www.biodicon.com Biological Diversity and Conservation

ISSN 1308-8084 Online ISSN 1308-5301 Print

Research article/Araştırma makalesi
DOI: 10.46309/biodicon.2024.1366147
17/2 (2024) 127-137

Fish fauna of lake Küçük Akgöl (Sakarya, Turkey)

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Abstract

This research was conducted to determine the ichthyofauna of lake Küçük Akgöl between March 2017 and March 2018. Sampling was conducted monthly and randomly using nets with different mesh sizes, fishing rods and fish scoops during field studies, resulting in a total of 99 fish samples collected. Through external morphology examinations based on traditional methods, it was determined that 9 fish species *Alburnus alburnus*, *Blicca bjoerkna*, *Carassius gibelio*, *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Esox lucius*, *Gambusia sp.*, *Perca fluviatilis*, *Lepomis gibbosus*) belonging to 5 families (Cyprinidae, Esocidae, Poecilidae, Percidae, Centrarchidae) inhabit lake Küçük Akgöl.

Keywords: Sakarya, biodiversity, ichthyofauna, morphological species definition

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Küçük Akgöl (Sakarya, Türkiye) balık faunası

Özet

Bu araştırma, Küçük Akgöl ihtiyofaunasını belirlemek amacıyla, Mart 2017-Mart 2018 tarihleri arasında yürütülmüştür. Aylık, rastgele örnekleme yapılarak yürütülen arazi çalışmalarında, farklı göz açıklığına sahip ağlar, oltalar ve balık kepçeleri kullanılmış ve toplam 99 balık örneği yakalanmıştır. Geleneksel yöntemle dış morfoloji esas alınarak yapılan incelemeler sonucunda, Küçük Akgöl'de 5 familyaya (Cyprinidae, Esocidae, Poecilidae, Percidae, Centrarchidae) ait 9 balık türünün (*Alburnus alburnus*, *Blicca bjoerkna*, *Carassius gibelio*, *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Esox lucius*, *Gambusia sp.*, *Perca fluviatilis*, *Lepomis gibbosus*) yaşadığı belirlenmiştir.

Anahtar kelimeler: Sakarya, biyoçeşitlilik, ihtiyofauna, morfolojik tür tanımı

1. Introduction

In Turkey, the lentic and lotic systems, separated from each other by natural geographical barriers, have presented a multitude of ecosystems with varying ecological conditions for living organisms. This separation has facilitated the development of various isolation mechanisms such as geographical and genetic isolation, greatly affecting the geographical distribution of species, and increasing diversity at the genetic, species, and ecosystem levels. The Sakarya river is the third-largest river in Turkey, and the longest river in northwest Anatolia in terms of its total length, surface area, and rainfall area (Figure 1). The basin of the Sakarya river is very rich in wetlands due to the abundance and diversity of underground and surface water sources [1]. Lake Küçük Akgöl, our research area, is located in the lower basin of the Sakarya river, very close to the river itself (Figure 2), and situated between 40°-41° northern latitudes and 30°'-31° eastern longitudes [1].

The research area is located in the northwest of Akgöl neighborhood, which borders the Söğütlü district in Sakarya province, situated 6 kilometers away from Söğütlü and 12 kilometers from Sakarya city center [2]. Lake Küçük Akgöl is fed by waters from below, and its average depth varies between 2 and 6 meters depending on the season [1].

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 Received: 25.09.2023; Published: xx.xx.2024 BioDiCon. 1123.250923

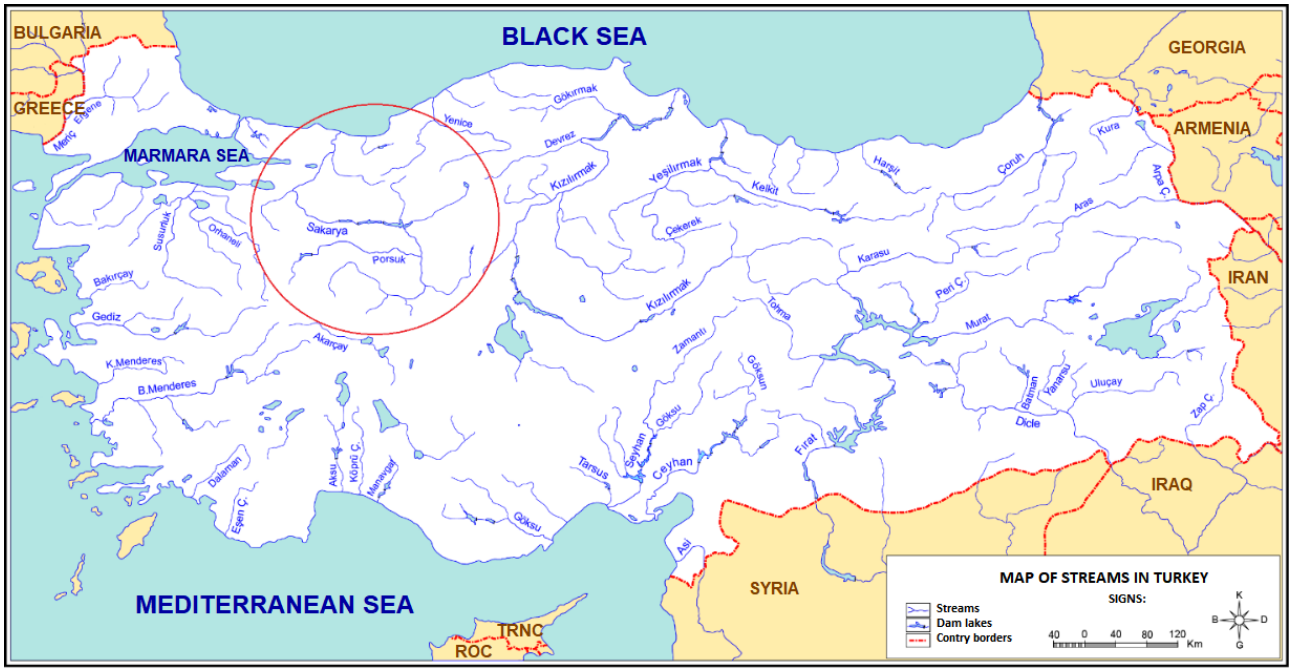


Figure 1. Map of rivers in Turkey [3]

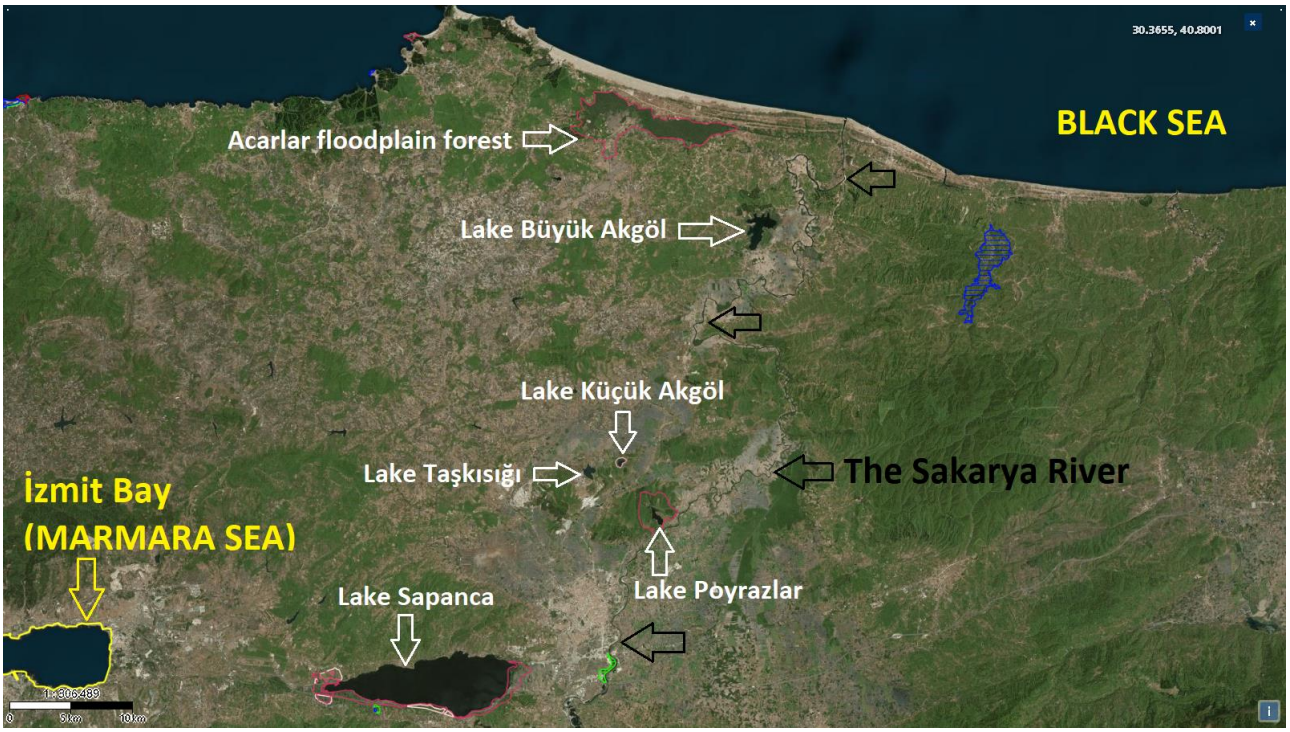


Figure 2. Map showing the lower basin of the Sakarya river [4]

According to the results obtained from geomorphological studies, lake Küçük Akgöl is a shallow alluvial embankment lake that is believed to have formed due to the Sakarya river and its tributaries, in response to past climate changes, sea level fluctuations, tectonic plate movements, and the high groundwater level in the Adapazari plain. This groundwater level is the primary factor in maintaining the existence of a lake assumed to have formed 5000 years ago. Additionally, there are many lakes assumed to have formed similarly in the lower basin of the Sakarya river [5].

Within the Sakarya river basin, there are special environmental protection zones such as national parks, nature parks, nature conservation areas, nature monuments, wildlife development areas, natural protected areas, nationally important wetlands, and wetlands of local importance [1].

Lake Küçük Akgöl and its nearby environment have been designated as two protected area at the national and regional management levels. Lake Küçük Akgöl has a surface area of approximately 20 hectares within a total region of 41 hectares. The lake has been declared a "Natural Site Area of Second Degree Importance" through decision number 8821, dated 2001, by Bursa Cultural and Natural Heritage Preservation Commission, which is affiliated with the Ministry of Culture and Tourism (Figures 3 and 4) [5]. In addition, a total region of 187 hectares, including lake Küçük Akgöl, has been designated as a "Wetland of Local Importance" by the General Directorate of Nature Conservation and National Parks affiliated with the Ministry of Agriculture and Forestry, on August 11th, 2019 [6].

Natural protected areas are classified into three categories: Sensitive areas for strict protection, qualified natural protection areas, and areas for sustainable protection and utilization under control [7]. The boundaries of these areas are represented respectively by pink, red, and blue colors in Figures 3 and 4.

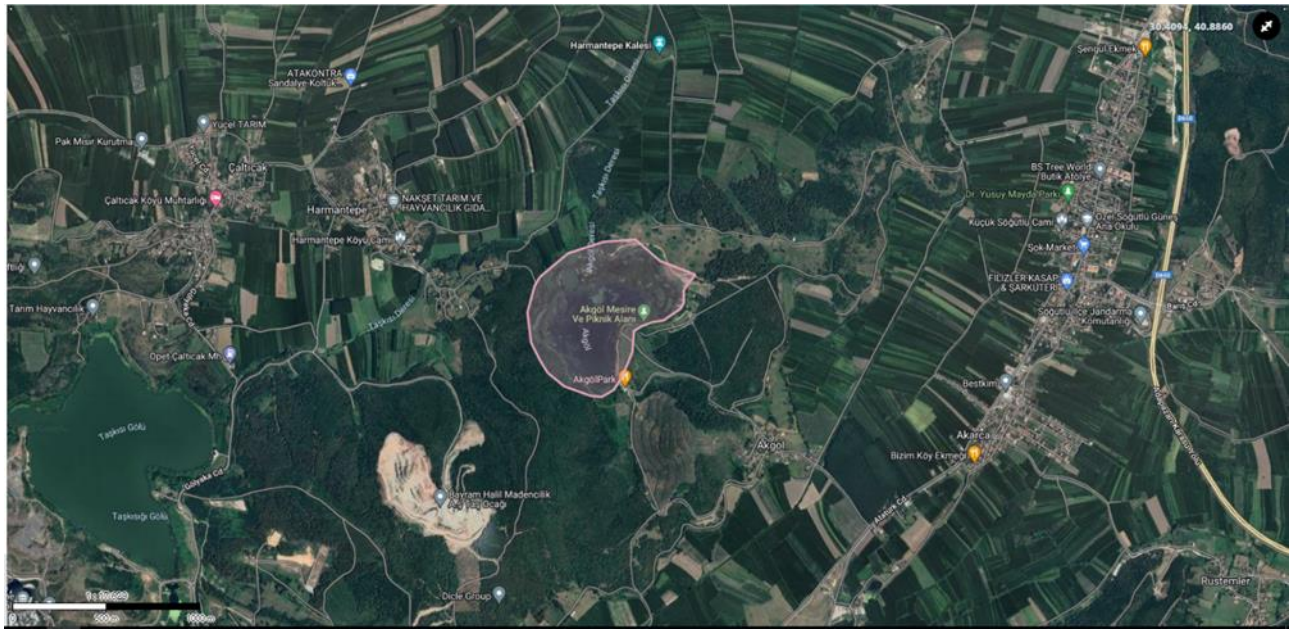
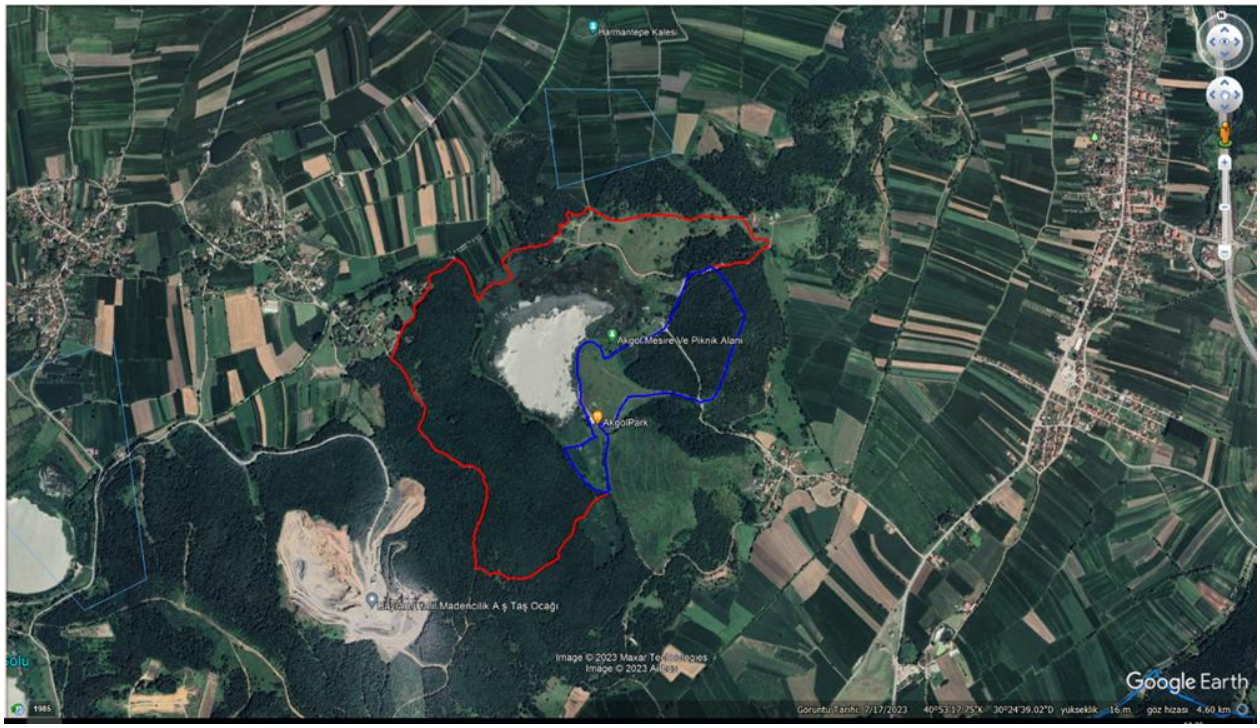


Figure 3. Map showing the natural protected area of lake Küçük Akgöl (Borders shown in pink) [4]

Figure 4. Map showing lake Küçük Akgöl and the surrounding areas suggested for protection through planning [4]



In addition to its current conservation status, lake Küçük Akgöl is not widely recognized as a wetland, thus its natural structure has remained largely intact without degradation. However, it is situated in close proximity to the Akgöl neighborhood, where human settlements, as well as agricultural and livestock activities, are still ongoing. Therefore, it is believed that the lake has been at least partially influenced by human activities (Figures 3 and 4) [5].

The total rainfall area of the Sakarya river basin constitutes approximately 1/8 of Turkey's landmass, spanning across parts or entireties of 13 provinces: Ankara, Eskişehir, Bolu, Kütahya, Bilecik, Afyonkarahisar, Bursa, Kocaeli, Düzce, Konya, Çankırı, Uşak, and Sakarya (Figure 1). Undoubtedly, the preservation or deterioration of wetland areas largely depends on the actions of the human inhabitants in these regions.

Lake Küçük Akgöl and its surrounding areas exhibit various features specified in the Regulation on Natural Protected Areas [7]. Some of these features are listed below:

a) It has species diversity, genetic diversity, and ecosystem diversity. For instance, the natural site area encompasses four different ecosystem types: Forest, lake, meadow, and swamp.

b) It possesses an adequate size that encompasses the primary elements of existing ecosystems and can sustain the functions of these ecosystems.

c) It holds social, cultural, and recreational values that contribute to the integrity of the landscape and its natural resources.

This study was conducted with the primary aim of determining the ichthyofauna of lake Küçük Akgöl. Subsequently, it sought to assess the damage to the fish community and natural structure of the study area caused by ongoing and increasing anthropogenic environmental degradation. Secondly, it aimed to understand how a degraded ecosystem responds to human intervention. Finally, it aimed to envision how the main ecological features and ecosystems in the area can contribute to achieving indicators of sustainable development targets through the status of the national protected area and the conservation efforts.

2. Materials and methods

This research was carried out to determine the fish species inhabiting lake Küçük Akgöl between March 2017 and March 2018. Due to the small size of the research area, fish sampling was conducted randomly on a monthly basis from the pelagic region of the lake during the research period. A total of 99 fish samples were caught using gillnets and trammel nets (with a wing length of 25-100 m, depth of 2-6 m, eye opening of 2-18 cm), fish scoops, and fishing rods.

The fresh fish samples collected during field studies were preserved as museum material, and identified based on external morphology using traditional methods at the family, genus, and species levels according to literature [8-20]. The current systematic position of each identified species' scientific name was referenced from Eschmeyer's Catalog of Fishes [21].

The following symbols and abbreviations are used in the text to denote the metric and meristic characters of the fish samples: SL (Standard Length), D (Dorsal fin), V (Pelvic fin), A (Anal fin), P (Pectoral fin), L.lat. (Lateral line scales), L.tran. (Linea transversal scales), Sq (Number of scales on a line between the back of the head and the beginning of the caudal fin in fish without a lateral line), PT (Pharyngeal teeth), GR_{Out} (Gill rakers on the outer margin of the first branchial arch), GR_{In} (Gill rakers on the inner margin of the first branchial arch), N (Specimen numbers).

3. Results

Following the evaluation of a total of 99 fish samples caught from the research area, it has been determined that 9 fish species (*Alburnus escherichii, Blicca bjoerkna, Carassius gibelio, Rutilus rutilus, Scardinius erythrophthalmus, Esox lucius, Gambusia holbrooki, Perca fluviatilis, Lepomis gibbosus*) belonging to 5 families (Cyprinidae, Esocidae, Poeciliidae, Percidae, Centrarchidae) inhabit lake Küçük Akgöl. The number of samples examined, along with qualitative and quantitative taxonomical characteristics, and original photographs for each fish species examined in this study, are provided below.

Family: Cyprinidae

Alburnus alburnus (Linnaeus, 1758)

SL: 91-113 mm. D: II-III 9-10 V: II 8 A: III 16 P: I 15-16 L.lat.: 47-48 L.tran.: 8-9/4 PT: 2.5-5.2 N: 4

The body shape is fusiform (Figure 5). The eyes are clearly large. The mouth is small and lacks barbels. The jaws are of equal length. In the middle of the upper and lower jaws, there is a recess and a round protrusion. The lateral line is complete and almost straight. Except for the head region and fins, the body is covered by cycloid scales, which are large and easily detached from the body. There is a prominent keel between the pelvic and anal fins. The body coloration is white with silver brilliance.

Figure 5. *Alburnus alburnus*

Blicca bjoerkna (Linnaeus, 1758)
SL: 93-171 mm. D: III 8-9 V: II 8 A: III 21-24 P: I 14-16 L.lat.: 46-49 L.tran.: 9-10/6 PT: 2.5-5.2 N: 6
The body shape is compressiform (Figure 6). The eyes are obviously large. The mouth is small, without barbels, and in a terminal position. The lateral line is complete and almost straight. Except for the head region and fins, the body is covered by cycloid scales, which are large and easily detached from the body. There is a prominent keel between the pelvic and anal fins, as well as in the predorsal region. The free edge of the dorsal and anal fins is concave. The body coloration is white with silver brilliance. Patterns such as spots or stripes are not seen throughout the body. Yellow-orange pigmentation in slightly lighter tones is especially visible in the ventral, anal, and caudal fins of mature specimens during the breeding season.

Figure 6. *Blicca bjoerkna*

Carassius gibelio (Bloch, 1782)
SL: 137-243 mm. D: IV 16-19 V: II 7-8 A: III 6 P: I 15-16 L.lat.: 30-33 L.tran.: 6-7/6-7 FD: 4-4 GR_{Out}: 52-53 GR_{In}: 58-64 N: 8
The body shape is short, blunt, and oval (Figure 7). The head is relatively small compared to the rest of the body. The eyes are quite prominent and large. The mouth is small, without barbels, and located terminally at the anterior part of the head. The lips have a slightly fleshy structure. The lateral line is complete and almost straight. Except for the head region

and fins, the body is covered by cycloid scales, which are large and easily detached from the body. The free edge of the last simple ray of the dorsal and anal fins has small serrations like sawtooth. The presence of a carina between the ventral fins and the anal fin is remarkable. The free edge of the dorsal and anal fins is straight. Although the body color varies depending on age, gender, and the ecosystem in which it lives, in general, the dorsal region and sides have an opaque silver color, and the ventral region has a bright white color. Patterns such as spots or stripes are not seen throughout the body.

Figure 7. *Carassius gibelio*

Rutilus rutilus (Linnaeus, 1758)
SL: 101-155 mm. D: (III) IV (9) 10-11 V: II (7) 8 A: III 10-12 P: I (14) 15-17 L.lat.: 41-43 L.tran.: 8/(3) 4 PT: 5-5, 6-5, 6-6 N: 14
The body shape is fusiform and slightly flattened from the sides (Figure 8). The head is relatively small compared to the rest of the body. The eyes are quite prominent and large, with orange-red pigmentation inside. The mouth is small, without barbels, protractile, and located terminally at the anterior part of the head. The lateral line is complete and slightly curved towards the ventral region, with the lateral line system continuing as pores on the head region. Except for the head region and fins, the body is covered by cycloid scales, which are large and easily detached from the body. There is a prominent keel between the pelvic and anal fins, as well as in the predorsal region. The free edge of the dorsal and anal fins is concave. The body coloration is white with silver brilliance. Patterns such as spots or stripes are not seen throughout the body. Yellow-orange pigmentation, neither dark nor light, is especially visible in the ventral, anal, and caudal fins of mature specimens during the breeding season.

Figure 8. *Rutilus rutilus*

Scardinius erythrophthalmus (Linnaeus, 1758)
SL: 128-165 mm. D: III 9-10 V: II 8 A: III (9) 11-13 P: I 14-16 L.lat.: 41-42 L.tran.: 7-8/3 PT: 2.5-5.2, 3.5-5.3 N: 8
The body shape is compressiform (Figure 9). The head is relatively small compared to the rest of the body. The eyes are quite prominent and large, with orange-red pigmentation inside. The mouth is small, without barbels, protractile, and located terminally at the anterior part of the head. The lateral line is complete and slightly curved towards the ventral region. Except for the head region and fins, the body is covered by cycloid scales, which are large and easily detached from the body. There is a prominent keel between the pelvic and anal fins, as well as in the predorsal region. The free edge of the dorsal and anal fins is concave. The body coloration is white with silver brilliance. Patterns such as spots or stripes are not seen throughout the body. Splendid dark red pigmentation is especially visible in the ventral, anal, and caudal fins of mature specimens during the breeding season.

Figure 9. *Scardinius erythrophthalmus*

Family: Esocidae
Esox lucius Linnaeus, 1758
SL: 443-515 mm. D: VIII, IX 14-15 V: II 9-10 A: VII 12-13 P: I 13-14 L.lat.: 120-130 L.tran.: 14/12-14 N: 3
The body shape is sagittiform (Figure 10). The head is relatively large compared to the rest of the body. The eyes are quite prominent and large. The mouth is large, elongated forward in the form of a duck's mouth, and the lower jaw is slightly longer than the upper jaw. Well-developed teeth are present on the jaws, tongue, and vomer bone. The lateral line is complete, but it is not clearly visible to the naked eye due to its spacing and the body's coloration. The lateral line system continues as pores all over the head region. A total of 10 submandibular pores were counted. The number of gill rays was counted at a total of 14-15. Except for the fins, the body is covered in small cycloid scales embedded in the skin. The dorsal and anal fins are located close to the caudal fin rather than the head. The vertical bands regularly found on the sides of the body in young and small immature individuals have turned into light-colored, nearly round-shaped, irregularly scattered spots in large and mature adult individuals.

Figure 10. *Esox lucius*

Family: Poeciliidae
Gambusia sp. Poey, 1854
SL: 10-40 mm. D: I-II 6-7 V: I 5 A: III (6-7) 8 P: (II-III) IV 8-10 Sq: 31-33 N: 34
The body shape exhibits a mosaic appearance; the head is depressiform, the trunk is fusiform, and the caudal is compressiform (Figure 11). The eyes are quite prominent and large. The dorsal part of the head is flat. The mouth is without barbels and in a superior position. The caudal fin is diphysercal shaped. Except for the head region and fins, the body is covered by cycloid scales, which are large and easily detached from the body. The lateral line is absent. The dorsal fin is located in the second half of the body. The body coloration is white with silver brilliance. There is black pigmentation like a large spot near the base of the anal fin on both sides of the body and black pigmentation like a thin stripe extending from the eyes to the lower chin. They are small-sized fish. In mature male individuals, the second and third simple rays and the first few branched rays in the anal fin are elongated by modification, forming a structure called a gonopodium, which serves as a copulation organ. Since all of our mosquitofish samples are female, we could not benefit from gonopodial features, and we did not identify at species level, so we decided to leave it genus level.

Figure 11. *Gambusia sp.* (Female)

Family: Percidae
Perca fluviatilis Linnaeus, 1758
SL: 102-204 mm. D_1: XIV-XVI D_2: II-III 13-15 V: I 5 A: II 9-10 P: II (10) 12-13 L.lat.: 62-66 L.tran.: 8-9/16-18 N: 10
The body shape is fusiform (Figure 12). The head is relatively large compared to the rest of the body. The eyes are quite prominent, large, and located closer to the top of the head. The mouth is large, protractile, in a terminal position, and without barbels. The free edge of the preoperculum is serrated like a sawtooth. The free edge of both operculum ends with a strong spine-like protrusion. The lateral line is complete and slightly curved towards the dorsal region, and the lateral line system continues as pores on the head region. The caudal peduncle can be thought of as thick compared to the height of the head and trunk. The space between the first and second dorsal fins is very small, almost none. Except for the fins, the body is covered by ctenoid scales embedded in the skin. There is a distinct black and large spot turning with a little orange pigmentation on the upper posterior margin of both operculum. There are a total of 8 dark-colored vertical bands positioned in parallel to each other on the sides of the body.

Figure 12. *Perca fluviatilis*

Family: Centrarchidae
Lepomis gibbosus (Linnaeus, 1758)
SL: 83-125 mm. D: X-XI 11-12 V: I 5 A: III (10) 11-12 P: II (10) 11 L.lat.: 40-44 L.tran.: 6-7/12-15 N: 12
The body shape is compressiform (Figure 13). The head is relatively small compared to the rest of the body. The eyes are quite prominent and large. The mouth is small, protractile, in a terminal position, and without barbels. The lateral line is complete and slightly curved towards the dorsal region, and the lateral line system continues as pores on the head region. Except for dorsal region of the head, throat and fins, the body is covered by cycloid scales, which are large and easily detached from the body. Cheeks, fins and the base of the fins are covered with scales. The free edge of both operculum are serrated like a sawtooth. They have wavy iridescent blue and brown lines on side of head. The lateral sides are covered densify spots colored of bright copper or gold. There is a distinct black and large spot on the upper-posterior margin of both operculum, as well as red-orange spot in a half-moon shape on the black ear flap in adults. They are small-sized fish.

Figure 13. *Lepomis gibbosus*

4. Conclusion and discussion

In this study, it has been identified that the fish community of lake Küçük Akgöl consists of 9 fish species (*Alburnus escherichii, Blicca bjoerkna, Carassius gibelio, Rutilus rutilus, Scardinius erythrophthalmus, Esox lucius, Gambusia holbrooki, Perca fluviatilis, Lepomis gibbosus*) belonging to 5 families (Cyprinidae, Esocidae, Poeciliidae, Percidae, Centrarchidae). Lake Küçük Akgöl is not a transparent lake; its water is turbid [1], and for this reason, although 9 taxa have been identified in this research, it is thought that there may be other fish species that cannot be captured. The best way to capture specimens belonging to the fish species forming the current ichthyofauna of a lotic ecosystem is fishing done using an electroshocker. This method is practical and not very time-consuming, and moreover, it makes it possible to collect fish samples in abundance and unspoiled. In seas, lagoons, and turbid lakes where the electrical conductivity is higher than freshwater sources with clear water, it is necessary to use a high-capacity generator to catch fish samples using an electroshocker device [16]. The electroshocker tool was not used in this study since the research area is a turbid lake.

The taxonomic characters of the fish species studied using the traditional method based on external morphology are similar to the data recorded in similar systematic studies published previously [8-20, 22-25]. In systematic studies where the external morphological characteristics of fish samples are examined, it is expected that all findings related to the taxonomic characters generally accord with the data recorded in similar studies conducted before. However, there may be small differences in at least a few taxonomic characters, and their importance can change depending on which character it is. Even within members of the same population, there may be similarities within species boundaries and endless variations on an individual basis because each individual is a partial representative of the gene pool to which it belongs [26]. Each ecosystem has its own unique elements and functions/dynamics. The ecological conditions in the aquatic environment have many different effects on the basic biological characteristics of living organisms, such as morphology, anatomy, physiology, metabolic rate, growth, development, ecological tolerance, geographical distribution, and migration [27], and these differences are reflected in biodiversity, with most of them considered as ecological variations within non-genetic individual variations [26]. Errors due to researchers can also cause differences. It is known that genetic and non-genetic variations create individual differences. If the differences are too remarkable to be neglected in terms of both qualitative and quantitative characteristics, the research area should be expanded, research methods should be diversified, and the number of samples should be increased, turning studies from the individual to the population level, and the possibility of a new species should be studied in more detail. For the reasons mentioned above, in similar systematic studies based on external morphology, it should be considered normal to find small differences in the taxonomic characters of the specimens belonging to the same species.

Lake Küçük Akgöl, with a surface area of 20 hectares, is an important food source for local people due to the qualities and quantities of its contained fish species. There is no doubt that the preservation of this wealth is as important as its determination. *Esox lucius* and *Perca fluviatilis*, found to be inhabiting lake Küçük Akgöl, have economic importance and are consumed by the regional people. *Carassius gibelio*, *Gambusia holbrooki* and *Lepomis gibbosus* are globally known invasive fish species inhabiting numerous wetlands, with the ability to rapidly breed, grow, and spread geographically [28, 29, 30]. It is known that invasive species can easily adapt to their environment, usually being euryoecious species, and can compete with native species for space and food. They can also damage eggs, larvae, juveniles as predators, spoil the genetic structure of native species by hybridizing with them, cause the extinction of native species through diseases and parasites brought from their original habitats, change interspecies relationships, damage certain abiotic features of the ecosystem, and enable changes in habitat features. Although there is not significant environmental degradation due to human activities in the natural structure of the study area, and it has had national protection status since 2001, the presence of invasive species is a concern.

It is possible to determine the current biodiversity and biogeographical regions in both aquatic and terrestrial environments through systematic research. Systematic studies have helped in correctly interpreting, protecting, and preserving the current biodiversity situation in the aquatic and terrestrial environment. They have also provided guidance for sustainable use and indicated directions for future studies.

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