THE INVESTIGATION OF THE SOME PHYSICOCHEMICAL PARAMETERS OF WATER QUALITY AND AQUATIC COLEOPTERA DIVERSITY IN IŞIKLI LAKE (DENİZLİ)

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ABSTRACT: This study was conducted to determine the physicochemical parameters (pH, temperature, electrical conductivity, salinity and dissolved oxygen) of water quality at Işıklı Lake in Denizli province. Additionally, we determined the effects of these parameters on aquatic Coleoptera diversity by taking water and insect samples every month from this lake between May 2009-September 2009 and April 2010-September 2010. As a result of the study 52 aquatic Coleoptera species were identified in lakes. The study also showed that the monthly fluctuations in the physicochemical parameters and the differences in the mean values are considered to be effective in the distributions of aquatic Coleoptera.

KEY WORDS: Water quality, aquatic Coleoptera, Işıklı lake, Denizli, Turkey

Aquatic insects, an important component of water ecosystems, are living as abundant and diverse group of various aquatic environments. They are used as bioindicators that play a vital role in ecosystem functioning, monitoring the anthropogenic stress of an ecosystem over a long period of time (Barman & Gupta, 2015).

Adaptation and sensitivity of environmental stresses are varied between orders and species in aquatic Coleptera. The composition and distribution of water insects is a reflection of water quality (Deusiano, 2017). Aquatic insects are commonly used as biological indicator have been effective in monitoring environmental pollution and water quality (Ummul et al., 2017; Deusiano, 2017). Therefore, determining the physicochemical properties of lake water is important to evaluating the parameter preferences of the species while identificating the lake fauna.

In this study, we aimed to determine some physical parameters of Işıklı Lake water in Denizli province and to determine the effects of these parameters on aquatic Coleptera distribution.

MATERIALS AND METHODS

Procedure and Physicochemical Analyses. This study was carried out in Işıklı Lake located in of Denizli province. In the study, we determined the effects of some physicochemical parameters on aquatic Coleoptera diversity by taking water and insect samples every month from lake between May 2009-September 2009 and April 2010-September 2010. Water samples of lakes were taken in pots with 120 ml. At the same time samples were measured with the Hagh Lange HQ40d multiparameter device every month. Then, pH, temperature, electrical conductivity, salinity and dissolved oxygen values were obtained from the stations with the station code were recorded together and transferred to the computer in the laboratory. Different types of aquatic equipments were used to collect the aquatic insect specimens. The net trap with a pore diameter of 1 mm was used in environments where water depth was high and aquatic plants were low. Metal sieves with a pore diameter of 0.5-1 mm were used in the shoreline where vegetation is thick and surface depth is less. All collected samples were placed in glass bottles containing 70% ethyl alcohol.

Research Area. Işıklı Lake is located in Çivril Plain and is used for irrigation of the plain on the sources feeding the Büyük Menderes River. The depth of the River is about 7 meters. It is fed with light streams and underground waters. Işıklı Dam, which is constructed in order to take Lake waters under control, is used as a reservoir where water is stored for the reservoir for the surrounding plains. The height of the dam is 7,50 m., the lake volume in normal water elevation is 237,80 hm^3 and the lake area in normal water elevation is 64,00 km^2 (Çakır & Minareci, 2015).

Statistics. Statistical significance was performed by ANOVA using SPSS 16.0. Means for physicochemical parameters were separated using by Fisher's least significant difference (LSD) at $p<0.05$ level. Relationships between parameters and distribution were analyzed by correlation and regression tests.

RESULTS

Physicochemical Results. pH, temperature, dissolved oxygen, electrical conductivity and salinity values of the physicochemical water quality parameters obtained from Işıklı Lake are given in the table below (Table 1).

In Figure 1, various physicochemical parameters of the surveyed Işıklı Lake are shown in terms of months during the research period. Projections and interpretations related to these pictures are discussed in the results section.

Biological Results. In the present study, total of 52 aquatic Coleoptera species have been identified and listed on the table below (Table 2).

RESULTS AND DISCUSSION

Physicochemical Results and Discussion. The results of this 11-month study were statistically evaluated on the mean values of the physicochemical parameters and are given in Table 1 (ANOVA $p<0,05$).

High pH and low oxygen have a lethal effect on living organisms (Tanyolaç, 2006). The most important factors affecting the distribution of the Dytiscidae family are pH and conductivity (Eyre et al., 1986). Every living thing has tolerance to a certain pH range. There is an opposing relationship between pH and oxygen (Ünlü & Uslu, 1999). The known opposite relationship between pH and oxygen is not fully visible in our study lakes ($p> 0,05$). In this case, fresh waters of the lake are thought to be effective despite the increasing pH value that the large spring waters feeding the River are effective.

Dissolved oxygen, which is negatively correlated with temperature, decreases with temperature and increases with decreasing temperature (Sarıhan, 1985). In this case, the dissolved oxygen values are expected to be high in the winter months. According to this information, it is expected that the dissolved oxygen value increases when the air is warmed up. However, it is thought that the snow water that joins the lake from Akdağ protects the dissolved oxygen level by adding the lake when it heats up in the air.

Electrical conductivity is known to be an environmental factor affecting aquatic insects (Eyre et al., 1986). Salinity increases in the summer months when evaporation is very high (Tepe, 2009). The relationship between temperature and salinity ($r=0,800$) was found to be strong. Electrical conductivity increases in parallel with salinity and temperature increase (Barlas et al., 1995). The relationship between conductivity and salinity was also found to be strong (r=0.825). The lowest Electrical conductivity value was measured as 315 µS/cm in April 2010, and the highest Electrical conductivity value was measured as 700 µS/cm in Lake in August 2010 (Fig. 1).

According to the US Salinity Laboratory System, water was collected under four groups according to their electrical conductivity. They are 0-250 µS/cm (low salinity), 250-750 µS/cm (medium saline), 750-2250 µS/cm (high saline) and more than 2250 µS/cm (very high) (Uslu, 2013). When the average electrical conductivity values are taken into consideration, it is seen that the light lake is included in the middle salt water class.

Salinity not only directly affects the osmoregulation of the living organism in the environment, but also indirectly affects the dissolved gas quantity, water density and viscosity (Tanyolaç, 2006). It is thought that in order to comment on salinity values and related to other parameters, it is necessary to examine and evaluate in detailed other anions, cations and compounds dissolved in water. The lowest salinity value was measured as % 0.16 in September 2009 and April 2010, and the highest salinity value was measured as % 0.41 in Lake in September 2009 (Fig. 1).

Oxygen is directly influence on the distribution, behavior and association of species with other organisms (Tanyolaç, 2006). Aquatic beetles can absorb and store oxygen from the water surface and use underwater. This ability can reduces their dependency of direct dissolved oxygen their response to dissolved oxygen. Instead of this, studies can be conducted during larval stage where the samples are more stable, would better demonstrate.

The classes of inland water resources according the Ministry of Environment (2004); pH value of water between 6.5-8.5 named as I and II. Class, between 6-9 named as III. Class and above to 9, named as IV. Class. From our results, we found that, in the Işıklı Lake, the lowest pH value was measured as 7.7 in April 2010 and the highest value was measured as 8,72 in September 2009 (Fig. 1). The average pH value of Işıklı Lake was determined as 8,13 and lake water has Class I. and II. water quality (Table 1). Additionally, the average pH values determined of the lake were found to be in accordance with the fresh water pH values reported in EPA (EPA, 2002).

According to the classes of inland water resources given by the Ministry of Environment (2004); when temperature value of lake is 25°C, named as I and II. Class, 30°C, named as III. Class, above 30°C, named as IV. Class water quality. When the measured values are taken into consideration, the lowest temperature value at Işıklı Lake was measured as 15,2°C April 2010 and the highest value in was measured as 27°C in August 2010 (Fig. 1). The average temperature value of the lake water was 20,3°C, so, lake water has I and II. Class water quality (Table 1).

According to the classes of inland water resources given by the Ministry of Environment (2004); Dissolved oxygen values of less than 8 mg/l for the clean water class, 6 mg/l for the less polluted water class, 3 mg/l for the polluted water class and 3 mg/l for the very polluted water class. When the measured values are taken into consideration, the lowest value at Işıklı Lake was measured as 6, 44 mg/l in May 2009 and the highest value was measured as 8,78 mg/l in April 2010 (Fig. 1). With monthly fluctuations, the average dissolved oxygen value, which is determined as 7,63 mg/l, brings the lake water into the clean water class (Class I) (Table 1).

Biological Results and Discussion. Haliplidae, Noteridae, Dytiscidae, Helophoridae and Hydrophilidae families. The family with the most species is Hydrophilidae (Table 2).

The Margaleff index which expresses species richness by evaluating different samples living in different habitats is a measure of the number of species found for the number of individuals obtained (Margalef, 1958). According to the Margaleff diversity index, the highest diversity value in terms of the month was found in Işıklı Lake in April 2010 and the lowest diversity value was found in Lake in August 2010. According to sampling points, the monthly diversity values were given at the Table 3.

The pH value in lake was found between 6.5-8.5 (Kara and Çömlekçioğlu, 2004), this value is suitable for aquatic life (Fig. 2). There was a negative relationship between pH and diversity of species (r=-0,649). However the diversity value has increased as the pH values approach the lower boundary, decreased as the pH values approach the upper boundary (Fig. 2). This result showed us that these sub-values are more appropriate for aquatic beetles, with the highest diversity value seen in april 2010 when pH was 7,7 (Fig. 1).

Insects are coldblooded organisms. The body temperatures are approximately the same as the ambient temperature. For this reason, temperature is the most important environmental factor affecting the behavior, distribution, development, survival and production of insects (Harrington et al., 2001). In our study, there was strong negative relationship between the temperature values and diversity of species (r=-0,891). Moreover, it was observed that aquatic Coleoptera did not distributed at very low and very high water temperatures. The highest diversity value was measured when the temperature was 15,2°C in April 2010 (Fig. 1).

It was reported that the increase of electrical conductivity parallel with the increase of salinity and temperature (Barlas et al., 1995). The electrical conductivity values of our studied lakes were in parallel with the salinity values (r=0,825). There was a strong negative relationship between the electrical conductivity values and diversity of species (r=-0,931). The highest diversity value was seen as 315 µS/cm in April 2010 (Fig. 1). This data also shown that aquatic beetles can exhibit higher diversity in their lower electrical conductivity values.

Salinity directly or indirectly affects the amount of dissolved gas, water density and viscosity on the osmoregulation of the living organism in the environment (Tanyolaç, 2006). A negative relationship (r=-0,827) was found between salinity values and diversity of species. The highest diversity value was determined as 0.16 % in April 2010 in Lake (Fig. 1). Aquatic Coleoptera species have been affected by high salinity, so they preferred lower salinity values.

When the dissolved oxygen values of lake water were examined, no significant relationship was observed (p> 0,05). When the obtained data were examined, it was observed that the low dissolved oxygen values of aquatic Coleoptera also varied (WPCR, 2004, Fig. 2). It is believed that the ability of aquatic beetles to absorb and store oxygen from the water surface under water reduces their direct dissolved oxygen dependence. The highest diversity was seen as 8.78 mg /L in April 2010 in Lake (Fig. 1).

In the study carried out at Işıklı Lake, various physicochemical parameters of the lake water were measured and the lake water was classified according to WPCR; in terms of dissolved oxygen II. class water quality in terms of water quality and other parameters (Çakır & Minareci, 2015). In another study, seasonal physicochemical parameters were measured in the Işıklı Lake and collected Invertebrata and Coleoptera species. In spring and summer, when lake water was analyzed to investigate dissolved oxygen and temperature, classified as I and II

.class water quality, but when the pH values are evaluated, lake water classified as IV. class water quality (Akbaba & Boyacı, 2015). In the present study, temperature, pH and dissolved oxygen values are evaluated and lake water classified as I and II water quality class according to WPCR (Table 1).

In the present study, we observed that the diversity values were higher in April, May and June. The lowest diversity values were seen in August and September (Table 3). The results of these articles support our findings. Many aquatic Coleptera species need aquatic plants to lay eggs and hatch (Bloechl et al., 2010). During the August and September due to increased temperature and evaporation, the lake is getting dry and resulted the drying coastal plants and the habitat is destroyed. It is known that many aquatic beetles actively flying insects and migrate to other habitats due to negative changes in the environment (İncekara, 2009). These changes are explained by Williams (2006) as adult Coleptera species have the ability to fly and leave the temporary waters before they dry and use the other waters. It is thought that the pH, temperature, salinity and conductivity values of the water have been negatively affected on the diversity of species since June. Many aquatic Coleptera species are known to be active volatiles and migrate to other habitats due to negative changes in the environment. In our study this is the reason why diversity values are low in these months. The current study will contribute to the study of more detailed basal giant vertebrae and water quality that needs to be done in the future.

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Map 1. Işıklı Lake area.

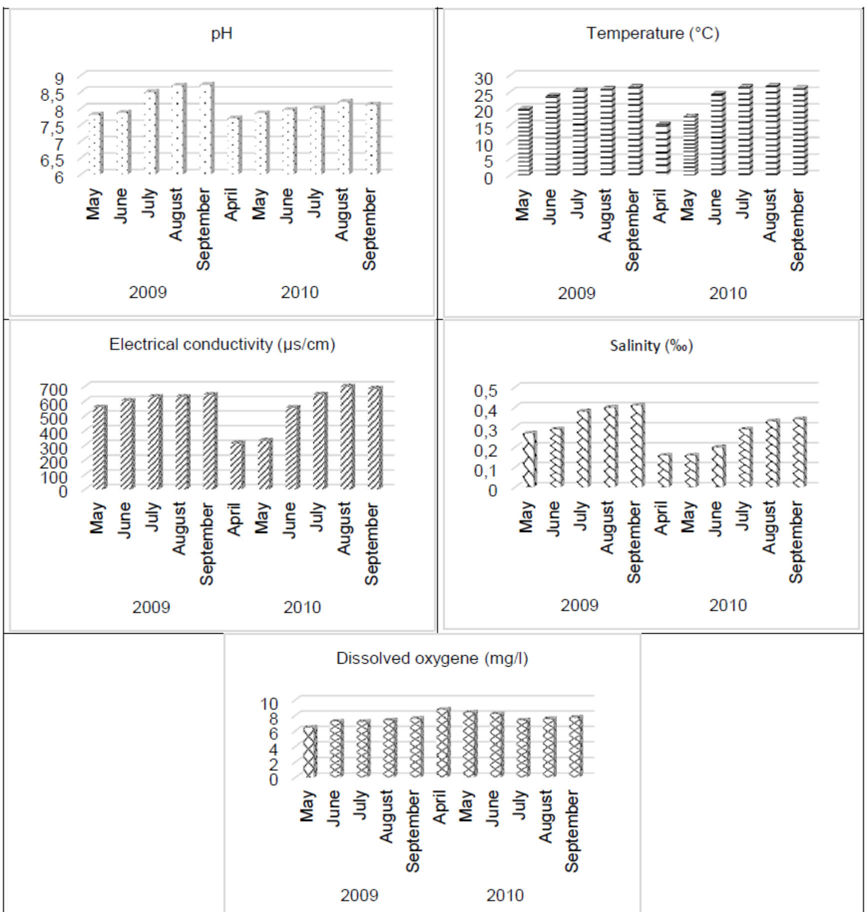

Figure 1. Monthly alterations of various physicochemical parameters values.

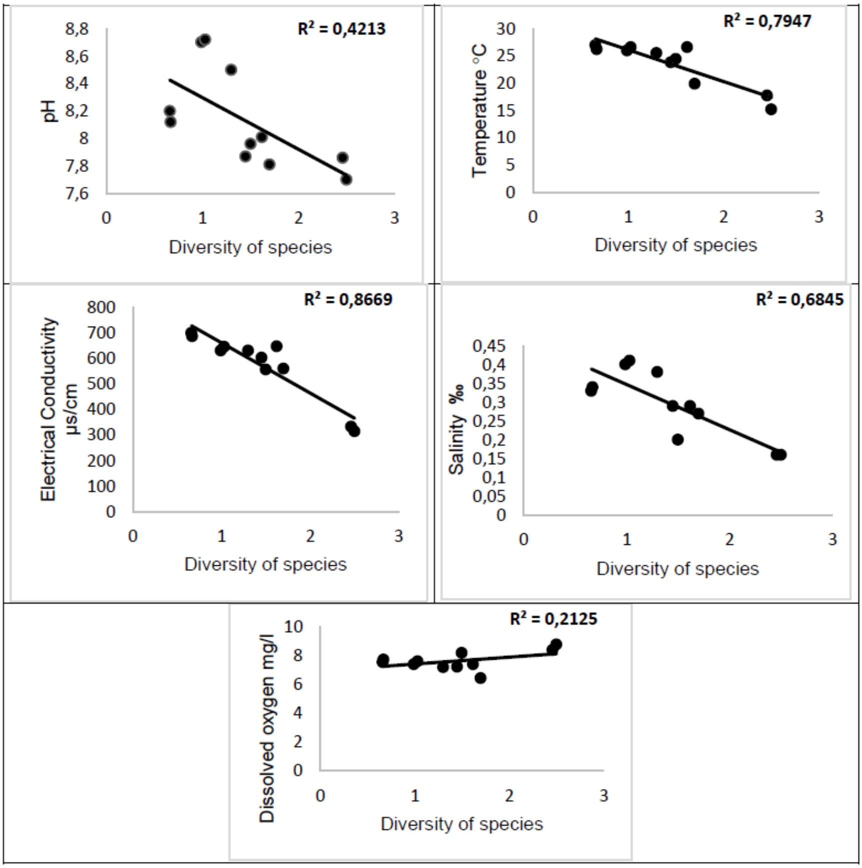

Figure 2. The relationship between aquatic Coleoptera diversity and physicochemical parameters.

Table 1. Water quality according to the average of physicochemical parameters is classified according to WPCR (Water Pollution Control Regulation), 2004. I: High quality water, II: Lightly polluted water.

Parameter	**Mean Value**	**WPCR Class**
pH	8,13	I and II
Temperature (°C)	23,53	I and II
Electrical conductivity (µs/cm)	573,36	-
Salinity (‰)	0,29	-
Dissolved oxygen (mg/l)	7,63	I

Table 2. Aquatic Coleoptera species.

Family	**Species**
Gyrinidae Latreille, 1810	*Gyrinus caspius* Ménétriés 1832
	Gyrinus dejeani Brullé 1832
	Gyrinus suffriani W. Scriba 1855
	Gyrinus urinator Illiger, 1807
Haliplidae Kirby, 1837	*Haliplus ruficollis* (De Geer, 1774)
	Haliplus fulvus (Fabricius, 1801)
	Peltodytes caesus (Duftschmid, 1805)
Noteridae C.G. Thomson, 1860	*Noterus clavicornis* (De Geer, 1774)
Dytiscidae Leach, 1815	*Agabus bipustulatus* (Linnaeus, 1767)
	Ilybius ater (De Geer, 1774)
	Ilybius fuliginosus (Fabricius, 1792)
	Colymbetes fuscus (Linnaeus, 1758)
	Graphoderus cinereus (Linnaeus, 1758)
	Cybister lateralimarginalis torquatus (Fischer von Waldheim, 1829)
	Dytiscus marginalis Linnaeus, 1758
	Hydaticus transversalis laevisculptus Zaitzev, 1910
	Bidessus nasutus Sharp, 1887
	Hydroglyphus geminus (Fabricius, 1792)
	Hydroporus angustatus Sturm, 1835
	Hydroporus planus (Fabricius, 1782)
	Porhydrus lineatus (Fabricius, 1775)
	Scarodytes halensis (Fabricius, 1787)
	Hydrovatus cuspidatus (Kunze, 1818)
	Hygrotus lernaeus (Schaum, 1857)
	Hygrotus inaequalis (Fabricius, 1777)
	Laccophilus minutus (Linnaeus, 1758)
	Laccophilus poecilus Klug, 1834
Helophoridae Leach, 1815	*Helophorus micans* Faldermann, 1835
	Helophorus brevipalpis Bedel, 1881
	Helophorus obscurus Mulsant, 1844
Hydrochidae Thomson, 1859	*Hydrochus elongatus* (Schaller, 1783)
Hydrophilidae Latreille, 1802	*Anacaena limbata* (Fabricius, 1792)
	Berosus affinis Brullé, 1835
	Berosus luridus (Linnaeus, 1760)
	Berosus signaticollis (Charpentier, 1825)
	Berosus frontifoveatus Kuwert, 1888
	Chasmogenus livornicus (Kuwert, 1890)
	Cymbiodyta marginella (Fabricius, 1792)
	Enochrus melanocephalus (Olivier, 1792)
	Enochrus fuscipennis (Thomson, 1884)
	Enochrus quadripunctatus (Herbst, 1797)
	Enochrus testaceus (Fabricius, 1801)
	Enochrus coarctatus (Gredler, 1863)
	Enochrus nigritus (Sharp, 1872)
	Helochares obscurus (O. F. Müller, 1776)
	Helochares punctatus Sharp, 1869
	Hydrobius fuscipes (Linnaeus, 1758)
	Limnoxenus niger (Gmelin, 1790)
	Hydrochara dichroma (Fairmaire, 1892)
	Hydrophilus piceus (Linnaeus, 1758)
	Coelostoma orbiculare (Fabricius, 1775)
	Cercyon circumcinctus Reitter, 1889

Table 3. Monthly diversity values of lake according to Margaleff Diversity Index.

	2009					**2010**					
Months	May	June	July	August	September	April	May	June	July	August	September
Value	1,7	1,45	1,3	0,99	1,03	2,5	2,46	1,5	1,62	0,66	0,77