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Length–weight Relationships of 19 Marine Fish Species from the Southern Coast of Black Sea Associated with Small-Scale Fisheries

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Abstract

This study presents the length-weight relationship (LWRs) estimates for 19 marine fish species belonging to 12 families from the southern coast of the Black Sea. The species were sampled using small-scale fishing gears such as gillnets and trammel nets at depths of 0-120 m from 2010 to 2021. The LWRs were calculated by the linear regression of natural log-transformed data concerning $W = a \times TL^b$. Growth type was evaluated according to Pauly's t-test. The slope (*b-value*) ranged between 2.5643 and 3.5745, corresponding to the commonly expected range (2.50–3.50) except for *Spicara flexuosum*. The coefficient of determination values (r^2) were above 0.90 except for *Chromis chromis*, *Gobius niger*, *Neogobius melanostomus, Sardina pilchardus* and *Uranoscopus scaber*. This study targeted specimens from small-scale fisheries-related gears; therefore, the results are primarily of interest to local fisheries management. The new LWRs cover substantially larger TL_{max} values than any previous study, and thus we can assume that all size classes of the species are adequately represented, and the new LWRs are more significant and species-specific than any previous estimate. This paper offers new insights into LWRs for the *Umbrina cirrosa* from the southern coast of the Black Sea.

Keywords LWR · Fish growth · Artisanal fishery · Black Sea · Türkiye

Introduction

The length-weight relationship (LWR) is one of the most useful for estimating fish conditions, indirect growth, and ecological modeling (Froese 2006; Camara et al. 2011). LWRs allow the estimation of biomass from length data and serve to morphologically compare different populations of the same species (Karachle and Stergiou 2012; Eduardo et al. 2019). Türkiye has the longest coast in the Black Sea with 1,700 km (Stanchev et al. 2011). The Black Sea is one of the most important regions in the fishing areas in Türkiye since approximately 80% of the total marine fish production is obtained from there (TUIK 2022). Many local fishers engage in small-scale fishing for their livelihood. Gillnets, trammel nets, hand lines, beam trawls, and deep-water cast nets are commonly used for fishing in the Black Sea (Zengin 2019; Karadurmuş et al. 2021).

This study aims to contribute to the sustainable management of small-scale fisheries in the Black Sea by generating primary biological data, which is the first step of fisheries management. Most previous LWR studies (Kalaycı et al. 2007; Ak et al. 2009; Özdemir and Duyar 2013; Çalık and Erdoğan Sağlam 2017; Samsun et al. 2017; Van et al. 2019; Onay and Dalgıç 2021; Samsun 2022; Dağtekin et al. 2022) have focused on industrial fisheries. Unlike the literature, this study presents the LWRs of 19 fish species collected from the southern shores of the Black Sea (Türkiye), focusing on small-scale fisheries. In fact, previously reported LWRs for some species were put forth so long ago that they may not be representative nowadays. Moreover, the information in this study is based on wider size ranges and larger sample sizes. The authors believe that the results of the study can contribute greatly toward the better understanding of the growth patterns of less studied species associated with small-scale fisheries of Black Sea and to improve the accuracy of the LWR estimates for the data-poor species.

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Table 1 Estimated length-weight relationship parameters of 19 marine fish species from the southern coast of the Black Sea

Species	*n*	Length range (*TL*, cm)	Weight range (*W*, g)	Regression parameters					*b* test	
				a-value	*b-value*	95% *Cl* of *a*	95% *Cl* of *b*	r^2	*t*	Growth
Alosa immaculata	75	15.1 – 33.0	24.9 – 319.0	0.0038	3.2459	0.0028 – 0.0050	3.1578 – 3.3340	0.987	5.540	A+
Chromis chromis	112	7.2 – 11.5	5.7 – 26.6	0.0127	3.1172	0.0070 – 0.0231	2.8545 – 3.3798	0.834	0.883	I
Dicentrarchus labrax	333	22.0 – 67.1	111.0 – 2756.8	0.0127	2.8151	0.0161 – 0.0261	2.7450 – 2.8852	0.950	5.190	A–
Diplodus puntazzo	276	15.3 – 45.4	50.6 – 1186.5	0.0399	2.7212	0.0330 – 0.0482	2.6653 – 2.7772	0.971	9.781	A+
Engraulis encrasicolus	528	3.9 – 13.7	0.2 – 14.3	0.0032	3.2313	0.0030 – 0.0035	3.1966 – 3.2660	0.985	13.025	A+
Gobius niger	443	7.2 – 14.0	3.6 – 27.4	0.0109	3.0016	0.0083 – 0.0144	2.8878 – 3.1154	0.859	0.034	I
Lithognathus mormyrus	269	15.7 – 31.0	49.2 – 393.8	0.0140	2.9658	0.0110 – 0.0179	2.8809 – 3.0508	0.946	0.782	I
Merlangius merlangus	800	10.3 – 34.8	6.4 – 403.2	0.0065	3.0332	0.0055 – 0.0078	2.9677 – 3.0988	0.912	0.994	I
Mesogobius batrachocephalus	641	5.3 – 34.0	1.3 – 377.5	0.0058	3.1480	0.0050 – 0.0067	3.0994 – 3.1965	0.962	5.986	A+
Mullus barbatus	1435	6.4 – 21.5	2.1 – 105.4	0.0088	3.0338	0.0081 – 0.0094	3.0047 – 3.0629	0.967	2.299	A+
Neogobius melanostomus	870	10.5 – 20.9	15.3 – 133.9	0.0096	3.0840	0.0080 – 0.0115	3.0149 – 3.1531	0.898	2.363	A+
Pomatomus saltatrix	165	16.7 – 32.8	47.1 – 372.5	0.0112	2.9662	0.0084 – 0.0151	2.8727 – 3.0596	0.960	0.719	I
Sardina pilchardus	276	12.8 – 17.7	12.7 – 46.2	0.0234	2.5643	0.0139 – 0.0394	2.3707 – 2.7578	0.713	4.490	A–
Sciaena umbra	319	11.7 – 58.0	16.4 – 2485.2	0.0065	3.2025	0.0056 – 0.0076	3.1565 – 3.2485	0.983	8.706	A+
Scorpaena porcus	2442	2.8 – 33.2	0.3 – 775.6	0.0165	3.0559	0.0155 – 0.0176	3.0320 – 3.0800	0.962	4.574	A+
Spicara flexuosum	43	17.0 – 22.3	46.7 – 121.0	0.0020	3.5745	0.0007 – 0.0058	3.2126 – 3.9365	0.907	3.198	A+
Trachurus mediterraneus	1307	6.9 – 19.0	2.3 – 59.9	0.0049	3.1757	0.0049 – 0.0054	3.1401 – 3.2114	0.959	9.736	A+
Umbrina cirrosa	104	4.8 – 104.0	1.0 – 11080.0	0.0093	3.0434	0.0082 – 0.0105	3.0076 – 3.0793	0.996	2.373	A+
Uranoscopus scaber	22	13.3 – 22.8	18.7 – 226.1	0.0068	3.2563	0.0003 – 0.1729	2.1459 – 4.3668	0.652	0.479	I

Note: *n*, sample size; *a-value*, regression intercept; *b-value*, regression slope; 95% *Cl*, 95% confidence intervals; r^2, coefficient of determination; A+, positive allometry; I, isometric; A–, negative allometry

Materials and Methods

Fish were sampled monthly from locations associated with small-scale fisheries along the Turkish coast of the Black Sea from 2010 to 2021. Specimens were captured using gillnets (mesh size 8–32 mm) and trammel nets (mesh size 16–52 mm) in a depth range between 0 and 120 m throughout the study period. The collected fish samples were transported in iceboxes, and the fresh samples were processed in the laboratory for measurements. Each individual was identified to the species level using standard keys (Fischer and Whitehead 1974; Fischer et al. 1995), and the taxonomic level was verified according to Froese and Pauly (2022). The total length (*TL*, cm) was used as a standard measure for all fish. *TL* was measured to the nearest mm using a plexiglass ichthyometer. Total body weight (*W*, g) was determined with an electronic balance of 0.01 g accuracy. Care was taken to collect an equal number of samples from each possible length group (between the minimum and maximum sizes), as dubious intercept and slope values may result if only a partial size spectrum is used (Froese 2006).

The LWRs were estimated by the linear regression of natural log-transformed weight-length model (Froese 2006): $W = a \times TL^b$. The intercept (*a-value*), slope (*b-value*), the 95% confidence limits (*Cl*) of parameters, and the coefficient of determination (r^2) were estimated from raw data. To detect possible outliers in the raw data, the visual inspection method was used with curvilinear plots of *TL* and *W* (Froese 2006). Pauly's t-test was used to test (Pauly 1984) if the *b-value* coefficient was significantly different from 3, in order to determine if fish growth is isometric or allometric (Ricker 1975; Zar 1999). All statistical tests were performed with SPSS Ver. 26 software (IBM Corp., Armonk, NY).

Results

This paper presents LWRs for 19 marine fish species, representing 12 families. The sample size (*n*), length range (cm), weight range (g), LWR parameters *a* and *b* with associated 95% *CI*, and r^2 for each species are provided in Table 1. The estimated *b* values ranged between 2.5643 and 3.5745, while the values of parameter *a* ranged between 0.0020 and 0.0399. Most of the species showed either isometric growth ($b = 3$) or positive allometric growth ($b > 3$), whereas a few species namely, *Dicentrarchus labrax* and *Sardina pilchardus*, exhibit negative allometric growth ($b < 3$). The r^2 values ranged from 0.652 to 0.996 for all specimens (Table 1).

Discussion

Mesogobius batrachocephalus can reach a maximum standard length (SL_{max}) of 35 cm. There are two LWRs in the literature, covering size ranges from 5.5 to 18 cm *TL*. This result includes a new size range from 5.3 to 34.0 m *TL*. *Spicara flexuosum* can reach 20 cm *SL* and reaches maturity around 9.1 cm. There are nine LWRs in the literature, covering size ranges from 6.5 to 20.0 cm *TL*. This study includes a new TL_{max} (22.3 cm) for *S. flexuosum*. However, although the estimated r^2 value in this study is low ($r^2 = 0.907$), the regression between the variables is significant ($p < 0.05$). *Umbrina cirrosa* can reach 73 cm *TL*. There are only three LWRs in the literature, covering size ranges from 6.5 to 66.5 cm *TL*. This study shows a larger size range, up to 104 cm, and the r^2 value of the estimate in this study is significant ($r^2 = 0.996$; $p < 0.05$).

The *b* values of the 18 sampled species corresponded to the expected range of $2.5 < b < 3.5$ (Carlander 1977). The estimates of *b* for *S. flexuosum* fell out of the expected range. There were several variations in the estimated *b* values in the current study for a few species in contrast with the previous estimates that exist in the Black Sea literature (Kalaycı et al. 2007; Ak et al. 2009; Özdemir and Duyar 2013; Kasapoğlu and Düzgüneş 2014; Yeşilçiçek et al. 2015; Çalık and Erdoğan Sağlam 2017; Onay and Dalgıç 2021; Dağtekin et al. 2022) and database of FishBase (Froese and Pauly 2022). The key factor which influences *b* is the sample size, depth of capture, length class, sex, maturity, and hydrographical and physico-chemical parameter of the environment (Bagenal and Tesch 1978; Thomas et al. 2003; Hossain et al. 2009). These components were not considered in the current study, and the observed differences in LWRs parameters could be based on the effect of single or multiple factors. It is thought that the difference between the LWR parameters is due to the selectivity and type of the fishing gears, depending on the sampling methods and the sampling season (Bautista-Romero et al. 2012; Moutopoulos et al. 2002).

Compared with the previous studies, minor differences in r^2 calculated in the current study were common, possibly due to factors such as season, length range, fish physiology, sampling size, and habitat (Froese 2006). Despite the relatively small r^2 values (< 0.95) and sample size in Table 1, the regression between the length and weight variables was statistically significant ($p < 0.05$) for all species. One reason the smaller size class are often missing is that commercial fishing gears targeting legal-size fish were used. In conclusion, the key biological data presented in the current study contribute to filling in the gaps and can support the sustainable management of marine fish. Additionally, the results of this study may also be useful for understanding of vulnerable (*Alosa immaculata*, *Pomatomus saltatrix*, and *Trachurus mediterraneus*) or near threatened (*Sciaena umbra*) species in the IUCN Red List of Threatened Species (IUCN 2022). Further studies involving additional size classes are highly recommended to help improve the species-specific LWR.

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Declarations

Ethical Approval and Consent to Participate Not applicable.

Human and Animal Ethics All applicable international, national and/or institutional guidelines for the care and use of animals were followed by the authors.

Consent for Publication Not applicable.

Availability of Supporting Data The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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