

Zooplankton diversity of three dam lakes in Turkey

Saler S.¹; Selamoglu Z.^{2*}

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1-Department of Fundamental Science, Faculty of Fisheries, Firat University, Elazig, Turkey

2-Department of Medical Biology, Faculty of Medicine, Nigde Ömer Halisdemir University, Nigde, Turkey

*Corresponding author's Email: zselamoglu@ohu.edu.tr

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Introduction

Zooplanktons are a basic link in transformation of energy from producers to consumers and play a key role as efficient filter feeders on phytoplankton and as food source for other invertebrates, fishes and their larvae. Zooplanktonic organisms are bioindicators of water quality and pollution because they are strongly influenced by environmental changes and respond quickly to alternations in water quality (Sharma *et al.*, 2010; Deksne *et al.*, 2011). Some studies have conducted on the zooplankton of different Turkish dam lakes such as Kesikköprü (Yiğit, 1998), Cip (Saler and Şen, 2000), Aslantaş (Bozkurt, 2002), Kapulukaya (Kök, 2005), Ömerli (Altunyurt, 2006), Gelingüllü (Kaya and Altındağ, 2007), Çamlığöze (Dirican and Musul, 2008), Sarıyar (Atıcı *et al.*, 2008), Tahtaköprü (Ülgü,

2008), Kemer (Tuna, 2009), Sarımsaklı (Aydın and Ahıska, 2009), Asartepe (Buyurgan *et al.*, 2010) Hasan Uğurlu, Suat Uğurlu (Bozkurt and Akın, 2012), Sürgü (İpek Alış and Saler, 2013), Kalecik (Bulut and Saler, 2013), Beyhan (Bulut and Saler, 2014), Uzunçayır (Saler *et al.*, 2014), Hancı (Saler and Alış, 2015) dam lakes.

The present study aimed to identify the zooplankton species and determine their seasonal composition and diversity in Tercan, Kuzgun and Demirdöven Dam Lakes where no earlier relevant data is available.

Materials and methods

The study was conducted on Tercan, Kuzgun and Demirdöven Dam Lakes. Seasonal samplings of zooplankton were taken between January to December 2014 (Fig. 1).



Figure 1: Locations of Kuzgun, Demirdöven and Tercan Dam Lakes.

Tercan Dam with an area of 9 km² and volume of 178 km³ is one of the most important drinking, irrigation and energy resource of Erzincan that was built on Tuzla Stream during 1969-1988. Kuzgun Dam with an area of 11 km² and storage capacity of 312 hm³ was built on Serçeme Stream between 1985-1986, for the purpose of irrigation and producing energy. Demirdöven Dam is a small dam with an area of 2 km² and volume of 34 hm³ which was constructed on Tımar Stream for irrigation.

Zooplankton samples were collected with a 55µ mesh Hydro-bios plankton net and preserved in 4% formaldehyde solution. The zooplankton identification to the species level was conducted by using the following references, and densities were calculated as the number of individuals per cubic meter (ind. m⁻³) Rylov, (1963), Dussart (1967, 1969), Kolisko, (1974), Koste (1978), Kiefer, (1978), Segers, (1995), Einsle, (1996),

Smirnov, (1974, 1992, 1996). Nogrady and Segers (2002) .

The species diversity was calculated by Shannon-Weaver diversity index (Shannon and Weaver, 1949), species dominance was determined by Simpson diversity index (Simpson, 1949) and the species evenness was estimated following Pielou (1966).

Sorensen's similarity index (Magurran, 2004), measures similarity in species composition for

Results and discussion

During this study all together 38 zooplankton species were identified, including 25 species of Rotifera, 8 species of Cladocera and 5 species of Copepoda. Systematic of the identified species is given in Table 1. Rotifera comprised 65.7%, Cladocera 21.1% and Copepoda 13.2% of the total zooplankton species. Seasonal individual number (ind. m⁻³) of zooplankton in Tercan, Kuzgun and

Demirdöven Dam Lakes are given in Table 2.

Keratella quadrata was observed in 10 samples. *P. dolichoptera* followed this species being present in 9 samples. During the study period *A. sieboldi*, *B. calcyflorus*, *K. quadrata*, *K. cochlearis*, *K. tecta*, *L. closteroerca*, *L. luna*, *L. lunaris*, *L. ohioensis*, *P. dolichoptera*, *C. sphaericus*, *D. cucullata*, *D. longispina*, *D. magna*, *M. micraura* and

A. denticornis were observed in all of the three dam lakes. *D. longispina* was the dominant Cladocera species which occurred in 6 samples. Among the copepod species *A. denticornis* had the highest frequency of occurrence. These species were present in 8 samples.

Temperature ($^{\circ}\text{C}$), dissolved oxygen (mg L^{-1}) and pH values of Tercan, Kuzgun and Demirdöven Dam Lakes are given in Table 3.

Table 1: Zooplankton species in the study area.

Classis	Subclassis	Order	Suborder	Family	Species
Eurotatoria	Monogononta	Ploima		Brachionidae	<i>Brachionus calcyflorus</i> Pallas, 1766 <i>B. urceolaris</i> (Müller, 1773) <i>Keratella quadrata</i> (Müller, 1786) <i>K. cochlearis</i> (Gosse, 1851) <i>K. tecta</i> (Lauterborn, 1900) <i>Kellicottia longispina</i> (Kellicott, 1879) <i>Euchlanis dilatata</i> Ehrenberg, 1832 <i>Trichotria tetractis</i> (Ehrenberg, 1830) <i>Colurella obtusa</i> (Gosse, 1886) <i>Lepadella ovalis</i> (Müller, 1786) <i>L. patella</i> (Müller, 1786) <i>Lecane luna</i> (Müller, 1776) <i>L. ohioensis</i> (Herrick, 1885) <i>L. ecane lunaris</i> (Ehrenberg, 1832) <i>L. closteroerca</i> Schmarda, 1859 <i>Cephalodella catellina</i> (Müller, 1786) <i>C. forficula</i> (Ehrenberg, 1830) <i>C. gibba</i> (Ehrenberg, 1830) <i>Notommata glyphura</i> Wulfert, 1935 <i>Trichocerca similis</i> (Wierzejski, 1893) <i>Ascomorpha saltans</i> Bartsch, 1870 <i>Polyarthra dolichoptera</i> Idelson, 1925 <i>Synchaeta pectinata</i> Ehrenberg, 1832 <i>Asplanchna sieboldi</i> (Leydig, 1854) <i>Filinia pejeri</i> Hutchinson, 1964
Branchiopoda	Phyllopoda	Flosculariacea Diplostraca	Cladocera	Lepadellidae	
				Lecanidae	
				Notommatidae	
				Trichocercidae	
				Gastropodidae	
				Synchaetidae	
				Asplanchnidae	
				Filiniidae	
				Daphniidae	<i>Daphnia magna</i> Straus, 1820 <i>D. cucullata</i> Sars, 1862: <i>D. longispina</i> Müller, 1785 <i>Diaphanosoma birgei</i> Korinek, 1981 <i>D. brachyurum</i> , (Liévin, 1848) <i>Bosmina longirostris</i> (Müller, 1785) <i>Chydorus sphaericus</i> (Müller, 1776) <i>Moina micrura</i> Kurz, 1874 <i>Acanthodiaptomus</i> <i>denticornis</i> (Wierzejski, 1887) <i>A. robustus</i> (Sars, 1863) <i>Cyclops abyssorum</i> Sars, 1863 <i>C. vicinus</i> Uljanin, 1875 <i>Megacyclops viridis</i> (Jurine, 1820)
				Sididae	
				Bosminidae	
				Chydoridae	
				Moinidae	
				Diaptomidae	
	Copepoda	Calanoida			
		Cyclopoida		Cyclopoidae	

Table 2: Seasonal individual number (ind. m^{-3}) of zooplanktons in Tercan, Kuzgun and Demirdöven Dam Lakes.

Species	Tercan Dam Lake				Kuzgun Dam Lake				Demirdöven Dam Lake			
	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi
<i>A. saltans</i>	2911							2911	2183			
<i>A. sieboldi</i>	1092					727					727	363
<i>B. calcyflorus</i>	363	1820			1820		727		1092			
<i>B. urceolaris</i>	727				727		727					
<i>C. catellina</i>									363			
<i>C. forficula</i>					727				363			

Table 2 continued:

<i>C. gibba</i>	363											
<i>C. obtusa</i>	1092											
<i>E. dilatata</i>		1056						363	727			
<i>F. pejleri</i>		3275						1092				
<i>K. longispina</i>					1820			1056				4730
<i>K. quadrata</i>	2911	4002		727	1092	4366	1092	10553		1056	1092	
<i>K. cochlearis</i>	4366	5095		363	12008	17103	4002	6914				
<i>K. tecta</i>			1092				3275					
<i>L. closterocerca</i>	1456	1092		727	363							
<i>L. luna</i>	1092		1056		363		1092					
<i>L. lunaris</i>		1092	1820			1092						
<i>L. ohioensis</i>	727		727		1092							
<i>L. ovalis</i>			727									
<i>L. patella</i>	363		1092									
<i>N. glyfura</i>			363	727								
<i>P. dolichoptera</i>	6550	1820			6186	26568	2547	6186	4366		2547	792
<i>S. pectinata</i>							1092		1092			
<i>T. similis</i>	363		1092						363			
<i>T. tetractis</i>	1092	727							363			
<i>B. longirostris</i>	727				1820	2183						
<i>C. sphaericus</i>	1820				1820	727			727		727	
<i>D. birgei</i>						727				5822	363	
<i>D. brachyurum</i>							1820					
<i>D. cuculata</i>	727				1092	727			727		727	
<i>D. longispina</i>	727				1820	3630				1092	2183	363
<i>D. magna</i>	363					5095			1092	727		
<i>M. micraura</i>				727	1820	727				1092		
<i>A. denticornis</i>	1820				4002	1092	727	1092		106258	1456	4366
<i>A. robustus</i>									1820			
<i>C. abyssorum</i>									1056	14180		2183
<i>C. vicinus</i>	727				6186	20742		1820				
<i>M. viridis</i>								1820				

Table 3: Temperature (C°), dissolved oxygen (mg L⁻¹) and pH values of Tercan Kuzgun and Demirdöven Dam Lakes.

	Tercan Dam Lake				Kuzgun Dam Lake				Demirdöven Dam Lake			
	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi
Temperature (C°)	17.2	21.2	18.1	6.2	14.3	20.8	16.9	5.6	16.2	22.8	14.7	5.3
DO (mg L ⁻¹)	7.9	5.9	6.1	8.9	8.2	6.2	6.3	9.1	8.1	6.7	6.9	9.4
pH	7.8	7.7	8.2	8.3	8.0	8.1	7.9	7.9	8.2	8.1	7.9	7.9

In all of the dam lakes the most number of taxa were recorded in spring and the least number of taxa were recorded in winter except Demirdöven Dam Lake. In this lake in winter and summer the same number of species (7 species) have been identified (Table 2). The most number of zooplankton was calculated as 129898 ind. m⁻³ in Demirdöven Dam Lake in summer, the

least number of individuals was recorded in Tercan Dam Lake with 3271 ind m⁻³ (Table 4, Fig. 2). Among the three dam lakes the most and least number of taxa were recorded in Tercan Dam Lake. In this lake 22 species were identified in spring, whereas only 5 species were identified in winter.

Table 4: The seasonal densities of zooplankton (individual m⁻³) in Tercan, Kuzgun and Demirdöven Dam Lakes.

Zooplanktonic Group	Tercan Dam Lake				Kuzgun Dam Lake				Demirdöven Dam Lake			
	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi
Rotifera	25468	19979	7969	2544	26198	49856	17465	27255	19974	727	4330	6977
Cladocera	4364	19979	7969	727	8372	13816	1820	0	2546	8733	4000	363
Copepoda	2547	0	0	0	10188	21834	727	4732	2876	120438	1456	6549
Total	32379	39958	15938	3271	44758	85506	20012	31987	25396	129898	9786	13889

In Tercan and Kuzgun Dam Lakes Rotifera were the dominant group in all seasons. In Demirdöven Dam Lake Rotifera lost its dominance in summer. In summer Copepoda were observed in high numbers.

In all of dam lakes Rotifera comprised the dominant group followed by

Cladocera. The highest numbers of taxa were observed in Tercan Dam Lake (28 species). Rotifera has got its maximum taxa (21 species) in this dam lake. In Tercan Dam Lake Rotifera was comprised 75%, in Kuzgun Dam Lake 61% and in Demirdöven Dam Lake 67% of the total zooplankton (Fig. 2).

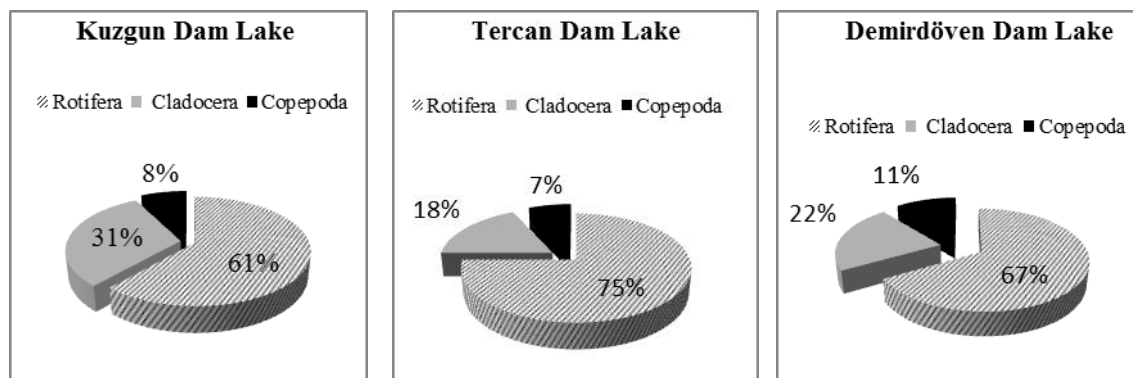


Figure 2: The relative density (%) of zooplankton taxa in the dam lakes.

In Cip (Saler and Şen, 2000), Kesikköprü (Yiğit, 1998), Göksu (Bekleyen, 2003), Kepektaş (Saler, 2009) Gelingüllü (Kaya and Altındağ, 2007) Çamlığöze (Dirican and Musul, 2008), Asartepe (Buyurgan *et al.*, 2010), Karakaya (Saler *et al.*, 2010), Hasan Uğurlu and Suat Uğurlu (Bozkurt and Akın, 2012), Beyhan (Bulut and Saler 2014) dam lakes rotifers were reported as dominant zooplanktonic group both in term of number of individuals and frequency of occurrence.

In Tercan, Kuzgun and Demirdöven Dam Lakes the highest number of species were recorded in spring followed by summer. Similar data were recorded in Kepektaş (Saler, 2009), Asartepe (Buyurgan *et al.*, 2010) and

Uzunçayır (Saler *et al.*, 2014) Dam Lakes.

Among the identified zooplankton, (*B. angularis*, *B. calyciflorus*, *C. gibba*, *L. lunaris*, *L. patella*, *K. cochlearis*, *K. quadrata*, *S. pectinata*, *P. dolichoptera*, *A. sieboldi*, *F. longiseta*, *E. dilatata*, *B. longirostris*, *C. sphaericus*, *P. aduncus*, *A. denticornis*, *C. vicinus*, *M. viridis*) are cosmopolite species and occur in pelagic region and aquatic macro vegetation areas (Kolisko, 1974; Braioni and Gelmini, 1983; Koste and Shiel, 1987; Ramdani *et al.*, 2001; Bozkurt and Akın, 2012). *K. quadrata* was the dominant rotifer species of all three dam lakes which is resistant to high changes in temperature and emerge among plants in lentic habitats and slow flowing lotic habitats (Braioni and Gelmini, 1983; Bozkurt and Akın,

2012). *C. vicinus* occurs in lakes, rivers, marshes, and the littoral regions of all varieties of aquatic habitats (Dussart, 1969). This species occurred in Tercan and Kuzgun Dam Lakes.

All of the index values have been consistent with each other. Shannon-Wiener index (H') values varied between 2.75 and 0.68. The highest H' value was recorded in the whole dam lakes in the spring, whereas the low value of the index was calculated in winter period (Table 5).

Margalef's species richness index (M) showed noticeable fluctuations. The lowest value (M=0.49) was observed in winter and the highest value (M=2.02) was recorded in spring. Both of these values were recorded in Tercan Dam Lake. Both of the Simpson's highest value (D=11.63, in spring), and lowest value (1.46, in summer) of dominance index (D) were measured in Demirdöven Dam Lake. The highest value of Equitability (Evenness) Pielou's index (J=0.98) was calculated in winter in Tercan Dam Lake, but the lowest index (J=0.35) was obtained in summer in Demirdöven Dam Lake. The variations were not major throughout the study period in all dam lakes (Table

5). Sorenson similarity index values were given by a cluster diagram (Fig. 4).

According to Ramdani *et al.*, (2001), the Cluster analysis provide an important visual figure of the comparison based on the zooplankton distribution. Cluster analysis of zooplankton species determined in three of the dam lakes are given in figure 4. The hierachical cluster analysis dendrogram has shown the highest similarty (77.7%) between the species of Demirdoven and Kuzgun Dam Lakes species (Fig. 5). According to Sorenson's coefficient, these communities had much overlap or similarity.

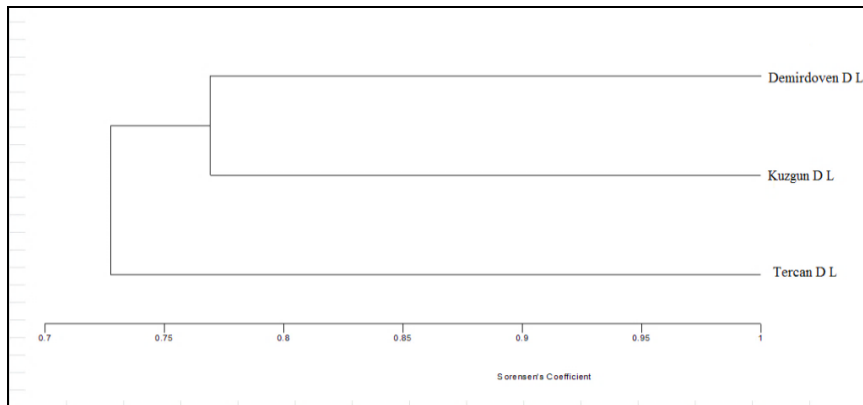
In the present study, seasonal changes showed variations in zooplankton population, and most of the species were least documented in during winter. Our results were similar to the zooplankton analysis of Singh *et al.* (2002). In all of the dam lakes, the maximum zooplankton populations were observed in spring and summer due to favourable conditions of high level nutrients, increased photo period and high intensity of light.

Table 5: Seasonal index values of Tercan, Kuzgun and Demirdöven Dam Lakes.

Name of index	Tercan Dam Lake			
	Spring	Summer	Autumn	Winter
Margalef index (M)	2.02	0.80	0.77	0.49
Simpson index (D)	10.89	6.30	6.90	4.76
Shannon-Wiener index (H')	2.71	1.99	2.01	1.58
Pielou index (J)	0.87	0.90	0.96	0.98
Total number of species (N)	22	9	8	5
Kuzgun Dam Lake				
Margalef index (M)	1.49	1.15	1.01	0.77
Simpson index (D)	7.66	4.88	7.98	4.84
Shannon-Wiener index (H')	2.38	1.89	2.21	1.80
Pielou index (J)	0.84	0.71	0.92	0.82
Total number of species (N)	17	14	11	9

Table 5 continued:

Demirdöven Dam Lake				
Margalef index (M)	1.97	0.51	0.76	0.62
Simpson index	11.63	1.46	5.91	3.99
Shannon-Wiener index (H')	2.75	0.68	1.91	1.57
Pielou index (J)	0.90	0.35	0.91	0.81
Total number of species (N)	21	7	8	7

**Figure 4: Sorenson similarity index values of Tercan, Kuzgun and Demirdöven Dam Lakes.**

The high value of Shannon index (H') demonstrated greater species diversity. This indicates a larger food chain and more favourable conditions of interspecific interactions which increases the stability of the community (Ludwick and Reynold, 1998). In present study, Demirdöven Dam Lake showed greater species diversity. Pielou index (J) that is also known as evenness index, indicates whether all species in a sample are equally abundant or not. It was also found that species evenness decreased with increasing the number of zooplankton population in the dam lakes. Thus evenness was relatively high at Tercan Dam Lake during winter and at Kuzgun and Demirdöven Dam Lakes in autumn.

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