



## Analysis of the Zooplankton Community by the Shannon - Weaver Index in Kesikköprü Dam Lake, Turkey

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**Abstract:** Kesikköprü Dam Lake that is oligotrophic is represented by 11 Rotifera, nine Cladocera and eight Copepoda species. The data obtained from the zooplankton community in Kesikköprü Dam Lake were analysed by the Shannon - Weaver index. The index values showed no positive correlation with the total number of zooplanktonic organisms. Therefore, the index value ( $H= 2.10$ ) is higher in autumn than in other seasons. The abundance data and Shannon - Weaver index values were both analysed by UPGM clustering method. Winter and summer seasons were found to be the most similar by using Shannon - Weaver index values, but spring and autumn showed similarity with seasonal abundance. In this respect, the Shannon - Weaver index is not useful for monitoring and determining the trophic status of Kesikköprü Dam Lake. However,  $H$  values express seasonal homogeneity in the species abundance of zooplankton community.

**Key Words:** Zooplankton, Shannon - Weaver, abundance, Turkey

### Kesikköprü Baraj Gölü (Türkiye) Zooplankton Kommünitesinin Shannon - Weaver İndeksi ile Analizi

**Öz:** Kesikköprü baraj gölü, 11 Rotifera, dokuz Cladocera ve sekiz Copepoda türüyle temsil edilen oligotrofik bir göldür. Kesikköprü Baraj Gölündeki zooplankton kommünitesinden alınan veriler Shannon - Weaver indeksine göre analiz edilmiştir. İndeks değerleri zooplanktonik organizmaların toplam sayısı ile pozitif korelasyon göstermemiştir. Bu nedenle indeks değeri ( $H=2,10$ ) sonbaharda diğer mevsimlere göre daha yüksektir, Bolluk ve Shannon - Weaver indeks değerlerinin her ikisinde UPGM cluster metodu ile analiz edilmiştir. Shannon - Weaver değerleri kullanılarak yapılan analizde yaz ve kış mevsimleri çok benzer olarak bulunmakla birlikte, ilkbahar ve sonbahar mevsimleri mevsimsel bolluk ile benzerlik göstermiştir. Bu açıdan Shannon - Weaver indeksi Kesikköprü Baraj Gölünün trofik düzeyinin belirlenmesi ve izlenmesinde kullanışlı değildir. Bununla birlikte  $H$  değerleri zooplankton kommünitesinin tür bolluğundaki mevsimsel homojeniteyi göstermektedir.

**Anahtar Kelimeler:** Zooplankton, Shannon - Weaver, bolluk, Türkiye

#### Introduction

Zooplankton groups are a characteristic indicator of water quality, eutrophication and pollution levels, and are an important source of food chain (SHARMA 1983, SAKSENA 1987). They play an important role as grazers, suspension feeders and predators within the zooplankton community. They also serve as an essential food source for invertebrate and vertebrate predators (HERZIG 1987). ROGOZIN (2000) stated that it is important to analyse the relationship between the trophic structure of the lake and the zooplankton community. Different indices such as the index of cenotic significance (ICS) and the Shannon-Weaver index have been used to examine this relationship (ROGOZIN 2000). Turkey is rich in

freshwaters with approximately 200 natural lakes and 120 dam lakes. The long-term effects of dam lakes on river ecosystems are still unknown in Turkey. Kesikköprü Dam Lake is one of five dam lakes constructed on the Kızılırmak river in Central Anatolia. Two indices, dominance and information statistical indices are used to measure diversity in an ecosystem. Dominance indices which give more weight to common or dominant species, were first developed by SIMPSON (1949). Information statistic indices such as the Shannon-Weaver index (SHANNON & WEAVER, 1949) assume that all species are represented in the sample and are randomly sampled. STILING (1996) stated that no index is perfect. In this study, the aim

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was to numerically analyse seasonal fluctuations in the zooplankton community in Kesikköprü Dam Lake using the Shannon-Weaver index in order to determine the relationship between the numerical expression of the zooplankton community and the trophic level of the lake. The problems associated with this index are also discussed.

## Material and Methods

Kesikköprü Dam Lake is located 110 km south-east of Ankara between the Kapulukaya and Hirfanlı dam lakes. Its total volume is 9500 hm<sup>3</sup>, maximum depth 30 m, and total area 650 ha. Kesikköprü Dam Lake is 750 m above sea level, and is fed by the Kızılırmak River. This study was conducted at five different stations in the lake, the depths of which were as follows: 1= 30 m, 2= 20 m, 3= 20 m, 4= 20 m, 5= 10 m (Fig. 1). Samples were collected from each station between April 1995 and May 1996 on a monthly basis, using a 55µ pore size Hydro-Bios Kiel plankton net, and with horizontal and vertical hauls. Vertical sampling from bottom to surface was performed every 10 m. The samples were evaluated quantitatively, and the species identified for horizontally collected samples. All specimens collected were preserved in 4 % formalin soon after collection. Identification of the specimens was performed according to KOLISKO (1974); KOSTE (1978); HARDING & SMITH (1974); WARD & WHIPPLE (1945) and DUSSART (1969). Quantitative analysis and evaluations were carried out according to EDMONDSON (1959) and TELES (1986). During all study periods, water temperature, secchi depth, dissolved oxygen (DO mg/l) and pH were measured *in situ* (Table 1). The significance of the seasonal abundance of Cladocera, Copepoda and Rotifera were determined by the Chi-square test (Microsoft Excel). In order to calculate species diversity, quantitative data of the zooplankton were analysed by the Shannon-Weaver index ( $H = -\sum p_i \ln p_i$ ) (SHANNON & WEAVER 1949). The seasonal abundance and  $H$  were also analysed by the NTSYS-*pc* computer program (ROHLF, 2000); Subtract option: MIN, Divide option: SQRR (SS), Coefficient: Manhattan, Clustering method: UPGMA.

## Results

Kesikköprü Dam Lake is one of five dam lakes constructed over the Kızılırmak River (Fig.1). Nutrient input to this lake is restricted to the steppe shores. The seasonal ranges of water temperature (°C), transparency (m), DO (mg/l) and pH are given in Table1. According to seasonal transparency criteria ranging from 7.2 to 12.4 m and average P

concentration (5.8 µ/l), this lake is oligotrophic. In the Dam Lake, Nine Cladocera, eight Copepoda and 11 Rotifera species were recorded (Table 2). The seasonal percentages of Cladocera, Copepoda and Rotifera are summarized in Table 3. The highest individual numbers of Cladocera was found in spring (64109±0.40 Ind / m<sup>3</sup>), followed by summer, autumn and winter respectively. The averages of seasonal abundances of Copepoda (78903 ±0.15Ind / m<sup>3</sup>) and Rotifera (65165±0.25 Ind / m<sup>3</sup>) were dominant in spring, followed by autumn, summer and winter in descending order. The average seasonal abundances of Cladocera, Copepoda and Rotifera were statistically significant (P< 0.01). Although individual numbers of zooplankton were highest in spring, Shannon-Weaver index gives the highest values in autumn and winter for Cladocera, Copepoda and Rotifera (Table 4). In addition, average individual numbers of Copepoda were highest in spring, whereas the Shannon-Weaver index gives the highest values for Rotifera (Table 4). The same tendency of the index is also shown for Cladocera in autumn and winter, except for the abundance of Cladocera in summer. When considering the seasonal species-wise percentages of these zooplankton groups, *Daphnia longispina* and *Daphnia pulex* were the most abundant species (67 %) in the total abundance of Cladocera in spring; this percentage decrease to 44 % in winter. In Copepoda species, *Arctodiaptomus acutilobatus* and *Eucyclops serrulatus* together had the highest percentages with 63% in spring, while their percentages receded to 39% in winter. *Keratella quadrata* and *Polyarthra vulgaris* were the most abundant species, comprising 58.8% of the total abundance of Rotifera in spring, but this value decreased to 43.6% in winter. These findings showed that certain species in any zooplankton group have higher individual numbers than others, and these get closer to each other in winter.

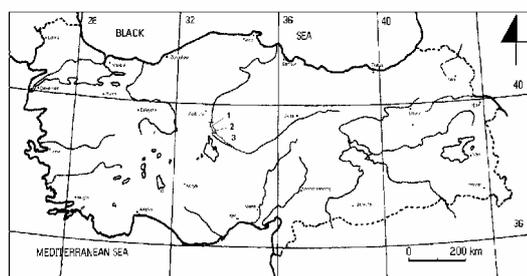


Figure 1. The map showing the location of Kesikköprü Dam Lake in Turkey, 1: Kapulukaya Dam Lake, 2: Kesikköprü Dam Lake, 3: Hirfanlı Dam Lake.

Table 1. The minimum and maximum values of some physico-chemical parameters of Kesikköprü Dam Lake

Seasons	Water temp (C°)	Secchi depth (m)	DO (mg / l)	pH
Spring	11.3 – 19.2	7.2 – 10.3	8.2 – 10.6	8.0 – 8.8
	19.0 – 24.1	7.0 – 10.1	8.0 – 9.1	7.2 – 8.4
Summer	9.0 – 19.1	6.0 – 8.1	8.2 – 10.3	7.8 – 8.5
	4.1 – 6.0	8.0 – 12.4	9.5 – 11.5	7.5 – 8.2
Winter	6.0	12.4	11.5	8.2

### Discussion

The Shannon-Weaver index shows diversity in zooplankton communities, and it is important to comment on the seasonal fluctuations of zooplanktons. For this reason, index value is important for expressing diversity in ecosystem management. These findings were also supported by the UPGMA clustering method (NTSYS). Two different sets of data were used in the cluster analyses. First was seasonal index value for zooplanktonic groups, and second was the total individual number in each season. By using the first data set, summer and winter values were similar to each other, and made up the first cluster. Spring values showed the highest divergence (Fig. 2). The low index value meant that the most unequal proportion of zooplanktonic organism species occurred in spring. With the second data set, as expected, individual numbers in spring and autumn made up the first cluster, and individual numbers in summer and winter connected to the first cluster, respectively (Fig. 3). Our results revealed that the Shannon-Weaver index gave higher values when the proportions of species in a sample were close to each other. In this respect, Copepoda has the highest total individual number in spring, but the Shannon-Weaver index was higher for Rotifera. The reason for this is the more equal proportions of Rotifer species than of the other zooplankton groups in a sample. These proportions came close to each other towards autumn and winter for Cladocera, and the highest value of the Shannon-Weaver index was for Cladocera. In winter, this value for Cladocera was followed by values of 1.78 in Copepoda and 1.75 in Rotifera. The zooplankton group with the more equal proportion in the total biomass is Cladocera, except for Rotifer in spring. In addition, it was seen that the Shannon-Weaver index was not affected by the number of species. Although Rotifera had the highest number of species, and its abundance was only higher than that of the other groups in autumn, Cladocera with a value of 2.10 has

the highest index value. In this respect, the Shannon-Weaver index has specific importance in the expression of equal proportions of zooplankton groups in a sample rather than the total number of individuals. In this dam lake, *D. longispina* and *D. pulex* in Cladocera, *A. acutilobatus* and *E. serrulatus* in Copepoda and *K. quadrata* in Rotifera showed marked summer peaks; these species are hot-stenothermal species. *Macrothrix laticornis* in Cladocera and *Notholca squamula* in Rotifera, which peaked in winter, are cold-stenothermal species. However, the total abundance of zooplankton is usually lower in autumn and winter than in spring and summer (Table 3). For this reason, the Shannon-Weaver index was higher in autumn and winter. In autumn, species diversity  $H$  is 2.10 for Cladocera, 1.95 for Rotifera and 1.83 for Copepoda. This means that Cladocera species have a more equal distribution in the total abundance of Cladocera than the other groups of zooplankton. In general, the proportions of Cladocera species in the total abundance of zooplankton were more equal in summer, autumn and winter, except for rotifera ( $H = 1.74$ ) in spring. In this respect,  $H$  is useful for expressing differing zooplankton abundance in the certain seasons, but because of the unequal weights of abundance of stenothermal species in spring and winter, the seasonal comparison of zooplanktonic organisms cannot be achieved by the Shannon-Weaver index or the increasing index value has no positive correlation to the seasonal abundance. The positive correlation appeared only when zooplanktonic organisms show homogen distribution in the total abundance. Thus  $H$  may give somehow contradictory results concerning the tropic status of the lake. MAGURRAN (1988) compared different diversity indices to find out their effectiveness, and stated that the Shannon-Weaver index is widely used, and its discriminant ability and sensitivity to sample size are moderate. STILING (1996) noted that the value of species diversity  $H$  is often found to fall between 1.0 and 6.0, and the maximum diversity of a sample is  $H_{max}$  when all species area equally abundant. The species diversity  $H$  for the zooplankton abundance of Kesikköprü Dam Lake was higher in winter and autumn than in spring and summer. This finding is consistent with those of STILING (1996). ROGOZIN (2000) studied the zooplankton structure in lakes differing in tropic status, and used the index of dominance ( $I = p\sqrt{B}$ ) for dominancy, the Shannon-Weaver index for species diversity and Czekanowski-Sorensen index for similarity. It was reported that the structure of communities is usually characterised using indices of diversity, of which the Shannon-Weaver information index  $H$  is the most popular (PESENKO 1982; ANDRONIKOVA 1993). ROGOZIN (2000) stated that the structure of zooplankton depends on the

Table 2. Zooplankton species identified in Kesikköprü Dam Lake

Cladocera	Copepoda	Rotifera
<i>Diaphanosoma lacustris</i>	<i>Cyclops vicinus</i>	<i>Brachionus angularis</i>
<i>Daphnia magna</i>	<i>Diacyclops bicuspidatus</i>	<i>Keratella quadrata</i>
<i>Daphnia pulex</i>	<i>Megacyclops viridis</i>	<i>Keratella cochlearis</i>
<i>Daphnia longispina</i>	<i>Cyclops abyssorum</i>	<i>Notholca acuminata</i>
<i>Bosmina longirostris</i>	<i>Eucyclops serrulatus</i>	<i>Notholca squamula</i>
<i>Macrothrix laticornis</i>	<i>Arctodiaptomus acutilobatus</i>	<i>Colurella adriatica</i>
<i>Disparalona rostrata</i>	<i>Acanthodiaptomus denticornis</i>	<i>Lepadella patella</i>
<i>Chydorus sphaericus</i>	<i>Nitocra hibernica</i>	<i>Lecane luna</i>
<i>Monospilus dispar</i>		<i>Asplanchna priodonta</i>
		<i>Synchaeta litoralis</i>
		<i>Polyarthra vulgaris</i>

Table 3. Percentages (%) of seasonal abundance of zooplankton in Kesikköprü Dam Lake

Season	Cladocera	Copepoda	Rotifera	Chi-square test
Spring	30.80	37.90	31.30	(p< 0.01)
Summer	41.32	28.79	29.89	(p< 0.01)
Autumn	27.70	35.43	36.86	(p< 0.01)
Winter	24.87	41.64	33.49	(p< 0.01)

Table 4. Species diversity (H) for Cladocera, Copepoda and Rotifera in four seasons of Kesikköprü Dam Lake.

Seasons	Cladocera	Copepoda	Rotifera
Spring	1,54	1,57	1,74
Summer	1,87	1,74	1,7
Autumn	2,1	1,83	1,95
Winter	1,92	1,78	1,75

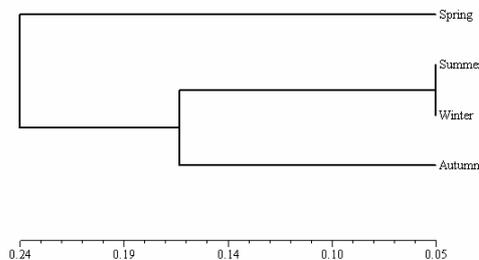


Figure 2. UPGMA dendrogram showing the distance according to average seasonal H values of

zooplankton groups

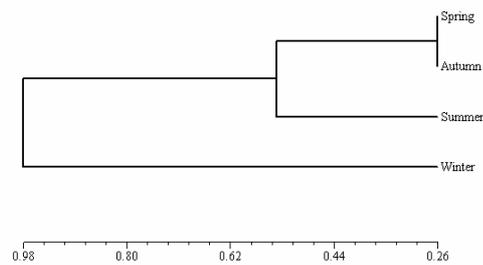


Figure 3. UPGMA cluster established according to the average seasonal abundance of zooplankton groups.

trophic status of the lake. The index of diversity weakly correlates with the trophic status of the lake. Thus, the index *H* for monitoring of trophic status of a lake may yield contradictory results (ROGOZIN, 2000). In the present study, the peaks caused by cold and hot-stenothermal species resulted in higher index values in winter and autumn. In this respect, higher index values express species diversity, but do not indicate the trophic status of the lake. WELCH (1935) reported that annual fluctuations occur in zooplankton abundance as well as two increases, in spring and autumn, and decreases in summer and winter. Similar fluctuations were observed in the zooplankton abundance in Kesikköprü Dam Lake. Thus, index values obtained from the lake are of importance when comparing the abundance of Cladocera, Copepoda and Rotifera in a certain season, and it can be concluded that the species diversity index is not useful for comparing zooplankton abundance in different seasons.

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