eISSN: 09748369, www.biolmedonline.com

Seasonal and spatial distribution of *Brachionus* (Pallas, 1966; Eurotatoria: Monogonanta: Brachionidae), a bioindicator of eutrophication in lake El-Manzalah, Egypt

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Abstract
Rotifers, especially *Brachionus* sp., are the major component of zooplankton in Egyptian eutrophic lakes. These species play an important role as bioindicator in these aquatic environments. In present study, twenty-four zooplankton samples were collected and investigated along six stations of southeastern sector of the lake from August 2009 to May 2010. *Brachionus* sp. were the most abundant species constituting 74.8 % of the total rotifers and 59.87 % of the total zooplankton. It was represented by 7 species which are; *Brachionus angularis, B. budapestinensis*, *B. calyciflorus*, *B. caudatus, B. plicatilis*, *B. urceolaris* and *B. quadridentatus*. The highest abundance of *Brachionus* sp. was recorded at Ibn Salam Station (4227493 Org./m^3) during summer due to the effect of water discharge rich in nutrients through 3 main drains in this area while the lowest abundance was recorded at El-Qaboti Station (333 Org./m^3) during winter. *Brachionus angularis* and *B. calyciflorus* formed collectively (92.16 % of the total *Brachionus* sp.). The presence of these species of *Brachionus* in high composition indicates eutrophication of Lake El-Manzalah.

Keywords: *Brachionus*; Eutrophication; Lake; Egypt.

Introduction

Lake El-Manzalah, the largest and the most productive of the Egyptian Delta lakes is considered as one of the essential sources of fisheries in Egypt. It has contributed nearly 50 % of the total country yield during early 1970s and about 35 % during 1980s (Bishai and Yossef, 1977; Khalil and Salib, 1986). The lake is situated in the north-eastern extremity of the Nile Delta. It lies between longitude 31°: 45\ -32°-50\ E and latitude 31°: 00- 31°: 35\ N (Moati and Dowidar, 1988; El-Bokhty, 1996; Mageed, 2008).

The lake is bounded by the Mediterranean Sea to the North, Suez Canal to the East, and Damietta Branch to the West (Fig. 1). The southern shores of the lake form the north boundary of Dakahiliya and Sharkiya Governorates. The lake is connected with the Mediterranean Sea by narrow sandy fringes namely El-Gamil, New El-Gamil, El -Boughdady and New Damietta Boughases (El-Enany, 2004). The lake is also connected with Suez Canal at Qabouti, few kilometers to the South of Port Said. The north-western side of the lake is connected with Damietta Branch of the River Nile by El-Souffra and El-Ratma Canals, north of Damitta City.

The islands in the lake divided it into several regions known to the local fishermen as Bohours. Each of them has more or less distinctive ecological character (Shehata, 1982; Abdel Moati and Dowidar, 1988; El-Bokhty, 1996). The lake is probably the shallowest of the Delta lakes and the rich food supply it contains render it excellent feeding and breeding ground for many species of fishes, except those fishes that perform annually a breeding migration to the sea like mullets and shrimps.

Zooplanktons are good indicators of particular environmental conditions and their change as revealed by many studies. Zooplankton has been used as indicator of water quality for a long time. Some species flourish in highly eutrophic waters while others are very sensitive to organic or chemical wastes (El-Enany, 2009). Rotifers constituted the main food of animal origin for the Cichlid species (Hegab, 2010). Rotifers, especially *Brachionus*, constitute an important link in the food chains of inland waters. They are considered preferred food for many fish larvae (Guerguess, 1993).

Eutrophication can be defined as nutrient and organic matter enrichment or both that results in high biological productivity or decrease in volume within an ecosystem (Likens and Bormann, 1972). Eutrophication was found to affect zooplankton composition, shifting the dominance from large species (Copepoda) to smaller species (Rotifera) (El-Shabrawy, 2000; Emam, 2006). El-Enany (2004) mentioned that the southeastern part of Lake El-Manzalah is

highly enriched than any other part of the lake due to the effect of drains in this area. Rotifers, especially *Brachionus plicatilis*, formed the most dominant species in the eutrophic water body which referred to the influence of eutrophication.

Zooplankton of the lakes was studied by El-Maghraby *et al*., (1963), Guerguess (1979), MacLaren (1982), Guerguess (1993), El-Sherif *et al*. (1994), Khalifa and Mageed (2002) and Mageed (2008). Hence, it was considered desirable to focus in this study on the *Brachionus* sp. which was collected seasonally from several sites from August 2009 to May 2010, so that the aim of the present work is to estimate seasonal variations and spatial distributions of recorded *Brachionus* species as a bioindicator for eutrophication of one of the most eutrophic lakes in Egypt in relation to some environmental factors (water temperature, transparency, conductivity, pH, and dissolved oxygen) in order to determine which one of these species could be used as indicator for eutophication.

Materials and Methods

Stations sampled

On the basis of ecology, six stations were selected and described from the southeastern part of the lake (Figure 1). This part of the lake was affected by many drains as follows:

Station 1 (Qaboti): Few kilometers from Port Said City.
Station 2 (El-Bashtir): Located in Bahr El-Bashtir, 7 km from Qaboti.
Station 3 (Bahar El-Bakar): At the discharge point of New Bahr El-Bakar drain.
Station 4 (El Boom): At the main channel west of Bahr El-Bakar drain.
Station 5 (Ibn Salam): At Bahr El-Genka in front of Ibn Salam island. Three main drains (Hadous, Ramsis and Old Bahr El-Bakar) discharge in this area.
Station 6 (El-Matariya): It is located in the front of El-Matariya City.

Collection and analysis of samples

Water samples and zooplankton samples were taken seasonally during the period from August 2009 to May 2010 from 6 stations at the same time during the four successive seasons (summer, autumn, winter and spring).

Air and water temperature were measured in shade during the time of sampling using a mercury thermometer graduated to 100 ^{0}C. Transparency of water (represented by Cm) column was determined using black and white enamel coated Secchi Disk with a diameter of 20 cm. Electrical conductivity (EC) was measured by the conductivity meter (model YSI SCT-33). The results are expressed as (µS/cm). Hydrogen ion concentration (pH) was directly measured by pH meter (model Jenway 3150). Dissolved oxygen was determined by modified Winkler method (APHA, 1992).

Zooplankton collection was carried out by filtration of 30 liters from the surface with a plankton net 55 µ, 25 cm diameter and 80 cm length. All samples were immediately fixed with 4 % formalin. In the laboratory, the samples were examined with Optic Research Microscope. Three subsamples (1 ml for each) of the homogenized plankton samples were transferred to accounting cell and the different plankters were counted. Zooplankton population was then calculated as the number of individuals of the different species per cubic meter. Planktonic organisms were classified, identified and described according to description and keys constructed by Edmondson (1966), Ruttner-Kolisko (1974), Pennak (1978), Pontin (1978) and Shehata *et al*. (1998a,b). Cluster analysis (similarity index) and correlation coefficient were carried out on data of *Brachionus* species and physico-chemical parameters at selected stations by MINITAB 12 on Windows.

Results and Discussion

1- Physico-chemical properties

The variations of water temperature (Table 1) showed agreement with air temperature. The highest temperature was recorded during summer (34 ^{0}C) and the lowest during winter (13 ^{0}C). Transparency ranged between 17 cm at Bahr El-Bakar station during winter due to the effect of drains which carry high amount of organic and suspended matter in this mixing point while the highest reading was recorded at Ibn Salam station (49 cm) during spring. Also, pH recorded its lowest value (6.98) at Bahr El-Bakar station during spring, the relative decrease of ph values in this station due to the effect of Bahr El-Bakar drain (Abdel-Satar, 2001) and the highest (8.64) was recorded at Qaboti Station during winter. Dissolved oxygen recorded its minimum values at Bahr El-Bakar being 2.20, 2.90 2.79 and 2.10 mg/l during

summer, autumn, winter and spring, respectively. This may be attributed to the effect of pollution by sewage and agricultural wastes discharged, as well as, biochemical composition of organic matter leads to increasing ammonia and sulphids causes mineralization of organic matter during eutophication and induced enormous oxygen depletion (Emam, 2006). The highest positive correlation between physico-chemical parameters (Table 2) was recorded between dissolved oxygen and transparency (r = 0.71).

2- Abundance and seasonal variations of genus *Brachionus*

Brachionus sp. was the most abundant species constituting 74.8 % of the total rotifers and 59.87 % of the total zooplankton during the study. It was represented by 7 species which are *Brachionus angularis, B. budapestinensis*, *B. calyciflorus*, *B. caudatus, B. plicatilis*, *B. urceolaris* and *B. quadridentatus* (Figure 2). According to Angeli (1976), the simultaneous presence of several species of the genus *Brachionus* is a good indication for the eutrophic nature of an aquatic ecosystem. Mageed (2008) and Uzma (2009) stated that presence of more than 5 species of *Brachionus* refers to the eutrophication of water bodies.

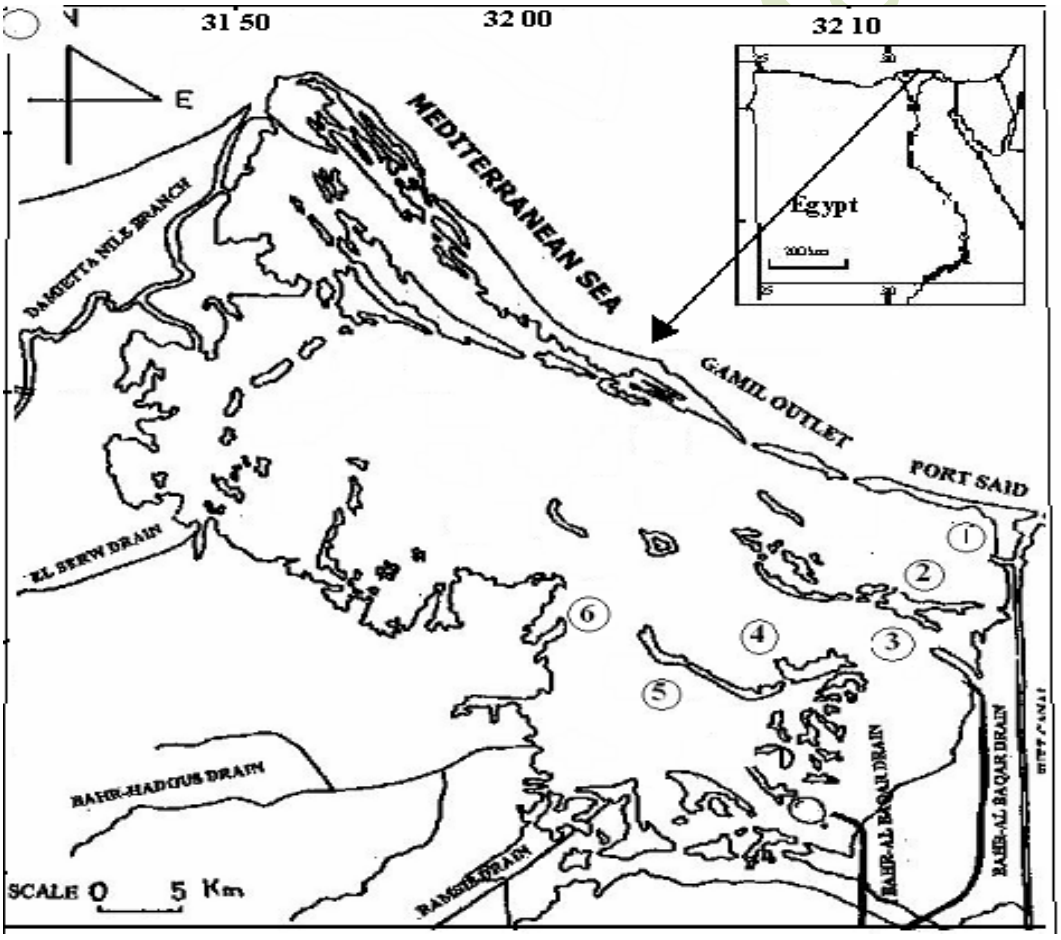

Figure 1: Map of Lake Manzala showing sampling stations.

Table 1: Physico-chemical parameters in the selected stations of Lake El-Manzalah during the period from August 2009 to May 2010.

Seasons	Stations	Air temp. (^{0}C)	Water temp. (^{0}C)	Trans. (Cm)	EC (mS/cm)	pH	DO (mg/l)
Summer	Qaboti	34	32	37	8.21	8.21	5.10
	El-Bashtir	34	32	24	5.15	7.67	5.00
	Bahar El-Bakar	34	31	21	5.21	8.14	2.20
	El boom	34	31	22	6.64	7.91	4.20
	Ibn salam	34	31	26	4.78	7.68	4.40
	El-Matariya	35	32	29	2.47	7.76	4.90
Autumn	Qaboti	26	23	44	9.56	8.15	6.40
	El-Bashtir	24	22	40	7.52	7.74	5.50
	Bahar El-Bakar	26	23	36	7.79	7.66	2.90
	El boom	26	21	37	9.24	7.81	6.20
	Ibn salam	25	22	46	7.22	7.62	6.10
	El-Matariya	26	23	45	3.96	7.43	6.30
Winter	Qaboti	14	16	22	5.68	8.64	3.63
	El-Bashtir	14	16	21	8.10	8.30	5.18
	Bahar El-Bakar	13	14	17	4.36	7.92	2.79
	El boom	13	15	19	4.66	8.27	2.98
	Ibn salam	13	15	20	3.42	7.89	2.19
	El-Matariya	14	16	22	2.35	7.74	1.50
Spring	Qaboti	23	22	40	19.89	7.97	5.50
	El-Bashtir	25	22	45	3.27	7.04	4.90
	Bahar El-Bakar	26	23	32	3.36	6.98	2.10
	El boom	25	23	47	5.67	7.23	5.30
	Ibn salam	26	23	49	4.17	7.41	5.40
	El-Matariya	25	22	46	2.39	7.49	5.90

Table 2: The correlation coefficient matrix between physico-chemical parameters and total *Brachionus* at Lake El-Manzalah during the study period.

Parameter	Water temp.	Trans.	EC	pH	DO
Total *Brachionus*	0.16	0.31	-0.10	-0.18	0.19
DO	0.25	0.71	0.36	-0.11	
pH	0.02	0.20	0.33		
EC	0.02	0.20			
Transparency	0.15				

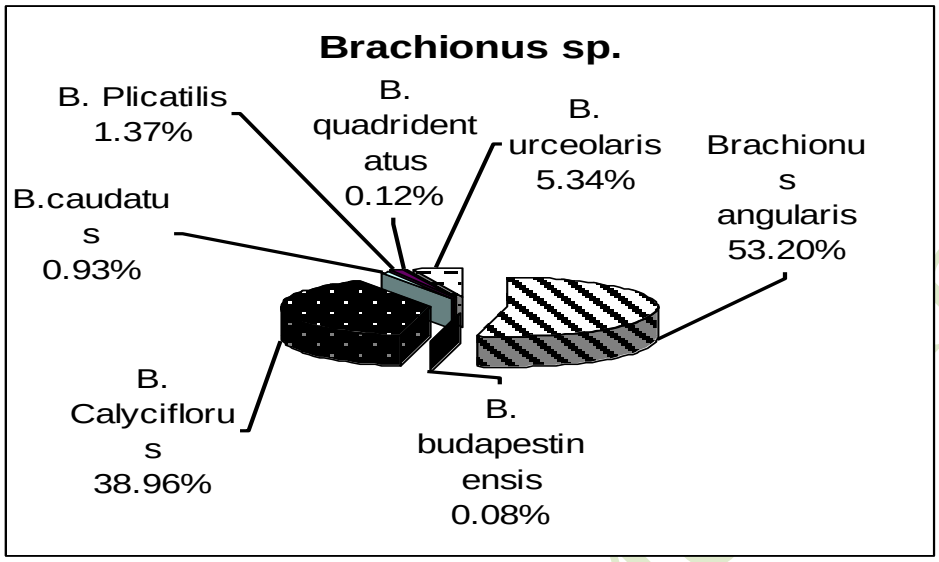

Figure 2: Percentage composition of the recorded *Brachionus* species in Lake El-Manzalah during the study.

The highest abundance of *Brachionus sp.* was recorded at Ibn Salam Station (4227493 Org./m^3) during summer due to the effect of water discharge rich in nutrients through 3 main drains (Hadous, Ramsis and Old Bahr El-Bakar) at this area. Kilmowicz (1961), Khalifa (2000), El-Bassat (2002), Bedair (2003) and Emam (2006) mentioned that genus *Brachionus* has ability to tolerate the pollution. The lowest abundance was recorded at El-Qaboti Station (333 Org./m^3) during winter may be due to this station considered away from the main drains of the lake.

The seasonal variations of total *Brachionus* showed that the highest average value of total *Brachionus* was recorded during spring (855171 Org./m^3) which decreased at summer (446779 Org./m^3) and winter (204999 Org./m^3), then reached its minimum average numbers (159538 Org./m^3) during autumn (Figure 3). On the other hand, the spatial variations of total *Brachionus* recorded its highest average density at Ibn Salam Station (1387792 Org./m^3) while the lowest average was recorded at Bahr El-Bakar Station (98495 Org./m^3) due to the effect of discharged sewage and the high pollution in this mixing point while there was progressive improvement and gradual biological recovery away from this mixing point. Khalifa (2000), El-Bassat (2002) and Emam (2006) recorded genus *Brachionus* from the most predominant rotiferan species in River Nile. Kilmowicz (1961), Khalifa (2000), El-Bassat (2002), Bedair (2003), Emam (2006) and Hegab (2010) mentioned that genus *Brachionus* has ability to tolerate the pollution.

The data of correlation coefficient reveled that there is appositive correlation between total *Brachionus* and water temperature, transparency and dissolved oxygen while it recorded negative correlation with pH and electrical conductivity (Table 2).

B. angularis was considered the most dominant species in Lake El-Manzalah during the study forming 43.18 % of the total Rotifers and 53.20 % of the total *Brachionus* species. From this data we can state that there is a high increase in *B. angularis* during the study because Gurergess (1979) recorded small numbers of this species in the lake while Mageed (2008) founded that *B. angularis* during the year 2003 was 35% of total rotifer crop. Slàdeček (1983) mentioned that this species is cosmopolitan with a broad distribution in the most strongly eutrophic water.

The seasonal variations of *B. angularis* showed that, the highest average value of *B. angularis* was recorded during spring (546255 Org./m^3), then decrease at summer (155223 Org./m^3) and winter (102665 Org./m^3), then reached to its minimum average numbers (82445 Org./m^3) during autumn (Figure 4). On the other hand, the spatial variations of *B. angularis* recorded its highest average density at Ibn Salam Station (809633 Org./m^3) while the lowest average was recorded at Bahr El-Bakar Station (73494 Org./m^3) due to the previous reasons.

B. calyciflorus considered the second dominant species during the study. It formed 31.62 % of the total Rotifers and 38.96 % of the total *Brachionus* species. This species considered as indicators of eutrophic condition by Pejler (1983) and Guisande and Joja (1988). These results agreed with that obtained by Mageed (2008). *B. calyciflorus* recorded its highest average density during summer i.e. 286788 Org./m^3. While, Bedair (2003) mentioned that *B. calciflours* flourished during winter. It was recorded from all studied sites even in the polluted area. This means that it can occur in the polluted area and this genus was recorded as the second predominant rotifer species in River Nile and represented by eight species dominated by *B. calciflours*. *Brachionus angularis* and *B. calyciflorus* formed collectively (92.16 % of the total *Brachionus sp.*). The presence of these species of *Brachionus* in high composition indicate eutrophication of Lake El-Manzalah.

B. urceolaris considered the third dominant species during the study. It formed 4.33 % of the total Rotifers and 5.34 % of the total *Brachionus* species. *B. Plicatilis* was considered the fourth dominant species during the study. It formed 1.11 % of the total Rotifers and 1.37 % of the total *Brachionus* species. The highest average number of this species was recorded at El-Boom Station (9584 Org./m^3). This may be due to it being the nearest station from Boghaz El-Gamil which providing the lake with saline water from Mediterranean Sea. Mageed (2008) mentioned that many species are indicator of the salinity as *B. plicatilis*. It is a widespread plastic euryhaline species which inhabits brackish water. Also, Arora (1966) and Gurergess (1993) recorded that *B. plicatilis* have low brackish water affinities.

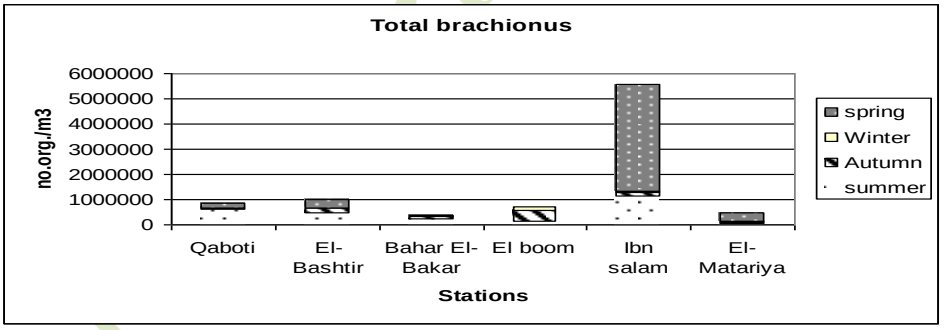

Figure 3: Seasonal variations of total *Brachionus* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

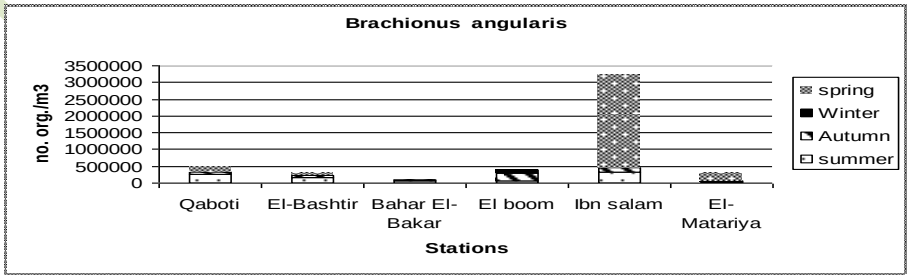

Figure 4: Seasonal variations of total *Brachionus angularis* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

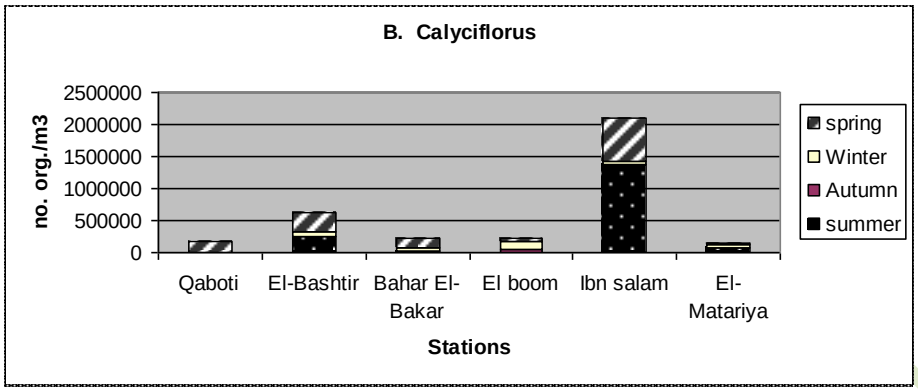

Figure 5: Seasonal variations of total *Brachionus calyciflorus* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

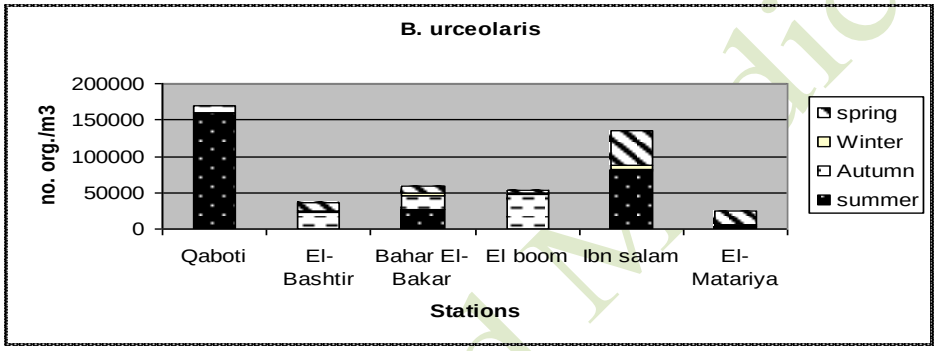

Figure 6: Seasonal variations of total *Brachionus urceolaris* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

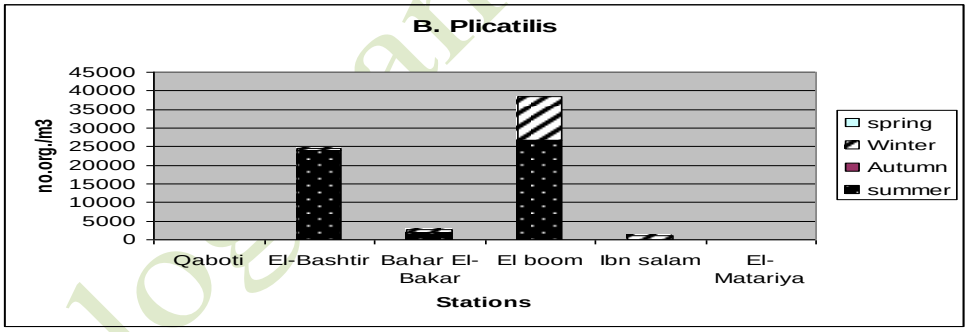

Figure 7: Seasonal variations of total *Brachionus plicatilis* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

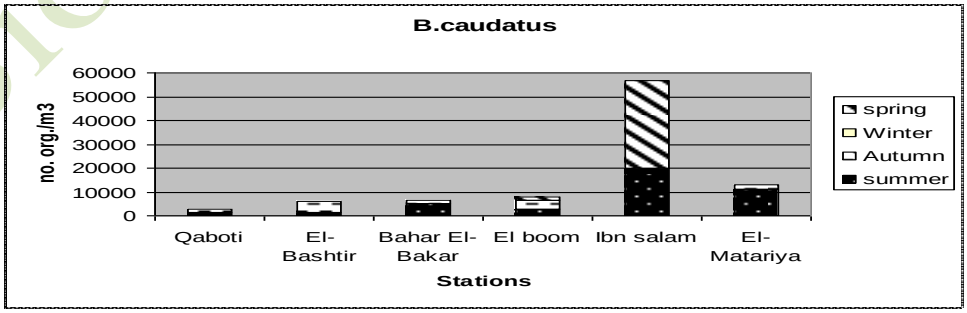

Figure 8: Seasonal variations of total *Brachionus caudatus* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

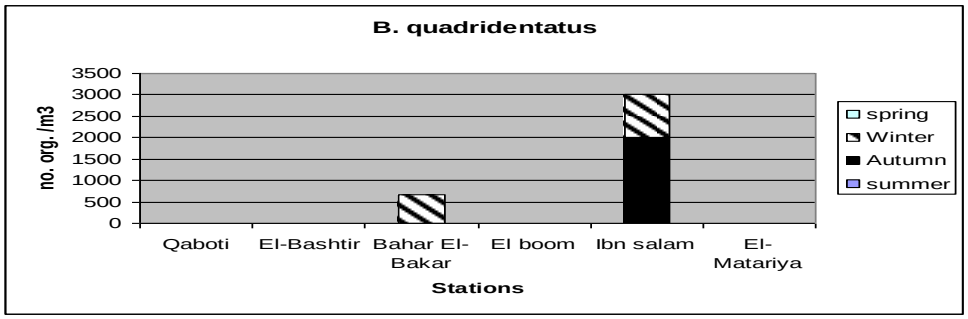

Figure 9: Seasonal variations of total *Brachionus quadridentatus* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

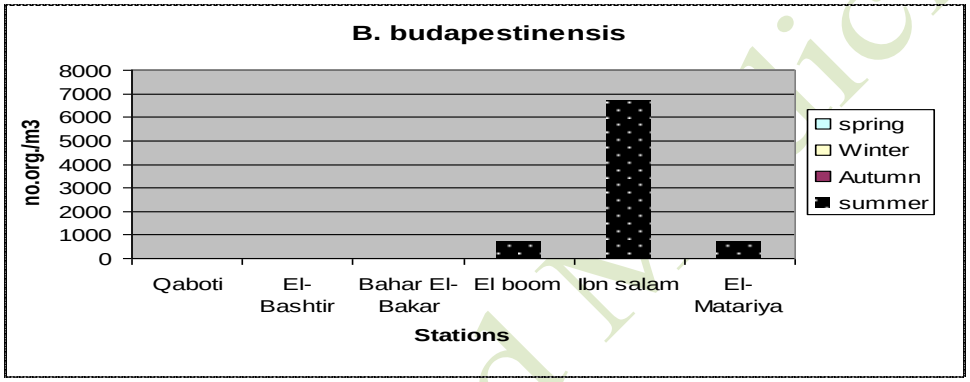

Figure 10: Seasonal variations of total *Brachionus budapestinensis* recorded in Lake El-Manzalah during the period from August, 2009 to May, 2010.

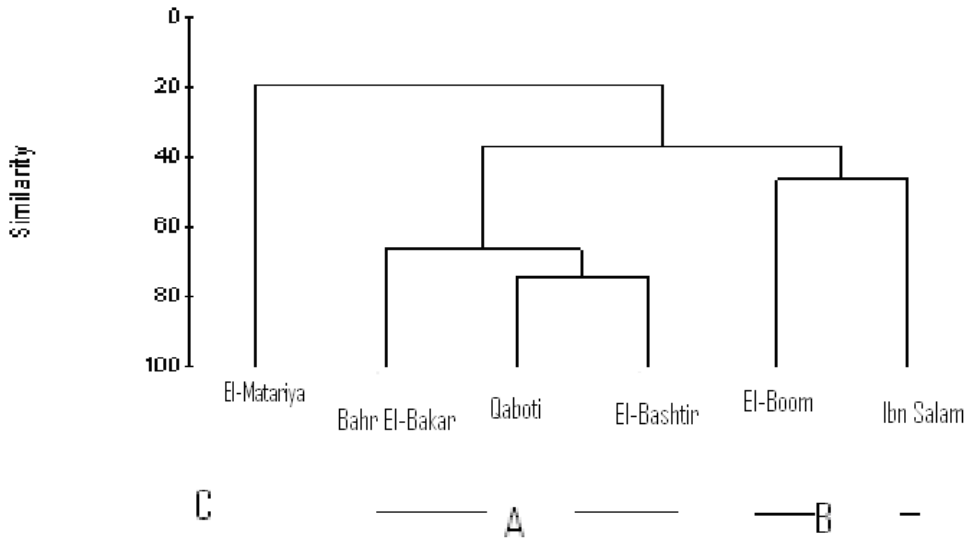

Figure 11: Similarity between stations according to different *Brachionus* species during the study.

B. caudatus, *B. quadridentatus and B. budapestinensis* considered the lowest dominant species in the lake it formed 0.75, 0.10 and 0.06 % of the total Rotifers and .93, 0.12 and 0.08 % of the total *Brachionus* species, respectively. The presence of these species with low abundance and infrequent expresses on pollution of the studied area this is due to these species occur in greater abundance in clean water (Figures 8, 9, 10). This observation agreed with that obtained by Arora (1966) and Gurergess (1993).

The similarity between stations depending on different *Brachionus* species (Figure 11) showed that in Group (A) the highest was recorded between Qaboti Station and El-Bashtir Station (75 %) due to the small distance between them, then between these two stations and Bahr El-Bakar Station (65 %) due to the effect of Bahr El-Bakar drain in the surrounding area. Group (B) showed moderate similarity (45%) between El-Boom and Ibn Salam stations which can be attributed to these stations being away relatively from the discharge points, progressive improvement and gradual biological recovery with high density of *Brachionus* species. Group (C) showed the lowest similarity between El-Matariya Station and all the selected Stations (20%) due to this station having a special biological characteristic as it was affected by different types of pollutants from agricultural sewage and human activity from El-Matariya harbor.

Finally, we can conclude that the presence of these species of *Brachionus*, especially *Brachionus angularis* and *B. calyciflorus*, among high numbers of *Brachionus* species (7 species) indicates the changing of Lake El-Manzalah from moderate eutrophication to highly eutrophic water. Therefore, we recommend treatment of drainage wastewater which discharges into the lake using more advanced methods prior to discharging it into the lake to decrease the pollutants, especially the high organic matter which is considered the main source of eutophication.

Acknowledgement

I would like to thank Prof. Asif A. Khan, and Dr. (Mrs) Saltanat Parveen of Zoology Department, Aligarh Muslim University, Aligarh, India, for their valuable and fruitful suggestions during the work.

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