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Authors: Ömer ERDOĞAN, Abdullah SAVAŞ

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Determination of Kovada Lake Water Quality According to Zooplankton

Ömer ERDOĞAN[1]*, Abdullah SAVAŞ[2]

[1]Isparta University of Applied Sciences, Yalvaç Vocational School of Technical Sciences, Environmental Protection and Control Program, 32400, Isparta, Türkiye.

[2] Isparta University of Applied Sciences, Faculty of Eğirdir Fisheries, Isparta, Türkiye.

***Corresponding Author:** omererdogan@isparta.edu.tr

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Abstract: In this study, between June 2012 and May 2013, zooplankton was sampled seasonally from 4 stations in Kovada Lake and various physicochemicals were measured. In our study, 23 species of Rotifera, 6 species of Claodocera and 3 species of Copepoda, total 32 species were identified. The highest zooplankton density in Kovada Lake was 243353.2 org/m^3 in summer season and the lowest was 62132.8 org/m^3 in winter season. According to Saprobi and WZI indices, the lake was found to be in mesotrophic water quality. However, the fact that zooplankton species such as *K.cochlearis, P.vulgaris* from Rotifera, *D.longspina, B.longirostris* from Cladocera, which are indicators of eutrophic waters, are dominant and frequent species for Kovada Lake is an indication that the trophic level of the lake is going towards eutrophic structure when evaluated in terms of zooplankton.

Key words: Lake Kovada, Zooplankton, Index, Water quality

1. INTRODUCTION

Zooplankton is one of the most important living elements in the aquatic ecosystem. In the food chain, consumer zooplankton helps the energy flow to take place efficiently by transferring the organic matter produced by primary producers through photosynthesis to higher parts of the chain. Like all living things, planktonic organisms have their preferred optimum environmental conditions and these conditions vary among zooplanktonic species. Such organisms, whose distribution and number of individuals are limited according to the environmental conditions and which indicate changes in the environment, are called indicator organisms. Nutrient concentration, nutrient quality (such as the presence of cyanobacteria), predation, physicochemical properties of water are among the factors affecting zooplankton distribution [1-4]. In recent studies, zooplanktonic organisms are frequently used to determine trophic status [5-9].

2. MATERIAL AND METHOD

Kovada Lake is located at the southern end of the Lakes Region in the Western Taurus Mountains in the Mediterranean Region at coordinates 37º40'N-30º 52'D, 18 km south of Lake Eğirdir in Eğirdir district of Isparta province, in the north-south direction. The lake with a catchment area of 77 km^2 is located at an altitude of approximately 904-905 m above sea level. The excess water of Lake Eğirdir reaches Lake Kovada through the 22 km long Kovada Canal. In this study, 4 stations were sampled seasonally from Lake Kovada between June 2012 and May 2013 (Figure 1).

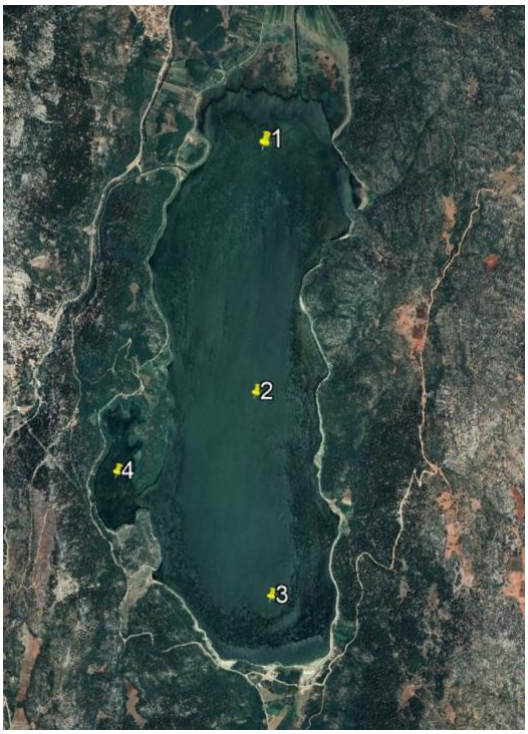

Figure 1. Lake Kovada and stations

Zooplanktonic organisms were obtained by vertical plankton pulling. A Hensen type plankton grab with a front mouth diameter of 17 cm and a mesh size of 55 µm was used. The collected samples were placed in 500 ml plastic sample preservation containers and fixed with 4% formaldehyde solution [2]. . Species identification and enumeration of the specimens brought to the laboratory were made by using the relevant sources [10-17].

In our study, parameters such as temperature, dissolved oxygen, pH, electrical conductivity, dissolved oxygen saturation, Secchi disk visibility were measured *in situ* during sampling. Water prefixes for chlorophyll-a samples were taken in 1 l, tightly sealable, dark-colored and light-proof polyethylene containers and brought to the laboratory as soon as possible, protected from sunlight, according to the 90% acetone extraction method [18-19].

2.1. Statistical analysis

Statistical analysis of the numerical data on water quality and plankton was performed using SPSS 16 package program and the differences between groups were determined by Duncan multiple comparison test. Significance level was chosen as $P < 0.05$. Shannon-Weaver's and Simpson's index were used for species diversity of zooplankton. Sørensen's similarity index was used for the similarity of stations and seasons with respect to species and UPGMA (Unweighted pair group mean averages) dendogram was given. Multi-Variate Statistical Packet (MVSP 3.1) program was used in the analysis [20].

2.2. Zooplankton Analysis

2.2.1. Wetland Zooplakton Index (WZI)

This index is calculated using weighted averages as in the equation below.

$WZI = \sum YiTiUi / \sum YiTi$

Here Yi is the abundance or presence of species, Ti is tolerance (1-3), Ui is optimum (1-5). The index ranges from 1 (low quality) to 5 (high quality). Ti and Ui values of the species were determined according to Lougheed and Chow-Fraser [5].

2.2.2. Saprobi Index

This index is calculated based on the number and relative density of indicator species using the following equation;

$S= \Sigma sh/\Sigma h$

Here; s is the species-specific saprobite value and h is the abundance value of the species. The relationship between saprobite values and water quality classes is given in Table 1 [21].

Table 1. Water quality classes according to Saprobi index values

Water Quality Class		**Saprobi İndeks**
I-	Very good	≤0.5
II-	Good	0.5-1.5
III-	Middle	1.6-2.5
IV-	Bad	2.6-3.5
V-	Very Bad	>3.5

3. RESULTS

3.1. Some Physical and Chemical Properties of Lake Kovada

Some physical and chemical analysis results of water samples taken seasonally (autumn 2012-summer 2013) from selected research stations in Kovada Lake are given in Table 2.

Table 2. Water quality values determined in Kovada Lake stations

Parameter	Autumn				Winter				Spring				Summer			
	1.	**2.**	**3.**	**4.**	**1.**	**2.**	**3.**	**4.**	**1.**	**2.**	**3.**	**4.**	**1.**	**2.**	**3.**	**4.**
pH	8.58	9.03	9.03	10.21	7.8	8.03	8.2	8.6	8.8	8.6	8.8	8.5	8.3	8.5	9.1	8.6
	Mean:9.21±0.69^{b}				**8.15±0.33^{a}**				**8.67±0.15^{ab}**				**8.62±0.34^{ab}**			
Water temperature (°C)	13.2	13.2	13.4	14.1	3.2	3.2	3.2	3.7	21.4	21.6	21.4	22.2	24.6	24.6	24.8	25.6
	13.47±0.42^{b}				**3.32±0.25^{a}**				**21.65±0.37^{c}**				**24.9±0.47^{d}**			
Sol. Oxygen (mg/l)	8.7	8.8	9.2	8.5	12.96	13.4	13.45	12.85	12.78	12.56	12.94	12.54	9.5	8	7.6	7.4
	8.8±0.29^{a}				**13.16±0.30^{b}**				**12.70±0.1907^{b}**				**8.12±0.95^{a}**			
%O_2 saturation	114	125	136	114	101	102	102	101	150.8	148.3	149.8	146.3	105	90	88	85
	122.25±10.5^{b}				**101.5±0.57^{a}**				**148.8±1.95^{c}**				**92±8.90^{a}**			
Salinity (ppt)	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1
	0.125±0.05^{a}				**0.1±0^{a}**				**0.1±0^{a}**				**0.15±0.05^{a}**			
El. Conductivity (µS/cm)	304.2	301.2	298.8	291.5	257	251	251	250	277.1	273.2	265.4	265.4	333.3	283.3	274.4	244.5
	298.92±5.42^{c}				**252.25±3.20^{a}**				**270.27±5.85ab**				**283.87±36.89^{c}**			
Chlorophyll a (mg/m^3)	6.2	4.52	4.9	4.5	3.5	2.5	2.2	2.2	2.48	2.85	2.67	4.33	2.94	3.35	3.02	4.44
	5.03±0.80^{b}				**2.6±0.61^{a}**				**3.08±0.84a**				**3.43±0.69a**			
Secchi Disk (m)	1.15	1.40	2.1	2.0	1.35	1.85	2.3	2.1	1.35	1.40	1.6	2.1	2.5	2.3	2.5	2.8
	1.66±0.46^{a}				**1.9±0.41^{a}**				**1.61±0.34^{a}**				**2.52±0.20^{b}**			

Different letters in the same row indicate differences between seasons ($P < 0.05$)

3.2. Zooplaktonic Organisms Detected in Lake Kovada

As a result of this research in Kovada Lake, 23 species of Rotifera, 6 species of Claodocera and 3 species of Copepoda, total 32 species were identified. These species are given in table 3 below according to groups.

Table 3. Zooplaktonic Organisms Detected in Lake Kovada

Rotifera	**Autumn**	**Winter**	**Spring**	**Summer**
Brachionus diversicornis (Müller, 1773)	-	-	+	+
Brachionus angularis (Müller, 1786)	+	+	+	+
Keratella cochlearis (Gosse, 1851)	+	+	+	+
K. tecta	-	+	+	+
Notholca squamula (Müller, 1786)	-	+	-	-
Euchlanis dilatata Ehr., 1832	-	-	+	-
Euchlanis deflexa (Gosse, 1851)	-	-	+	-
Colurella adritica (Ehr., 1830)	-	-	+	-
Lepadella ovalis **(**Müller**,** 1786)	-	+	-	-
Lecane lunaris (Ehr., 1832)	-	-	-	+
Cephalodella gibba (Ehr., 1838)	-	+	+	-
Trichocerca similis (Wierzejski, 1893)	+	-	+	+
Trichocerca bicristata	-	-	+	+
Asplanchnous sp.	-	-	+	-
Synchaeta pectinata Ehr., 1832	-	+	+	+
Synchaeta oblonga Ehr., 1831	-	+	+	+
Polyarthra vulgaris (Carlin, 1943)	+	+	+	+
Asplanchna priodonta Gosse, 1850	+	+	+	+
Hexarthra mira (Hudson**,** 1871)	-	+	+	-
Filinia longiseta (Ehrenberg**,** 1834)	+	-	+	+
Filinia terminalis (Plate**,** 1886)	-	-	+	+
Rotaria neptunia (Ehrenberg**,** 1832)	-	-	+	-

Cladocera	**Autumn**	**Winter**	**Spring**	**Summer**
Diaphanosoma brachyurum Lievin,1848	-	-	-	+
Daphnia longispina O. F. Müller, 1785	+	+	-	+
D. galeata Sars, 1864.	+	+	+	-
Bosmina longirostris (O. F. Müller, 1785)	+	+	+	+
Pleuroxus aduncus (Jurine, 1820)	+	+	-	-
Chydorus sphaericus (O. F. Müller, 1776)	-	+	+	-
Alona quadrangularis (O. F. Müller, 1785)	+	+	-	-
Copepoda				
Cyclops strenuus Kozminski,1933	+	+	+	+
Macrocyclops albidus Jürine 1820	+	+	-	-
Nitocra hibernica (G. S. Brady, 1880)	-	+	+	+

Seasonal distribution of zooplankton clusters is given in Table 4. The highest zooplankton density in Kovada Lake was 243353.2 org/m^3 in summer season and the lowest was 62132.8 org/m^3 in winter season.

Table 4. Seasonal distribution of zooplankton aggregations

Seasons	**Rotifera Org/m^3**	**Cladocera Org/m^3**	**Copepoda Org/m^3**	**Toplam Org/m^3**
Spring	166674	33059.31	8264.827	207998.1
Summer	204324.9	23187.43	15840,92	243353.2
Autumn	84657.28	20050.72	37031.19	141739.2
Winter	47482.55	6828.806	7821.448	62132.8
Annual average	125784.7	20781.57	17239.6	163805.8

The annual average density of Rotifera group organisms in Kovada Lake zooplankton was found to be 125784.7 org/m^3 (Table 3). The highest density value was observed in summer (204324.9 org/m^3) and the lowest in winter (47482.55 org/m^3) (Figure 2). The organisms that reached the highest density in the Rotifera group were *Keratella cochlearis* (71343 org/m^3) and *Polyarthra vulgaris* (74383 org/m^3). The highest rotifera density was 217640 org/m^3 at station 4 in summer and the lowest was 22016 org/m^3 at station 3 in winter.

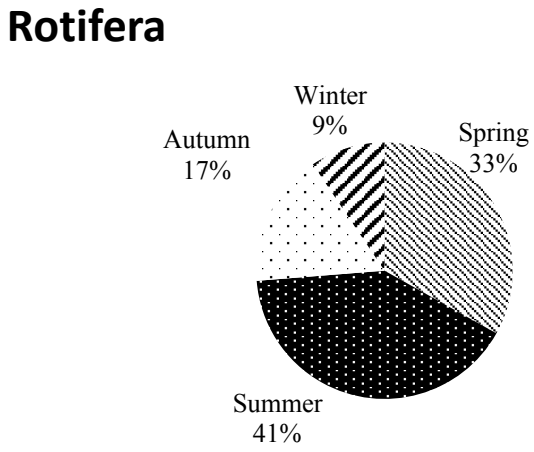

Figure 2. Proportional distribution of Rotifera in Kovada Lake zooplankton according to seasons

The annual average density of Cladocera group organisms in Kovada Lake zooplankton was found to be 18439.71 org/m^3 (Figure 3). When the density changes of this group were analyzed according to the seasons, the highest density value was observed in spring (33059.31 org/^{m3}) and the lowest in winter (6828.80 org/m^3) (Figure 3). *Bosmina longirostris* (24794 org/m^3) and *Daphnia longispina* (11019 org/m^3) were the organisms that reached the highest density within the Cladocera group. The highest cladocera density was 41324 org/m^3 at station 2 in spring and the lowest was 3085 org/m^3 at station 1 in winter.

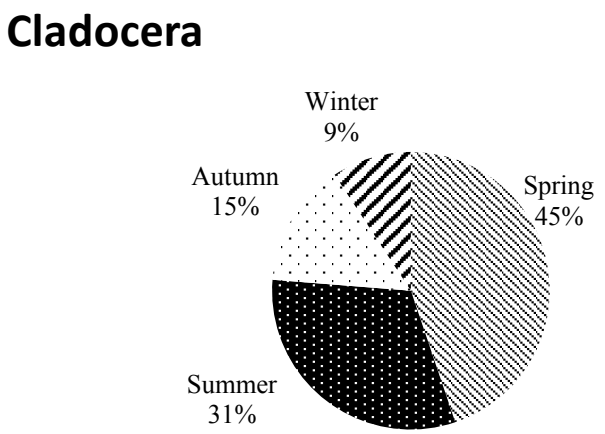

Figure 3. Proportional distribution of Cladocera in Kovada Lake zooplankton according to seasons

The annual average density of Copepoda group organisms in Kovada Lake zooplankton was found to be 17239.6 org/m^3. The highest density value was observed in spring (37031.19 org/m^3) and the lowest in winter (7821,44 org/m^3) (Figure 4). *Cyclops strenuus* (27439 org/m^3) was the organism with the highest density in the Copepoda group. The highest copepoda density was 54879 org/m^3 at station 4 in the fall season and the lowest was 1100.82 org/m^3 at station 3 in the winter season.

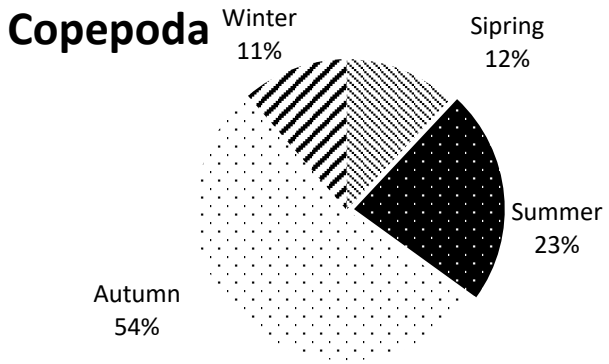

Figure 4. Proportional distribution of Copepoda in Lake Kovada zooplankton according to seasons

In Kovada Lake, the highest zooplankton diversity was observed in spring at station 4 and the lowest in winter at station 4. Seasonally, the highest diversity was determined in summer and the lowest in fall (Table 5).

Table 5. Shannon-Weaver (H') and Simpson (D) diversity index values according to stations and seasons in Lake Kovada

Stations								
	1		**2**		**3**		**4**	
	H'	D	H'	D	H'	D	H'	D
Spring	2,172	0,811	2,186	0,824	1,96	0,797	2,902	0,931
Summer	2,325	0,882	2,368	0,883	2,528	0,892	2,097	0,863
Autumn	1,441	0,665	1,901	0,79	1,532	0,706	1,966	0,819
Winter	1,583	0,703	1,804	0,763	2,221	0,872	1,62	0,66

Seasons							
Spring		**Summer**		**Autumn**		**Winter**	
H'	D	H'	D	H'	D	H'	D
2,48	0,86	2,50	0,89	1,96	0,79	2,07	0,76

According to the seasonal similarities in the distribution of zooplankton species, it was determined that spring and summer seasons were the most similar and fall was the least similar. Again, according to the stations, it was determined that the 1st and 3rd stations were the most similar to each other and the 4th station was the least similar (Figure 5).

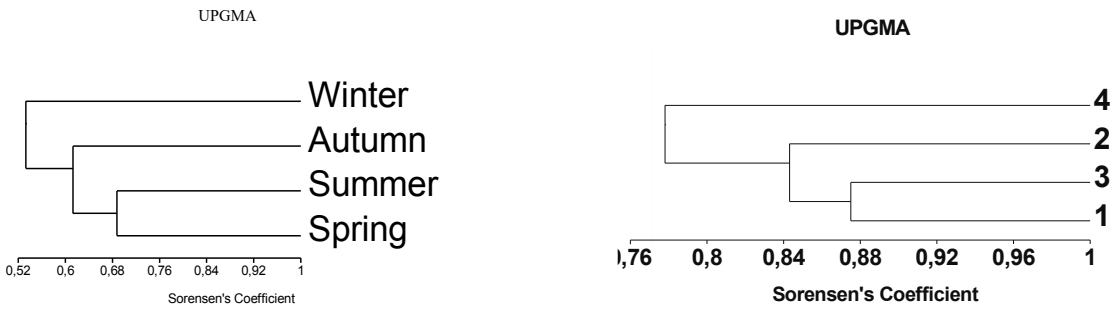

Figure 5. Zooplankton species by seasons (a) and stations (b) according to Sorensen similarity index

Saprobi and WZI values according to the species identified at four stations in Kovada Lake are given in the table below. Saprobi values varied between 1.50 and 1.99 and WZI values varied between 2.11 and 3.08 according to seasons and stations (Table 6).

Table 6. Zooplankton values according to Saprobi and WZI indices

Stations	**1**		**2**		**3**		**4**	
Seasons	**Saprobi**	**WZI**	**Saprobi**	**WZI**	**Saprobi**	**WZI**	**Saprobi**	**WZI**
Winter	1.82	2.97	1.75	2.45	1.72	2.11	1.78	2.70
Spring	1.73	2.84	1.81	2.79	1.99	2.73	1.74	2.86
Summer	1.64	2.68	1.51	2.98	1.68	2.74	1.49	3.08
Autumn	1.77	2.68	1.86	2.69	1.76	2.55	1.95	2.67

According to the water quality classification made according to Saprobi values, Lake Kovada shows medium water quality class. Since it is between 1 (bad) and 5 (good) in our study, Lake Kovada shows the characteristics of medium water quality class according to WZI values.

4. CONCLUSIONS

Water temperature has important effects on water solubility, oxygen saturation, diffusion, etc. [22]. In Kovada Lake, the lowest temperature was measured as 3.20 C (Winter 1,2 and 3. stations) and the highest temperature was 22.20 C (Summer 4. station). In every period, the water temperature was higher at the 4th sample site compared to the other sample sites. This situation is thought to be due to the fact that the 4th sample site is located in the more stable part of Kovada Lake where it forms a pocket. The lowest value of dissolved oxygen, which is another factor such as temperature in the distribution of living organisms, was measured as 7.8 mg/l (summer 4th station) and the highest value was measured as 13.45 mg/l (winter 3rd station). It is thought that the presence of a complete mixture in the 3rd station during windy times and accordingly increasing the water circulation caused an increase in oxygen level. In the 4th station, on the contrary, the water is more stagnant. Weak water circulation and high temperature in these stations caused the oxygen level to decrease.

The Secchi disk, which is used as an indicator of the trophic state, changes depending on the increase in the amount of suspended solids in the water [3]. In the measurements made with Secchi disk, the highest visibility value was 2.8 m at station 4 in the summer season and the lowest value was 1.15 m at station 1 in the fall season. Visibility was high in the summer season due to the increase in light and the station 4 being stationary. The lowest chlorophyll-a value was 2.2 (winter, station 3) and the highest was 6.2 mg/m^3 (fall, station 1). It is thought that chlorophyll-a increased in this season due to the low increase in phytoplankton in the winter period and the increase in phytoplankton with mixing in the autumn period.

Although there are various studies conducted in Kovada Lake [23-30], there is only one study on zooplankton systematics [27].

As a result of this research in Kovada Lake, 23 species of Rotifera, 6 species of Claodocera and 3 species of Copepoda, a total of 32 species were identified. When the distribution of Lake Kovada zooplankton in terms of species and density is analyzed, it is seen that Rotifera is the dominant group in terms of both number of species and density. This group is followed by Cladocera and Copepoda, respectively. In freshwater ecosystems, the numerical abundance of Rotifera compared to other zooplankton groups depends on the high nutrient levels, the reproductive success of Rotifera species and most importantly, the suppression of Cladocera and Copepoda population growth by fish. Rotifer is the dominant group in all seasons and reaches the highest number of individuals in summer, Cladocera in spring and Copepoda in fall [29-31].

The highest zooplankton density in Kovada Lake was 243353.2 org/m^3 in summer season and the lowest was 62132.8 org/m^3 in winter season. It is thought that this situation causes a decrease in phytoplanktonic organisms due to temperature and lack of light in winter season and an increase in the number of zooplanktonic organisms in parallel with the increase in temperature and light in summer season.

In Kovada Lake, *K.cochlearis, P.vulgaris, D.longspina, B.longirostris* from Cladocera were the dominant species. These species are also accepted as indicators of eutrophic lakes [31-36].

Previously, Gülle (1999) examined the zooplankton of Lake Kovada and found 57 species and the average zooplankton density was 87566 org/m^3. In our study, 32 species were identified in Kovada Lake and the average zooplankton density was 163805 org/m^3. It is thought that the presence of fewer species and higher density in our study may be due to the seasonal nature of the study as well as the eutrophic character of the lake over time. Zeybek that Kovada Lake is in the polluted water category and that the source of pollution of the lake comes from the waste dumped into the Kovada canal entering the lake [29].

According to Sørensen's similarity index in the distribution of zooplankton species, stations 1 and 3 are the most similar to each other, while station 4 is the least similar. Stations 1 and 3 are the stations representing both shores of the lake, while station 4 is the more stationary and closed station of the lake. The location of the stations is related to the similarity in zooplankton distribution.

The WZI index includes values between 1 (low quality) and 5 (high quality). In our study, WZI values varied between 2.11 and 3.08. Saprobi values varied between 1.50 and 1.99 according to seasons and stations. According to these results, it is seen that Kovada Lake is in

the medium water quality class, but is approaching the polluted water class. We believe that better results will be obtained in determining the trophic status by determining the index values of more species, to which WZI and saprobi index contribute to determining the trophic structure of the lake.

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