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First record of the big-scale sand smelt (*Atherina boyeri* Risso, 1810, Pisces: Atherinidae) from Porsuk Dam Lake, Türkiye

by

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Abstract

This study represents a preliminary report on the occurrence of *Atherina boyeri* in the Porsuk Dam Lake, with a total of 420 individuals obtained from local fishermen between May and July 2023. Of these specimens, 34.76% (146 individuals) were males and 65.24% (274 individuals) were females, resulting in a calculated sex ratio (females:males) of 1:0.53. The total length of the sampled fish ranged from 6.06 to 10.84 cm and their weight ranged from 1.34 to 8.60 g. The length–weight relationship (LWR) based on total length was calculated as $W = 0.00001003\ L^{2.9359}$ for the female population, $W = 0.00000525\ L^{3.0665}$ for the male population, and $W = 0.00000474\ L^{3.0975}$ for the entire population. The exponential value of the total length to weight ratio, denoted as 'b', was determined as 3.0975, indicating isometric growth for the species. The mean value of the condition factor for females, males, and all individuals of *A. boyeri* was determined as 0.755 ± 0.085, 0.710 ± 0.076, and 0.740 ± 0.084, respectively. This study not only provides preliminary and valuable data on the presence of *A. boyeri* in the Porsuk Dam Lake, but also offers a significant perspective on the biodiversity of the new habitat. The findings of the study are considered to be applicable to local fisheries management authorities and decision-makers to ensure the sustainability of fishery resources and the implementation of appropriate fisheries management strategies.

Key words: *Atherina boyeri*; big-scale sand smelt; first record; Porsuk Dam Lake

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1. Introduction

The big-scale sand smelt fish, known by its scientific name *Atherina boyeri* Risso, 1810, is a small fish species naturally found in the Mediterranean and surrounding seas (Fricke et al. 2007; Vasil'eva 2017). This fish shows a wide geographical distribution, including the northeastern Atlantic, the Mediterranean Sea, the Aegean Sea, the Marmara Sea, and the Black Sea (Quignard & Pras 1986; Fricke et al. 2007). Its body is compressed at the sides and has a silver coloration (Coad 2015). One of its characteristic features is a prominent 'lateral line' – a bright stripe extending along the sides. This bright stripe enhances the aesthetic appearance of the fish and facilitates its identification (Fernandez-Delgado et al. 1988). *A. boyeri* demonstrates tolerance to a wide range of salinities, which allows it to occur in both saltwater and freshwater habitats (Freyhof & Kottelat 2008). Individuals of this species inhabit various environments, ranging from coastal estuarine waters to coastal marine areas and even freshwater lakes and estuaries (Patimar et al. 2009). This adaptability makes it a versatile fish species capable of thriving in a variety of ecosystems (Ramos-Merchante & Prenda 2018).

A. boyeri is a pelagic species, feeding on small crustaceans, worms, mollusks, and fry in lakes and freshwater ecosystems, making it an essential link in the food chain and a significant source of food for other organisms in the ecosystem (Chrisafi et al. 2007; Froese & Pauly 2022; Kale et al. 2022). Its presence in freshwater sources is of crucial importance to scientific researchers and water resource managers (Baron et al. 2022). The impact of *A. boyeri* on aquatic ecosystems, population dynamics, and ecology is of great importance for the sustainable management of water resources and biodiversity. *A. boyeri* is an intriguing fish species with beautiful, bright colors and a wide geographical distribution, which adds to its ecological importance (Gore Miller 2015). Its significant role in marine ecosystems and freshwater habitats underlines the ecological importance of this fish (Caliani et al. 2019).

A. boyeri has entered Turkish inland waters through illegal channels (Tarkan et al. 2014; Cilbiz & Uysal 2023). The presence of *A. boyeri* has been previously reported in numerous freshwater habitats in Türkiye (Kırankaya et al. 2014; Saç et al. 2015; Gençoğlu & Ekmekçi 2016; Partal et al. 2019; Gençoğlu et al. 2020; Ağdamar et al. 2021; Kale et al. 2022a, 2022b; Şimşek 2022; Cilbiz & Uysal 2023; Benzer & Benzer 2023).

According to the IUCN Red List of Threatened Species, the conservation status of *A. boyeri* is defined as Least Concern (LC), meaning that it is not currently considered to be at significant risk of extinction (Freyhof & Kottelat 2008).

A. boyeri, previously exported fresh to foreign markets, is currently in demand by European Union countries as a frozen product (Çolakoğlu et al. 2006). According to the data from the Turkish Statistical Institute, 6796 tonnes of big-scale sand smelt were caught in 2022 (Turkstat 2023), and most of this catch is destined for export, as the fish is not used as human food in Türkiye (İlhan & İlhan 2018).

Patimar et al. (2009) emphasized that the prolonged breeding period of *A. boyeri* is a species-specific characteristic and should be considered as an indication of increased reproductive effort. Consequently, the species may pose a potential risk to inland waters, necessitating continuous monitoring. Given the establishment of fishing cooperatives with the purpose of exporting this fish from the Porsuk Dam Lake and the lack of studies on its presence in this location, it is considered crucial to conduct research to monitor the species. This will enable fisheries-related authorities to make informed decisions for the future.

2. Materials and methods

The Porsuk Dam Lake is situated between the coordinates of 39°38'07"N and 30°16'45"E, within the boundaries of Eskişehir and Kütahya provinces in Türkiye. The altitude of the region is approximately 850 m above sea level. The construction of the dam was tendered in 1943 and completed in 1949. It was raised in 1972 to increase its flood capacity. The dam is located in Eskişehir, while the Porsuk Dam Lake lies within the borders of Kütahya. The lake is an important source of freshwater in the area and plays a crucial role in irrigating the surrounding agricultural fields. In addition, the dam is used to generate electricity and serves as an important source of water for nearby villages and the city of Eskişehir (Fig. 1; Karakaya 2003).

Samples of big-scale sand smelt were collected monthly from May 2023 to July 2023 using a type of fyke net with a mesh size of 11 mm and a length of 100 m from local fishermen at the Porsuk Dam Lake. In this scientific study focused on fish specimens, a series of baseline measurements were meticulously recorded. These measurements included total length (TL), fork length (FL), and standard length (SL) of the fish, all meticulously measured to the nearest 0.1 mm. Furthermore, the total body weight (W) of each individual fish was meticulously gauged, ensuring an accuracy of up to 0.01 g. Employing a macroscopic approach to identification, the sex of the samples was

Figure 1

Study area of Porsuk Dam Lake.

determined. One of the main points of this research was to analyze the correlation between the length and weight of the fish. This relationship was expressed using the mathematical expression:

$$W = a\ TL^b,$$

where *W* signifies the total weight, *TL* denotes the total length, *a* represents the intercept of the regression line, and *b* denotes the regression coefficient (Ricker 1973). The level of association between variables was evaluated using the coefficient of determination (r^2). To identify potential outliers in the data, a check was performed assessing whether the coefficient fell below 0.95, following the approach outlined by Barnett and Lewis (1994). It is worth noting that this formula was not only applied across the entire spectrum of fish samples, but was also performed separately for each sex. Comprehensive computations and data analyses were effectively conducted using Microsoft Excel, which facilitated the efficient processing and interpretation of the amassed data.

The correlation between *TL* and *W* can be further conveyed through the employment of the condition factor index, a metric characterizing the overall health of a population (Sparre & Venema 1992). Fulton's condition factor (*CF*) was determined for all specimens used in the current investigation, following the formula:

$$CF = 100\ (W / TL^3)$$ (Sparre & Venema 1992).

3. Results

During the study, it was determined that out of the examined 420 specimens of big-scale sand smelt (*Atherina boyeri*), 34.76% (146 specimens) were male individuals, while 65.24% (274 specimens) were female individuals. The sex ratio (females:males) in the population was calculated as 1:0.53. This study presents the first record of *A. boyeri* in the Porsuk Dam Lake in Kütahya, Türkiye (Fig. 2).

The fish ranged in length from 6.06 to 10.84 cm (*TL*) and weight from 1.34 and 8.60 g, with mean length and weight values, along with corresponding standard error values, calculated as 8.96 ± 0.73 cm and 5.43 ± 1.33 g, respectively.

The length–weight relationship (*LWR*) was calculated for female, male, and all individuals of *A. boyeri* from the Porsuk Dam Lake based on *TL*, *SL*, and *FL* (Table 1, Fig. 3). *LWR* for female, male, and all individuals of *A. boyeri* was determined as $W = 0.00001003TL^{2.9359}$, $W = 0.00000525TL^{3.0665}$, and $W = 0.00000474TL^{3.0975}$, respectively. The exponential value *b* of *LWR* was calculated as 2.9359 ($r^2 = 0.989$), 3.0665 ($r^2 = 0.985$) and 3.0975 ($r^2 = 0.985$) for females, males and all individuals, respectively (Table 1, Fig. 3). This indicates that all *A. boyeri* individuals exhibited an isometric growth. The equation obtained by calculating the *LWR* based on *TL* for individuals from the Porsuk Dam Lake was used, and the actual length–weight values and standard error values of 420 individuals are presented in Fig. 4.

Figure 2

A. boyeri sample from Porsuk Dam Lake.

For all specimens collected from the Porsuk Dam Lake between May and July 2023, using total length (*TL*) as a measure, Fulton's condition factor (*CF*) value ranged from 0.455 to 1.149, with a calculated mean value of 0.740 ± 0.084.

4. Discussion

The Porsuk Dam Lake has the potential to provide new habitats for fish and other aquatic species. Therefore, identifying the recent population dynamics of the species in the region is crucial for the effective implementation of fisheries management strategies and ensuring the sustainability of fisheries resources. This study presents the first scientific data on the distribution and biology of *A. boyeri*, a species previously not recorded in the Porsuk Dam Lake.

The slope (*b*) value of the length–weight relationship (*LWR*) based on *TL* for *A. boyeri* individuals in the Porsuk Dam Lake was determined as 3.0975. The b value obtained in this study is lower than those reported by Kırankaya et al. (2014), Lorenzoni et al. (2016), Gençoğlu & Ekmekçi (2016), Boudinar et al. (2016), and Partal et al. (2019), whereas it is higher than values reported by Benzer (2020), Patimar et al. (2009), Benzer & Benzer (2017, 2019, 2023) (Table 2).

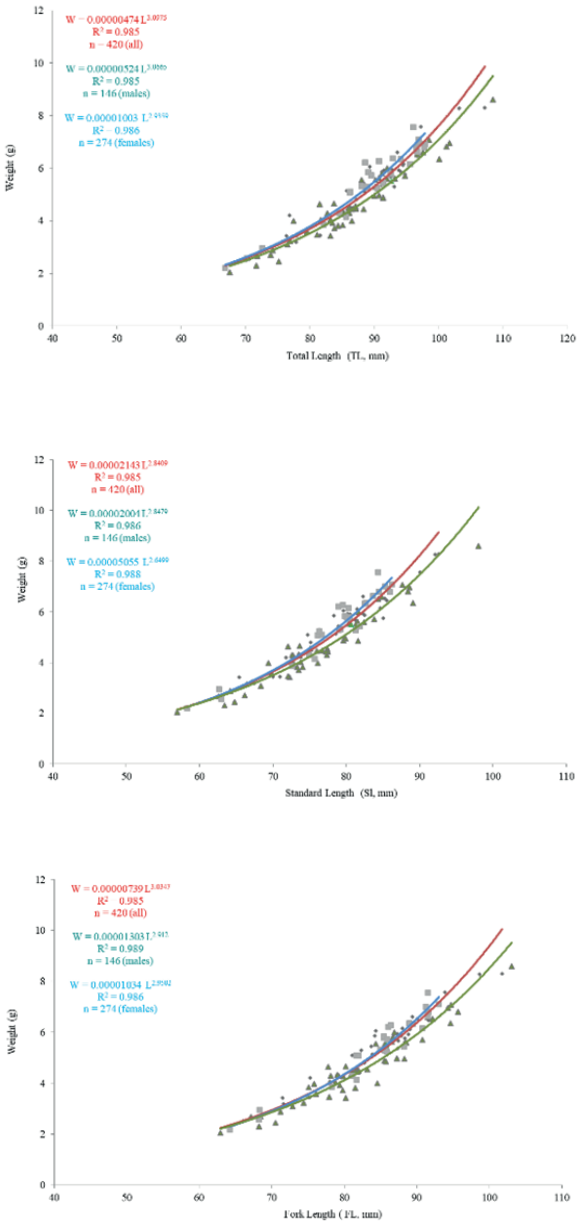

Figure 3

Relationship of length (TL/SL/FL) to weight for females, males, and females + males of *A. boyeri* from Porsuk Dam Lake.

Table 1

LWR parameters for females, males, and females + males of *A. boyeri* from the Porsuk Dam Lake.

Sex (No. of ind.)	*TL*		*SL*		*FL*	
	LWRs equations	r^2	LWRs equations	r^2	LWRs equations	r^2
Females (274)	$W = 0.00001003\ L^{2.9359}$	0.989	$W = 0.00005055\ L^{2.6499}$	0.988	$W = 0.00001303\ L^{2.9120}$	0.989
Males (146)	$W = 0.00000525\ L^{3.0665}$	0.985	$W = 0.00002004\ L^{2.8479}$	0.986	$W = 0.00001034\ L^{2.9502}$	0.986
Females + Males (420)	$W = 0.00000474\ L^{3.0975}$	0.985	$W = 0.00002143\ L^{2.8409}$	0.985	$W = 0.00000739\ L^{3.0347}$	0.985

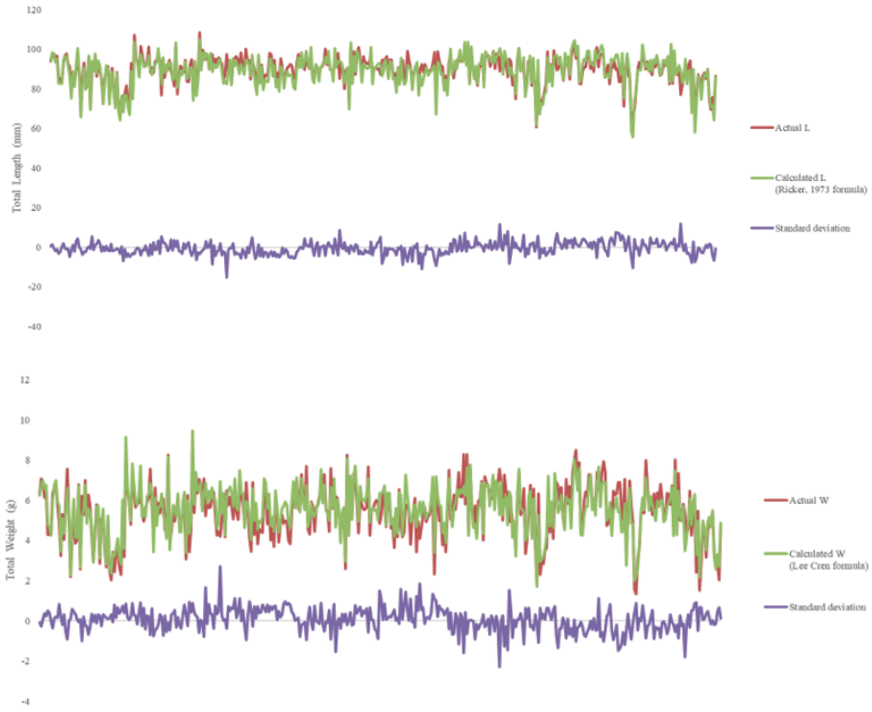

Figure 4

Actual and calculated *TL* and *W* values for *A. boyeri* from Porsuk Dam Lake.

Table 2

LWR variation in *A. boyeri* across different geographical locations.

Study area	*n*	*a*	*b*	r^2	*GT*	Ref.
Gomishan Wetland	2256	$5.3 \times 10^{-3*}$ $5.0 \times 10^{-3*}$	3.06^{m} 3.0630^{f}	-	A+	Patimar et al. (2009)
Hirfanlı Reservoir	323	–2.4023	3.2376	0,97	A+	Kırankaya et al. (2014)
Trasimeno Lake	3998	–2.326 –2.366	3.139^{m} 3.168^{f}	0.956 0.968	A+ A+	Lorenzoni et al. (2015)
Hirfanlı Dam Lake	674	3×10^{-6}*	3.16	-	A+	Gençoğlu & Ekmekçi (2016)
Mellah Lagoon	1402	4.6×10^{-3}	3.179	0.944	A+	Boudinar et al. (2016)
Hirfanlı Dam Lake	1449	$1.3 \times 10^{-2*}$ $1.7 \times 10^{-2*}$ $1.39 \times 10^{-2*}$	2.77^{m} 2.62^{f} 2.74	0.971 0.977 0.973	A– A– A–	Benzer & Benzer (2017)
Bayramiç Reservoir	98	0.0044	3.2556	0.989	A+	Partal et al. (2019)
Süreyyabey Dam Lake	394	1.2×10^{-3} 6.7×10^{-3} 6.4×10^{-3}	2.67^{m} 2.95^{f} 3.00	0.983 0.969 0.970	A– A– I	Benzer & Benzer (2019)
Yamula Dam Lake	594 516	9.7×10^{-3} 10.7×10^{-2}	2.8690 2.8169	0.950 0.934	A– A– Allometric	Benzer (2020)
Reyhanlı Dam Lake	103	0.004	3.091	0.613	I	Şimşek (2022)
Atikhisar Reservoir	353 618 1103	0.00001* 0.0002* 0.0002*	2.886^{m} 2.173^{f} 2.921	0.94 0.79 0.80	A– A– A–	Kale et al. (2023)
Lake İznik	635	$1.570 \times 10^{-5*}$ $1.437 \times 10^{-5*}$ $1.328 \times 10^{-5*}$	2.8266^{m} 2.8602^{f} 2.8717	0.942 0.947 0.941	A– A– A–	Benzer & Benzer (2023)
Posuk Dam Lake	420	$1.003 \times 10^{-5*}$ $0.525 \times 10^{-5*}$ $0.474 \times 10^{-5*}$	3.0665^{m} 2.9359^{f} 3.0975	0.989 0.985 0.985	I A– I	This study

n – number; *a* – regression intercept; *b* – regression slope; r^2 – coefficient of determination; *SEb* – standard error of *b*; *GT* – shape of growth; *I* – isometric; *A* – allometric; *m* – male; *f* – female; * – mm

The *b* value below 3 indicates insufficiently favorable environmental conditions and inadequate total growth for the fish (Kuriakose, 2017). This suggests that the environmental conditions for *A. boyeri* individuals in the Porsuk Dam Lake are favorable.

The condition factor value based on *TL* for *A. boyeri* individuals in the Porsuk Dam Lake was determined as 0.740. Although there is limited research on the condition factor for *A. boyeri* in the literature, Çetinkaya et al. (2011) reported similar condition factors for *A. boyeri* in Lake İznik (0.780 for males and 0.822 for females), Kırankaya et al. (2014) reported values for the Hirfanlı Reservoir (0.621 for all individuals), Şimşek (2022) reported values for the Reyhanlı Dam Lake (1.106 for all individuals), Kale et al. (2023) reported similar condition factors for the Atikhisar Reservoir (0.614 for all individuals), and Benzer and Benzer (2023) reported similar condition factors for *A. boyeri* in Lake İznik (0.730 for males, 0.510 for females, and 0.640 for all individuals).

Intensive amateur and commercial fishing activities are conducted by the public in the Porsuk Dam Lake; among the target species of this intense catch are stressed species such as *Silurus glanis* (Başkurt 2012), *Rutilus rutilus* (Başkurt 2012), *Carassius gibelio* (Altınmeşe 2011), and *Cyprinus carpio* (Özden 2008). The Sofça Fishery Cooperative in Kütahya Province exports a significant portion of this species caught in various habitats of Anatolia. In this context, *A. boyeri* could potentially become a new economic target species for regional fisheries. However, being an invasive fish, *A. boyeri* may cause changes in the presence of other species in the Porsuk Dam Lake.

5. Conclusion

This article covers the preliminary documentation for *A. boyeri* in the Porsuk Dam Lake, located in Kütahya, Türkiye, and constitutes a noteworthy contribution to the scientific literature. The Porsuk Dam Lake turns out to be not only a new distribution area for *A. boyeri*, but also for various other aquatic species. In this context, the study not only identifies the spatial distribution of *A. boyeri*, but also provides significant insights into the overall biodiversity of the Dam Lake. In order to better understand the ecosystem and biological diversity of the Porsuk Dam Lake, future studies should be meticulously carried out to establish the population dynamics in the lake.

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