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RESEARCH PAPER

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First Knowledge on Data Poor Stock: LWR and Condition Factor of a Recently Established Population of *Atherina boyeri* in Atikhisar Reservoir, Türkiye

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Abstract

Fisheries management practices require reliable data for the assessment of data poor stocks. This paper reported the first knowledge on length-weight relationship (LWR) and condition factor of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye. A total of 1103 individuals of which 132 were immature was captured in June 2021. The sex ratio male to female was 1:1.75. The relationship between weight (W) and total length (TL), standard length (SL), and fork length (FL) were estimated as $W=9E\text{-}06TL^{2.9212}$, $W=1E\text{-}05SL^{2.9082}$, and $W=9E\text{-}06FL^{2.9495}$. *A. boyeri* exhibited a negative allometric growth. The mean of Fulton's condition factor of *A. boyeri* population in Atikhisar Reservoir was determined as 0.619±0.061. The mean Fulton's condition factor for female individuals were higher than the males' condition factor and the difference between sexes was statistically significant. The present study made available valuable information on the data poor stock by providing LWR and condition factor of *A. boyeri* in Atikhisar Reservoir, a new freshwater system for the very euryhaline amphidromous species. The findings of the present study will substantially contribute to the knowledge of the population dynamics of the commercially important species for fisheries managers and decision-makers to maintain sustainable population levels.

Introduction

Atherinid populations are polymorphic fish that inhabit different temperature and salinity levels of fresh and brackish aquatic environments (Focant et al. 1999; Andreu-Soler et al. 2003). *Atherina boyeri* (Risso, 1810) is distributed along the eastern coasts of the Mediterranean, Black Sea and Atlantic Ocean (Antonucci et al. 2012). Although it has abundant and successful populations in inland waters in Anatolia, it is mainly regarded as a marine species (Gençoğlu and Ekmekçi 2016).

The presence of *A. boyeri*, which is accepted as least concern (LC) category in the IUCN Red List (Freyhof and Kottelat 2008), has been reported in many different aquatic environments (Balık et al. 2005; Onaran et al. 2006; Özuluğ 2008; Birecikligil and Çiçek 2011; Bok et al. 2011; Yerli et al. 2013; Saç et al. 2015; Bostanci and Yedier 2018; Yedier et al. 2019; İlhan et al. 2020; Kelleci et al. 2021; Douligeri et al. 2021). Population parameters (Tarkan et al. 2006; Gaygusuz et al. 2006; Apaydin Yagci et al. 2015) and biometric characteristics (Taskavak et al. 2012) for *A. boyeri* has also been documented. The

distribution of *A. boyeri* in natural and artificial lakes in Türkiye has been reported by many researchers (Altun 1999; Gaygusuz et al. 2006; Küçük et al. 2012; Güçlü et al. 2013; Kırankaya et al. 2014; Saç et al. 2015, 2016; Apaydın Yağcı et al. 2016, 2021; Gençoğlu and Ekmekçi 2016; Ünlü et al. 2017; Benzer 2018, 2020; Çevik et al. 2018; Partal et al. 2019; Benzer and Benzer 2020; Cilbiz et al. 2020; Ağdamar et al. 2021). However, there has been no information about the *A. boyeri* population in Atikhisar Reservoir.

Kale et al. (2022) recently confirmed the occurrence of *A. boyeri* in Atikhisar Reservoir and suggested carrying out further studies to understand the population dynamics of *A. boyeri* in this reservoir. Therefore, the present study aimed to provide the first information on data-poor stock by investigating the length-weight relationships and condition factor of *A. boyeri* in Atikhisar Reservoir.

Materils and Methods

Study Area

Atikhisar Reservoir (Figure 1) has been built on Sarıçay Stream to provide water for drinking purposes (Kale 2019). It is the sole water source supplying water for drinking purposes to communities living in Çanakkale (Kale and Acarlı 2019a). The reservoir also provides water for both agricultural and anthropogenic activities to the nearby area (Kale and Acarlı 2019a; Kale and Acarlı 2019b). Total surface area of the reservoir was ranged between 1.72 km^2 and 3.84km^2 between 1975 and 2017 (Kale and Acarlı 2019a). The normal water level of the reservoir is 61 m and its volume is 40 hm^3 at the normal water level (Kale 2019). The occurrence of several aquatic animals such as *Squalis cii* (Akbulut et al. 2008; Koca 2011; Selvi et al. 2015), *Cyprinus carpio* (Akbulut et al. 2008; Koca 2011), *Anguilla anguilla* (Koca 2011), *Esox lucius* (Selvi and Kaya 2013), *Cobitis taenia* (Akbulut et al. 2008), Gobius niger (Akbulut et al. 2008), *Pontastacus leptodactylus* (Kale et al. 2020, Kale et al. 2021a) *Mauremys rivulata* (Kale et al. 2021b) have been reported. Recently, Kale et al. (2022) declared the first presence of *A. boyeri* in the reservoir.

Sampling

Sampling was carried out during the daytime in June 2021 in Atikhisar Reservoir, Çanakkale, Türkiye (Figure 1). The ground has a muddy substrate in the sampling location. A total of 1103 big-scale sand smelt individuals were sampled using a 1.5 m long and 1 m high beach seine with 10 mm mesh size. Collected fish were kept in 10% formalin solution and brought to the laboratory. A 1 mm scale fish measuring board was used for total, standard and fork length measurements (TL, SL and FL), and a digital scale with a precision of 0.01 g for weights (W). Totally 1103 individuals were measured for TL (female:618, male:353 undetermined: 132) while 1033 individuals were measured for SL and FL (female:616, male:351 undetermined: 66). For sex determination of the species, samples were dissected and sex ratios were determined.

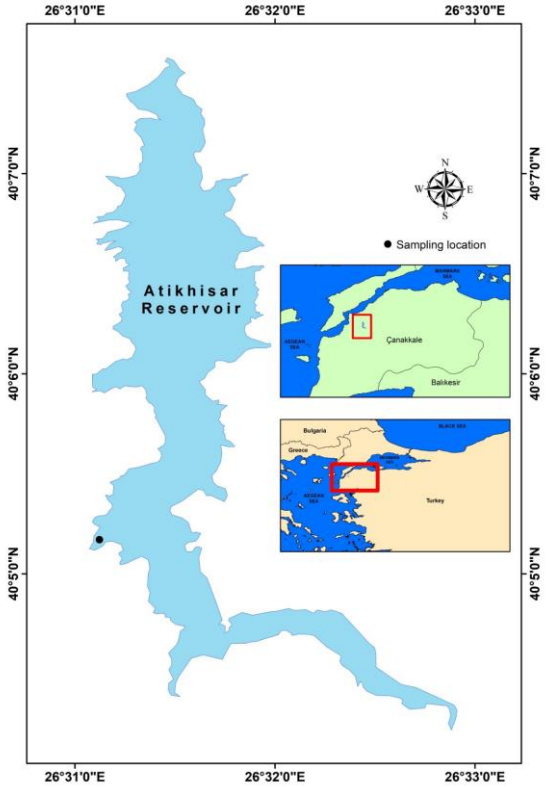

Figure 1. Sampling location of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

Data Analysis

The length-weight relationships (LWRs) were estimated according to the Eq. (1) as suggested by Ricker (1975).

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

where *W* is the weight, *a* is the intercept, *L* is the length type (TL), and *b* is the slope. The coefficient of determination (R^2) was calculated to measure the goodness of fit for the length-weight relationship and for *b* values for all three types of growth pattern: *b* = 3 indicates isometric growth, *b*>3 positive allometric growth, and *b*<3 negative allometric.

Fulton's condition factor (Ricker 1979) was used to determine the condition index for the recently established big-scale sand smelt population (Eq. 2).

$$K = 100\frac{W}{L^3} \quad (2)$$

In this equation, *K* is the condition factor, *W* is the total weight (g), *L* is the total length (mm) for fish species.

The *Chi-square goodness of fit test* (χ^2) was applied to test significance of differences in sex ratio equality (Miller and Siegmund 1982). The *t-test* (STATISTICA 11) was used to determine the statistical difference of total length and condition factor values between the sexes.

Results

A total of 1103 big-scale sand smelt were caught in the study, of which 618 (56.03%) were female, 353 (32%) were male, and 132 (11.97%) were undetermined. In the study, the male/female ratio was calculated as 0.57, and there was no statistical difference (P>0.05) between the expected and observed number of the genders according to the χ2 test.

Sampled individuals ranged between 0.11 g and 5.31 g in W, between 27 and 95 mm in TL, between 26 and 90 mm in FL, and between 24 and 84 mm in SL. The mean total length of big-scale sand smelt individuals distributed in Atikhisar Reservoir was 73.87±9.51 mm for all individuals combined. Statistically significant difference of total length between sexes was evident (t_{cal}=101.089, p=0.000001). Female individuals had a greater mean length, 76.71±3.336 mm.

The total length-frequency distribution of the big-scale sand smelt was provided in Figure 2. While the most frequent length group among all individuals was between 70.0-79.9 mm (73.80%), the least number of individuals was observed between 40.0-49.9 mm (0.36%). The dominant length frequencies for males and females were found to be between 70.0-79.9 mm with a ratio of 73.94% and 79.29%, respectively.

Relationship between total length and weight of female, male and pooled *A. boyeri* in Atikhisar Reservoir was illustrated in Figure 3. LWR parameters were estimated for females as $W=0.0002TL^{2.1735}$ (R^2 = 0.6365), for males $W = 1E\text{-}05TL^{2.8862}$ (R^2 = 0.8796), and for pooled sex $W = 9E\text{-}06TL^{2.9212}$ (R^2 = 0.9683). The relation between total length and weight of males was found stronger than females, however, it was highly stronger when both sexes pooled to estimate the parameters.

The relatively stronger relationships between total length-standard length, total length-fork length, and standard length-fork length for all individuals pooled were estimated as SL=0.8841TL-0.6725 (R^2=0.9707), FL=0.9416TL-0.4531 (R^2= 0.9807), and SL=0.9317FL+0.2592 (R^2=0.9746). Relationships between each length types of *A. boyeri* were shown in Figure 4, Figure 5, and Figure 6.

Relationships between standard length and weight of *A. boyeri* were also presented in Figure 7 and relationship between fork length and weight of *A. boyeri* were presented in Figure 8. LWRs were provided for both sexes and pooled individuals for both standard length and fork length.

As a result of the regression analysis of the calculated *b* value in the total length-weight relationship, it was determined that both sexes, male and female individuals, showed negative allometric growth (2.173±0.690 95% confidence interval (CI) for females; 2.886±0.420 95% CI for males). Allometric

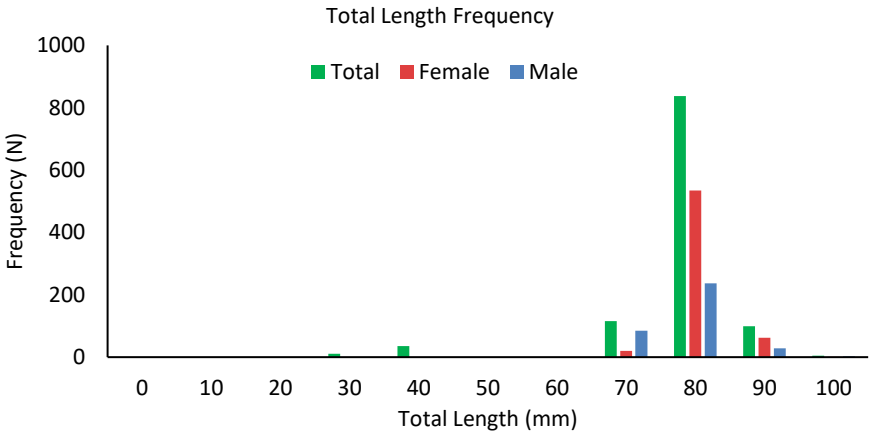

Figure 2. Total length frequency (N) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

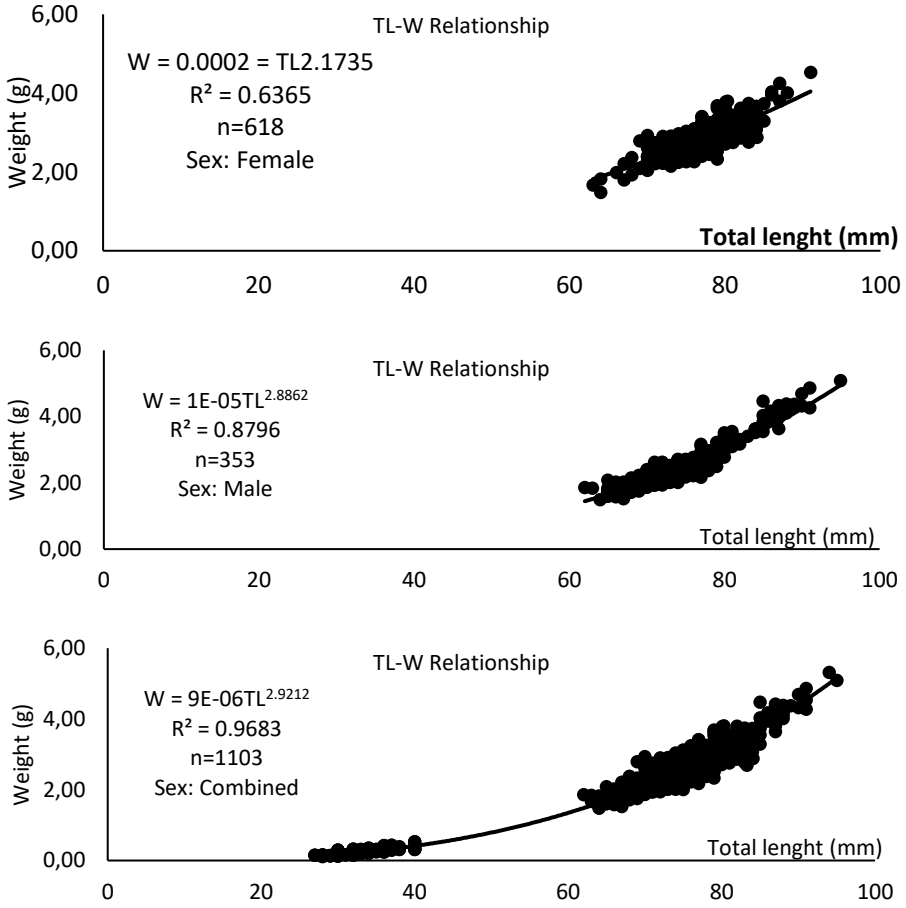

Figure 3. Relationship between total length (mm) and weight (g) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

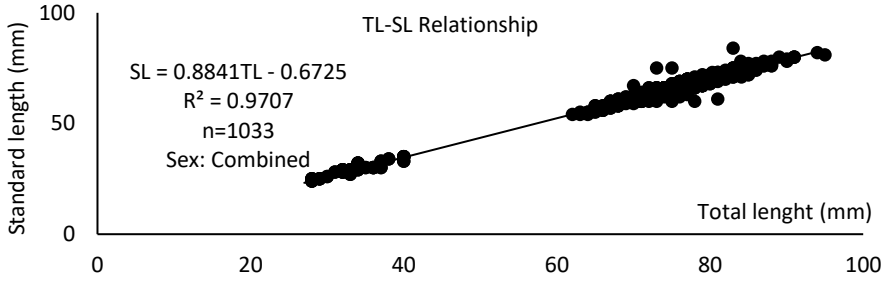

Figure 4. Relationship between total length (mm) and standard length (mm) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

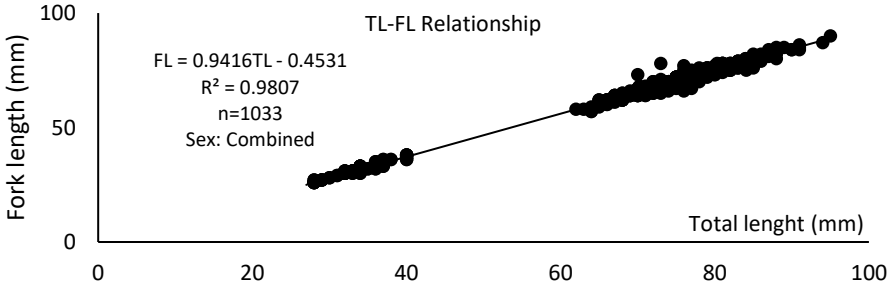

Figure 5. Relationship between total length (mm) and fork length (mm) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

growth models of *A. boyeri* according to the $W=aL^b$ equation were tabulated in Table 1.

It was determined that the total length, fork length, and standard length values in big-scale sand smelt samples increased as the body weight values increased (Table 1). However, although female and male individuals showed negative allometric growth, the growth rate of females in terms of standard length and fork length was noticeably lower compared to male individuals.

Condition values of big-scale sand smelt population in Atikhisar Reservoir are provided for both sexes and for all individuals combined in Table 2. The mean of Fulton's condition factor of big-scale sand smelt population in Atikhisar Reservoir was determined as 0.614±0.061. The mean Fulton's condition factor for female individuals were higher than the males' condition factor and the difference between sexes was statistically significant (t_{cal}=6.511, f-ratio=1.232, P<0.05).

Table 3 provides the regression results of the condition factor values based on total length values for each sex. According to the results of the regression analysis, the relationship between total length and Fulton's condition factor was significantly stronger in female individuals compared to males of the population in Atikhisar Reservoir (t_{cal}=-10.266, P<0.05).

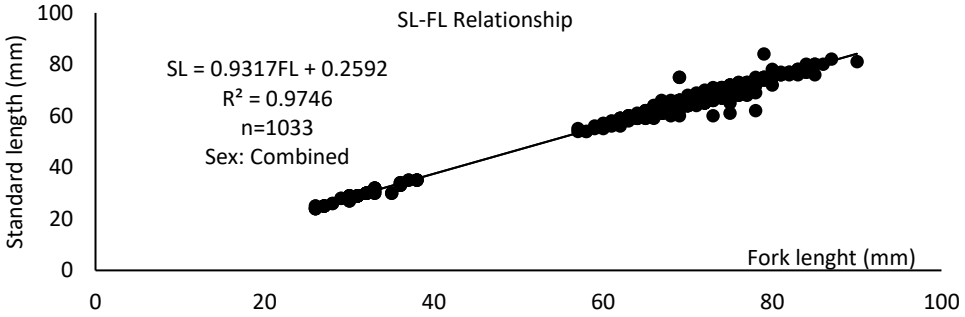

Figure 6. Relationship between fork length (mm) and standard length (mm) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

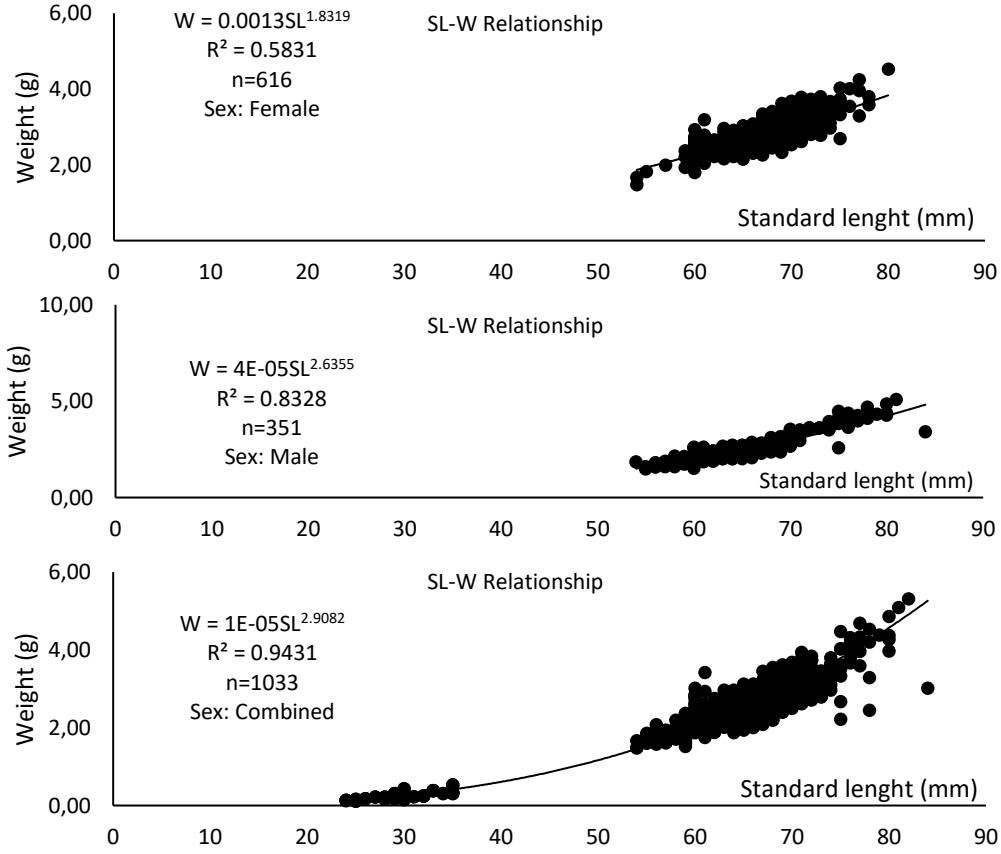

Figure 7. Relationship between standard length (mm) and weight (g) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

Discussion

A. boyeri has been commercially exploited in Türkiye and several Mediterranean countries including Greece, Italy, Spain and Croatia (Lorenzoni et al. 2015). The species hastily adapted to the aquatic environment and create plenty populations in numerous freshwater resources in Türkiye. It has an economic value for the local fishermen. The first introducing time of the big-scale sand smelt to the Atikhisar Reservoir is not known. However, Kale et al. (2022) recently reported the first occurrence of the species in this reservoir. Nevertheless, there is no information on the biology and ecology of this species in the Atikhisar Reservoir. In this study, the first information on length-weight relationship and condition factor of big-scale sand smelt in Atikhisar Reservoir has been reported. Our results provided new data for FishBase (Froese and Pauly 2022), besides for

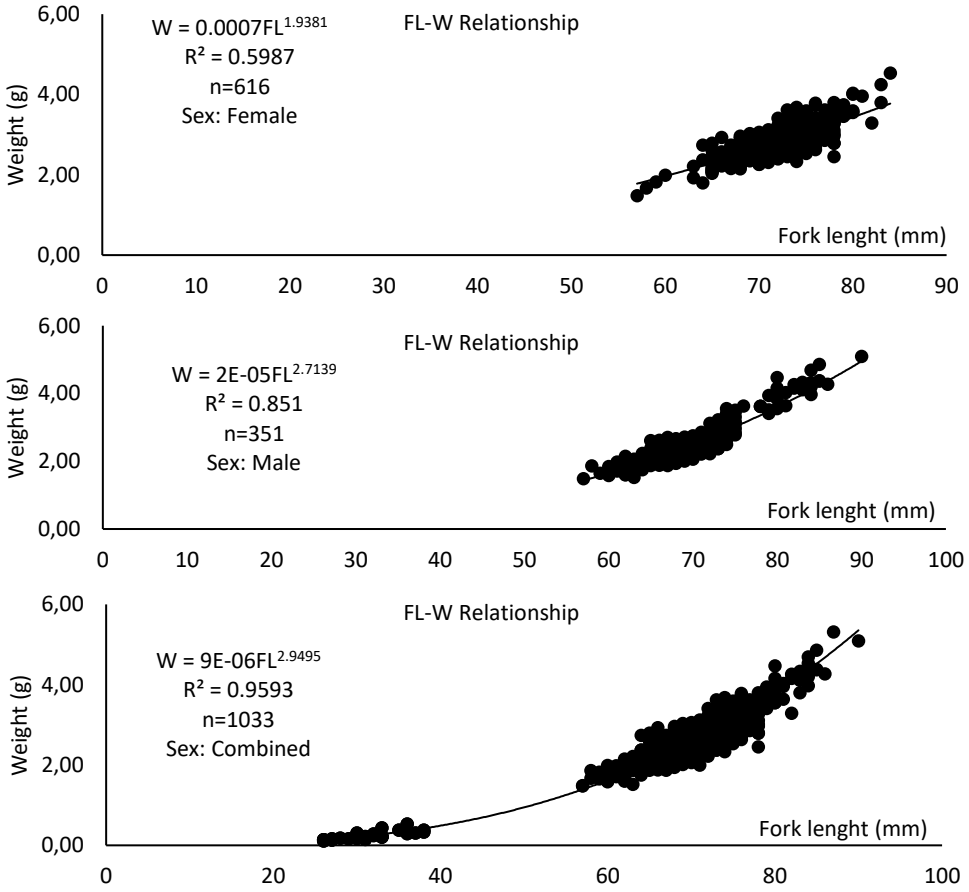

Figure 8. Relationship between fork length (mm) and weight (g) of *Atherina boyeri* in Atikhisar Reservoir, Çanakkale, Türkiye

Table 1. Allometric growth models of *Atherina boyeri* according to the $W=aL^b$ equation

Parameters	*Male*			Female			Combined Sexes		
	a	*b*	*r*	*a*	*b*	*r*	*a*	*b*	*r*
Total Length	0.00001	2.8862	0.94	0.0002	2.1735	0.79	0.0002	2.9212	0.80
Standard Length	0.00004	2.6355	0.91	0.0013	1.8319	0.76	0.00001	2.9082	0.97
Fork Length	0.00002	2.7139	0.92	0.0007	1.9381	0.77	0.00009	2.9495	0.98

Table 2. Fulton's condition factor (*K*) of big-scale sand smelt population in Atikhisar Reservoir (mean ± standard deviation)

Condition Factor	Female	Male	All	P
K	0.619±0.056	0.534 ±0.063	0.614±0.06	P<0.05*

**P<0.05: statistically different*

Table 3. Regression results for Fulton's condition factor (*K*) based on total length of big-scale sand smelt population in Atikhisar Reservoir

	Female	Male	P
TL/*K*	y=-0.0064+1.113 (R^2= 0.146)	y=-0.001+0.670 (R^2= 0.007)	P<0.05*

**P<0.05: statistically different*

Table 4. Comparison of LWR results of previous studies for *A. boyeri* from inland waters in Türkiye

Location	Sex	N	Length (cm)			Weight (g)		Parameters			Reference
			Length Type	*Min*	*Max*	*Min*	*Max*	*a*	*b*	r^2	
Aslantaş Reservoir (Osmaniye)	F+M	409	TL (mm)	23.87	115.35	0.11	9.64	-2.247	3.106	0.978	Gençoğlu et al. (2020)
Bayramiç Reservoir (Çanakkale)	F+M	98	TL (cm)	2.4	8.2	0.06	4.31	0.0044	3.2556	0.9888	Partal et al. (2019)
Demirköprü Dam Lake (Manisa)	F+M	41	TL (cm)	3.9	13.6	0.4	16.5	0.008	2.949	0.99	İnnal and Engin (2020)
Hirfanlı Reservoir (Kırşehir)	F+M	323	TL (mm)	40.98	110.25	*N/A*	*N/A*	-2.4023	3.2376	0.97	Kırankaya et al. (2014)
Hirfanlı Reservoir (Kırşehir)	F	288	TL (mm)	34.29	115.65	0.23	10.48	0.000002	3.2929	0.9763	Gençoğlu and Ekmekçi (2016)
Hirfanlı Reservoir (Kırşehir)	M	269	TL (mm)	29.20	88.92	0.12	5.42	0.000002	3.2313	0.9783	Gençoğlu and Ekmekçi (2016)
Hirfanlı Reservoir (Kırşehir)	*N/A*	64	TL (mm)	5.76	35.53	0.01	0.42	0.000002	3.5001	0.9726	Gençoğlu and Ekmekçi (2016)
Hirfanlı Reservoir (Kırşehir)	F+M	674	TL (mm)	5.76	115.65	0.01	10.48	0.000003	3.16	*N/A*	Gençoğlu and Ekmekçi (2016)
Hirfanlı Reservoir (Kırşehir)	F	504	TL (mm)	*N/A*	*N/A*	*N/A*	*N/A*	0.01747655	2.6245	0.977	Benzer and Benzer (2017)
Hirfanlı Reservoir (Kırşehir)	M	945	TL (mm)	*N/A*	*N/A*	*N/A*	*N/A*	0.013006145	2.7723	0.971	Benzer and Benzer (2017)
Hirfanlı Reservoir (Kırşehir)	F+M	1449	TL (mm)	29.0	95.0	0.14	6.42	0.01399306	2.7385	0.973	Benzer and Benzer (2017)
Hirfanlı Reservoir (Kırşehir)	F+M	35	TL (cm)	6.5	8.6	1.53	4.13	*N/A*	*N/A*	*N/A*	Benzer (2019)
Hirfanlı Reservoir (Kırşehir)	F+M	369	TL (mm)	38.64	113.20	0.34	10.94	-2.160	3.011	0.917	Gençoğlu et al. (2020)
Homa Lagoon (İzmir)	F+M	103	TL (cm)	3.4	10.6	0.29	8.40	0.0070	2.963	0.999	Acarlı et al. (2014)
Karacaören-1 Dam Lake (Burdur)	F	229	TL (mm)	4.8	8.5	0.7	4.1	0.0099	2.7746	0.8997	Becer and Kılıç (2018)
Karacaören-1 Dam Lake (Burdur)	M	284	TL (mm)	4.5	6.9	0.633	2.282	0.0097	2.7826	0.827	Becer and Kılıç (2018)
Karacaören-1 Dam Lake (Burdur)	F+M	513	TL (mm)	4.5	8.5	0.63	4.10	0.0096	2.7912	0.8722	Becer and Kılıç (2018)
Köyceğiz Lagoon (Muğla)	F+M	355	TL (mm)	27.93	97.03	0.12	6.60	-2.355	3.206	0.953	Gençoğlu et al. (2020)
Küçükçekmece Lagoon (İstanbul)	F+M	15	TL (cm)	3.9	11.1	*N/A*	*N/A*	0.0035	3.31	0.992	Tarkan et al. (2006)
Lake Bafa (Muğla)	F+M	2204	TL (cm)	5.0	10.7	1.00	10.59	0.0082	2.9418	0.8962	Ofluoğlu et al. (2021)
Lake Eğirdir (Isparta)	F+M	12041	FL (cm)	1.6	9.8	0.15	9.42	0.0059	3.2015	0.9597	Apaydin Yagci et al. (2015)
Lake Eğirdir (Isparta)	F+M	464	TL (mm)	34.43	95.45	0.39	6.67	-2.233	3.075	0.941	Gençoğlu et al. (2020)
Lake Eğirdir (Isparta)	F+M	114	TL (cm)	3.9	6.6	0.27	1.45	0.006	2.781	0.83	İnnal and Engin (2020)
Lake Gölmarmara (Manisa)	F+M	20	TL (cm)	3.8	4.7	0.36	0.64	0.001	2.580	0.88	İnnal and Engin (2020)
Lake İznik (Bursa)	F+M	922	TL (mm)	8.0	115.0	0.001	11.00	0.004	3.209	0.978	Özeren (2009)
Lake İznik (Bursa)	M	233	TL (mm)	30	110	0.1	9.00	0.004	3.062	0.933	Özeren (2009)
Lake İznik (Bursa)	F	402	TL (mm)	42	115	0.5	11.00	0.002	3.485	0.911	Özeren (2009)
Lake İznik (Bursa)	F+M	237	FL (cm)	2.0	10.6	0.06	10.50	0.007345	3.0511	0.994	Çetinkaya et al. (2011)
Lake İznik (Bursa)	F+M	290	TL (mm)	27.21	115.65	0.08	9.79	-2.279	3.131	0.9658	Gençoğlu et al. (2020)
Marmara Lake (Manisa)	F+M	101	TL (cm)	3.70	8.70	0.40	5.40	0.0084	2.908	0.971	İlhan and Sarı (2015)
Ömerli Reservoir (İstanbul)	F+M	442	TL (cm)	7.7	12.9	*N/A*	*N/A*	0.0159	2.66	0.826	Tarkan et al. (2006)
Süreyyabey Dam Lake (Yozgat)	F+M	394	TL (mm)	32.0	90.0	0.225	4.062	0.00641527	2.9987	0.970	Benzer and Benzer (2019)
Tepeköy Stream (Çanakkale)	F+M	2	SL (mm)	41.0	53.0	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	Ağdamar et al. (2021)
Reyhanlı Dam Lake (Hatay)	F+M	103	TL (cm)	6.52	8.57	1.44	3.46	0.004	3.091	0.613	Şimşek (2022)
Atikhisar Reservoir (Çanakkale)	F+M	130	TL (cm)	3.20	9.10	0.17	4.38	*N/A*	*N/A*	*N/A*	Kale et al. (2022)
Atikhisar Reservoir (Çanakkale)	F	618	TL (mm)	63	91	1.48	4.53	0.0002	2.173	0.79	Present Study
Atikhisar Reservoir (Çanakkale)	F	616	SL (mm)	57	84	1.48	4.53	0.0013	1.831	0.76	Present Study
Atikhisar Reservoir (Çanakkale)	F	616	FL (mm)	54	80	1.48	4.53	0.0007	1.938	0.77	Present Study
Atikhisar Reservoir (Çanakkale)	M	353	TL (mm)	62	95	1.49	5.09	0.00001	2.886	0.94	Present Study
Atikhisar Reservoir (Çanakkale)	M	351	SL (mm)	54	84	1.49	5.09	0.00004	2.635	0.91	Present Study
Atikhisar Reservoir (Çanakkale)	M	351	FL (mm)	57	90	1.49	5.09	0.00002	2.713	0.92	Present Study
Atikhisar Reservoir (Çanakkale)	F+M+U	1103	TL (mm)	27	95	0.11	5.31	0.0002	2.9212	0.80	Present Study
Atikhisar Reservoir (Çanakkale)	F+M+U	1033	SL (mm)	24	84	0.11	5.31	0.00001	2.9082	0.97	Present Study
Atikhisar Reservoir (Çanakkale)	F+M+U	1033	FL (mm)	26	90	0.11	5.31	0.00009	2.9495	0.98	Present Study

understanding the growth pattern of *A. boyeri* and establishing conservation measures of fish resources in the Atikhisar Reservoir.

Sampled individuals ranged between 0.11 g and 5.31 g in W, between 27 and 95 mm in TL, between 26 and 90 mm in FL, and between 24 and 84 mm in SL. It is known that the maximum sizes for total length reported for different *A. boyeri* populations from the Mediterranean basin ranged between 91 mm and 125 mm (Lamprakis et al. 2003; Koutrakis and Tsikliras 2003; Gaygusuz et al. 2006; Tarkan et al. 2006; Dulčić and Glamuzina 2006; Taskavak et al. 2012; Lorenzoni et al. 2015; Innal and Engin 2020; Kale et al. 2022). The maximum total length varied between 47 mm and 136 mm in inland water ecosystems in Türkiye (Table 4). Likewise, in this study, the largest total length value measured was 95 mm, which was relatively similar to the results of the previous studies, particularly in nearby locations in Çanakkale, Kale et al. (2022) documented that the maximum TL was 91 mm in Atikhisar Reservoir while Partal et al. (2019) noted that the maximum TL was 82 mm in Bayramiç Reservoir. Comparison of LWR results of previous studies for *A. boyeri* from inland waters in Türkiye was provided in Table 4.

The relationship between weight (W) and total length (TL), standard length (SL), and fork length (FL) were estimated as $W=9E\text{-}06TL^{2.9212}$, $W=1E\text{-}05SL^{2.9082}$, and $W=9E\text{-}06FL^{2.9495}$. Although the relationship between length and weight of species can be used to convert length to weight and vice versa, Le Cren (1951) indicated that length is measured rapidly and more precisely than weight. Several factors can affect the LWR such as season, location, gender, and fishing gear (Jellyman et al. 2013; Valle et al. 2021). Nevertheless, Ricker (1975) specified that some ecological factors such as species-specific biological characteristics, environmental conditions, and sampling season could have impact on the differences in the *b* values. Similarly, Moutopoulos and Stergiou (2002) suggested that differences in the *b* values might be associated with the sample size, sampling area, and seasonal conditions. Furthermore, Cabbar and Yigin (2021) stated that the difference in the values has been affected by the selectivity of fishing gears and sampling depth. In the present study, samplings were conducted only during the daytime in June. In addition, commercial fishing is prohibited in the study area. Therefore, a comprehensive sampling period (e.g., throughout the year) may provide stronger LWR in future studies as suggested by Acarli et al. (2022).

The numerical value of *b* in fish makes it easier to interpret the variation of allometric growth in fish according to regions. Tesch (1971) noted that the *b* values are generally extended between 2.4 and 4.0 while Carlander (1969) suggested that the *b* values should range between 2.5 and 3.5. The *b* values of *A. boyeri*, calculated for the Aegean Sea and the Marmara, were reported to be between 3.2 and 3.3 (Leonardos and Sinis 2000; Lamprakis et al. 2003; Koutrakis and Tsikliras 2003; Tarkan et al. 2006; Taskavak et al. 2012). However, it was ranged between 2.580 and 2.949 in freshwater ecosystem in Türkiye (Table 4). In the present study, the *b* values ranged between 2.6355 and 2.8862 for males, 1.8319 and 2.1735 for females, and 2.9082 and 2.949 for the overall sample. The *b* values were found in the expected range for males and the overall sample; however, they were out of the expected range for females although the *b* values were nearly ranged among described values by Carlander (1969) and Tesch (1971). Moreover, the estimated *b* values were similar to previously reported *b* values (Tarkan et al. 2006; İnnal and Engin 2020). It is known that the different *b* values vary between studies depending on the season, habitat, condition, nutrition, sex, and the number of samples (Tesch 1971). The *b* value in the present study indicates that the *A. boyeri* population in a lake environment essentially exhibits a negative allometric growth performance. Determination of length-weight relationships is very important in terms of fish's condition, biomass predictions according to length measurements, isometric or allometric growth progress, and also comparing their lives between regions (Ricker 1975; Binohlan and Pauly 1998). Moreover, when length-length relationships (LLR) data are further added to these assessments, the condition, reproduction, and life stages of fish species can be investigated in more detail (Taskavak et al. 2012).

Determining the condition factor is closely related to whether the food source for fish is exploited well. A condition value as less than 0.9 g cm^3 for young *Solea solea* is an indication that the fat stores in fish are depleted (Amara et al. 2007). Therefore, the relatively low *K* values obtained in this study suggested that the recently established big-scale sand smelt population in Atikhisar Reservoir was most likely experiencing food deficiency. On the other hand, it may have been caused by the reproduction activities of the species during the spawning period. However, considering TL/Fulton's *K* values, it was observed that the mean condition values were different from each other, for both males and females. This showed that the Fulton's condition factor of female individuals distributed in the reservoir environment was slightly higher than that of males (t_{cal}=-10.266, $P<0.05$).

Good management practices are essential for sustainability and good management requires reliable data that can help evaluate resource availability and production capacity. Collecting the primary data typically used in stock management is of great importance for determining the management approaches in data-poor stocks. Evaluation outcomes yielded by data-poor stock assessment models can be considered by most regional fisheries management authorities only in the context of precautionary management. Therefore, advanced stock assessment methods that require data are scarcely practical for small-scale fisheries management in developing countries. The first knowledge of the data-poor stock in Atikhisar Reservoir obtained from the present study will

be useful for decision-makers and fisheries management authorities.

To ensure the sustainable use of local fisheries resources, the implementation of appropriate fisheries management approaches and the development of policies are of great importance in terms of the effective management of fisheries resources in the reservoir. Fisheries managers and decision-makers should consider the results from this study in order to manage the economically important big-scale sand smelt fisheries effectively and successfully in Atikhisar Reservoir. Our findings provide a better understanding of population development and management of *A. boyeri* species, which will enable fishers to better manage their catch. In the future, more data would help fisheries to develop effective management programs.

Conclusion

This study made available the first knowledge on the data-poor stock by providing the length-weight relationship and condition factor of big-scale sand smelt species distributed in Atikhisar Reservoir. In this respect, it has been determined that this species established a relatively dense population in Atikhisar Reservoir, contributing significantly to the scientific knowledge. It is thought that big-scale sand smelt is negatively affected by the ecological conditions of the lake in terms of condition and growth. On the other hand, the relatively high population rate might be a result of genetic factors and ability to adapt to variable water temperature and salinity.

Ethical Statement

No approval of research ethics committees was required to accomplish the goals of this study.

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The authors have no relevant financial or non-financial interests to disclose.

Author Contribution

SK: Conceptualisation, Conducting the research, Data analysis, Preparation figures & tables, Writing - original draft preparation SB: Conceptualisation, Conducting the research DA: Conceptualisation, Developing methods, Conducting the research ŞG: Data analysis, Data interpretation, Preparation figures & tables, Writing

Conflict of Interest

The authors declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

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