

Full Paper

Monthly distribution of zooplankton in Kapikaya Reservoir, Turkey

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Abstract: The zooplankton of Kapikaya Reservoir were investigated monthly. A total of 38 species were identified, i.e. 30 Rotifera (79%), 5 Cladocera (13%) and 3 Copepoda (8%) species. Samples were taken monthly from two stations from Kapikaya Reservoir between March 2013 and February 2014. Water temperature, pH and dissolved oxygen were determined *in situ*. Rotifera was the most dominant among the zooplankton groups. The rotifers *Keratella cochlearis* and *Polyarthra dolichoptera* were observed in all months. The cladoceran *Bosmina longirostris* and copepod *Cyclops vicinus* were the dominant species of their groups.

In the present study the Shannon Wiener index showed that species richness was highest at the 1st station in March ($H' = 2.72$) and lowest at the 2nd station in January ($H' = 0.69$). According to the Margalef index for this reservoir, the highest value in March at the 1st station was 1.81, and the lowest value in January at the 2nd station was 0.14.

Key words: Kapikaya Reservoir, Cladocera, Copepoda, Rotifera, Zooplankton, Turkey

INTRODUCTION

In aquatic environment, zooplankton plays an important role in the transfer of energy from primary producers to the higher levels in the food chain. Zooplanktonic organisms are the most important source of food for invertebrates, fishes and some aquatic birds. Some species were reported as indicators of water quality, pollution and eutrophication due to their sensitivity to environmental changes and therefore studies of zooplankton in lakes have acquired significant importance [1-3].

Zooplanktonic species vary among sites within the same location with similar ecological conditions, Thus, both qualitative and quantitative studies of zooplankton in a

waterbody are of great importance in managing a successful aquaculture operation [4]. Zooplankton are often an important link in the transfer of energy from producers to aquatic carnivores. They are a good indicator of changes in water quality because they are sensitive to environmental conditions and responds quickly to changes in physical and chemical conditions as well as environmental conditions [5].

Some studies have been conducted on the zooplankton in reservoirs of Turkey, for example Goksu Dam Lake [6], Devegecidi Dam Lake [7], Uzuncayir Dam Lake [8], Kalecik Dam Lake [9] and Beyhan Dam Lake [10].

Kapikaya Reservoir is located in south-eastern Malatya on Mamikan River 30 km from the city centre. This reservoir was built between 1998-2004 to produce electricity and supply irrigation. The aim of the present study is to qualitatively and quantitatively determine the zooplankton and to evaluate the zooplankton community in Kapikaya Reservoir. To the best of our knowledge, zooplankton species in Kapikaya Reservoir have not been identified.

MATERIALS AND METHODS

The plankton samples were collected monthly from Kapikaya Reservoir between March 2013-February 2014 using a standard plankton net (55- μ m mesh size) from two stations. Coordinates of the two stations in Kapikaya Dam Lake are: Station 1; 38°21'4.67" N 38°36'17.91" E, Station 2; 38°21'30.22" N, 38°37'21.49" E.

The samples were fixed in 4 % formalin, analysed under an inverted microscope (GMBH D-6330 diavert inverted microscope, Earnst Leitz Ltd., Canada) and identified under a compound microscope (Nikon Eclipse E 100, Nikon Instruments Inc., Japan). The species were identified according to Ruttner-Kolisko [11], Koste [12,13], Dumont and De Ridder [14], Segers [15], Flossner [16], Negrea [17], Kiefer [18] and Einsle [19]. Counting of zooplankton species was done in petri dishes with 5-ml sub-samples. A minimum of 200 individuals were quantified per replicate and the final density was converted to individuals per cubic metre. Monthly changes of total zooplankton at the 1st and 2nd stations were recorded.

Temperature and dissolved oxygen were measured by an Oxi 315i/SET oxygen-meter and pH by a Lamotte (pH 5-WC) model pH meter. Species richness and species diversity were calculated using Margalef and Shannon-Wiener indices respectively.

Shannon-Wiener Diversity index (H') was calculated using the following formula [20]:

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

where p_i is the proportion of individuals found in the species i . Margalef index was calculated by the formula $S-1/\ln N$, where S is the number of species and N is the total number of individuals [20].

RESULTS AND DISCUSSION

A total of 38 zooplankton taxa were identified in this study area. The most dominant group was Rotifera (30), followed by Cladocera (5) and Copepoda (3):

Rotifera

Ascomorpha saltans Bartsch, 1870

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Asplanchna priodonta Gosse, 1850

Asplanchna sieboldi Leydig, 1854

Brachionus angularis Gosse, 1851

Brachionus urceolaris Muller, 1773

Brachionus quadridentatus Hermann, 1783

Cephalodella forficula (Ehrenberg, 1830)

Cephalodella gibba (Ehrenberg, 1830)

Colletheca mutabilis (Hudson, 1885)

Colurella colurus (Ehrenberg, 1830)

Colurella uncinata (Muller, 1773)

Conochilus dossiarius Hudson, 1885

Euchlanis dilatata Ehrenberg, 1832

Filinia longiseta (Ehrenberg, 1834)

Filinia terminalis (Plate, 1886)

Kellicottia longispina (Kellicott, 1879)

Keratella cochlearis (Gosse, 1851)

Keratella quadrata (Muller, 1786)

Keratella tropica (Apstein, 1907)

Lecane cornuta (Muller, 1786)

Lecane luna (Muller, 1776)

Lecane lunaris (Ehrenberg, 1832)

Lepadella ovalis (Muller, 1786)

Lindia torulosa Dujardin, 1841

Notholca acuminata (Ehrenberg, 1832)

Notholca squamula (Muller, 1786)

Polyarthra dolichoptera Idelson, 1925

Synchaeta pectinata Ehrenberg, 1832

Trichocerca porcellus (Gosse, 1851)

Trichocerca similis grandis Hauer, 1965

Cladocera

Coronatella rectangula (Sars, 1862)

Bosmina longirostris (Muller, 1785)

Chydorus sphaericus (Muller, 1776)

Daphnia cucullata Sars 1862

Macrothrix hirsuticornis Norman & Brady, 1867

Copepoda

Acanthocyclops robustus (G.O.Sars, 1863)

Cyclops vicinus Ulyanin, 1875

Diacyclops bicuspidatus (Claus, 1857)

The distribution of zooplankton species at the two stations is given in Table 1. From Rotifera, *Keratella cochlearis* and *Polyarthra dolichoptera* were observed during all months

of the year. *Bosmina longirostris* and *Cyclops vicinus* were the most dominant species from Cladocera and Copepoda respectively.

Table 1. Monthly distribution of Rotifera, Cladocera and Copepoda

Rotifera	Month																							
	M		A		M		J		J		A		S		O		N		D		J		F	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
<i>Ascomorpha saltans</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Asplanchna priodonta</i>	+	+	-	-	+	+	+	-	-	-	-	-	-	-	+	+	-	-	+	-	-	-	-	-
<i>A. sieboldi</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Brachionus angularis</i>	+	+	+	-	+	-	-	-	-	-	-	-	+	+	-	-	+	-	-	+	+	-	+	-
<i>B. urceolaris</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>B. quadridentatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
<i>Cephalodella forcifcula</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>C. gibba</i>	-	-	-	-	+	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-
<i>Colletheca mutabilis</i>	-	-	-	-	+	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Colurella colurus</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>C. uncinata</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Conochilus dossiarius</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-
<i>Euchlanis dilatata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-
<i>Filinia longiseta</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-
<i>F. terminalis</i>	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-
<i>Kellicottia longispina</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Keratella cochlearis</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>K. quadrata</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>K. tropica</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lecane cornuta</i>	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>L. luna</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>L. lunaris</i>	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepadella ovalis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lindia torulosa</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Notholca acuminata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>N. squamula</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polyarthra dolichoptera</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Synchaeta pectinata</i>	-	-	+	-	-	-	-	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-
<i>Trichocerca porcellus</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>T. similis grandis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cladocera																								
<i>Coronatella rectangulara</i>	+	+	-	-	-	-	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
<i>Bosmina longirostris</i>	+	+	+	-	+	+	-	+	-	-	+	+	+	+	-	-	+	+	-	-	+	-	-	-
<i>Chydorus sphaericus</i>	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Daphnia cucullata</i>	+	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Machrothrix hirsuticornis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copepoda																								
<i>Acanthocyclops robustus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Cyclops vicinus</i>	+	+	-	-	+	-	-	+	+	-	+	+	-	-	-	+	-	+	+	-	-	+	+	
<i>Diacyclops bicuspidatus</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: + = present - = absent

In Kapikaya Dam Lake, the maximum water temperature (28.2°C) was recorded in August and the minimum average temperature (5.2°C) was recorded in December. The lowest mean dissolved oxygen level, 7.10 mgL⁻¹, was recorded in June and the highest, 8.6 mgL⁻¹, was recorded in January. The highest mean pH value of 8.6 was recorded in June and the lowest value of 7.1 was recorded in April. The mean values of temperature, dissolved oxygen and pH at the two stations are given in Table 2. Margalef richness index (D) and Shannon-Wiener diversity index (*H'*) of the species in Kapikaya Reservoir were obtained monthly for each station and given in Tables 3 and 4.

Table 2. Monthly average values of temperature, dissolved oxygen and pH

Month												
	Mar.	Ap.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
°C	8	18	23	26.5	28	28.2	20	19	10.1	5.2	5.5	9.8
Dis.Oxy	8.1	8.2	7.4	6.8	7.1	7.9	7.9	8.0	8.4	8.7	8.6	8.5
pH	7.1	7.0	8.3	8.9	7.6	8.2	8.1	7.8	7.5	7.6	7.3	7.2

Table 3. Seasonal variation of Margalef Richness Index (D) and Shannon-Wiener diversity Index (*H'*) at 1st Station of Kapikaya Dam Lake

Month													Mean Value
	Mar.	Ap.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	
D	1.81	0.83	1.18	0.44	0.75	0.46	0.69	0.73	0.88	0.65	0.38	0.37	0.76
<i>H'</i>	2.72	1.84	2.20	1.26	1.93	1.41	1.78	1.81	2.01	1.82	1.33	1.33	1.78

Table 4. Seasonal variation of Margalef Richness Index (D) and Shannon-Wiener diversity index (*H'*) at 2nd Station of Kapikaya Dam Lake

Month													Mean Value
	Mar.	Ap.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	
D	1.32	0.33	0.44	0.26	0.70	0.27	0.34	0.68	0.39	0.46	0.14	0.38	0.47
<i>H'</i>	2.41	1.14	1.20	1.04	1.88	1.09	1.09	1.82	1.38	1.47	0.69	1.33	1.37

In Kapikaya Dam Lake the highest Shannon-Wiener diversity index was obtained at the 1st station in March (*H'* = 2.72) and the lowest at the 2nd station in January (*H'* = 0.69). The Margalef index reached the highest value in March at the 1st station (D = 1.81) and dropped to the lowest in January at the 2nd station (D = 0.14).

Based on the relative density, Rotifers were the dominant group (74-71%) at the two stations followed by Cladocera (15-20%) and Copepoda (11-9%) (Figure 1). The monthly changes of total zooplankton at Kapikaya Dam Lake were at their highest at the 1st station in March (35149 individuals/m³) and at their lowest at the 2nd station in January (1018 individuals/m³) (Figures 2 and 3).

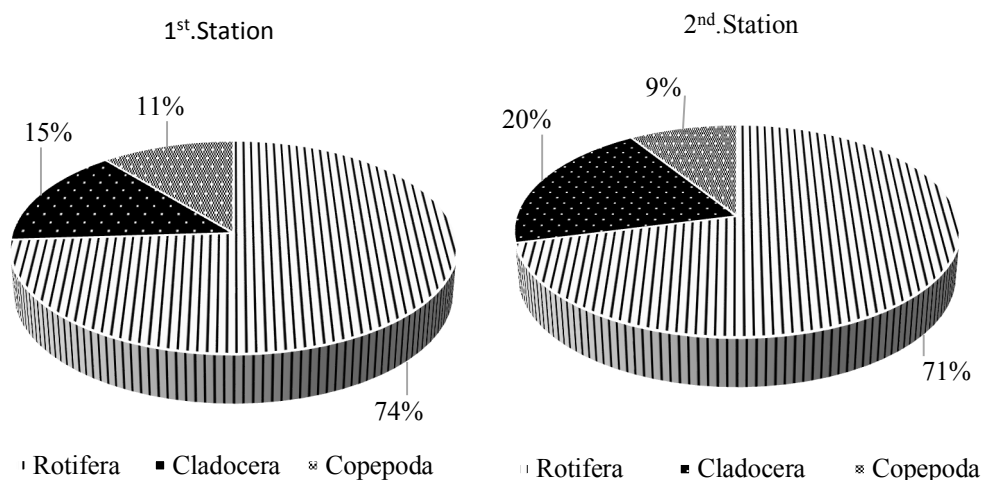


Figure 1. Relative density (%) of zooplanktonic groups in Kapikaya Reservoir

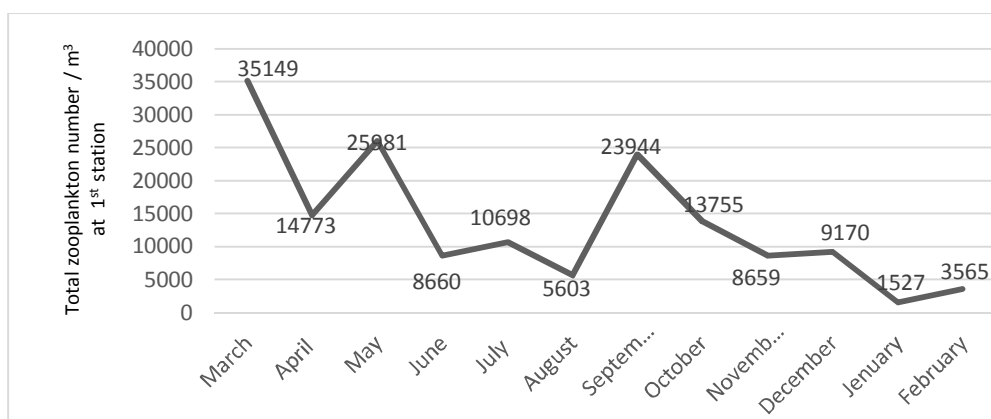


Figure 2. Monthly changes of total zooplankton in Kapikaya Reservoir at 1st station

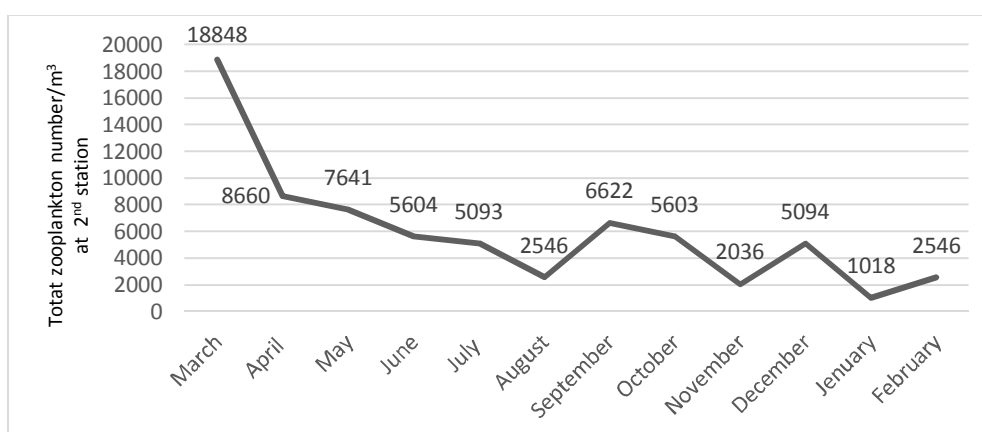


Figure 3. Monthly changes of total zooplankton in Kapikaya Reservoir at 2nd station

Rotifers are more sensitive to environmental changes than cladocerans and copepods, and are known to be characteristic indicators of water quality [11]. Furthermore, Sladecek [21] and Saksena [22] indicated that rotifer species were bioindicators of water quality and

rotifer density was characteristic of eutrophic waters. *Bosmina longirostris* were densely found in eutrophic waters [23]. Additionally, species richness is an important factor in ecological studies. In Karakaya Reservoir [24], which is located in the same region with Kapikaya, 14 Rotifera, 5 Cladocera and 1 Copepoda species were identified. In Kalecik Dam Lake [9], 25 Rotifera, 11 Cladocera and 4 Copepoda species, in Beyhan Dam Lake [10], 24 Rotifera, 5 Cladocera and 3 Copepoda species were recorded. In all these dam lakes Rotifera species being the dominant group, followed by Cladocera and Copepoda groups. Kapikaya Reservoir exhibited a similar zooplankton distribution profile with these dam lakes.

Ruttner-Kolisko [11] reported that *Polyarthra dolichoptera* and *Keratella cochlearis* are perennial species. *K. cochlearis* and *P. dolichoptera* from Rotifera were recorded in all months in Kapikaya Dam Lake, while *Bosmina longirostris* from Cladocera and *Cyclops vicinus* from Copepoda were the most prevalent species. The following species were only observed in one month: *Asplanchna sieboldi*, *Ascomorpha saltans*, *Brachionus urceolaris*, *B. quadridentatus*, *Colurella colurus*, *C. uncinata*, *Kellicottia longispina*, *Keratella tropica*, *Lepadella ovalis*, *Lindia torulosa*, *Notholca acuminata*, *N. squamula*, *Trichocerca porcellus*, *T. similis grandis* (from Rotifera), *Machrothrix hirsuticornis* (from Cladocera) and *Diacyclops bicuspidatus* (from Copepoda).

Keratella cochlearis and *Polyarthra dolichoptera* from Rotifera, *Bosmina longirostris* from Cladocera and *Cyclops vicinus* from Copepoda are common species in Kapikaya Reservoir. Especially *K. cochlearis* and *P. dolichoptera* were observed in all samplings. In Kalecik [9] and Beyhan Dam Lakes [10] all of these species were recorded as dominant zooplanktonic species.

In some lakes and rivers the Rotifera group is used as bioindicators; while Brachionidae species are used as the indicator in eutrophic waters, Trichocerca species are used as the indicators of oligotrophic-mesotrophic waters [25]. Blacher [25] reported that cyclopoids could be more abundant in eutrophic lakes when compared with calanoids. Three species of Copepoda, the cyclopoid species *Acanthocyclops robustus*, *Cyclops vicinus* and *Diacyclops bicuspidatus*, were observed in Kapikaya Reservoir.

Gannon and Stremberger [26], stated rotifers as opportunistic species in extreme conditions. In the last decade because of the degradation of water quality of many wetlands for a number of reasons (pollution, eutrophication and effects of global warming), rotifers have become the dominant species in several lakes in Turkey [6-10]. Consistent with those findings, in the present study the majority of the zooplankton species have also been reported from Rotifera.

Zooplankton species showed an increase in spring and autumn and a decrease in winter. The zooplankton profiles of Uzuncayir, Kalecik, Beyhan, Keban, Kepektas and Hancagiz Dam Lakes also showed similarities with our findings [8-10, 27-29]. In all of these dam lakes, rotifer species were found to be the dominant species with respect to species richness and frequency of occurrence. In this study species from the family Brachionidae (*Keratella cochlearis*, *K. quadrata*, *K. tropica*, *Kellicottia longispina* and *Notholca squamula*) were found as the most dominant group

Mostly species richness is determined by Margalef index (D) while species diversity is determined by Shannon-Wiener index (H'). Margalef index has a good discriminant capacity with its log series, but is weighted more towards species richness. The most widely used index, Shannon-Wiener index, is influenced less by evenness than the other diversity

indices; it is an insensitive measure of species abundance distribution. Thus, Shannon-Wiener index would be a useful index for the community in which two or three species were dominant [30].

In Kapikaya Reservoir the highest H' value (2.72) was recorded at the 1st station in March. In Karakaya Dam Lake [24] and Maryap Pond [31] the highest H' values (1.11 and 2.23 respectively) were also recorded in March. The Shannon-Wiener diversity index (H') is used extensively in environmental studies to estimate species richness and abundance of ecosystems. The typical Shannon-Wiener values are generally between 1.5-3.5 in many ecological studies [32]. A value over 2.5 shows that the habitat is rich in terms of species. Margalef index (D) results also demonstrated that Kapikaya Reservoir (1st station) had the highest species richness during the month of March (D=1.81).

CONCLUSIONS

In Kapikaya Reservoir 38 zooplankton species have been identified. Species from Rotifera took the first place in terms of number of species (30 species) followed by Cladocera (5 species) and Copepoda (3 species). *Keratella cochlearis* and *Polyarthra dolichoptera* from Rotifera were observed at every station and in every month.

In terms of zooplankton diversity and species richness, the trophic status of Kapikaya Reservoir is considered to be low and species richness is also determined to be low (mean H' value = 1.78).

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