

ORIGINAL ARTICLE

# The ichthyofauna of the Konya Endorheic Basin: an ichthyological hotspot in Türkiye

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**Article history:**  
Accepted 11 September 2023

## Abstract

The Konya endorheic basin covers a large area, and there are many different water habitats in this basin containing a high endemic fish diversity. A total of 39 fish species have been reported in this basin, with 27 (69.2%) being endemic to Türkiye and 19 local endemics exclusively distributed within this basin. When considering the IUCN categories of fish species, it is observed that *Alburnus akili* is extinct (EX), one is DD, 11 are LC, one is NT, three are VU, eight are EN, five are CR, and 10 have not been evaluated (NE). Threats to fish biodiversity in this basin are more diverse and intense, including drought, changes in river regime, habitat destruction, shrinking, and loss, invasive species, illegal and unconscious hunting, and water pollution. Recently, some of the wetlands in this basin have completely dried up, while the ecosystem integrity of other wetlands has been deteriorating annually. It is of great importance to establish a master plan to put forward the situation in the basin and take protection measures.

**Keywords:** Lake Beyşehir, Tuz Lake Basin, Exotic, Endemism.

## INTRODUCTION

Konya Endorheic Basin, one of the 25 inland water basins of Türkiye, covers an area of 53,850 km<sup>2</sup>, with a water potential of 5.42 billion m<sup>3</sup>/year. With a yield value of 2.5 l/s/km<sup>2</sup>, it is below the average of Türkiye (7.9 l/s/km<sup>2</sup>). However, because of its geological history and the hosting of many different aquatic habitats, it has a rich endemic fish diversity (Çiçek et al. 2018). There are some studies on the species fauna of this basin (Kosswig & Sözer 1945; Akşiray 1948; Neer et al. 1999; Wildekamp et al. 1999; Çubuk et al. 2006; Yeğen et al. 2006; Küçük et al. 2009, 2013, 2016; Freyhof & Özuluğ 2010; Özuluğ & Freyhof 2011; Yılmaz et al. 2011; Meke et al. 2012; Erk'akan et al. 2013; Özdemir 2013; İlhan et al. 2014; Bayçelebi et al. 2020; Güçlü et al., 2023), showing its remarkable biodiversity. Considering the biodiversity of the Konya Endorheic Basin, it has an endemism rate of 64.10%, above the average of Türkiye (50.6%) (Çiçek et al. 2018, 2020, 2023).

The aquatic ecosystems of this basin have been facing major problems in recent years; therefore, its unique biodiversity is under threat (Tunçok & Bozkurt 2005). Human needs have changed river regimes, and

drought has led to the destruction of many wetlands, disrupting their functioning and significantly reducing their areas. Complete drying out has led to the loss of wetlands like Meke Lake and Akgöl, Eşmekaya, and Ereğli marshes. In addition, invasive fish and water pollution from agricultural, domestic, and industrial sources causes major problems for the biodiversity of this basin (Çiçek et al. 2022).

A hotspot is an area with a high biodiversity of endemic species that is threatened by human habitation (Myers 1988). Considering the unique biodiversity of the Konya endorheic basin, it is an important hot spot in Anatolian geography. Previous publications have provided information on some parts of this basin. In this regard, this study aimed to reveal the fish diversity in the whole Konya endorheic basin, with discussions on its systematics, conservation status, threats, and solution suggestions.

## MATERIAL AND METHODS

The list of species distributed in the basin was based on species reported in previous studies and new species records. Fieldwork conducted between 2012 and 2022 also contributed samples for analysis. Fish

caught by commercial fishermen were also taken and analysed. We also re-examined the samples collected for different projects and preserved them in the laboratory.

The list of abbreviations in terms of the occurrence is: [N]: Natural; [E]: Endemic; [E\*]: Endemic to the Basin; [I]: Exotic; [T]: Translocated. All species were classified according to their IUCN Red List Categories (IUCN 2023) with abbreviations of NE, Not Evaluated; DD, Data Deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered; and EX, Extinct.

## RESULTS AND DISCUSSION

The review of the studies conducted so far revealed that the Konya endorheic basin is home to 39 species from 14 families belonging to 8 orders (Table 1).

**Endemism:** Of the 39 species distributed in the basin, 27 are endemic species, and 19 of them are endemic to the basin. While the rate of endemism in Türkiye's ichthyofauna is 50.6%, the basin with the highest rate of endemism among the 25 basins is the Konya endorheic basin with 69.2%. Endemic fish are an important part of the natural heritage of each country (Çiçek et al. 2018, 2020, 2023). Geological and climatic factors influence the evolutionary reasons behind this diversity. One of the main reasons for the high endemism is the fact that the last extinction of the Tethys Sea affected a large part of this basin. Indeed, the closure of the Tethys Sea during the Oligocene-Miocene period had a significant impact on the distribution of organisms (Hrbek & Meyer 2003). This process directly influences the distribution and diversity of species in the Aphaniidae family. Phylogenetic relationships indicate that this process also affected and shaped the species belonging to the genus *Seminemacheilus*, which is endemic to Türkiye (Çiçek 2020). In addition, aquatic areas with different salinities, reeds, and marshy areas, Beyşehir Lake, one of the largest lakes in Türkiye, and habitat diversity due to large and small rivers are other factors in the rich biodiversity of this basin.

Salt Lake in the basin has an important barrier effect on the distribution of living organisms. As a

result, isolated populations in certain confined habitats completed the speciation process. Akgöl Reeds (Ereğli) is the type locality of five species, and these species have a very narrow distribution area even within the basin. The distribution of some Aphaniidae species in the basin is also very limited. Lake Beyşehir, another important speciation center, is home to six locally endemic fish species (Bayçelebi et al. 2020). Saline ecosystems isolate the distribution of species in the basin, like *Gobio*. Therefore, researchers identified five species belonging to this genus based on the variations in morphometric and meristic characteristics among the populations in this basin.

**Exotic species:** There are four exotic species among the 39 species distributed in the Konya endorheic basin. Researchers have found that *C. gibelio* negatively impacts biodiversity and fisheries in the ecosystems where it is found, especially in Beyşehir Lake (Yeğen et al. 2006). *Gambusia holbrooki*, which was introduced to Türkiye for mosquito control, inhabits some backwaters, wetlands, and canals. In this basin, there are a small number of river areas that allow salmonid fish. We found *Oncorhynchus mykiss* specimens in some headwater areas and *Pseudorasbora parva* in some stagnant water ecosystems and in some slow-flowing streams. In addition to this, four species with natural distributions in Türkiye were found to have been introduced to the basin fauna through translocation. *Sander lucioperca*, introduced to Beyşehir Lake for fishery enhancement, has successfully established itself. As it became dominant in the lake over time and reached high population densities, it caused the extinction of *A. akili*, which was endemic to the lake (Yeğen et al. 2006; Küçük 2012). Currently, other endemic species in the lake are also under great threat. The purpose and timing of *A. escherichii* translocation to this basin remain unclear (Gülle et al. 2017). In a recent study (Bayçelebi 2020), it was reported that *A. escherichii* is found in Beyşehir Lake and related rivers. Therefore, it is necessary to clarify the distribution of *A. escherichii* in different parts of this basin.

*Knipowitschia caucasica* was reported from Beyşehir Lake, but it is not known how or when it was

**Table 1.** Systematic status, origins, and IUCN categories of the fish fauna of Konya endorheic basin.

Order/Family	Species	Origin	IUCN
CYPRINIFORMES			
COBITIDAE	<i>Cobitis battalgilae</i> Băcescu, 1962	E	[EN]
	<i>Cobitis bilseli</i> Battalgil, 1942	E*	[EN]
	<i>Cobitis turcica</i> Hankó, 1925	E*	[EN]
NEMACHEILIDAE	<i>Oxynoemacheilus axylos</i> Yoğurtçuoğlu, Kaya & Freyhof, 2022	E*	[NE]
	<i>Oxynoemacheilus eregliensis</i> (Banarescu & Nalbant, 1978)	E*	[VU]
	<i>Seminemacheilus dursunavsari</i> Çiçek, 2020	E	[NE]
	<i>Seminemacheilus ekmekciae</i> Yoğurtçuoğlu, Kaya, Geiger & Freyhof, 2020	E*	[NE]
CYPRINIDAE	<i>Capoeta pestai</i> (Pietschmann, 1933)	E	[EN]
	<i>Carassius gibelio</i> (Bloch, 1782)	I	[NE]
	<i>Cyprinus carpio</i> Linnaeus, 1758	N	[VU]
	<i>Garra kemali</i> (Hankó, 1925)	E	[EN]
GOBIONIDAE	<i>Gobio gymnotethus</i> Ladiges, 1960	E*	[DD]
	<i>Gobio hettitorum</i> Ladiges, 1960	E*	[CR]
	<i>Gobio insuyanus</i> Ladiges, 1960	E*	[CR]
	<i>Gobio microlepidotus</i> Battalgil, 1942	E	[VU]
	<i>Pseudorasbora parva</i> (Temminck & Schlegel, 1846)	I	[LC]
LEUCISCIDAE	<i>Alburnus akili</i> Battalgil, 1942	E*	[EX]
	<i>Alburnus escherichii</i> Steindachner, 1897	E-T	[LC]
	<i>Chondrostoma beysehirense</i> Bogutskaya, 1997	E*	[EN]
	<i>Pseudophoxinus anatolicus</i> (Hankó, 1925)	E*	[EN]
	<i>Pseudophoxinus battalgilae</i> Bogutskaya, 1997	E	[NE]
	<i>Pseudophoxinus caralis</i> (Battalgil, 1942)	E*	[NE]
	<i>Pseudophoxinus crassus</i> (Ladiges, 1960)	E*	[EN]
	<i>Pseudophoxinus hittitorum</i> Freyhof & Özuluğ, 2010	E*	[EN]
	<i>Pseudophoxinus iconii</i> Küçük, Gülle & Güçlü, 2016	E*	[NE]
	<i>Squalius anatolicus</i> (Bogutskaya, 1997)	E*	[LC]
<i>Squalius cappadocicus</i> Özuluğ & Freyhof, 2011	E*	[CR]	
TINCIDAE	<i>Tinca tinca</i> (Linnaeus, 1758)	N	[LC]
SILURIFORMES			
SILURIDAE	<i>Silurus glanis</i> Linnaeus, 1758	N	[LC]
SALMONIFORMES			
SALMONIDAE	<i>Oncorhynchus mykiss</i> (Walbaum, 1792)	I	[NE]
	<i>Salmo trutta</i> Linnaeus, 1758	N	[LC]
ESOCIFORMES			
ESOCIDAE	<i>Esox lucius</i> Linnaeus, 1758	N	[LC]
GOBIIFORMES			
GOBIIDAE	<i>Knipowitschia caucasica</i> (Berg, 1916)	N-T	[LC]
ATHERINIFORMES			
ATHERINIDAE	<i>Atherina boyeri</i> Risso, 1810	N-T	[LC]
CYPRINODONTIFORMES			
CYPRINODONTIDAE	<i>Anatolichthys anatoliae</i> (Leidenfrost, 1912)	E	[NT]
	<i>Anatolichthys iconii</i> Akşiray, 1948	E*	[NE]
	<i>Paraphanius similis</i> (Akşiray, 1948)	E*	[NE]
POECILIIDAE	<i>Gambusia holbrooki</i> Girard, 1859	I	[LC]
PERCIFORMES			
PERCIDAE	<i>Sander lucioperca</i> (Linnaeus, 1758)	N-T	[LC]

introduced into this basin; however, it may be a new species. Therefore, researchers should systematically examine this species, which is distributed in our inland waters. Since 2012, the field studies have observed a

continuous expansion of the distribution area of the *A. boyeri* species on a yearly basis.

**IUCN conservation status:** Out of the 39 species distributed in the basin, 10 species were not evaluated

[NE]. Of the 31 species that have been assessed, 11 are listed in the low-risk category [LC], and *A. anatoliae* is assessed as near threatened [NT] (IUCN 2023). A total of 16 species (41.0%) are listed as threatened, of which three are vulnerable [VU], five are critically endangered [CR] and eight are endangered [EN]. Furthermore, Küçük (2012) claimed that the introduction of *S. lucioperca* led to the extinction [EX] of *A. akili*.

Determining the IUCN status of endemic species distributed in Türkiye is an important issue for their conservation. Hence, it is necessary to determine the categorisation of the species in the NE category, and even instead of global conservation statuses, the preparation of the Turkish Fish Red Species List should be brought to the agenda. In addition, the IUCN categories proposed for some species do not reflect the truth in our field observations; e.g., based on our observations, the population density of *S. cappadocicus*, which is in the CR category, is high and its distribution area is wider than previous reports.

**Threats:** The Konya endorheic basin is located in a semi-arid climate zone with very low rainfall and hot and dry summers (Inan et al. 2006; Sen & Basaran 2007). Konya Plain is one of the most important regions of Türkiye in terms of agricultural production, constituting 14% of country's agricultural land and having only 3% of the available water resources. As a result, the agricultural water needs in this basin lead to excessive exploitation of surface and ground waters, specifically when there is insufficient rainfall, resulting in overexploitation of the surface and ground waters. During the field studies, we observed rivers with high pollution loads that were devoid of any species. Furthermore, we detected eutrophication in certain aquatic ecosystems as a result of excessive nutrient input.

The presence of alien species has had devastating effects on the biodiversity of this basin. Considering that *A. akili* became extinct shortly after the introduction of *S. lucioperca* into Beyşehir Lake, it can be argued that endemic species are very fragile (Yeğen et al. 2006; Küçük 2012). Hence, determining the effects of exotic species in this basin's ichthyofauna

and developing strategies to reduce their effects by monitoring them due to possible effects are crucial (Çetinkaya 2006; Yılmaz et al. 2011). To protect the unique biodiversity of this basin, it is crucial to propose solutions, and it would be appropriate to establish a facility for both research and breeding purposes to protect endemic fish.

**Taxonomic issues:** An obvious starting point and fundamental step to conserve biodiversity and management strategies is the correct identification and delineation of taxonomic units (populations or species) and their distributions, especially for endemic and native faunal elements. Küçük et al. (2009) identified individuals belonging to the genus *Capoeta* in Beyşehir Lake as a new species of *C. mauricii*, while *C. pestai*, whose type locality is Lake Eğirdir, was reported to be distributed in the Konya endorheic basin. Currently, Çiçek et al. (2021a) treat *C. mauricii* as a junior synonym of *C. pestai*.

A total of 13 species belonging to the genus *Gobio* are distributed in Türkiye, 10 of which are endemic, and three species are locally endemic to the Konya endorheic basin (Çiçek et al. 2018). However, molecular findings revealed that the genetic differences between these species are very low (0.10-0.60%), and they may be synonyms (Geiger et al. 2014; Aksu & Bektaş, 2019). Çiçek et al. (2021a) determined *G. battalgilae* as a junior synonym of *G. microlepidotus* since there were no distinctive morphological differences between the five species found in this basin.

Furthermore, six out of 21 endemic *Pseudophoxinus* species in Türkiye are endemic to this basin, and the taxonomic status of the sympatric species (*P. anatolicus*, *P. hittitorum*, and *P. caralis*) in Beyşehir Lake should be clarified (Çiçek et al. 2018). Indeed, the low genetic distance between *P. anatolicus* and *P. caralis* in the study of Geiger et al. (2014) supports this claim.

The genus *Aphanius* is one of the most taxonomically complex genera in Türkiye (grouped under four genera, *Aphanius*, *Anatolichthys*, *Kosswigichthys*, and *Paraphanius* in recent studies), and it is known that *A. anatoliae*, *A. iconii*, and *P. similis* are distributed in the Konya endorheic basin

(Freyhof & Yoğurtçuoğlu 2020). However, considering the historical records, three subspecies, *A. aphanus venustus* Kosswig & Sözer, 1945 from Insuyu Stream, *A. aphanus aksaranus* Akşiray, 1948 from Sultanhanı, Esmekaya Springs, and *A. aphanus obrukensis* Akşiray, 1948 from an obruk in the south of Tuz Lake (Kosswig & Sözer 1945; Akşiray 1948) were accepted as synonyms of other species (Wildekamp et al. 1999). However, in recent studies, it has been concluded that a large number of species belong to Aphanidae, given the species or subspecies level, and synonymised as valid (Çiçek 2018). It is of great importance to determine whether the same situation is valid for the above three subspecies or not. Moreover, today the water sources where these species are distributed have partially or completely dried up.

Researchers have reported 18 *Salmo* species from Türkiye, with 14 of them having their type locality in Anatolia (Çiçek et al. 2020, 2023). The status of the species of the genus *Salmo* distributed in Türkiye has become chaotic with new species descriptions in recent years. Populations from different regions, which are almost genetically indistinguishable from each other, are defined as new species according to characters such as colour, pattern, and number of spots, etc., which cannot be considered valid (Bardakçı et al. 2006; Turan et al. 2008; Arslan & Bardakçı 2010). The *Salmo* population in the Konya endorheic basin was accepted as *Salmo trutta* until it was defined as a new species due to the very small differences in their body shape, colour, and pattern!

## CONCLUSION

Considering the unique biodiversity of the Konya endorheic basin, it is clear that this basin is a hotspot. However, the species distributed in the basin face significant threats. An action plan should prioritize the protection of endemic species throughout this basin. Species constitute the basis of conservation biology and management activities. For this reason, the accurate identification of species and the determination of their distribution are of great importance. If detailed studies cannot be conducted,

that remains unidentified may be at the risk of extinction. A population with high phenotypic plasticity may identify itself as a new species (Seçer et al. 2022). In this case, conserving a non-existent species may result in a waste of resources, such as species action plans that were prepared for *Alburnus nasreddini* (synonym of *A. escherichii*) and *C. maurici* (synonym of *C. pestai*), which were not valid (Güçlü et al., 2014; Küçük et al., 2014; Bayçelebi et al., 2021; Çiçek et al., 2021b).

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## مقاله کامل

### فون ماهیان حوضه داخلی قونیه: یک ناحیه داغ از نظر تنوع زیستی ماهی در ترکیه

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**چکیده:** حوضه داخلی قونیه مساحت زیادی را اشغال کرده و زیستگاه‌های آبی بسیار مختلفی با تنوع بالایی از ماهیان بومی در آن یافت می‌گردد. در مجموع ۳۹ گونه ماهی که ۲۷ گونه (۶۹/۲ درصد) آن بومی کشور ترکیه و ۱۹ گونه بومی اختصاصی این حوضه هستند، در این حوضه گزارش شده است. براساس طبقه‌بندی IUCN، *Alburnus akili* منقرض شده (EX)، یک گونه کمبود اطلاعات (DD)، ۱۱ گونه کمترین نگرانی (LC)، ۱ گونه نزدیک به تهدید (NT)، ۳ گونه آسیب‌پذیر (VU)، هشت گونه در معرض خطر (EN)، پنج گونه به شدت در معرض خطر (CR) و ۱۰ گونه نیز ارزیابی نشده (NE) هستند. تهدیدات تنوع زیستی در این حوضه متنوع و شدید شامل خشکسالی، تغییر در رژیم رودخانه، تخریب زیستگاه، کوچک شدن و از بین رفتن زیستگاه، حضور گونه‌های مهاجم، صید غیرقانونی و ناآگاهانه و آلودگی آب می‌باشند. اخیراً برخی از تالاب‌های این حوضه به‌طور کامل خشک شده‌اند، در حالی که یکپارچگی اکوسیستم سایر تالاب‌ها سالانه رو به زوال بوده است. ایجاد یک طرح جامع برای پیشبرد وضعیت حوضه و انجام اقدامات حفاظتی از اهمیت بالایی برخوردار است.

**کلمات کلیدی:** دریاچه بیشهر، حوضه دریاچه نمک، غیربومی، بومی.