SHORT COMMUNICATION   **KISA ARAŞTIRMA**

Length-weight relationships for 11 fish species from the Central Black Sea, Turkey

Orta Karadeniz'den 11 balık türünün boy-ağırlık ilişkileri

Osman Samsun[1] ● Okan Akyol[2]* 🆔 **● Tevfik Ceyhan[2] ● Yakup Erdem[1]**

[1] Sinop University Faculty of Fisheries, Sinop, Turkey
[2] Ege University Faculty of Fisheries, Izmir, Turkey
* Corresponding author: okan.akyol@ege.edu.tr

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Abstract: This study reports length-weight relationships (LWRs) of the 11 fish species in the Central Black Sea. The values of *b* ranged from 2.523 (±0.62) for *Liza aurata* to 3.445 (±0.56) for *Sarda sarda*. The median value of *b* was 2.933. The information about the length-weight relationships of fish species in the Black Sea is still very scarce and incomplete. The LWR for *Sparus aurata* was not recorded before for the Black Sea. Consequently, this paper contributes the LWR of some Black Sea fishes, especially with *S. aurata* and *Diplodus annularis,* which are given for the first time.

Keywords: Length-weight relationship, fish, size, Black Sea

Abstract: Bu çalışma Orta Karadeniz'den 11 balık türünün boy-ağırlık ilişkilerini rapor etmektedir. İlişkilerin b değeri *Liza aurata* için 2.523 (±0.62)'ten *Sarda sarda* için 3.445 (±0.56)'e değişmektedir. *b*'nin medyan değeri 2.933'tür. Karadeniz'de balık türlerinin boy-ağırlık ilişkileri üzerine bilgi hala eksik ve tamamlanmamıştır. Sonuç olarak bu makale, özellikle ilk kez verilen *S. aurata* ve *Diplodus annularis*'le birlikte bazı Karadeniz balıklarının, boy-ağırlık ilişkilerine katkıda bulunmaktadır.

Anahtar kelimeler: Boy-ağırlık ilişkisi, balık, boyut, Karadeniz

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INTRODUCTION

Length-weight relationship (LWR) studies are useful for fisheries research because they: (a) allow the conversion of growth-in-length equations to growth-in-weight for use in stock assessment models; (b) allow the estimation of biomass from length observations; (c) allow an estimate of the condition of the fish; and (d) to make interregional comparisons of life histories of species (Stergio and Mautopoulos, 2001).

The knowledge of some biological parameters of fish such as size values (i.e. minimum, maximum, and mean), and size relationships (i.e. length-weight) helps for the sustainable exploitation of the Black Sea's natural resources (Yankova et al., 2011). Besides, LWRs are important for FishBase, as well. However, when we looked into the FishBase, LWR parameters of fishes from the Black Sea are not enough; therefore, it should be improved.

This study presents the parameters of LWR for 11 fish species from the Central Black Sea of Turkey, including *Alosa immaculata* Bennett, 1835, *Belone belone* (Linnaeus, 1761), *Diplodus annularis* (Linnaeus, 1758), *Trachurus mediterraneus* (Steindachner, 1868), *Engraulis encrasicolus* (Linnaeus, 1758),

Liza aurata (Risso, 1810), *Merlangius merlangus* (Linnaeus, 1758), *Mullus barbatus ponticus* Essipov, 1927, *Pomatomus saltatrix* (Linnaeus, 1766), *Sarda sarda* (Bloch, 1793) and *Sparus aurata* Linnaeus, 1758.

MATERIAL AND METHODS

Total of 19092 specimens were collected from commercial coastal gillnet and bottom trawl fisheries, which have especially landed at Sinop fishing ports in the Central Black Sea, between September 2016 and February 2017.

Total length (TL) of fish was measured to nearest ± 0.1 cm and ± 0.1 g. Length-weight relationship (LWR) was computed from the following formula: $W = a \times TL^b$, which is estimated through logarithmic transformation: $\log W = \log a + b \log L$,

Where W is weight, *a* and *b* are constants. The obtained coefficients were analysed with ANOVA (Zar, 1996). The degree of relationship between the variables was computed by the determination coefficient, R^2. The null hypothesis of isometric growth (H_0: $b = 3$) was tested by *t*-test, using the statistic: $t_s = (b-3)/S_b$, where S_b is the standard error of the slope

for α = 0.05 (Sokal and Rohlf, 1987). All calculations were performed using the SPSS 20.0 software package.

RESULTS AND DISCUSSION

The sample size, minimum, maximum length and weights for each species, the parameters *a* and *b* of the LWRs, the SE of *b,* and the coefficient of determination R^2 are indicated in Table 1.

The values of *b* ranged from 2.523 (±0.62) for *L. aurata* to 3.445 (±0.56) for *S. sarda*. The median value of *b* was 2.933 (Figure 1). The exponent *b* was mostly close to 3. Concerning the type of growth, isometric growth in 9 species, negative allometry in 1 species, and positive allometry in 1 species were obtained. The R^2 values ranged from 0.864 for *S. aurata* to 0.981 for *A. immaculata*

Table 1. Following are the descriptive statistics and estimated parameters of the LWR of fish species caught from the Central Black Sea. L = total length, n = sample size, SE = standard error, R^2 = coefficient of determination, *a* = intercept, *b* = slope

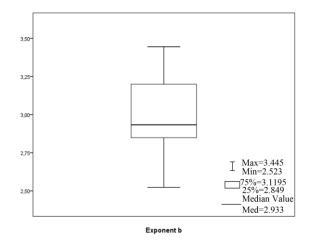| Species	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	±SE (b)	R^2	t-test
Alosa immaculata	1312	11.5-34.9	9.5-381.2	0.028	3.32	0.13	0.98	p<0.05
Belone belone	647	28.8-51.6	26.9-177.2	0.008	3.09	0.47	0.87	p>0.05
Diplodus annularis	210	12.5-23.4	39.9-249.3	0.031	2.84	0.56	0.92	p>0.05
Trachurus mediterraneus	1870	7.1-20.3	3.2-67.7	0.010	2.93	0.23	0.89	p>0.05
Engraulis encrasicolus	10062	5.5-14.5	0.9-17.4	0.008	2.86	0.10	0.89	p>0.05
Liza aurata	255	20.2-40.8	81.2-618.4	0.044	2.52	0.62	0.87	p>0.05
Merlangius merlangus	1891	7.5-23.4	3.7-113.8	0.010	2.90	0.19	0.93	p>0.05
Mullus barbatus ponticus	1602	8.2-19.8	5.6-86.5	0.007	3.15	0.14	0.97	p>0.05
Pomatomus saltatrix	820	16.1-27.5	32.5-227.9	0.005	3.25	0.27	0.95	p>0.05
Sarda sarda	314	24.8-62.8	152.6-2478.5	0.002	3.45	0.56	0.97	p>0.05
Sparus aurata	109	15.7-21.2	62.2-136.8	0.035	2.70	0.10	0.86	p<0.05

Figure 1. Box-whisker plots of the exponent *b* of the LWR for 11 fish species from the Central Black Sea, Turkey

The information about the length-weight relationships of fish species in the Black Sea is still very scarce and incomplete. Data about previous studies of LWRs for fish species from the Black Sea are presented in Table 2. Among these fishes, LWR for two species, *D. annularis* and *S. aurata* could not found in the previous studies.

Table 2. Some of the results of LWR parameters estimated in different localities of the Black Sea for the similar fish species targeted in the present study

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Mullus barbatus ponticus						
Kalaycı et al. (2007)	176	6.6-18.4	2.9-60.2	0.011	2.96	0.98
Demirhan and Can (2007)	432	6.8-14.6	-	0.005	3.24	0.97
Ak et al. (2009)	714	6.1-21.9	2.1-161.1	0.007	3.14	0.99
Aksu et al. (2011)	699	7.3-18.7	-	0.011	2.97	0.98
Özdemir and Duyar (2013)	225	9.3-20.1	8.6-87.9	0.011	2.98	0.97
Aydın and Karadurmuş (2013)	1435	6.4-21.5	2.1-105.4	0.009	3.03	0.97
Kasapoğlu and Düzgüneş (2014)	2693	5.3-19.0	1.2-73.4	0.007	3.12	0.96
This study	1602	8.2-19.8	5.6-86.5	0.007	3.15	0.97

Merlangius merlangus

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Kalaycı et al. (2007)	176	6.6-18.4	2.9-60.2	0.011	2.96	0.98
Demirhan and Can (2007)	432	6.8-14.6	-	0.005	3.24	0.97
Ak et al. (2009)	714	6.1-21.9	2.1-161.1	0.007	3.14	0.99
Aksu et al. (2011)	699	7.3-18.7	-	0.011	2.97	0.98
Yankova et al. (2011)*	3715	5.5-22.5	1.1-80.9	0.004	3.15	0.99
Erdoğan-Sağlam and Sağlam (2012)	1884	10.1-23.1	6.3-96.7	0.006	3.04	0.88
Özdemir and Duyar (2013)	225	9.3-20.1	8.6-87.9	0.011	2.98	0.97
Aydın and Karadurmuş (2013)	1435	6.4-21.5	2.1-105.4	0.009	3.03	0.97
Kasapoğlu and Düzgüneş (2014)	2292	5.9-22.2	1.4-73.7	0.005	3.15	0.92
This study	1891	7.5-23.4	3.7-113.8	0.010	2.90	0.93

Pomatomus saltatrix

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Kalaycı et al. (2007)	143	13.2-21.7	23.2-88.2	0.013	2.86	0.92
Ak et al. (2009)	14	11.6-21.2	12.0-131	0.003	3.34	0.96
Özdemir et al. (2010)	529	9.7-23.1	9.8-126.9	0.003	3.40	0.98
Özdemir and Duyar (2013)	207	12.2-24.0	15.4-127.2	0.005	3.25	0.98
Kasapoğlu and Düzgüneş (2014)	25	12.5-20.2	16.0-75.2	0.009	3.01	0.87
This study	820	16.1-27.5	32.5-227.9	0.005	3.25	0.95

Engraulis encrasicolus

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Kalaycı et al. (2007)	575	8.0-14.7	2.9-19.1	0.017	2.60	0.85
Özdemir et al. (2010)	363	7.6-14.6	2.7-18.8	0.009	2.83	0.96
Yankova et al. (2011)*	4027	10.3-15.7	8.3-24.5	0.024	2.51	0.99
Özdemir and Duyar (2013)	696	8.0-13.6	3.5-16.4	0.018	2.62	0.88
Kasapoğlu and Düzgüneş (2014)	1588	5.9-14.6	1.1-18.1	0.012	2.77	0.94
This study	10062	5.5-14.5	0.9-17.4	0.008	2.86	0.89

Alosa immaculata

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Kalaycı et al. (2007)	227	11.9-27.6	10.0-177.0	0.005	3.12	0.94
Özdemir et al. (2010)	529	13.6-33.6	14.7-297.7	0.039	3.18	0.98
Yankova et al. (2011)*	191	24.2-37.7	175.0-515.0	0.071	2.49	0.78
Özdemir and Duyar (2013)	489	13.6-35.2	10.2-300.3	0.004	3.21	0.98
This study	1312	11.5-34.9	9.5-381.2	0.028	3.32	0.98

Trachurus mediterraneus

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Özdemir et al. (2010)	1300	7.8-18.0	3.6-49.8	0.009	3.05	0.96
Yankova et al. (2011)*	1432	7.0-18.4	4.5-55.0	0.005	3.17	0.92
Özdemir and Duyar (2013)	526	9.4-15.1	4.6-25.2	0.003	3.30	0.90
This study	1870	7.1-20.3	3.2-67.7	0.001	2.93	0.89

Belone belone

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Samsun (1995)	643	31.2-52.2	31.6-167.7	0.0006	3.18	0.94
Polat et al. (2009)	278	23.7-60.3	12.0-277.0	0.0005	3.25	0.94
Bilgin et al. (2014)	1211	22.2-65.1	-	0.0005	3.14	0.92
This study	647	28.8-51.6	26.9-177.2	0.008	3.10	0.87

Liza aurata

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Bilgin et al. (2006)	500	16.2-44.0	10.0-917.0	0.004	3.21	0.75
This study	255	20.2-40.8	81.2-618.4	0.044	2.52	0.87

Sarda sarda

Authors	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	R^2
Oray et al. (1997)**	332	31.0-66.0	380-4848	0.007	3.23	0.94
Oray et al. (2004)**	415	21.8-70.5	110-5000	0.004	3.33	-
Ateş et al. (2008)**	694	23.5-71.0	122-4724	0.005	3.22	0.98
Yankova et al. (2011)*	411	29.0-37.6	300-880	0.001	3.84	0.89
Kahraman et al. (2014)**	212	17.7-63.0	69-3860	0.010	3.09	0.99
Kasapoğlu and Düzgüneş (2014)	36	28.1-37.5	234-518	0.050	2.56	0.89
This study	314	24.8-62.8	152.6-2479	0.0022	3.45	0.97

* Bulgarian Black Sea waters
**Fish from both Black Sea and the Sea of Marmara

The values of parameter *b* for all fish species in the study were between 2.5 and 3.5 as recommended by Froese (2006). The LWR for *Sparus aurata* was not being recorded before for the Black Sea. Additionally, the LWRs of *B. belone, D. annularis, L. aurata,* and *S. aurata* from the Black Sea were not presented in FishBase, as well. Fish samples in this study were monthly collected throughout two seasons, autumn, and winter. So, the data are representative seasonally, and estimated

parameters of LWR should not be considered as mean annual values. In addition, Froese (2006) stated that small specimens have a different LWR from larger specimens. Due to the gear's selection properties (*i.e.,* legal mesh sizes), our fish samples do not include small sized individuals for all the species.

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