

## Seasonal Variation in Planktonic Microcrustacea (Copepoda, Cladocera) Diversity in Kadıköy Reservoir (Edirne/Turkey)

Hüseyin GÜHER<sup>ORCID</sup>

Trakya University, Faculty of Science, Department of Biology, 22030, Edirne- Turkey

Corresponding Author: [huseying@trakya.edu.tr](mailto:huseying@trakya.edu.tr)

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### Abstract

This study was carried out to determine the diversity, abundance and seasonal distribution of microcrustacea (Cladocera, Copepoda) in Kadıköy Reservoir. For this purpose, microcrustacea and water samples were taken at monthly intervals from March 2010 to February 2011 in three different stations from the reservoir. As a result of qualitative and quantitative analyses of the samples, a total of 27 taxa, 19 taxa from Cladocera and 8 taxa from Copepoda were identified. The quantitative evaluation of the samples revealed an average value of 51463 ind/m<sup>3</sup> in the reservoir. The annual average values according to the groups were 33766 ind/m<sup>3</sup> (66%) for Cladocera and 17697 ind/m<sup>3</sup> (34%) for Copepoda. According to the water quality standards, the temperature, pH, nitrate nitrogen, sulphate and phosphate were found at first and second quality levels. In terms of dissolved oxygen the water was found at first quality level, nitrite nitrogen was found between second and third quality levels. Microcrustacea fauna and physicochemical parameters were evaluated together and the reservoir was concluded to be a meso-eutrophic water body

**Keywords:** Microcrustacea, diversity, seasonal distribution, water quality, reservoir

### Kadıköy Barajı'nın (Edirne/Türkiye) Planktonik Microcrustacea (Copepoda, Cladocera) Faunası ve Mevsimsel Değişimi

#### Özet

Bu araştırma Kadıköy baraj gölünün planktonik Microcrustacea (Cladocera, Copepoda) faunasını ve mevsimsel dağılımını belirlemek amacıyla yapılmıştır. Bu amaçla baraj gölünde belirlenen üç istasyonda Mart 2010-Şubat 2011 tarihleri arasında aylık periyotlar halinde plankton ve su örnekleri alınmıştır. Plankton örneklerinin kalitatif ve kantitatif değerlendirilmesi sonucunda Cladocera'da 19 Copepoda'da 8 tür bulunurken baraj gölünde yıllık ortalama 51463 birey/m<sup>3</sup> microcrustacea bulunmuştur. Bu organizmalardan 33766 birey/m<sup>3</sup> (%66) Cladocera ve 17697 birey/m<sup>3</sup> (%34) Copepoda grubuna aittir. Kadıköy baraj gölünde ölçülen çevresel parametreler Yüzeysel Su Kalitesi Yönetmeliği'ne göre değerlendirilmiş ve göl suyu su sıcaklığı, pH, Nitrat, Sulfat ve Fosfat açısından I ila II; Çözünmüş oksijen açısından I; Nitrit açısından III ila IV sınıf su kalitesi arasında değiştiği tespit edilmiştir. Baraj gölünde tespit edilen Microcrustacea faunasının yapısına ve ölçülen fizikokimyasal parametrelere göre baraj gölünün mezo-ötrofik karakterde olduğu belirlenmiştir.

**Anahtar kelimeler:** Microcrustacea, tür çeşitliliği, mevsimsel dağılım, su kalitesi, baraj gölü

## INTRODUCTION

Zooplankton communities occupy a central place in food webs in fresh water ecosystems regulating the flow of matter and energy to higher-level consumers from primary producers (Wetzel, 2001). Zooplanktonic organisms are bioindicators of water quality and pollution levels because they are strongly influenced by environmental changes and respond quickly to changes in ecosystem quality (Gannon and Stemberger, 1978).

The typical zooplankton communities of an aquatic ecosystem are usually made up of Protozoa, Rotifera and Planktonic microcrustacea (Copepoda, Cladocera) (Rocha et al., 1999). Cladocera which known as water fleas are tiny aquatic crustaceans and are mostly filter-feeders, gathering phytoplankton or detritus from the water column (Negrea, 1983). They are highly sensitive to pollutants and therefore serve as good biological indicators of water pollution. Copepoda are also known as the most abundant zooplankton in the fresh water ecosystems.

Few species are predatory that are carnivorous even as immature stages (copepodites) (Lampert and Sommer, 2007).

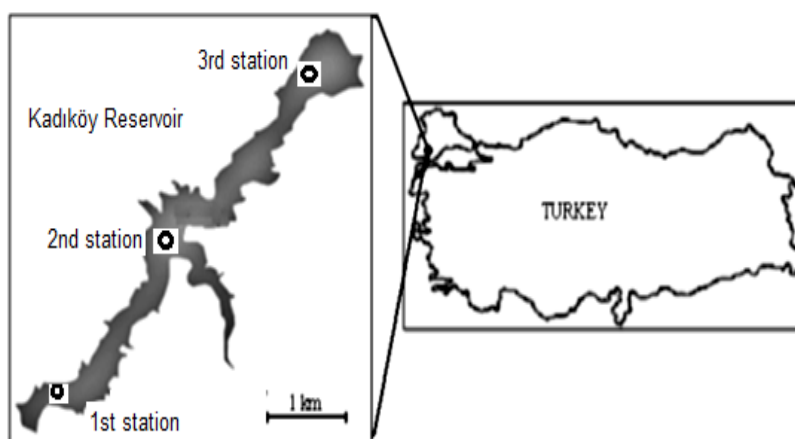
The zooplankton community, an important element in freshwater ecosystems, generally exhibits dramatic changes in response to changes in the physico-chemical properties of the aquatic environment. Hence zooplankton association, abundance, seasonal variation, richness and diversity can be used as for the assessment of water pollution and for lake management applications. Therefore, studies on seasonal variations of the planktonic microcrustacea (Cladocera and Copepoda) in aquatic ecosystems are very important. A number of studies have been carried out to examine the distribution and diversity of microcrustacea (Cladocera and Copepoda) in inland waters, especially in dam lakes and lakes in Turkey among which some reported a great deal of microcrustacea data for Turkish reservoirs (Alper et al., 2007; Özdemir Mis et al., 2009; Buyurgan et al., 2010; Yıldız, 2012; Saler and Alış, 2014; Bulut and Saler, 2014; Saler et al., 2017; Saler, 2017; Özdemir Mis and Ustaoglu, 2018). But the planktonic microcrustacea (Cladocera and Copepoda) of Kadıköy reservoir has not been studied so far. The only study carried out by Öterler (2013) and Elipek et al. (2017) who studied the phytoplankton composite, water quality, respectively, in the Kadıköy reservoir. The aim of this study is to determine the Cladocera and Copepoda fauna, abundance, seasonal distribution of Kadıköy reservoir and to determine some environmental parameters.

## MATERIALS AND METHODS

### The Study Area

The Kadıköy Reservoir is situated 20 km south-east of Keşan district in Edirne province. It was built for flood control and irrigation purposes and also provides drinking and domestic water of Keşan district. It has a maximum depth of 20 m and a surface area of 6.2 km<sup>2</sup>. Although the reservoir is fed mainly by the Doğanca Stream, it is also replenished by other small streams in the region and rainfall (Figure 1).

The present study was performed at the reservoir in monthly intervals from March 2010 to February 2011. Three sampling stations were determined in the reservoir and the plankton samples in each were collected with the Hensen type plankton net (mesh size 55 µm) vertically up to the surface from the bottom point. Collected samples were immediately preserved in 4% formaldehyde and brought to the laboratory for further analyses. In the laboratory, samples were identified at species level according to Goulden-Fery (1963), Flössner (1972), Smirnov (1974), Margaritora (1983), Korinek (1987), Kaya and Altındağ (2006), Forro et al. (2008) for Cladocera and Dussart (1967, 1969), Kiefer (1978), Apostolov- Marinov (1988), Boxshall and Defaye (2008) for Copepoda. The counting of the samples was made according to Wetzel (2001) using an Olympus inverted microscope. Densities are presented as the number of individuals per cubic meter (ind/m<sup>3</sup>). Some physicochemical parameters (water temperature, light permeability, conductivity, pH and dissolved oxygen) were measured on site simultaneously with the sampling time. A Ruttner water sampler was used for water samplings in order to determine other physical-chemical features of the reservoir water in the laboratory. The analysis was done in laboratories of Trakya University Technology Research Development Application and Research Center.



**Figure 1.** Location of Kadıköy reservoir and the sampling stations.

Margalef Index was used to determine the species richness (Jaccard, 1912; Margalef, 1958) and Shannon-Weaver index (Shannon and Weaver, 1949) was used to determine the species diversity of planktonic microcrustacea (Cladocera and Copepoda) in the reservoir. Pearson Correlation was used to determine the relationship of Cladocera and Copepoda groups with each other and with environmental parameters (Krebs, 1999).

## RESULTS

### Physical and Chemical Variables

The minimum and maximum values of the physico-chemical parameters measured in the reservoir are given in Table 1. The comparison of the results of physico-chemical analyses with National Standard for Turkish inland water revealed that comparison temperature, pH, Nitrate nitrogen, Sulphate, Phosphate were found at first and second quality level. In terms of dissolved oxygen the water was found at first quality level, Nitrite nitrogen was found between second and third quality levels and Biological oxygen demand was found at third and fourth quality levels (Anonymous, 2015).

**Table 1.** The measurement data of physico-chemical parameters, minimum, maximum and average values were given for all measured parameter.

	Min.	Max.	Average
Water temperature (°C)	2.00	29.00	16.48 ± 10.027
Dissolved oxygen (mg/L)	3.40	15.73	7.65 ± 3.813
Light permeability (cm)	36.3	105.0	71.6 ± 22.958
pH	7.53	8.63	8.29 ± 0.283
Conductivity (µS/cm)	388.00	613.67	523.03 ± 88.695
Biological oxygen demand (mg/L)	11.80	64.57	41.00 ± 19.617
Nitrate nitrogen (mg/L)	0.00	9.89	3.49 ± 2.934
Nitrite nitrogen (mg/L)	0.00	0.09	0.05 ± 0.029
Ortho-phosphate (mg/L)	0.000	0.068	0.010 ± 0.020
Sulphate (mg/L)	0.43	1.60	1.10 ± 0.368
Salinity (‰)	0.070	0.100	0.082 ± 0.010
Chloride (mg/L)	18.99	33.32	27.02 ± 4.228
Total hardness (FH)	11.00	30.00	23.79 ± 4.705
Calcium (mg/L)	24.53	61.70	39.69 ± 9.326
Magnesium (mg/L)	9.93	44.83	34.84 ± 9.840

### Cladocera and Copepoda Community Structure

As a result of the qualitative evaluation of the samples, 19 Cladocera and 8 Copepoda species were found in Kadıköy reservoir during the study period (Table 2). In addition, Cyclopoid copepodites, Harpacticoid copepodites and Nauplius larvae have been found. When the sampling months were evaluated in terms of species diversity, the highest number of species were found in May (12 Cladocera, 7 Copepoda species) followed by June (7 Cladocera, 3 Copepoda) and December (5 Cladocera, 3 Copepoda), while the lowest species number was found in August (2 Cladocera, 2 Copepoda) and October (3 Cladocera 1 Copepoda). *Moina micrura*, *Daphnia pulex*, *Macrothrix laticornis*, *Macrothrix hirsuticornis*, *Leydigia leydigi*, *Disparalona rostrata*, *Alona quadrangularis*, *Leptodora kindtii*, *Megacyclops viridis*, *Eucyclops serrulatus* were sampled only in one month during the study. The most common species in the reservoir were *Diaphanosoma brachyurum*, *Bosmina longirostris*, *Daphnia longispina*, *Ceriodaphnia quadrangula* and *Chydorus sphaericus* from Cladocera found in all sampling months. In addition, *Cyclops vicinus*, *Acanthocyclops robustus* and *Eudiaptomus vulgaris* from Copepoda are the most common species found during eight months.

Monthly changes in species richness, diversity and maximum dominance of zooplankton are given in Table 3. According to the results of Simpsons Diversity, while species richness is the maximum (10.206) in May, it reached its lowest value (7.119) in December. According to Margalef Index and Shannon diversity index, no significant differences in the species diversity were observed between months ( $P < 0.005$ ) (Table 3).

**Table 2.** Cladocera and Copepoda species and minimum, maximum and average values of their annual numbers per m<sup>3</sup>.

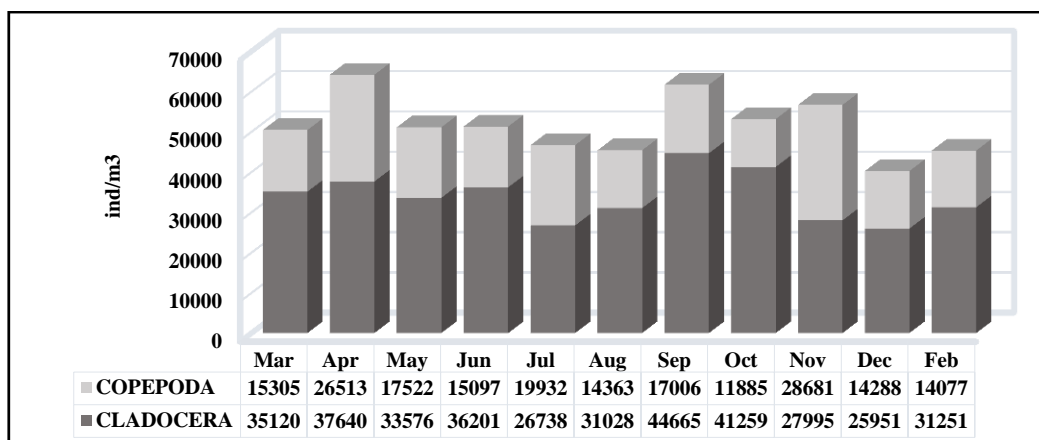
<b>CLADOCERA</b>	<b>Min.</b>	<b>Max.</b>	<b>Average</b>	<b>%</b>
<i>Diaphanosoma brachyurum</i> (Lievin, 1848)	1125	8931	4887	14.45
<i>Bosmina longirostris</i> (O.F.Müller, 1776)	2100	4975	3868	11.43
<i>Moina micrura</i> Kurz, 1875	0	1446	162	0.48
<i>Moina brachiata</i> (Jurine, 1820)	0	2100	893	2.64
<i>Daphnia pulex</i> Leydig, 1860	3150	7675	5260	15.55
<i>Daphnia longispina</i> (O. F. Müller; 1776)	3534	9275	6007	17.76
<i>Daphnia hyalina</i> Leydig, 1860	0	0	289	0.85
<i>Daphnia galeata</i> Sars, 1863	0	319	189	0.56
<i>Ceriodaphnia quadrangula</i> (O.F.Müller, 1785)	1446	9156	5538	16.37
<i>Macrothrix laticornis</i> (Jurine 1820)	0	1446	180	0.53
<i>Macrothrix hirsuticornis</i> Norman & Brady, 1867	0	0	355	1.05
<i>Leydigia leydigi</i> (Schoedler 1863)	0	425	110	0.32
<i>Chydorus sphaericus</i> (O.F.Müller, 1776)	1446	8625	5850	17.29
<i>Chydorus ovalis</i> Kurz, 1875	0	69	15	0.05
<i>Disparalona rostrata</i> (Koch, 1841)	0	456	104	0.31
<i>Alona costata</i> Sars, 1862	0	69	42	0.12
<i>Alona guttata</i> Sars, 1862	0	69	25	0.07
<i>Alona quadrangularis</i> (O.F.Müller, 1776)	0	319	42	0.12
<i>Leptodora kindtii</i> (Focke, 1844)	0	0	13	0.04
<b>Total</b>			<b>33766</b>	<b>100.00</b>
<b>COPEPODA</b>				
<i>Cyclops vicinus</i> Uljanin, 1875	0	9156	3737	21.12
<i>Cyclops abyssorum</i> G.O. Sars, 1863	0	2100	382	2.16
<i>Cyclops insignis</i> Claus, 1857	0	0	362	2.04
<i>Acanthocyclops robustus</i> (G.O. Sars, 1863)	0	5838	3568	20.16
<i>Megacyclops viridis</i> (Jurine, 1820)	0	0	321	1.82
<i>Eucyclops serrulatus</i> (Fischer, 1851)	0	200	60	0.34
<i>Thermocyclops crassus</i> (Fischer, 1853)	0	456	66	0.37
<i>Eudiaptomus vulgaris</i> (Schmeil, 1898)	0	425	140	0.79
Cyclopoid Copepoda	425	3534	1731	9.78
Harpacticoid Copepoda	0	200	122	0.69
Nauplius	4831	13175	7208	40.73
<b>Total</b>			<b>17697</b>	<b>100.00</b>

**Table 3.** Species diversity and species richness values of zooplankton according to the sampling months.

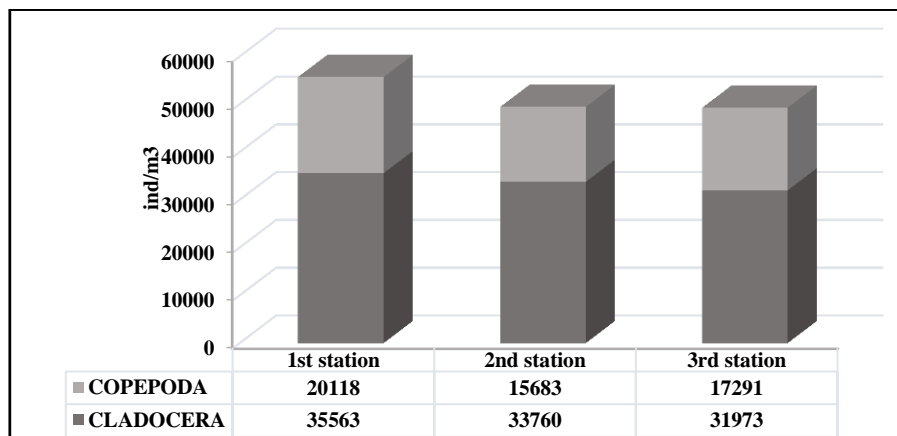
Index	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Feb
<b>Margalef indeksi (M)</b>	6.167	6.033	6.159	6.157	6.211	6.227	6.054	6.137	6.101	6.298	6.228
<b>Simpsons Diversity (D)</b>	9.503	9.47	10.206	9.863	8.451	8.196	8.494	8.959	7.841	7.119	8.301
<b>Shannon J'</b>	0.83	0.873	0.799	0.833	0.886	0.858	0.813	0.865	0.887	0.848	0.845

The quantitative evaluation of the samples revealed an average value of 51463 ind/m<sup>3</sup> in the reservoir. The annual average values according to the groups were 33766 ind/m<sup>3</sup> for Cladocera and 17697 ind/m<sup>3</sup> for Copepoda (Table 2).

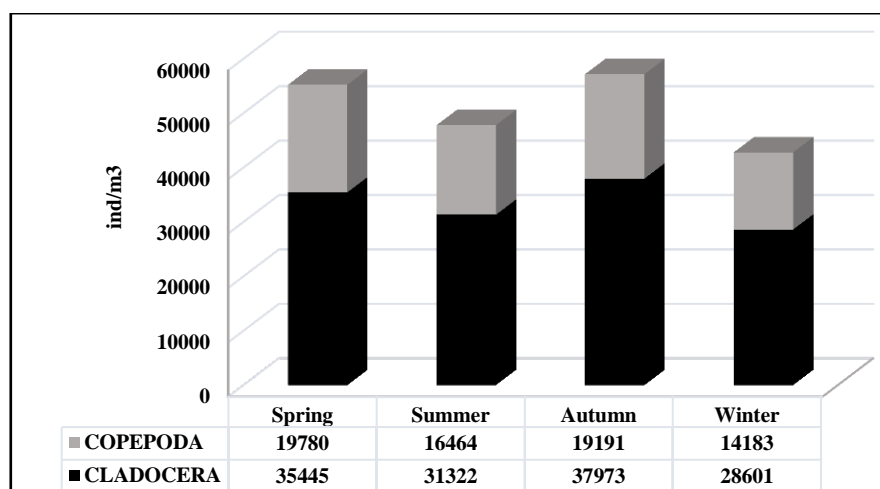
When the sampling months were evaluated based on average individual values per m<sup>3</sup>, the maximum number of microcrustacea (Cladocera and Copepoda) was found in April (64153 ind/m<sup>3</sup>) followed by September (61671 ind/m<sup>3</sup>) and the minimum was found in December (40239 ind/m<sup>3</sup>) followed by February (45328 ind/m<sup>3</sup>) (Figure 2).

**Figure 2.** Total abundance of microcrustacea according to the sampling months.

The maximum number of microcrustacea (Cladocera and Copepoda) in Kadıköy reservoir were recorded in the 1<sup>st</sup> station (55681 ind/m<sup>3</sup>). This is followed by the 2<sup>nd</sup> and 3<sup>rd</sup> stations with 49443 ind/m<sup>3</sup> and 49264 ind/m<sup>3</sup>, respectively (Figure 3).

**Figure 3.** Abundance values of microcrustacea according to the sampling stations.

When the results were evaluated in terms of sampling months, the maximum organism number was found in autumn (57164 ind/m<sup>3</sup>), followed by spring (55225 ind/m<sup>3</sup>) and summer (47786 ind/m<sup>3</sup>) and the minimum was found in winter (42784 ind/m<sup>3</sup>) (Figure 4).



**Figure 4.** Seasonal abundances of microcrustacea in the reservoir.

According to the Pearson correlation index, no significant relationship was found between Copepoda and Cladocera groups. However, there was a positive correlation between water temperature between pH, Conductivity, Nitrite nitrogen, Calcium and with Dissolved oxygen between Conductivity, Ortho-phosphate and with pH between Total hardness, Magnesium ( $P < 0.01$ ) (Table 4).

**Table 4.** The relationship between environmental parameters and microcrustacea groups in the reservoir as revealed by the Pearson Correlation index (Cop: Copepoda, Cla: Cladocera).

	Cl	Cop	WT	DO	LP	pH	EC	BOD <sub>5</sub>	NO <sub>3</sub> N	NO <sub>2</sub> N	oPO <sub>4</sub>	SO <sub>4</sub>	Sal	Cl	TH	Ca	Mg
Cl	1																
Cop	-,190	1															
WT	-,074	,158	1														
DO	,470	-,358	-,581	1													
LP	,060	,000	,300	-,067	1												
pH	-,065	-,097	-,662*	,520	-,184	1											
EC	-,207	,199	,898**	-,751**	,466	-,601	1										
BOD <sub>5</sub>	,391	,117	-,328	,689*	-,288	,007	-,614*	1									
NO <sub>3</sub> N	-,512	-,125	-,222	-,290	,398	,267	,106	-,621*	1								
NO <sub>2</sub> N	-,281	,161	,843**	-,589	,424	-,406	,885**	-,600	,091	1							
oPO <sub>4</sub>	,582	-,382	-,594	,768**	,132	,440	-,522	,309	,018	-,451	1						
SO <sub>4</sub>	-,151	-,372	,250	-,258	-,161	,091	,246	-,545	,324	,432	-,088	1					
Sal	-,319	,271	-,083	,234	,248	,245	-,083	,114	,163	,239	,118	-,069	1				
Cl	,163	,319	-,053	-,356	,016	-,479	,120	,066	,127	-,224	,010	-,229	-,413	1			
TH	-,299	,284	-,495	,098	-,215	,857**	-,321	-,220	,324	-,200	,135	,053	,180	-,256	1		
Ca	,068	-,262	-,784**	,575	,010	,557	-,589	,121	,249	-,440	,781**	-,131	,260	-,067	,419	1	
Mg	-,393	,458	-,129	-,223	-,251	,627*	-,042	-,307	,234	,000	-,306	,106	,055	-,234	,862**	-,095	1

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\* . Correlation is significant at the 0.01 level (2-tailed).

## DISCUSSION

As a result of the qualitative evaluation of the samples, 19 Cladocera and 8 Copepoda species were found in Kadıköy reservoir during the study period. In addition, Cyclopoid copepodites, Harpacticod copepodites and Nauplius larvae were found (Table 2). All the species determined are recorded for the first time in Kadıköy reservoir. According to Gündüz (1997), Ustaoglu (2004, 2015) and Güher (2014), all the species recorded in the Kadıköy reservoir are widely distributed in Turkey. *Diaphanosoma brachyurum*, *Bosmina longirostris*, *Daphnia longispina*, *Ceriodaphnia quadrangula*

and *Chydorus sphaericus* from Cladocera; *Cyclops vicinus*, *Acanthocyclops robustus* and *Eudiaptomus vulgaris* from Copepoda were determined as the most common species during the study.

The quantitative evaluation of the samples revealed an average value of 51463 ind/m<sup>3</sup> in the reservoir. The annual average values according to the groups were 33766 ind/m<sup>3</sup> (66%) for Cladocera and 17697 ind/m<sup>3</sup> (34%) for Copepoda. Cladocera was found as the leading group in both diversity and abundance. When the present result was compared with the zooplankton data formerly reported in Turkey, it appeared that different water source studied revealed different result in terms of Cladocera and Copepoda abundance. For instance, Saler et al. (2017) reported 13 Cladocera (39.4%) and 3 Copepoda (9.1%) species in the Boztepe Tecai Kutan reservoir, Yıldız (2012) reported 2 Cladocera (5%) and 2 Copepoda (1%) in the Zerneke reservoir; Alper et al. (2007) identified 8 Cladocera and 4 Copepoda species in the İkizcetepeler Dam Lake; Bulut and Saler (2014) reported 5 Cladocera (3.99%) and 3 Copepoda (2.63%) taxa in the Beyhan Dam Lake and Saler and Aliş (2014) found 11 of Cladocera (21.2%) and 7 of Copepoda (13.4%) in the Hancağız Dam Lake.

In the present study, while the maximum numbers of microcrustacea (Cladocera and Copepoda) in Kadıköy reservoir were found in autumn (57164 ind/m<sup>3</sup>) and at 1<sup>st</sup> station (55681 ind/m<sup>3</sup>), the minimum numbers were recorded in winter (42784 ind/m<sup>3</sup>) and at 3<sup>rd</sup> stations (49264 ind/m<sup>3</sup>). *Diaphanosoma brachyurum*, *Bosmina longirostris*, *Moina brachiata*, *Daphnia pulex*, *Daphnia longispina*, *Ceriodaphnia quadrangula* and *Chydorus sphaericus* from Cladocera and *Cyclops vicinus*, *Acanthocyclops robustus* and *Eudiaptomus vulgaris* from Copepoda were observed in all seasons and stations as in the case of similar in various reservoirs in Turkey (Özdemir Mis et al., 2009; Yıldız, 2012; Bulut and Saler, 2014; Saler et al., 2017; Saler, 2017; Özdemir Mis and Ustaoglu, 2018).

Zooplanktonic organisms play an important role as indicator in determining water quality, eutrophication and water pollution level. Especially, Cladocera and Cyclopoid copepods are well adapted to eutrophic conditions (Gannon and Stemberger, 1978). *Chydorus sphaericus* (58501 ind/m<sup>3</sup>; 17.28%), *Bosmina longirostris* (3868 ind/m<sup>3</sup>; 11.43%) and *Cyclops vicinus* (3737 ind/m<sup>3</sup>, 21.12%) in Kadıköy reservoir are known as typical indicators of eutrophic lakes (Ryding and Rast, 1989; Makarewicz, 1993).

According to the National Standard for Turkish inland water, water temperature (16.48 °C), pH (8.29), Nitrate nitrogen (3.49 mg/L), Sulphate (1.10 mg/L) and Orthophosphate (0.010 mg/L) were found at first and second quality level. In terms of Dissolved oxygen demand (7.65 mg/L) the water was found at the first quality level, Nitrite nitrogen (0.09 mg/L) was found between second and third quality levels and Biological oxygen demand (41.00 mg/L) was found at third and fourth quality levels (Anonymous, 2015).

In conclusion, a total of 27 species from microcrustacea (19 Cladocera and 8 Copepoda) were found in Kadıköy reservoir during the study period. As a result of quantitative evaluation of zooplankton samples, an average value of 33766 ind./m<sup>3</sup> Cladocera (66%), 17697 ind./m<sup>3</sup> Copepoda (34%) and an average of 51463 ind/m<sup>3</sup> planktonic microcrustacea were determined in the reservoir. When the structure of microcrustacea fauna determined in the reservoir and the physicochemical parameters were evaluated together it has been concluded that Kadıköy reservoir is in meso- eutrophic character in terms of zooplankton.

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