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Diversity and distribution of *Brachionus* community (Rotifera: Brachionidae) at lake Maryout, Alexandria, Egypt

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Abstract
Brachionus diversity was studied seasonally at lake Maryout during the period from September 2014 to August 2015 at the surface water samples of nine selected sampling locations to examine its spatial and temporal variability in relation to some physicochemical parameters. A total of ten *Brachionus* species were recorded during this study period viz, *Brachionus plicatilis*, *B. angularis, B. calyciflorus, B. urceolaris, B. caudatus, B. quadridentatus*, *B. budapestinensis*, *B. dimidiatus*, *B. falcatus* and *B. rubens*. The highest abundance (1376000 ind./m^3) of *Brachionus* community was recorded at site 2 during winter while the lowest one (300 ind./m^3) was recorded at sites 4, 8, 9 during autumn and site 4 during summer. *B. plicatilis, B. angularis* and *B. calyciflorus* formed collectively (91.1% of the total *Brachionus* community). The presence of these species of *Brachionus* in high composition indicates eutrophication of the Lake. The highest diversity (9 species) was recorded at sampling locations 4 and 7 but the lowest one (4 species) occurred at site 9.

Keywords: Rotifera, *Brachionus*, Maryout Lake, diversity, distribution

1. Introduction
Lake Maryout is a brackish lake, situates along the Mediterranean coast of Egypt, south Alexandria. It is actually isolated from the open sea [1, 2]. It receives agricultural drainage water from the surrounding cultivated lands mainly through El-Umum drain, southwest and by El-Qalaa drain, southeast. Domestic and industrial sewages are discharged from Alexandria city to the northern lake. The pump station at El-Mex keeps its level of water below the level of the cultivated lands [3, 4]. Its area of about 17000 acres which formed four basins; the Main Basin occupying 6000 acres, Fishery Basin with an area of 1000 acres, Northwestern Basin of 3000 acres, Southwestern Basin of 7000 acres [5].
Rotifers, especially *Brachionus*, constitutes an important link in the food chains of inland waters. They constitute the main food of animal origin for the Cichlid species [6] also they are considered as prefered food for many fish larvae [7]. Zooplankton of lake Maryout was studied by [8-10, 3, 5]. Hence, it was considered desirable to focus in this study on *Brachionus* community which was collected seasonally at several sites from autumn 2014 to summer 2015, so that this work aimed to evaluated the effect of some environmental factors on diversity, distribution and abundance of genus *Brachionus* along Maryout lake.

2. Materials and Methods
2.1 Sites sampled
Ecologically, nine sites were selected and described in Lake Maryout Fig. (1) and Table (1).

Table 1: GPS locations of the selected study sites at Maryout Lake, from autumn 2014 to summer 2015.

Basins	Sites	Latitude	Longitude	Depth (m)	Area (acres)
Fish Farm	1	31^0 09.149'	29^0 55.365'	1.5	1000
Main Basin	2	$31^0$7'41.56'	$29^0$53'12.73'	1.8	6000
	3	31^0 08.894'	29^0 52.396'	1.2	
	4	31^0 07.549'	29^0 53.641'	1.2	
Umum drain	5	31^0 08.466'	29^0 51.466'	8	-------
Northwest Basin	6	31^0 06.844'	29^0 53.389'	1.5	3000
	7	31^0 05.351'	29^0 53.062'	1.2	
Southwest Basin	8	31^0 07.489'	29^0 52.499'	1	7000
	9	310 05.302'	290 53.439'	1	

GPS= Global Positioning System.

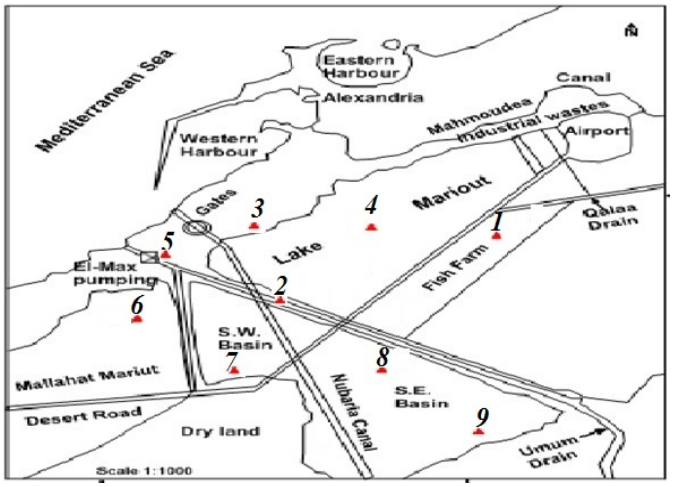

Fig. 1: Map showing the study area and the selected sites at Lake Maryout from autumn 2014 to summer 2015.

2.2 Collection and analysis of samples

Water and *Brachionus* samples were collected during four seasons (autumn 2014- summer 2015). Physico-chemical parameters (Water temperature Temp. (ºC), Salinity (S‰), Hydrogen ion concentration (pH), Biological Oxygen Demand (BOD), Dissolved oxygen (DO) and Ammonia) were measured in the field using portable Hydrolab meters (Multi 340i/SET).

The *Brachionus* samples were collected by filtration of 50 L. of the lake water using standard plankton net of 55µm mesh size and a mouth diameter of 30 cm. Collected samples were preserved in 4% neutral formalin solution and their volumes were concentrated to 100ml. Three subsamples (1 ml of each) were transferred into a counting cell and each *Brachionus* species were identified and counted under a binocular research microscope as (individual/m^3) which was calculated according to the following formula suggested by [11].

$$N = n (v/V) * 1000$$

Where: -

N= Total number of *Brachionus* per cubic meter of water filtered;

n = average number of *Brachionus* in 1 ml of zooplankton sample

v = volume of *Brachionus* concentrate (ml)

V= Volume of total water filtered (L)

The identification of collected *Brachionus* species was done according to [12-16].

2.3 Statistical analysis

Diversity indices: Species Richness, Evenness index and Shannon and Wiener index (H) were used to estimate the community structure [17]. It was sampling station with the Prima 5 Statistical Package Program.

Correlation coefficient were carried out on data of *Brachionus* species abundance and physico-chemical parameters at selected sites.

3. Results and Discussion

3.1 Physicochemical parameters

The average of water temperature values fluctuated between 30.6 ± 0.3 ºC in summer, and 16.09 ± 0.82 ºC in winter, the highest water temperature value (32.6 ºC) was measured at site 6 in summer but the lowest one (13 ºC) occurred at the same site in winter. The highest average value of salinity (4.23 ± 0.55‰) was recorded in spring but the lowest one (3.6 ± 0.47‰) was measured in autumn, the maximum salinity values (7.52 and 7.4‰) was measured during summer and spring at sites 1 and 7 respectively while the minimum one (1.76‰) occurred at site 3 in autumn. The hydrogen ion concentration lies on the alkaline side and recorded averages of 7.72 ± 0.2, 8.03 ± 0.19, 8.43 ± 0.07 and 7.82 ± 0.11 for autumn, winter, spring and summer seasons, respectively while its maximum value (8.9) occurred at site 1 in winter but the minimum ones (7.21 and 7.29) were listed at sites 5 and 6 in autumn, the decrease of pH values in these sites is due to the effect of Umum drain. This agrees with that reported by [18]. The maximum average of dissolved oxygen (7.84 ± 1.64 mg/L) was recorded in winter but the minimum one (5.12 ± 1.6 mg/L) was reported in autumn. This may be attributed to the effect of pollution by sewage and agricultural wastes discharged, as well as, biochemical composition of organic matter which causes mineralization of organic matter and induced enormous oxygen depletion [19] while its highest value (14 mg/L) occurred at site 6 in winter but it disappeared

at sites 3 and 5. This due to the presence of high pollutants at these sites. The biological oxygen demand of water recorded its highest average (125.7 ± 69.25 mg/L) in autumn but the lowest one (36.96 ± 25.37 mg/L) occurred in winter while its maximum values (493.21 and 490.57mg/L) occurred at sites 3 and 5 in autumn respectively but the minimum one (1.36 mg/L) happened at site 9 in summer. The ammonium concentration of water recorded its highest average (6.63±5.36 ppm) in spring but the lowest one (3.30 ± 2 ppm) was measured in winter, its maximum value (49.23 ppm) occurred at site 3 in spring while its minimum one happened at sites 1, 6 and 9 being 0.01 ppm in winter (Table, 2 and Fig. 2).

Table 2: Physicochemical parameters of selected sites in the lake from autumn 2014 to summer 2015.

	Parameters	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	Aver. ±SE
Autumn	Temp. (°C)	21	21	22	20	21	19	20.3	21	20	20.49±0.29
	S (‰)	5.7	5.6	1.8	2.3	3.2	2.5	4.67	3.4	3.3	3.6±0.47
	pH	8.7	8.8	7.4	7.4	7.2	7.3	7.39	7.5	7.8	7.72±0.2
	DO. (mg/L)	9.4	13	0	1	0	1.5	6.01	5.4	10	5.12±1.6
	BOD (mg/L)	22	20	493	28	491	24	25.8	26	2.5	125.7±69.25
	Amm. (ppm)	0.4	0.2	19	1.2	14	0.2	0.71	1.1	0.2	4.19±2.43
Winter	Temp. (°C)	20	20	18	15	16	13	16	14	14	16.09±0.82
	S (‰)	4.9	4.9	2.1	2.5	3.1	2.7	5.66	4.1	3.9	3.77±0.41
	pH	8.9	7.6	7.3	7.8	8	7.9	8.61	7.5	8.7	8.03±0.19
	DO. (mg/L)	9.2	9.4	0	7.9	0	14	12.3	7.8	9.1	7.84±1.64
	BOD (mg/L)	4.3	5.3	237	9.8	43	7.5	13.8	6	5.9	36.96±25.37
	Amm. (ppm)	0	0	30	1.2	5.6	0	0.73	0.1	0	4.15±3.24
Spring	Temp. (°C)	26	24	25	28	26	27	26	24	27	26.08±0.48
	S (‰)	5.5	5.4	2.2	2.7	3.4	3.2	7.4	4.4	4	4.23±0.55
	pH	8.6	8.5	8.3	8.3	8.2	8.6	8.44	8.8	8.2	8.43±0.07
	DO. (mg/L)	4.87	7.91	0	4.79	0	9.8	12.89	7.95	8.03	6.18±1.43
	BOD (mg/L)	27	21	159	21	43	29	12.7	25	21	49.34±18.01
	Amm. (ppm)	0.4	0.4	49	1.4	6.1	0.5	0.51	0.8	0.4	6.63±5.36
Summer	Temp. (°C)	31	29	31	30	30	33	30.3	31	31	30.6±0.3
	S (‰)	7.5	2.5	2.7	2.9	4	5.8	4.85	4.5	3.2	4.22±0.55
	pH	8.2	7.7	7.3	8	7.5	8	8.3	7.7	7.7	7.82±0.11
	DO. (mg/L)	7.27	4.5	2.4	5.15	2.3	8.72	4.22	11.7	5.2	5.72±1.02
	BOD (mg/L)	5.7	4.7	53	11	246	11	6.24	12	1.4	39.02±26.38
	Amm. (ppm)	0.3	0.4	16	0.7	12	0.1	0.48	0.2	0.1	3.3±2

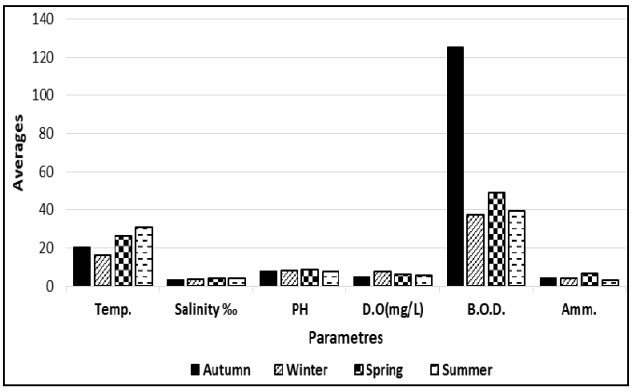

Fig. 2: The average values of physicochemical parameters at Maryout lake from autumn 2014 to summer 2015.

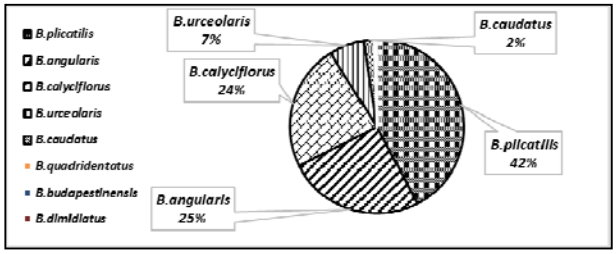

Fig 3: The percentage of total *Brachionus* at lake Maryout, from autumn 2014 to summer 2015.

3.2 Diversity and abundance of genus *Brachionus*

During the present study ten *Brachionus* species were recorded. They were dominated by *B. plicatilis* with an annual average density being 89806 ind/m^3 which formed 42.3% of the total *Brachionus* counts, followed by *B. angularis* (53533 ind/m^3, 25.2%) and *B. calyciflorus* (49992 ind/m^3, 23.5%) while *B. urceolaris* was the fourth dominant species, it formed (13669 ind/m^3, 6.4%). On the other hand, *B. caudatus, B. quadridentatus*, *B. budapestinensis*, *B. dimidiatus*, *B. falcatus* and *B. rubens* were considered as rare species which represented by 1.86, 0.32, 0.2, 0.05, 0.03, and 0.01% respectively (Table 3 and Fig. 3).

El Hawary [8] has concluded that the characteristic type of zooplankton in Lake Maryout was *Brachionus spp*. Samaan [9] have recorded five species of *Brachionus* (*B. urceolaris*, *B. plicatilis, B. angularis, B. quadridentatus* and *B. quadratus)*. Abdel Aziz [10] listed six species viz, *B. urceolaris, B. plicatilis, B. angularis, B. quadridentatus, B. calyciflorus and B. caudatus.* Guerguess [3] have recorded seven species of *Brachionus* viz, the previously mentioned species in addition to *B. budapestinensis*. Also, Abdel Aziz [5] have mentioned that genus *Brachionus* was represented in the lake by six species viz, the previously mentioned species except *Brachionus sp.* The highest densities were observed in the Main Basin.

According to Angeli [20], the simultaneous presence of several species of the genus *Brachionus* is a good indication for the eutrophic nature of an aquatic ecosystem. Mageed [21] and Uzma [22] have stated that the presence of more than five species of *Brachionus* refers to the eutrophication of water bodies.

Table 3: Density of *Brachionus* community (ind./m^3) at selected sites in lake Maryout from autumn 2014 to summer 2015.

Species	seasons	Sites									Aver. ± SE.
		St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	
B. plicatilis	Autumn	0	265200	3600	12300	0	58000	0	0	2700	37978±29079.8
B. urceolaris		2000	0	2400	7500	19200	53500	23700	1800	1500	12400±5869.2
B. angularis		2000	0	600	50100	18600	3500	0	900	900	8511±5555.6
B. calyciflorus		400	1200	1800	84300	81600	15500	0	15300	300	22267±11656
B. caudatus		0	0	600	67500	22200	0	0	0	0	10033±7586
B. quadridentatus		0	0	0	3000	0	3000	0	300	0	700±435.9
B. falcatus		0	0	600	0	0	0	0	0	0	67±66.7
B. budapestinensis		0	0	0	300	0	0	0	10800	0	1233±1196.3
B. plicatilis	Winter	68400	1376000	0	2000	0	600	0	1600	600	161022.2±152055.7
B. urceolaris		0	4000	0	7000	156000	600	0	1600	1200	18933.3±17150.9
B. angularis		37200	1000	0	289000	30000	1200	0	0	1200	39955.6±31499.7
B. rubens		0	0	0	500	0	0	0	0	0	55.6±55.6
B. calyciflorus		6000	2000	1000	148500	109000	1200	4500	1600	600	30488.9±18868.2
B. caudatus		0	0	1000	1000	0	0	0	0	0	222.2±147
B. quadridentatus		1200	0	0	0	4000	0	0	0	0	577.8±447.8
B. falcatus		0	0	0	0	0	0	0	1600	0	177.8±177.8
B. plicatilis	Spring	266000	45000	16800	8800	181200	69600	312000	16000	1000	101822.2±39984.3
B. urceolaris		2000	54000	0	31800	33600	3200	2400	20000	1000	16444.4±6501.5
B. angularis		1000	90000	1200	818200	313200	6400	133200	65000	1000	158800±89030.3
B. calyciflorus		1000	159000	14400	342300	274800	4000	244800	165000	2000	134144.4±44627
B. caudatus		0	12000	6000	12300	4800	2400	0	7000	0	4944.4±1620.5
B. quadridentatus		0	0	0	3000	3600	0	0	0	0	733.3±487.6
B. budapestinensis		0	1500	0	0	0	0	0	0	0	166.7±166.7
B. plicatilis	Summer	136800	10200	1800	11400	39600	198600	90600	1200	35400	58400±23192.9
B. urceolaris		2400	17400	0	3900	9600	6000	18000	3600	1200	6900±2241.7
B. angularis		48600	2400	0	6000	3000	600	0	600	600	6867±5256.5
B. rubens		0	0	0	300	0	0	0	0	0	33±33.3
B. calyciflorus		600	28200	0	45600	33600	600	7800	600	600	13067±5926.5
B. caudatus		1200	0	0	1200	3000	0	0	0	0	600±364.4
B. quadridentatus		600	1200	0	3300	600	0	0	600	0	700±353.6
B. dimidiatus		0	0	0	3600	0	0	0	0	0	400±400
B. budapestinensis		0	1800	0	300	0	0	600	0	0	300±200.

SE. = Standard Error - Aver. = Average

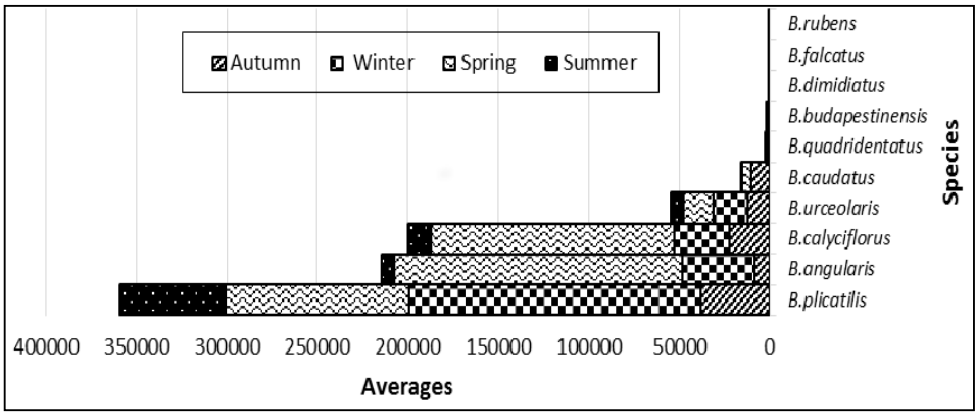

Fig 4: The averages of *Brachionus* species (ind./m^3) in different seasons at Maryout Lake from autumn 2014 to summer 2015.

3.3 Temporal distribution of *Brachionus* species

The temporal variations of the genus *Brachionus* showed that the recorded *Brachionus* species were more abundant in spring season with an average count of 417055.6 Ind./m^3 (49.13% of the total *Brachionus* count), followed by winter (251433.3 Ind./m^3, 29.6%) while the lowest *Brachionus* abundance was recorded in summer and autumn seasons with averages of 87267 Ind./m^3 and 93188.9 Ind./m^3 (10.3% and 10.97%) respectively (Table 3 and Fig. 5). This is similar with that was reported by [23].

B. plicatilis reached its highest density (161022 ind./m^3) during winter but the lowest one (37978 ind./m^3) occurred in autumn. Mageed [21] mentioned that many *Brachionus* species are indicator of salinity as *B. plicatilis*. It is a widespread euryhaline species which inhabits brackish water. Also, Arora [24] and Gurergess [7] have recorded that *B. plicatilis* have low brackish water affinities. *B. angularis* appeared its highest density (158800 ind./m^3) in spring but the lowest one (6867 ind./m^3) occurred in summer. Slàdeček [25] have mentioned that this species is cosmopolitan with a broad distribution in the most strongly eutrophic water.

B. calyciflorus recorded its maximum abundance (134144

ind./m^3) in spring while its lowest one (13067 ind./m^3) occurred in summer. This species is considered as indicators of eutrophic condition. Similar observation was detected by Pejler [26] and Guisande [27]. These results agree that obtained by Mageed [21]. At the same time Mola [23] showed that *B. calyciflorus* recorded its highest average density during summer. While, Bedair [28] mentioned that this species flourished during winter and it was recorded from all studied sites even in the polluted area.

Genus *Brachionus* was represented by nine species in summer, eight species in each autumn and winter seasons and 7 species in spring (Table 3).

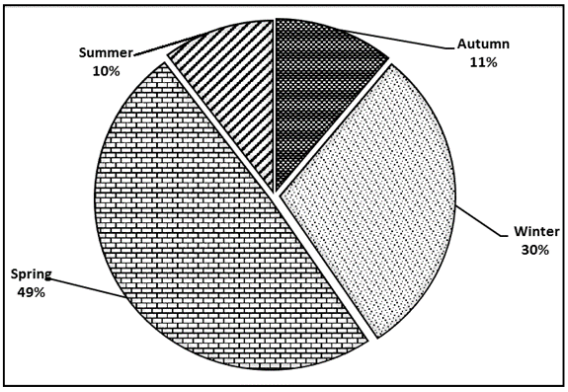

Fig 5: The percentage of total *Brachionus* during the four studied seasons at Maryout Lake from autumn 2014 to summer 2015.

3.4 Spatial distribution of *Brachionus*

Figure (6) explain the spatial distribution of genus *Brachionus* along Lake Maryout. The present collected species varied in the four lake basins between five species at Southwest Basin (sites 8 and 9) to ten species at the main basin (sites 2, 3 and 4) (Fig. 6).

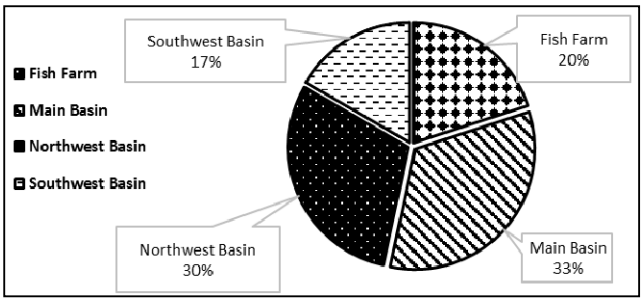

Fig 6: The percentage of total *Brachionus* at the four basins at Maryout Lake from autumn 2014 to summer 2015.

The highest *Brachionus* abundance was recorded at site 5 that contain 32.39% of the total *Brachionus* count, followed by site 7 (20.23%) Fig. (6). This due to the effect of water discharge which is rich in nutrients through Umum and Qalaa drains at these sites. Kilmowicz [29]; Khalifa [30]; El-Bassat [31]; Bedair [28] and Emam [19] have reported that genus *Brachionus* has the ability to tolerate the pollution. At the same time, site 3 (0.31% of the *Brachionus* count) is the lowest site has *Brachionus* percentage. This due to the highest values of Biological Oxygen Demand which lead to consume the Dissolved Oxygen at this site.

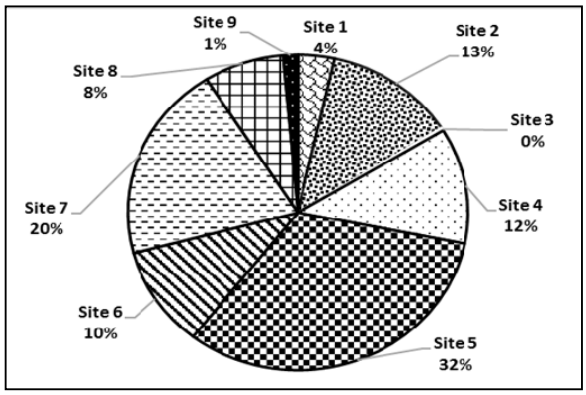

Fig 7: The percentage of total *Brachionus* at the studied sites at Maryout lake from autumn 2014 to summer 2015.

It is clear from the figure (7) that the most *Brachionus* species (9 species) were recorded at site 7 and site 4, followed by site 2 (7 species), while control site (9) has the lowest species number of *Brachionus* (4 species), followed by site 8 (5 species).

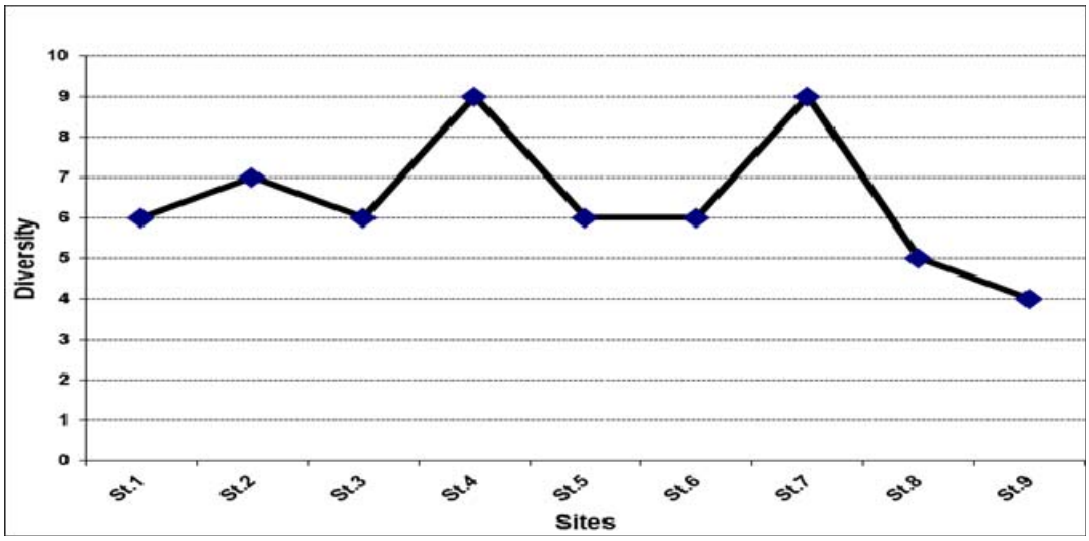

Fig 8: Diversity of *Brachionus* at selected sites at Maryout lake from autumn 2014 to summer 2015.

3.5 The correlation between physicochemical parameters and abundant species

The data of correlation coefficient revealed that there are positive correlations between *B. plicatilis* and both of salinity (r=0.32) and DO (r=0.20) but negative ones occurred between it and both of BOD (r=-0.13) and Amm. (r=-0.14). At the same time, negative correlations appeared between *B. urceolaris* and all studied parameters. Also there are positive correlations between *B. angularis* and both of temperature (r=0.14) and pH (r=0.14) while *B. calyciflorus* showed positive correlation with pH (r=0.18).

3.6 Diversity indices

The data in table (00) showed that the number of species ranged between 4 to 9 species at the studied sites. The richness indices were found to be varied between 0.27637 in site 9 and 0.55289 in site 8. The results of Evenness index analysis showed that the highest value (0.79) occurred at site 5 while the lowest one (0.331) happened at sites 1 and 2. The lowest value of Shannon species diversity index was 0.59 at site 1, but the highest one was calculated in sites 5 being 1.43.

Table 5: The diversity indices between the selected sites in Lake Maryout during this study.

Sites	Total species	Total ind.	Species Richness	Evenness	Shannon
1	6	577400	0.3769	0.331	0.59
2	8	2072100	0.4813	0.331	0.688
3	6	51800	0.46061	0.737	1.32
4	9	1965000	0.55207	0.461	1.01
5	6	1341200	0.35438	0.798	1.43
6	6	428500	0.38556	0.446	0.80
7	5	837600	0.29329	0.725	1.16
8	8	315100	0.55289	0.609	1.26
9	4	51800	0.27637	0.575	0.79

4. Conclusion

Finally, we can conclude that during the present study:

a. Ten Brachionus species were recorded.
b. They were dominated by *B. plicatilis* followed by *B. angularis* and *B. calyciflorus*.
c. *Brachionus* community were more abundant in spring season.
d. The present collected species varied in the four lake basins between 5 species at Southwest Basin to 10 species at the main basin.

5. Reference

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