Study on composition and abundance of zooplankton assemblages in Eğirdir Lake (Isparta, Turkey)

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Abstract

To determine the composition and abundance of zooplankton assemblages in Eğirdir Lake-Turkey, monthly surveys were conducted from January to December 2010 at four stations. A total of 65 major zooplankton species were identified. Rotifera was the most abundant taxon dominated mainly by the species *Polyarthra dolichoptera* and *Keratella cochlearis*. Rotifers were recorded at the maximum abundance of 5.609 individuals/L in October at the fourth station, and their highest mean abundance was 783±1358 individuals/L at the third station. There was a highly significant difference (p<0.001) that October was differentiated from other sampling months with the highest rotifera and zooplanktonic abundance. Although the mean total zooplankton abundance at four stations was changed between 357±429 and 841±1375 individuals/L, no significant difference was recorded amongst sampling statitons in view point of abundance variation (p>0.05). The zooplankton abundance comprised: Rotifera = 89.62 %; Cladocera = 7.78 % and; Copepoda = 2.60 %. Newly reported species from the lake were: the rotifers *Conochilus dossuarius, Euchlanis dilatata, Trichotria tetractis, Trichocerca bicristata, Trichocerca capucina, Trichocerca cylindrica, Lecane stenroosi and Lepadella patella,* and the cladocerans *Biapertura affinis, Coronatella rectangula, Alona qaudrangularis, Alona guttata, Alonella excisa, Alonella nana, Disparalona rostrata, IIyocryptus sordidus, Acroperus harpae, Monospilus dispar* and *Camptocercus uncinatus*. The annual mean concentration of chlorophyll-a was 3.0±0.2 mg/m^3. According to the Carlson's trophic state index, Eğirdir Lake is mesotrophic–eutrophic. A *Brachionus*: *Trichocerca* quotient value of 1.25 was calculated, clearly indicating that the lake is mesotrophic. Zooplankton composition data were analyzed using Shannon's diversity index and ranged from 0.90–1.77.

Keywords: Zooplankton, Diversity, Abundance, Mesotrophic, Eğirdir Lake.

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Introduction

Zooplankton constitutes the main food source for most fish species during juvenile and post-larval stage. Filter-feeding zooplankton responds to a change from poorer quality imported detrital particles to improved quality of algal and bacterial particles by increasing in abundance (Wetzel, 2001). In addition, some species of zooplankton are usually considered to be useful indicators of water quality and trophic state (Michaloudi *et al*., 1997). Rajashekhar *et al*. (2009) stated that Rotifera are sensitive to environmental changes and are therefore useful as indicators of water quality. Canfield and Jones (1996) have reported that increases in zooplankton density are in proportion to the increase of trophic levels in a lake. Eğirdir Lake is located in southern Turkey at an elevation of 918 m above sea level. The surface area and mean depth of the lake are 47.250 ha and 7–8 m, respectively (Yarar and Magnin, 1997). The lake serves as a municipal water source for the city of Isparta, and therefore, maintenance of good water quality is important within the lake. Over recent decades, numerous investigations of zooplankton abundance and composition in various water masses have been conducted (Akbulut, 2000; Ferrara *et al*., 2002; Bozkurt, 2006; Patra *et al*., 2011; Saler, 2011; Ustaoğlu *et al*., 2012a). Previous studies have provided basic information and showed that certain biotic formations were related to lake trophic state (Sendacz *et al*., 2006; Frutos *et al*., 2009; Demirkalp *et al*., 2010; Rahmati *et al*., 2011).

Previous investigations of zooplankton in Eğirdir Lake occurred between 1940 and 2002, and were especially directed towards the identification of taxa. Other research (Mann, 1940; Kiefer, 1952, 1955; Numann, 1958; Fiers, 1978; Gündüz, 1984; Dumont and De Ridder, 1987; Gündüz, 1987; Rahe and Pelister, 1987; Demirhindi, 1991; Emir, 1991; Gündüz, 1997; Kazancı *et al*., 1999; Aksoylar and Ertan, 2002; Kaya and Altındağ, 2007a, b; Didinen and Boyacı, 2007) provided taxonomic information for rotifers, cladocerans and copepods. Detailed information on limnology and diversity of zooplankton were presented by Aksoylar and Ertan (2002). The aim of this research was to describe the recent zooplankton composition as well as annual changes, and to compare results with those of previous studies to recognize possible trophic state of the lake.

Materials and methods

Monthly sampling was conducted during January –December 2010 from four stations on Eğirdir Lake (Fig.1). Zooplankton samples were collected with Hydro-Bios plankton net (55 µm) at the surface and vertically within the water column, filtered through a 55 µm plankton net, and fixed in formaldehyde (4%). Zooplankton taxa present in the samples were identified according to the following authors: Dussart (1967, 1969); Koste (1978); Negrea (1983); Korovchinsky (1992); Segers (1995); Smirnov (1996); Nogrady and Segers (2002) and; Ustaoğlu *et al*., (2012b) and counted under an inverted microscope. Three sub-samples were transferred into a 1ml Sedwick Rafter counting chamber to determine the species composition and abundance of zooplankton (Edmondson, 1959).

Horizontal profiles of water temperature, conductivity and pH (YSI 63 model) were measured during each sampling period. Dissolved Oxygen (DO) was measured in-situ at each station using an YSI oxygen meter (model 55). All water quality variable measurements were performed on raw water samples collected from the surface according to the techniques outlined in the standard methods (Egemen and Sunlu, 1996; Wetzel and Likens, 2000). Water quality variables analyzed included temperature, pH, conductivity, DO, transparency (Secchi depth or SD), chlorophyll-a (chl-a), nitrate, total-phosphate (TP), sulfate, silica, ammonium and total hardness.

Normality of data was tested using the Shapiro-Wilk's test. Since the data were non-normally distributed, abundance of zooplanktonic groups was compared using a signed rank test (Wicoxon/Kruskal-Wallis) and followed by post hoc test (Tukey's HSD test). Statistical tests were carried out using JMP (Version 8.0).

Carlson's Trophic State Index (TSI) was calculated for TP, SD and chl-a (Carlson, 1977). Shannon's Diversity Index (H') was calculated for zooplankton data at each sampling date (Molles, 2002). Where P_i is proportion by the number of zooplankton species i.

$$H' = -\sum_{i=1}^{s} p_i \log_e p_i$$

The *Brachionus*: *Trichocerca* quotient ($Q_{B/T}$) (Sládeček, 1983) was also calculated to determine the trophic level of Eğirdir Lake in the present study.

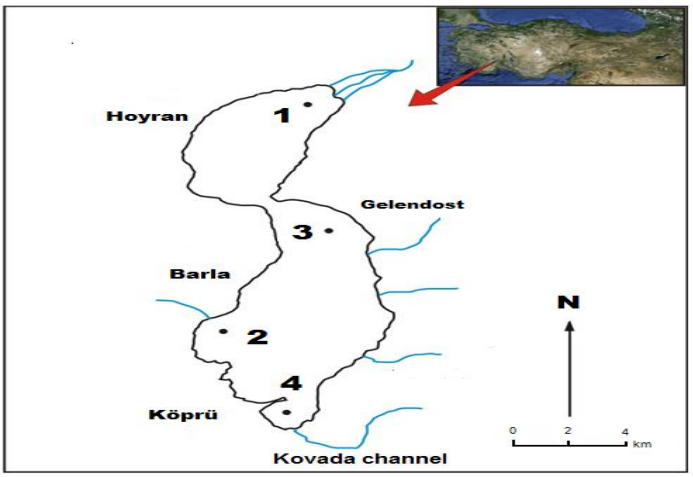

Figure 1: Map of the study area and sampling stations in Eğirdir Lake. (Isparta, Turkey)
1st Station: 38º 15' 48"N, 30º 49' 17"E
2nd Station: 37º 58' 50"N, 30º 47' 32"E,
3rd Station: 38º 05' 14"N, 30º 55' 45"E,
4th Station: 37º 50' 52"N, 30º 51' 29"E.

Results

Zooplankton composition and abundance:

The zooplankton found in Eğirdir Lake belonged predominantly to Rotifera, Cladocera and Copepoda groups. A total of 65 species were identified. The monthly distributions of the species are given in Table 1. Zooplankton abundance changed monthly between 7 and 5668 individuals/L (Table 2). Mean abundances of Rotifera and Copepoda were the highest in October (3016±2424 and 53±32 individuals/L respectively), while the highest mean abundance of Cladocera was 245±84 individuals/L in December. Nonparametric test showed that October, in point of view of mean abundance of Rotifera and Cladocera, was significantly different from the other months (Table 2). Although a trend of high mean zooplankton abundance was appeared at stations 3 and 4 (841±1375 and 719±1572 individuals/L respectively), a significant spatial variation was not recorded between the sampling stations (p>0.05) in spite of a clear temporal variation (Table 2). The mean zooplankton abundance in the lake ranged from 42±24 to 3092±2435 individuals/L throughout the period of the study. The zooplankton community was dominated by rotifers which constituted up to 89.6 percent of annual mean abundance. The proportions of zooplankton belonging to Cladocera and Copepoda were found to be 7.8 % and 2.6 %, respectively (Fig. 2).

Table 3 shows zooplankton taxa encountered in the lake and their abundances at sampled stations. *P.dolichoptera* consistently occurred at all stations and was the most abundant species. Other common species include *K. cochlearis*, *B.angularis*, and *B.longirostris*. Monthly variation in zooplankton diversity and chl-*a* was averaged for the four sampling stations and are shown in Fig. 3. Generally, diversity was highest in July (1.77) and January (1.52), and lowest in October (0.90).

Water quality

Monthly variations of the water quality variables are presented in Table 4. Water temperature ranged from 6.9–26.8 throughout the study period with a mean of 16.4 °C. Values of pH ranged from 8.4 in November to 9.6 in December 2010. Transparency at the study site ranged from 0.5 m recorded in February to 2.4 m in August with a mean value of 1.54 m. DO was highest in December (12.6 mg/L) and lowest (4.17 mg/L) in August with a mean value of 9.44 mg/L. The highest conductivity value (417.5 µS/cm) was recorded in July while the lowest value (261.8 µS/cm) was in February with a mean of 342 µS/cm. The lowest total hardness value (24.3 mg/L) was recorded during June and July while the highest (30.8 mg/L) was in December. Nitrate was highest (3.8 mg/L) in August, while the lowest value (0.9 mg/L) was recorded in September. Ammonium ranged from 0.1 mg/L–0.4 mg/L. Measured TP concentrations ranged from 0.42 mg/L recorded in August to 0.06 mg/L in May. Sulfate concentrations ranged widely from 19.7 mg/L recorded in January to 53.3 mg/L in August. Silica concentrations ranged from 6.7 mg/L recorded in November to 2.40 mg/L in April, with a mean of 4.4 mg/L. Chl-a concentration ranged from 1.3 mg/m^3 recorded in February to 6.1 mg/m^3 in May.

The minimum depth of 4.1 m was measured in November while the maximum depth of 5.9 m was measured in March. TSI values for TP averaged between 46 in October to 67 during February–August (Fig. 4). The TSI of chl-a and secchi depth presented lower values than the TSI for TP concentration.

Table 1: Check-list of zooplankton species in Eğirdir Lake (Isparta, Turkey) – 2010.

Family/Species	J	F	M	A	M	J	J	A	S	O	N	D
Phylum:ROTIFERA												
Subclass: Bdelloidea Hudson 1884												
Fam. Philodinidae Ehrenberg 1838												
Rotaria sp.	-	+	-	-	-	-	-	-	-	-	-	-
Subclass: Monogononta Plate 1889												
Fam. Brachionidae Ehrenberg 1838												
P. quadricornis (Ehrenberg 1832)	+	-	-	-	+	+	+	+	-	-	-	-
B.angularis Gosse 1851	-	-	-	-	-	+	+	+	+	+	+	-
B.calyciflorus Pallas 1766	+	+	+	+	+	+	-	-	-	-	-	-
B.patulus (Müller 1786)	-	-	-	-	-	-	-	+	-	-	-	-
B.quadridentatus Hermann 1783	-	-	-	-	+	-	+	-	-	-	-	-
B. urceolaris Müller 1773	+	-	-	-	-	-	-	-	-	-	-	-
K.cochlearis (Gosse 1851)	+	+	+	+	+	+	+	+	+	+	+	+
K.quadrata (Müller 1786)	-	-	-	+	-	-	-	-	-	+	-	-
N.acuminata (Ehrenberg 1832)	-	+	-	+	-	-	-	-	-	-	-	-
N. squamula (Müller 1786)	-	+	-	-	-	-	-	-	-	-	-	-
E. dilatata Ehrenberg 1832	-	-	-	-	+	+	+	+	+	+	-	+
Mytilina sp.	-	-	-	-	-	-	+	+	-	-	-	-
T.pocillum (Müller 1766)	-	-	+	-	+	-	-	+	-	-	-	-
T. tetractis (Ehrenberg 1830)	-	+	-	-	-	-	+	+	-	-	-	-
C.colurus (Ehrenberg 1830)	-	-	-	-	-	-	-	-	+	-	-	-
Squatinella sp.	-	-	-	-	-	-	-	+	-	-	-	-
L. patella (Müller 1773)	-	-	-	-	-	-	-	+	-	-	-	-
Fam. Lecanidae Remane 1933												
L.flexilis (Gosse 1886)	-	-	-	-	+	-	-	-	-	+	-	-
L.luna (Müller 1776)	+	-	-	-	+	+	+	+	+	-	-	-
L. bulla (Gosse 1851)	-	-	-	-	+	+	+	+	+	+	-	-
L. clostrocerca (Schmarda 1859)	-	-	-	-	+	-	+	+	-	+	+	-
L. lunaris (Ehrenberg 1832)	-	-	-	-	-	-	-	+	-	-	+	-
L. quadridentata (Ehrenberg 1832)	-	-	-	-	-	-	-	-	-	+	-	-
L.stenroosi (Meissner 1908)	-	-	-	-	-	-	+	+	+	-	-	-
Lecane sp.	-	-	-	-	-	-	-	-	+	-	+	-
Fam. Scaridiidae Manfredi 1927												
S.longicaudum (Müller 1786)	-	-	-	-	-	+	-	+	-	-	-	-
Fam. Notommatidae Hudson & Gosse 1886												
C.gibba (Ehrenberg 1830)	-	-	-	+	+	-	+	-	-	-	+	-
Fam. Trichocercidae Harring 1913												
T. bicristata (Gosse 1887)	-	-	-	-	-	-	+	+	+	+	-	-
T. capucina (Wierzejski&Zacharias 1893)	-	-	-	-	-	+	+	+	+	+	-	-
T. cylindrica (Imhof 1891)	-	-	-	-	-	-	+	+	+	+	+	-
T. similis (Wierzejski 1893)	-	-	-	-	-	-	+	+	+	+	+	-
Fam. Gastropodidae Harring 1913												
Ascomorpha sp.	+	+	-	-	-	+	+	+	+	+	+	-
Fam. Synchaetidae Hudson & Gosse 1886												
S.pectinata Ehrenberg 1832	+	+	+	+	+	+	+	+	+	+	+	+
P.dolichoptera Idelson 1925	+	+	+	+	+	+	+	+	+	+	+	+
Fam. Asplanchnidae Eckstein 1883												

Table 1 continued:												
A.priodonta Gosse 1850	+	+	+	+	+	+	+	+	+	+	+	+
Fam. Testudinellidae Harring 1913												
T.patina (Hermann 1783)	-	+	-	-	+	+	+	+	-	-	+	+
Fam. Conochilidae Harring 1913												
C. dossuarius (Hudson 1885)	-	-	+	-	+	+	+	+	+	+	+	+
Fam. Hexarthridae Bartos 1959												
H. mira (Hudson 1871)	-	-	-	-	-	+	+	+	+	-	-	-
Fam. Filiniidae Harring & Myers 1926												
F.longiseta (Ehrenberg 1834)	+	+	-	-	-	+	+	+	+	+	-	+
Phylum: ARTHROPODA												
Order: Diplostraca Gerstaecker 1866												
Suborder: CLADOCERA												
Fam. Sididae Baird 1850												
S.crystallina (Müller 1776)	-	-	-	-	-	+	-	+	-	-	-	-
D.lacustris Korinek 1981	-	-	-	-	-	-	-	+	+	+	-	-
Fam. Daphniidae Sars 1865												
D.cucullata Sars 1862	+	+	-	-	+	+	+	+	+	+	-	-
C.quadrangula (Müller 1785)	-	-	-	-	-	-	+	+	+	-	+	+
Fam. Moinidae Goulden 1968												
M. micrura Kurz 1874	-	-	-	-	-	-	-	+	-	-	-	-
Fam. IIyocryptidae Sars 1862												
I.sordidus (Liévin 1848)	-	-	-	-	-	-	-	-	-	-	+	-
Fam. Macrothricidae Norman & Brady 1867												
M. laticornis (Fischer 1851)	+	-	-	-	-	+	+	+	-	-	-	-
Fam. Bosminidae Baird 1845												
B. longirostris (Müller 1785)	+	+	+	+	+	+	+	+	+	+	+	+
Fam. Chydoridae Stebbing 1902												
P. aduncus (Jurine 1820)	-	+	-	-	+	-	+	+	-	-	-	-
A.excisa (Fischer 1854)	-	+	+	-	-	-	-	-	-	-	-	+
A. nana (Baird 1850)	+	+	-	-	-	-	-	-	-	-	+	+
D. rostrata (Koch 1841)	+	+	-	-	+	+	+	+	+	+	-	+
C.sphaericus (Müller 1776)	+	+	+	+	+	+	+	+	+	+	+	+
A. guttata Sars 1862	-	-	-	-	+	+	+	-	-	+	+	+
A.quadrangularis (Müller 1776)	+	+	-	+	+	+	+	+	-	-	+	+
C. rectangula (Sars 1861)	+	-	-	-	+	+	+	+	-	-	+	+
C. uncinatus Smirnov 1971	-	-	-	-	-	-	+	+	-	-	-	-
A.harpae (Baird 1834)	-	-	-	-	-	-	-	+	+	+	+	-
G. testudinaria (Fischer 1848)	+	+	-	-	+	+	+	-	-	-	+	-
L.leydigi (Schoedler 1863)	-	-	+	-	+	+	+	+	-	-	+	-
B. affinis (Leydig 1860)	+	+	-	-	+	-	-	-	-	-	-	+
M.dispar Sars 1861	-	-	-	-	+	+	+	-	-	-	-	-
Subclass: COPEPODA												
Order: Cyclopoida Sars 1918												
Fam. Cyclopoidae G.O.Sars 1913												
E.speratus (Lilljeborg 1901)	-	+	-	-	-	-	+	-	-	-	+	+
M.leuckarti bodanicola (Kiefer 1928)	+	+	-	+	+	+	+	+	+	+	+	+
Order: Harpacticoida												
Fam. Ameiridae												
N. hibernica (Brady 1880)	+	+	-	+	+	+	+	+	+	+	+	+

Table 2: Temporal and spatial variation (mean ± SD) of abundance (individuals/L) of zooplanktonic groups. Values in phrases are minimum and maximum abundances. Values within the same columns not sharing a common superscript letter were significantly different (Tukey's HSD test, $p<0.001$).

	Rotifera	Cladocera	Copepoda	Total abundance
		Temporal variation		
J	98±38^{a} (62-151)	12±7^{a} (6-20)	7±14^{a} (0-28)	117±36^{a} (94-170)
F	59±37^{a} (17-107)	11±7^{a} (7-21)	6±7^{a} (0-14)	76±49^{a} (24-141)
M	34±23^{a} (0-52)	7±1^{a} (5-8)	2±4^{a} (0-8)	42±24^{a} (7-58)
A	92±37^{a} (57-140)	9±3^{a} (7-13)	7±6^{a} (0-15)	109±32^{a} (79-149)
M	128±140^{a} (36-333)	10±3^{a} (8-13)	5±8^{a} (0-16)	143±144^{a} (44-352)
J	908±858^{a} (399-2189)	13±8^{a} (6-24)	23±13^{ab} (12-43)	944±869^{a} (424-2241)
J	153±59^{a} (70-199)	17±7^{a} (10-25)	19±9^{a} (13-33)	189±54^{a} (112-232)
A	182±173^{a} (70-440)	47±51^{a} (14-122)	22±12^{ab} (14-39)	251±161^{a} (142-485)
S	1025±772^{a} (175-1883)	18±6^{a} (11-25)	21±4^{a} (17-25)	1064±771^{a} (224-1927)
O	3016±2424^{b} (660-5609)	23±5^{a} (17-28)	53±32^{b} (30-98)	3092±2435^{b} (707-5668)
N	368±457^{a} (55-1046)	131±165^{ab} (31-377)	9±3^{a} (8-13)	508±427^{a} (116-1090)
D	184±83^{a} (90-292)	245±84^{b} (126-321)	6±7^{a} (0-15)	435±18^{a} (411-448)
Spatial variation				
1st Station	312±416 (0-1267)	26±33 (6-126)	19±13 (0-52)	357±429 (7-1346)
2nd Station	321±524 (36-1883)	73±124 (5-377)	11±13 (0-39)	406±527 (44-1927)
3rd Station	783±1358 (39-4528)	37±70 (8-257)	20±28 (0-98)	841±1375 (54-4646)
4th Station	665±1570 (17-5609)	44±89 (7-321)	10±10 (0-31)	719±1572 (24-5668)

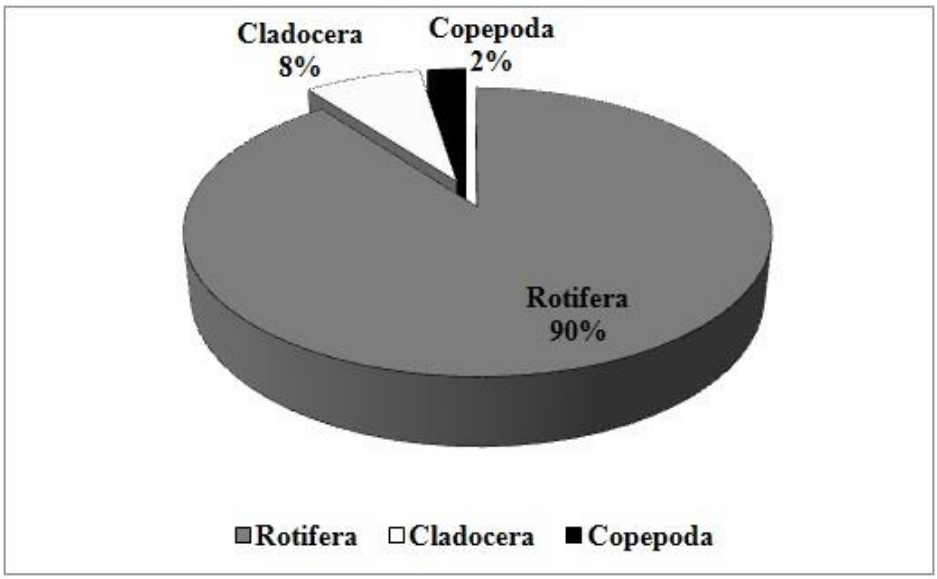

Figure 2: Distribution of zooplankton abundance in Eğirdir Lake (Isparta, Turkey) – 2010.

Table 3: Zooplankton species abundance during the study period in Eğirdir Lake (Isparta, Turkey) - 2010.

	Sampling Stations			
Species	**I. station**	**II.station**	**III.station**	**IV. station**
Rotifera				
K. cochlearis	++	+	+	++
K. quadrata				+
A. priodonta	+	+	+	+
S. pectinata	+	+	+	+
P. dolichoptera	++	++	+++	+++
F.longiseta	+	+	+	+
B. angularis	+	+	+	++
B.calyciflorus		+		+
B. patulus				+
H. mira	++		+	+
Ascomorpha sp.	+	+	+	+
C.dossuarius	+	+	+	+
T. similis	+	+	+	+
T.cylindrica	+	+	+	
T. bicristata	+	+		
T.capucina		+	+	+
T.patina	+			
N. squamula			+	
L. flexilis			+	
P.quadricornis				
C. gibba				+

Table 3 continued:

Cladocera				
B.longirostris	+	++	+	+
A. quadrangularis	+	+		+
C. rectangula	+			
C. sphaericus	+			+
C.quadrangula	+	+	+	
D. cucullata	+	+	+	+
A.harpae	+			+
D.lacutris		+	+	+
G.testudinaria				+
Copepoda				
N. hibernica	+	+	+	+
E. speratus	+			
M.leuckarti bodanicola	+	+	+	+
N. larva	+	+	+	+

\+ -Few (below 50 Ind/L)
++ -Abundant (between 50 and 400 Ind/L)
+++ - Most Abundant (400 Ind/L and above)

Table 4: Monthly variations of water quality variables during the study period in Eğirdir Lake (Isparta, Turkey) – 2010.

Months	January	February	March	April	May	June	July	August	September	November	October	December	Mean±SD
Temperature (°C)	7.2±0.2	6.9±0.5	12.5±1.9	15.0±1.9	18.8±0.5	22.8±0.7	26.2±1.0	26.8±0.4	22.8±0.4	16.3±0.4	13.0±0.6	8.2±0.1	16.4±0.4
pH	8.7±0.2	8.7±0.2	8.7±0.1	8.8±0.1	8.8±0.2	8.6±0.8	8.9±0.1	9.0±0.2	9.1±0.2	8.4±0.1	9.1±0.3	9.6±0.1	8.9±0.2
Conductivity (µS/cm)	271.4±5.4	261.8±11.3	310.5±20.8	336.1±25.9	365.3±11.3	390.5±10.2	417.5±39.7	379.1±50.6	372.8±49.2	400.5±15.3	323.6±9.7	273.8±19.9	342±5.0
Depth (m)	4.7±2.0	5.4±1.0	5.9±1.0	5.1±0.7	5.1±1.5	5.8±1.2	5.1±0.9	4.9±1.3	5.6±1.1	4.1±1.9	5.1±0.6	5.7±0.4	5.2±0.9
Transparency (m)	1.7±1.0	0.5±0.3	1.3±0.4	1.2±0.2	1.6±0.2	1.8±0.8	2.0±0.8	2.4±1.1	1.5±0.4	1.7±0.8	2.0±1.2	0.8±0.4	1.5±0.4
Dissolved oxygen (mg/L)	11.3±0.7	11.9±0.3	10.6±0.4	10.0±0.4	8.0±0.5	7.6±0.2	7.6±1.4	4.2±0.2	7.8±1.2	10.8±0.7	10.9±1.1	12.6±0.6	9.4±0.02
Saturation of dissolved oxygen (%)	93.3±5.1	95.5±6.6	98.7±2.6	98.2±5.0	87.3±6.3	91.5±2.7	94.0±18.1	52.3±2.8	87.7±8.2	102.1±7.9	101.6±10.1	106.5±4.8	92.4±1.6
Chlorophyll-a (mg/m^3)	4.3±1.6	1.3±0.5	2.4±0.6	3.2±0.3	6.1±2.7	2.4±0.8	1.7±0.7	2.8±0.6	2.0±0.3	4.4±1.4	2.8±1.3	2.9±0.4	3.0±0.2
Nitrate (mg/L)	1.2±0.3	1.0±0.7	1.0±0.4	1.1±0.1	1.3±0.3	2.6±0.2	2.6±1.2	3.8±0.7	0.9±0.2	1.1±0.2	1.4±0.5	2.6±1.1	1.7±0.1
Ammonium (mg/L)	0.1±0.0	0.3±0.4	0.1±0.0	0.1±0.0	0.1±0.1	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.4±0.3	0.2±0.0	0.13±0.05
Total-phosphate (mg/L)	0.3±0.2	0.3±0.1	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.2±0.1	0.4±0.4	0.1±0.1	0.1±0.1	0.4±0.4	0.1±0.0	0.2±0.1
Sulfate (mg/L)	19.7±10.5	47.1±21.8	50.9±17.3	43.6±12.3	39.4±14.6	35.3±3.1	25.7±6.5	53.3±19.4	42.9±14.5	48.3±16.3	27.3±7.8	40.4±5.2	39.5±10.7
Silica (mg/L)	4.4±1.7	4.8±1.9	2.4±0.9	2.4±0.4	3.2±0.9	3.3±0.8	4.7±1.7	4.6±0.7	5.3±0.4	6.7±0.5	6.3±0.7	4.6±0.5	4.4±0.3
Total hardness (°F)	26.3±1.0	24.5±2.6	27.3±2.8	30.3±1.9	26.5±2.1	24.5±0.6	24.3±2.5	24.3±1.7	25.3±2.5	27.3±1.7	30.0±0.8	30.8±2.9	26.8±0.9

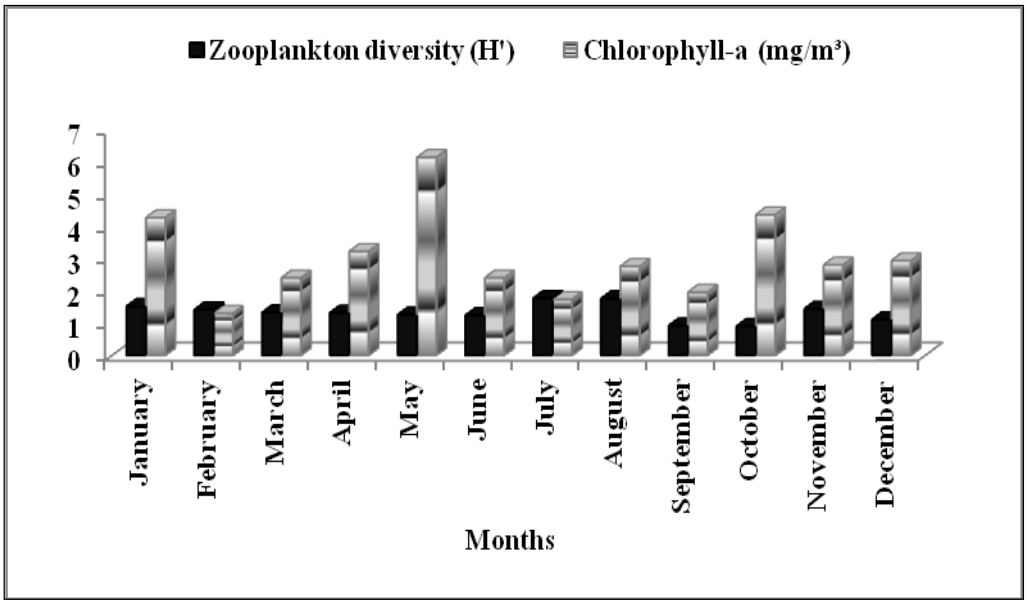

Figure 3: Variations in zooplankton diversity and chlorophyll-a during the study period in Eğirdir Lake (Isparta, Turkey) – 2010.

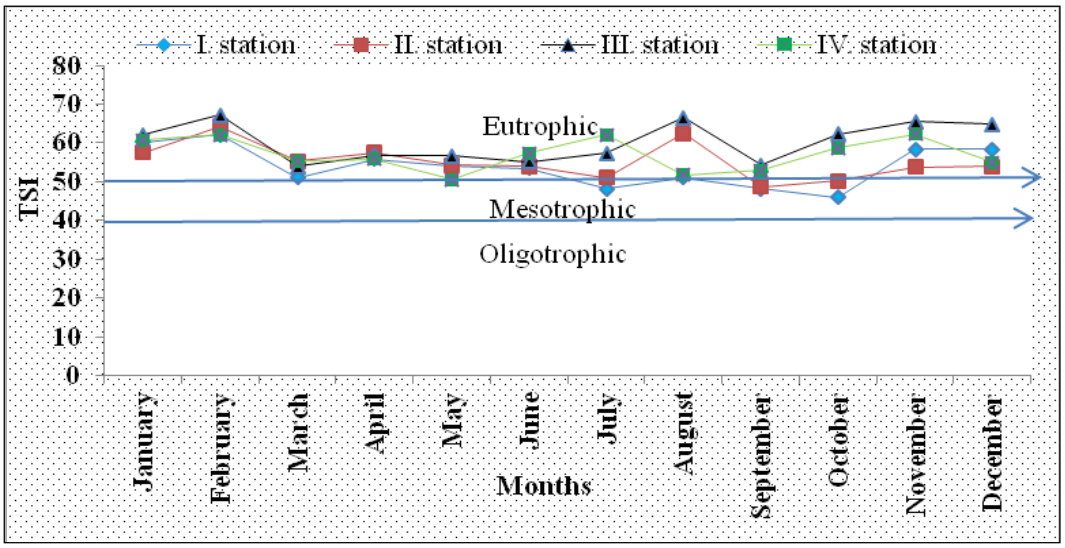

Figure 4: Monthly variations in trophic state index (TSI) during the study period in Eğirdir Lake (Isparta, Turkey) - 2010.

Discusson

Zooplankton composition and abundance

In this study, a total of 65 zooplankton species were identified in Eğirdir Lake: 40 species belonged to Rotifera; 22 species belonged to Cladocera and 3 Copepod species. Among the species identified, *K. cochlearis, Synchaeta pectinata, P. dolichoptera, A.priodonta, C.dossuarius,*

B. longirostris, *C.sphaericus* and *M. leuckarti bodanicola* were recorded throughout the sampling period. In contrast, *B. patulus, C. colurus, Squatinella* sp., *L.patella, L. quadridentata, M.micrura,* and *I.sordidus* were rarely found in the lake. *K. cochlearis, B.quadridentatus, T.pocillum, L.bulla, B. longirostris, and M.leuckarti bodanicola* were the most frequently observed species of zooplankton in the lake, since they have been identified in previous research (Table 5). During this study, a total of 43 species were common with those reported by Mann (1940), Kiefer (1952–1955), Fiers (1978), Gündüz (1984), Rahe and Pelister (1987), Gündüz (1987), Demirhindi (1991), Emir (1991), Gündüz (1997), Kazancı *et al*. (1999), Aksoylar and Ertan (2002), Kaya and Altındağ (2007a, b) and Didinen and Boyacı (2007). Of the species identified during previous studies, a total of 27 species (Mann, 1940; Kiefer, 1952,1955; Numann, 1958; Fiers, 1978; Gündüz, 1984; Dumont and De Ridder, 1987; Gündüz, 1987; Rahe and Pelister, 1987; Demirhindi, 1991; Kazancı *et al*., 1999; Aksoylar and Ertan, 2002; Kaya and Altındağ, 2007a, b; Didinen and Boyacı, 2007) were not observed during our study (Table 5).

The preliminary study on the zooplankton within the lake was initiated by Numan in 1940. According to Aksoylar and Ertan (2002), 41 Rotifera, 10 Cladocera and 4 Copepoda species were reported within the lake. The zooplankton community within the lake is currently dominated by Rotiferans, as it was in previous studies (Aksoylar and Ertan, 2002). Until 2000, *E.drieschi, E.vulgaris, and L.kindtii* were the most important zooplankton species found in the lake. However, these species were not found during this research. Apart from the Rotiferans and Cladocerans, *B. longirostris* was also relatively abundant in the lake. In contrast, *C. sphaericus* showed lower abundance. While the maximum number of 28 Rotiferan and 15 Cladoceran species were recorded in August, the minimum number of species belonged to Copepoda which was recorded in March (Table 1).

Table 5: List of zooplankton species examined during the present and previous studies in Eğirdir Lake (Isparta, Turkey) – 2010.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	Present study	Indicators of mesotrophic-eutrophic
Filinia terminalis					●						●				
Filinia longiseta	●											●	●	●	X
Polyarthra vulgaris									●		●	●	●		
Polyarthra dolichoptera									●					●	X
Polyarthra remata					●				●			●			
Polyarthra sp.								●							
Synchaeta sp.												●	●		
Synchaeta pectinata												●	●	●	
Synchaeta stylata												●			
Hexarthra mira												●	●	●	
Asplanchna sieboldi												●			

Table 5 continued:

Asplanchna priodonta								●	●	●	
Asplanchna sp.	●			●	●						
Asplanchnopus sp.					●						
Anuraeopsis sp.									●		
Ascomorpha sp.									●	●	
Keretalla cochlearis	●					●	●	●	●	●	X
Keratella quadrata							●	●		●	X
Keratella tropica								●			
Keretalla aculeata	●										
Brachionus sp.				●							
Brachionus quadridentatus			●					●	●	●	X
Brachionus urceolaris			●		●			●		●	X
Brachionus angularis			●					●		●	X
Brachionus patulus								●		●	
Brachionus calyciflorus								●		●	X
Notholca sp.					●						
Notholca acuminata								●	●	●	
Notholca squamula									●	●	
Monommata sp.								●	●		
Platyias quadricornis								●	●	●	X
Gastropus sp.					●				●		
Cephalodella gibba								●		●	
Cephalodella sp.									●		
Colletheca sp.									●		
Colurella sp.									●		
Colurella colurus								●		●	
Colurella unicinata								●			
***Conochilus dossuarius**										●	X
***Euchlanis dilatata**										●	
Euchlanis sp.								●	●		X
Mytilina sp.										●	
Mytilina mucronata								●			
Mytilina ventralis								●			
Trichotria pocillum							●	●	●	●	
***Trichotria tetractis**										●	
Trichocerca longiseta							●	●	●		
Trichocerca similis								●	●	●	
Trichocerca elongata								●			
Trichocerca taurocephala		●									
***Trichocerca bicristata**										●	
***Trichocerca capucina**										●	X
***Trichocerca cylindrica**										●	X
Lecane sp.								●			
Lecane bulla							●	●	●	●	
Lecane luna								●		●	X
Lecane lunaris								●		●	
Lecane clostrocerca								●	●	●	
Lecane flexilis								●	●	●	
Lecane ludwigi									●		
Lecane quadridentata								●		●	
***Lecane stenroosi**										●	
Lecane sp.										●	
Lepadella sp.								●			
Lepadella ehrenbergi									●		
Lepadella ovalis									●		
***Lepadella patella**										●	
Rotaria sp.									●	●	X

Table 5 continued:

Scaridium longicaudatum										●	●	●	
Squatinella sp.												●	
Squatinella rostrum											●		
Testudinella patina										●		●	X
Bosmina longirostris						●	●			●		●	X
Diaphanosoma brachyurum	●			●	●	●			●				
Diaphanosoma lacustris									●	●		●	
Diaphanosoma sp.			●										
Daphnia longispina					●	●			●	●			
Daphnia cucullata						●						●	
Daphnia cf. curvirostris								●					
Ceriodaphnia quadrangula										●		●	
Macrothrix laticornis										●		●	
Simocephalus vetulus								●					
Moina micrura					●				●			●	
Leydigia leydigi									●			●	
Pleuroxus aduncus										●		●	
Chydorus sphaericus										●		●	X
Graptoleberis testudinaria										●		●	X
****Biapertura affinis***												●	
****Coronatella rectangula***												●	
****Alona quadrangularis***												●	
****Alona guttata***												●	
Alona sp.										●			
****Alonella excisa***												●	
****Alonella nana***												●	
****Disparalona rostrata***												●	
Leptodora kindtii	●		●			●				●			
Sida crystallina									●			●	
****Ilyocryptus sordidus***												●	
****Camptocercus uncinatus***												●	
****Acroperus harpae***												●	
****Monospilus dispar***												●	
Eudiaptomus drieschi					●					●			
Eudiaptomus vulgaris	●	●	●			●			●				
Eucyclops speratus										●		●	
Mesocyclops l. bodanicola	●	●		●		●			●	●		●	X
Nitokra hibernica										●		●	
Nitokra hibernica incerta		●											

(1)Mann (1940), (2) Kiefer (1952, 1955), (3) Numann (1958), (4) Rahe and Pelister (1987), (5) Dumont and De Ridder (1987), (6) Fiers (1978), (7) Emir (1991), (8) Demirhindi (1991), (9) Kazancı *et al*., (1999), (10) Kaya and Altındağ a, b (2007), (11) Gündüz (1984, 1987, 1997), (12) Aksoylar and Ertan (2002), (13) Didinen and Boyacı (2007). Asterisks indicate new records for Eğirdir Lake

The highest total zooplankton abundance was recorded in October, whereas the lowest was recorded in March (Table 2). A mean peak abundance of 5.668 individuals/L was recorded in October. Rotiferan species dominated the zooplankton community and were the dominant group in all sampling dates, accounting for 96.36% of total zooplankton abundance in September and 97.55% in October. Cladocera species showed maximum abundance during winter months and comprised of 7.78 % of total zooplankton abundance. This study revealed that the average abundance of zooplankton in the lake in March was lower than that in February. The annual mean zooplankton recorded during the present study (581±860 individuals/L) was higher than the 26 individuals/L recorded by Aksoylar and Ertan (2002).

Zooplankton indicators of the lake trophic level

Among recorded species, *Brachionus calyciflorus, B. angularis, C. dossuarius, F.longiseta, T.capucina, B. longirostris, G. testudinaria* (Makarewicz, 1993; Bos and Cumming, 2003; Sendacz *et al*., 2006), and *F.longiseta, K.cochlearis, K.quadrata, T. cylindrica* (Saksena, 1987; Geng *et al*., 2005) are the most well-known indicators of eutrophic conditions. The rotifer *L. bulla* (Saksena, 1987) and the cladoceran *M. micrura* (Sendacz *et al*., 2006) are among the characteristic species of oligotrophic lakes. Frutos et al. (2009) reported that *P.dolichoptera, K. ochlearis, Conochilus* sp., *Brachionus* sp., and *Trichocerca* sp. are present in mesotrophic conditions. It is reported that calanoid copepods best adapt to oligo-mesotrophic lakes, and among the cyclopoid copepods, *M. leuckarti bodanicola* prefers oligo-mesotrophic conditions (Maier, 1996). Among cladocerans, *D. lacustris* in Ferrara *et al*. (2002) is a characteristic species of oligo-mesotrophic lakes. On the other hand, the community structure of zooplankton showed a mixed composition of mesotrophic to eutrophic species. According to the $Q_{B/T}$ Rotifera index as stated by Sládeček (1983), Van Lake with a $Q_{B/T} = 1$ (Yildiz *et al*., 2010), Beyşehir Lake with a $Q_{B/T}=2$ (Altındağ and Yiğit, 2004), Akşehir Lake with $Q_{B/T} =1.25$ (Altındağ and Yiğit, 1999), and Lake Sazlıgöl with $Q_{B/T} =1$ (Ustaoğlu *et al*., 2004) have shown to be mesotrophic. In determining the trophic level of the lake, rotifer species are used as an indicator. During this research carried out in Eğirdir Lake, $Q_{B/T}$ was found to be 1.25. Consequently, an evaluation based on the rotifer index says that the lake has mesotrophic characteristics in terms of zooplankton. According to the Trophic State Index (Carlson, 1977), TSI<30, 30–50, 50–70, 70> are classified as oligotrophic, mesotrophic, eutrophic, and hypereutrophic, respectively. Baloch and Suzuki (2009) suggested that İkeda Lake was in a mesotrophic state according to Carlson's (1977) trophic state index. In addition, Lake Bracciano was assessed to be in an oligo-mesotrophic state (Ferrara *et al*., 2002).

Water quality variables and trophic indicators

During this study, the mean values of TSI_{TP}, $TSI_{Chl\ a}$, and TSI_{SD} were 76, 41, and 55, respectively. TSI values based on TSI_{TP}

and TSI_{SD} strongly suggested that Eğirdir Lake is in a eutrophic state, while $TSI_{Chl\text{-}a}$ suggests the lake is in amesotrophic state. This index was taken to be the criterion for trophic classification of Eğirdir Lake. The mean TSI value of 57 indicated that the lake is in a mesotrophic-eutrophic state. Temperature values were highest during summer (average 25.3 °C). Conductivity values were higher during summer season compared to winter. Transparency was higher during summer than during other seasons and average transparency was 1.5 m. Mean chl-a concentration during our study was 3.0 mg/m^3. Chl-values were higher during spring months than during summer months. Throughout the year, similar features were noted in distribution of chl-a in the lake. The maximum chl-a in the lake was particularly pronounced in May. This is in agreement with Tanyolaç (2009), who found that chl-a was a main factor influencing zooplankton productivity. Aksoylar and Ertan (2002) observed high concentrations of chl-a in Eğirdir Lake, with the mean value being 5.6 mg/m^3. Similarly, Mohsenpour Azary *et al*. (2010) indicated that Bukan Dam was mesotrophic with a chl-value of 3.6 µg/L. In addittion, the chl-a content indicated that Eğirdir Lake was in a mesotrophic state (Fig. 3).

In lakes, increased nutrient loading can lead to over production of organic matter primarily by phytoplankton. TP ranged from 0.06 mg/L in May to 0.42 mg/L in August, while nitrate concentrations varied from 0.9 mg/L in September to 3.8 mg/L in August. The TP content was found to be low but was comparatively higher than that in 2002 (0.05 mg/L) (Aksoylar and Ertan 2002). Silica concentrations were higher during autumn than during summer months. The presence of higher silica concentrations, especially during rainy months, stems from the silica dissolved in rainfall-runoff that reaches the lake. Sulfate concentrations showed changes during the year. Aksoylar and Ertan (2002) reported sulfate concentration in the lake to be 11.1 mg/L. Mean sulfate concentration during the study was 39.5 mg/L, and therefore, a significant increase is observed in the quantity of sulfate. Mean total hardness was 26.8 mg/L, which is at an intermediate water quality level. The fauna of most hard-water lakes is dominated by *C. sphaericus* with *L.leydigi* as the major subdominant (Kerfoot, 1980). The results of the water quality variable analysis have been assessed according to the Turkish standards (Anonymous, 2004). The water quality of Eğirdir Lake was found to fall into class I and class II in terms of nitrate, phosphate, and sulfate (Table 4). The annual Shannon diversity index was calculated as 1.33. The Shannon-Weaver diversity index was determined to be between 0.90–1.77. The maximum value of 1.77 for the Shannon's diversity index was recorded in July. The study indicated that the lake has low zooplankton diversity.

The oligotrophic character of the lake has been indicated by some authors (Numann, 1958; Kazancı *et al*., 1999). While it has been stated that the lake was oligotrophic in terms of nitrate, TP and chl-a between 1958 and 1999 (Numann, 1958; Kazancı *et al*., 1999), it was expressed by Gülle *et al*. (2008) that the lake will become mesotrophic/eutrophic because of the increase in nutrient loading. It was

expressed by Sömek *et al*. (2008) that chl-a in the lake reached a peak of 117 mg/L during summer and autumn, and a *M.aeuriginosa* (a Cyanophyte algae) bloom took place. Aksoylar and Ertan (2002) reported that the trophic state of the lake was meso-eutrophic. Total zooplankton abundance (78 %) and the number of rotifera species (40) increased with the lake trophic status. *P. dolichoptera* and *K.cochlearis* were frequently found at all sampling stations along the lake. These species are considered to be indicators of mesotrophic conditions (Frutos *et al*., 2009). The results indicate that the lake has already reached the stage of meso-eutrophic. Although the present study has contributed increasingly to the knowledge of the zooplankton species and abundance occurring in Turkish lakes, data on monthly composition and abundance of the zooplankton community are still lacking for some lakes. In conclusion, beside the decrease of abundance and number of species of Copepoda, the increase of the number of species and abundance of Rotifera shows that Eğirdir Lake has shifted to a mesotrophic-eutrophic state.

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References

Akbulut (Emir), N., 2000. Community structure of zooplanktonic organisms in Lake Akşehir. *Turkish Journal of Zoology*, 24, 271-278.

Aksoylar, M. Y. and Ertan, Ö. O., 2002. Eğirdir Gölü'nün Hidrobiyolojik Özelliklerinin Tespiti. *SDÜ Eğirdir Su Ürünleri Fakültesi DPT 97K122330 Project*, Eğirdir, Isparta, Türkiye, 178P.

Altındağ, A. and Yiğit, S., 1999. A taxonomical study on the rotifer fauna of Akşehir Lake. *Turkish Journal of Zoology*, 23(**1**), 1-6.

Altındağ, A. and Yiğit, S., 2004. The zooplankton fauna and seasonal distribution of Beyşehir Lake. *G.U, Gazi Eğitim Fakültesi Dergisi*, 24(**3**), 217-225.

Anonymous, 2004. Water pollution control regulations. *25687 Sayılı Resmi Gazete*. Türkiye.

Baloch, W.A. and Suzuki, H., 2009. Summer zooplankton composition, vertical distribution and biomass In Lake Ikeda, Southern Kyushu, Japan. *Sindh University Research Journal*, 41(**2**), 35-40.

Bos, D.G. and Cumming, B.F., 2003. Sedimentary cladoceran remains and their relationship to nutrients and other limnological variables in 53 lakes from British Columbia, Canada.

Canadian Journal of Fisheries and Aquatic Sciences, 60 (**10**), 1177-1189.

Bozkurt, A., 2006. Zooplankton of Yenişehir Lake (Reyhanlı, Hatay). *EU Journal of Fisheries and Aquatic Sciences*, 23(**1/1**), 39-43.

Canfield, T.J. and Jones, J.R., 1996. Zooplankton abundance, biomass, and size-distribution in selected midwestern waterbodies and relation with trophic state. *Journal Freshwater Ecology*, 11, 171-181.

Carlson, R.E., 1977. A Trophic state index for lakes. *Limnology and Oceanography*, 22, 361-369.

Demirhindi, Ü., 1991. Planktonic organisms of Eğirdir Lake. Symposium on fresh water resources protection and environmental problems in lake district, Isparta, Turkey. pp. 381-391.

Demirkalp, F.Y., Saygı, Y., Çağlar, S.S., Gündüz, E. and Kılınç, S., 2010. Limnological assesment on the brackish shallow lake from Kizilirmak Delta (Turkey). *Journal of Animal and Veterinary Advances*, 9(**16**), 2132-2139.

Didinen, H. and Boyacı, Y.Ö., 2007. Determination on base systematic and ecology of rotifer fauna (rotifera) in hoyran region of Eğirdir Lake. *EU Journal of Fisheries & Aquatic Sciences*, 24(**1-2**), 31-37.

Dumont, H.J. and De Ridder, M., 1987. Rotifers from Turkey. *Hidrobiologia*, 147, 65-73.

Dussart, B., 1967. Les copepodes des eaux continentales d'europe occidentale, tome i, calanoides et harpacticoides, N. Boubee *et al*, Paris, 500P.

Dussart, B., 1969. Les copepodes des eaux continentales d'europe occidentale, tome ii, cyclopoides et biologie, N Boubee et cie, Paris, 292P.

Edmondson, W.T., 1959. Freshwater biology, Second edition. John Wiley Sons, Inc. London, Chapman & Hall Limited, 1248P.

Egemen, Ö. and Sunlu, U., 1996. Water quality. *Ege Üniversitesi Su Ürünleri Fakültesi Yayınları*, İzmir, Türkiye, 14, 153P.

Emir, N., 1991. Some rotifers from Turkey. *Turkish Journal of Zoology*, 15, 39-45.

Ferrara, O., Vagaggini, D. and Margaritora, F.G., 2002. Zooplankton abundance and diversity in Lake Bracciano, Latium, Italy. *Journal of Limnology*, 61(**2**), 169-175.

Fiers, F., 1978. Bijdrage tot de limnologische kennis van turkije met nadruk op de entomostraca (crustacea). *Rıjs Universiteit Gent. Fac. Der Wetenschappen Afd. Bio. Group Dierkunde*: pp.1-119.

Frutos, S.M., Neiff, P.D. and Neiff, J.J., 2009. Zooplankton abundance and species diversity in two lakes with different trophic state (Corrientes, Argentina). *Acta Limnologica Brasiliensia*, 21(**3**), 367-375.

Geng, H., Xie, P., Deng, D. and Zhou, Q., 2005. The rotifer assemblage in a

shallow, eutrophic Chinese Lake and its relationsships with cyanobacterial blooms and crustacean zooplankton. *Journal of Freshwater Ecology*, 20(**1**), 93-100.

Gülle, İ., Yıldırım, M.Z. and Küçük, F., 2008. Limnological history of Eğirdir Lake (Turkey): From 1950's to the Present. *Natura Montenegrina, Podgorica*, 7(**2**), 115-128.

Gündüz, E., 1984. Zooplankton species identification of Karamuk and Hoyran Lakesand pollution effects on zooplankton (PhD Thesis). *Hacettepe Üniversitesi Fen Bilimleri Enstitüsü, Biyoloji Anabilim Dalı*, Ankara, Türkiye, 83P.

Gündüz, E., 1987. A Taxonomic study cladocera (crustacea) species on the Karamuk and Hoyran Lakes. *Doğa Türk Zooloji Dergisi*, 11(**1**), 26-36.

Gündüz, E., 1997. A checklist of cladoceran species (crustacea) living in Turkish inland waters. *Turkish Journal of Zoology*, 21, 37-45.

Kaya, M. and Altındağ, A., 2007a. Some cladoceran species from Turkish inland waters. *SDÜ Fen Edebiyat Dergisi*, 2 (**1**), 60-76.

Kaya, M. and Altındağ, A., 2007b. Brachionidae (rotifera: monogononta) species from Turkey. *Asian Journal of Animal Sciences*, pp. 1-6.

Kazancı, N., Girgin, S., Dügel, M., Oğuzkurt, D., Mutlu, B., Dere, Ş., Barlas, M. and Özçelik, M., 1999. Köyceğiz, Beyşehir, Eğirdir, Akşehir, Eber, Çorak, Kovada Yarışlı, Bafa, Salda, Karataş, Çavuşçu Gölleri, Küçük ve Büyük Menderes Deltası, Güllük Sazlığı, and Karamuk Bataklığının Limnolojisi, Çevre Kalitesi ve Biyolojik Çeşitliliği, *Türkiye İç Suları Araştırmaları Dizisi*, Ankara, Türkiye, IV, 371P.

Kerfoot, W., 1980. Evolution and ecology of zooplankton communities. Thomas L. Crisman, chydorid cladoceran assemblages from subtropical Florida. 58 Parts. New England Press. 657-668.

Kiefer, F., 1952. Freilebende ruderfusskrebse (crustacea, copepoda) aus türkischen binnengewassern. I Calanoida. İ.Ü.F.F. *Hidrobiyoloji Araştırma Enstitüsü Yayınları*, 1(**2**), 103-132.

Kiefer, F., 1955. Freilebende ruderfusskrebse (crustacea, copepoda) aus türkischen binnengewassern, Cyclopoida und harpacticoida. İ.Ü.F.F. *Hidrobiyoloji Araştırma Enstitüsü Yayınları*, 2(**4**), 108-132.

Korovchinsky, N. M., 1992. Sididae and holopedidae (crustacea: daphniiformes), guides to identification of the microinvertebrates of the continental waters of the world, SPB Academic Pub., The Netherlands, 82P.

Koste, W., 1978. Rotatoria, Die Rädertiere Mitteleuropas Ein Bestimmungswerk, Begründet von Max Voigt Überordnung Monogononta, I Textband. Gebrüder

Borntraeger, Berlin, Stuttgart, 672P and II Textband, 234P.

Maier, G., 1996. Copepod communities in lakes of varying trophic degree. *Archiv für Hydrobiologie.*, 136(**4**), 455-465.

Makarewicz, J. C., 1993. A lakewide comparison of zooplankton biomass and ıts species composition in Lake Erie. *Journal of Great Lakes Research JGLRDE,* 19(**2**), 275-290.

Mann, A.K., 1940. Über pelagische copepoden Turkischer Seen. Int. Revue der Gesam. *Hydrobiology*, 40, 1-87.

Michaloudi, E., Zarfdjian, M. and Economidis, P., 1997. The zooplankton of Lake Micri Prespa. *Hydrobiologia*, 351, 77-94.

Mohsenpour Azary, A., Ahmadi, R., Mohebbi, F., Motallebi, A.A.; Agamaliyev, F.O. and Aliyev, A.R., 2010. Fluctuation in density of ciliates in Bukan Dam Reservoir, Zahrinehrud, Iran. *Iranian Journal of Fisheries Sciences*, 9(**3**), 453-444.

Molles, M.C., 2002. Ecology, concepts and applications. Mc Graw-Hill Higher Education, New York, USA, 585P.

Negrea, S., 1983. Fauna republici socialiste Romania. Crustacea, Cladocera. 4, 12, Acedemia Rep. Soc. Romania, Bucuresti, 367P.

Nogrady, T. and Segers, H., 2002. Asplanchnidae, Gastropodidae, Lindiidae, Microcodidae, Synchaetidae, Trochosphaeridae and Filinia, Vol.6, Guides to the identification of the microinvertebrates of the continental waters of the world. Coordinating editor: H. J. F. Dumont. Kingston, Ont. Canada, Gent Univ., Belgium, Backhuys Pub., Leiden, The Netherlands, 264P.

Numann, W., 1958. Anadolunun Muhtelif Göllerinde Limnolojik ve Balıkçılık İlmi Bakımından Araştırmalar ve Bu Göllerde Yaşayan Sazanlar Hakkında Özel Bir Etüd. *İstanbul Üniversitesi Fen Fakültesi Hidrobiyoloji Araştırma Enstitüsü Yayınlarından*, **7**: 114P.

Patra, A., Santra, K.B. and Manna, C.K., 2011. Ecology and diversity of zooplankton in relation to physico-chemical characteristics of water of Santragachi Jheel, West Bengal, India. *Journal Wetlands Ecology*, 5, 20-39.

Rahe, R. and Pelister Ö., 1987. Comparative limnological and fisheries-biological investigations at four Central-Anatolian Lakes (Eber, Akşehir, Beyşehir, Eğirdir). *Journal of Aquatic Products, University of İstanbul*, 1(**1**), 1-42.

Rahmati, R., Pourgholam, R., Najafpou, S.H. and Doustdar, M., 2011. Trophic status of a shallow lake (North of Iran) based on the water quality and the phytoplankton community. *World Applied Sciences Journal*, 14, 112-120.

Rajashekhar, M., Vijaykumar, K. and Parveen, Z., 2009. Zooplankton diversity of three freshwater lakes with relation to trophic status,

Gulbarga District, North-East Karnataka, South India. *International Journal of Systems Biology*, 1(**2**), 32-37.

Saksena, D.N., 1987. Rotifers as indicators of water quality. *Acta. Hydrobiologica*, 15, 481-485.

Saler, S., 2011. Zooplankton of Munzur River (Tunceli-Turkey). *Journal of Animal and Veterinary Advances*, 10(**2**), 192-194.

Segers, H., 1995. The Lecanidae (Monogononta), Vol. 2, Guides to the identification of the microinvertebrates of the continental waters of the world, coordinating editor: H. J. F. Dumont. Gent Univ., Belgium, SPB Academic Publishing., The Netherlands, 226P.

Sendacz, S., Caleffi, S. and Santos-Soares, J., 2006. Zooplankton biomass of reservoirs in different trophic conditions in the state of São Paulo, *Brazil. Brazilian Journal of Biology*., 66(**1B**), 337-350.

Sládeček, V., 1983. Rotifers as indicators of water quality. *Hydrobiology*, 100, 169-201.

Smirnov, N.N., 1996. Guides to the identification of the microinvertabrates of the continental waters of the word. Cladocera: The Chydorinae and Sayciinae (Chydoridae) of the World. No. 11, Coordinating editor: H. J. F. Dumont. Gent Univ., Belgium, SPB Academic., The Netherlands, 197P.

Sömek, H., Ustaoğlu, M.R. and Yağcı, M., 2008. A case report: Algal bloom of *Microcystis aeruginosa* in a drinking-water body, Eğirdir Lake, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, 8, 177-179.

Tanyolaç, J., 2009. Limnology. Hatiboğlu Yayınevi, 5. Baskı, Ankara, Türkiye, 294P.

Ustaoğlu, M.R., Balık, S. and Özdemir Mis, D., 2004. The rotifer fauna of Lake Sazlıgöl (Menemen-İzmir). *Turkish Journal of Zoology*, 28, 267-272.

Ustaoğlu, M.R., Özdemir Mis, D. and Aygen, C., 2012a. Observations on zooplankton in some lagoons in Turkey. *Journal Black Sea/Mediterranean Environment*, 18(**2**), 208-222.

Ustaoğlu, M.R., Altındağ, A., Kaya, M., Akbulut, N., Bozkurt, A., Özdemir Mis, D., Atasagun, S., Erdoğan, S., Bekleyen, A., Saler, S. and Okgerman, H., 2012b. A checklist of Turkish rotifers. *Journal of Zoology*, 36 (**5**), 607-622.

Wetzel, R.G., 2001. Limnology: Lake and river ecosystems, Third Edition. Academic Press, London, 1006P.

Wetzel, R.G. and Likens, G.E., 2000. Limnological analyses, 3rd Edition. Springer-Verlag, New York, 429P.

Yarar, M. and Magnin, G., 1997. Türkiyenin Önemli Kuş Alanları. *Doğal Hayatı Koruma Derneği*, Türkiye, 313P.

Yildiz, Ş., Özgökçe, M.S., Özgökçe, F., Karaca, İ. and Polat, E., 2010. Zooplankton composition of Van

coastline in Turkey. *African Journal of Biotechnology*, 9(**48**), 8248-8252.