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Research Article

Benthic Macroinvertebrate Fauna (Clitellata and Chironomidae) of Lake Limni, Gümüşhane, Turkiye

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ABSTRACT

Benthic macroinvertebrate groups, which have adapted to life in a wide variety of aquatic habitats from fresh to saltwater, are often used as bioindicators to determine the status of aquatic ecosystems. Streams and lakes face the dangers of pollution due to anthropogenic impact, especially due to recreational uses. So far, a total of 262 protected nature parks have been declared in Türkiye, one of which is Lake Limni, the area under study. Lake Limni is located in the province of Gümüşhane in the Eastern Black Sea Basin. No studies were previously conducted to determine the macroinvertebrate fauna in the lake. To fill this gap, sampling was carried out from 2 stations in 2020 to determine the macroinvertebrate fauna of the lake. As a result of laboratory studies, 25 species belonging to 18 genera were identified. It was determined that the zoobenthic community of the lake consisted of Clitellata and Chironomidae individuals and that the dominant taxon of the lake was *Limnodrilus hoffmeisteri* from Oligochaeta with 14.71% dominancy. The high population density of Oligochaeta and Chironomidae individuals in the study area and the low species diversity indicate poor water quality. It is also possible to say that the water quality of Lake Limni has changed from eutrophic to hypereutrophic.

Keywords: Chironomidae, Oligochaeta, pollution

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INTRODUCTION

Aquatic habitats are home to a wide variety of species, which is one of the most essential aspects to preserve an aquatic ecosystem's resilience and stability. Biota in aquatic ecosystems is reliant on the water's physical, chemical, and biological properties which serve as direct controlling factors (Yaqoob & Pandit, 2009). Benthic communities, which make up a significant portion of the total biota in both lentic and lotic systems, are among these controlling factors and constitute an essential component of any aquatic ecosystem. By acting as grazers, collectors, shredders, or predators, they serve a variety of purposes (Pearson & Rosenberg, 2006). Benthic macroinvertebrates are extremely sensitive to physical and chemical disturbances (Furse et al., 2006; Jess-Crespo & Ramrez, 2011), as these disturbances lead to a decrease in the diversity and abundance of their assemblies and an increase in the dominance of species that can withstand challenging conditions (Wang et al., 2012). Their distribution, occurrence, and abundance are strongly influenced by the dominant environmental features. Their variability is typically attributed to abiotic factors, primarily substrate characteristics, such as temperature, depth, and food resources (Sanseverino & Nessimian, 2001; Chapman et al., 2010; Cesar & Henry, 2017). Additionally, they are sensitive to changes in the amount of dissolved oxygen (Hirabayashi & Hayashi, 1994).

Water resources are sensitive to variations in climatic patterns. It is believed that there will be changes in water resources due to climate change from the impacts of runoff, floods, drought, snowmelt and glacier melt, water quality, groundwater, transboundary problems and agriculture (Singh et al., 2014). Globally, research into the preservation, restoration, and monitoring of these resources has grown (Türkmen & Kazancı, 2010). Türkiye is privileged to have a variety of lentic and lotic resources, including 135 globally significant wetlands, more than 120 natural lakes, 107 major rivers and 25 river basins. Türkiye's water resources and wetlands are starting to disappear, and some areas have also noticed deteriorating water quality and rising levels of water pollution (Türkmen & Kazancı, 2010).

In this article, Lake Limni located in Gümüşhane Province was chosen as the study area. To date, no studies have been conducted on the macroinvertebrate fauna of Lake Limni. While some studies have been conducted in the area, these discussed the lake's recreational potential (Birinci et al., 2016; Yeşil & Hacıoğlu, 2018; Çalık & Pir, 2019; Tozkoporan et al., 2020). According to the results of these studies, Limni Lake Natural Park has a high recreational potential due to factors such as its location near main transportation routes, flora and fauna, and fresh air. One study, however, has analyzed the species composition and diversity of epipelic algae and physicochemical characteristics in Lake Limni (Şahin, 2008). This study aims to determine the aquatic benthic macroinvertebrate fauna of Lake Limni. It, as such, addresses a major gap in the literature on Lake Limni and its biota, particularly its macroinvertebrate fauna.

MATERIAL AND METHODS

Lake Limni is located in the Gümüşhane province in Eastern Black Sea Basin of Türkiye. It has a surface area of about 72 ha. On average, the lake is 1 meter deep and 1850 m above sea level. The East Anatolian regional climate has an impact on the study area. This region experiences cold winters and hot, dry summers (seasonal average temperature of 16.2 °C, highest temperature of 39.5 °C, lowest temperature of -8.9 °C, and precipitation total of 39 mm) (Anonym, 1999; Şahin, 2008). On July 1, 2011, Lake Limni was designated as a nature park (Gümüşhane Çevre ve Şehircilik İl Müdürlüğü, 2020).

Benthic macroinvertebrate samples were collected using a grid frame hand net (according to standard of ISO 10870:2012) in Lake Limni at two stations in August 2020 (Figure 1). Samples were washed with sieves of decreasing mesh size and fixed in 70% ethyl alcohol. Moreover, some parameters (pH, temperature, dissolved oxygen and depth) were measured *in situ* from under the surface with Hach Lange DR40d. Benthic macroinvertebrate samples were taken to the laboratory and sorted under a stereomicroscope. Then, macrozoobenthic specimens were prepared with glycerin and identified to species level. Macroinvertebrate individuals were identified using different identification keys by Nilsson (1996), Brinkhurst and Jamieson (1971), Timm (2009), Thorp and Rogers (2019). Diversity indices were analyzed with ASTERICS 3.1 software (AQEM Consortium 2002). Additionally, dominancy values of macrozoobenthic samples were also calculated using Bellan-Santini's dominance index formula (Bellan-Santini 1969). A similarity diagram was created using the Wards method according to the abundances (using standard of ISO 10870:2012) and ecological requirements, considering measured physicochemical parameters of the detected species. In addition, cluster analysis was applied in Past program to create similarity dendrograms according to the abundance, distribution, and ecological requirements of the detected species (Hammer, 2001).

Figure 1. Geographical positions of sampling stations.

RESULTS AND DISCUSSION

This study determines the macroinvertebrate fauna of Lake Limni, which is a very small lake whose macroinvertebrate fauna has not been previously investigated. As a result of the research, 25 species belonging to 18 genera were identified. Their abundances as percentages of the general zoobenthic community and the taxonomic group they belong to are given in Table 1.

According to the indices results, the Lake Limni zoobenthos was quite poor in terms of taxonomic diversity. Oligochaeta (73.78%) individuals constituted the majority of the benthic community structure. This was followed by Chironomidae with a dominance rate of 24.76%. Members of both groups (with the exception of partially low-tolerant stenoecious species) are used as bioindicators in biomonitoring studies of surface waters as they contain species with a high tolerance to pollution (Bode et al., 1996).

Limnodrilus hoffmeisteri Claparède, 1862 was the dominant taxon of the lake, with a dominance rate of 14.71% from Oligochaeta (based on mean % abundance), followed by *Limnodrilus udekemianus* Claparède, 1862 (10.46%), *Stylaria lacustris* (Linnaeus, 1767) (11.82%), and *Nais elinguis* Müller, 1774 (13.22%) (Table 1). It has been shown that most Tubificin species include cosmopolitan species with a wide distribution worldwide (Wetzel et al., 2000). Species belonging to the genus *Limnodrilus* and *Tubifex* are especially capable of adapting to a wide range of environmental conditions. Moreover, they can live in very different habitats from α-β mesosaprobic environments to sewage waters (Kathman & Brinkhurst, 1998) and are also a rare species that can survive in the zoobenthic community in the face of changing environmental conditions and increasing pressure factors. Due to these features, they are used as indicators to determine the trophic levels of lakes (Langdon et al., 2006). The fact that these two species represented a quarter of the overall zoobenthic structure in Lake Limni (25.17% in total), as well as the low diversity of taxa in the community, indicates that the environmental conditions are no longer a suitable habitat for zoobenthic fauna elements.

Table 1. Taxon list of macrozoobenthic individuals which were determined in Lake Limni and their proportional as % (AIG: Abundance in group), water parameters and index values of sampling stations (individual numbers were given as in m^2).

	Sampling stations		Mean	AIG
Taxa	**1**	**2**		
Class: Clitellata				
Subclass: Oligochaeta				
Stylaria lacustris (Linnaeus, 1767)	14.98	8.67	11.82	16.61
Nais elinguis Müller, 1774	11.45	7.51	9.48	13.22
Nais pardalis Piguet, 1906	4.85	5.20	5.02	6.78
Nais communis (Piguet, 1906)	0.88	2.31	1.60	2.03
Dero digitata (Müller, 1773)	1.32	0.58	0.95	1.36
Dero furcatus (Müller, 1774)	0.44	0.00	0.22	0.34
Ophidonais serpentina (Müller, 1773)	3.52	3.47	3.50	4.75
Slavina appendiculata (d'Udekem, 1845)	0.88	0.00	0.44	0.68
Uncinais uncinata (Ørsted, 1842)	3.96	2.89	3.43	4.75
Tubifex tubifex (Müller, 1774)	3.08	6.36	4.72	6.10
Limnodrilus udekemianus Claparède, 1862	7.05	13.87	10.46	13.56
Limnodrilus hoffmeisteri Claparède, 1862	14.98	14.45	14.71	20.00
Potamothrix hammoniensis (Michaelsen, 1901)	6.17	4.62	5.40	7.46
Psammoryctides albicola (Michaelsen, 1901)	0.00	4.05	2.02	2.37
Hirudinea spp.	1.76	1.16	1.46	
Order: Diptera				
Familya: Chironomidae				
Tanypodinae				
Tanypus punctipennis Meigen, 1818	0.44	0.00	0.22	1.01
Chironominae	**0.00**	**0.00**	**0.00**	**0.00**
Cryptochironomus defectus (Kieffer, 1913)	0.44	0.00	0.22	1.01
Chironomus thummi (Kieffer, 1911)	7.93	3.47	5.70	24.24
Chironomus (Camptoch) tentans Fabricius, 1805	3.96	1.73	2.85	12.12
Chironomus plumosus (Linnaeus, 1758)	5.29	5.20	5.24	21.21
Chironomus anthracinus Zetterstedt, 1860	2.20	5.20	3.70	14.14
Polypedilum scalaenum (Schrank, 1803)	0.88	2.31	1.60	6.06
Tanytarsini				
Paratanytarsus lauterborni (Kieffer, 1909)	0.88	2.89	1.89	7.07
Cladotanytarsus mancus (Walker, 1856)	0.44	2.31	1.38	5.05
Virgotanytarsus arduensis (Kieffer, 1909)	1.76	1.16	1.46	6.06
Tanytarsus gregarius Kieffer, 1909	0.44	0.58	0.51	2.02
Water parameters	**1**	**2**		
pH	7.9	7.9		
Temperature (°C)	21	20		
Dissolved oxygen (mg/L)	2.0	2.6		
Depth (m)	0.5	0.6		
Indices	**1**	**2**		
Number of taxa	25	22		
Individuals	227	173		
Shannon_H	2.73	2.80		
Evenness_e^H/S	0.61	0.74		
Margalef	4.42	4.07		

Additionally, it is well-known that *Stylaria lacustris* and *Nais elinguis*, the other dominant Oligochaeta species in the lake can tolerate salinity even at levels lethal for many freshwater species, can live in brackish waters with salinity less than 7‰, even in the profundal zones of lakes, and can tolerate low oxygen concentrations and low temperatures (down to –8 °C) (Timm, 1970;

Dumnicka, 1978; Davis, 1982). Furthermore, *S. lacustris* is a phytophile species and this feature increases its adaptability (Schwank, 1982). It has also been reported that *N. elinguis*, which is less frequently detected than other *Nais* species, can increase in population in waters rich in organic matter and can easily tolerate environmental variables (cold, muddy-odorous areas, poorly oxygenated waters) (Timm, 2003). The high population density of *Potamothrix hammoniensis*, which has a 5.40% abundance in lake zoobenthos (Table 1), has been reported to indicate eutrophic conditions or organic pollution in lake systems (Milbrink, 1980). In line with all this information and the results of the research, it can be concluded that the trophic level of the lake has passed into a serious hypertrophic stage.

The dominant Chironomidae species in the lake after Oligochaeta are *Chironomus thummi* (5.70%), *Chironomus plumosus* (5.24%), and *Chironomus anthracinus* (3.70%). It is known that *Chironomus* species in lakes and rivers are generally found in sediments, in polluted and turbid water or in waters rich in nitrogen and phosphorus and low in oxygen (Epler, 1995). Besides, they can live in muddy sediments where secondary aquatic plants are dense (Bat et al., 2000), even in puddles, and their abundance increases in the littoral zones of lakes, including brackish waters and the sublittoral zone, and among reeds. In addition, it has been reported that most *Chironomus* species are able to bind oxygen due to their high hemoglobin content and that they can easily compete with other species in the environment and survive by their gills (Pinder & Riess, 1983). The abundance of highly tolerant Chironomidae species followed by the highly tolerant Oligochaeta species in the lake and no individuals other than these tolerant groups identified in the lake are all natural warning signs for Lake Limni in ecological terms.

Although Lake Limni is a small lake, the index values calculated according to the data obtained from the two sampling stations are given in Table 1. In addition, the similarity diagram made using the Wards method according to the abundances and ecological requirements of the identified species is given in Figure 2 (introduced in 1963 by Joe H. Ward, the Ward clustering method aims to minimize the error squares between two merged clusters (Sharma, 1996; Xu & Wunsch, 2009)). This method, which is based on classical sum-of-squares criteria, is preferred among other cluster analysis methods because it is the only method that enables the formation of clusters by minimizing intragroup dispersion (Murtagh & Legendre, 2014).

The number of taxa detected in Lake Limni varied between 22 and 25, with the highest Shannon value at 2.8 while the Margalef value was 4.07 (Table 1). Both index values were higher than expected for an aquatic system with high trophic levels. Since these diversity indices work on the basis of the number of taxa and individuals detected in the area, these values were normal.

As can be seen in Figure 2, four specific species (*Limnodrilus udekemianus, Limnodrilus hoffmeisteri, Stylaria lacustris*, and *Nais elinguis*) of the taxa forming the zoobenthic community were in a different cluster from the other species. As explained in detail above, it was stated that although most of the species detected in the lake were highly tolerant, the four species in question have the ability to tolerate all kinds of environmental variables, including salinity. The tolerance of macrozoobenthic groups to changing environmental conditions prepared by Mandaville (2002) was examined and shown with values ranging from 1 to 10, from sensitive to tolerant species. Accordingly, the tolerance value of the Oligochaeta group was given as 8 without giving the species name. This value is not the upper limit, but Bode et al. (1996), in their species-based tolerance assessment, gave a maximum value of 10 for *Limnodrilus* species and *Nais elinguis*. It can be said that while the tolerance limits of the species in the other two main groups in the dendrogram are close to each other, these four species, which are the dominant species of the zoobenthic community, have a higher tolerance than the others.

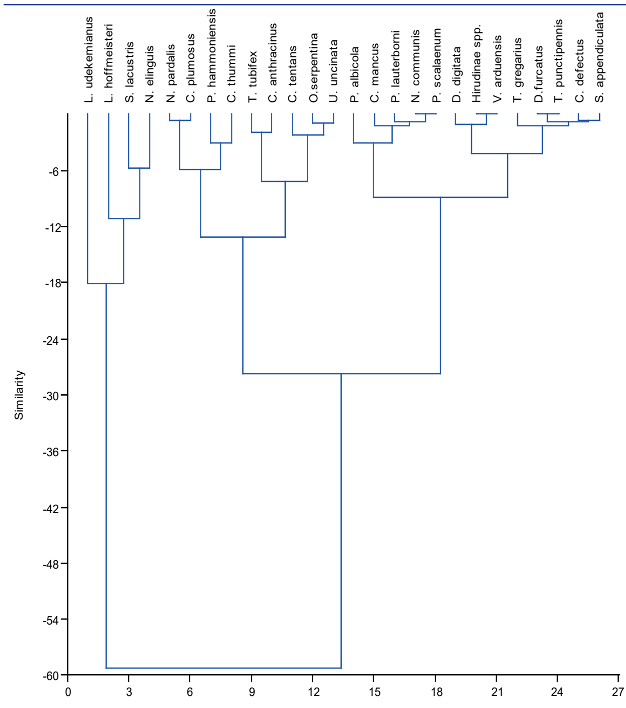

Figure 2. Similarity dendrogram of the species identified in Lake Limni according to their abundance, distribution, and ecological requirements.

High population densities of Oligochaeta and Chironomidae, which are known to be tolerant to increased organic and (or) inorganic pollution due to stressors in surface waters, and low species diversity of the overall zoobenthic community, are generally considered as indicators of poor water quality (Rosenberg and Resh, 1993). Such environments are generally known to have low dissolved oxygen and high nutrient concentrations (Langdon et al., 2006). Although very few water quality parameters were measured in this study, the low dissolved oxygen levels probably indicated water class IV. In a study conducted by Şahin (2008) in the same lake 17 years ago, the SO_4^{-2} value was determined as 1 mg/L, the NO_2-N value was 0.001 mg/L, the NO_3-N value was between 0.3 and 1.1 mg/L, and the o-PO_4 value was between 0.41 and 0.54 mg/L. In the study where epipelic algae were identified, Lake Limni was classified as an eutrophic lake with its morphometric structure, water parameters, and algal flora structure. In the same study, the dissolved oxygen value was between 8.3 and 10.9 mg/L. It is possible to say that this value has decreased significantly in the last 17 years and that the lake has passed from an eutrophic to hypereutrophic state, as stated by Şahin (2008), in terms of both water parameters and zoobenthic community structure.

CONCLUSION

Undoubtedly, a country's surface water is among the most important elements of its biological, cultural, and touristic heritage. Streams and lakes face the dangers of pollution from anthropogenic impact, especially due to their recreational use. So far, there are 262 protected nature parks in Türkiye. Lake Limni was declared the Lake Limni Nature Park by the General Directorate of Nature Conservation and National Parks in 2011. With this study, 25 species belonging to 18 genera were identified. It was determined that the zoobenthic community of the lake consisted of Clitellata and Chironomidae individuals and the dominant taxon of the lake was *Limnodrilus hoffmeisteri* from Oligochaeta. The high population density of Oligochaeta and Chironomidae individuals in the study area and the low species diversity of the general zoobenthic community indicate poor water quality. It is also possible to say that the water quality of Lake Limni has changed from eutrophic to hypereutrophic. It is necessary to take measures to protect the sustainability of the lake, inspect the surrounding businesses and picnic areas, and monitor the water quality parameters of the lake water and zoobenthic community diversity at regular intervals, since there is no river source that feeds the lake other than snow water and precipitation.

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