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ZOOPLANKTON COMMUNITY IN LAKE EDKU

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Key words: Zooplankton, Correlation coefficient, and Phytoplankton -zooplankton relationship.

ABSTRACT

Zooplankton community in Lake Edku was studied seasonally during the period February-November 2000. Results showed that five groups dominated the population namely: Protozoa, Rotifera, Copepoda, Ostracoda and Cladocera. Besides, seven groups appeared as rare forms they are Nematoda, Trematoda, Polychaeta, Cirripedia, Decapoda, Amphipoda, Insecta and fish eggs. The counts of the total zooplankton averaged 326 X 10^3 organisms m^3 for the whole period of investigation.

Rotifera contributed more than 76% by number to the total zooplankton community and was dominated by the genus Brachionus which formed the highest counts to the total rotifer. Three species namely: B. calyciflorus, B. angularis and B. urceolaris contributed about 57% to the total rotifer counts. Rotifers represent one of the most important components of the freshwater zooplankton especially in organically polluted (eutrophic) areas and some rotifer species considered as indicator for domestic pollution as well as trematodes and nematodes. Generally, the lake is regarded as polluted habitat. Zooplankton standing stocks in Lake Edku showed remarkable decrease when compared with the previously recorded in 1995-1996. Correlation coefficient between physico-chemical parameters and zooplankton , its main groups and species were considered. Phytoplankton-zooplankton relationships were also discussed

INTRODUCTION

Lake Edku is a shallow brackish coastal lagoon, located in the northwestern part of the Nile Delta, at latitude 31° 10´ and 31° 18´N and longitudes 30° 8´ and 30° 22´ E. It is connected to the Mediterranean sea by a narrow channel (Boughaz El-Maadiya) that opens at its north margin. The lake has an average depth of about 1 meter. It is about 27 Km long with maximum width of 11 Km and the surface area of about 126 km^2 most of it (particularly the eastern side) is densely vegetated.

The lake is subjected to various effluents from agricultural , sewage and Fish farms wastes. Huge amounts of drainage water are discharged from the surrounding cultivated lands of El-Behaira Province through Edku, El-Bousily and Barzik drains which discharge about 83-280X10^3 m^3 /day (Shraidah & Tayel 1992). The first two drains are situated at its northeastern margins. Barzik Drain opens at the southeastern part. The lake also receives seawater at its western part through Boughaz El-Maadiya from Abu-Qir Bay which is a semicircular shallow basin receiving considerable amounts of raw industrial wastes from many factories through El-Tabia pumping station with an average of about 1850X10^3 m^3 /day.

There are signs of the excessive incorporation of sewage wastes in the disposed water as indicated by the presence of high numbers of pathogenic coliform bacteria near the inlets of the drains(El-Shenawy ***et al.***, 2000). The southern part of the lake is characterized by excessive growth of hydrophytes such as *Phragmites communis* (L.), *Typha australis* (Schumt&Thoron). In addition to water Hyacinth, *Potamogeton pectinatus*(L.), *Ceratophyllum demersum*(L.) and *Limnea* sp.(Samaan,1976 & Gharib,1999).

Many studies were carried out on the ecological characteristics of Lake Edku, such as Saad(1970, 1978, 1979, 1988) El-Samra(1973); Kinawy (1974); Zazoau(1977); Mohamed(1981), El-Sabaroti and El-Sokkary (1982); Hemeda(1988);Abdel Moati(1991); El-Sayed ***et al***(1991a & b) and Abbas ***et al***. (in press). El-Shenawy (1994) and El-Shenawy ***et al***. (2000). Zooplankton ecological studies received less attention in Lake Edku , such as Samaan(1976); Gharib(1983); Soliman(1983); Guerguess(1993); Gharib and Soliman (1998); Abdel Aziz and Dorgham(1999) and Abdel Aziz(2000). None of these works

have properly dealt with the zooplankton of the lake. Our knowledge on the magnitude of zooplankton production and variations in the lake; species composition . distribution in time and space of the various groups and species of the zooplankton community and the role of the different zooplankton species in the food chain of the lake are from being satisfactory.

The present study deals with the distribution and community composition of the zooplankton organisms in Lake Edku. Such a study was demand necessary since during the past few decades the area of the lake has been exposed to many environmental hazards mainly due to industrial projects and various tourists resorts that have been developed in its vicinity and which usually lead to environmental and health problems.

The present environmental investigation is a part of the first phase of the research plan of the Fisheries Division of the National Institute of Oceanography and Fisheries. This plan aims to the management and development of fisheries in the northern Delta lakes.

It is a matter of fact that the study of the ecological conditions in these lakes contributes to understand the different factors that affect the feeding, reproduction and survival of various fish species living in these lakes.

MATERIALS AND METHODS

Samples of zooplankton were collected seasonally in February, April, June and November, 2000. A total of ten sampling stations were selected to represent the different habitats in the lake (Fig.1). The zooplankton samples were collected by filtering 50 liters of lake water at each station through a small standard plankton net No.25 (mesh size 30 µm) using a plastic container of ten liters capacity. The collected samples were preserved directly with 4% neutral formalin solution. The volume of each sample was concentrated to 100 ml and sub-samples of 2 ml were transferred into a counting cell and each zoo-plankter was counted separately using a research binocular microscope (150X). The density of zooplankton organisms was calculated as their total number per cubic meter.

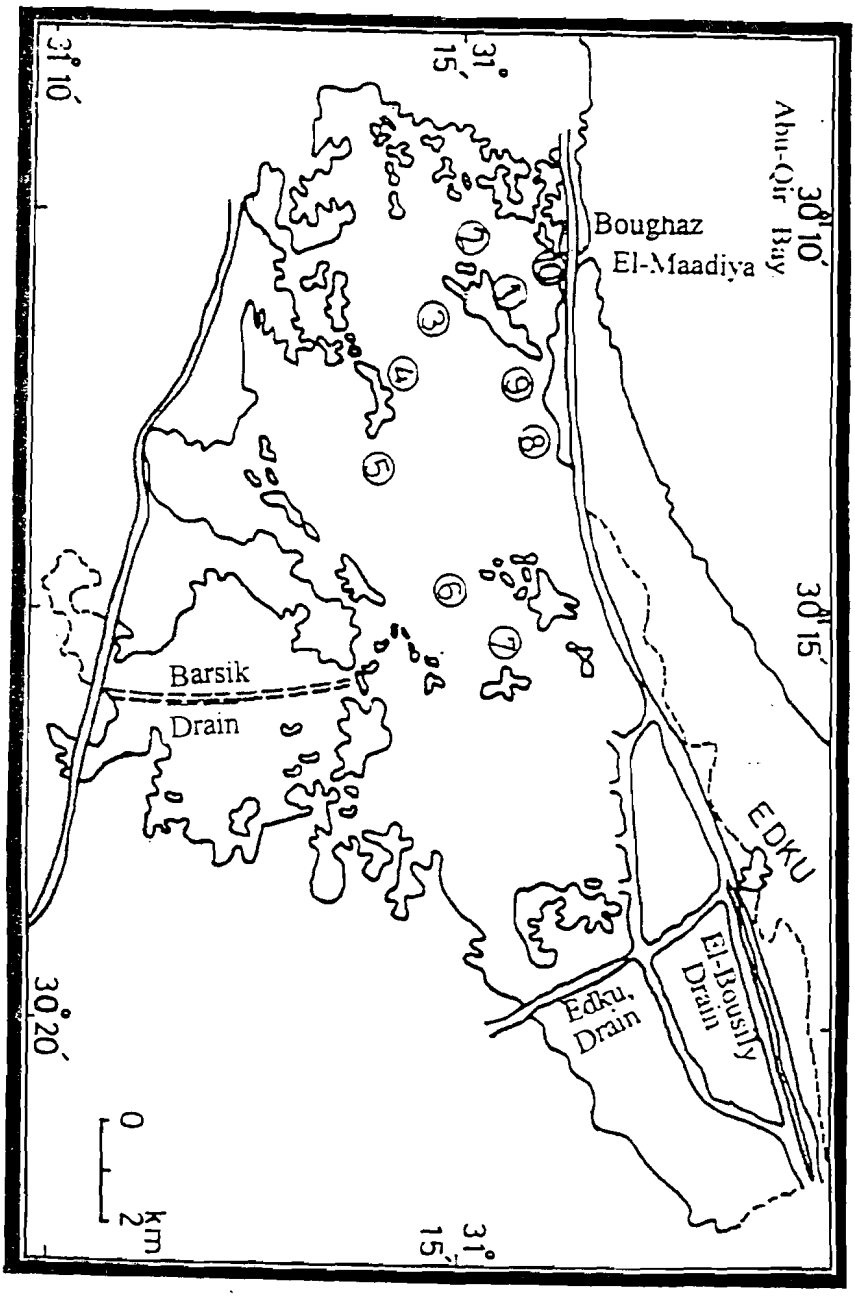

Fig.(1): The location map of sampling stations in Lake Edku.

For the identification of the different species of zooplankton the following textbooks were consulted; Sars (1926); Gurney (1926, 1931, 1932 & 1933); Pennak (1953); Tregouboff & Rose (1957); Edmondson (1959); Berzins (1960); Klimowicz (1961 a,b & 1962); Hutchinson (1967); and Al-Hussaini and Demian (1982).

Physico-chemical parameters including hydrogen ion concentration (pH), temperature, total dissolved solids (T.D.S.), ammonia(NH_4), nitrite(NO_2), phosphate(PO_4), reactive silicate(S_iO_2) and dissolved oxygen(DO) were estimated by Abbas ***et al*** (in press) at the same time and situations. Bacteriological analyses were also made by El-Shenawy ***et. al***. (2000). The impact of pollution on phytoplankton community structure was studied by Zaghloul and Hussein (2000).

Correlation coefficient as well as stepwise multiple regression equations at a confidence limit 95% were evaluated for the whole year (n=40) to quantize the zooplankton population, dominant groups and dominant species in relation to the most correlative environmental factors.

RESULTS AND DISCUSSION

Community composition of zooplankton

The zooplankton populations recorded during the present investigation comprised 111 taxa included in seven groups namely; Protozoa, Rotifera, Insecta, Nematoda, Trematoda, Polychaeta and Crustacea (Copepoda, Cladocera, Ostracoda, Amphipoda, Cirripedia and Decapoda).

Four groups predominated over other groups and comprised 96 species namely; Protozoa (20), Rotifer (49), Copepod (19) and Cladocera (8). They constituted collectively about 98% by number of the zooplankton population. Other rare forms (2%) included four species of ostracods, four nematode species, one amphipod in addition to eggs of two trematode species, two decapods, one insect larva, spionid and trochophore larvae of polychaetes.

Rotifers were the most important group since they formed more than 76% by number to the zooplankton population in the lake with an annual average

248.3X10^3 organisms/m^3. They were represented by 26 genera. The genus *Brachionus* (47.5% by number to the total zooplankton) dominated other genera and comprised 11 species, which were dominated by *B. calyciflorus*, *B. angularis* and *B. urceolaris* (39.6%, 31.2% and 20% to the genus counts respectively) forming 57% to the total rotifer counts. Other three genera were infrequently recorded in the period of investigation. They are *Polyarthra*, *Synchaeta* and *Keratella* (8.7%, 7.6% and 5.7% by number to the total rotifers respectively).

Copepods and their larvae ranked second importance group in Lake Edku during the period of investigation and formed about 16% by number to zooplankton population with annual average 52 X 10^3 organisms/m^3. They were represented in the lake by 14 genera, which were dominated by the genus *Acanthocyclops*. The nauplii predominated over the adults (36.2 X 10^3 nauplii/m^3) contributing 69.5% by number to the total copepods.

Protozoa were infrequently encountered and formed 3.4% by number to the zooplankton standing stock (average 10975 organisms/m^3). They were represented by 18 genera which were dominated by *Difflugia*(0.7% by number to zooplankton population) , *Tintinnopsis*(0.6% to the zooplankton counts) , *Askenasia* and *Tintinnidium*(0.3% for each). They formed collectively 55.6% by number to the total Protozoa counts.

Cladocera contributed 2.5% to the zooplankton counts (average 8X10^3 organisms/m^3). They were represented by 8 species (included in 6 genera) They were dominated with *Moina micrura* (76% by number to the total Cladocera). Ostracoda were rarely encountered (1% to the total zooplankton counts) and represented by 4 genera namely: *Cypridopsis*, *Cyclocypris*, *Canadona* and *Eucypris*.

The present results showed an a eutrophic phenomena in Lake Edku. When compared with the previous records during 1969-1970 by Samaan (1976) who estimated only 1140 organisms/m^3 and reported that Lake Edku was relatively poor in zooplankton community and showed mesotrophic properties as he studied the distribution of zooplankton for one year at five stations representing different habitats. He recorded the predominance of Cladocera, Cirriped larvae of *Balance* spp. and Copepoda over the other groups contributed collectively more than 90% to the total counts. This decrease in zooplankton community

during that period might due to change in environmental conditions throughout the last decades. As well as the differences in the methods of sampling where they had been collected through a small plankton net of bolting silk having 44 mesh/cm. by towing it horizontally for about 100 meters. He also attributed the decrease in zooplankton community to the increased density of submerged hydrophytes which hinder the growth of zooplankton such as *Potamogeton* spp. and *Ceratophyllum* sp. The zooplankton community is also to less extent higher than that recorded during 1976-1977 by Soliman (1983) who studied plankton in relation to the local environmental conditions in both the lake and drains. She noticed that the standing crop in the lake is much higher than the drains forming about $60.7X10^3$ organisms/m^3. Rotifers were predominated over other groups(56% to zooplankton population) followed by copepods (32%) (Table 1). Abdel Aziz(2000) estimated $86.5X10^3$ organisms /m^3 of zooplankton during 1997 from four stations around Boughaz El-Maadiya. One of them in side the lake. The others at the sea side and El-Boughaz area. The collection of the latter two periods was carried out by a standard plankton net of mesh size 55µm. The magnitude of zooplankton standing stock in the present study was lower than that recorded in the period 1995-1996 when the zooplankton community attained outstanding stocks to about $2.7X10^6$ organisms/m^3 resulting from the increased numbers of rotifer species with more than 92% to the total numbers of zooplankton population(Gharib&Soliman,1998 and Soliman "unpublished") as the lake was received huge volumes of drainage waters from the surrounding cultivated lands of El-Behaira Governorate.

Spatial distribution of the total zooplankton:

The annual average of the zooplankton standing stock in Lake Edku ($326.4 X 10^3$ organisms/m^3) indicated that it is relatively productive area when compared with Lake Burollus which estimated $183X10^3$ organisms/m^3 during 1987 (Aboul Ezz,1995) and Lake Maryout with approximately $216X10^3$ organisms/m^3 during 1996-1997 (Aboul Ezz. in press). But it is lower than the out standing productive Lake Menzalah during 1990 which amounted more than $5X10^6$ organisms/m^3 (El-Sherif ***et al.*** 1994). The highest standing stock of zooplankton in the lake (averages $580.7 X 10^3$ and $525 X10^3$ organsims/m^3

Table (1) : The annual average of numerical density of the different zooplankton groups (organisms / m^3), their percentage frequencies and number of species during 1969-1970 (Samaan, 1976); 1976-1977 (Soliman, 1983); 1995-1996 (Gharib & Soliman, 1998 and Soliman "unpublished") and the present study (2000).

	1969-1970			1976-1977			1995-1996			2000		
Groups	NO/m3	%	No.of sp	No/m3	%	No. of sp	No/m3	%	No. of sp	No/m3	%	No. of sp
Protozoa	0	0	0	5850	9.6	9	2650	0.1	6	10975	3.4	20
Rotifera	17	1.5	6	33997	56	26	2454510	92.1	24	248300	76	49
Copepoda	135	11.8	6	19350	31.9	2	191332	7.2	9	52200	16	19
Cladocera	619	54.3	5	656	1.1	5	8327	0.3	3	8000	2.5	8
Ostracoda				0	0	0	4386	0.2	2	3025	0.9	4
Cirripedia	282	24.8	1							25		1
Nematoda	41	3.6								2650	0.8	4
Other groups	45	3.9	10	871	1.4	0	2819	0.1	0	1225	0.4	6
Total	1140	100	28	60724	100	42	2664024	100	44	326400		111

respectively) occurred at stations 1 and 5 (Table 2) which lay faraway the inlets of the drain waters These stations contributed the highest T.D.S. (averaged to 3087 and 2512 mg/l respectively) and high DO contents (9 &10.7mlO_2/l). This agrees with the opinion of Train(1979) who mentioned that the amount of dissolved oxygen required the healthy growth of fresh water biota must be over 5 mlO_2/l. Arora (1966) advocated that the increased values of dissolved oxygen may have a productive effect on rotifers. They contained low concentrations of inorganic nitrogen contents (2.5 & 2.2 µg at/l respectively for ammonia and 1.4 & 2.6µgat/l respectively for nitrite). The lowest density of zooplankton appeared at stations 6 and 7 (157 X 10^3 and 146.5 X10^3 organisms/m^3 respectively). They are directly affected by the drainage water from Edku and El-Bousily drains which reflect high values of nutrients such as, ammonia (3.1 & 13.4 µg at/l), nitrite (4.5 & 15.7 µg at/l), phosphate (11.1 & 16.2 µg at/l). Kramer ***et al.*** (1972) attributed the increase of phosphate to the excretion of zooplankton organisms and/or decomposition of the dead plankton. These stations also contain high reactive silicate (172.1 & 90.6 µgat/l) which reflects a strong negative correlation between silicate content and number of phytoplankton (r=-0.7) (Gharib & Soliman,1998). This in turn reduced the zooplankton community there. They contained relatively low values of dissolved oxygen (7.4 and 5.5 ml O_2/l respectively) and low total dissolved solids (2410 and 1395 mg/l respectively according to Abbas ***et al***, in press). The contaminated nature of the water in this area is also demonstrated by the presence of the highest concentrations of some infected bacterial organisms such as total coliform (1293 & 2933 cell/ml). *Escherchia coli* (1044 & 2173 cell/ml), *Streptococcus faecalis* (480 &820 cell/ml) and *Vibrio* sp.(2245 & 2548 cell/ml) as recorded by El-Shenawy ***et al.,*** 2000).

Rotifers were dominated over other groups at all stations (Fig. 2). Their peaks of abundance were attained at stations 1 and 5 (494 X 10^3 and 420 X 10^3 organisms/m^3 respectively). *Brachionus angularis* (152 X 10^3 organisms/m^3), *B.calcyiflorus* (106X10^3 organisms/m3) *B.urceolaris* (51.5X10^3 organisms/m^3) and *Keratella quadrata* (55X10^3 organisms/m^3) were the main components at station 1. While the community at station 5 was dominated by *B.calyciflorus* (123 X 10^3 organisms/m^3), *B.urceolaris* (110 X 10^3 organisms/m^3), *B. angularis* (44.5 X 10^3 organisms/m^3) and *Monostyla closterocerca* (43 X 10^3 organisms/m^3 as shown in Fig 4). Rotifers were also predominated over other groups in Lake Maryout (Abdel Aziz, 1987 &Aboul Ezz, in press) and Lake Menzalah (El-Sherif ***et al.*** 1994). They were also represented the dominant

Table(2) : Spatial distribution of the dominant groups of the zooplankton (organisms/m3) in Lake Edku (average of the four seasons).

Stations / Groups	1	2	3	4	5	6	7	8	9	10	av.	
	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	No/m^3	%
Protozoa	20000	1500	7750	18750	13000	8000	13000	21000	2500	4250	10980	3.4
Rotifera	494250	163500	380750	295500	420000	109750	100250	189250	183250	146250	248300	76.1
Copepoda	65250	33250	78000	91250	67500	29250	11250	59750	64250	22250	52200	16
Ostracoda	250	1250	2000	250	4750	6250	2250	2000	6750	4500	3025	0.9
Cladocera	750	4500	4000	9000	5000	2250	5500	41000	6750	1250	8000	2.5
Cirripedia	0	0	0	0	0	0	0	0	0	250	25	0
Decapoda	0	0	0	0	0	0	0	0	750	500	125	0.04
Amphipoda	0	0	0	0	0	0	0	0	0	250	25	0
Insecta	0	0	0	0	1250	0	500	0	0	0	175	0.05
Nematoda	250	250	1750	500	8500	1250	11250	2000	500	250	2650	0.8
Trematoda	0	0	0	0	0	250	250	500	0	0	100	0.03
Polychaeta	0	250	0	0	5000	0	1500	250	0	250	725	0.2
Fish eggs and larv	0	0	0	0	0	0	750	0	0	0	75	0.02
Total	580750	204500	474250	415250	525000	157000	146500	315750	264750	180000	328400	

group in the previous studies on Lake Edku except during 1969-1970 (Table 1). But they showed some variations in species composition. In the present study, the dominant genera were *Brachionus* (47.5% by number to the zooplankton counts), *Polyarthra* (7.0%), *Syncheata* (5.7%) and *Keratella* (4.4%), that during 1976-1977 were *Monostyla* (36.6%), *Lecane* (5.9%), *Brachionus* (5.7%) and *Keratella* (2.8%) and that of 1995-1996 were *Brachionus* (77.5%), *Filinia* and *Polyarthra* (5.8% by number to the total zooplankton for each). All these genera designate eutrophy and usually appeared in mixotrophic water (Jarenfelt,1952 & Pejler,1974). Generally, rotifers perform an important link in the food chain and constitute the main food items for great variety of aquatic organisms including fish larvae. They also share in the transfer of energy from primary producers to the higher trophic levels(Stemberger,1990). The community composition during the period 1969-1970 was completely different, as it was mostly composed of Cladocera (54.3%), cirriped larvae of *Balance improvisus* (24.8%) and copepods (11.8%). Cladocera were represented by 6 species which were dominated with *Moina micrura*, *Alona rectangula* and *Chydorus sphericus*. In the present study, Cladocera are represented by: *Moina micrura*, *Bosmina longirostris*, *Alona intermedia*, *Ceriodaphnia reticulate*, *Simocephalus* sp., *Daphnia* spp. beside ephippia of *Daphnia*. They had their peak at station 8 and smaller one at station 4 (Table 2). They were mainly composed of *Moina micrura* ($40X10^3$ and $7.7X10^3$ organisms $/m^3$ respectively).

Copepods, their nauplii and copepode stages ranked second importance at most stations with an average of 52.2 X 10^3 organisms/m^3, showing their peaks at stations 3 and 4 (Table 2) which contained the lowest values of silicate (62.1 &52.7µg at/l) and low inorganic nitrogen compounds. These two stations harbored the highest counts of diatoms (*Nitzschia* spp.) and Chlorophyceae (*Carteria* sp). As recorded by Zaghloul & Hussein (2000). Nauplii larvae and copepodide stages were the main components. Ostracoda contributed 0.9 % by number to the zooplankton counts and showed peaks at stations 6 and 9 (Table 2). These stations contributed high reactive silicate values (172 & 118.7µg at/l) and low total dissolved solids (2410 & 1912 mg/l), according to Abbas ***et al.***, in press.

Seasonal variations

Seasonal variations of the total zooplankton counts and their different groups are given in table 3 and figure 3. The peaks of abundance were observed

in winter (February) and spring (April) due to the increased number of rotifers which appeared the most dominant group in the whole period of investigation.

In winter they formed more than 80% of the zooplankton counts showing their maximum values at station 3 (1.137 X 10^6 organisms/m^3). *B.calyciflorus* (52.5% to the total rotifer counts), *Keratella quadrata* (18.8%), *B.angularis* (12.7%) and *B.urceolaris* (4%) were the most dominant species (Fig.4). This station is characterized by high pH value (9.4). These dominant species showed their maximum distribution in alkaline waters, this is confirmed by the observations of Pennak (1953) who mentioned that the hydrogen ion concentration (pH) has long been considered to be an important determinant factor for rotifer community composition. Michael (1969) also claimed that rotifers prefer more alkaline waters. Kettle ***et al.*** (1987) recoded that the distribution of *Brachionus* spp., *Polyarthra vulgaris* and *Keratella* spp. are limited to alkaline waters. This station is also contained low values of ammonia and nitrite (4.3 and 0.08 µg at/l respectively), phosphate (4.0 µg at/l) and silicate (3.44 µg at/l. Abbas ***et al.***, in press). It is also contributed the highest counts of diatoms which consume most nutrient salts (Zaghloul & Hussein, 2000). All the dominant rotifer species in the lake showed an inverse relationship with water temperature (r = -0.35, table 4). These species attained their maximum occurrence in winter and they may be regarded as stenothermic forms (Winner, 1975). This is manifested by observations of Gulati (1978) who considered temperature variations are among the important physical factors controlling the distribution of rotifers as they generally prefer cold waters. Other two peaks were observed at stations 1 and 5 also due to the rotifer species (709 X 10^3 and 640 X 10^3 organisms/m^3 respectively): *K.quadrata* (31%), *B. angularis* (30 %), *B.urceolaris* (7.5%) and *B. calyciflorus* (5 %) were dominated at station 1. While the dominant species at station 5 were *B.calyciflorus* (37.5%), *B.urceolaris* (33%), *B.angularis* (12.5%) and *K.quadrata* (6.3%). These two stations are characterized by highest T.D.S. (5940 and 3280 mg/l respectively) and low inorganic nitrogen compounds.

Spring peaks were recorded at stations 1,5 and 8 (872X10^3 , 526X10^3 and 527X10^3 respectively). The community at stations 1 and 5 were mainly *B.calyciflorus* ,*B.angularis and B.urceolaris* they formed collectively 46% and 65.5% by number to the zooplankton population. While that at station 8 comprised *B.calyciflorus*, *B.angularis* and the cladoceran *Moina micrura* (33.2%, 7.6% and 30.4% by number to the zooplankton counts respectively) (Fig4).

Table(3) : Seasonal variations of the different groups of zooplankton (organisms/m^3),number of species and their percentage frequency in Lake Edku during the year 2000 (average of all stations).

Seasons / Groups	Winter(February)			Spring(April)			Summer(June)			Autumn(November)			av.		
	No/m3	*No.of sp*	*%*	*No/m3*	*No.of sp*	*%*	*No/m3*	*No. of sp*	*%*	*No/m3*	*No.of sp*	*%*	*No/m3*	*No.of sp*	*%*
Protozoa	5500	*10*	1	17900	10	5.7	11800	12	5.3	8700	8	3.6	10980	20	3.4
Rotifera	429200	35	80.8	216200	25	68.6	182200	30	82.5	165500	21	69.3	248300	49	76.1
Copepoda	83500	9	15.7	61800	13	19.6	7400	5	3.3	56100	10	23.5	52200	19	16
Ostracoda	3400	3	0.6	600	3	0.2	4800	4	2.2	3300	2	1.4	3025	4	0.9
Cladocera	4100	6	0.77	17400	3	5.5	5500	3	2.5	5000	3	2.1	8000	8	2.5
Cirripedia	0	0	0	0	0	0	100	1	0.04	0	0	0	25	1	0
Decapoda	0	0	0	300	1	0.1	200	2	0.09	0	0	0	125	2	0.04
Amphipoda	100	1	0.02	0	0	0	0	0	0	0	0	0	25	1	
Insecta	200	0	0.04	0	0	0	400	1	0.18	100	1	0.04	175	1	0.05
Nematoda	4200	3	0.8	800	3	0.25	5500	3	2.5	100	2	0.04	2650	4	0.8
Trematoda	0	0	0	100	1	0.03	200	1	0.09	100	1	0.04	100	2	0.03
Polychaeta	600	0	0.1	0	0	0	2300	0	1.04	0	0	0	725	0	0.2
Fish eggs and larvae	0	0	0	0	0	0	300	1	0.14	0	0	0	75	0	0.02
Total	530800	67		315100	59		220700	63		238900	48		326400	111	

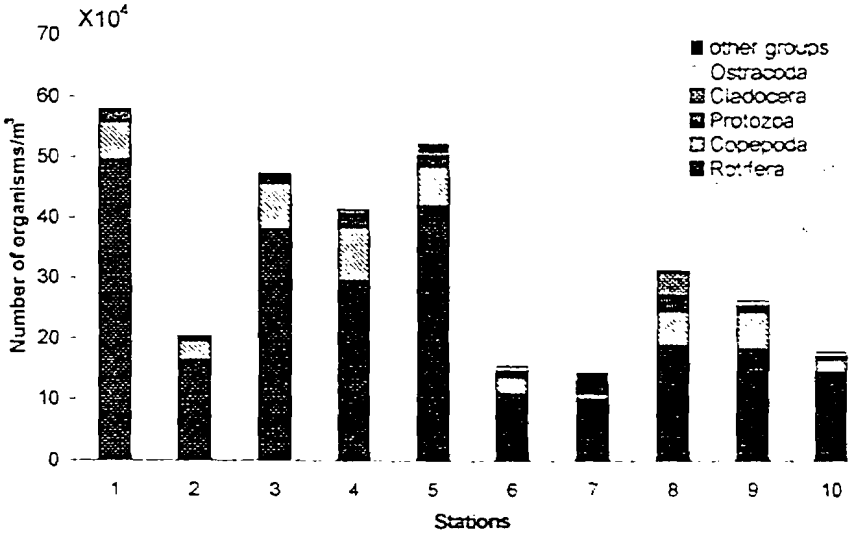

Fig (2) Annual average numbers of the dominant groups of zooplankton (organisms/m^3) at the different stations in Lake Edku during the year 2000

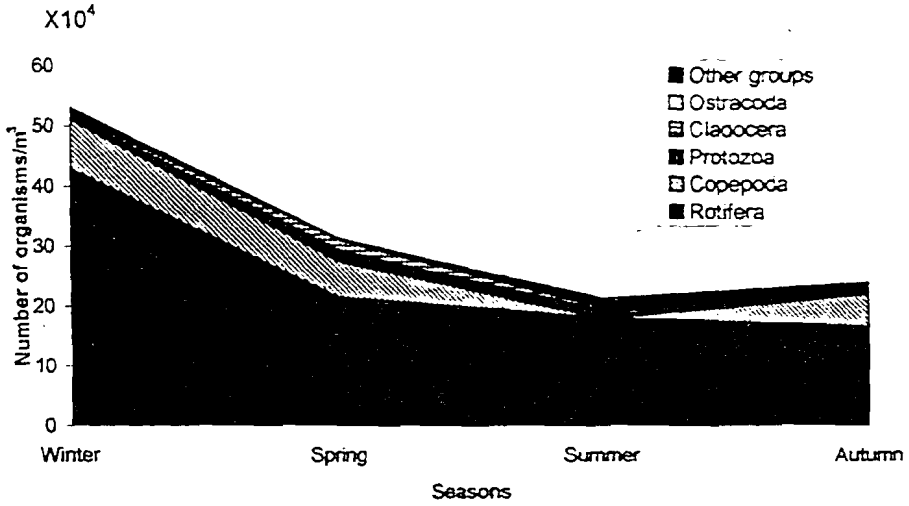

Fig (3) : Seasonal variations of dominant groups of zooplankton (organisms/m^3) in Lake Edku.(average of all stations)

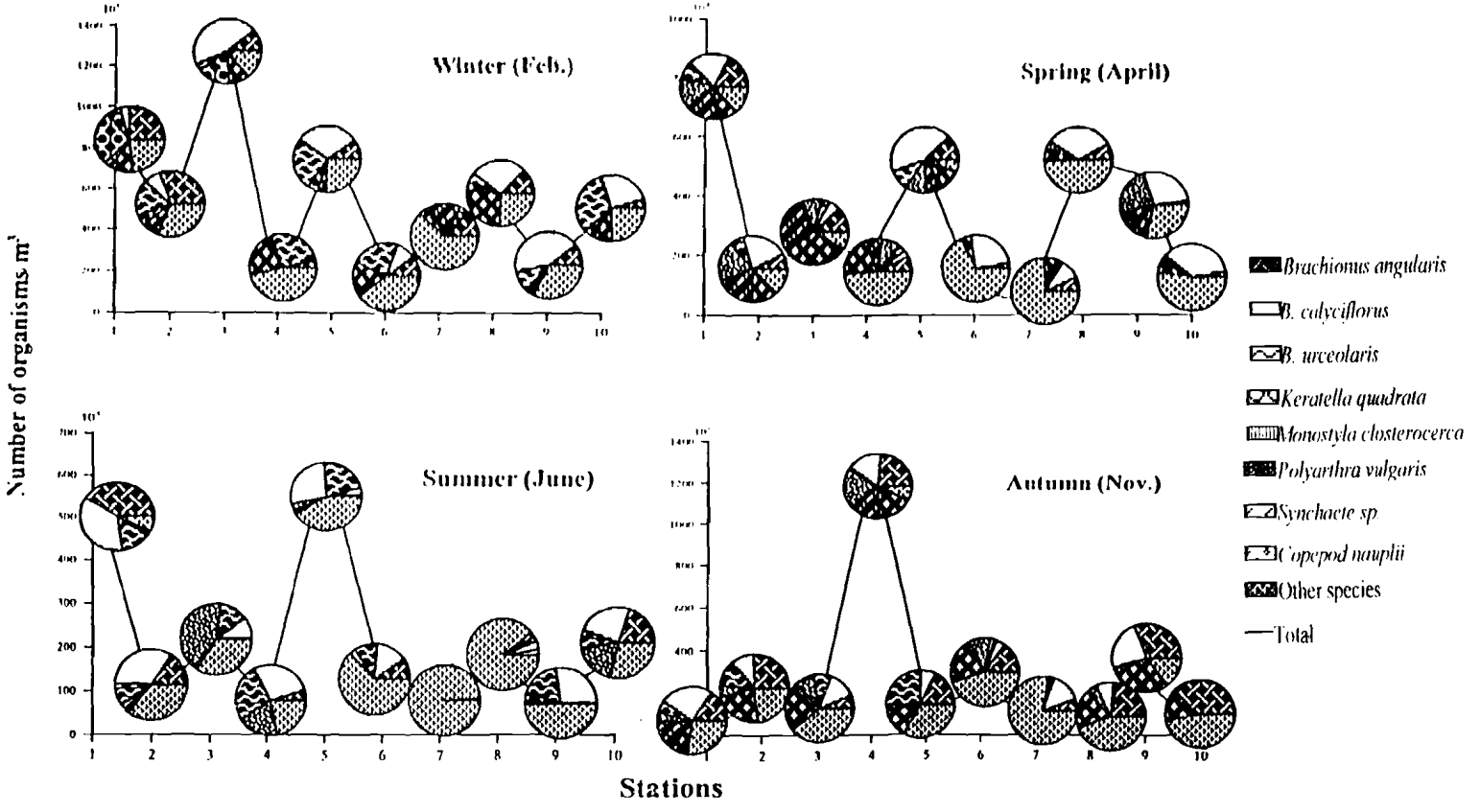

Fig. (4): Distribution of the dominant species of zooplankton (organisms/m³) in Lake Edku during the four seasons of the year,2000.

Copepods showed their highest percentage during autumn (23.5%) and spring (19.6%). Cladocera appeared with infrequent counts during spring and summer. Nematodes were rarely encountered at all stations showing their highest values at stations 7 and 5 during winter and summer (Tables 2 & 3). Polychaetes rarely appeared as spionid and trochophore larvae during summer and autumn with infrequent values at stations 5 and 7. Ostracoda showed peaks in summer (2.2%) and autumn (1.4%). Cirriped larvae of *Balance* were rarely recorded in summer at station 10 near El-Boughaz area . While decapod larvae of *Leander* sp. and zoea of crab were scarcely encountered at stations 9 and 10 respectively during spring and summer. The amphipod *Corophium vollutator* appeared in winter at station 10. The insect larvae and pupae of *Chironomus* sp. were recorded during all seasons at stations 5 and 7 except in spring. Trematoda appeared rare and were represented by eggs of *Schistosoma haematobium* at station 6 in April and eggs of *Fasciola* sp. at stations 7 and 8 during autumn and summer respectively as the result of inflowing domestic sewage from the northeastern drains (El-Bousily and Edku) with considerable volumes during these seasons into the lake. Fish eggs rarely appeared in the zooplankton population at station 7 in summer.

Zooplankton and environmental conditions

The correlation coefficient of zooplankton standing stock and its main groups and dominant species with some physicochemical parameters are given in table (4). The results revealed that Lake Edku during the period of investigation was characterized by high nutrient salt concentrations with annual averages of 5.4µg at/l for nitrite , 4.5µg at/l for ammonia, 7.8µg at/l for phosphate and 97.7µg at/l for reactive silicate (Abbas ***et al.***, in press). Such values of nutrients are much higher than previously recorded during the last ten years (Gharib & Soliman, 1998). This is mostly due to the huge volumes of different drainage and wastewater discharged into the lake that creates eutrophication conditions during most seasons. High values of total dissolved solids occurred in winter (2835mg/l), ammonia and phosphate in spring (6.7 & 12.82 µg at/l respectively), silicates during spring and summer (106.2 & 167.5 µg at/l respectively) and nitrite (13.1 µg at/l) in autumn. The lake water contained relatively high values of dissolved oxygen that ranged between 4.3 mlO_2/l (spring at station 6) and 15.6 ml O_2/l (summer at station 4) with an annual average value of 8.25 ml O_2/l.

Table (4) : Correlation coeficient at P≤ 0.05of biological components with some physico-chemical environmental factors in Edku Lake during year 2000.

Parameters	PH	Temp.	T.D.S.	NH_3	No_2	Po_4	Sio_2	$D.O_2$
Total zooplankton	0.47	-0.41	0.38	0	-0.32	0	-0.23	0.37
Protozoa	0	0.23	0	0.25	0	0	0	0
Rotifera	0.43	-0.35	0.37	0	0.23	0	-0.22	0.32
Copepoda	0.26	-0.36	0.23	0	0	0	-0.25	0
Ostracoda	-0.36	0	0	0	0	0	0.53	0
Cladocera	0	0	0	0.54	0	0	0	0
Brachionus angularis	0.28	-0.24	0.38	0	0	-0.24	0	0
Brachionus calyciflorus	0.39	-0.28	0	0	-0.25	0	0	0
Brachionus urceolaris	0.29	-0.41	0.39	-0.3	-0.31	0	0	0.39
Keratella quadrata	0.35	-0.42	0.57	0	0	0	-0.26	0.3
Monostyla closterocerc	0	0	0	0	0	0	0	0.33
Polyarthra vulgaris	0	0.23	0	0	0	0	0	0
Synchaeta sp	0	0	0	0	0	0	0	0
Copepod nauplii	0.29	-0.31	0	0	0	0	-0.26	0

The correlation coefficient of total zooplankton population showed that the recorded species are euryhaline freshwater forms. They showed positive correlation with pH values. The dominant rotifer species in the lake is preferred and limited to alkaline waters as previously mentioned. Also the occurrence of some rotifer species in abundance gives a true picture of the water quality (Patrick, 1950) .Thus all zooplankton groups showed a positive correlation with the total dissolved solids and ammonia which reflects the increase of phytoplankton in the lake (Zaghloul & Hussien, 2000) and in turn the dominance of some rotifer species which are considered as indicator of trophic level for their habitats, as *Brachionus* and *Keratella*. This agrees with the reported of Winner (1975) and Pejler (1974). An inverse relationship had been observed between total zooplankton and water temperature. The most dominant rotifer species *Brachionus calyciflorus* and *B.angularis* attained their maximum occurrence in winter and they regarded as stenothermic forms.

Stepwise multiple regression models showed the dependence of the zooplankton standing stock on the most correlative environmental conditions as follows: -

Total zooplankton = $-2052 \times 10^{-2} + 241671$ pH $+132$ T.D.S. $+19254$ NH_4
($R^2 = 0.33$, $r = 0.623$)

Total Rotifera = $-15910 \times 10^{-2} + 190381$ pH $+109$ T.D.S. $+ 9669$ NH_4
($R^2 = 0.23$, $r = 0.535$)

B.calyciflorus = $-332493 + 62458$ pH $- 4824$ Temp.
($R^2 = 0.13$, $r = 0.41$)

B.angularis = $-216570 + 25035$ pH $+28$ T.D.S
($R^2 = 0.14$, $r = 0.432$)

These models are adequate at a significant level 95% ($P \leq 0.05$). Comparison of observed and calculated values for the zooplankton population and its main components, showed small average error at most stations (Fig.5). This may be due to the effect of the different pollutant effluents discharged into the lake.

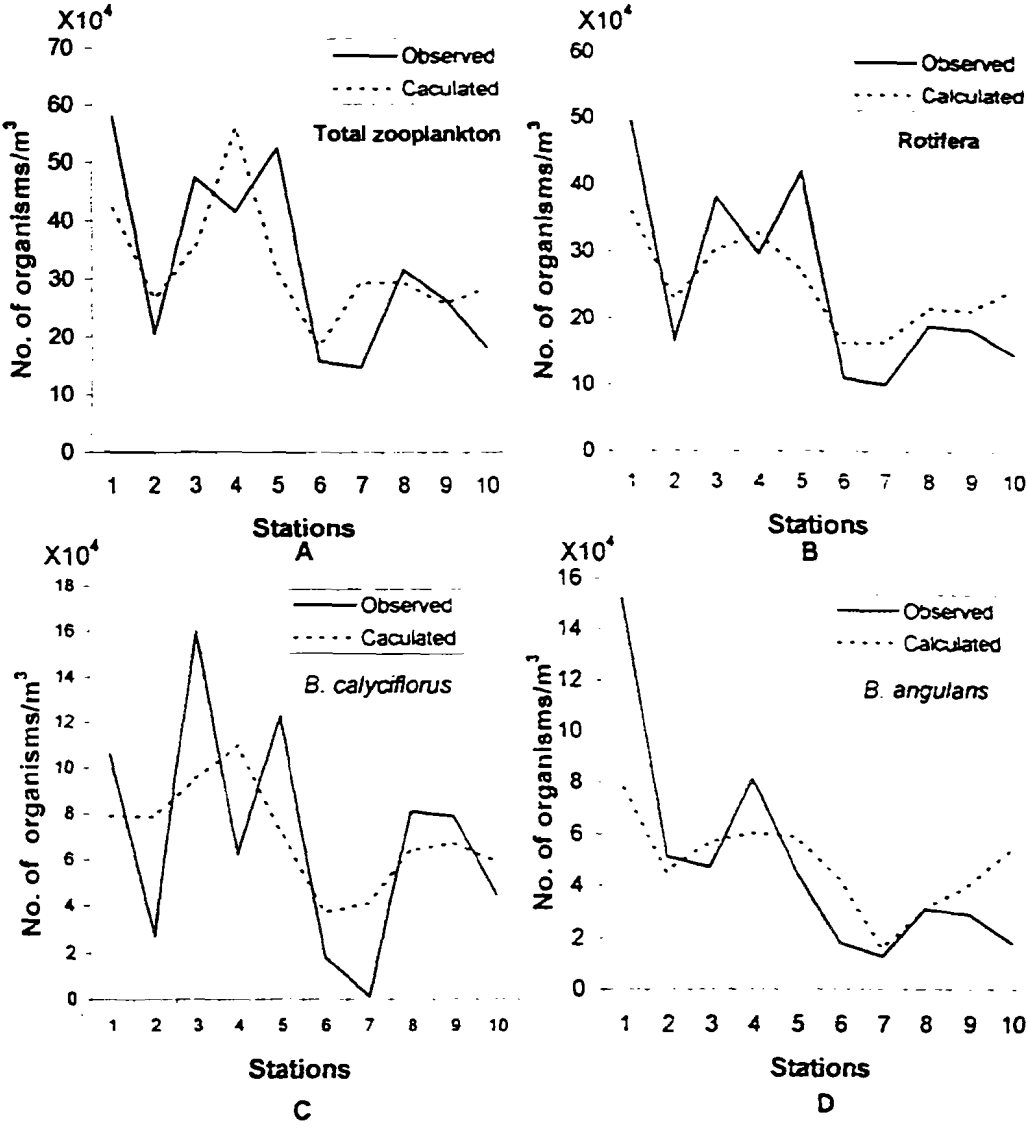

Fig. (5): Comparison of the obsereved density of total zooplankton and it's main components with calculated values as determined by a multiple regression analysis of the relationship between zooplankton and enviromental factors.

Phytoplankton - Zooplankton relationship.

Regarding the food cycle in lakes, the phytoplankton represents the main food supply for all herbivores zooplankton and bottom fauna, as it constitutes the basic tool for the production of organic matter and furnishes the main food supply for different aquatic animals. The increased density in the biota of the different trophic levels leads finally to the increase of the annual fish catch. Parallel studies for phytoplankton community in the lake were carried out by Zaghloul and Hussein (2000).

Several planktonic species are important in the food chain of lakes (Gualti, 1978). In eutrophic areas the grazing of zooplankton has no pronounced effect on the standing crop of phytoplankton as its growth rate exceeds their consumption. The zooplankton organisms in turn form the basic food for fish and bottom animals. They also add to release of nutrients through the rapid decomposition of their bodies (Harris, 1959 and Barlow & Bishop, 1965).

Generally, the algal composition is regarded as an important factor in determining the grazing efficiency as the different algal species are consumed at different rates (Vanni & Temte,1990). Regions with high algal production showed also increased zooplankton biomass(Steemann Nielsen *c.f.* Raymont, 1980). This to less extent agrees with the present results whereas, the estimated correlation coefficient showed a linear relationship between the two communities ($r = 0.64$) which reflects eutrophic nature of the lake in this time.

The algal community in Lake Edku is mainly represented by members of Chlorophyceae, Bacillariophyceae, Euglenophyceae, Cyanobacteria and Dinophyceae. The annual average values of total phytoplankton in the lake amounted 4.5×10^6 unit/l. Chlorophyceae contributed the bulk of phytoplankton standing crop (55.3% to the total phytoplankton; Zaghloul & Hussein, 2000).

Regionally, the annual average of the zooplankton and phytoplankton communities showed to less extent a direct relationship (Fig.6). This agrees with observations of Markarewicz and Likens(1979). An inverse relation was well observed at stations 1 and 5 which contributed the highest zooplankton counts of small herbivorous filter feeder forms that were dominated with the three rotifer species *B. calyciflorus*, *B. angularis* and *B. urceolaris* beside

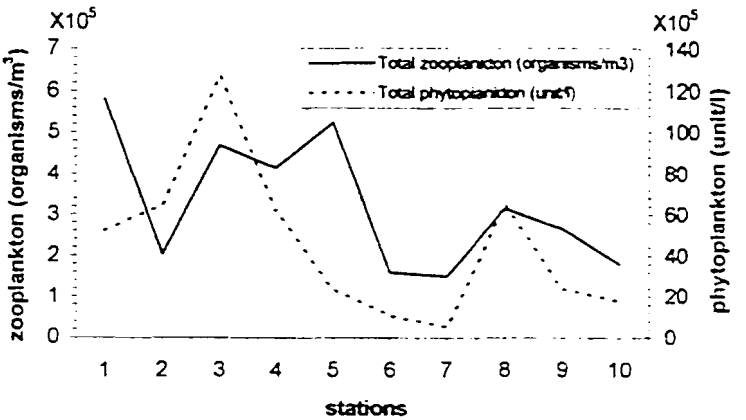

Fig (6) : Spatial distribution of the average standing crop of zooplankton (organisms/m^3) and phytoplankton (unit/l) in Lake Edku during the year 2000 (compiled from Zaghloul & Hussein, 2000.).

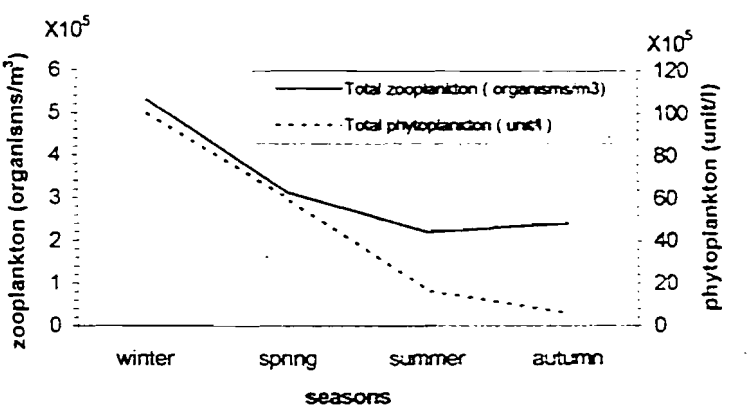

Fig (7) : Seasonal variations of the average standing crop of zooplankton (organisms/m^3) and phytoplankton (unit/l) in Lake Edku during the year 2000 (compiled from Zaghloul & Hussein, *2000.*).

Synchaeta spp and *Polyarthra vulgaris*. At the same time they showed relatively low counts of phytoplankton ($5.2X10^6$ & $2.4X10^6$ unit/l respectively) (Zaghloul & Hussein, 2000). Chlorophyceae (*Ankistrodesemus* & *Scenedesemus*) and the diatoms (*Navicula* & *Melosira*) were completely disappeared as they may be consumed by these dominant rotifer species. This agrees with the foundations of Pourriot(1957) that *Scenedesemus grandicauda* represents an important diet for *Brachionus* spp.. Also, the annual average of *Cyclotella meneghiniana* ($0.8X10^6$ & $0.1X10^6$ respectively) and *Euglena* ($0.19X10^6$ & $0.03X10^6$) were rarely encountered at the two mentioned stations. This agrees with the observations of Guerguess (1979) about the presence of *Cyclotella meneghiniana* and *Euglena* in the stomach content of *B.calyciflorus* in Lake Menzalah. Similarly Ryther, 1954 (*c.f.* Hutchinson, 1967) reported that Cladocera feed on *Navicula* and *Scenedesemus*. They showed their peaks of abundance at stations 4 and 8 (Table 2) resulting from the highest numbers of *Moina micrura* particularly during autumn ($23X10^3$ organisms/m^3) and spring ($160X10^3$ organisms/m^3) respectively. They may consume *Scenedesemus* which was completely disappeared from these stations during the two seasons. *Phacus* and *Euglena* also may be consumed by *Moina micrura* whereas they were rarely recorded ($0.1X10^6$ unit/l at station 4) or disappeared (St.8) during spring and autumn. Hutchinson (1967) reported that the gut contents of the dominant Cladocera of Daphniidae such as *Moina* seems to prefer a diet of small delicate flagellates especially *Euglena* and *Phacus* than detritus and bacteria It is obviously known that species composition of zooplankton community plays an important role for determining this relation. Thus, the high counts of herbivorous rotifers and cladocerans are usually responsible for reduction of phytoplankton density (Pourriot, 1957; Makarewicz & Likens, 1979 and Champ & Pourriot, 1977).

In the present study the average standing crop of phytoplankton showed linear relationships with the total zooplankton during the four seasons (Fig7). Peaks of abundance attained in winter due to the increased numbers of the Chlorophyceae; *Carteria* (3.4 X 10^6cell/l), *Ankistrodesemus* (0.307 X 10^6 cell/l) and the diatoms; *Cyclotella* (2 X 10^6 cell/l), *Nitzschia* (0.6 X 10^6 cell/l) and *Navicula* (0.47 X 10^6 cell/l; Zaghloul & Hussein, 2000) and numbers of the rotifers *Brachionus calyciflorus*, *B.angularis* and *B.urceolaris* (129100, 76200 and 67900 organisms/m^3 respectively).

The controlling effect of zooplankton on the size of the phytoplankton crop in Lake Edku was generally not pronounced during the different seasons particularly in winter and spring when the consumption rate of phytoplankton by zooplankton was nearly balanced by the rate of phytoplankton production which reflects the eutrophic characters of the lake during the period of study as well as the previously recorded during 1995-1996 (Gharib & Soliman, 1998). However, it was observed that the lowest counts of phytoplankton standing crop recorded during autumn was accompanied with relatively high counts of zooplankton groups. Thus the remarkable decline in phytoplankton density during autumn and summer seasons may be due to the grazing effect of the dominant rotifers; *B.angularis* and *B.calyciflorus* (52.4 X 10^3 and 33.4 X 10^3 organisms/m^3 respectively) on *Ankistrodesemus*, *Scenedesemus*, *Melosira* and *Euglena* which completely disappeared and less so on *Phacus*, *Nitizschia*, *Navicula* and *Cyclotella*. Generally, the dominant zooplankton of rotifer species and Cladocera play an important role in determine the relation between phytoplankton and zooplankton communities in the present studies.

Conclusion

In conclusion, the results revealed that rotifers predominated over other plankton in the lake as they perform an important link in the food chain and constitute the main food items for great variety of aquatic organisms. Many rotifer species such as *Brachionus* spp., *Keratella* spp., *Polyarthra vulgaris* are considered as indicator for the trophic level of their habitats. Also the presence of *Brachionus* spp. in great abundance indicates semi-polluted environs and typical of trophic nature. Generally, occurrence of some species in abundance give a true picture of the quality of waters.

Lake Edku is now classified among the eutrophic lakes as a result of the inputs of nutrient effluents, which was manifested by extensive growth of the macrophyte *Phragmites communis* (L.). It is also contaminated with the discharged of drainage waters enriched with chemical fertilizers in addition to domestic sewage effluents rich in organic matter especially at stations 6 and 7 as they lie in the vicinity of the drain inlets. The contaminated nature of the water of this area is also demonstrated by its relatively low dissolved oxygen content. As well as the presence of some bacterial organisms with high percentages during all seasons which reflects the water quality of the lake. Also the appearance of nematode species and trematode eggs announced that the lake suffers from pollution effluents particularly the domestic sewage of wastewater.

We recommend controlling the discharge the domestic sewage or it must be exposed to primary and secondary treatments before discharged into the lake. Also the use of chemical fertilizers in agriculture should be minimized .

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