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Original Article

Determination of Benthic Macroinvertebrate Fauna and Some Physicochemical Properties of Balaban Lake (Menderes- Izmir)

Alperen Ertaş[1], Tugba Boz[1], İnci Tuney Kızılkaya[1]

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ABSTRACT

In this study, we aimed to identify the benthic macroinvertebrate fauna and some physicochemical characteristics of Balaban Lake located in Menderes, Izmir. For this, benthic macroinvertebrate and water samples were taken from 5 stations of the lake from October 2019 to August 2020. As a result, a total of 25 taxa were identified and were classified as Annelida (Oligochaeta and Hirudinea), Mollusca (Bivalvia and Gastropoda), Crustacea and other Insecta (Trichoptera, Coleoptera and Diptera). The sampling stations were clustered by using the Bray-Curtis UPGMA analysis in terms of the distribution of the benthic macroinvertebrates. As a result of the UPGMA analysis, the 2nd and 3rd stations (88%) were the most similar to each other. The second most similar stations to each other were determined as the 1st and 4th stations (75%). This situation can be explained by the bottom structure (rich vegetation) of these stations. According to Pearson Correlation, there is a strong positive correlation *(p<0.01)* of TU, EC, TDS and TP with *Nais communis*, while there is strong positive correlation *(p<0.05)* of TU, EC and TDS with *Nais elinguis*. On the other hand, there is a strong negative correlation *(p<0.01)* of TU, pH, EC, TDS and TP with *Gammarus* sp. This study is the first study for determining Balaban Lake benthic fauna. That's why all the taxa diagnosed in the stream has been recorded for the first time.

Keywords: Balaban Lake, Benthic Macroinvertebrates, Physicochemical Parameters

ORCID IDs of the author:
A.E. 0000-0001-8510-6100;
T.B. 0000-0001-5491-4367;
İ.T.K. 0000-0003-0293-6964

[1]Ege University, Faculty of Science, Department of Biology, Izmir, Turkey

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Correspondence:
Alperen Ertaş
E-mail:
alperenertas@hotmail.com

INTRODUCTION

The general purpose of limnological studies is to reveal the natural richness of aquatic ecosystems. In this context, the natural wealth of inland waters undoubtedly depends on the flora and fauna of the environment. It is necessary to determine the relationships of living groups living in aquatic ecosystems among themselves and with the physical and chemical characteristics of the ecosystem in which they are located, both in determining the limits of benefiting from the ecosystem in terms of fisheries and aquaculture, and in determining the basic biological efficiency of the aquatic ecosystem (Kırgız, 1984).

Studies on benthic fauna in inland waters constitute one of the important parts of limnological studies. The groups that make up the benthic fauna, the distribution of these groups and the investigation of various factors affecting their distribution are the subjects of study in this context. Benthic macroinvertebrates are defined as organisms that live on the bottom of water bodies, larger than 0.5 mm, visible and have no vertebrae. They are called "benthos" for short. Benthic macroinvertebrates are organisms that inhabit sediment and live on or in the bottom substrates of freshwater and marine ecosystems. In the water, they live on rocks, sediments, debris and aquatic plants, they can make sheaths attached to the substrate they live on or in during their lifetime or for some time in their lives. They have limited mobility. They live in seas, lakes, rivers, pools, swamps and ponds. While some groups feed on organisms such as algae and bacteria at the bottom of the food chain, some groups feed by breaking down plant and wood pieces and debris in the water (Wetzel, 2001; Tanyolaç, 2004). Benthic macroinvertebrates living in lake ecosystems constitute the third link of the food chain in the lake after phytoplanktonic and zooplanktonic organisms and gain importance as the active organisms in the biological productivity of the lake.

It is an undeniable fact that the distribution and taxonomic and ecological characteristics of benthic invertebrates, which constitute one of the basic building blocks of aquatic ecosystems, should be taken in the form of an inventory. In this regard, although there have been some studies done in Turkey (Balık et al., 2004; Balık et al., 2005; Balık et al., 2006; Toksöz and Ustaoğlu, 2005; Yardım et al., 2008; Yıldız et al., 2008; Taşdemir et al., 2010; Akkan Kökçü, 2016; Özbek et al., 2016), faunistic data on aquatic ecosystems is still quite inadequate. On the other hand, there are some studies showing the relationships between physicochemical characters and benthic invertebrate species distribution in our country (Kalyoncu et al., 2008; Kalyoncu and Zeybek, 2009; Ünlü et al., 2008; Zeybek et al., 2014; Yorulmaz et al., 2015; Zeybek 2016). For this reason, both taxonomic and ecological studies on benthic invertebrates, which are distributed in the inland waters of our country, should accelerate and new interpretations should be made in the light of the information to be obtained.

Anatolia is a region that has always preserved its importance in terms of zoogeography throughout various geographical periods. Due to its location between Asia, Europe and Africa, it constitutes one of the important passages and refuge areas for both terrestrial and aquatic species. For this reason, Anatolia is in a very rich situation in terms of species diversity. Izmir with its historical importance is localized on the Mediterranean coast in the West of Anatolia of Turkey. Izmir is the third-largest city in Turkey. Izmir is the fastest-growing city with a population of 4,320 million and an annual population growth rate of 9.5% in Western Anatolia. Balaban Lake was determined as a case area because it is an important drinking water source for Izmir. Balaban Lake is one of the important water sources of the Tahtalı Dam Lake basin in the Menderes district of Izmir. The Lake basin supplies 40% of city water needs. There are many industrial establishments, agricultural lands, and animal farms around Balaban Lake. There has been no study on the benthic macroinvertebrate fauna and physicochemical parameters of Balaban Lake thus far. The aim of this study is to identify the benthic macroinvertebrate fauna and physicochemical characteristics of Balaban Lake. Additionally, it was aimed to demonstrate the effective physicochemical parameters on benthic macroinvertebrates by using Pearson correlation and Unweighted Pair Group Method with Arithmetic Mean (UPGMA) analysis. This study further aimed to contribute to the taxonomical and environmental studies performed in Turkish lakes.

MATERIALS AND METHODS

The study area is located 40 km south of the city center of Izmir, within the area surrounded by the villages Yeniköy and Efemçukuru. The rock structure of Balaban Lake consists of highly metamorphic rocks, recrystallized limestones, metaquartzite, phyllite, and schist rocks (Hetzel et al., 1995). The deepest part of Balaban Lake is 10 meters. The lake's long axis is 4 km and the widest part of the lake is 250m. Kozluoluk Stream is one of the main sources bringing water to the lake. The lake water flows through underground water channels and Balaban Stream to Tahtalı Dam. The study was carried out seasonally at five sampling points in Balaban Lake. Spring sampling was carried out in April 2020, summer sampling in August 2020, autumn sampling in October 2019 and winter sampling in January 2020. Sampling points and coordinates are also given in Table 1 and Figure 1.

The 1st and 2nd stations are located just near Balaban Stream. Both stations have rich vegetation. The 3rd and 4th stations are located in the middle of the lake. The 5th station is located where the Kozluoluk Stream meets the lake and has rich vegetation, being the shallowest part of the lake. The water samples were preserved in the study area by using 2.0 L polyethylene plastic bottles. In this study, 8 physicochemical parameters were monitored over a period of a year. The pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC) and Turbidity (TU) were measured by using CyberScan Series 600 Waterproof- Portable Meter while the Temperature (T), Dissolved oxygen (DO) and Oxygen saturation (Sat. O_2) of each water sample were measured at the sampling sites by using Oxi 315i/ SET WTW Oxygenmeter. Total Phosphate (TP) was analyzed by using appropriate Merck kits according to manufacturer's instructions (Merck Phosphate Test Kits).

Benthic macroinvertebrates were collected from each station by using a classic 50x30 sized 250 μm mesh hand net and Ekman grab (approximately 250 cm^2) according to the literature (AQEM Consortium 2002). The AQEM sorting protocol was done completely in the laboratory and required that a defined subsample was taken prior to sorting. The subsample corresponded to 1/6 of the sample and at least 700 individuals were sorted. If 1/6 of the sample contained < 700 individuals, the sub sample was increased until ≥ 700 organisms are sorted. All individuals of the subsample were picked and counted without magnification and then determined. The result was a taxa list giving the number of individuals extrapolated to the whole sample. The taken samples were kept in 70% alcohol and 4% formaldehyde throughout the field study, and then brought to the Ege University Hydrobiology Research Laboratory. The benthic macroinvertebrate samples were categorized and diagnosed to the level of genus or species under a stereomicroscope. Brauer (1909), Almeida & Mise (2009) were used to diagnose the Coleoptera samples. Edington and Hildrew (1981), Morse (1983), Wallace et al. (1887) were used to diagnose the Trichoptera samples. Only Gledhill et al. (1993) was used in the diagnosis of the Crustacea sub-class. Korneyev & Evstigneev (2013) was used to diagnose the Diptera samples. Brinkhurst and Jamieson (1971) and Timm (1999) were used to diagnose the Oligochaeta and Hirudinea samples. Norman (1998) and Siddiqui et al. (2007) were used to diagnose the Mollusca samples based on morphological characteristics of the shell.

All the mathematical and statistical analyses between the physicochemical data sets and biotic parameters were made using Excel 2019 (Microsoft Office^R) and PAST 3 software. In this study, the dominance of the species was calculated by dividing the number of individuals of a species determined in the station by the total number of individuals of all species. In this study, the faunal sim-

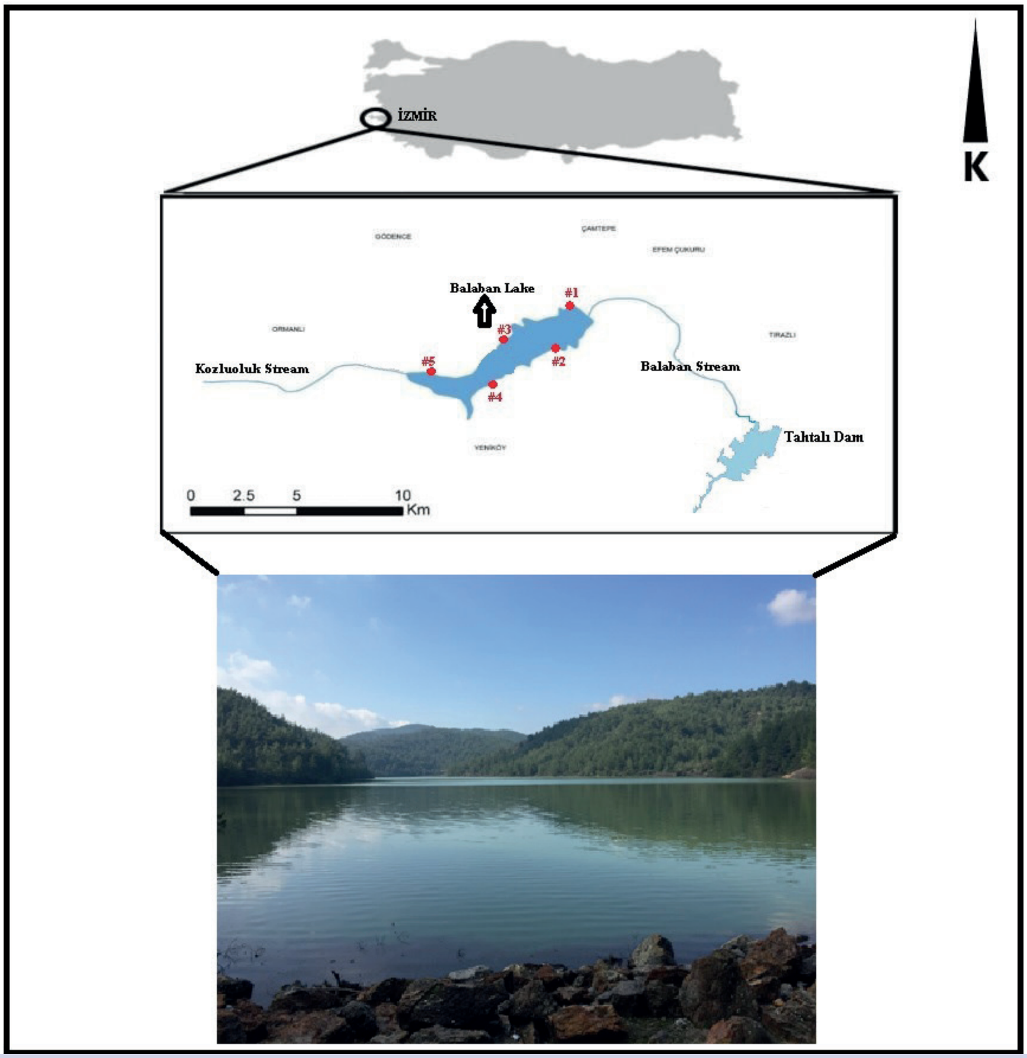

Figure 1. Study Area.

Table 1. Balaban Lake sampling points, coordinates and average depths.

Stations	Coordinates
Station 1	38°23′19.17″N-27°02′68.31″E
Station 2	38°22′98.69″N-27°02′78.50″E
Station 3	38°22′94.14″N-27°02′25.07″E
Station 4	38°22′68.85″N-27°02′23.68″E
Station 5	38°22′69.70″N-27°01′93.42″E

ilarities based on benthic macroinvertebrates between the sampling stations were assessed by using Bray-Curtis similarity index. UPGMA was used to illustrate existent clustering relationships based on Bray-Curtis similarity index. Bray-Curtis is the most frequently preferred method for clustering faunistic data (Somerfield, 2008). In this study, the relationship between physicochemical parameters and macroinvertebrates were determined by using Pearson correlation analysis.

RESULTS AND DISCUSSION

Physical and chemical parameters

The results of the analyzed physicochemical variables of water in five sampling stations along the stream are presented in Table 2.

Temperature (T) is a very important parameter for aquatic life, as it changes the viscosity and density of water, affects the rate of biochemical reactions occurring in the aquatic environment and the solubility of gases. It is known that the metabolism of organisms, especially fish and benthic macroinvertebrates, varies with temperature. Macroinvertebrates are generally eurothermal and tolerant up to 30°C, except for stenothermal organisms such as Plecoptera found in regions close to the source. However, if there is organic contamination in the environment besides the increasing water temperature, the decrease in oxygen concentration creates a problem for macroinvertebrates (Wetzel, 2001; Tanyolaç, 2004). For example, carp is euriterm but begins feeding (8-10°C) and breeding (15°C) only after certain temperatures (Nikolsky, 1963). The most suitable water temperature for trout is 8-16°C (Tanyolaç, 2004). The T level of the Balaban Lake fluctuat-

Table 2. Statistics of physicochemical parameters in sampling stations.

Parameters		Station 1	Station 2	Station 3	Station 4	Station 5
T	R	13.6-14.8	13.9-15.2	14.9-16.9	14.4-15.7	15.0-17.1
(°C)	M±Sd.	14.2±0.51	14.6±0.57	15.9±0.95	15.1±0.57	16.2±1.01
pH	R	6.95-7.15	6.70-6.95	6.70-6.95	6.90-7.05	6.80-6.90
	M±Sd.	7.02±0.09	6.84±0.11	6.84±0.11	6.99±0.06	6.88±0.05
EC	R	78.0-94.0	222-267	241-303	82.0-91.0	249-276
(µS/cm)	M±Sd.	89.3±7.63	248.5±20.5	282.8±28.2	87.8±4.03	262.8±12.8
TDS	R	83.0-100	229-274	248-311	87.0-96.0	254-280
(ppt)	M±Sd	94.5±7.85	257.5±20.3	289±28.1	92.5±4.04	268.8±12.4
TU	R	2.05-2.91	41.3-50.1	52.1-60.1	2.22-3.12	47.4-56.8
(ppt)	M±Sd.	2.46±0.36	46.1±3.73	56.3±3.74	2.62±0.45	51.1±4.07
DO	R	13.4-14.1	12.4-14.0	11.1-13.5	12.6-13.5	10.8-12.4
(mg/l)	M±Sd.	13.8±0.29	13.4±0.71	12.1±1.07	13.0±0.40	11.5±0.73
Sat. O_2	R	90.0-93.0	87.0-90.0	80.0-84.0	92.0-95.0	78.0-82.0
(%)	M±Sd.	91.5±1.29	88.5±1.29	82.0±1.83	93.8±1.26	80.3±1.71
TP	R	4.02-4.97	8.23-10.14	11.8-13.6	3.11-4.23	10.2-12.5
(mg N/L)	M±Sd.	4.49±0.38	9.42±0.84	12.6±0.76	3.82±0.49	11.6±0.98

R: Range; M: Mean; Sd: Standard deviation

ed between 14.2°C and 16.2°C during the study period. This fluctuation was caused by seasonal temperature changes in the weather. Similar physicochemical results were found in various studies conducted in Kılıçkaya Dam Lake (Dirican, 2008); Karacalar D am Lake (Mutlu et al., 2014); Çamlıgöze Dam Lake (Dirican, 2015); Sivas 4 Eylül Dam Lake (Yıldız & Karakuş, 2018).

?? Dissolved oxygen(DO) and saturated oxygen level (Sat. $O_{2)}$, which are vital for aquatic organisms, varies depending on the temperature as well as the photosynthesis rate of plants and the trophic level of the lakes. In addition, the oxygen holding capacity of water is affected by temperature, pressure and salts dissolved in water. Ephemeroptera, Plecoptera and Trichoptera are abundant in waters with high DO content. These organisms are intolerant of low oxygen conditions. Diptera and Oligochaeta species can survive at the bottom of lentic ecosystems with low DO content. They are tolerant of high water temperatures and low DO concentrations (Wetzel, 2001; Tanyolaç, 2004). It is desired that waters in which fish are grown be saturated with oxygen. Bremond & Vuichard (1973) stated that the minimum amount of DO required for the cyprinid species to survive should be 5.0 mg/L. For trout, the oxygen of the water should be at least 7.0 mg/L (Özdemir, 1994). In Balaban Lake, the DO level was observed to fluctuate between 11.5 mg/L to 13.8 mg/L during the study period. The Sat. O_2 level was observed to fluctuate between 80.3% to 93.8% during the study period The DO and Sat. O_2 levels did not vary much among the stations. Further, in Karacalar Dam Lake, it was reported that DO was 11.12 mg/L on average (Mutlu et al., 2014). In a study conducted by Yıldız & Karakuş (2018), it was reported that the DO amount in surface waters was found to be 7.88 mg/L on average.

pH, which is an indicator of the acidity of water, is one of the important factors affecting aquatic life. In lake waters that are not contaminated in any way, the pH value varies between 6.0 and 9.0. Most industrial wastes are highly alkaline or acidic, but other factors make it difficult to determine the direct effect of pH on freshwater communities. While gastropods are seen above pH 7, bivalves are found in the range of pH 5.6-8.3. Among insects, Coleoptera tolerate a wide tolerance range, Helminths tolerate pH 4.5-8.5 range. While Chironomidae (Diptera) is dominant at pH> 8.5 and at a pH <4.5, Orthocladinae family is not encountered. Some members of Plecoptera, Trichoptera and Hemiptera are tolerant to high pH and some to low pH (Wetzel, 2001; Tanyolaç, 2004). While many fish species show good growth in waters with a pH of 6.5-8.5 (Arrignon, 1976; Dauba, 1981), waters with a pH higher than 10.8 and less than 5.0 have a lethal effect for the Cyprinidae (especially carp) (Svobodá et al., 1993). Generally, alkaline waters are more suitable for trout production. Although trout can live in waters with a pH between 4.5-10, the best are waters with a pH of 7.5-8.0 (Özdemir, 1994). The waters of the stations detected on Balaban Lake have a slightly alkaline character in terms of pH values. For cyprinid health, the mandatory pH range in waters is expected to be 6.00 – 9.00 (EC, 2006). According to the pH data determined in the region, there is no risk for Cyprinid species. In the study performed in Kılıçkaya Dam Lake (Sivas) and Çamlıgöze Dam Lake (Sivas), it were reported that both lakes were suitable for aquatic life (Dirican 2008; Dirican 2015). In another other study which was performed by Mutlu et al., (2014) in Karacalar Dam Lake (Ulaş-Sivas), it was reported that the lake water had a pH level of 8.33 on average. Further, in the 4 Eylül Dam Lake (Sivas) by Yıldız & Karakuş (2018) the pH level of the surface water was reported to be 7.73 on average. According to Kesici et al., (2012) the average pH values were changing between the 6.89-9.12 in Bafa Lake.

The ?? Electrical conductivity (EC) of waters is a measure of the amount of salts or soluble substances in the water and depends on both geological and external factors (Höll, 1979). As a result of the wastes, the increase in the concentration of the salts found naturally in rivers and the deterioration of the balance cause toxic conditions. Macroinvertebrates vary in their tolerance to salinity.

Of the leeches, Piscicola geometra is less tolerant than the Erpobdellidae and Glossiphonidae families. However, salinity tolerance is higher in cold waters than in warm waters (Wetzel, 2001; Tanyolaç, 2004). Tolerant groups to high chloride concentrations (> 1000 mg/L) include only the Baetidae family from Odonata, Diptera (especially Chironomidae) and Ephemeroptera. Plecoptera is not seen in waters with increased salinity (Kalyoncu et al., 2008). The EC level of the Balaban Lake water was observed to have values ranging from 87.8 µS/cm to 282.8 µS/cm. The highest values of EC were recorded at the 3rd and 5th station. These stations are the points where the Kozluoluk Stream meets the lake. The pollution from the stream may have increased when combined with the dam. The EC value may be high due to pollution. In a study conducted at 4 Eylül Dam Lake, Yıldız & Karakuş (2018) reported that the surface water had an EC level of 181.5 µS/cm.

?? Total dissolved solids (TDS) originate from natural resources, domestic and industrial wastewater and agricultural areas. The main ions that contribute to the total amount of dissolved solids are carbonate, bicarbonate, chloride, sulfate, nitrate, sodium, potassium, calcium, magnesium, etc. In addition, silt, clay, small particles of organic structures, inorganic substances, organic compounds that can be dissolved, plankton and other microscopic organisms compose TDS (Tanyolaç, 2004). The amount of TDS affects the properties of drinking water such as taste, hardness and corrosion. The TDS level of the Balaban Lake water was observed to have values ranging from 92.5 ppt to 289 ppt.

?? Turbidity (TU) is seen in waters containing suspended solids, which prevent the passage of light. TU can be caused by many organic or inorganic substances (Wetzel, 2001). TU is important for 3 reasons in terms of the environment. First, the aesthetic use is avoided, the second is the low filterability and finally the disinfectability is not effective (Wetzel, 2001). It is recommended not to exceed 1 NTU (turbidity unit) by the EPA (1979) and World Health Organization (WHO, 2011). TU leads to an increase in the amount of prey by reducing the predator's influence in the prey-predator relationship. It has been reported that the amount of leeches (Hirudinae), which are the food of the fish, is increased in waters with high turbidity (Wetzel, 2001; Tanyolaç, 2004). The TU level of the Balaban Lake water was observed to have values ranging from 2.46 ppt to 56.3 ppt.

Phosphorus is a necessary element for aquatic life. Phosphorus is the most basic element of eutrophication occurring in water (Harper, 1992). It is found in very small amounts in uncontaminated waters and determines the richness of lakes (Tepe & Boyd, 2003). Phosphorus values above 0.3mg/L are entirely due to the pollution produced by humans in surface waters. It can be thought that algae and aquatic plants are overfed as a result of a phosphorus concentration above 0.5 mg/L and the presence of sufficient nitrogen compounds at the same time. As a result, biological equality is disturbed in stagnant waters. In this case, eutrophication is accelerated. Oxygen-free conditions caused by eutrophication adversely affect the population of Ephemeroptera, Plecoptera and Trichoptera groups (Wetzel, 2001; Tanyolaç, 2004). In Balaban Lake, the TP level was reported to fluctuate between 3.82 mg/L and 12.6 mg/L during the study period. In a study performed by Mutlu et al., (2014), the phosphorus level was reported to be between 0.001 mg/L and 0.017 mg/L in Karacalar Dam Lake. Uslu & Türkman (1987) reported that detergents used in cleaning had reached the receiving water environment through wastewater and is a factor affecting phosphorus concentration. It has been calculated that 91% of phosphate comes from domestic and industrial wastewater and 9% from agricultural areas to receiving waters (Egemen & Sunlu 1999).

Benthic macroinvertebrate data

In this study, a total of 2,008 benthic macroinvertebrate samples were collected; all the specimens collected belong to four groups: Mollusca, Annelida, Crustacea, and Insecta. The maximum numbers of individual were collected at station #3 (613 individuals), while the minimum numbers of individual were collected at station #5 (247 individuals). The lowest number of individuals was determined in winter while the highest number of individuals was determined in autumn with the collection of all benthic invertebrate samples (Figure 2).

As a result of diagnosis, the most dominant group in all benthic macroinvertebrate groups was Insecta in the stream (Figure 3). In this study, Crustacea was represented by a total of 219 individuals, Annelida with a total of 258 individuals, Mollusca with a total of 678 individuals and Insecta with a total of 853 individuals. In Kanak Lake the Insecta group was found as the dominant group. This may be due to either the high DO observed in the lake that can maintain the life cycle of insects, or it may be related to the age of the lake. In a study conducted at Sarıkum Lake (Sinop) by Akbulut et al., (2002) the Insecta group was also found to be the dominant group.

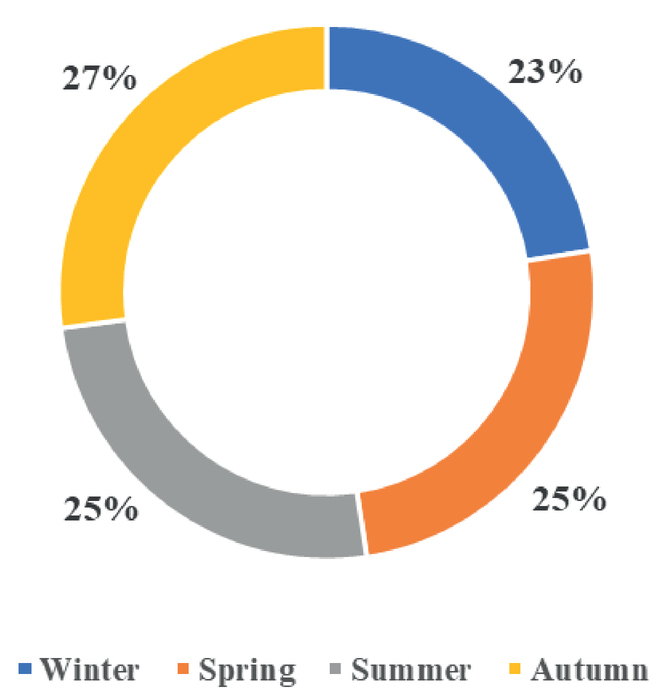

Figure 2. The total percent of benthic macroinvertebrates according to season.

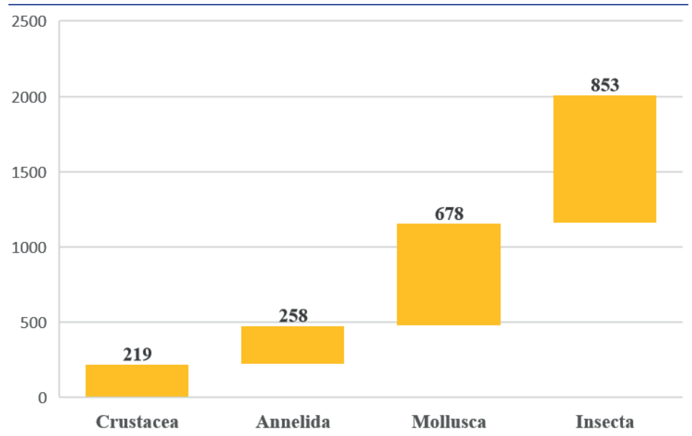

Figure 3. Benthic invertebrate groups in Balaban Lake.

Distributions of the recorded macrozoo-benthic invertebrates in Balaban Lake are shown in Table 3.

Considering all taxonomic groups in Balaban Lake, Bivalvia were the most dominant group in summer (25%) and winter (28%). The second most dominant group was Diptera in summer (21%) and winter (20%). Diptera was the most dominant group in autumn (27%) and spring (24%). The second most dominant group was Bivalvia in autumn (25%) and spring (19%) (Figure 4).

Out of 12 families identified, Insects were the richest group represented with 5 families: Trichoptera (3), Coleoptera (1) and Diptera (1) making up 41.7% of the macroinvertebrates of the Balaban Lake. Crustacea were represented with 2 families: Gammaridae, and Geryonidae which consisted 16.7% of the macroinvertebrates. Annelida were represented with 2 families: Naididae and Erpobdellidae, which consisted 16.7% of the macroinvertebrates. Mollusca were represented with 3 families: Physidae, Pla-

Table 3. Distributions and relative occurrence (%) of benthic macroinvertebrates in the stations.

	Station 1	Station 2	Station 3	Station 4	Station 5
MOLLUSCA					
BIVALVIA					
Dreissenidae					
Dreissena sp.	-	44.7	41.9	-	-
GASTROPODA					
Physidae					
Physa acuta Draparnaud, 1805	7.21	2.77	5.05	-	6.88
Planorbidae					
Gyraulus albus O. F. Müller, 1774	-	4.35	6.03	-	5.26
Planorbis planorbis Linnaeus, 1758	-	1.78	1.95	2.77	3.23
ANNELIDA					
HIRUDINEA					
Erpobdellidae					
Erpobdella octoculata Linnaeus, 1758	-	-	-	11.7	-
OLIGOCHAETA					
Naididae					
Nais communis Piguet, 1906	-	1.58	2.28	-	3.64
Nais elinguis Müller, 1774	-	2.57	2.44	-	2.83
Tubifex costatus Claparède, 1863	4.07	1.18	2.61	2.77	1.61
Tubifex tubifex O. F. Müller, 1774	9.40	1.78	1.95	13.2	4.85
CRUSTACEA					
Gammaridae					
Gammarus sp.	37.3	-	-	29.9	-
Geryonidae					
Potamon potamios Olivier. 1804	-	-	0.48	-	-
INSECTA					
Trichoptera					
Ecnomidae					
Ecnomus tenellus Rambur, 1842	4.07	-	1.46	4.32	-
Hydropsychidae					
Hydropsyche sp.	5.32	2.57	1.79	7.40	4.04
Hydropsyche fulvipes Curtis, 1834	4.07	2.97	2.12	6.17	5.26
Hydropsyche bulbifera McLachlan, 1878	2.82	-	-	3.08	-
Leptoceridae					
Oecetis ochracea Curtis, 1825	-	1.78	1.14	-	3.23
Oecetis furva Rambur, 1842	-	1.58	1.14	-	2.83

Table 3. Continue

	Station 1	Station 2	Station 3	Station 4	Station 5
Coleoptera					
Dytiscidae					
Cybister sp.	2.19	2.17	1.63	-	4.85
Hydaticus sp.	2.82	3.36	1.95	3.08	4.85
Methles sp.	2.19	1.98	1.63	-	4.04
Diptera					
Chironomidae					
Orthocladius sp.	3.76	6.73	6.19	3.70	10.9
Polypedilum sp.	3.13	4.15	4.24	4.93	9.31
Procladius sp.	4.07	3.96	3.58	2.77	7.28
Sergentia sp.	2.19	3.16	3.75	-	6.07
Tanytarsus sp.	5.32	4.75	4.56	4.01	8.90

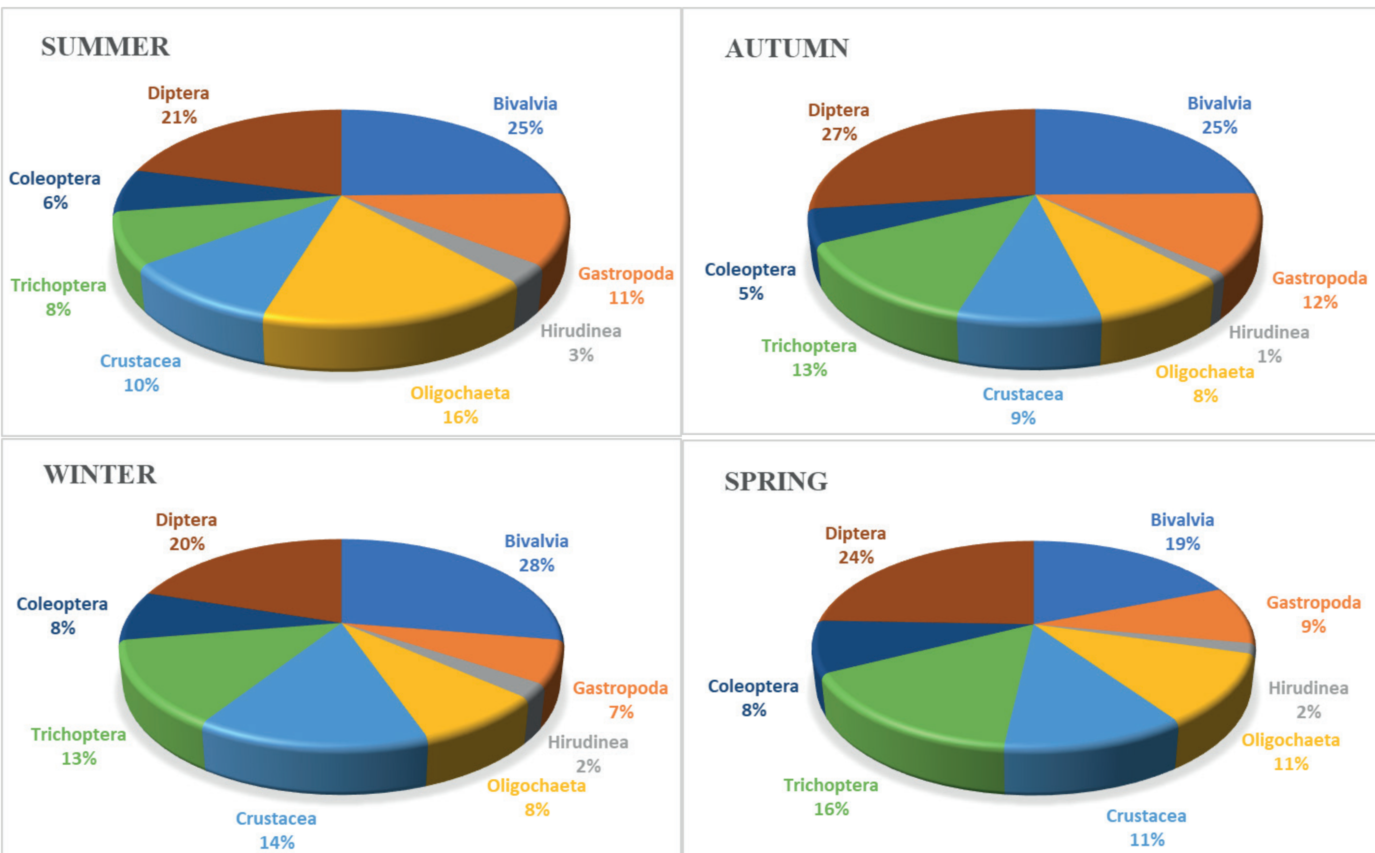

Figure 4. Distribution of taxonomic groups in Balaban Lake.

norbidae and Dreissenidae, which consisted 24.9% of the macroinvertebrates.

The dominance of benthic macroinvertebrate species according to the stations is shown in Figure 5. As a result of the observations, *Gammarus* sp. was dominant in the 1st and 4th stations. *Gammarus* sp., which belongs to the group of Amphipoda, was found in low polluted river sections (Meyer, 1987). *Orthocladius* sp. and *Tanytarsus* sp. were dominant species in the 2nd and 5th stations. These species are an indicator for oliosaprobic (clean) aquatic systems (Tanyolaç, 2004). According to Tanyolaç (2004) these organisms tolerance range is low. They can be found in high DO (mg/l) concentration, Sat O_2 (%) and T (°C). Existent abundance of the organic matter is favorable for benthic macroinvertebrates such as Diptera and Oligochaeta (Rashid and Pandit, 2014).

Oligochaeta and Diptera species are one of the most important freshwater species and are important food resources for some benthic macroinvertebrates and fishes (Brinkhurst & Jamieson, 1971). Numerous studies have shown a correlation between the population of Diptera and the number of diverse species of Oli-

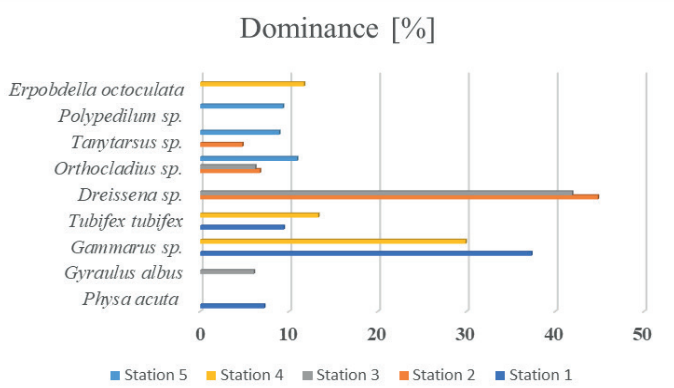

Figure 5. Dominance (%) of taxon of benthic macroinvertebrates at the stations.

gochaeta, and this correlation was observed to be negative (Darby, 1962; Ponyı, 1983). In these studies, Diptera was found to be the dominant group when larval Oligochaeta were found at a low density. In a study conducted by Kırgız (1988), it was reported that Oligochaeta had an abundance level of 18.16% while Chironomidae had 77.27% in Seyhan Lake of the Adana Province of Turkey. In another study conducted at Terkos Lake in the province of Istanbul, a contrasting result was reported, that Oligochaeta was the dominant group in the lake (82% Oligochaeta, 10% and 8% in other groups) Çamur-Elipek (2003). Further, in a study by Balık et al., (2004), Diptera was found as the dominant group with a 86.50% abundance, while Oligochaeta was found to have a 8.72% abundance in Buldan Reservoir in the province of Denizli. In Kemer Lake in the province of Aydın, Oligochaeta was found to be the dominant group with 10 taxa (Yıldız et al., 2008).

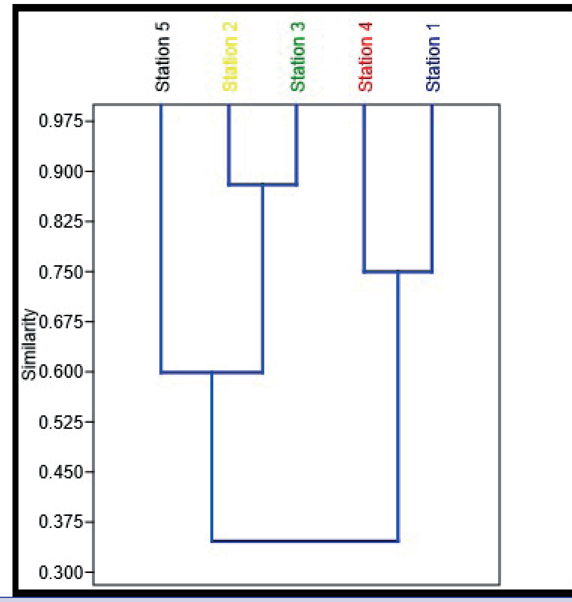

Figure 6. Classification of stations based on similarities of in Balaban Lake.

Table 4. Pearson's based correlation assessment between physicochemical parameters and macroinvertebrate species of the lake.

	T	DO	Sat. Oxy.	TU	pH	EC	TDS	TP
Dreissena sp.	0.099	-0.072	-0.337	0.669	-0.781	0.678	0.683	0.618
Physa acuta	0.188	-0.214	-0.602	0.501	-0.346	0.504	0.501	0.596
Gyraulus albus	0.484	-0.469	-0.69	0.875	-0.891*	0.878	0.878	0.873
Planorbis planorbis	0.663	-0.611	-0.446	0.655	-0.764	0.651	0.65	0.614
Erpobdella octoculata	-0.066	0.135	0.625	-0.605	0.467	-0.612	-0.614	-0.631
Nais communis	0.679	-0.682	-0.872	0.966**	-0.925*	0,966**	0,964**	0,978**
Nais elinguis	0.408	-0.405	-0.665	0.914*	-0.956*	0.918*	0.921*	0.874
Tubifex costatus	-0.138	0.187	0.098	-0.161	0.19	-0.159	-0.163	-0.058
Tubifex tubifex	-0.387	0.433	0.798	-0.928*	0.876	-0.932*	-0.935*	-0.899*
Gammarus sp.	-0.638	0.656	0.818	-0.983**	0.982**	-0.983**	-0,.984**	-0.939*
Potamon potamios	0.463	-0.417	-0.496	0.511	-0.48	0.509	0.504	0.591
Ecnomus tenellus	-0.35	0.41	0.627	-0.771	0.758	-0.774	-0.779	-0.688
Hydropsyche sp.	-0.493	0.548	0.900*	-0.888*	0.758	-0.890*	-0.889*	-0.910*
Hydropsyche fulvipes	-0.185	0.251	0.681	-0.537	0.341	-0.54	-0.538	-0.61
Hydropsyche bulbifera	-0.567	0.598	0.85	-0.989**	0.957*	-0,990**	-0.992**	-0.957*
Oecetis ochracea	0.5	-0.532	-0.77	0.957*	-0.957*	0.960**	0.963**	0.897*
Oecetis furva	0.52	-0.547	-0.787	0.974**	-0.974**	0.977**	0.979**	0.922*
Cybister sp.	0.329	-0.396	-0.8	0.829	-0.717	0.833	0.835	0.825
Hydaticus sp.	0.019	-0.036	-0.27	0.657	-0.797	0.666	0.676	0.519
Methles sp.	0.273	-0.332	-0.771	0.812	-0.705	0.818	0.82	0.817
Orthocladius sp.	0.486	-0.49	-0.739	0,953*	-0.973**	0.957*	0.959*	0.920*
Polypedilum sp.	0.798	-0.786	-0.809	0,928*	-0.931*	0.925*	0.922*	0.917*
Procladius sp.	0.417	-0.441	-0.79	0,936*	-0.899*	0.940*	0.942*	0.926*
Sergentia sp.	0.483	-0.503	-0.831	0,924*	-0.862	0.927*	0.927*	0.940*
Tanytarsus sp.	0.447	-0.462	-0.789	0,922*	-0.884*	0.926*	0.927*	0.926*

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

According to Tanyolaç (2004) the most dominant group was Diptera (*Chironomus thummi*) followed by Oligochaeta (*Limnodrilus* sp. and *Limnodrilus hoffmeisteri*) in eutrophic (polluted) lakes. In this study, *Nais communis* and *Nais elinguis* diagnosed in addition to Limnodrilus species in Balaban Lake. In a study conducted in the Lakes Region, Yıldız & Balık (2006) reported that *Dero digitata* was the most dominant organism in the region and the second most dominant organism in Topçam Dam Lake. Trichoptera are a good indicator of pollution-free water as they dwell in clean water and are very sensitive to polluted water. They can be found anywhere from warm streams to cool streams including lakes, ponds and marshes (Haldar et al., 2016). In this study the DO value of the lake was found to be abundant.

The classification of the stations based on benthic macroinvertebrates composition was illustrated by using Bray-Curtis UPGMA analysis (Figure 6). As a result of the UPGMA analysis, the 2nd and 3rd stations (88%) were the most similar to each other. The second most similar stations to each other were determined in the 1st and 4th stations (75%). This situation can be explained by the bottom structure (rich vegetation) of these stations.

In this study, the random sample cases (*10% select case*) were made on the biotic indices and physicochemical parameters to verify data sets and to determine that the data was transferred without errors in the PAST3. Table 4 indicates the correlations of physicochemical parameters and benthic macroinverterates species.

There is a strong positive correlation ($p<0.01$) of TU, EC, TDS and TP with *Nais communis*, while there is strong positive correlation ($p<0.05$) of TU, EC and TDS with *Nais elinguis*. There is a strong negative correlation ($p<0.01$) of TU, pH, EC, TDS and TP with *Gammarus* sp. There is a strong positive correlation ($p<0.01$) of TU, EC, TDS and TP with Chironomidae species.

CONCLUSIONS

With this study, we aimed to determine some physicochemical properties and benthic macroinvertebrate fauna of Balaban Lake. As a result of the research, 25 taxa were identified. It was observed that the benthic macroinvertebrates were presented as Insecta group > Annelida group > Mollusca group > Crustacea group. The identified taxa were the first recorded for the lake. Relationships between certain benthic macroinvertebrate species and physicochemical parameters were revealed in this study. We believe that this study will provide data for future monitoring studies. However, the change of populations in freshwater, which is under threat due to drought caused by climate change, must be determined over time.

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