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Zooplankton Composition and Distribution in Vegetated and Unvegetated Area of Three Reservoirs in Hatay, Turkey

Ahmet Bozkurt and Suleyman Ertugrul Guven
Faculty of Fisheries, Mustafa Kemal University, 31200, Iskenderun, Hatay, Turkey

Abstract: The effects of vegetation on the spatial distribution and abundance of freshwater zooplankton and richness in species were studied in 3 reservoirs; Lake Golbasi (36°30'17"N 36°29'35"E), Lake Golkent (36°53'54"N 36° 05' 21"E) and Kampus Reservoir (36° 19' 46" N 36° 11' 65" E) in Northeastern Mediterranean Region (Hatay). The abundance of certain species, for example *Euchlanis dilatata* Ehrenberg, 1832, *Lecane closterocerca* (Schmarda, 1859) and *L. lunaris* (Ehrenberg, 1832) differed significantly between macrophyte species. Other planktonic forms such as *Ascomorpha saltans* Bartsch, 1870, *Keratella cochlearis* (Gosse, 1851) and *Synchaeta oblonga* Ehrenberg, 1832, however, showed no significant preference for macrophyte species. A significant correlation were found between zooplankton and water quality parameters in vegetated and unvegetated areas with few exceptions and it was found that zooplankton species did not prefer any macrophyt species for living. The species richness of Rotifera, Cladocera and Copepoda were higher in the vegetated areas than in unvegetated areas of the reservoirs as well abundance of them, especially copepod and cladocer species.

Key words: Zooplankton, rotifer, cladocer, copepod, distribution, macrophyte

INTRODUCTION

Macrophytes are recognized as being a major factor determining the spatial structuring of microcrustacean and macrofaunal communities in the littoral of lakes (Dvorak, 1970; Shiel, 1976; Talbot and Ward, 1987). Macrophytes alter habitat complexity and physical conditions thus affecting abiotic and biotic characteristics of the water system. A variety of both biotic and abiotic factors have been implicated in determining the boundaries of species distributions. Biotic factors important to segregation include resources and predators. Abiotic factors such as dissolved oxygen, temperature and light can also influce the distribution of species.

The type and the abundance of macrophyte vegetation changes predictably from nearshore to offshore with increasing depth of a lake and can form distinct habitats for microcrustaceans. Specifically, microcrustaceans are expected to prefer or avoid habitats on the basis of the growth form or release of inhibitory chemicals by the vegetation, or associated changes in the physicochemical properties of the water, food resources and predators (Smiley and Tessier, 1998).

Many members of the meiofauna are associated with aquatic macrophytes where they may obtain shelter and food (Chapman and Lewis, 1976; Suren, 1992). Macrophytes provide a diverse array of surface for colonization and feeding as well as various interstices for concealment from predators. Where, macrophytes are abundant in the littoral of lakes, zooplankton especially, rotifers are abundant and diverse. Variation in zooplankton composition across the littoral is likely to be affected by the gradient in macrophyte species providing variability in habitat structure through differences in, for example, plant morphology, epiphyte community composition and the differential exclusion of predators.

The aim of the present study, was to examine the distribution and habitat preference of the zooplankton species and the variation in zooplankton community composition and abundance in vegetated and unvegetated areas with a view to study the ecology of zooplankton in Lake Golbasi, Lake Golkent and Kampus reservoir in Hatay, Turkey.

MATERIALS AND METHODS

The study was carried out during February, April, June and September 2006 by collecting zooplankton and water samples seasonally. Four stations (2 stations in vegetated area, 2 stations in unvegetated area) were

Corresponding Author: Ahmet Bozkurt, Faculty of Fisheries, Mustafa Kemal University, 31200, Iskenderun, Hatay, Turkey

determined on each of the three lakes. All three inland water bodies are located in the Eastern Mediterranean Region of Turkey.

Lake Golbasi (36° 30′ 17″ N 36° 29′ 35″ E) is located on 50 km North of the city of Antakya. It is a natural lake with a surface area of 12 km^2 at an altitude of 18 m. Stations depths of the lake ranged from 1-4 m. Lake Golkent (36° 53′ 54″ N 36° 05′ 21″ E) is located on 100 km North of Antakya. It is a man-made lake with a surface area of 11 km^2 situated nearby the sea and depths of the stations were between 1 and 5 m. Kampus Reservoir (36° 19′ 46″ N 36° 11′ 65″ E), is an other man-made water body with a surface area of 2000 m^2 fed by spring water, is located on 15 km (Station depths were around 1-2 m) North of Antakya, Turkey.

Zooplankton samples were taken by horizontal and vertical draws using 60 μm mesh size plankton net. Plankton net was hauled horizontally 15 min from unvegetated areas and zooplankton samples were replaced into glass jars and fixed with 4% formaldehyde for the qualitative zooplankton analysis. At the same time, 7 L of water samples were taken from each meter depths of both vegetated and unvegetated areas for quantitative and chemical analyses with Nansen bottle. Before being transferred to the laboratories, sample water from each depth of a station was collected and mixed in a bucket, then 5 L were filtered with 60 μm mesh size collector for quantitative analyses. Oxygen, water temperature and pH were measured onsite by the means of digital (YSI model 52 oxygen meter and Orion model 420A pH meter) instruments.

Analyses for ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), phosphate (PO_4) and chlorophyll-a were done on the same day according to standard procedures with Shimadzu brand UV-1601PC model spectrophotometer in the Plankton Laboratory.

The following taxonomic literatures were used for identifying the zooplankton groups; Edmondson (1959), Borutskii (1964), Scourfield and Harding (1966), Dussart (1969), Ruttner-Kolisko (1974), Kiefer and Fryer (1978), Koste (1978), Stemberger (1979) and Negrea (1983). For the quantitative analysis of zooplankton, a known volume of water was filtered through a 60 μm filter and fixed in formaldehyde (4%). Microcrustacean zooplankton were determined, counted and measured under an inverted microscope. All samples are kept in the Plankton Laboratory of Fisheries Faculty, Mustafa Kemal University. T-tests were used to test if the differences between groups and samples statistically significant.

RESULTS

The variations in temperature, dissolved oxygen, pH, nitrate, nitrite, amonium, phosphate and chlorophyll-a concentrations were given in Fig. 1. Temperature varied from 21.4-29.4°C with a mean value of 24.6±3.29°C. Mean chlorophyll-a concentration was 9.58±6.15 with the range of 3.27 mg L^{-1} in unvegetated area (Lake Golbasi) and 17.75 mg L^{-1} in vegetated area (Lake Golbasi). Nitrate (12.23±5.56) ranged from 5.42 mg L^{-1} (vegetated area in Lake Golkent) to 19.01 mg L^{-1} (unvegetated area in Kampus Reservoir), nitrite (0.04±0.02) varied from 0.02 mg L^{-1} (vegetated area in Lake Golkent) to 0.08 mg L^{-1} (unvegetated area in Lake Golbasi), amonium (0.17±0.05) varied from 0.11 mg L^{-1} (vegetated area in Kampus Reservoir) to 0.23 mg L^{-1} (vegetated area in Lake Golgasi). Mean dissolved oxygen was 6.63±1.17 mg L^{-1} with the range of 5.10 mg L^{-1} in vegetated area in Kampus Reservoir and 8.0 mg L^{-1} in unvegetated area in Lake Golbasi. pH (8.62±0.53) varied from 8.03 mg L^{-1} (vegetated area in Lake Golbasi) to 9.41 mg L^{-1} (unvegetated area in Lake Golkent) and phosphate (0.13±0.16) ranged from 0.04 mg L^{-1} (unvegetated area in Lake Golkent) to 0.43 mg L^{-1} (vegetated in Lake Golkent).

Except higher chlorophyll-*a* and phosphate but lower nitrate and pH in the vegetated stations, water quality parameters were not significantly affected by the vegetation (Fig. 1).

A significant correlation was found between zooplankton and water quality parameters in vegetated and unvegetated areas with few exceptions (Table 1). According to Table 1, a weak correlation was found between rotifer-total nitrogen ($r = 0.45$), rotifer- phosphate ($r = 0.24$), Cladocera- phosphate ($r = 0.37$) and copepod-Dissolved Oxygen (DO) ($r = 0.32$) in unvegetated area. Similarly, weak correlations were observed between Cladocera-phosphate $r = 0.08$, Cladocera-temperature ($r = 0.19$), Cladocera-pH ($r = 0.27$), copepod-total nitrogen ($r = 0.13$), copepod- temperature ($r = 0.48$) and copepod-pH ($r = 0.40$) in vegetated area.

Marginal vegetation is a narrow band surrounding the inland water bodies; Lake Golbasi, Lake Golkent and Kampus Reservoir with dominant vegetation types such as *Typha latifolia* L., *Lemna minor* L, *Nuphar lutea* (L) and *Juncus* sp. common to most lakes in Hatay province. It was found out that zooplankton species did not prefer any macrophyt species. They inhabited every macrophyte bed.

The species richness of Rotifera, Cladocera and Copepoda were higher in the vegetated areas than in

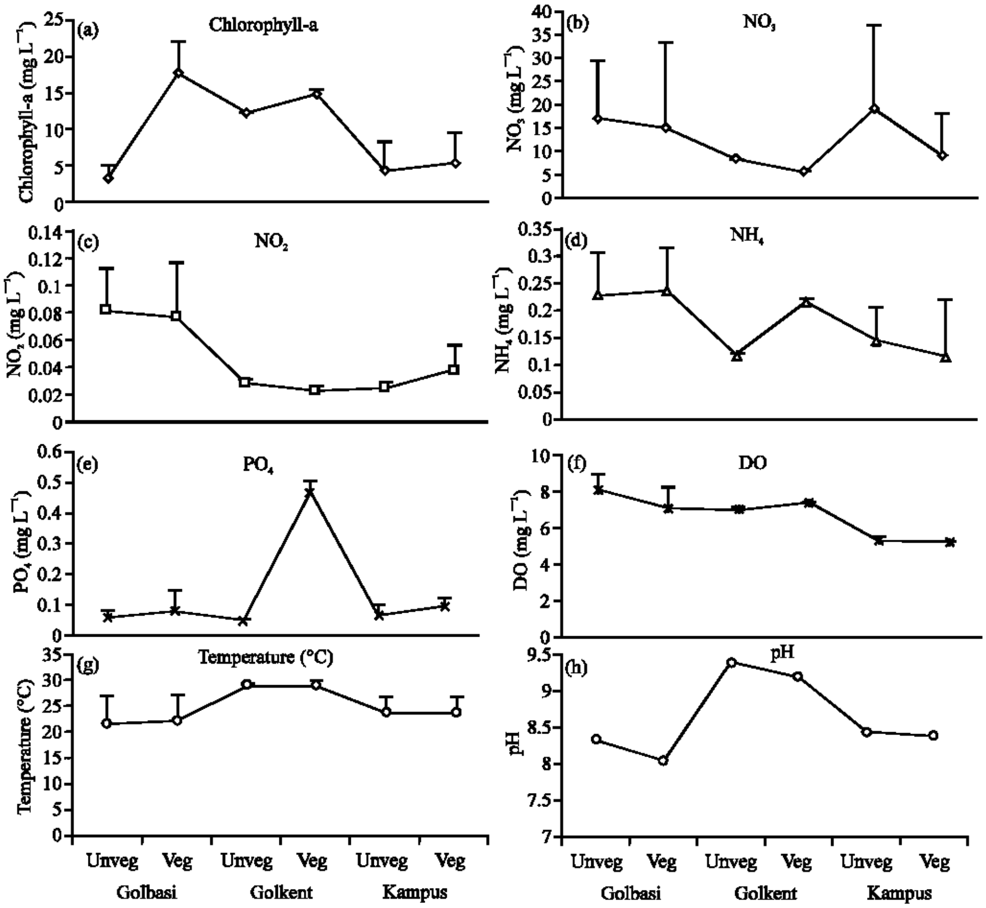

Fig. 1: Water quality parameters of lakes and reservoir

Table 1: Interaction between zooplankton and water quality parameters in vegetated and unvegetated area

	Correlation		
Parameters	Rotifer	Cladocera	Copepod
Unvegetated areas			
Total nitrogen	r = 0.45	r = 0.57	r = 0.99
Phosphate	r = 0.24	r = 0.37	r = 0.98
DO	r = 0.79	r = 0.72	r = 0.32
Temperature	r = 0.78	r = 0.86	r = 0.89
pH	r = 0.63	r = 0.73	r = 0.96
Chlorophyll-a	r = 0.69	r = 0.78	r = 0.96
Vegetated areas			
Total nitrogen	r = 0.60	r = 0.56	r = 0.13
Phosphate	r = 0.93	r = 0.08	r = 0.63
DO	r = 0.83	r = 0.87	r = 0.99
Temperature	r = 0.85	r = 0.19	r = 0.48
pH	r = 0.80	r = 0.27	r = 0.40
Chlorophyll-*a*	r = 0.67	r = 0.98	r = 0.96

unvegetated areas of the inland water bodies. Most of rotifer species occurred in vegetated area of Golbasi Lake (44 species) and followed by vegetated area of Lake Golkent (31 species). Similarly, the most cladocer and copepod species were found in vegetated area with

Table 2: The composition of zooplankton species in lakes and reservoir

		Species number of groups		
Lakes and reservoir	Stations	Rotifera	Cladocera	Copepoda
Golbasi	Unvegetated	22	9	7
	Vegetated	44	16	11
Gölkent	Unvegetated	22	4	-
	Vegetated	31	8	3
Kampus	Unvegetated	12	5	1
	Vegetated	18	7	6

16 and 11 species for Lake Golbasi and 7 and 6 species for Kampus Reservoir respectively (Table 2). Mean rotifer abundance was higher in the unvegetated areas of Lake Golkent (7552 individual m^{-3} ±13822.90) and Kampus Reservoir (10682 ind m^{-3} ±20636.26) than in vegetated areas of the same water bodies (Lake Golkent: 5264 ind m^{-3}±7881.65 and Kampus Reservoir: 1273 ind m^{-3} ±1914.34, respectively) (Table 3). However no significant difference was observed between vegetated and unvegetated areas of Lake Golkent according to statistical analyses (p = 0.2798), there was a significant difference

Table 3: Zooplankton abundance of lakes and reservoir

		Mean occurrence of groups (ind.m^3)					
		Rotifera		Cladocera		Copepoda	
Lakes and reservoir	Stations	Mean	SD	Mean	SD	Mean	SD
Golbasi	Unvegetated	1250	2875.40	607	283.67	498	408.56
	Vegetated	3290	11141.01	2437	2956.40	1463	1631.52
Golkent	Unvegetated	7552	13822.90	1031	830.50	0	0
	Vegetated	5264	7881.65	3846	3742.59	1190	948.34
Kampus	Unvegetated	10682	20636.26	590	538.25	315	24
	Vegetated	1273	1914.34	3658	2702.37	2761	2012.25

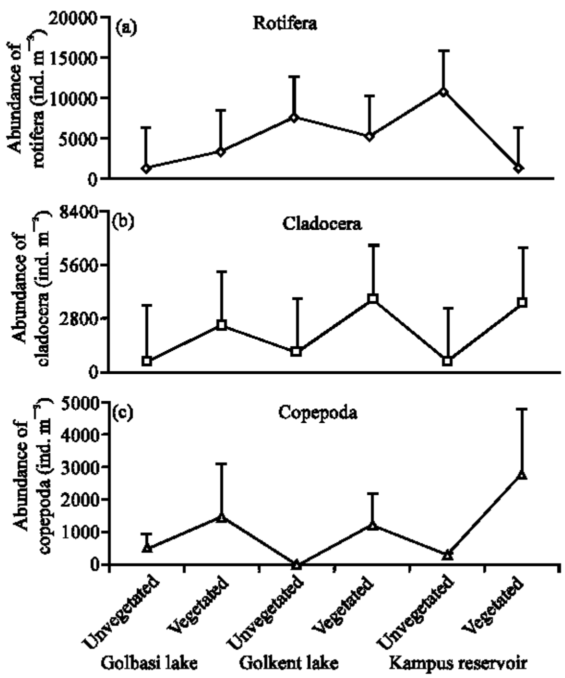

Fig. 2: Zooplankton (rotifer, cladocer and copepod) abundance in unvegetated and vegetated areas in lakes and reservoir

between rotifer abundance of both areas of Kampus Reservoir (p = 0.0001). Rotifer abundance was low (1250 ind m^{-3} ±2875.40) in the unvegetated areas of Lake Golbasi according to vegetated areas (3290 ind m^{-3} ±11141.01) (Fig. 2a), on the contrary of the Lake Golkent and Kampus Reservoir, however no statistically significant difference was found (p = 0.2702).

Abundance and species richness of Copepoda was less than that of cladoceran's throughout the study period in Lake Golbasi.

Cladocer abundance in the unvegetated areas was low (607 ind m^{-3}±283.67) but in the vegetated areas was significantly higher (2437 ind m^{-3} ±2956.40) (p = 0.0112). Similarly, copepod abundance in vegetated areas (1463 ind m^3 ±1631.52) was higher than in unvegetated areas (498 ind m^{-3} ±408.56) (p = 0.0777) (Fig. 2b and c) but no difference was found statistically. In Lake Golkent, the less cladocer and copepod species were found when compared with Lake Golbasi. The richness in species and the abundance of Cladocera exceeded that of Copepoda throughout the study period. Abundance of Cladocera in the vegetated area was about 6 times as high (3846 ind m^{-3} ±3742.59) as the that of the unvegetated (1031 ind m^{-3} ±830.50). Statistical analysis indicated that cladocer abundance in the vegetated area of Lake Golkent significantly differed unvegetated area (p = 0.0030) (Fig. 2b). While, no copepod species was found in the unvegetated area, three species detected the vegetated areas with an abundance of 1190±948.34 ind m^{-3} (p = 0.0001). Abundance and species richness of copepoda was less than cladoceran's during the study period in Kampus Reservoir. Cladocer abundance in the unvegetated areas was low (590 ind m^{-3} ±538.25) but significantly higher in the vegetated areas (3658 ind m^{-3} ±2702.37) (p = 0.0002). Similarly, copepod abundance of vegetated areas (2761 ind m^{-3} ±2012.25) was nine times as high as in the unvegetated areas (315 ind m^{-3} ±24.52) and copepod abundance of vegetated area was significantly differed from unvegetated area (p = 0.0041) (Fig. 2c).

It was found out that species richness of Cladocera and Copepoda was somewhat high in the vegetated areas.

In the present study, some of zooplankton species were found in only vegetated areas, while some in unvegetated areas but most of them in both areas. Thus, from rotifers in Lake Golbasi, *Brachionus angularis* Gosse, 1851, *B. quadridentatus* Hermann, 1783, *B. patulus* (Muller, 1786), *L. bulla* (Gosse, 1851), *L. quadridentata* (Ehrenberg, 1832), *L. lunaris* (Ehrenberg, 1832), *L. ohioensis* (Herrick, 1885), *L. ludwigi* (Eckstein, 1883), *L. hamata* (Stokes, 1896), *Lophocharis salpina* (Ehrenberg, 1834), *T. mucronata* (Gosse, 1886), *T. reflexa* (Gosse, 1887), *K. cochlearis cochlearis* (Gosse, 1851), *Trichotria tetractis* (Ehrenberg, 1830), *T. pocillum* (Muller, 1776), *Lepadella rhomboides* (Gosse, 1886), *Lepadella ehrenbergi* (Perty, 1850), *Trichocerca longiseta* (Schrank, 1802), *T. bicristata* (Gosse, 1887), *Colurella adriatica* (Ehrenberg, 1831), *C. uncinata* (Muller, 1773), *Monommata longiseta* (Muller, 1786), *Scaridium longicaudum* (Muller, 1786) and *Notommata copeus* Ehrenberg, 1934 were found in only vegetated area, but *Keratella valga* (Ehrenberg, 1834) and *Notholca squamula* (Muller, 1786) were found in only unvegetated area. On the other hand, *Polyarthra dolichoptera* Idelson, 1925, *Hexarthra fennica* (Levander, 1892), *Keratella quadrata* (Muller, 1786), *Mytilina unguipes* (Lucks, 1912) and *Anuraeopsis fissa* (Gosse, 1851) were found in both areas but they were more abundant in the unvegetated area of Lake Golbasi. Some other rotifers (*Lecane closterocerca* (Schmarda, 1859), *L. stenroosi* (Meissner, 1908), *L. luna* (Muller, 1776), *Testudinella patina* (Hermann, 1783), *Synchaeta elsteri* (Hauer, 1963), *Euchlanis dilatata, Dipleuchlanis propatula* (Gosse, 1886), *Dicranophorus grandis* (Ehrenberg, 1832), *Lepadella ovalis* (Muller, 1786), *Trichocerca porcellus* (Gosse, 1886), *Trichocerca elongata* (Gosse, 1886), *Platyias quadricornis* (Ehrenberg, 1832), *Mytilina mucronata* (Mueller, 1773), *M. ventralis* (Ehrenberg, 1832), *Cephalodella gibba* (Ehrenberg, 1832) were lower in the vegetated area of Lake Golbasi.

Rotifers in Lake Golkent, *Lecane ohioensis*, *L. ludwigi*, *L. hamata*, *Euchlanis dilatata*, *Platyias quadricornis*, *Scaridium longicaudum*, *Cephalodella gibba* Ehrenberg, 1832, *Macrochaetus* sp. and *Dissotrocha aculeata* (Ehrenberg, 1832) were found in only vegetated areas. *Brachionus angularis*, *B. calyciflorus* Pallas, 1766, *Polyarthra dolichoptera*, *Hexarthra fennica*, *H. oxyuris* (Sernov, 1903), *Lepadella ovalis*, *Trichocerca* sp. and *Asplanchna sieboldi* were more abundant in unvegetated areas, while some other rotifer species, *B. quadridentatus*, *Lecane clasterocerca*, *L. bulla*, *L. lunaris*, *L. luna*, *Testudinella patina*, *Trichotria tetractis*, *Dicranophorus grandis*, *Lepadella ehrenbergi*, *Trichocerca porcellus*, *M. ventralis*, *Anuraeopsis fissa* and *Collotheca mutabilis* (Hudson, 1885) were found to be more abundant in the vegetated areas of Lake Golkent.

Rotifers in Kampus Reservoir, *B. quadridentatus*, *Lecane bulla*, *Testudinella mucronata*, *Trichotria tetractis*, *Trichocerca porcellus*, *Monommata longiseta*, *Platyias quadricornis*, *Notommata copeus* and *Rotaria neptunia* (Ehrenberg, 1832) occured in only vegetated areas, whereas some of them, *Brachionus angularis, Cephalodella gibba* and *Asplanchna sieboldi* (Leydig, 1854) were found in only unvegetated areas. Rotifers found in two areas in the lake, including *Lecane stenroosi, Testudinella patina, Trichotria pocillum, Lepadella ovalis* were more abundant in the vegetated areas but some others, *L. luna, Polyarthra dolichoptera, Synchaeta elsteri*, *Trichocerca* sp. and *Anuraeopsis fissa* were more abundant in the unvegetated areas of Kampus Reservoir (Table 4).

In Lake Golbasi among Cladocera, *Diaphanosoma brachyurum* (Lievin, 1848), *Ceriodaphnia reticulata* (Jurine, 1820), *Ceriodaphnia pulchella* Sars, 1862, *Scapholeberis kingi* (Sars, 1888), *Ilyocryptus sordidus* (Lievin, 1848), *Leydigia acanthocercoides* (Fischer, 1854), *Camptocercus uncinatus* (Smirnov, 1971), *Alona rectangula* (Sars, 1861) from Copepoda group *Macrocyclops albidus* (Jurine, 1820), *Tropocyclops prasinus* (Fischer, 1860), *Ectocyclops phaleratus* (Koch, 1838), *Phyllognathopus viguieri* (Maupas, 1892), *Bryocamptus minutus* (Claus, 1863) were found in only vegetated areas. Among Cladocera, *Graptoleberis testudinaria* (Fischer, 1848) and among Copepoda, *Paracyclops fimbriatus* (Fischer, 1853) were observed in only unvegetated areas during study period and others including *Simocephalus vetulus* (Muller, 1776), *Alona costata* (Sars, 1862), *Alonella exigua* (Lilljeborg, 1853), *A. excisa* (Fischer, 1854), *Chydorus sphaericus* (Mueller, 1785), *Pleuroxus laevis* (Sars, 1861) and *P. aduncus* (Jurine, 1820) were more abundant in the vegetated areas. On the other hand, *Bosmina longirostris* (Muller, 1785) was more abundant in the unvegetated areas in Lake Golbasi (Table 5).

The only species from crustacea detected in the vegetated areas during study period were *Simocephalus vetulus*, *Alonella exigua* (Lilljeborg, 1853), *Pleuroxus laevis*, *P. aduncus*, *Mesocyclops leuckarti* (Claus, 1857), *Paracyclops fimbriatus* and *Leptocaris brevicornis* (Van Douwe, 1905) in Lake Golkent (Table 5).

Results of zooplankton analysis showed that some rotifer species, *Lecane ohioensis*, *L. ludwigi*, *L. hamata*, *Testudinella mucronata*, *Monommata longiseta*, *Scaridium longicaudum* and *Notommata copeus* were found in only vegetated area. Generally, there were fewer rotifer species in the unvegetated area than in vegetated area but the abundance of them in the unvegetated area was somewhat higher in Golkent and Kampus Reservoir (Table 4). Richness of cladocer and copepod species was similar to rotifer's. There was

Table 4: Rotifer composition and distribution of the lakes and reservoir

Lakes and reservoir/	Golbasi lake		Golkent lake		Kampus reservoir	
Rotifera	Unvegetated	Vegetated	Unvegetated	Vegetated	Unvegetated	Vegetated
Brachionus angularis (Gosse, 1851)	-	266±204.74	37618±4253.78	4771±3658.43	1298±62.93	-
B. quadridentatus (Hermann, 1783)	-	610±10.00	1170±493.70	17976±15585.98	-	308±9.19
B. calyciflorus (Pallas, 1766)	-	-	34699±2766.91	2703±2488.31	-	-
B. patulus (Müller, 1786)	-	490±10.00	-	-	-	-
Lecane closterocerca (Schmarda,1859)	312±1.53	3939±5371.74	1110±226.27	17187±15917.41	-	-
L. stenroosi(Meissner, 1908)	310±1.00	1316±1274.16	-	-	1271±26.87	1901±13.44
L . bulla (Gosse, 1851)	-	1770±2214.57	3873±2427.20	37469±8561.75	-	330±23.33
L. quadridentata (Ehrenberg, 1832)	-	376±63.69	-	-	-	-
L. lunaris (Ehrenberg, 1832)	-	466±274.92	930±14.14	14182±240.42	-	-
L. ohioensis(Herrick, 1885)	-	261±9.61	-	3386±1666.36	-	-
L. luna (Müller, 1776)	317±0.58	1165±581.96	760±42.43	708±335.17	1329±329.51	963±27.58
L. ludwigi (Eckstein, 1883)	-	2010±1553.71	-	923±32.53	-	-
L. hamata (Stokes, 1896)	-	912±249.43	-	642±14.85	-	-
L. flexilis (Gosse, 1886)	-	-	314±2.83	333±24.75	-	-
Polyarthra dolichoptera Idelson, 1925	5919±3624.97	420±181.08	12091±9186.65	6438±3751.91	71310±562.86	1237±35.36
Lophocharis salpina (Ehrenberg, 1834)	-	1028±24.75	-	-	-	-
Testudinella patina(Hermann, 1783)	520±172.05	6359±5901.92	844±237.43	15684±15428	2741±2993.89	7714±9683.83
T. mucronata (Gosse, 1886)	-	1035±1023.89	-	-	-	191±9.90
T. reflaxa (Gosse, 1887)	-	4679±7397.44	-	-	-	-
Hexarthra fennica (Levander, 1892)	344±40.13	-	11691±9283.16	3445±3203.32	-	-
Hexarthra oxyuris (Sernov, 1903)	-	-	48107±35790.1	6246±4599.89	-	-
Keratella valga (Ehrenberg, 1834)	297±40.71	-	-	-	-	-
K . cochlearis cochlearis (Gosse, 1851)	-	265±10.97	-	-	-	-
K. quadrata (Müller, 1786)	1216±401.64	248±4.24	-	-	-	-
Synchaeta elsteri Hauer, 1963	12958±1243.44	72982±142233.5	-	-	19623±7162.28	1105±236.17
Trichotria tetractis (Ehrenberg, 1830)	-	634±418.23	314±2.83	918±38.89	-	308±11.31
T. pocillum (Muller, 1776)	-	610±9.02	-	-	335±31.11	458±21.92
Euchlanis dilatata Ehrenberg, 1832	293±37.07	5859±5413.36	-	4286±4872.48	-	-
Dipleuchlanis propatula (Gosse, 1886)	315±2.83	708±513.09	-	-	-	-
Dicranophorus grandis (Ehrenberg, 1832)	317±5.66	505±124.91	321±2.12	709±557.20	-	-
Lepadella ovalis (Müller,1786)	1082±772.52	4229±5256.02	1885±20.51	789±671.04	296±22.63	903±169.71
L. rhomboides (Gosse, 1886)	-	1521±675.99	-	-	-	-
Lepadella ehrenbergi (Perty, 1850)	-	2601±72.12	394±110.31	2678±2448.06	-	-
Trichocerca porcellus (Gosse, 1886)	293±32.08	3025±2775.40	313±3.54	946±893.08	-	474±225.57
Trichocerca sp.	-	-	1318±240.31	1276±19.80	5193±24.75	627±8.49
T. elongata (Gosse, 1886)	250±1.53	2264±871.50	-	-	-	-
T. longiseta (Schrank, 1802)	-	241±14.85	-	-	-	-
T. bicristata (Gosse, 1887)	-	2268±166.88	-	-	-	-
Colurella adriatica (Ehrenberg, 1831)	-	271±27.58	-	-	-	-
C. uncinata (Muller, 1773)	-	1053±67.18	-	-	-	-
Notholca squamula (Muller, 1786)	251±1.00	-	-	-	-	-
Monommata longiseta (Muller, 1786)	-	522±26.16	-	-	-	315±1.41
Platyias quadricornis (Ehrenberg, 1832)	313±2.52	481±288.41	-	339±33.23	-	308±7.78
Scaridium longicaudum (Müller, 1786)	-	425±197.78	-	630±446.89	-	-
Notommata copeus (Ehrenberg, 1934)	-	616±36.06	-	-	-	4669±111.02
Mytilina mucronata (Mueller, 1773)	316±3.61	2131±2343.34	-	-	-	-
M. ventralis (Ehrenberg, 1832)	451±319.90	5765±8857.47	554±340.83	7653±3334.21	-	-
Mytilina sp.	317±2.52	-	-	-	-	-
Cephalodella gibba (Ehrenberg, 1832)	636±311.75	1546±1693.52	-	658±37.48	630±2.83	-
Anuraeopsis fissa (Gosse, 1851)	471±155.00	316±3.21	903±650.22	2037±2094.39	23292±1469.37	780±12.73
Asplanchna sieboldi (Leydig, 1854)	-	-	3801±2591.45	1417±1559.88	862±114.55	-
Macrochaetus sp.	-	-	-	4003±4153.55	-	-
Dissotrocha aculeata (Ehrenberg, 1832)	-	-	-	462±14.85	-	-
Collotheca mutabilis (Hudson, 1885)	-	-	3138±38.89	2287±1936.57	-	-
Rotaria neptunia (Ehrenberg, 1832)	-	-	-	-	-	330±23.33
Total	27494±2875.40	138188±11141.0	166148±13822.90	163170±7881.65	128180±20636.26	22921±1914.34

fewer species of Cladocera and Copepoda in the unvegetated area such as rotifer's but abundance of cladocer and copepod were very high in the vegetated area in the tree lakes during the study period (Table 5).

Table 5: Cladocer and copepod composition and distribution of the lakes and reservoir

Lakes and reservoir	Golbasi lake		Golkent lake		Kampus reservoir	
	Unvegetated	Vegetated	Unvegetated	Vegetated	Unvegetated	Vegetated
Cladocera						
Diaphanosoma brachyurum (Liévin, 1848)	-	311±5.66	-	-	-	-
Ceriodaphnia reticulata (Jurine, 1820)	-	1220±25.46	-	-	316±5.66	7530±9984.35
C. pulchella (Sars, 1862)	-	508±8.49	-	-	-	-
Simocephalus vetulus (Müller, 1776)	635±10.61	3402±4941.67	-	1066±1063.49	1546±22.63	6866±6173.75
Bosmina longirostris (Müller, 1785)	1230±23.33	321±7.78	-	-	-	-
Scapholeberis kingi (Sars, 1888)	-	4849±3336.39	-	-	-	-
Ilyocryptus sordidus (Liévin, 1848)	-	281±43.13	-	-	-	-
Moina micrura Kurz, 1874	-	-	1903±3.54	311±5.66	-	-
Leydigia acanthocercoides (Fischer, 1854)	-	320±6.36	-	-	311±2.83	1548±21.92
Camptocercus uncinatus (Smirnov, 1971)	-	2536±1495.24	1578±11.31	4248±2894.19	-	-
Alona rectangula (Sars, 1861)	-	1347±466.11	320±5.66	1720±262.03	-	1540±38.89
A. costata Sars, 1862	745±697.21	1442±551.42	-	-	-	-
Alonella exigua (Lilljeborg 1853)	626±9.19	1398±1026.83	-	6707±12.73	-	-
A. excise (Fischer, 1854)	310±4.24	1193±1028.84	-	-	-	-
Graptoleberis testudinaria (Fischer, 1848)	615±17.68	-	-	-	-	-
Chydorus sphaericus (Mueller, 1785)	360±152.74	6433±7939.14	-	-	462±13.44	1730±893.08
Pleuroxus laevis Sars, 1861	314±5.66	11386±18714.1	-	312±4.24	-	-
P. aduncus (Jurine, 1820)	625±8.49	2039±2536.77	-	5509±4089.96	-	1544±1144.10
Oxyurella tenuicaudis (Sars, 1862)	-	-	321±7.07	10896±11629.08	315±4.24	4845±3301.48
Total	5460±283.67	38986±2956.40	4122±830.50	30769±3742.59	2950±538.25	25603±2702.37
Copepoda						
Macrocyclops albidus (Jurine, 1820)	-	1377±20.51	-	-	-	-
Eucyclops speratus (Lilljeborg, 1901)	310±4.24	951±395.98	-	-	-	1985±4.95
Diacyclops bicuspidatus (Claus 1857)	503±355.67	729±213.60	-	-	315±4.24	309±7.07
Cryptocyclops bicolour (Sars, 1863)	316±3.54	1541±1330.27	-	-	-	4524±30.41
Megacyclops viridis (Jurine, 1820)	1411±220.62	6302±5472.47	-	-	-	3912±13.44
Tropocyclops prasinus (Fischer, 1860)	-	656±271.71	-	-	-	-
Mesocyclops leuckarti Claus, 1857	319±3.54	982±403.76	-	2207±7.78	-	5058±56.57
Ectocyclops pholeratus (Koch, 1838)	-	652±15.56	-	-	-	-
Paracyclops fimbriatus (Fischer, 1853)	308±7.78	-	-	329±21.21	-	780±8.49
Phyllognathopus viguieri (Maupas, 1892)	-	698±589.02	-	-	-	-
Nitokra hibernica (Brady, 1880)	323±13.44	1088±1093.19	-	-	-	-
Bryocamptus minutus (Claus, 1863)	-	1120±218.50	-	-	-	-
Leptocaris brevicornis (Van Douwe, 1905)	-	-	-	1035±48.67	-	-
Total	3488±408.56	16094±1631.52	-	3570±948.34	315±24.52	16567±2012.25

DISCUSSION

Though not significant in view of statistical aspect it was found out in water quality analyses that chlorophyll-a and phosphate rate were low in all three lakes within unvegetated areas and the nitrate and pH rates were low in vegetated areas. It was also observed that nitrite, dissolved oxygen (DO) temperature and ammonium did not exhibit a regular variation in the research areas. Also, observed was significant relation between zooplankton and water quality parameters. Armengol *et al.* (1998) pointed out that ecological factors have a prominent role in determining the abundance and distribution of rotifers. Wolfinbarger (1999) reported that ecological factors had an impact on seasonal succession of zooplankton and that temperature was one of the most important factors which affected the distribution and abundance of zooplankton.

It was also, pointed out by several researchers that there is a direct relation between increase in nitrite, nitrate, phosphate and the abundance of zooplankton (rotifer, cladocer and copepod) (Esler *et al.*, 2001; Vakkilainen *et al.*, 2004). Here, when nitrate and phosphate decrease due to consumption by primary product, namely phytoplankton the letter also triggers an increase in zooplankton; thus, any decline in phytoplankton will naturally lead to a decrease in zooplankton meanwhile causing an increase in unused inorganic substance.

Mageed (2005) claimed that certain deaths occurred due to stress by high pH, which also had a synergistic action upon zooplankton together with ammoniac and that there was a direct relationship between temperature increase in water and the increase in zooplankton. In addition, Patalas and Salki (1992) found that higher temperature affect physiology of several living organisms and their distribution. Gerten and Adrian (2002) also noted that the abundance of cyclopoid copepod particularly in summer time was related with water temperature. Devol (1981) pointed out that water containing lower rate of dissolved oxygen (DO) adversely effect the distribution, the reproduction and the growth of zooplankton and that zooplankton, which suffer from respiration trouble in freshwaters with < mg L^{-1} DO, migrated from their habitat and that the growth of zooplankton in deep water was hindered. Similar, findings were observed on the major impact by environmental parameters such as water temperature and DO on the distribution of zooplankton in our study as well.

It was reported in several studies that the quantitative of zooplankton species is closely related to aquatic vegetation and that zooplankton among vegetation was richer in qualitative and quantitative aspects due to fact that aquatic vegetation provided shelter and nutrient for zooplankton (Jeppesen *et al*., 2002; Timms and Moss, 1984; Lauridsen and Lodge, 1996; Norlin *et al*., 2005). Zooplankton (particularly cladocer) migrating to feeding areas in littoral zone where, phytoplankton is among other vegetation settle here leading to a remarkable increase in zooplankton quantity in the fauna (Hann and Goldsborough, 1997). Furthermore, Cladocera and Copepoda enforced to carry out a horizontal migration towards vegetation to shelter from light in shallow lakes where vertical migration is restricted during day light, which in turn contributes to diversity and the abundance of species in vegetated area (Timms and Moss, 1984; Lauridsen and Buenk, 1996; Lauridsen and Lodge, 1996).

Increased zooplankton in areas with abundant aquatic vegetation (particularly copepod, cladocer) lead to a decline in chlorophyll-a level due to phytoplankton consumption of living organisms the area, which in turn boosts quantity of nitrogen and phosphorus (Norlin *et al*., 2005). Similar results were obtain in this study, which detected more cladocer and copepod in vegetated area as well as an inverse and remarkable high relation between the levels of zooplankton and chlorophyll-a both in vegetated and unvegetated area.

Rotifer in unvegetated areas in Lake Golkent and Kampus Reservoir was found to be quantitatively more abundant while, the same was more abundant in vegetated areas in Lake Golbasi. However, this rotifer abundance was found to be statistically significant in only unvegetated areas within Kampus Reservoir ($p = 0.0001$) while others were not found to be worth recording.

Among different opinions on rotifer-macrophyte relationship, for instance Duggan (2001) suggested that quantity of rotifer diminished in areas where, macrophyte were abundant, on the other hand macrophyte had a major role in rotifer distribution especially, in littoral zone whereas, Pontin and Shiel (1995) claimed that variation in rotifer composition in vegetated areas dependent on the type of macrophyte, the morphology of vegetation, the epiphyte composition and the pressure by predator.

Macrophyte exhibits various distribution patterns in colonization, feeding and providing shelter against predators of several rotifer species. As reported by Duggan *et al*. (1998) regarding the study in Lake Rotomanuka (New Zealand) distribution of macrophytes play an essential role in rotifer distribution under various water quality parameters and seasonal conditions. Also, Duggan *et al*. (2001) noted that there are few studies on the ecology of rotifers relation with the macrophyte.

During the our study more rotifers were detected in Lake Golbasi among macrophyte than in unvegetated area just as pointed out by the literature whereas more rotifer occurred in unvegetated area in Lake Golkent and Kampus Reservoir, which is contrary to the literature. Similarly, Modenutti and Claps (1988) reported that rotifers were fewer in aquatic medium where floating vegetation were dominant in 14 rivers, Argentina. Since, floating plants prevailed in Lake Golkent and Kampus Reservoir, we are of the opinion that the quantity of rotifers might accordingly smaller.

It was determined in the study that the quantity of cladocer and copepod was higher in vegetated areas than in unvegetated stations in each of the 3 lakes throughout the sampling time. On the other hand, copepod abundance in vegetated areas in Lake Golbasi was not statistically significant, while cladocer in vegetated area in Lake Golbasi as well as the quantitative of copepod and cladocer in vegetated areas in Kampus Reservoir and in Lake Golkent was found to be statistically significant. It was reported by Blindow *et al*. (2000) that particularly Cladocera concentrated in places where macrophytes were concentrated. Zooplankton make use of underwater plant as shelter during day light, thus they can not only shelter against carnivorous but also get abundant food for themselves (Blindow *et al*., 2000; Lauridsen *et al*., 1996). Total herbivorous zooplankton biomass occurs in maximum level in vegetated area and it decreases in quantity as one gets further from vegetated area. According to findings from several studies, lush vegetation is in direct proportion with abundant zooplankton due to protective nature (Irvine *et al*., 1989; Paterson, 1993; Beklioglu and Moss, 1996a, b). Additionally Chow-Fraser *et al*. (1998) reported that as a result of decline in aquatic plants, particularly relatively larger zooplankton declined and disappeard and that many of them were attracted by predator fish in shallow lakes. Underwater plants as well as these with floating leave protect bigger zooplankton organisms from predator fish (Moss *et al*., 1998; Stansfield *et al*., 1997). Another reason for zooplankton to prefer vegetated areas as habitat is that more periphyton and bacteria occur among macrophyte than in unvegetated areas. Since, periphyton and bacteria form food resource for several zooplanktons, they attract them to vegetated areas (Burks *et al*., 2002). In several studies zooplankton species were determined to have values habitat preferences.

It was reported in a study by Duggan *et al*. (2001) that the abundance of certain rotifers i.e., *Cephalodella* sp., *Collotheca* sp., *Euchlanis dilatata*, *Keratella cochlearis*, *Lecane* sp., *Polyarthra* sp., *Synchaeta* sp., *Testudinella* sp. was caused largely by macrophytes. Meanwhile *Keratella cochlearis* a species less which has, less local dependance but more mobility, as reported not to have a preference for vegetated or unvegetated areas (Pejler, 1962; Pejler and Berzins, 1989). Paralel results were obtained in our study, where *Brachionus patulus* was detected among vegetation only in one lake namely Golbasi whereas *B. quadridentatus* occured in both unvegetated and vegetated zones, however, it was detected more in vegetated area. Similarly, certain species from genus *Lecane* were detected in both stations but more abundant in vegetated areas. On the other hand, species such as *L. ohioensis*, *L. ludwigi*, *L. hamata* occured only in vegetated stations.

Testudinella mucronata, *Monommata longiseta*, *Scaridium longicaudum* and *Notommata copeus* were detected only in unvgetated areas while other rotifer species occured both in vegetated and unvegetated area. In the literature, *Simocephalus vetulus*, *Ceriodaphnia* sp, *Chydorus sphaericus*, *Diaphanosoma* sp., *Pleuroxus* sp. and *Bosmina longirostris* which migrate horizontally in vegetated areas were reported to have relation with macrophytes which are more common such areas (Blindow *et al*., 2000; Lauridsen *et al*., 1996; Quade, 1969; Fairchild, 1981; Lehtovaara and Sarvala, 1984; Paterson, 1994; Jarvis *et al*., 1987; Vuille, 1991). In another study, by Smiley and Tessier (1998), *Diaphanosoma brachyurum*, *Simocephalus vetulus* and *Chydorus sphaericus* were reported to occur in both areas, more abundantly in vegetated areas and *Bosmina* and *Ceriodaphnia* were detected more in unvegetated area. Kornijo´w *et al*. (2005) reported that *Thermocyclops* and *Mesocyclops* belonging to Cyclopoid copepod occured more abundantly in vegetated areas.

In our study, it was find out that *Simocephalus vetulus*, *Chydorus sphaericus*, *Diaphanosoma brachyurum*, *Pleuroxus* sp. were more abundant in vegetated areas than in unvegetated stations and that *Ceriodaphnia* sp. occured in vegetated areas only in one lake namely Lake Golbasi. Meanwhile, *Bosmina longirostris* was detected in both vegetated unvegetated stations in one lake (Golbasi) as to other cladocer species, these mostly occured in both stations. Copepod species were detected more abundantly in vegetated station, as is described in former literatures.

CONCLUTION

Our observations on zooplankton ecology gave a valuable data for the inland water bodies in the sub-tropic latitudes of the world.

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