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First record of economically important big-scale sand smelt (*Atherina boyeri* Risso, 1810, Pisces: Atherinidae) with some biological parameters from Reyhanlı Dam Lake, Türkiye

by

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Abstract

This paper is the first report on the occurrence of *Atherina boyeri* in this region. A total of 103 individuals of *A. boyeri* were caught with fyke-nets (mesh size: 5 mm, polyamide) in May and June 2022. The length and weight of the sampled fish ranged from 6.52 to 8.57 cm and 1.44 to 3.46 g, respectively. The exponent b of length/weight ratio was calculated as 3.091 indicating that species presented an isometric growth. The mean value of the relative condition factor K_n was calculated as 1.106 ± 0.011. In conclusion, this study provides the first and valuable information about the spatial distribution of *A. boyeri* and the biodiversity of the new habitat of Reyhanlı Dam Lake. Within the scope of the traceability of a newly formed ecosystem, it would be beneficial to more extensively investigate this species in terms of the food web, population dynamics, etc. Therefore, more studies should be carried out to determine the aquatic biodiversity and population dynamics of the fishery resources in the lake. The results of this study should be considered by local fishery management authorities and decision-makers to ensure the sustainability of fishery resources and to implement appropriate fishery management approaches.

Key words: big-scale sand smelt, biological introduction, Hatay, north-eastern Mediterranean, Türkiye

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1. Introduction

Atherina boyeri (Risso, 1810) is native to a wide range of marine environments, from the north-east Atlantic to the Mediterranean Sea, including the Aegean Sea, the Marmara Sea and the Black Sea (Kottelat & Freyhof 2007; Antonucci et al. 2012). *A. boyeri* is tolerant of a wide range of salinities which expand their habitats to different environments from coastal estuarine waters to freshwater habitats (Freyhof & Kottelat, 2008). The presence of *A. boyeri* in several freshwater environments in Türkiye has been reported previously (Kırankaya et al. 2014; Saç et al. 2015; Apaydın Yağcı et al. 2015; Gençoğlu & Ekmekçi 2016; Ünlü et al. 2017; Partal et al. 2019; Ağdamar et al. 2021; Kale et al. 2022).

A. boyeri is a pelagic, carnivorous species that mainly feeds on small crustaceans, worms, molluscs and fish larvae in lakes (Vizzini & Mazzola 2005; Özesen Çolak 2013; Froese & Pauly 2022; Kale et al. 2022). They were categorised under 'Least Concern' on the IUCN Red List of Threatened Species (Freyhof & Kottelat 2008). Even though *A. boyeri* is identified as a non-invasive species, it has been reported in previous studies that the species very quickly becomes dominant in lake systems (Küçük et al. 2009; Gençoğlu & Ekmekçi 2016).

A. boyeri is also an economically important species in Turkish inland waters, and it is caught in many lakes, such as İznik Lake. Even though the domestic consumption of this species is negligible (Ofluoğlu et al. 2021), it is exported to many countries – mainly Greece, Lebanon and Syria (AEA 2022). While this export is provided from the Marmara Region of Türkiye, it has been distributed throughout the country in recent years, due to the established population of *A. boyeri* in different freshwater sources in Türkiye.

A. boyeri has translocated species and has been sighted in many dam lakes in Türkiye (Altındağ & Ahiska 2006; Gaygusuz et al. 2006; Tarkan et al. 2007; Becer-Ozvarol & Karabacak 2011; Ünlü et al. 2017; Kale et al. 2022), though until now there had not been a confirmed record for any fish species in Reyhanlı Dam Lake. Therefore, the present study aimed to present a new distribution area of *A. boyeri* along with some biological and fishery parameters from Reyhanlı Dam Lake.

2. Materials and methods

Reyhanlı Dam Lake (Hatay, Türkiye) was established in 2020 for agricultural irrigation. The dam was filled artificially with the overflowing waters of the Afrin and Karasu Streams, located in the Asi River Basin (Figure 1).

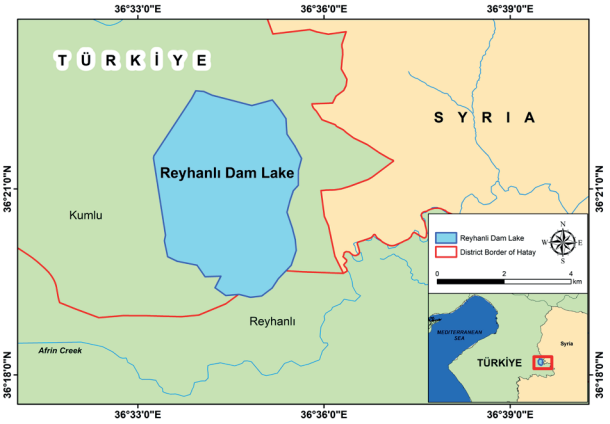

Figure 1
Map of the study area

The total height of the dam is 29 m, and the volume is 21 million m^3. Although it was constructed to provide sufficient water for agricultural irrigation, it also creates new habitats for many aquatic animals.

In the study, the temperature (°C) and dissolved oxygen (DO; mg l^{-1}) were measured with a YSI 50 oxygen meter, and the conductivity (µS cm^{-1}) was measured with YSI 30 probes. The temperature, dissolved oxygen concentration and conductivity were recorded as 23.9°C, 8.5 mg l^{-1} and 152 µS cm^{-1}, respectively.

A. boyeri specimens were identified according to Turan et al. (2007). Samples were collected between May and June 2022 with fyke-nets (mesh size: 5 mm, polyamide) with a domain of 20 × 50 m^2. These fyke-nets were double sets with a single entry, intermediate set-net, 5 circles and 3 partitions. The total length was approximately 10 m. The entrance height of the net was 80 cm. The total length (TL) was measured to the nearest 1.0 mm and the total wet basis weight (W) was measured to the nearest 0.01 g.

The length/weight relation of *A. boyeri* was calculated with Equation (1) according to Ricker (1975). The parameters of the equation $W = aL^b$ were estimated on log-transformed data:

$$logW = loga + b \times logTL$$

where *W* is the weight, *TL* is the total length and *a* and *b* are constants.

$$W = aL^b \quad (1)$$

In addition, the relative condition factor K_n was calculated using Equation (2), proposed by Le Cren (1951):

$$K_n = \frac{W}{aL^b} \quad (2)$$

where K_n is the relative condition factor, a is the intercept, b is the slope derived from the LWR estimation, W is the total weight (g) and L is the total length (cm).

In this study, the catch per unit (CPU) per fyke-net was calculated. Biomass (B) was estimated using Equation (3). For this, the total area of the dam lake was taken as the basis.

$$B = \frac{\overline{C_w / a}}{X_1} \quad (3)$$

where C_w is the product caught at time t, a is the scanned area at time t and X_1 is the catch coefficient of a fyke-net (this value was set at 1) (Bingel, 2002).

Moreover, raw data on the catch and export of *A. boyeri* were obtained from the Ministry of Agriculture and Forestry and the Aegean Exporters' Association. These data were evaluated in order to understand the domestic consumption of *A. boyeri.* All calculations were made with Microsoft Excel.

3. Results

This study reports the first record of *A. boyeri* in Reyhanlı Dam Lake in Hatay, Türkiye (Figure 2). A total of 103 specimens of *A. boyeri* were collected from Reyhanlı Dam Lake and evaluated. The fish length ranged from 6.52 to 8.57 cm (TL) and the fish weight ranged between 1.44 and 3.46 g. The mean length and mean weight with standard error values were calculated as 7.71 ± 0.03 cm and 2.25 ± 0.03 g, respectively (Figure 3).

Figure 2

A. boyeri from Reyhanlı Dam Lake (Hatay, Turkiye)

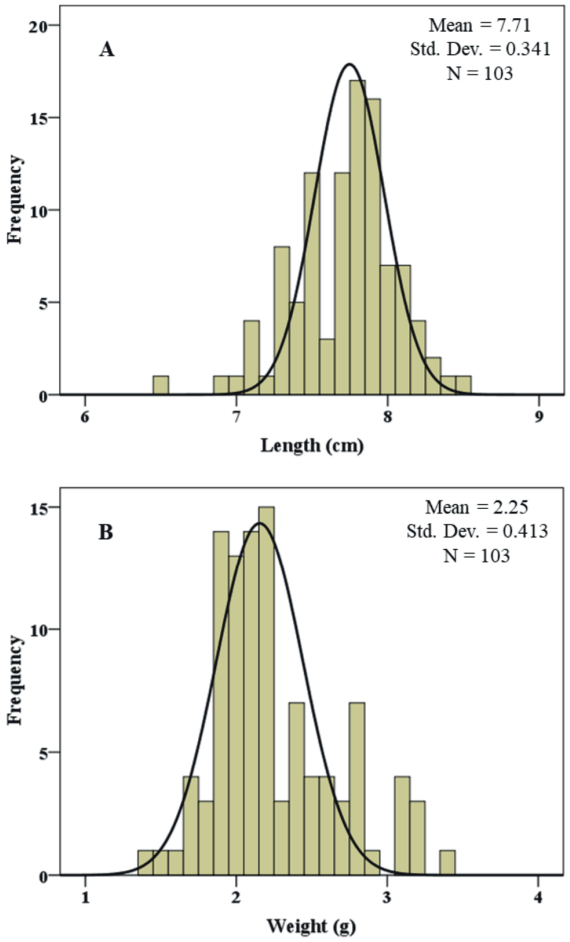

Figure 3

Frequency of the lengths (A) and weights (B) of *A. boyeri* in the sampling period from Reyhanlı Dam Lake, Türkiye

The quantity of catch per fyke-net was used to estimate the possible stock in the lake. The *A. boyeri* biomass in the Reyhanlı Dam was estimated as 1895 kg. However, considering the high variation in the catch yield, the preliminary results presented in this study may be lower than predicted. Even though more detailed research is required in this area, the results of the study show that the stock of *A. boyeri* was abundant in the study area.

The length/weight ratio (LWR) was calculated for the *A. boyeri* from Reyhanlı Dam Lake (Figure 4). The LWR of *A. boyeri* was documented as $W=0.004 \times TL^{3.091}$. The exponent b of the LWR was 3.091 ± 0.244 with 95% confidence limits of 2.308–3.874, meaning that *A. boyeri* presented an isometric growth.

The value of the relative condition factor K_n ranged between 0.743 and 1.293, and the mean value was calculated as 1.106 ± 0.011 (with standard deviations) for all specimens collected from Reyhanlı Dam Lake in May and June 2022.

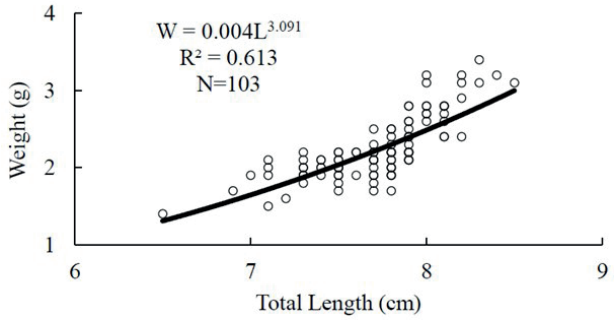

Figure 4

The length/weight ratio of *A. boyeri* collected from Reyhanlı Dam Lake

4. Discussion

Reyhanlı Dam Lake has great potential to provide new habitats for fish and other aquatic species. In order to effectively implement fishery management strategies and to ensure the sustainability of fishery resources, it is important to know which species have recently established a population in this region. There was no previous scientific record of *A. boyeri* in Reyhanlı Dam Lake. Moreover, the findings of the present study represent the first scientific data on the distribution and biology of *A. boyeri* from Reyhanlı Dam Lake.

A. boyeri is highly adaptable and creates large populations (Becer & Bilgin 2018; Kale et al. 2022). In Türkiye, several studies have reported the presence of this species from different freshwater ecosystems, such as Yuvarlakçay (Balık et al. 2005), Eşen Stream (Onaran et al. 2006), Durusu Lake Basin (Özuluğ 2008), Karasu Stream (Birecikligil & Çiçek 2011), Eğirdir Lake (Yerli et al. 2013), Büyükçekmece Reservoir (Saç et al. 2015), Bayramiç Reservoir (Partal et al. 2019), Bakırçay Stream (İlhan et al. 2020), Uluırmak Stream (Kelleci et al. 2021) and Atikhisar Reservoir (Kale et al. 2022).

Even though this species mainly lives in marine environments, the records from freshwater ecosystems have led to debate regarding the distribution of this species in freshwater systems, where its connection with the sea is unknown. Partal et al. (2019) suggested that migratory waterfowl could play a role in the distribution of *A. boyeri* among closed watersheds. Kale et al. (2022) noted that the species has been illegally introduced to various freshwater ecosystems by small-scale fishermen engaged in sport fishing and amateur fisheries. In this study, it is considered that this species is more likely to be artificially transported to Reyhanlı Dam Lake because of its high economic value in export and commercial use. The commercial value of *A. boyeri* has increased significantly in the last decade, considering the amount of exports and domestic consumption (Figure 5).

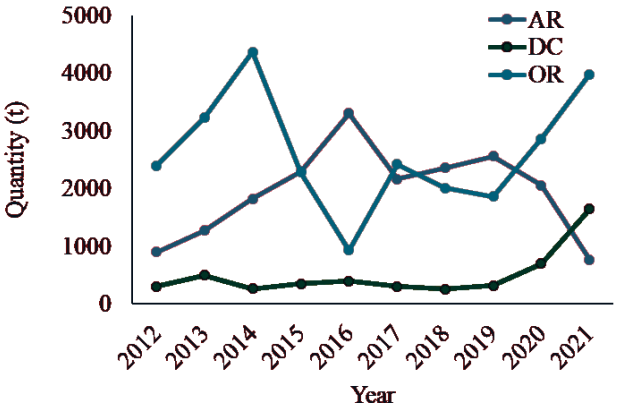

Figure 5

A. boyeri from Reyhanlı Dam Lake (Hatay, Turkiye)

Several studies have investigated the length/weight ratio from different habitats in Türkiye (Table 1). The length distribution obtained in this study was consistent with previous reports.

The slope of the LWR exponent b is a useful tool for describing the growth type of fish stocks. In this study, the growth of *A. boyeri* was assessed as isometric, similar to the previous studies in different regions of Türkiye. Although some studies show the growth of the species as isometric or allometric (Tarkan et al. 2006; Becer & Kılıç 2018; Innal & Engin 2020), it is understood that this invasive species has successfully established a population in many freshwater ecosystems in Türkiye.

The condition factor is an index that presents the relative status between biotic and abiotic elements in the physiological situation of fishes. Le Cren (1951) specified that a value higher than 1 means good habitat conditions for fish, while a value lower than 1 means unsuitable environmental conditions. In this study, the mean condition factor for all sampled individuals of *A. boyeri* was calculated to be higher than l, indicating that Reyhanlı Dam Lake may be a suitable habitat for the species.

In the Asi River basin, intensive amateur and commercial fishing activities are carried out by the public. Target species in this intense catch are stressed species, including *Anguilla anguilla*, *Clarias gariepinus* and Cyprinid species (Demirci & Demirci 2009; Demirci et al. 2020; Şimşek et al. 2022). In this sense, *A. boyeri* may become a new economic target species for regional fisheries. Companies in Hatay Province export a significant proportion of this species, which is caught in different habitats of Anatolia (MAF 2022).

Table 1

Length/weight ratio of *A. boyeri* reported in freshwater ecosystems in Türkiye

Reference	Location	N	Total Length (cm)		Weight (g)		LWR		
			Min	Max	Min	Max	a	b	r^2
Tarkan et al. (2006)	Küçükçekmece Lagoon	15	3.90	11.10	N/A	N/A	0.0035	3.310	0.992
	Ömerli Dam Lake	442	7.70	12.90	N/A	N/A	0.0159	2.660	0.826
Özeren (2009)	Lake İznik	922	0.80	11.50	0.001	11.00	0.0040	3.209	0.978
Bostancı et al. (2014)	Lake Eğirdir	182	5.90	9.50	1.35	5.39	0.000002	3.255	0.983
Kırankaya et al. (2014)	Hirfanlı Reservoir	323	4.10	11.03	N/A	N/A	-2.4023	3.238	0.970
İlhan & Sarı (2015)	Lake Marmara	101	3.70	8.70	0.40	5.40	0.0084	2.908	0.971
Benzer & Benzer (2017)	Hirfanlı Reservoir	1449	2.90	9.50	0.14	6.42	0.0180	2.800	0.973
Becer & Kılıç (2018)	Karacaören-1 Dam Lake	513	0.45	0.85	0.63	4.10	0.0096	2.791	0.872
Benzer & Benzer (2019)	Süreyyabey Dam Lake	394	3.20	9.00	0.23	4.06	0.0064	3.000	0.970
Gençoğlu et al. (2020)	Aslantaş Reservoir	409	2.39	11.54	0.11	9.64	-2.247	3.106	0.978
	Hirfanlı Reservoir	369	3.86	11.32	0.34	10.94	-2.160	3.011	0.917
	Köyceğiz Lagoon	355	2.79	9.70	0.12	6.60	-2.355	3.206	0.953
	Lake İznik	290	2.72	11.57	0.08	9.79	-2.279	3.131	0.966
	Lake Eğirdir	464	3.44	9.55	0.39	6.67	-2.233	3.075	0.941
İnnal & Engin (2020)	Demirköprü Dam Lake	41	3.90	13.60	0.40	16.5	0.0080	2.949	0.990
	Lake Eğirdir	114	3.90	6.60	0.27	1.45	0.0060	2.781	0.830
	Lake Gölmarmara	20	3.80	4.70	0.36	0.64	0.0010	2.580	0.880
Güçlü & Küçük (2021)	Demirköprü Reservoir	101	6.61	10.48	1.84	8.98	0.0029	3.423	0.964
	Lake Marmara	19	5.93	7.44	1.37	2.66	0.0082	3.921	0.777
Ofluoğlu et al. (2021)	Lake Bafa	2204	5.00	10.70	1.00	10.59	0.0082	2.942	0.947
Apaydın Yağcı et al. (2022)	Lake Eğirdir	2098	2.70	10.4	0.12	9.42	0.0048	3.173	0.966
This study (2022)	**Reyhanlı Dam Lake**	**103**	**6.52**	**8.57**	**1.44**	**3.46**	**0.0040**	**3.091**	**0.613**

N – number of samples; L – length (cm); W – weight (g); a – intercept of the ratio; b – slope of the ratio; r^2 – coefficient of correlation

Because *A. boyeri* has been found in Reyhanlı Dam Lake, further research in other nearby water resources is required. The preliminary stock estimation indicates that there is at least 1895 kg of catchable stock in this lake area. It is assumed that realistic stock is much higher than the estimated value. AEA (2022) indicates a consistent export demand and rising domestic consumption of this species (Figure 5). Therefore, the economic value of this species has been increasing within the last decade. In this context, it is understood that the export of *A. boyeri* is about $4/kg, according to the AEA (2022), which is important for the artisanal fisheries of the region. Due to the high economic potential of the species, the foreign exchange inflow through exports attracts attention as a source of employment and income for the local people with a sustainable fishery management approach.

5. Conclusion

This paper presents the first report of *A. boyeri* in Reyhanlı Dam Lake (Hatay, Türkiye) and provides a significant contribution to the literature. Reyhanlı Dam Lake is a new distribution area, not only for *A. boyeri* but also for other aquatic species. Therefore, the study provides significant knowledge on the spatial distribution of *A. boyeri* and the biodiversity of the Dam Lake. More studies should be carried out to determine the population dynamics in the lake.

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