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Zooplankton Fauna and Seasonal Changes of Two Karstic Sinkhole Lakes: Meyil and Kızören (Konya/Türkiye)

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ABSTRACT

Meyil and Kızören sinkholes are large karstic formations located in the Konya plain, Türkiye. Seasonal distribution of planktonic community of these two karstic lakes have yet to be studied. In this study, samples were collected from pelagic station in different seasonal periods (March-July-October 2018) and their physico-chemical parameters were determined and evaluated with seasonal species composition. As a result, fourty zooplankton species were identified in the two lakes, amongst which are thirty-four rotifers, five cladocerans and one copepod. Rotifers were founded as the dominant group for both lakes. All species identified as a new record for Meyil and Kızören sinkhole lakes. Furthermore, this study contributes to the literature by explaining the first detailed data for zooplankton fauna of sinkhole lakes in Türkiye as of the sampling date.

Keywords: Zooplankton fauna, karstic lake, Kızören Sinkhole, Meyil Sinkhole, Türkiye

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İki Karstik Obruk Gölünün Zooplankton Faunası ve Mevsimsel Değişimleri: Meyil ve Kızören (Konya/Türkiye)

Öz: Meyil ve Kızören obrukları, Türkiye'de Konya ovasında yer alan büyük karstik oluşumlardır. Bu iki karstik gölün planktonik topluluğunun mevsimsel dağılımı henüz çalışılmamıştır. Bu çalışmada, farklı mevsimsel dönemlerde (Mart-Temmuz-Ekim 2018) pelajik istasyondan örnekler toplanmış ve bunların fiziko-kimyasal parametreleri belirlenmiş ve mevsimsel tür kompozisyonu ile değerlendirilmiştir. Sonuç olarak, iki gölde otuz dört rotifer, beş kladoser ve bir kopepod olmak üzere kırk zooplankton türü tespit edilmiştir. Her iki gölde de baskın grup olarak Rotifera belirlenmiştir. Tüm türler Meyil ve Kızören obruk gölleri için yeni kayıt olarak belirlenmiştir. Ayrıca bu çalışma, örnekleme tarihi itibariyle Türkiye'deki obruk göllerinin zooplankton faunasına ilişkin ilk detaylı verileri ortaya koyarak literatüre katkı sağlamaktadır.

Anahtar kelimeler: Zooplankton faunası, karstik göl, Kızören Obruğu, Meyil Obruğu, Türkiye

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Introduction

The name in Turkish "Obruk" which is the most critical karstic formation consisting of wide and deep cylindrical well-shaped sinkholes in Konya plain in Türkiye (Canik and Çörekçioğlu 1985; Ertek 2009; Günay et al. 2011). Sinkholes are observed in areas where underground caves are formed due to the erosion of limestone on the surface and groundwater filling the void created by the collapse of these caves (Palmer 1991). The sinkholes in Türkiye are mostly located in Konya Province, and to date, the number of sinkholes within the borders of this province is around 332 (Orhan et al. 2020). Community research, which is the subject of lake studies, provides researchers with information about climate change or the ecosystem's structure (Olden et al. 2006; Gürbüzer et al. 2019). Zooplanktonic organisms are both crucial components of the food chain and one of the biological study communities in freshwater ecosystems that are used as an indicator for environmental changes (Attayde and Hansson 2001; Jeppesen et al. 2001; Yağci 2016; Montes-Ortiz and Elias-Gutierrez 2018).

Many previous freshwater zooplankton researches have been conducted in Türkiye, and these are mainly focused on lakes and rivers. Such as those

by Daday (1903), Geliday (1949), Tokat (1972), Dumont (1981), Ustaoğlu and Balık (1987), Emir (1991), Gündüz (1991), Segers et al. (1992), Altındağ (1999), Altındağ and Yiğit (2002), Ustaoğlu (2004), Kaya et al. (2008), Altındağ et al. (2009), Buyurgan et al. (2010), Gürbüzer et al. (2017) and Gürbüzer et al. (2019). Bozkurt and Bozça (2019), Bozkurt (2019) and Apaydın Yağcı et al. (2021).

However, concerning the sinkhole lakes of Türkiye, there were no detailed studies on the zooplankton fauna (Rotifera, Clodocera and Copepoda) in the literature. We aimed this study to explain the zooplankton fauna of the Meyil and Kızören sinkholes and discuss species diversity in three different seasons. Seasonal species composition was evaluated along with some physical and chemical parameters. At the same time, we aimed to contribute to the literature by explaining the first detailed data for zooplankton fauna of the sinkhole lakes in Türkiye as of the sampling date.

Materials and Methods

Studied Sites

The Meyil Sinkhole is located in a formation called uvala, and it spreads over a large area reaching 650 meters in diameter with an asymmetrical slope. The northern slopes of the sinkhole are significantly steeper than the southern slopes. Meyil Sinkhole contains Neogene rocks such as; limestone, marl, and sandstone. The total depth of the sinkhole is 104 meters; the depth of the lake inside is 40 meters. Accordingly, the height of the slopes between the lake level and the plateau surface is 64 meters (Biricik 1992). It is located near Meyil Plateau in the northern part of Karapınar District in Konya Province and located at 37°59'17.83"N - 33°21'12.98"E coordinates (Figure 1).

The Kızören Sinkhole is located at the 75th kilometer of the Konya-Aksaray highway, near Kızören Town. The steepness of the sinkhole slopes is varied-the gradients within the section consisting of crystalline limestone forming a steeper profile. The sinkhole slopes are largely covered with travertine sediments showing water level changes. The total depth of the sinkhole is 171 meters; the depth of the lake inside is 145 meters. The sinkhole diameter is 300 meters; The diameter of the lake inside is about 240 meters (Biricik 1992). Kızören Sinkhole is located in the Karatay District of Konya Province and located at 38°10'29.61"N - 33°11'8.89"E coordinates (Figure 1).

The formation of the sinkhole is directly related to the groundwater level. Climate is an essential factor for groundwater. There is a direct relationship between precipitation and groundwater (Yılmaz 2010). Around the Konya Plain, determined that drought and excessive water use, which occurred due to global climate change, caused the groundwater level to decrease (Bozyiğit and Tapur 2009). For this reason, a direct relationship is not expected between the annual average rainfall and the water levels in the Meyil and Kızören Sinkholes.

Figure 1. Map of study areas (Central Anatolia Region, Türkiye)

Sample Collecting

Zooplankton samples were collected with a plankton net (Hydro-Bios, mesh size 55 μm and 25 cm in diameter) in seasonal periods (March-July-October 2018). After collection, samples were immediately fixed with 4% formaldehyde in 100 ml

plastic bottles. Zooplankton sampling was carried out at one station from each lake due to safety concerns on the shores. The distance between the plateau and the water surface is approximately 30 meters at Kızören Sinkhole and is surrounded by steep slopes. Therefore, zooplankton and water samples were collected only from an old pier. As for Meyil Sinkhole, the coastal zone, which consists of loose material, had almost become swampy with the drop in the water levels. Therefore, zooplankton and water samples were collected from only one spot with firm soil. In the winter season, sampling was not possible due to rugged terrain and weather conditions for both lakes (Figure 2).

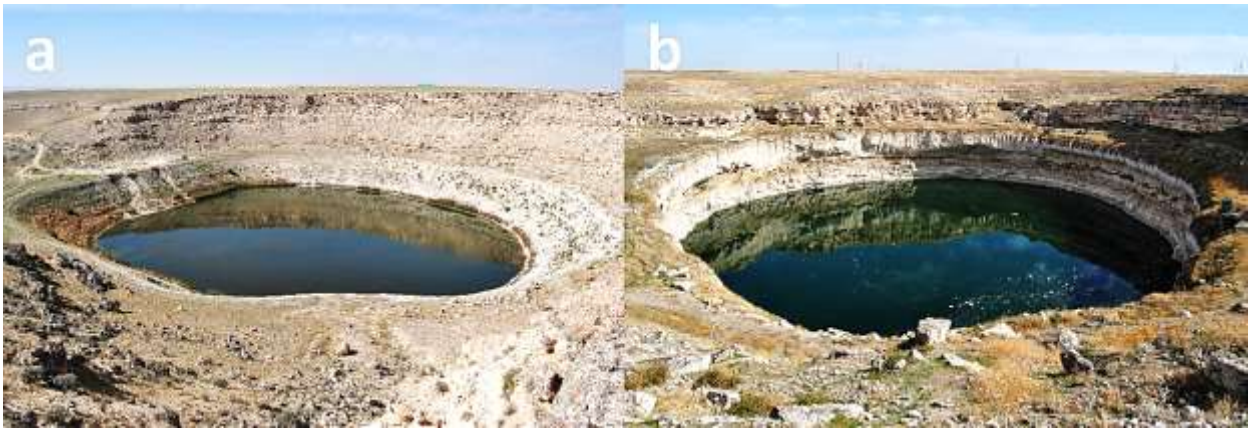

Figure 2. Study sites; a) Meyil Sinkhole and b) Kızören Sinkhole (Photographs taken by Oğuzhan Durmaz, 2015)

In addition, for both lakes, some physical and chemical parameters (pH, temperature, dissolved oxygen and electrical conductivity) were measured during the sampling periods. These measurements were made with Hanna HI 9812-5 (Romania) Multiparameter and Ohaus Starter 300D (USA) oxygen meter devices.

Identification of Zooplankton Species

The zooplankton species in this study were described down to species level based on monographs published by previous researchers (Ward and Whipple 1945; Donner 1965; Kolisko 1974; Koste 1978; Edmonson 1959; De Smet 1996; Smirnov 1996; Harding and Smith 1974; Nogrady et al. 1995). A microscope (Leica DMIL inverted, Leica DMSL stereo) and digital camera (DFC320, Leica Suite Application, Germany) were used for species identification of the collected zooplankton samples.

Results

The zooplankton fauna of Meyil and Kızören Sinkhole Lakes were researched in different seasonal periods (March-July-October 2018). Some zooplankton species identified were determined only in one season in the Meyil and Kızören sinkhole lakes (Table 1). *Filinia longiseta* (Rotifera) has been recorded at Kızören sinkhole lake during spring whereas, at Meyil, four species from Rotifera and only *Arctodiaptomus* sp. from Copepoda have been recorded. It was not identified at the species level because no adult samples were found. Ten species belonging to Rotifera and one belonging to Copepoda were recorded in Meyil Sinkhole, and a total of 30 species from Rotifera and five from Cladocera were recorded in Kızören Sinkhole (Table 1) overall

Table 1. Seasonal list of zooplankton taxa recorded from Meyil and Kızören sinkhole lakes

Species	**Meyil Sinkhole**			**Kızören Sinkhole**		
Rotifera	Spring	Summer	Autumn	Spring	Summer	Autumn
Asplanchna priodonta Gosse, 1850	-	-	-	-	-	+
Asplanchna girodi de Guerre, 1888	-	-	-	-	-	+
Brachionus angularis Gosse, 1851	+	-	-	-	-	-
Brachionus calyciflorus Pallas, 1766	-	-	-	-	+	-
Brachionus plicatilis Müller, 1786	-	+	-	-	-	-
Brachionus quadridentatus Hermann, 1783	+	-	+	-	-	+
Brachionus urceolaris Müller, 1773	-	-	+	-	-	+
Cephalodella forficula (Ehrenberg, 1830)	-	-	-	-	-	+
Cephalodella sp. (Bory de St.Vincent, 1826)	-	-	+	-	-	-
Colurella adriatica Ehrenberg, 1831	-	-	-	-	-	+
Colurella colurus (Ehrenberg, 1830)	-	-	-	-	-	+
Colurella obtusa (Gosse, 1886)	-	-	-	-	-	+
Dicranophorus epicharis Harring & Myers, 1928	-	-	-	-	-	+
Euchlanis dilatata Ehrenberg, 1832	-	-	-	-	-	+
Filinia longiseta (Ehrenberg, 1834)	+	-	-	+	+	+
Hexarthra polyodonta (Hauer, 1957)	+	+	-	-	+	+
Keratella quadrata (Müller, 1786)	-	+	-	-	+	+
Keratella tropica (Apstein, 1907)	-	-	-	-	-	+
Lecane bulla (Gosse, 1851)	-	-	-	-	+	+
Lecane clostrocerca (Schmarda, 1859)	-	-	-	-	+	+
Lecane grandis (Murray, 1913)	-	-	-	-	-	+
Lecane hamata (Stokes, 1896)	-	-	-	-	+	+
Lecane lamellata (Daday, 1893)	-	+	-	-	-	-
Lecane luna (Müller, 1776)	-	-	-	-	-	+
Lecane lunaris (Ehrenberg, 1832)	-	-	-	-	-	+
Lecane nana (Murray, 1913)	-	-	-	-	-	+
Lecane ohiensis (Herrick, 1885)	-	-	-	-	-	+
Lepadella patella (Müller, 1773)	-	-	-	-	+	+
Philodina megalotrocha Ehrenberg, 1832	-	-	-	-	+	+
Polyarthra vulgaris Carlin, 1943	-	+	-	-	+	-
Synchaeta pectinate Ehrenberg, 1832	-	-	-	-	-	+
Trichocerca pusilla (Jennings, 1903)	-	-	-	-	-	+
Trichotria pocillum (Müller, 1776)	-	-	-	-	+	+
Trichotria tetractis (Ehrenberg, 1830)	-	-	-	-	-	+
Cladocera						
Alona guttata Sars, 1862	-	-	-	-	+	+
Chydorus ovalis Kurz, 1875	-	-	-	-	-	+
Chydorus sphaericus (O.F.Müller, 1776)	-	-	-	-	-	+
Coronatella rectangula Sars, 1862	-	-	-	-	-	+
Oxyurella tenuicaudis (Sars, 1862)	-	-	-	-	-	+
Copepoda						
Arctodiaptomus sp. (Kiefer, 1932)	+	-	-	-	-	-
Total number of taxa	5	5	3	1	12	33

The dominant zooplankton group was formed by the Rotifera phylum for both lakes. According to Segers (2007), most of the rotifer species found are cosmopolitan. In addition, some water parameters (pH, dissolved oxygen, electrical conductivity and water temperature) were measured and evaluated with seasonal species composition for both lakes (Table 2).

Table 2. Seasonal measured water parameters during sampling for both lakes

Water	**Meyil Sinkhole Lake**			**Kızören Sinkhole Lake**		
Parameters	Spring	Summer	Autumn	Spring	Summer	Autumn
pH	9.3	9.2	9,0	8.2	8.0	8.3
DO	10.48	3.30	5.71	7.60	7.48	4.25
EC	920	930	1000	980	860	669
T	16	26	21,5	15	24	20,5

DO: Dissolved oxygen (mg/L), EC: Electrical (µS/cm), T: temperature (°C)

Discussion

The results showed that different seasonal conditions and water parameters might be structurally affected by zooplankton species composition. These data are essential in terms of ecological evaluation (Table 2). In lakes located in calcareous regions, the dissolved carbonate can increase the pH to around 9. In lakes that do not have an external flow, there is an accumulation of alkaline substances with evaporation, and the pH can rise to 12 (Tanyolaç 2011). In freshwaters, pH is in relationship with many chemical parameters. This relationship also dramatically affects the zooplankton species distribution. It is known that the alkaline limit in terms of zooplankton abundance is 8.5 pH (Bērziņš and Pejler 1987). There is an inverse relationship between oxygen and pH. High pH and low oxygen values have a lethal effect on living things (Tanyolaç 2011). It is known that both sinkholes consist of limestone rocks. Thus, both sinkhole lakes were classified as alkaline according to mean pH values. Significant differences were not observed between seasonal pH values (Table 2). Accordingly, it's seen that pH is not a solely dominant limiting factor in species richness between seasons.

However, for Meyil Sinkhole, pH values of 9 or more may be associated with low numbers of species in all seasons (Table 2). In Meyil Sinkhole Lake, EC values did not yield essential differences during seasonal measurements. In Kızören Sinkhole Lake, an inverse proportion was observed between seasonal EC values and a seasonal number of species (Table2). Considering that the maximum acceptable EC value for fisheries is 500 µs / cm (McKee and Wolf 1963), the average EC values for both lakes are high. Most rotifer species are tolerant of a wide range of conductivity values (Neschuk et al. 2002; Malekzadeh Viayeh and Špoljar 2012). However, in this study, the highest number of Rotifer species was identified in the Kızören Sinkhole in autumn, with the lowest electrical conductivity values. Electrical conductivity values may affect species diversity and richness. Akdemir (2008) investigated ostracod samples collected from two separate maar lakes (Acı and Meke) and a sinkhole lake (Meyil) in Konya, Türkiye, in another study he conducted in Meyil Sinkhole Lake. As a result of his research, he suggested that the most significant number of species is found only in Lake Meyil, which may be related to low salinity and increased oxygen levels.

Temperature is a limiting factor for the abundance and distribution of zooplankton (Mikschi 1989). Our study observed an inverse proportion between seasonal water surface temperature and dissolved oxygen in Meyil Sinkhole (Table 2). The highest temperature in Kızören Sinkhole is observed in summer. However, the dissolved oxygen value was lower in autumn than in summer. It was thought that the low dissolved oxygen values measured in the summer season were caused by the decrease in the water level for both sinkholes and the reduction in the groundwater level due to the evaporation effect. However, the low dissolved oxygen value in the Kızören Sinkhole in autumn can be explained by the decrease in the water level as well as the increase in zooplankton species diversity (Table 1). Unlike other karst lakes, the coastal zone of the sinkhole lakes is generally in the form of a circle, and there are no indentations (Figure 2). This situation may affect zooplankton species diversity. There are studies on zooplankton in karstic sinkholes with similar structures in the literature. Cervantes-Martinez and Gutiérrez-Aguirre (2015) identified the zooplankton species from two karstic sinkholes in Mexico. Those are *Lecane bulla*, *Lecane lunaris* and *Lepadella patella* from Rotifera and we identified these species at the Kızören sinkhole. The rotifer species (*Lecane bulla*, *Lecane lunaris* and *Lepadella patella*) identified in this study are similar to those at Kızören sinkhole lake. Another detailed research was conducted by Montes-Ortiz and Elias-Gutierrez (2018); they identified the zooplankton species in different seasonal periods in Cenote Azul Sinkhole in Mexico. *Coronatella rectangula* from Cladocera, one of these identified species, was also recognised at the Kızören Sinkhole. However, Cladocera was the most abundant zooplanktonic group in Cenote Azul Sinkhole (Montes-Ortiz and Elias-Gutierrez 2018).

It is known that biological studies on sinkholes are quite limited in Türkiye. This situation reveals that more studies are needed to determine the biological diversity in the sinkholes. It may be recommended to carry out further studies on the diversity and abundance of organisms living in both sinkholes with applications where the sampling frequency and the number of stations will be increased. As a result, this study will contribute to future research on the fauna of sinkhole lakes with a valuable and primary data set.

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