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Macrozoobenthic Fauna and Water Quality of the Glacial Lakes in Tunceli Province (Kepir 1, 2)

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ABSTRACT

This study was conducted to investigate certain physicochemical parameters and the benthic macroinvertebrate fauna of high-altitude glacial lakes (Kepir Plateau 1 and 2) located in Tunceli Province, Türkiye. For this purpose, fieldwork was carried out on August 8, 2023. In situ measurements of water temperature, dissolved oxygen, electrical conductivity, and pH were taken at the study sites. Additionally, benthic macroinvertebrate samples were collected from the lakes. A total of 45 benthic macroinvertebrate taxa were identified. All recorded taxa were determined to be new records for the study area. The ecological distribution of the identified taxa is presented, and the findings are compared with those of previous studies conducted on glacial lakes in Türkiye. Furthermore, several recommendations are provided for the sustainable use of these glacial lakes.

Keywords: Munzur, Glacial, macroinvertebrate

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Tunceli İli Buzul Göllerinin (Kepir 1, 2) Makrozoobentik Faunası ve Su Kalitesi

Öz: Bu çalışma, Türkiye'nin Tunceli ilinde yer alan yüksek irtifa buzul gölleri (Kepir Platosu 1 ve 2) ile ilgili bazı fizikokimyasal parametreler ve bentik makroomurgalı faunayı araştırmak amacıyla yürütülmüştür. Bu amaçla, saha çalışması 8 Ağustos 2023 tarihinde gerçekleştirilmiştir. Çalışma alanlarında su sıcaklığı, çözünmüş oksijen, elektrik iletkenliği ve pH değerleri yerinde ölçülmüştür. Ayrıca, göllerden bentik makroomurgalı örnekleri toplanmıştır. Toplamda 45 bentik makroomurgalı taksonu belirlenmiştir. Tespit edilen tüm taksonlar, çalışma alanı için yeni kayıtlar olarak belirlenmiştir. Belirlenen taksonların ekolojik dağılımları sunulmuş ve bulgular, Türkiye'deki buzul göllerinde yapılan önceki çalışmalarla karşılaştırılmıştır. Ayrıca, bu buzul göllerinin sürdürülebilir kullanımı için çeşitli önerilerde bulunulmuştur.

Anahtar kelimeler: Munzur, buzul, makroomurgasız

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Introduction

High mountains and mountain ranges not only act as significant natural barriers limiting the distribution of organisms, but also serve as refuges for various groups of organisms due to their extreme climatic conditions. Therefore, they are ecologically important as they often host endemic species that have adapted to distinct environmental conditions. Moreover, high-altitude lakes are relatively undisturbed freshwater ecosystems, remote from human activities, and are thus considered valuable reference sites for assessing the impacts of environmental degradation on ecosystems (Taşdemir & Ustaoğlu, 2016). For these reasons, documenting the species composition, distribution, and calculating diversity indices of benthic fauna in high-altitude lakes is of considerable importance.

Türkiye possesses a rich diversity of inland water resources, with over 200 natural lakes (Taşdemir et al., 2011). Due to the inaccessibility of glacial lakes and their being ice-covered for much of the year, there is a limited number of limnological studies on

high mountain lakes in the country (Geldiay & Tareen, 1972; Ustaoğlu, 1980; Taşdemir et al., 2004; Toksöz & Ustaoğlu, 2005; Ustaoğlu et al., 2008; Yıldız et al., 2007; 2009). A study on the macroinvertebrate fauna of Lake Eğrigöl, located in the Taurus Mountains, was conducted by Yıldız et al. (2005). In addition, separate studies on the fauna of the same lake have been carried out focusing on Mollusca (Balık et al., 2003), Malacostraca (Ustaoğlu et al., 2004), Zooplankton (Ustaoğlu et al., 2005), Oligochaeta (Yıldız et al., 2007), and Insecta (Topkara et al., 2009).

Tunceli Province is located in the Upper Euphrates section of the Eastern Anatolia Region of Türkiye, covering an area of 7,582 km². It is bordered by the Bingöl Mountains and Peri Stream to the east, the Keban Dam Lake to the south, and the Munzur Mountains and Karasu River to the north and west. Surrounded by natural boundaries, Tunceli shares borders with the provinces of Bingöl and Elazığ to the east, Erzincan to the west and north, and Elazığ to the south. The northwestern, northern, and northeastern parts of the province are dominated by the Munzur, Mercan, Karasakal, Avcı, and Bağır Paşa Mountains, which form part of the Eastern Taurus mountain range extending in an east–west direction. Numerous glacial lakes have formed in the summit regions of these mountains, where ancient glacial beds have gradually filled with water over time. Among these, the largest is Karagöl, located at an altitude of 2,400 meters to the north of Koyungölü Village in the Ovacık district (Tunceli Environmental Status Report, 2021).

Benthic macroinvertebrates inhabiting aquatic ecosystems occupy a wide range of ecological niches due to their presence at different trophic levels. Many of these organisms play a crucial role in the transfer of matter and energy from the lower to the upper levels of the aquatic food web. For this reason, they are also used as indicators to assess the basic biological productivity of aquatic ecosystems (Akbaba & Boyacı, 2015). In order for an ecosystem to function properly, it is essential to maintain biodiversity at moderate to high levels. Macrozoobenthic organisms are widely used as key biological quality components in determining and monitoring water quality, serving as important bioindicators (Kazancı et al., 1997; Koşal-Şahin & Albayrak, 2018). Given these factors, research on benthic invertebrates in aquatic ecosystems has gained increasing importance and prevalence.

This study aims to investigate certain physicochemical parameters and the benthic macroinvertebrate fauna of the Kepir 1 and Kepir 2 glacial lakes located on the Kepir Plateau. The identified benthic macroinvertebrate taxa are also compared with findings from previous studies conducted on other glacial lakes in Türkiye. The absence of previous studies on the Kepir 1 and Kepir 2 glacial lakes, which constitute the study area, further enhances the originality and significance of this research. In addition, several recommendations are provided to support the sustainable use of these glacial lakes.

Materials and Methods

Tunceli Province, located in the Upper Euphrates Basin of the Eastern Anatolia Region of Türkiye, lies between 38º19′ and 40º26′ east longitudes and 39º36′ and 38º46′ north latitudes. It is bordered by the Bingöl Mountains and Bingöl Province to the east, Erzincan Province to the north and west, and the Keban Dam Lake and Elazığ Province to the south. The province covers an area of 7,774 km² and has an elevation of 914 meters above sea level. The topography of the province rises from south to north and from west to east, with mountains covering approximately 70% of the land area, plateaus 25%, and plains and lowlands making up the remaining 5% (Tunceli Environmental Status Report, 2021).

The Munzur Valley, which constitutes the study area, is characterized by a harsh continental climate. Due to the positioning of the surrounding mountains, winters are very cold with heavy snowfall. The valley remains snow-covered for approximately six to seven months of the year (Tunceli Environmental Status Report, 2021). Precipitation begins in the autumn, peaks during the winter months, and gradually decreases in the spring, reaching its lowest levels in the summer (Yüce-Babacan & Eker, 2017). The average annual precipitation is 71 mm. The highest monthly precipitation has been recorded in December at 128.9 kg/m², while the lowest is in August at 2.6 kg/m² (mgm.gov.tr, 2016;Yüce- Babacan & Eker, 2017). During the summer, dry temperatures can reach as high as 35–40°C. In the summit zones of these mountains, small crater lakes have formed over time as glacial beds gradually filled with water.

Kepir Plateau is located near the Aksu Valley. It is a polygenetic closed basin formed by karstic and glacial processes, situated at an elevation range of 2600–2700 meters. The basin covers an area of 1.52 km². Morainic deposits located in the lowest part of the basin (eastern section) separate it from the Memo Meadow and Düldül Ayağı plateaus, transforming it into a closed basin. The waters draining the basin flow into the Kepir Stream, which disappears underground through the Kepir Cave, a sinkhole feature. This hydrological characteristic, involving subterranean drainage and surface runoff, is rarely observed in the Munzur Mountains.

There are two distinct lakes on Kepir Plateau: Mavi Lake and Hızır Lake. Mavi Lake is situated on glacially excavated terrain and is located near the pastoral tents used for seasonal grazing. The lake's surroundings are covered with grasses and herbs. It lies within the largest north-facing cirque of the basin, where snow cover can be found until autumn (Tunceli Environmental Status Report, 2021). Situated to the north of the city center of Tunceli at the confluence of the Munzur and Pülümür rivers, the area locally referred to as Hızır Lake constitutes a naturally formed lacustrine body resulting from surface water accumulation. The geological formation of the lake is closely linked to the tectonic framework and valley-dominated geomorphology of the Tunceli region; within a topographic setting characterized by high mountain ranges and deeply incised fluvial valleys, the lake developed in association with minor structural depressions and the convergence of surface drainage systems. The surrounding natural landscape supports various plant communities and faunal elements, including migratory bird species, thereby contributing to the local ecological balance. However, the site has been subjected to anthropogenic pressure, as it falls within the reservoir catchment area of the Uzunçayır Dam and Hydroelectric Power Plant, the construction of which commenced in 1994; consequently, the area was transformed into a park in 2011 (Tunceli Provincial Directorate of Environment and Urbanization, 2017).

A map of the study area and sampling points is presented in Figure 1.

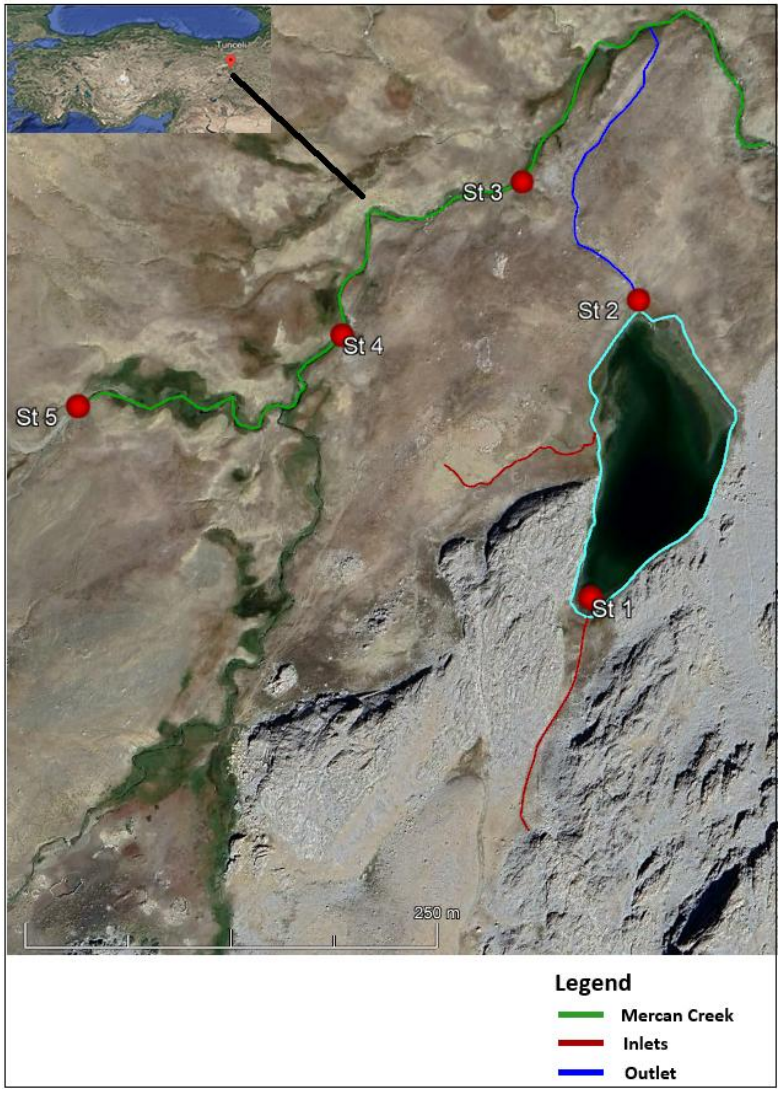


Figure 1. Locations of sampling sites in Kepir (1, 2) glacial lakes

A total of five sampling stations were established across the glacial lake to represent environmental heterogeneity. Due to the extreme environmental conditions of the study area, the stations were positioned relatively close to each other. The first station was selected at the

section where water enters the lake (inlet), while the second station was designated to represent the area where water exits the lake (outlet). The third station is located in an area inhabited by local communities practicing highland pastoralism. In this region, small ruminants are commonly grazed around the lake, and the station is characterized by a dense macrophyte cover, with the lakebed largely composed of macrophytes. Furthermore, anthropogenic pressures at this station were observed to be more pronounced compared to the other stations. The fourth station is situated slightly downstream of the third station, whereas the fifth and final station represents an area where snowmelt accumulates, forming a more stagnant water body. Some photographs of the stations selected from Kepir (1, 2) glacial lakes are shown in Figure 2.



Figure 2. Some photographs of the sampling stations

Due to the difficult accessibility of the stations, sampling was conducted only once. Fieldwork was carried out on August 8, 2023, at Kepir Lake located on Kepir Plateau in the Munzur glacial mountains. Certain physicochemical parameters of the lake water and benthic macroinvertebrates were investigated. Water samples were collected in accordance with standard protocols to determine the physicochemical characteristics of the lake water. Water temperature (°C) was measured in situ using a thermometer, and dissolved oxygen concentration (mg/L) was measured during sampling using a portable Hach HQ40D device. Electrical conductivity (µS/cm) and pH values were also measured on-site with the same portable Hach HQ40D device.

Benthic macroinvertebrate samples were collected using hand-operated mud scoops of various sizes, and the collected specimens were fixed and preserved in plastic bottles containing 70% ethanol. Water and benthic samples were taken from both the littoral and profundal zones of each lake. Benthic macroinvertebrates from the littoral zone were collected using a Surber net with a 500 µm mesh size by sampling beneath rocks, stones, gravel, and among aquatic vegetation. Sampling in the deeper parts of the lake was conducted using an Ekman-Birge grab sampler (15x15 cm) from a Zodiac boat. The sediment samples were subsequently sieved through a 500 µm mesh sieve for preliminary sorting in the field and then fixed and preserved in tubes containing 70% ethanol.

Benthic macroinvertebrates brought to the laboratory were separated from the sediments in which they were found using a Nikon SMZ18 stereo microscope. They were then preserved in bottles containing 70% ethanol, with small labels indicating the station number and date, and stored in glass and plastic tubes. Identification of the obtained benthic macroinvertebrates was carried out by experts in the field to the finest possible taxonomic level. For the identification of Chironomidae, the following references were utilized: Brinkhurst (1971), Bryce & Hobart (1972), Macan (1977), Fittkau and Roback (1983), Boesel (1985), Şahin (1984; 1991), Merritt & Cummins (1996), and Özkan (2003; 2022). For Oligochaetes, permanent mounts were prepared using CMCP-10 (polyvinyl lactophenol), and species identification was based on Brinkhurst & Jamieson (1971), Kathman and Brinkhurst (1998), Timm (2009), and Wetzel et al. (2000).

Results

The physicochemical data obtained from water samples collected from the glacial lakes Kepir (1, 2) are presented in Table 1.

Table 1. Measured physicochemical parameters and their average values in the Kepir (1, 2) glacial lakes.

Parameters	ST1	ST2	ST3	ST4	ST5	Average
Water Temperature (°C)	20.9	19.93	20.1	22.3	21.7	20.98
Dissolved Oxygen (mg/l)	7.56	16.26	13.7	13.7	12.9	12.82
Electirical conductivity (µS/cm)	7.37	12.93	17.96	19.5	17.8	15.11
pH	8.25	8.61	8.40	8.70	8.60	8.51

Among the measured parameters, the highest water temperature was recorded at Station 4 with 22.3 °C, while the lowest was observed at Station 2 with 19.93 °C. The average water temperature was found to be 20.98 °C. The highest dissolved oxygen concentration was measured at Station 2 with 16.26 mg/L, whereas the lowest was at Station 1 with 7.56 mg/L. The average dissolved oxygen concentration was calculated as 12.82 mg/L. Electrical conductivity values ranged from a minimum of 7.37 µS/cm at Station 1 to a maximum of 19.5 µS/cm at Station 4, with an average value of 15.11 µS/cm. The pH values varied between 8.25 at Station 1 (the lowest) and 8.7 at Station 4 (the highest), with an average pH of 8.51.

As a result of the analysis of benthic macroinvertebrate samples, individuals belonging to the groups Ephemeroptera, Trichoptera, Plecoptera, Gastropoda, Chironomidae, Oligochaeta and Ostracoda were identified. The number of taxa detected at each station is presented in Table 2.

An analysis of benthic macroinvertebrates in the lakes revealed that the highest density was recorded at Station 3, with 392 individuals. This was followed by Station 1 with 191 individuals and Station 4 with 132 individuals. The lowest density was observed at Station 5, with 34 individuals (Table 2).

Table 2. Distribution and abundance of benthic macroinvertebrate taxa in the glacial lakes by sampling stations

TAXONS	**STATIONS**				
	ST1	**ST2**	**ST3**	**ST4**	**ST5**
EPHEMEROPTERA					
Baetis sp.	31	11	6	5	3
Ephemerella sp.		8	6	4	
Ephemeralla ignita (Poda, 1761)		3	12	7	
Electrogena sp.		4	5	2	
Epeorus sp.			4	8	
Epeorus zaitsevi			9	2	
Epeorus magnus (Braasch, 1978)		6			
Epeorus caucasicus (Tshernova, 1938)		4		11	4

Table 2. *Continued*

TRICHOPTERA					
Sericostoma personatum (Kirby & Spence, 1826)		1		3	
Agapetus sp.		1	3	4	
Goera pilosa (Fabricius, 1775)				12	
Hydropsyche sp.			4		
Cheumatopsyche sp.				3	
Phychomyia pussilla (Fabricius, 1781)		6		7	
Hydropsyche angustipennis (Curtis, 1834)		7	2		5
Hydropsyche bulbifera (McLachlan, 1878)	11	4		7	
Hydropsyche contubernalis (McLachlan, 1865)		3		7	
Hydropsyche fulvipes (Curtis, 1834)				3	17
Hydropsyche instabilis (Curtis, 1834)		3		5	
Hydropsyche tenuis (Navás, 1932)		9		7	
Hydropsyche sp.				19	
Cheumatopsyche lepida (Pictet, 1834)		21			1
Metanoea sp.		5			
Stenophylax sp.			3	9	
Limnephilus sp.		11			
Philopotamus montanus (Donovan, 1813)		4			
PLECOPTERA					
Protonemura sp.		3			2
Leuctra sp.				7	2
GASTROPODA					
Bithynia sp.		4			
CHIRINOMIDAE					
Glyptotendipes gripekoveni (Kieffer, 1913)			281		
Dicrotendipes nervosus (Staeger,1939)			1		
Micropsectra notescens (Walker, 1856)			1		
Rheotanytarsus sp.			7		
Metriocnemus cubitalis (Kieffer, 1911)			23		
Orthocladius frigidus (Zetterstedt, 1838)			3		
Halocladius fucicola (Edwards, 1926)			5		
Paratrissocladius excerptus (Walker, 1856)			4		
Cardiocladius capucinus (Zetterstedt, 1850)			1		
Macropelopis nebulosa (Meigen, 1804)			1		
Procladius (Holotanypus) sp.			1		
Arctopelopia barbitarsis (Zetterstedt, 1850)			2		
Pseudodiamesa orientalis (Chernovskij, 1949)			4		
OLIGOCHAETA					
Limnodrilus hoffmeisteri (Claparéde, 1862)	8				
OSTRACODA					
Eucypris sp.	100				
Tonnacypris sp.	40				
Candona sp.	1				
Number of taxa	**6**	**19**	**24**	**20**	**7**
Total	***191***	***114***	***392***	***132***	***34***

An analysis of benthic macroinvertebrates in the lakes revealed that the highest density was recorded at Station 3, with 392 individuals. This was followed by Station 1 with 191 individuals and Station 4 with 132 individuals. The lowest density was observed at Station 5, with 34 individuals (Table 2).

In terms of the number of benthic macroinvertebrate taxa, Station 3 had the highest diversity with 24 taxa, followed by Station 4 with 20 taxa and Station 2 with 19 taxa. The lowest taxon richness was found at Station 1 with 6 taxa and at Station 5 with 7 taxa (Table 2).

Taxa belonging to Ephemeroptera, Trichoptera, and Plecoptera were identified at Stations 1, 2, 4, and 5. At Station 3, taxa from Ephemeroptera, Trichoptera, Gastropoda, and Chironomidae were recorded (Table 2).

A total of 8 taxa belonging to the order Ephemeroptera, 18 to Trichoptera, 2 to Plecoptera, 13 to the family Chironomidae, 1 species of Oligochaeta, and 3 taxa of Ostracoda were identified in the glacial lakes.

Agapetus sp. (order *Trichoptera*) was also recorded at Stations 2, 3, and 4.

Protonemura sp. was recorded at Stations 2 and 5, while *Lectura* sp. was found at Stations 4 and 5 (Table 2). *Bithynia* sp. was observed at Station 3 (Table 2). All taxa belonging to the family Chironomidae were found exclusively at Station 3. Taxa from Oligochaeta and Ostracoda were detected only at Station 1 (Table 2).

Discussion

Among freshwater components, aquatic macroinvertebrates are the most sensitive to anthropogenic pressures (Ko et al., 2020). Macroinvertebrates universally respond to the condition of aquatic ecosystems and are used alongside various indices to monitor freshwater ecosystems and support decision-making in management (Edegbene et al., 2021; Tampo et al., 2020). Additionally, freshwater macroinvertebrate groups are sensitive to levels of organic pollution; thus, their diversity and composition are utilized to infer pollution loads (Wan Abdul Ghani et al., 2018). Generally, natural, undisturbed ecosystems exhibit high abundance and species richness (Barbour et al., 1999).

Recent studies highlight that biological methods, especially the use of aquatic macroinvertebrates, are effective for assessing natural and anthropogenic impacts on waters, as biota respond sensitively to stress factors (Kurthen et al., 2020).

In this study, a total of 45 taxa belonging to *Ephemeroptera*, *Trichoptera*, *Plecoptera*, *Gastropoda*, *Chironomidae*, *Oligochaeta* taxa found in the lake were also evaluated in terms of their habitats, compared with previous studies conducted on glacial lakes, and some recommendations were made for the sustainable use of glacial lakes.

Ephemeropterans typically inhabit cold, well-oxygenated, fast-flowing or still running waters; they are sometimes found in lake bottoms and spring waters. Their larval stage is mostly aquatic. They are highly sensitive to environmental factors such as pH, temperature, dissolved oxygen, conductivity, and nutrient levels. Therefore, they are considered important bioindicators in ecological monitoring studies within the scope of the "EPT index" (Ephemeroptera, Plecoptera, Trichoptera) (Kazancı et al., 1997). As a result of investigations conducted in the glacial lakes, a total of 8 taxa belonging to the order Ephemeroptera were identified. Among the identified taxa, *Baetis* sp. was recorded at all sampling stations. According to Meyer (1987), species belonging to the genus Baetis can be found in less-polluted freshwater regions, classified as I–II. *Ephemerella* sp., *Ephemerella ignita*, and *Electrogena* sp. were found at Stations 2, 3, and 4. The most dominant taxa were determined to be *Baetis* sp. and *Ephemerella ignita*. The presence of Ephemeroptera at all stations may indicate that the water has not yet been polluted.

Trichoptera larvae inhabit clean, oxygen-rich aquatic environments. They protect themselves by constructing cases and silk webs around their bodies. They serve as indicators of water quality and play important roles in biological monitoring and ecosystem engineering (Morse et al., 2019). In the study, a total of 18 taxa of Trichoptera were identified. The most dominant taxa were found to be *Cheumatopsyche lepida* and Hydropsyche sp. It has been reported that *C. lepida* occurs at elevations above 150 m and prefers high-flow habitats, with average water temperatures ranging between 8 and 20 °C (Graf et al., 2008). In his study, Akyıldız (2008) reported that Hydropsyche sp. is found in aquatic ecosystems with second-class water quality. Both studies support the findings of the present research.

Plecoptera (stonefly) larvae occupy ecologically specialized habitats and play a critical role as indicators of ecosystem water quality. The larvae live in cold, fast-flowing, well-oxygenated streams and rivers, often beneath stones and leaf accumulations. These habitats provide high levels of dissolved oxygen necessary for the respiration and survival of stoneflies. They are highly sensitive to water pollution, and their presence generally indicates high water quality (https://turkiyeyabanhayati.org/species/detail/plecoptera). In this study, two taxa of Plecoptera were identified. *Protonemura* sp. was recorded at stations 2 and 5, while *Leuctra* sp. was found at stations 4 and 5. Vidinova et al. (2000) reported that Plecoptera are predominantly found in the outflows (outlets) of glacial lakes. The occurrence of these taxa at stations 2, 4, and 5 in the present study indicates that the lake

is well-oxygenated and exhibits high water quality. These findings also suggest that Plecoptera can serve as reliable indicators of water quality.

Balık et al. (2003), in their study to identify the Mollusca fauna of some lakes located in the Taurus Mountains, recorded a total of 20 taxa, including 13 taxa from the class Gastropoda and 7 from Bivalvia. Since no similar study had been conducted previously in the region, all identified taxa were reported as new records for the area. Moreover, species such as *Gyraulus crista f. cristatus*, *Pisidium subtruncatum*, *Pisidium obtusale*, *Sphaerium rivicola*, and *Sphaerium corneum f. mamillanum* were reported as first records for Turkey. Bityhnia species are known to be significant indicators of water quality, due to their widespread distribution in different geographical locations and the presence within aquatic environments (Duft *et al*. 2007). The amount of dissolved oxygen in the water is an important indicator of the abundance of some species, particularly Bithynia (Økland, 1990; Odabaşı et al., 2024; Akay et al., 2024).

The ecological significance of *Glyptotendipes* species stems from their sensitivity to environmental changes, making them useful indicators of water quality and habitat conditions. For instance, fluctuations in their abundance or presence may reflect alterations in water chemistry, temperature, or pollutant inputs. According to research by the United States Environmental Protection Agency, midges such as those in the genus *Glyptotendipes* are valuable for biomonitoring due to their wide distribution and sensitivity to environmental stressors. These species inhabit a variety of wetland habitats including lake shorelines, riverbanks, and temporary wetlands. Larvae of these species play an important role in ecosystem decomposition processes and nutrient cycling, feeding on detritus, algae, and small invertebrates. Within the Chironomidae family, *Glyptotendipes gripekoveni* was the most abundant species at Station 3, with a total of 281 individuals recorded. The high abundance of this species at Station 3 may be attributed to the fact that this station exhibits distinct characteristics compared to the other stations in terms of both habitat structure and potential anthropogenic influences. During grazing activities around the lake, the feces of small ruminants are likely to accumulate in these areas, and this material is expected to be transported into the lake with snowmelt runoff.

Dicrotendipes nervosus was represented in this study by a single individual at one station; however, it is generally a widespread species found in plant and rocky habitats (Özkan, 2006).

Procladius (Holotanypus) sp. is a cosmopolitan species found worldwide in a range of stagnant and flowing water habitats including sand, mud, vegetation, and rock substrates (Özkan, 2006). *Procladius* is primarily characterized as a predator and constitutes a fundamental component of free-living aquatic food webs (Vodopich and Cowell, 1984), although it also consumes various sediment-dwelling diatoms and desmids (Hershey, 1986). Larvae of *Procladius* play a key role in the decomposition of organic matter and nutrient recycling in aquatic ecosystems. Despite being ubiquitous in northern lentic habitats, *Procladius* exhibits tolerance to low oxygen conditions. In oligotrophic lakes, the profundal chironomid community is more diverse but still poorer compared to littoral zones. Due to their sensitivity to environmental changes, *Procladius* species are also used as indicators of water quality.

Micropsectra notescens is traditionally considered a cold stenothermic and polyoxybiontic species (Säwedal, 1976). It has been documented in mountain, boreal, and forest springs and headwaters (Lencioni et al., 2012), as well as in alpine lakes and ponds (Oertli et al., 2010; Lods-Crozet et al., 2012). In this study, *Micropsectra notescens* was recorded at Station 3 with only a single individual. The presence of Chironomidae larvae in only one of the mountain lake stations suggests that this station may have finer sediment and higher organic matter content compared to the others. The literature also indicates that Chironomidae exhibit high tolerance to such environmental conditions and that their distributions wihin lakes can be heterogeneous (Rosenberg & Resh, 1993; Wetzel, 2001; Merritt et al., 2008).

The aquatic habitats favored by *Metriocnemus* species include accumulations of leaves, woody debris, or decomposing leaf litter in water-filled areas (Fish, 1983).

Among Oligochaeta, *Limnodrilus hoffmeisteri* has been reported to inhabit organically enriched surface water sources (Brinkhurst, 1975; Wetzel et al., 2000; Hare and Shooner, 1995). *Limnodrilus hoffmeisteri* is a pollution-tolerant species and is one of the most widely distributed freshwater Oligochaeta worldwide (Arslan and İlhan, 2010; Odabaşı et al., 2018). Yıldız et al. (2005), aiming to determine the macrobenthic invertebrate fauna of Eğrigöl, located at an altitude of 2000 m in the Taşeli Plateau of the Central Taurus Mountains, found an average density of 1036 individuals. Of these, 939 individuals belonged to Oligochaeta, 95 to Chironomidae, and 2 to Chaoboridae larvae. All identified species were reported as first records for the lake, and *Potamothrix moldaviensis* from the Oligochaeta group was noted as a first record for the Turkish fauna. Yıldız et al. (2012) sampled 59 lakes

of varying sizes and depths in the Eastern Black Sea Mountains. This study aimed to investigate the relationship between Oligochaetes and environmental factors. A significant positive correlation was found between total individual counts and altitude.

Yıldız & Ustaoğlu (2016) carried out a study to determine the Oligochaeta (Annelida) fauna of Kartal Lake and Gökçeova Pond in the Sandıras and Çiçekbaba Mountains, as well as Saklıgöl and Karagöl. Oligochaeta species were identified in varying numbers from all sampled lakes. Individuals belonging to the families Tubificida, Enchytraeida, and Lumbriculida were characterized.

Yıldız et al. (2007) conducted a study to identify the Oligochaeta fauna of 16 high mountain lakes located in the Taurus Mountains. They reported a total of 15 species, including 11 species from the family Tubificidae, 3 species from Naididae, and 1 species from Lumbriculidae. They noted that this study represented the first faunistic survey conducted in the region.

Ostracods are microscopic, typically around 1 mm in size, small shelled crustaceans belonging to the class of shelled arthropods. Their ecological habitats range widely, including freshwater, marine, brackish, semi-terrestrial moist soils, and thermal springs. Water parameters such as temperature, pH, salinity, conductivity, dissolved oxygen, and redox potential are key factors determining species distribution. Ostracods are sensitive to environmental changes and are considered reliable indicators for assessing water quality (Külköylüoğlu et al., 2012).

Ustaoğlu et al. (2008) investigated the zooplankton, macroinvertebrate, and vertebrate fauna of five glacier lakes (Karagöl, Kilimligöl, Aynalıgöl, Buzlugöl, and Heybeligöl) located in Uludağ. Sampling was conducted on July 8 and August 19, 2003, covering the five glacier lakes as well as five streams (Güvercinlik Creek, Deliçay, Nilüfer River, Kalburt Creek, and Hamamlı Creek). A total of 82 taxa were identified, comprising 36 zooplankton, 38 benthic invertebrates, and 8 vertebrates. Among these taxa, *Microcodides hertha* from Rotifera was recorded as a new species for the Turkish fauna.

Topkara et al. (2009), aiming to determine the limnological characteristics of 12 high mountain lakes in the Taurus mountain range, identified a total of 31 taxa belonging to the orders Hemiptera, Coleoptera, Ephemeroptera, and Trichoptera, of which 2 were identified at the genus level and 29 at the species level.

Topkara &Ustaoğlu (2011) surveyed the aquatic Coleoptera fauna of 22 high mountain lakes in the Eastern Black Sea region of Turkey, identifying 21 taxa belonging to 4 families.

Taşdemir et al. (2011) conducted a study to identify the Chironomidae and Chaoboridae fauna in 11 lakes located in the Taurus Mountains. They reported a total of 19 taxa, including 17 from the family Chironomidae and 2 from Chaoboridae.

When compared to previous studies, similar groups were found in glacier lakes. This study aimed to reveal the fauna of Turkey's glacier lakes. All species identified in this study represent first records for the sampled region. The contribution to the macroinvertebrate biodiversity knowledge of Turkey's glacier lakes underlines the importance of this study. Furthermore, it can serve as a reference for future research in the region.

The sustainable use of glacier lakes is of great importance for both preserving ecological balance and ensuring the long-term management of water resources. Due to global climate change, the rapid melting of glaciers causes significant alterations in the hydrological regimes of glacier lakes, threatening the fragile structure of these ecosystems. Within this context, global measures to reduce greenhouse gas emissions are a fundamental requirement for sustainability. Additionally, the environmental impacts of planned agricultural, tourism, and industrial activities in glacier lake regions should be carefully regulated; conscious and controlled use of water resources must be ensured; the environmental awareness of local communities should be increased; and science-based monitoring systems should be established. These measures constitute effective strategies for the protection of glacier lakes.

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