Turk. J. Fish.& Aquat. Sci. 26(7), TRJFAS27928
https://doi.org/10.4194/TRJFAS27928

Turkish Journal of FISHERIES and AQUATIC SCIENCES

PROOF
RESEARCH PAPER

Length–Weight Relationships and Condition Factors of Freshwater Fishes in the Sapanca Lake Basin (NW Türkiye)

Ali İlhan[1], Özcan Gaygusuz[2], Gülşah Saç[3], Sencer Akalın[1,*], Esat Tarık Topkara[1], Dilek İlhan[1], Latife Köker[2], Çiğdem Gürsoy Gaygusuz[4]

[1]Ege University, Faculty of Fisheries, 35100 Bornova/İzmir, Türkiye.
[2]İstanbul University, Faculty of Aquatic Sciences, Fatih/İstanbul, Türkiye.
[3]İstanbul University, Faculty of Science, Fatih/İstanbul, Türkiye.
[4]Trakya University, Keşan Vocational High School, Edirne, Türkiye.

How to Cite

İlhan, A., Gaygusuz, Ö., Saç, G., Akalın, S., Topkara, E.T., İlhan, D., Köker, L., Gaygusuz, Ç.G. (2026). Length–Weight Relationships and Condition Factors of Freshwater Fishes in the Sapanca Lake Basin (NW Türkiye). *Turkish Journal of Fisheries and Aquatic Sciences*, *26(7)*, *TRJFAS27928.* https://doi.org/10.4194/TRJFAS27928

Article History
Received 14 February 2025
Accepted 29 December 2025
First Online 13 February 2026

Corresponding Author
E-mail: sencer.akalin@ege.edu.tr

Keywords
Allometric growth
b value
Coefficient of determination
Ecological monitoring
Growth type

Abstract

This study analysed the length–weight relationships (LWR) and Fulton's condition factors (K) of 20 fish species inhabiting the Sapanca Lake basin (North-West Anatolia, Türkiye). Fish specimens were collected from the lake and its streams in several times between May 2022 and December 2024 using gill nets and portable electro-shocker devices. LWR and K analyses were based on a total of 5993 specimens, ranging from five (*Esox lucius*) to 1674 (*Rhodeus amarus*). The allometric coefficient "b" estimated using a linear regression model of LWR ranged from 2.7684 (*Clupeonella cultriventris*) to 3.3555 (*Neogobius melanostomus*) and most species (12) showed positive allometric growth. The coefficient of determination (R^2) values of the LWRs ranged from 0.8953 (*C. cultriventris*) to 0.9991 (*Alosa maeotica*). K values were minimum for *Atherina boyeri* (0.422) and maximum for *Petroleuciscus borysthenicus* (2.608). This study provides the first contribution to the LWR and K parameters of six species (*A. boyeri, C. cultriventris, Leucaspius delineatus, N. fluviatilis, R. amarus, Squalius pursakensis*) in the Sapanca Lake Basin. The findings of this study can serve as a resource for assessing the impact of ecosystem health on fish growth in the lake basin.

Introduction

The length-weight relationship (LWR) is one of the fundamental tools for the effective exploitation and management of fish populations. The standardisation of outputs from fish sampling programmes is instrumental in the estimation of growth patterns, size and age structures, and other demographic parameters of fish stocks. Furthermore, LWR estimates are imperative for the conversion of length-based growth equations into weight-based metrics within stock assessment frameworks, the evaluation of fish condition, the comparison of life-history and morphological traits across geographically distinct populations, and the estimation of biomass from length-frequency data (Famoofo & Abdul, 2020; Froese, 2006). It can be also used to estimate various components (e.g. growth rate and age structure) of fish population dynamics models (Kohler et al., 1995). Although length-weight relationships (LWRs) offer useful insights into species-specific growth and condition, their explanatory power regarding complex ecological attributes—such as overall ecosystem health—should be considered with caution. Population dynamics parameters such as Fulton's condition factor (K) reflect population health and are vital for sustainability (Famoofo & Abdul, 2020; Onay et al., 2024). K is widely used to compare the condition, fatness or well-being of fish, based on the assumption that heavier fish of a given length are in better condition (Tesch, 1968; Froese, 2006). Since the mid-20th century, LWR and K have become standard tools in fisheries research and remain fundamental in fisheries management, stock assessment and ecological monitoring studies.

Lake Sapanca, a tectonic freshwater lake in northwestern Anatolia, supports 26 fish species and regional fisheries due to its ecological and socio-economic wetland services (İlhan et al., 2024). Used also for industry, agriculture, and recreation, protecting its unique ecosystem is vital.

In Lake Sapanca, only a limited number of studies have focused on estimating LWR parameters (Okgerman & Oral, 2004, 2005; Tarkan et al., 2006, 2009; Okgerman, 2008a; Top et al., 2018; Karakuş et al., 2018). In this study, we present the LWR parameters, condition factor (K), and growth type for 20 common fish species, including six endemics to Türkiye, from the Sapanca Lake basin. The growth patterns analysed in this study will provide valuable bio-ecological information about these species and may assist in future research, conservation and management studies.

Materials and Methods

Study Area

Lake Sapanca has a surface area of 45.8 km^2, a height of 30 m above sea level and a depth of 52 m (Albay et al., 2003). The lake, which has a catchment area of about 300 km^2 and is well fed by floods and streams, is the main source of drinking water for the surrounding settlements (İlhan et al., 2024). Lake Sapanca is a relic lake (Kaçmaz, 2010) and resembles an ellipse in shape, although the western side is slightly elongated. Both sides of the lake, especially the eastern side, are shallow and covered with reeds (Saraçoğlu, 1990). Lake Sapanca is mainly fed by small streams (Yanık, Kurtköy, Mahmudiye, İstanbuldere, and Keçidere) descending from the Samanlı Mountains to the south of the lake, all of which were sampled. In addition, the Balıkhane Stream in the west and the Değirmen and Maden streams in the north were also sampled. The lake discharges its excess water through the Çarksuyu Stream located in the east, which connects to the Sakarya River and ultimately flows into the Black Sea.

Field Surveys and Sampling Methods

Field surveys were conducted several times from May 2022 to December 2024. In the lake, fish were collected using multi-mesh gillnets, including both benthic and pelagic types. Benthic gillnets (30 m long, 1.5 m wide) had 12 mesh sizes ranging from 5 mm to 55 mm, while pelagic gillnets (27.5 m long, 6.0 m wide) had 11 mesh sizes ranging from 6.25 mm to 55 mm (CEN, 2015). These gillnets were deployed at sunset and retrieved approximately 12 hours later at dawn. Sampling was carried out at 26 stations: 24 with benthic nets in the littoral parts of the lake and two with pelagic nets in the deep regions (Figure 1). In addition, a seine and a hand net were used in the coastal areas of the lake. These sampling methods were used in May and September 2022.

In the streams, sampling was carried out at 12 stations on eight streams, both in the lower basin near the lake and in the upper reaches (Figure 1). Fish samples were collected using two electro-fishing devices (SAMUS 725-G portable electro-shocker; frequency: 50–55 Hz; water depth: 5–100 cm), with sampling performed against the direction of water flow (CEN, 2003). In each stream, fish were captured from consistent areas without the use of stop nets. This sampling method was used in May and September 2022, and monthly from February 2023 to December 2024.

After capture, fish were immediately euthanised with pure (99.5%) phenoxyethanol (1 ml/L) and then fixed in 4% formaldehyde solution.

Laboratory Studies and Analysis

Fish brought to the laboratory were examined in detail to identify the species and to determine the number of individuals according to the location where they were caught. Fricke et al. (2025) was followed for the up-to-date nomenclature of fish species. All the

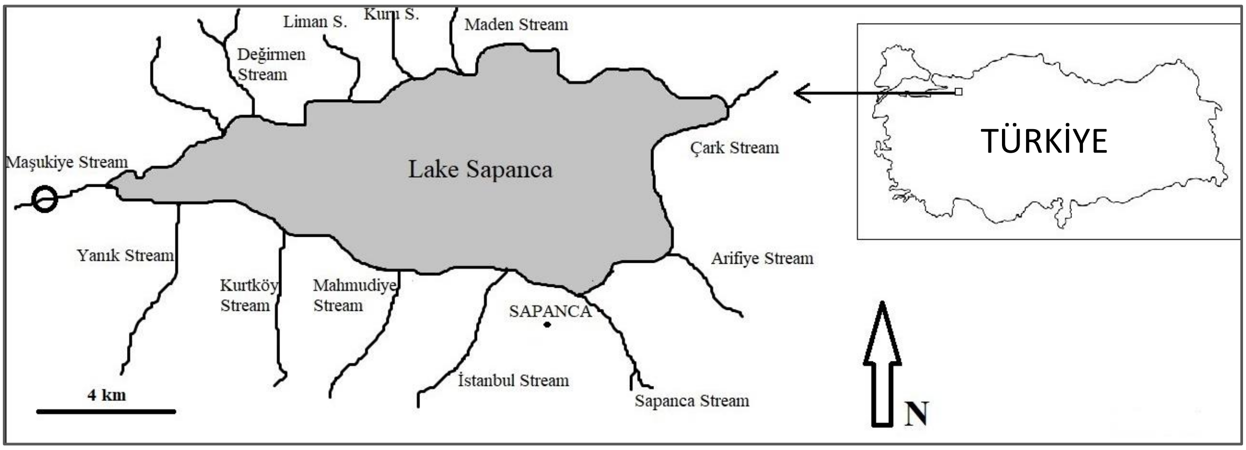

Figure 1. Sampling stations in Lake Sapanca and the streams flowing into the lake.

preserved fish specimens were measured for total length (TL, cm) and body weight (W, g) to an accuracy of ±0.1 cm and ±0.01 g, respectively. Linear regression analysis between fish length (TL) and weight (W) was used to determine the regression parameters *a* (intercept) and *b* (slope), for which the equation $W= aTL^b$ was log-transformed (logW= log*a* + *b*logTL) (Le Cren, 1951; Froese, 2006; King, 2007). Checks for heteroscedasticity and influential outliers were performed during the calculation of length-weight relationship parameters. Data points that could potentially cause such issues were identified and excluded from the analysis. The degree of association between the variables (TL and W) was calculated using the coefficient of determination (R^2) (Ricker, 1973). To determine the growth type, 95% confidence intervals (CI) of slope *b* were estimated by the equation: 95% CI= x ± ($t_{0.05}$ × SE) (x: *b*; t: table value of t (t-test at 95% confidence); SE: standard error value of *b*) (King, 2007). The Fulton's condition factor was determined using the following equation: $K= (W/TL^3) \times 100$ (Ricker, 1975). The LWRs and Ks were calculated for only those species represented by ≥5 individuals in the study. All the analyses were performed in IBM SPSS Statistics 29.0 (IBM Corp, 2022) for Windows.

Results

During the field surveys, 26 fish species (5993 individuals) belonging to 14 families (Acheilognathidae, Atherinidae, Clupeidae, Cobitidae, Cyprinidae, Esocidae, Gobiidae, Gobionidae, Leuciscidae, Poecilidae, Salmonidae, Siluridae, Syngnathidae, and Tincidae) were caught and 20 of them were analyzed to estimate the LWR and K. Six species with less than 5 individuals were excluded. The number of individuals, TL, and W ranges of these species are as follows; *Gobio sakaryaensis*, 1 individuals, 4.8 cm TL, 0.81 g W; *Cyprinus carpio*, 2 ind., 5.0-5.8 cm TL, 2.35-3.40 g W; *Syngnathus abaster*, 2 ind., 8.2-8.6 cm TL, 0.30-0.36 g W; *Oncorhynchus mykiss*, 3 ind., 15.1-23.8 cm TL, 42.40-190.17 g W; *Silurus glanis,* 3 ind., 30.0-41.5 cm TL, 187.47-652.35 g W; *Tinca tinca*, 4 ind., 4.6-14.9 cm TL, 1.97-51.92 g W.

For 20 fish species, individual numbers (n), TL and W distributions, estimated parameters of the LWR, K, and GT are given in Table 1. Accordingly, the sample size ranged from five individuals of *Esox lucius* to 1674 individuals of *Rhodeus amarus*. The minimum TL and W values were recorded as 1.3 cm and 0.03 g for *R. amarus*, while the maximum TL and W values were 50.0 cm and 852.74 g for *E. lucius*. The estimate for the *b* value of the LWR varied between 2.7684 (*Clupeonella cultriventris*) and 3.3555 (*Neogobius melanostomus*). According to the confidence intervals of the *b* value, most of the species investigated (12 species) showed positive allometric growth (b>3), except for *Babka gymnotrachelus, Cobitis emrei, E. lucius, N. fluviatilis, Petroleuciscus borysthenicus,* and *Vimba vimba,* which showed isometric growth (b=3). In contrast, *Atherina boyeri* and *C. cultriventris* showed negative allometric growth (b<3). The R^2 value was below 0.95 for only three species (*C. cultriventris, Gambusia holbrooki,* and *R. amarus*) and the highest value being 0.9991 for *Alosa maeotica*. The Fulton's condition factor values were lowest for *A. boyeri* (0.422) and highest for *P. borysthenicus* (2.608).

Discussion

Although ranges of parameter b have been calculated between 2 and 4 for fish with different body shapes (short & deep, fusiform, elongated and eel-like), values below b=2.5 and above b=3.5 are based on very small numbers of LWR and therefore the parameter *b* is expected to be in the range 2.5<b<3.5 with even closer to 3 (Froese, 2006). In this study, estimates for parameter *b* (from 2.7684 to 3.3555) are between the expected range and tend to be close to 3 for most species (Table 1). A wide distribution of length, weight and number of individuals is very important to provide the most reliable *b* value. For example, although only 5 and 6 individuals were used for *E. lucius* and *A. maeotica,* respectively, the fact that the total length range was between 11.8 and 50.0 cm and 7.5 – 33.3 cm allowed the *b* value to be within the expected range (2.7706-3.2341 and 3.1200-3.3842, respectively). Although the values derived for *E. lucius* (n= 5) and *A. meotica* (n= 6) seem plausible given the sample sizes, the limited number of specimens reduces the statistical robustness of the length-weight relationship and condition factor estimates. Therefore, the results for these species should be interpreted with particular caution.

Except for some exceptional fish body shapes mentioned above, the overall growth pattern of the species is generally 'isometric' if the 95% confidence intervals include 3.0. Deviations from 3 are considered 'allometric': b<3 indicates that fish show negative allometric growth with longer and leaner bodies, while b>3 indicates that fish show positive allometric growth with thicker or plump bodies. In this study, six species, *B. gymnotrachelus*, *C. emrei*, *E. lucius*, *L. delineatus*, *N. fluviatilis*, and *V. vimba*, showed isometric growth (b=3) while most of them (12 species) performed positive allometric growth (b>3) (Table 1). Fishes with negative allometric growth (b<3) were *C. cultriventris* and *A. boyeri*. Allometric growth was determined for these two species in studies conducted in different water bodies with different size ranges, sexes and numbers of individuals. In the studies conducted in three different populations (Ömerli and Atikhisar reservoirs and Lake Bafa), similarly, it was observed that *A. boyeri* exhibited a negative allometric growth (Tarkan et al., 2006; Ofluoğlu et al., 2021; Kale et al., 2022). However, Özeren (2009) and Cilbiz & Uysal (2020), Apaydın Yağcı et al. (2022), Gençoğlu & Ekmekçi (2016), and İlhan & İlhan (2018) have estimated a positive allometric growth

Table 1. Individual numbers (n), length (TL) and weight (W) distributions, estimated parameters of the LWR and Fulton's condition factor (CF) for freshwater fish inhabiting Sapanca Lake basin

Species	TL (cm) min.-max.	W (g) min.-max.	*a*	*b*	95% CL of *b*	r^2	CF min. - max.	CF mean ±SE	GT	n
Alburnus istanbulensis	2.4-26.1	0.06-196.99	0.0059	3.1194	3.0913-3.1474	0.9966	0.434-1.147	0.767±0.008	A+	165
Alosa maeotica	7.5-33.3	2.89-360.37	0.0040	3.2521	3.1200-3.3842	0.9991	0.685-0.986	0.844±0.051	A+	6
Atherina boyeri	3.2-10.8	0.20-7.58	0.0076	2.8575	2.8053-2.9098	0.9683	0.422-1.024	0.586±0.004	A-	381
Babka gymnotrachelus	3.0-12.7	0.30-22.40	0.0098	3.0270	2.9557-3.0982	0.9887	0.839-1.290	1.032±0.012	I	84
Blicca bjoerkna	4.7-29.7	0.97-348.8	0.0068	3.1811	3.1460-3.2162	0.9835	0.606-1.601	1.071±0.006	A+	532
Clupeonella cultriventris	5.0-9.3	0.64-5.60	0.0092	2.7684	2.5958-2.9410	0.8953	0.434-0.733	0.604±0.006	A-	120
Cobitis emrei	3.3-9.2	0.23-5.18	0.0062	3.0183	2.8232-3.2134	0.9874	0.513-0.852	0.646±0.021	I	16
Esox lucius	11.8-50.0	11.19-852.74	0.0064	3.0024	2.7706-3.2341	0.9982	0.585-0.682	0.648±0.019	I	5
Gambusia holbrooki	1.8-4.6	0.06-1.18	0.0086	3.1670	3.0717-3.2624	0.9200	0.656-1.920	1.030±0.008	A+	372
Leucaspius delineatus	1.8-5.1	0.05-1.18	0.0060	3.2943	3.1934-3.3951	0.9574	0.575-1.255	0.902±0.010	A+	187
Neogobius fluviatilis	2.2-12.7	0.11-20.84	0.0087	3.0026	2.9558-3.0493	0.9826	0.638-1.585	0.882±0.007	I	286
Neogobius melanostomus	3.0-15.1	0.26-62.05	0.0065	3.3555	3.2161-3.4949	0.9817	0.823-1.802	1.295±0.030	A+	46
Petroleuciscus borysthenicus	4.1-12.1	0.72-23.88	0.0131	2.9963	2.8843-3.1084	0.9510	0.451-2.608	1.323±0.019	I	146
Phoxinus strandjae	2.2-7.6	0.09-6.02	0.0071	3.3192	3.2756-3.3628	0.9784	0.625-1.880	1.160±0.008	A+	495
Proterorhinus semilunaris	1.7-6.5	0.06-3.98	0.0078	3.3013	3.2512-3.3513	0.9736	0.683-1.892	1.172±0.009	A+	457
Rhodeus amarus	1.3-6.7	0.03-4.99	0.0097	3.1620	3.1206-3.2034	0.9307	0.626-2.317	1.252±0.005	A+	1674
Rutilus rutilus	3.6-31.8	0.51-532.99	0.0057	3.2460	3.2128-3.2792	0.9947	0.673-1.657	1.082±0.014	A+	202
Scardinius erythrophthalmus	1.7-32.3	0.05-507.26	0.0080	3.1220	3.0805-3.1635	0.9921	0.719-1.937	1.094±0.012	A+	177
Squalius pursakensis	2.7-26.5	0.19-276.81	0.0086	3.1333	3.1118-3.1548	0.9937	0.729-1.679	1.145±0.007	A+	522
Vimba vimba	7.2-32.7	3.15-319.57	0.0091	3.0356	2.9622-3.1091	0.9827	0.777-1.240	1.002±0.008	I	120

(b>3) for *A. boyeri* populations in İznik Lake, Eğirdir Lake, Hirfanlı Reservoir, and Marmara Lake, respectively. For the species *C. cultriventris* three different studies mentioned that fish showed both positive (b>3; Tarkan et al., 2006 and Aydoğan & Özuluğ, 2020) and negative allometric growth (b<3; Saç, 2006) in the same water body, Lake Büyükçekmece.

Table 2 summarized the LWR studies conducted in the Lake Sapanca. The first *b* values for fish species inhabiting the lake were calculated for *R. rutilus* and *E. lucius* (Okgerman & Oral, 2004, 2005), respectively. Female and male individuals of *R. rutilus* were found to have negative allometric growth (Okgerman & Oral, 2004). In *E. lucius*, males were found to have negative allometric growth, while females and all individuals combined had positive allometric growth (Okgerman & Oral, 2005). Okgerman (2008a) identified 20 fish species from Lake Sapanca and calculated LWR for five of them [*B. bjoerkna* (♀*b*=3.392; ♂*b*=3.314); *S. erythrophthalmus* (♀*b*=3.341; ♂*b*=3.347), *R. rutilus* (♀*b*=2.9723; ♂*b*=2.9336); *V. vimba* (♀*b*=3.1572; ♂*b*=3.1813); *E. lucius* (♀*b*=3.0854; ♂*b*=2.9497)] reported LWR and growth parameters in the lake (Okgerman, 2008b) (Table 2). Tarkan et al. (2006), in their study conducted in the Marmara Region, reported that there were 11 fish species ranging in TL from 6.0 cm (*R. rutilus*) to 57.6 cm (*E. lucius*) in Lake Sapanca. In mentioned study, the estimates of the parameter *b* ranged from 2.79 to 3.56 (Table 2). Tarkan et al. (2009) reported in another study they conducted in Lake Sapanca that they found the *b* values of six species with standard lengths between 1.4 cm (*G. holbrooki*) and 9.1 cm (*P. borysthenicus*). The parameter *b* ranged between 2.44 and 3.35, respectively (Table 2). In studies conducted on *N. fluviatilis* and *P. semilunaris* species inhabiting Lake Sapanca (Karakuş et al., 2018; Top et al., 2018), the *b* values were calculated as 2.907 and 3.153, respectively. Although isometric growth (b= 3) is occasionally observed in nature (Bagenal & Tesch, 1978), most aquatic organisms deviate from this pattern due to morphological changes during growth (Thomas et al., 2003). The direction and extent of this deviation are shaped by environmental productivity—positive allometry being more common in nutrient-rich areas, and negative allometry in low-productivity zones like deep lakes. Moreover, *b* values vary not only between species but also among stocks of the same species, influenced by factors such as maturity, season, feeding type, resorce availability, and stomach fullness (Bagenal & Tesch, 1978).

When comparing our results with all previous studies, similarities and differences in the *b* value are observed. For example, the *b* value we determined for the species *B. gymnotrachelus* was higher than that reported by Tarkan et al. (2009), while for the species *P. borysthenicus* our calculated *b* value was lower and the value reported by Tarkan et al. (2009) was higher. A similar situation applies to some other species. For species other than those showing such differences, the *b* values are relatively close. Although the change in *b* values depends primarily on the shape and fatness of the species, several factors may be responsible for the differences in parameters of length-weight relationships between seasons and years, such as temperature, salinity, quality and quantity of food, sex, gonadal maturity and time of year (Ricker, 1973; Pauly, 1984; Sparre & Venema, 1992), all of which were not considered in this study. This study presents, for the first time, the LWR parameters of six Lake Sapanca species previously unreported: *A. boyeri*, *C. cultriventris*, *L. delineatus*, *N. fluviatilis*, *R. amarus*, and *S. pursakensis*. However, all the R^2 values (except for three species; *C. cultriventris, Gambusia holbrooki,* and *R. amarus*) were above 0.95, indicating the significant correlation between TL and W. The detected R^2 values below 0.95 (yet exceeding 0.89) for the three aforementioned species are most likely a consequence of sample size or the variation in length and weight.

As the K is calculated from the TL and W of the fish, it varies with many biotic and abiotic factors (Onay et al., 2024), just like the parameter *b*. An analysis of Table 1 indicates that K varies over a wide range for many species. While the minimum K was determined for *Atherina boyeri* at 0.422, the maximum K was calculated for *Petroleuciscus borysthenicus* at 2.608 in the research area. K values are not available in the literature for most species accounted for in the study. Only Okgerman et al. (2009) reported this value as 0.1241 (for females) and 1.221 (for males) for *R. rutilus*, and Okgerman and Oral (2005) reported it as 0.0616 for *E. lucius*.

These differences within the same population of a species vary according to age or size, sex, gonad maturation, time of year, whether the fish is diseased or not, whether the digestive tract is full or empty, and even annual differences in environmental conditions (Tesch, 1968; Froese, 2006).

In this study, important information was obtained on the LWR and K of fish species inhabiting Lake Sapanca basin, contributing to a better understanding of their population structures. Moreover, the findings offer useful insights for the optimal utilization of these species in the future. The Sapanca Lake Basin is undergoing rapid change due to increasing anthropogenic pressures, which are intensifying the stress on the ecosystem. Monitoring the growth patterns of fish species is considered important for the management of fish stocks. It is expected that any changes occurring within the lake basin may influence these species through environmental alterations, potentially leading to shifts in GT. Illegal fishing activities within the basin, particularly those targeting commercially valuable species, must be carefully monitored to prevent overexploitation. To gain a more comprehensive understanding of these parameters, further studies should be encouraged on biometric data, LWRs, and K, covering additional species in the lake. Furthermore, detailed investigations into species

Table 2. Estimated parameters of the LWRs in different studies carried out in the Sapanca Lake basin

Species		Okgerman and Oral (2004)			Okgerman and Oral (2005)			Tarkan et al. (2006)			Okgerman (2008b)			Tarkan et al. (2009)			Karakuş et al. (2018)			Top et al. (2018)			Present Study		
		n	*a*	*b*	n	*a*	*b*	n	*a*	*b*	n	*a*	*b*	n	*a*	*b*	n	*a*	*b*	n	*a*	*b*	n	*a*	*b*
	♀																								
Alosa maeotica	♂																								
	♂+♀							18	0.0053	3.15													6	0.0040	3.2521
	♀																								
Cobitis emrei	♂																								
	♂+♀													11	0.0083	3.19							16	0.0062	3.0183
	♀				58	0.0045	3.0854				71	0.0045	3.0854												
Esox lucius	♂				71	0.0045	2.9497				58	0.0045	2.9497												
	♂+♀				129	0.0056	3.0250	13	0.0030	3.21													5	0.0064	3.0024
	♀																								
Babka gymnotrachelus	♂																								
	♂+♀													15	0.0549	2.44							84	0.0098	3.0270
	♀																								
Neogobius melanostomus	♂																								
	♂+♀							17	0.0142	3.00													46	0.0065	3.3555
	♀																								
Neogobius fluviatilis	♂																								
	♂+♀																127	0.00001	2.907				286	0.0087	3.0026
	♀																								
Proterorhinus semilunaris	♂																								
	♂+♀													52	0.0305	2.85				184	0.009	3.153	457	0.0078	3.3013
	♀																								
Alburnus istanbulensis	♂																								
	♂+♀							57	0.0017	3.56													165	0.0059	3.1194
	♀										148	0.0040	3.392												
Blicca bjoerkna	♂										202	0.046	3.314												
	♂+♀							196	0.0072	3.18													532	0.0069	3.1811
	♀																								
Phoxinus strandjae	♂																								
	♂+♀													132	0.0150	3.23							495	0.0071	3.3192
	♀	262	0.013	2.972							262	0.0133	2.9723												
Rutilus rutilus	♂	136	0.0148	2.9336							136	0.0148	2.9336												
	♂+♀							711	0.0072	3.17													202	0.0057	3.2460
	♀										221		3.341												
Scardinius erythrophthalmus	♂										188		3.347												
	♂+♀							278	0.0116	3.02	409		3.34										177	0.0080	3.1220
	♀										221	0.008397	3.1572												
Vimba vimba	♂										119	0.008874	3.1813												
	♂+♀							132	0.0055	3.20													120	0.0091	3.0356
	♀																								
Petroleuciscus borysthenicus	♂																								
	♂+♀													13	0.0136	3.35							146	0.0131	2.9963
	♀																								
Gambusia holbrooki	♂																								
	♂+♀													58	0.0252	2.68							372	0.0086	3.1670

composition, habitat preferences, and biological characteristics are essential for the sustainable use of fishery resources. In addition, to ensure sustainable fisheries, fishers should be actively involved in the decision-making process; otherwise, traditional fishers whose livelihoods depend on fishing may ignore or violate rules and regulations.

In conclusion, Lake Sapanca plays a crucial role in the region by supporting both commercial and recreational fisheries and providing a primary source of drinking water for surrounding communities. Safeguarding this vital function is a key priority for local authorities and simultaneously promotes the sustainability of the lake's aquatic resources. The results of the present study offer essential insights for future stock assessments and ecological evaluations. Overall, this research is expected to inform management strategies and conservation efforts, contributing to the long-term preservation and sustainable use of the lake's biological and socio-economic resources.

Ethical Statement

The care and use of experimental animals, sampling and analysis techniques used in this work are approved by "Ege University Animal Experiments Ethics Committee" with decree no "2021/078".

Funding Information

The study was funded by Ege University Scientific Research Projects Coordinations Unit, Türkiye (FGA-2021- 23151); TÜBİTAK 1001 (Project No: 122Y318).

Author Contribution

First Author: Project Administration, Resources, Sampling Methodology; Second Author: Project Administration, Data Curation, Resources; Third to Fifth Authors: Sampling, Laboratory Studies, Writing or Editing Original Draft; Sixth Author: Laboratory Studies, Writing - Review and Editing; The last two authors: Writing - Review and Editing.

Conflict of Interest

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

Acknowledgements

We would like to express our appreciation to Istanbul University, Faculty of Aquatic Sciences, and the Sapanca Inland Fisheries Production Research and Application Unit for their support. This research was financially supported by the Ege University Scientific Research Projects Coordinations Unit, Türkiye (FGA-2021- 23151) and TÜBİTAK 1001 (Project No: 122Y318).

References

Albay, M., Akçaalan, R., Tüfekçi, H., Metcalf, J. S. Beattie, K. A., & Codd, G. A. (2003). Depth profiles of cyanobacterial hepatotoxins (Microcystins) in three Turkish freshwater lakes. *Hydrobiologia*, 505, 89-95. https://doi.org/10.1023/B:HYDR.0000007297.29998.5f

Apaydın Yağcı, M., Alp, A., Yağcı, A., Uysal, R., Bilgin, F., Cesur, M., & Yeğen V. (2022). Length-weight relationships of ten fish species from Lake Eğirdir, Turkey. *Journal of Anatolian Environmental and Animal Sciences,* 7(2), 105-109.

Aydoğan, K., & Özuluğ, M. (2020). Length-weight relationships of two *Clupeonella* species (Clupeidae) from Northwestern Turkey. *Turkish Journal of Bioscience and Collections*, 4(1), 27–29. https://doi.org/10.26650/tjbc.20200012

Bagenal, T.B. & Tesch, F.W. (1978) Age and Growth. In: Bagenal, T., Ed., Methods for Assessment of Fish Production in Fresh Waters, 3rd Edition, IBP Handbook No. 3, Blackwell Science Publications, Oxford.

CEN, European Committee for Standardization, 2003. European Standard EN 14011: Water quality - sampling of fish with electricity.

CEN, European Committee for Standardization, 2015. European Standard EN 14757: Water quality - sampling of fish with multi-mesh gillnets.

Cilbiz, M., Uysal, R., Tosunoğlu, Z., Aydın, C., Alp, A., & Bilgin, F. (2020). New approach for codend selectivity: A case study of coastal beach seine for big-scale sand smelt (*Atherina boyeri*) fishery in İznik Lake. *Turkish Journal of Fisheries and Aquatic Sciences*, 20(9), 681-692. https://doi.org/10.4194/1303-2712-v20_9_03

Famoofo, O. O., & Abdul, W.O. 2020. Biometry, condition factors and length-weight relationships of sixteen fish species in Iwopin fresh-water ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria. Heliyon. 6 (1): e02957. https://doi.org/10.1016/j.heliyon.2019.e02957

Fricke, R., Eschmeyer, W. N., & Van der Laan, R. (eds) (2025). Eschmeyer's Catalog of Fishes: Genera, Species, References. (http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp). Electronic version accessed 11 January 2025.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 25, 241-253. https://doi.org/10.1111/j.14390426.2006.00805.x

Gençoğlu, L., & Ekmekçi, F.G. (2016). Growth and reproduction of a marine fish, *Atherina boyeri* Risso 1810, in a freshwater ecosystem. *Turkish Journal of Zoology*, 40, 534-542. https://doi.org/10.3906/zoo-1406-42

IBM Corp. (2022). IBM SPSS Statistics for Windows (Version 25.0) [Computer software]. IBM Corp. https://www.ibm.com/products/spss-statistics

İlhan, A., & İlhan, D. (2018). Length-weight relationship and condition of big-scale sand smelt (*Atherina boyeri* Risso, 1810) from Marmara Lake (Manisa) and Homa Lagoon (İzmir). *The Black Sea Journal of Sciences*, 8(1), 25-34

İlhan, A., Saç, G., Gaygusuz, Ö., Akalın, S., Topkara, E.T., İlhan, D., Gürsoy Gaygusuz, Ç., & Sarı, H.M. (2024) Fish species composition and seasonal variations in Lake Sapanca and its tributaries. *Ege Journal of Fisheries and Aquatic Sciences*, 41(4), 286-294. https://doi.org/10.12714/egejfas.41.4.05

Kaçmaz, M. (2010). Sapanca gölü havzası'nda arazi kullanımı ve mekânsal değişim. (Tez No. 264459). [Doktora tezi, İstanbul Üniversitesi]. YÖK Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/giris.jsp

Kale, S., Berber, S., Acarlı, D., & Gürkan, Ş. (2023). First knowledge on data poor stock: LWR and condition factor of a recently established population of *Atherina boyeri* in Atikhisar Reservoir, Türkiye. *Turkish Journal of Fisheries and Aquatic Sciences*, 23(SI), TRJFAS22503. https://doi.org/10.4194/TRJFAS22503

Karakuş, U., Top, N., Tepeköy, E. G., Britton J. R., & Tarkan, A. S. (2018). Life history characteristics of the potentially invasive Ponto-Caspian goby *Neogobius fluviatilis* in natural lakes from its native range (Black Sea region of Turkey). *Marine and Freshwater Research*, 69, 1544–1556. https://doi.org/10.1071/MF17350

King, M. (2007). *Fisheries Biology, Assessment and Management* (2nd ed.). Oxford: Blackwell Scientific Publications, 381 p.

Kohler, N., Casey, J., & Turner, P. (1995). Length-weight relationships for 13 species of sharks from the western North Atlantic. *Fishery Bulletin*, 93, 412–418.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and conditions in the perch *Perca fluviatilis*. *Journal of Animal Ecology,* 20, 201–219. https://doi.org/10.2307/1540

Ofluoğlu, Ö., Kurtul, I., İlhan, A., & Sarı, H. M. (2021). Length-weight relationship of the sand smelt (*Atherina boyeri* Risso, 1810) population distributed in Lake Bafa (Aydın). *The Black Sea Journal of Sciences*, 11(1), 29-40. https://doi.org/10.31466/kfbd.831737

Okgerman, H., & Oral, M. (2004). Biological aspects of *Rutilus rutilus* (roach) in Sapanca Lake. International conference on behaviour and ecology of freshwater fish: linking individual behaviour and ecology. 22-26 August 2004, Freshwater Centre, Silkeborg, Denmark.

Okgerman, H., & Oral, M. (2005). Some population characteristics of pike (*Esox lucius* Linnaeus) in Sapanca Lake (Turkey). *İstanbul Üniversitesi Su Ürünleri Fakültesi Dergisi*, 19, 17-30.

Okgerman, H. (2008a). *Sapanca Gölü Balıkları*. Hacer Okgerman, Gülşen Altuğ (Editör), Sapanca Gölü'ne Bilimsel Açıdan Bakış. ISBN: 978-975-8825-20-2. TÜDAV Yayınları, No: 28, 161 s.

Okgerman, H. (2008b). Sapanca Gölü'nde bazı Cyprinidae türleri ve turna balığının (*Esox lucius* L.) biyolojik özellikleri. Hacer Okgerman, Gülşen Altuğ (Editör), Sapanca Gölü'ne Bilimsel Açıdan Bakış. ISBN: 978-975-8825-20-2. TÜDAV Yayınları, No: 28, 161 s.

Özeren, S. C. (2009). Age, growth and reproductive biology of the sand smelt *Atherina boyeri*, Risso 1810 (Pisces: Atherinidae) in Lake Iznik, Turkey. *Journal of Fisheries International*, 4(2), 34-39

Onay, H., Kurtul, I., Kaya, C., Turan, D., & Bayçelebi, E., 2024. Length–weight relations and condition factors of several endemic and native fish species from Anatolian freshwater. *Oceanological and Hydrobiological Studies*, 53(4), 386-395. https://doi.org/10.26881/oahs-2024.4.06

Pauly, D. (1984). *Fish Population Dynamics in Tropical Waters*: A Manual for Use with Programmable Calculators. ICLARM Studies and Reviews 8. ICLARM, Manila.

Ricker, W. E. (1973). Linear regressions in fishery research. *Journal of the Fisheries Research Board of Canada*, 30(3), 409–434. https://doi.org/10.1139/f73-072

Ricker W. E. (1975). Computations and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada,* 191, 1–382.

Saç, G. (2012). Some biological characteristics of *Clupeonella cultriventris* (Nordmann, 1840) living in Büyükçekmece Reservoir (İstanbul). *Istanbul University Journal of Fisheries & Aquatic Sciences,* 27(2), 23–33.

Saraçoğlu, H. (1990). Bitki Örtüsü Akarsular ve Göller. Öğretmen Kitapları Dizisi. 90.34.Y0002.655. Milli Eğitim Basımevi, s. 399-400.

Sparre, P., & Venema, S. C. (1992). *Introduction to tropical fish stock assessment.* Part 1. Manual. FAO Fisheries Technical Paper, No. 306/1, Rev.1, FAO, Rome.

Tarkan, A. S., Gaygusuz, Ö., Acıpınar, H., Gürsoy, Ç., Özuluğ, M. (2006). Length-weight relationship of fishes from the Marmara region (NW-Turkey). *Journal of Applied Ichthyology*, 22, 271-273. https://doi.org/10.1111/j.1439-0426.2008.01201.x

Tarkan, A. S., Gaygusuz, Ö., Özuluğ, M., Gürsoy Gaygusuz, Ç., & Saç, G. (2009). Length-weight relationships of six freshwater fishes from the small streams flowing into Lake Sapanca, NW Turkey. *Journal of Applied Ichthyology,* 25(2), 230-231. https://doi.org/10.1111/j.1439-0426.2008.01201.x

Tesch, F. W. (1968). *Age and growth. In: Methods for assessment of fish production in fresh waters*. W. E. Ricker (Ed.). Blackwell Scientific Publications, Oxford.

Thomas, J. & Venu, S. & Kurup, B.M., 2003. Length-weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the west coast of India, *Naga*, 26(2), 17-21.

Top, N., Karakuş, U., Tepeköy, E. G., Britton, J. R., & Tarkan, A. S. (2018). Plasticity in life history traits of the native *Proterorhinus semilunaris* suggests high adaptive capacity in its invasive range. *Knowledge and Management of Aquatic Ecosystems*, 419, 48. https://doi.org/10.1051/kmae/2018032