the northern lake margin (Loizeau and Stanley 1993; Bernasconi and Stanley 1994). *Favella serrata* was scarcely observed at one month or other except during October it represented 18.2% to the total counts where Rotifera and Copepoda were of minor importance, thus rotifers and copepods had some regularity effect on Protozoa. Arndt (1991) concluded that ciliates were the common part of the food of most rotifer species. Also Ingrid *et al.* (1996) stated that early stages of copepods might compete for food with ciliates, so it decreased ciliates indirectly. *Oithona nana* and *Moina micrura* showed high occurrence between June and September.

Lake sector

The community mainly comprised brackish and fresh water forms. Chlorosity varied within a narrow range (0.21-1.3 gm Cl l^{-1}). The concentrations of oxidizable organic matter and oxygen were relatively high, while those of dissolved inorganic nitrogen were low (Table 2). Rotifera were characterized by multi-dominant species. *Brachionus* species (5 species) were the dominant throughout the year with the dominance of *B. plicatilis* during summer months, *B. argularis* in autumn months and *B. calyciflorus* during other months. *Polyarthra vulgaris* occurred throughout the year with maximum rising during summer months. It was formarly listed as one of the dominant rotifers in Egyptian inland fresh water (Abdel Aziz 1997, Aboul Ezz *et al.*1996, Khalifa 2000 and El-Bassat 2002). *Filinia longiseta* also shared with 23%

to the total count during August. Gannon (1981) indicated that rotifers are more sensetive indicator of water quality because they can rapidly respond to environmental changes caused by higher turnover rates. The presence of *Brachionus* species and *Filinia* species in any water body is an indicator of eutrophy (Pejler 1957), while El-Bassat (1995) considered *F. longiseta* among pollution indicator. Also *Polyarthra vulgaris* is considered a good indicator of eutrophication (Attayed & Bonzlli 1998). Thus, lake sector was classified as highly eutrophic and polluted.

Table (2): Range and mean values of the physico-chemical in the four sectors during 1995-1996 (After Charib and Soliman 1998).

Parameters	Sea		Boughaz		Lake		Drains	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Secchi depth (cm)	12.5-35	29.6	15-50	30.2	10-32.35	25	5-17.20	15
Water temperature (^oC)	16-0.5	23.4	66-29.3	22.4	15.7-29.3	22.8	15-29.5	22.9
pH value	7-8.6	7.85	7.91-8.42	8.05	7.98-8.67	8.32	7.4-8.2	7.68
Chlorosity (gm cl.$^{-1}$)	6.94-21.76	17.31	0.53-13.97	4.3	0.2-1.30	0.96	0.17-0.97	0.52
Oxidizable organic matter	1.68-7.95	3.61	2.13-11.43	5.5	1.96-13.44	9.53	0.95-10.75	4.07
Dissolved oxygen (ml O_2. l^{-1})	0.0-9.6	3.94	1.5-9.5	5.25	4.7-15.7	10.83	0.8-10.5	6.99
Ammonium (μ mol. l^{-1})	0-22.45	6.07	0.0-18.96	6.97	0.0-22.99	7.15	0.0-34.79	9.16
Nitrate (μ mol. l^{-1})	6-28.17	11.16	0.0-47.82	16.44	0.0-41.19	50.2	0.0-58.71	26.16
Nitrite (μ mol. l^{-1})	0.88-51.44	6.91	2.48-28.80	8.45	0.64-8.12	2.13	2.1-23.60	11.94
Phosphate (μ mol. l^{-1})	0.07-2.23	1.29	0.90-8.30	4.78	1-6.65	2.57	0.7-12.24	7.99
Silicate (μ mol. l^{-1})	14.3-107.56	47.92	54.16-159.84	126.15	0.16-146.68	88.1	54.12-159.20	140

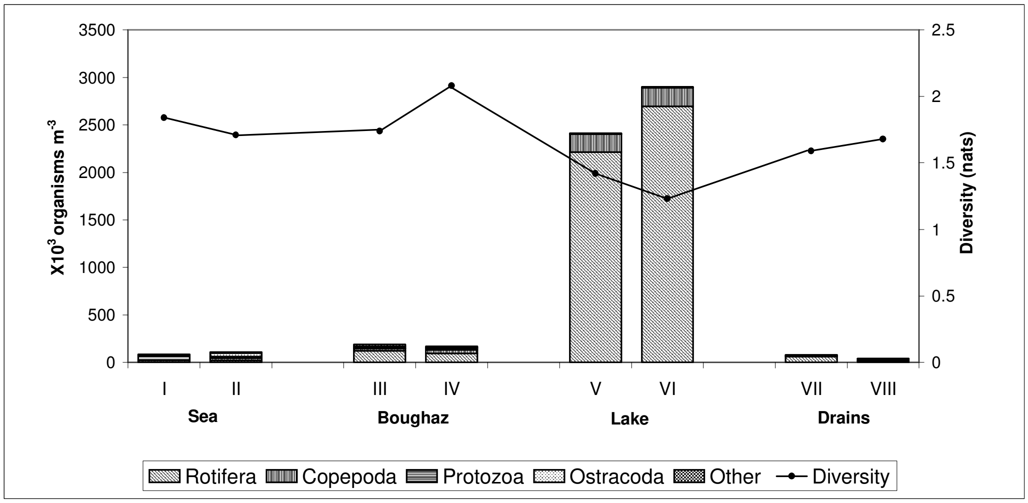

Fig (2): Distribution of zooplankton standing stock, its main components (X10^3 organisms m^{-3}) and diversity values at different stations during 1995-1996.

Drains sector

Drains sector was characterized by low values of chlorosity, dissolved oxygen and oxidizable organic matter (Table 2). The succession of zooplankton in drains showed rapid changes in species composition (Fig. 4). A pronounced increase in the standing stock was recorded during August and December (Fig. 3). The genus *Brachionus* was mainly represented by *B. plicatilis* with dominating in August (55%) and January (25%) while, *B. calyciflorus* was peaked in December (82%). The protozoan *Mesodinium acarcus* was rarely recorded most of the year with outstanding peak during July formed about 41% to the total count.

A series of statistical regression models were calculated describing the dependence of zooplankton standing stock and its main groups on the controlling abiotic factors at the different sectors.

Sea sector:

Total zooplankton=-1072-6942 Transparency + 1698 pH + 8688 OOM + 7955 Ammonium.

Rotifera = -2158 -2077 Temperature + 3766 pH

Protozoa= - 9258 -5291 Transparency + 1135 pH + 1144 Oxidizable organic matter (OOM) + 8188 Ammonium

Boughaz sector

Total zooplankton= 604906 -27706 chlorosity -6474 phosphate.

Rotifera = 12605 +46704 O_2 -1816 chlorosity -7756 Nitrite +5700 phosphate.

Protozoa = 53735 -1231 Transp. -1053 OOM +2601 Nitrate -1018 Nitrite -3013 phosphate.

Lake sector

Total zooplankton = -1449 +1722 Temp. -1760 chlorosity +7425 OOM +3674 Nitrate.

Rotifera= -1817 +1828 Temp. + 33288 Nitrate.

Protozoa= 2653 -435 Ammonium + 4300 silicate.

Drains sector:

Total zooplankton = 11604 +2893 pH -1239 silicate.

Rotifera = 5628 +3295 pH -1339 silicate.

Protozoa had no correlation.

These models are adequate at a significant level 95% ($P \geq .05$). It was cleared that the controlling factors appeared to be more or less different from one sector to another. pH values were effective in sea sector, chlorosity and phosphate in Boughaz sector, temperature in Lake and pH and silicate in Drains. The degree of importance of each parameter included in the model equation to zooplankton standing stock (Eigen values) for the four sectors are shown in figure (5).

Diversity

Generally, diversity has always been used as an index of ecosystem, well beings with species rich communities being healthier than those poor in species numbers (Magurran 1988). The zooplankton community at Boughaz sector was rich is species number (53 species) decreased to 44 species at both Sea and Lake sectors, while Drains had 46 species. The diversity index showed irregular variations throughout the study period at the different sectors (Fig. 3) relative to analogous changes in the number of species.

The average values of the estimated diversity index was high, amounted to 1.91 nats at the Boughaz sector, this may be due to effect of mixing both marine and fresh water species (Margalef 1960). Also Aboul Ezz *et al.* (1995) concluded that high diversity illustrated that a community has higher ability to sustain the relationship between species and resist the change of the community within a certain period. The diversity index decreased to 1.32 nats towards Lake sector, attributed to relatively environmental changes that may be prevent the survival of non-tolerant species. At Sea sector relatively low diversity (1.77 nats) may be due the stress of sewage and industrial wastes from El-Tapia pumping station accompanied with sharp fluctuation in chlorosity. The drains sector attained diversity index 1.63 nats.

A steady state appeared when more than 80% of zooplankton numbers will be shared by no more than three species (Sommer *et al.,* 1993). This clearly appeared at Lake sector lasted approximately during most of the year and rarely observed at the sea and drains sector. A steady state phase was not recorded at the Boughaz sector with high diversity values.

At Sea sector, diversity values ranged between 1.29 to 2.19 nats. It attained its highest values during April (Fig. 3) accompanied with relatively high zooplankton count (0.3×10^6 organisms m^{-1}) as well as many species shared in the community (21 species). This attributed to the dominance of the protozoan species, *Globigerina inflata* (33% to the total density in April). *Cycloforina contorta* (15%), *Ammonia beccarii* and *Favella serrata* (2% for each). The lowest diversity was observed during March (1.29 nats) when the ostracod species peaked (60%). At Boughaz sector, the diversity index falling within the range of 1.5 during July to 2.21 nats during September related to the species number and the population density. The low value in July when the community was dominated by *Moina micrura* (21% to the total counts) and high value in September when the community was composed of a large numbers of species (24 species) with no distinct dominance. At Lake sector, the diversity values ranged from 0.79 to 2.30 nats related to number of species. The lowest value was in December with the absolute dominance of *B. calyciflorus* (85%). The highest value attained in January when rotifer population dominated with multi-dominant species. At Drains sector, the diversity index was widely varied between 0.63 and 2.12 nats. The lowest diversity was in October, with low number of species (6 species) and low density, when *Centropyxis aculeata* peaked (82%). The highest value in January with the dominance of rotifer species and the cladoceran *Bosmina longirostris.*

In conclusion, as a result of the effect of drains water(poor in zooplankton) enriched with agricultural fertilizers in addition to domestic industrial effluents, Lake sector became eutrophic. This reflects more rich in zooplankton standing stock and low diversity values. The invasion of lake water towards the sea insured by the predominant brackish zooplankton species at Bougaz sector. This was companied by certain preference on the dominance of some species considered as indicator of water pollution. It is recommended to control discharge of drainage and sewage water into the lake.

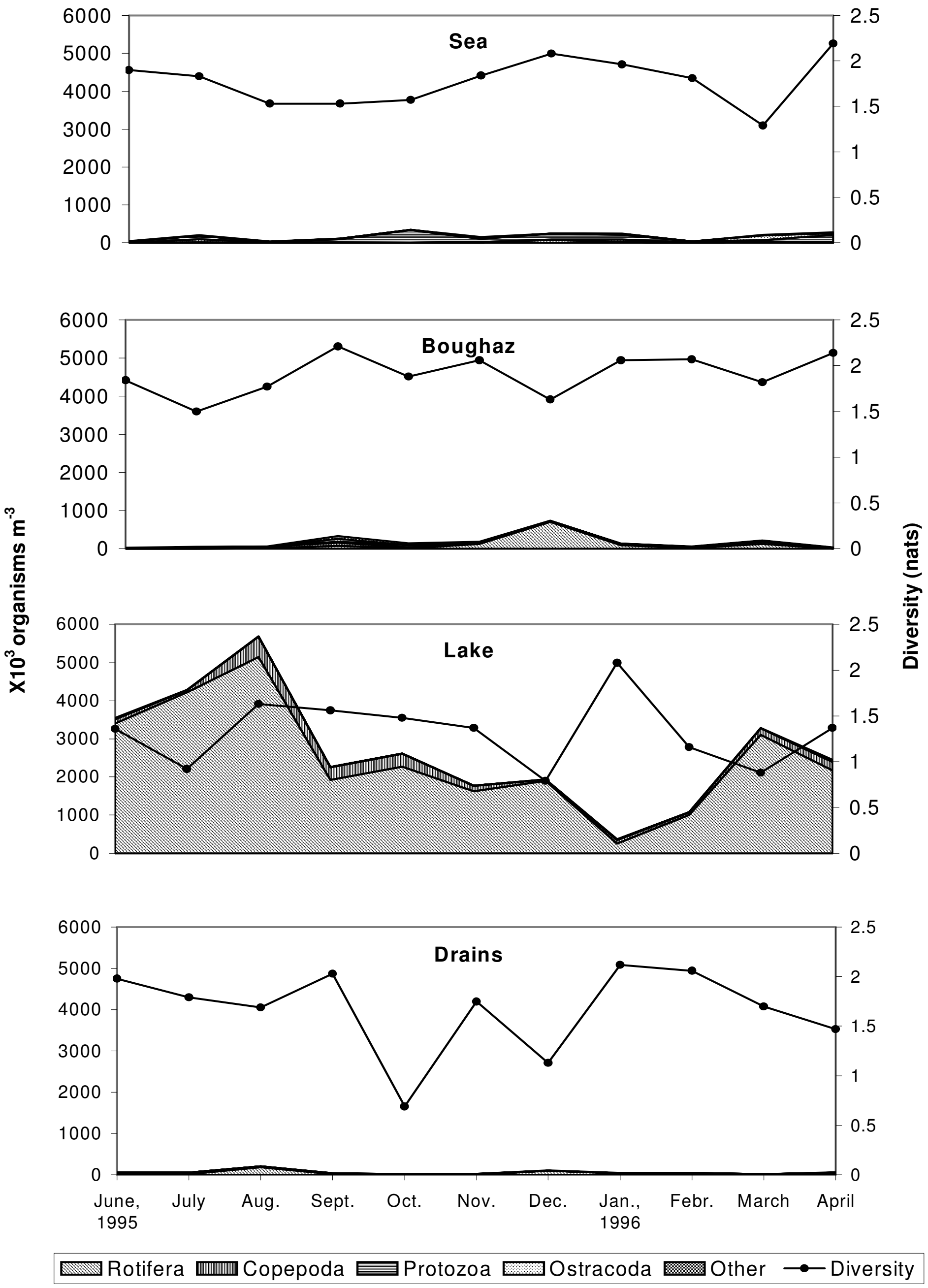

Fig. (3): Monthly variations of zooplankton standing stock, its main components ($X10^3$ organisms m^{-3}) and diversity values at the different sectors during 1995-1996.

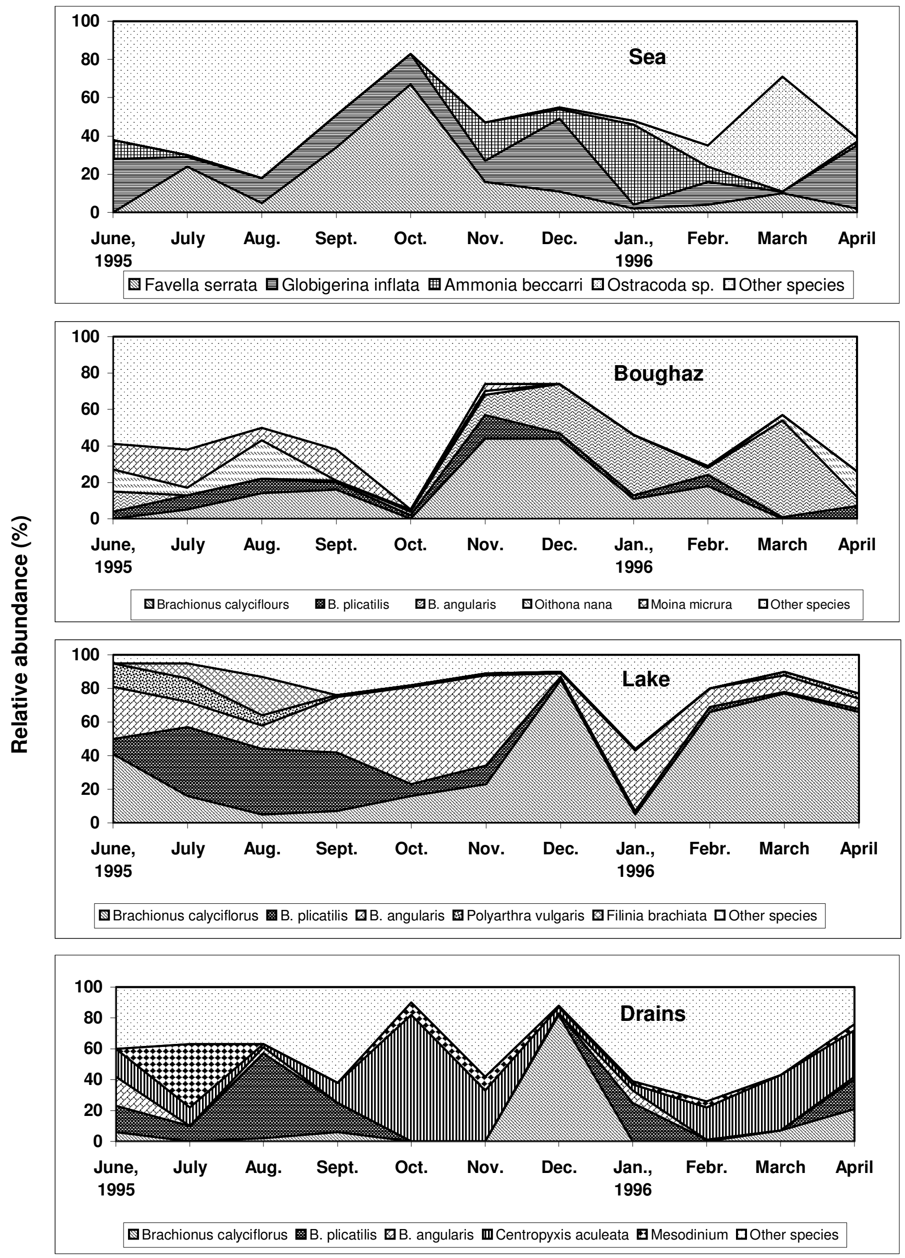

Fig. (4): Monthly variations of relative abundance of the major zooplankton species at the different sectors during 1995-1996.

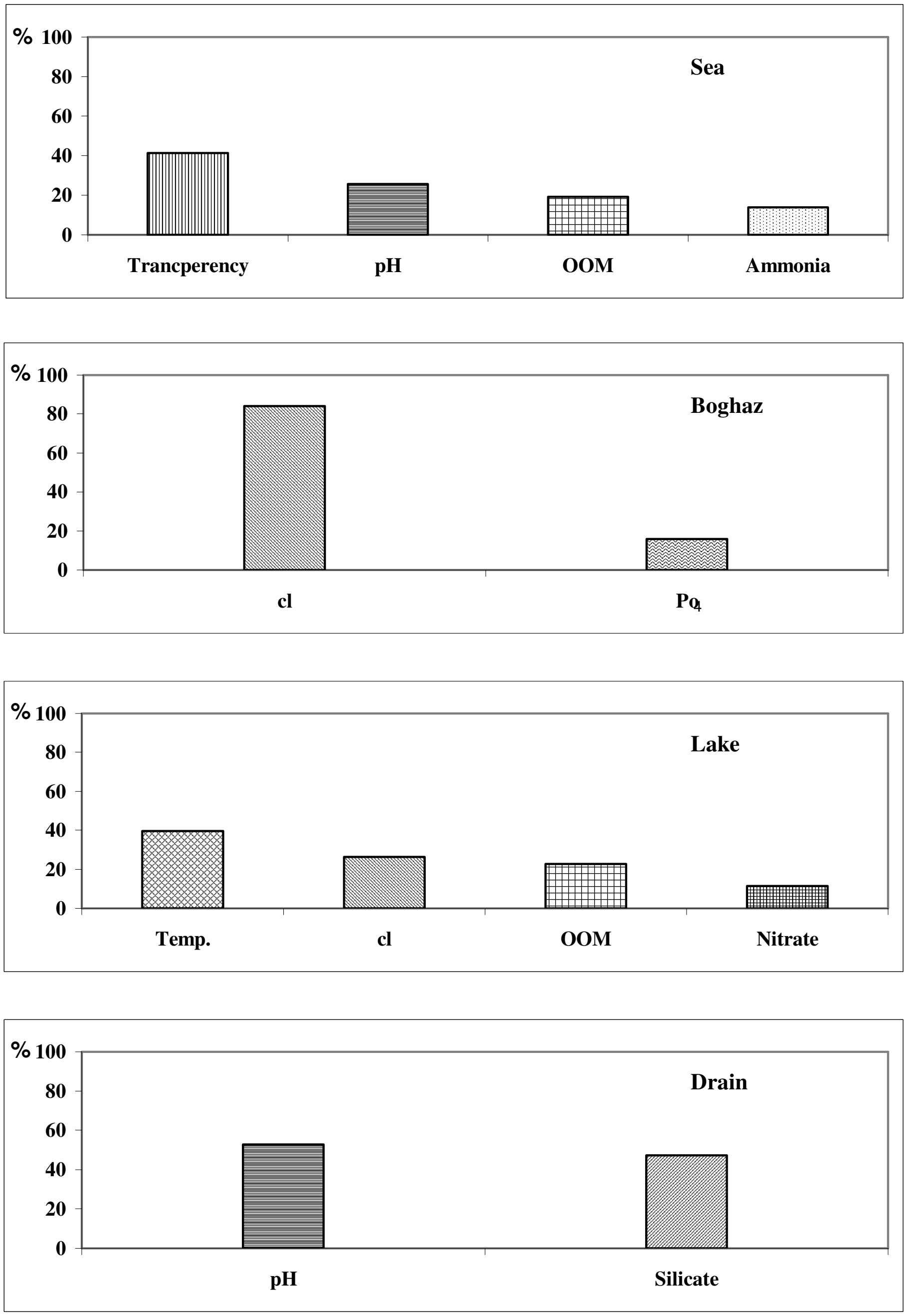

Fig. (5) Eigen values of total zooplankton standing stock at the different sectors.

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