İSTANBUL UNIVERSITY PRESS

EISSN 2602-473X

AQUATIC SCIENCES AND ENGINEERING

Aquat Sci Eng 2022; 37(3): 175-181 • DOI: https://doi.org/10.26650/ASE20221075908

Research Article

Benthic Macroinvertebrate Fauna of Some High-Altitude Lakes in the Aladağlar Mountains (Niğde)

Selda Öztürk[1], Sevil Sungur[2], Burak Seçer[1], Erdoğan Çiçek[1]

Cite this article as: Ozturk, S., Sungur, S., Secer, B., & Cicek, E. (2022). Benthic macroinvertebrate fauna of some high-altitude lakes in the Aladağlar Mountains (Niğde). *Aquatic Sciences and Engineering, 37*(3), 175-181. DOI: https://doi.org/10.26650/ASE20221075908

ABSTRACT

This study was carried out in July and August 2019 as a preliminary study to determine the benthic macroinvertebrate fauna of Karagöl, Çömçe and Yıldız Lakes, which are high-altitude lakes in the Aladağlar mountains. As a result of the examination of the collected macrobenthic fauna, seven species belonging to three families from three orders (Diptera, Coleoptera and Trichoptera) in Karagöl Lake, four species belonging to three families from two orders (Diptera, Haplotaxida) in Çömçe Lake, and five species belonging to three families from three orders (Diptera, Trichoptera, Haplotaxida) in Yıldız Lake were determined. The taxa detected is a new record for the studied lakes. Shannon-Weaver diversity (H) and Shannon-Evenness density (EH) indices were applied in order to determine the species richness of the lakes and the density relationships among the species, respectively. Accordingly, the highest diversity was observed in Çömçe Lake with a value of 1.18, followed by Karagöl Lake, and Yıldız Lake with values of 0.87 and 0.83, respectively. While the most balanced distribution was observed in Çömçe Lake with a value of 0.81, this was followed by Yıldız Lake and Karagöl Lake, with values of 0.46 and 0.34, respectively. In order to determine the similarities between the stations according to the distribution of the detected taxa, a two-way clustering analysis based on the Bray-Curtis similarity index was applied. Accordingly, while the highest similarity was calculated between Karagöl Lake and Yıldız Lake, it was determined that there was no similarity between Yıldız Lake and Çömçe Lake.

Keywords: Benthic macroinvertebrate, diversity index, high-altitude lake, Aladağlar, Taurus Mountains

ORCID IDs of the author:
S.Ö. 0000-0002-5639-7962;
S.S. 0000-0003-4018-6375;
B.S. 0000-0002-8763-131X;
E.Ç. 0000-0002-5334-5737

[1]Nevşehir Hacı Bektaş Veli University, Faculty of Arts and Sciences, Department of Biology, Nevşehir, Turkiye

[2]Nevşehir Hacı Bektaş Veli University, Vocational School of Health Services, Nevşehir, Turkiye

Submitted:
17.02.2022

Revision Requested:
12.03.2022

Last Revision Received:
02.04.2022

Accepted:
02.04.2022

Online Published:
27.06.2022

Correspondence:
Selda Öztürk
E-mail:
seldaozturkk50@gmail.com

INTRODUCTION

High mountains have extreme climatic conditions, and are important formations in terms of hosting endemic species adapted to these conditions. There are many high-altitude lakes in these systems, which are seasonal or permanent water bodies and important ecosystems in terms of biodiversity (Ustaoğlu et al., 2008).

High-altitude lakes in the Alpine belt are aquatic ecosystems that are very sensitive to environmental changes, as they are isolated from anthropogenic effects due to their location (Williamson et al., 2008). In the mountainous regions where these lakes are located, the temperature, atmospheric pressure and amount of usable land decrease with the increase in altitude. These climatic or spatial differences limit the distribution of populations of species in both terrestrial and aquatic ecosystems. (Dullinger et al., 2012). For this reason, these ecosystems are represented by relatively low numbers of endemic or adapted species to extreme environmental conditions (Galas, 2004; Krno et al., 2006; Sömek & Ustaoğlu, 2016). In this respect, these lakes are reference points in testing the effects of environmental degradation on the ecosystem (Galas, 2004; Taşdemir & Ustaoğlu, 2016).

Benthic macroinvertebrates, which are one of the most important indicators of biological productivity in aquatic systems, form a wide niche in terms of taking place at different nutritional levels. Most of these creatures have a key role in the transfer of matter and energy from the lower steps of the food pyramid to the upper steps in aquatic ecosystems. With these features, these living groups are important biological indicators used to determine the ecological structure, water quality, pollution and eutrophication in aquatic ecosystems (Dügel & Kazancı, 2004; Toksöz & Ustaoğlu, 2005; Akbaba & Boyacı, 2015; Şimşek, 2015). Therefore, the qualitative and quantitative distribution of benthic fauna and the determination of various factors affecting this distribution are important both within the scope of biodiversity and in ecosystem monitoring and index studies (Bayrak, 2015; Kıymaz, 2018; Baydar, 2020). However, limnological studies in our country have generally been carried out on lowland lakes, which provide convenience in terms of transportation. Very few studies have been carried out on glacial or other lakes of different origin located at high altitudes (Balık et al., 2003; Ustaoğlu et al., 2004; Yıldız et al., 2005, 2007; Ustaoğlu et al., 2008; Topkara et al., 2009, 2011; Zeybek et al., 2012; Taşdemir & Ustaoğlu, 2016; Topkara et al., 2018).

The aim of this preliminary study was to determine the benthic macroinvertebrate fauna of Karagöl, Çömçe Lake and Yıldız Lake, which are high-altitude lakes in Aladağlar mountains.

MATERIALS AND METHODS

Aladağlar is a mountainous areas located in the Central Taurus Mountains of the Taurus Mountains, stretching between the Ecemiş Stream in the west and the Zamantı Stream valley in the east. This mountain range is located on the natural border between the Central Anatolia Region and the Mediterranean Region and separates the provinces of Kayseri, Niğde and Adana from each other. It is a unique area of Turkey in terms of natural life and rare species due to its transitional position between these two regions and its highly diverse geomorphological structure (Gürgen et al., 2010; Zreda et al., 2011).

There are many peaks, such as Kızılkaya (3771 m), Demirkazık (3756 m), Kaldı (3734 m) and Emler (3726 m), in Aladağlar, an important mountain range where the highest peaks of the Taurus Mountains are located (Yence, 2019). There are many high-altitude lakes of various sizes on these peaks and these lakes have the characteristics of crater lakes that occur during orogenic and epyrogenic movements, they are very important ecosystems in terms of serving as a shelter for many living groups (Balık et al., 2003). Having a variable climatic structure, Aladağlar has a Mediterranean climate on its southern slopes and a typical continental climate on its northern slopes (Toroğlu & Ünaldı, 2008).

Within the scope of this study, field studies were carried out in July and August 2019 to determine the benthic macroinvertebrate fauna of three high-altitude lakes in the Aladağlar mountains. Location maps and general information about the study areas are given in Figure 1 and Table 1.

The benthic macroinvertebrate samples were made from the littoral parts of the lakes using a dip net with a 500 µm mesh, depending on the multihabitat sampling method. The benthic macroinvertebrate samples obtained were cleared of their mud and fixed in plastic drums containing 4% formaldehyde solution and transported to Nevşehir Hacı Bektaş Veli University Hydrobiology Research Laboratory. First, systematic separation of the samples brought to the laboratory was made under the stereomicroscope, and then diagnostic procedures were completed using the light microscope to the lowest possible systematic category. For taxonomical identification of the specimens, the following were used: for Coleoptera, Illies (1955) and Brauer (1909);

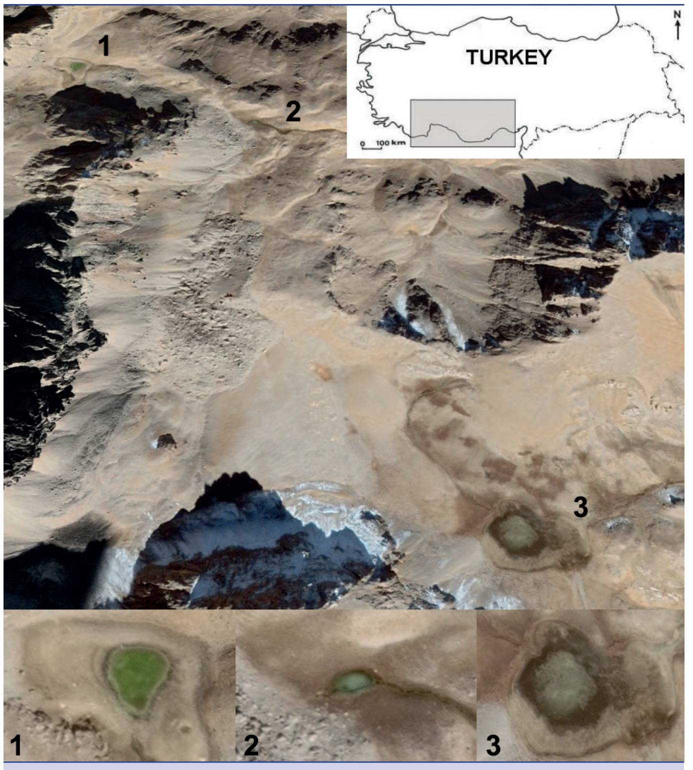

Figure 1. Location map of lakes.

Table 1. Information on the studied lakes

No	Lake	Altitude	Coordinate	Characteristic	Surface area (m²)
1	Yıldız Lake	3084	37°51′37.46″K-35°11′27.72″D	Seasonal-bottom structure muddy	16024
2	Çömçe Lake	2974	37°52′17.23″K-35°11′07.68″D	The permanent-bottom structure is muddy and aquatic plants are present.	356
3	Karagöl Lake	2876	37°52′25.94″K-35°10′48.17″D	Permanent-bottom structure muddy	1626

for Trichoptera, Ulmer (1961), Jansson & Vuoristo (1979), Brohmer (1979), Morse (1983) and Wallace et al., (1990); for Diptera, Şahin (1987, 1991) and Pennak (1989); for Haplotaxida, Brinkhurst & Jamieson (1971), Brinkhurst & Gelder (1991), Milligan (1997), Timm (1999) and Wetzel et al. (2000).

Regarding the benthic macroinvertebrate groups: Dominance analysis (Kocataş, 1997) was used to examine the community structure, and two-way cluster analysis based on the Bray-Curtis similarity index (Bray & Curtis, 1957) was applied to determine the distinctions between stations depending on the distribution of species. Shannon-Weaver diversity and Shannon-Evenness density indices (Shannon & Weaver, 1949) were applied, respectively, to determine species diversity and density relationships among species. Analyses were carried out using PAST 3.0, CAP 4.0 and PC-ORD software packages.

RESULTS AND DISCUSSION

As a result of the sampling studies, a total of 1297 individuals were examined and as a result of the diagnoses, 11 species belonging to five families and 11 genera were identified in four orders (Diptera, Coleoptera, Trichoptera, Haplotaxida) (Table 2).

Among the 1297 individuals examined, the highest dominances (914 individuals (70.47%); 211 individuals (16.27%); 157 individuals (12.10%); 15 individuals (1.16%)) were observed in Trichoptera, Haplotaxida, Diptera and Coleoptera orders, respectively.

According to the evaluation made in the species category, the most dominant species was *L. bipunctatus* (70.47%), followed by *U. uncinata* (13.88%). The lowest dominance was found in the taxa of *T. tubifex* (0.31%) and *P. limbatellus* (0.62%).

Regarding the distribution of macrobenthic fauna in the studied lakes: in Karagöl Lake, 465 individuals were examined and seven species were identified from three families (Chironomidae, Dytiscidae and Limnephilidae) in three orders (Diptera, Coleoptera and Trichoptera). Among the examined individuals, the highest dominance (78.71%) was observed in *L. bipunctatus*, while the lowest dominance (1.29%) was detected in *M. nebulosa*. In Çömçe Lake, 54 individuals were examined and four species were identified from three families (Chironomidae, Naididae, Enchytraeidae) in two orders (Diptera, Haplotaxida). Among them, the highest dominance was observed in *C. sphagnetorum* (50.00%), while the lowest dominance was detected in *T. tubifex* (7.41%). In Yıldız Lake, 778 individuals were examined and five

Table 2. Taxa distribution of lakes and calculated index values (*: Tolerance level evaluated at genus level)

Systematic Categories	Lakes			Tolerance	Reference
	Karagöl Lake	Çömçe Lake	Yıldız Lake		
Diptera					
Chironomidae					
Virgatanytarsus arduennensis (Goetghebuer, 1922)	+				
Chironomus tentans (Fabricius, 1805)	+		+		
Micropsectra paraecox (Wiedemann, 1818)	+	+		7*	Bode et al., 2002
Macropelopia nebulosa (Meigen, 1804)	+		+		
Procladius sp.	+		+	9	Bode et al., 1996
Psectroladius limbatellus (Brundin, 1949)		+			
Coleoptera					
Dytiscidae					
Porhydrus lineatus (Fabricius, 1775)	+				
Trichoptera					
Limnephilidae					
Limnephilus bipunctatus (Curtis, 1834)	+		+	3*	Bode et al., 1996
Haplotaksida					
Naididae					
Tubifex tubifex (Müller, 1774)		+		10	Bode et al., 1996
Uncinais uncinata (Ørsted, 1842)			+		
Enchytraeidae					
Cognettia sphagnetorum (Veydovsky, 1878)		+			
Number of Species	7	4	5		
Species Number of Individuals	465	54	778		
Calculated Indexes					
Shannon-Weaver (H) Diversity	0.867	1.178	0.830		
Shannon Evenness (EH) Density	0.340	0.812	0.458		

species were identified from three families (Chironomidae, Naididae, Limnephilidae) in three orders (Diptera, Trichoptera, Haplotaxida). Among them, the highest dominance was observed in *L. bipunctatus* (70.44%), while the lowest dominance was detected in *C. tentans* (1.54%).

In determining the diversity of an ecosystem, the number of species in that ecosystem and the number of individuals attached to each species are very important (Magurran, 1988). When the species richness in the habitats is compared, the highest diversity belongs to Karagöl Lake, with seven species, followed by Yıldız Lake, with five species. The lake with the lowest diversity was determined to be Çömçe Lake, which is represented by four species. According to the results of Shannon-Weaver diversity index (H) calculated using the abundance values of the determined macrobenthic fauna, the highest diversity was observed in Lake Çömçe with a value of 1.18, followed by Karagöl Lake and Yıldız Lake with values of 0.87 and 0.83, respectively. According to the results of Shannon Evenness density index (EH), in which the balance-equality values was calculated depending on the distribution of the species, the lake with the most balanced distribution was Çömçe Lake with a value of 0.81, followed by Yıldız Lake and Karagöl Lake with values of 0.46 and 0.34, respectively (Table 2 and Figure 2).

The differences in the calculated diversity values between stations that are the same in terms of species richness are due to the differences in the distribution characteristics of the species that are there. Likewise, the stations that have a higher ratio in terms of H value, which expresses diversity, however many lower species they contain, are also related to the distribution characteristics of the individuals belonging to the species that are found there. Therefore, although the species richness of Çömçe Lake is lower than that of Yıldız Lake and Karagöl Lake, the higher calculated diversity value (H) is explained by the more balanced distribution of the species found there. As a matter of fact, according to the Shannon Evenness index (EH) results applied to calculate the balance-equality characteristics of the species belonging to the lake ecosystems, it was observed that the EH value calculated for Çömçe Lake was 0.81, while this value was calculated 0.46 and 0.34 in Yıldız Lake and Karagöl Lake, respectively.

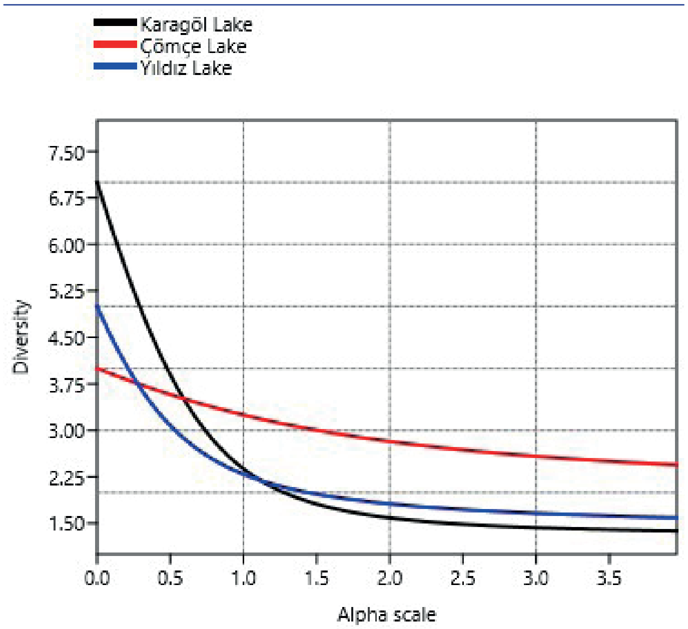

Figure 2. Diversity profile of lakes.

It is known that the diversity and density of macrobenthic fauna elements are low in limnological studies on mountain lakes (Rieradevall et al., 1999). This is in agreement with the findings in our study.

According to the results of the applied two-way cluster analysis; while the highest similarity was calculated between Karagöl Lake and Yıldız Lake with a rate of 0.65%, it was determined that there was no similarity between Yıldız Lake and Çömçe Lake (Table 3, Figure 3 and Figure 4). Regarding the distinctions among lakes, the following were determined to be distinctive taxa: for Karagöl, *V. arduennensis* and *P. lineatus*, for Çömçe Lake, *P. limbatellus*, *T. tubifex* and *C. sphagnetorum* and for Yıldız Lake, *U. uncinata*.

Table 3. Similarity rates between stations (Bray-Curtis)

	Karagöl Lake	Çömçe Lake	Yıldız Lake
Karagöl Lake	1		
Çömçe Lake	0.03	1	
Yıldız Lake	0.65	0.00	1

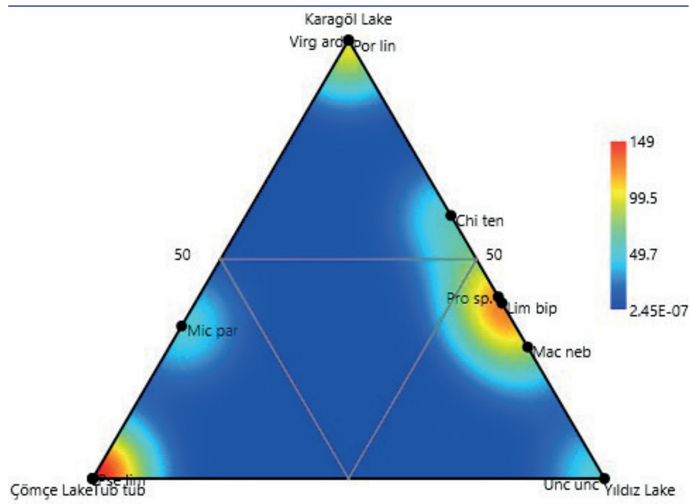

Figure 3. Distribution of detected taxa in lakes (*Virg ard: Virgatanytarsus arduennensis, Chi ten: Chironomus tentans, Mic par: Micropsectra paraecox, Mac neb: Macropelopia nebulosa, Pro sp.: Procladius sp., Pse lim: Psectroladius limbatellus, Por lin: Porhydrus lineatus, Lim bip: Limnephilus bipunctatus, Tub tub: Tubifex tubifex, Cog sph: Cognettia sphagnetorum, Unc unc: Uncinais uncinata*).

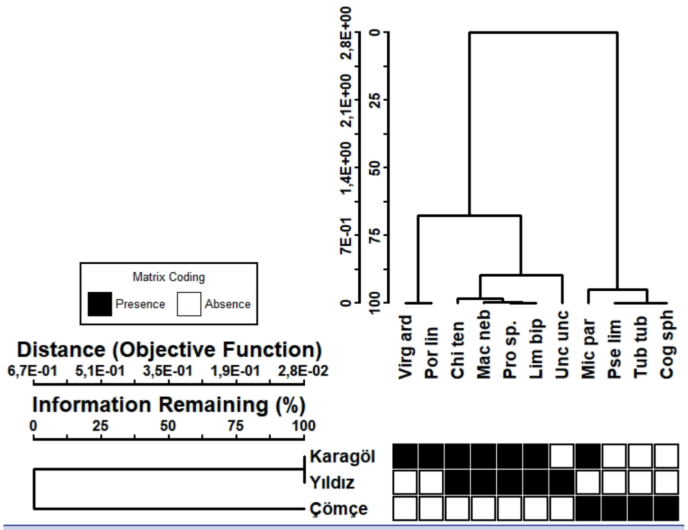

Figure 4. Two-way cluster cluster dendogram of lakes (Bray-Curtis).

Within the scope of the study, the most dominant group in terms of number of individuals is the Trichoptera order with a dominance rate of 70.47%. The members of this order are known for their high population rates in freshwater habitats and their low tolerance for organic pollution. Therefore, the members of this order are important biological indicators used in water quality determination studies (Wiggins & Mackay, 1978; Bouchard, 2004). In our study, *L. bipunctatus* (tolerance level=3) (Bode et al., 1996) species belonging to the Limnephilidae family determined in this order was observed as the dominant species in Karagöl Lake and Yıldız Lake. The species belonging to the genus *Limnephilus* are generally the species that can live in lakes and are widely distributed in Palearctic and Holarctic regions (Sipahiler, 2010). Records of *L. coenosus* and *L. lunatus* species belonging to this genus were given in some lakes on the Taurus Mountains (Topkara et al., 2009; Zeybek et al., 2012). *L. bipuctatus* larvae usually live in stagnant or slowly flowing waters such as ditches, streams and small rivers, and their feeding areas can be permanent or temporary (Wallace et al., 2003). In our study, this species was found in muddy soils with stone and rocky biotopes.

The order represented as the second dominant group in terms of the number of individuals was observed as Haplotaxida, with a dominance rate of 16.47%. The taxa belonging to this order are generally cosmopolitan species and their records have been reported from some high mountain lakes in Turkey (Brinhurst, 1969; Geldiay & Tareen, 1972; Milbrink, 1980; Ustaoğlu, 1980; Taşdemir et al., 2004; Yıldız & Ustaoğlu, 2016; Topkara et al., 2018). The species identified in this order in our study belong to the families of Nadidae and Enchytraeidae. The species belonging to the Nadidae family are known to have high ecological tolerance (Brinkhurst and Jamieson, 1971). The *T. tubifex* species, which was determined to be in the Nadidae family, was only observed with four individuals in Lake Çömçe. It is known that the *T. tubifex* species (tolerance level=10) is abundant in aquatic systems with high pollution level and organic matter input (Bode et al., 1996; Yıldız, 2003). It is thought that this species is represented by few individuals in Çömçe Lake because the lake water exhibits oxygen-rich clean water and there is no organic pollution due to the absence of any livestock activities around the lake. While many species belonging to the order Haplotaxida have been reported from some lakes on the Taurus Mountains, records of *T. montanus*, *T. nerthus*, *T. bergi* and *T. ignotus* taxa belonging to the *Tubifex* genus have also been given (Yıldız et al., 2005, 2007). *U. uncinata* species, which was determined to be in the same family, was only found in Yıldız Lake. This species is known for its high population rates in freshwater ecosystems (Baturina, 2012). The *C. sphagnetorum* species, which was determined to be in the Enchytraeidae family, was observed only in Çömçe Lake. This species, which is known to have a very high ecological tolerance, is known to spread in coastal areas in fresh water and rarely in the bottom water of oligotrophic lakes (Zeybek et al., 2016).

In our study, six species belonging to Chironomidae family were identified in the Diptera order, which is represented by the highest species richness. Chironomidae species have a cosmopolitan distribution and show a wide distribution in many environments, from clean water to very polluted water (Stribling et al., 1998). The observation of the members of this family with high density in aquatic systems allows to make an evaluation about the heavy metal accumulation in the environment. Records belonging to this family have been reported from some mountain lakes in Turkey (Ustaoğlu et al., 2008; Taşdemir & Ustaoğlu, 2016; Topkara et al., 2018). In our study, *C. tentans*, *M. nebulosa* and *Procladius* sp. species identified from this family were found in Karagöl Lake and Yıldız Lake, *M. paraecox* species were detected in Karagöl Lake and Çömçe Lake, *V. arduennensis* was only detected in Karagöl Lake and *P. limbatellus* was only detected in Çömçe Lake. It is known that *C. tentans* is generally distributed in a wide tolerance range (tolerance level=10) in eutrophic lakes (Hilsenhoff, 1987; Bode et al., 1996; Kazancı et al., 1997; Ayık, 2006). In our study, this species was found in shallow water on the shores of lakes. It is known that *M. praecox* (tolerance level=7) and *M. nebulosa* species are commonly found in lakes with moderate oligotrophic properties (Bode et al., 2002; Kökçü, 2016). It is known that *Procladius* sp. has a high tolerance range (tolerance level = 9) and is distributed in slow flowing or shallow regions of aquatic systems (Bode et al., 1996; Taşdemir et al., 2010). It is known that *P. limbatellus* can adapt to different environmental conditions and can spread in different habitats (such as stagnant or flowing waters and rackish waters) (Taşdemir et al., 2010). In some lakes on the Taurus mountain range, the taxa of *C. plumosus*, *C. thummi*, *C. tentans*, *C. viridicollis* and *C. anthracinus* belonging to the *Chironomus* genus, *M. notescens* and *M. junci* belonging to the *Micropsectra* genus and *Procladius* sp belonging to the *Procladius* genus have been reported (Yıldız et al., 2005; Taşdemir et al., 2011).

Dytiscidae members identified in the Coleoptera order are generally adapted to all aquatic habitats (Nilsson 1996). Records of many taxa belonging to this order have been reported from mountain lakes in Turkey (Ustaoğlu et al., 2008; Topkara & Ustaoğlu, 2011, 2015; Zeybek et al., 2012; Topkara et al., 2018). In our study, the *P. lineatus* detected in this family was determined to be from the regions where vegetation is abundant in Çömçe Lake. In a study on the Taurus mountains, the record of this species was reported (Topkara et al., 2009).

Although there are some studies on the determination of the macrobenthic fauna of some lakes in the Taurus mountain range, there is no study on the determination of the macrobenthic fauna in the lakes included in this study (Sipahiler, 1992; Balık et al., 2003; Ustaoğlu et al., 2004; Yıldız et al., 2005, 2007; Topkara et al., 2009; Taşdemir et al., 2011; Yence, 2019). Therefore, the taxa detected is a new record for the relevant lakes.

CONCLUSION

It is important to determine the biological diversity of high-altitude lakes, which are special ecosystems, by increasing the number of studies done on them. The results obtained from this study are a prestudy in determining the biodiversity in lakes. In a study with a longer sampling period in which all the high-altitude lakes in the Aladağlar mountains are included, it will be of great importance to evaluate the macrobenthic fauna of these lakes together with the physicochemical parameters of the lakes and to reveal them fully. In addition, it should not be forgotten that these ecosystems should be protected and the negative effects that may occur on the existing fauna and flora should be taken into account against possible future ecotourism activities.

Conflict of interests: The authors declared no conflict of interest.

Ethics committee approval: Ethics committee approval was not required.

Funding: -

REFERENCES

Akbaba, G. & Boyacı, Y. Ö. (2015). Işıklı Gölü (Denizli) makrobentik faunasının mevsimsel değişimi. *Eğirdir Su Ürünleri Fakültesi Dergisi*, 11(2), 8-19. [CrossRef]

Ayık, Ö. (2006). Uluabat (Apolyont) Gölü Chironomidae (Diptera) limnofaunası. *Osmangazi Üniversitesi, Yüksek Lisans Tezi*, s. 112-123.

Balık S, Ustaoğlu M. R. & Özbek, M. (2003). Toros Dağları (Güney Anadolu) üzerindeki bazı göllerin Mollusca faunası. *Ege Üniversitesi Su Ürünleri Dergisi*, 20, 351-355.

Baturina, M. (2012). Distribution and diversity of aquatic Oligochaeta in small streams of the middle taiga. *Turkish Journal of Zoology*, 36(1), 75-84.

Baydar, T. (2020). Büyük Menderes Nehri su kalitesinin bentik makroomurgasız fauna çeşitliliği kullanılarak tahmini. *Aydın Adnan Menderes Üniversitesi, Yüksek Lisans Tezi*, s. 6

Bayrak Arslan, A. (2015). Su Çerçeve Direktifine göre biyolojik kalite unsuru: bentik makroomurgasız. *T.C. Orman ve Su İşleri Bakanlığı. Uzmanlık Tezi*, s. 8.

Bode, R. W., Novak, M. A. & Abele, L. E. (1996). Quality assurance work plan for biological stream monitoring in New York State. *NYS Department of Environmental Conservation*, pp. 89, Albany.

Bode, R. W., Novak, M. A. & Abele, L. E. (2002). Under preparation quality assurance work plan for biological stream monitoring in New York State. *NYS Department of Environmental Conservation*, pp. 115, Albany.

Bouchard, J. R. W. (2004). Guide to awuatic ınvertebrates of the upper midwest. *University of Minnesota*, pp. 207.

Brauer, A. (1909). Die süsswasserfauna deutschland (Coleoptera). *Verlag von Gustav Fischer Jena*, 235 pp. Berlin.

Bray, J. R. & Curtis, J. T. (1957). An ordination of upland forest communities of southern Wisconsin. *Ecological Monographs*, 325-349. [CrossRef]

Brinkhurst, R. O. & Gelder, S. R. (1991). Annelida: Oligochaete and Branchipodellida. In ecology and classification of North American fresh water invertabrates. (Ed. J.H. THORP and A.P. COVICH). *Academic Press*, pp. 401-435.

Brinkhurst, R.O. & Jamieson, B.G.M. (1971). Aquatic Oligochaeta of the world, (Oliver and Boyd). pp. 860, Edinburg. [CrossRef]

Brinkhurst, RO. (1969). The fauna of pollution, In: D.V. ANDERSON (ed.). *The Great Lakes as an Environment*, *Lake Institute University of Toronto*, 97-115.

Brohmer, P. (1979). Fauna von Deutschland. pp. 581, Heidelberg.

Dullinger, S., Gattringer, A., Thuiller, W., Moser, D., Zimmermann, N. E., Guisan, A., Willner, W., Plutzar, C., Leitner, M., Mang, T., Caccianiga, M., Dirnboeck, T., Ertl, S., Fischer, A., Lenoir, J., Svenning, J. C., Psomas, A., Schmatz, D. R., Silc, U., Vittoz, P. & Huelber, K. (2012). Extinction debt of high-mountain plants under twenty-first-century climate change. *Nature Climate Change*, 2(8), 619-622. [CrossRef]

Dügel, M. & Kazancı, N. (2004). Büyük Menderes Nehri'nin (Türkiye) su kalitesinin makro omurgasızların ve çevresel değişkenlerin sıralanması ve sınıflandırılması kullanılarak değerlendirilmesi. *Tatlı Su Ekolojisi Dergisi*, 19(4), 605-612.

Galas, J. (2004). Invertebrate communities of high mountain lakes. *Teka Komisji Ochronyi Kształtowania Środowiska*, (1), 57-63.

Geldiay, R. & Tareen, I. U. (1972). Bottom fauna of Gölcük Lake, 1. population study of Chironomids, Chaoborus and Oligochaeta. *Scientific reports of Faculty of Science*,137: 15 pp.

Gürgen, G., Çalışkan, O., Yılmaz, E. & Yeşilyurt, S. (2010). Yedigöller Platosu ve Emli Vadisi'nde (Aladağlar) döküntü örtülü buzullar, *e-Journal of New World Sciences Academy Nature Sciences*, 5(2), 98-116.

Hilsenhoff, W. L. (1987). An ımproved biotic ındex of organic stream pollution. *Great Lakes Entomologist*, 20, 31-39.

Illies, J. (1955). Die tierwelt deutschlands Plecoptera. pp. 150, Germany.

Jansson, A. & Vuoristo, T. (1979). Significance of stridulation in larval Hydropsychidae (Trichoptera). *Behaviour*, 71, 167-185. [CrossRef]

Kazancı, N., Girgin, S., Dügel, M. & Oğuzkurt, D. (1997). Türkiye iç suları araştırmaları dizisi II. akarsuların çevre kalitesi yönünden değerlendirilmesinde ve izlenmesinde biyotik indeks yöntemi. ISBN 975-7852-38-4, *Form Ofset*, s. 100, Ankara.

Kıymaz, G. (2018). Aşağı Gediz Havzası nehir sularının kalitesinin değerlendirilmesi ve fizikokimyasal parametrelerin makroomurgasız üzerine etkilerinin incelenmesi. *Hacettepe Üniversitesi, Yüksek Lisans Tezi*, s.12.

Kocataş, A. (1997). Ekoloji ve çevre biyolojisi. *Ege Üniversitesi Su Ürünleri Fakültesi Yayınları*, ISBN:975-483-177-7, 4. baskı, s. 564, İzmir.

Kökçü, C. A. (2016). Sapanca Gölü ekolojik kalitesinin makroomurgasızlara dayalı olarak su çerçeve direktifi (SÇD) doğrultusunda değerlendirilmesi. *Osmangazi Üniversitesi, Doktora Tezi*, s. 162.

Krno, I. J., Šporka, F., Galas, J., Hamerlík, L., Zaovičová, Z. & Bitušík, P. (2006). Littoral benthic macroinvertebrates of mountain lakes in the Tatra Mountains (Slovakia, Poland). *Biologia*, 61(18). [CrossRef]

Magurran, A. E. (1988). Ecological diversity and ıts measurement, *Princeton University Press*, pp.179. [CrossRef]

Milbrink, G. (1980). Oligochaete communities in pollution biology: The European situation with special reference to lakes in Scandinavia In: Aquatic Oligochaeta Biology (eds. R.O. Brinkhurst and D.G. Cook). *Plenum Press*. New York, pp. 433-455. [CrossRef]

Milligan, M.R. (1997). Identification manual for the aquatic Oligochaeta of Florida, Vol:I, Freshwater Oligochaetes. *State of Florida Department of Environmental Protection Tallahassee*, pp. 175, Florida.

Morse, J.C. (1983). Proceedings of the fourth ınternational symposium on Trichoptera', *Junk Publishers*, pp. 486, South Carolina.

Nilsson, A.N. (1996). Aquatic insects of North Europe, a taxonomic handbook. *Apollo Books*, pp.172, Stenstrup.

Pennak, R. W. (1989). Fresh water invertebrates of United States Protozoa to Mollusca. *Third Edition, London John Wiley & Sons Inc*, pp. 613.

Rieradevall, M., Bonada, N. & Prat, N. (1999). Substrate and depth preferences of macroinvertebrates along a transect in a Pyrenean high mountain lake (Lake Redó, NE Spain) Limnetica. *Asociación Española de Limnología*, 17, 127-134. [CrossRef]

Shannon, C. E. & Weaver, W. (1949). The mathematical theory of communication. Urbana: *University of Illinois Press*. pp. 1-117.

Sipahiler, F. (1992). Two new species and a new subspecies of Trichoptera from Turkey and Spain (Insecta). *Spixiana (München)*, 15 (3), 293-297.

Sipahiler, F. (2010). Türkiye Trichoptera (Insecta) faunasının özellikleri ve endemik türlerin listesi. *Kırsal Çevre Yıllığı*, s. 66-77.

Sömek, H. & Ustaoğlu, M. R. (2016). Yaz Aylarında Batı Anadolu'nun Bazı dağ göllerinin (Denizli-Muğla) fitoplankton kompozisyonu ve trofik durum indeksi değerleri. *Ege Üniversitesi Su Ürünleri Dergisi*, 33 (2), 121-128. [CrossRef]

Stribling, J. M, Cornwell, J. C. & Currin, C. (1998). Variability of stable sulfur isotopic ratios in Spartina alterniflora. *Marine Ecology Progress Series*, 166, 73-81. [CrossRef]

Şahin, Y. (1987). Eğirdir Gölü Chrinomidae (Diptera) larvaları ve yayılışları. *Doğa Türk Zooloji Dergisi*, 11(1), 60-66.

Şahin, Y. (1991). Türkiye Chironomidae potamofaunası. *TBAG-869 ve VHAG-347, TBAG-669, TBAG-792 nolu projeler*, s. 88.

Şimşek, B. (2015). Sır Baraj Gölü (Kahramanmaraş) makroinvertebrat faunası. *Kahramanmaraş Sütçü İmam Üniversitesi, Yüksek Lisans Tezi*, s.12.

Taşdemir, A. & Ustaoğlu, M. R. (2016). Denizli'deki dağ göllerinin Chironomidae ve Chaoboridae (Diptera-Insecta) faunası üzerine gözlemler. *Ege Journal of Fisheries and Aquatic Sciences*, 33(3), 279-284. [CrossRef]

Taşdemir, A., Ustaoğlu, M. R. & Balık, S. (2011). Contribution to the knowledge on the distribution of Chironomidae and Chaoboridae (Diptera: Insecta) species of lakes on Taurus mountain range (Turkey). *Journal of the Entomological Research Society*, 13(2), 15-25.

Taşdemir, A., Yıldız, S., Özbek, M., Ustaoğlu, M. R. & Balık, S. (2010). Tahtalı Baraj Gölü'nün (İZMİR) makrobentik (Oligochaeta, Chironomidae, Amphipoda) faunası. *Journal of FisheriesSciences*, 4(4), 376-383.

Taşdemir, A., Yıldız, S., Topkara, E., Özbek, M., Ustaoğlu, M. R. & Balık, S. (2004). Yayla Gölü'nün (Buldan-Denizli) bentik faunası. *Türk Sucul Yaşam Dergisi*, 2(3), 182-190.

Timm, T. (1999). A guide to the Estonian Annelida. Naturalist's handbooks 1. Tartu-Tallinn: *Estonian Academy Publishers*, pp. 208.

Toksöz, A. & Ustaoğlu, M. R. (2005). Gölcük Gölü'nün (Bozdağ, Ödemiş) profundal makrobentik faunası üzerine araştırmalar. *Ege Üniversitesi Su Ürünleri Dergisi*, 22(1-2),173-175.

Topkara, E. T. & Ustaoğlu, M. R. (2015). A study on the aquatic Coleoptera and aquatic semiaquatic Heteroptera (Insecta) fauna of Lake Kartal (Denizli) and ecological notes. *Ege Journal of Fisheries and Aquatic Sciences*, 32(1), 45-50. [CrossRef]

Topkara, E. T., Jäch, M. & Kasapoğlu, A. (2011). *Ochthebius ustaoglui* sp. nov. (Coleoptera: Hydraenidae), a new species of the *O. metallescens* group from Turkey. *Zootaxa*, 2913(1), 59-62. [CrossRef]

Topkara, E.T., Taşdemir, A., Yıldız, S., Balık, S., Ustaoğlu, M. R. & Özbek, M. (2009). Toros dağ silsilesi üzerindeki bazı göllerin sucul böcek (insecta) faunasına katkılar. *Journal of Fisheries Sciences*, 3(1) 10-17. [CrossRef]

Topkara, E. T., Taşdemir, A. & Yıldız, S. (2018). Karagöl (Dikili-İzmir)'ün bentik makroomurgasız faunası üzerine bir araştırma. *Süleyman Demirel Üniversitesi Eğirdir Su Ürünleri Fakültesi Dergisi*, 14(1), 34-41. [CrossRef]

Toroğlu, E. & Eser Ünaldı, Ü. (2008). Aladağlar'da (Toros dağları) bitki örtüsünün ekolojik şartları. *Fırat Üniversitesi Sosyal Bilimler Dergisi*, 18 (2), 23-49.

Ulmer, G. (1961). Die süsswasserfauna Deutschlands, Trichoptera. pp. 201, Berlin.

Ustaoğlu, M. R. (1980). Karagöl'ün (Yamanlar-İzmir) bentik faunası (Oligochaeta, Chaoboridae, Chironomidae) üzerinde araştırmalar. *TÜBİTAK VII. Bilim Kongresi (Biyoloji Seksiyonu) 6-10 Ekim*, s. 331-334, Aydın.

Ustaoğlu, M. R., Balık, S. & Özbek, M. (2004). Contributions to the knowledge of Malacostraca (Crustacea) fauna of the Taurus Mountains district (Southern Anatolia). *Turkish Journal of Zoology*. 28, 91-94.

Ustaoğlu, M. R., Balık, S., Sarı, H. M., Mis, D. Ö., Aygen, C., Özbek, M., İlhan, A., Taşdemir, A., Yıldız, S. & Topkara, E. T. (2008). Uludağ (Bursa)'daki buzul gölleri ve akarsularında faunal bir çalışma. *Ege Üniversitesi Su Ürünleri Dergisi*, 25, 295-299.

Wallace, I. D., Wallace, B. & Philipson, G. N. (1990). A key to the case-bearing caddish larvae of Britain and Ireland', *Freshwater Biological Association*, 51, 237.

Wallace, I. D., Wallace, B. & Philipson, G. N. (2003) Keys to the Case-bearing Caddis Larvae of Britain and Ireland. *Freshwater Biological Association, Scientific Publication*, 61, 1-259.

Wetzel, M. J., Kathman, R. D., Fend, S. V. & Coates, K. A. (2000). Taxonomy, systematics and ecology of freshwater Oligochaeta', *Workbook Prepared for North American Benthological Society Technical Information Workshop, 48th Annual Meeting, Keystone Resort, CO.*, pp. 120.

Wiggins, G. B. & Mackay, R. J. (1978). Some relationships between systematics and trophic ecology in Neartic aquatic insects, with special reference to Trichoptera Ecology. *Wiley*, 59 (6), 1211-1220. [CrossRef]

Williamson, C. E., Dodds, W., Kratz, T. K. & Palmer, M. A. (2008). Lakes and streams as sentinels of environmental change in terrestrial and atmospheric processes. *Frontiers in Ecology and the Environment*, 6, 247-254. [CrossRef]

Yence, K. (2019). Aladağlar Milli Parkı Lygaeidae (Hemiptera: Heteroptera) faunası üzerine taksonomik ve faunistik çalışmalar. *Trakya Üniversitesi, Yüksek Lisans Tezi*, 121 s.

Yıldız, S, Ustaoğlu, M. R. & Balık, S. (2007). Contributions to the knowledge of the Oligochaeta (Annelida) fauna of some lakes in the Taurus Mountain range (Turkey). *Turkish Journal of Zoology*, 31(3), 249-254.

Yıldız, S. & Ustaoğlu, M. (2016). Denizli'deki dağ göllerinin Oligochaeta(Annelida) faunası üzerine gözlemler. *Ege Journal of Fisheries and Aquatic Sciences*, 2(33), 89-96. [CrossRef]

Yıldız, S. (2003). Göller bölgesi iç sularının Oligochaeta (Annelida) faunasının taksonomik ve ekolojik yönlerden incelenmesi. *Ege Üniversitesi, Doktora Tezi*, s.126-158.

Yıldız, S., Taşdemir, A., Özbek, M., Balık, S. & Ustaoğlu, M. R. (2005). Macrobenthic invertebrate fauna of lake Eğrigöl (Gündoğmuş - Antalya). *Turkish Journal of Zoology*, 29, 275-282.

Zeybek, M. , Kalyoncu, H. , Ertan, Ö. & Çiçek, N. (2012). Köprüçay Irmağı (Antalya) Bentik Omurgasız Faunası. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 16*(2), 146-153. [CrossRef]

Zeybek, M., Ahıska, S. & Yıldız, S. (2016). Dicle Nehri (Türkiye) Oligochaeta (Annelida) faunasının taksonomik açıdan belirlenmesine yönelik bir ön araştırma . *Ege Journal of Fisheries and Aquatic Sciences*, 33 (1), 47-53. [CrossRef]

Zreda, M., Çiner, A., Sarıkaya, M. A., Zweck, C. & Bayarı, S. (2011). Remarkably extensive glaciation and fast deglaciation and climate change in Turkey near the Pleistocene Holocene boundary. *Geology*, 39 (11), 1051-1054. [CrossRef]