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RESEARCH ARTICLE

Length-weight relationships of four *Symphodus* species (Actinopterygii: Perciformes: Labridae) from Eastern Black Sea (Turkey)

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ABSTRACT

This study provides the length-weight relationships of four fish species that belong to the Labridae family from the Rize coast in the south-eastern Black Sea, Turkey; (*Symphodus ocellatus* (Linnaeus, 1758), *Symphodus cinereus* (Bonnaterre, 1788), *Symphodus tinca* (Linnaeus, 1758*)* and *Symphodus roissali* (Risso, 1810)). A total of 720 fish samples were collected with trammel net between June 2015 and May 2016. The sample sizes, minimum and maximum lengths and weights, length-weight relationships, parameters of *a* and *b*, ± 95% CI of *b*, r^2, growth type and statistical analyses of the relationship were determined. The *b* value estimates varied between 2.73 and 3.21. The r^2 value estimates varied between 0.76 (*S. ocellatus*) and 0.91 (other species).

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Introduction

The *Symphodus* species distributed in the East Atlantic, Black Sea and the Mediterranean to a depth of 1-50 m, on near cliffs and eel-grass beds (Whitehead et al., 1986). Some of its species may show sexual dimorphism and sex reversal (Whitehead et al., 1986). Some previous studies about the characterization of length-weight relationship (LWR) for fish species in the Black Sea, the coast of Turkey were discussed by Demirhan & Can, 2007; Kalaycı et al., 2007; Ak et al., 2009; Yankova et al., 2011; Ergüden et al., 2011; Özdemir & Duyar, 2013; Kasapoğlu & Düzgüneş, 2013; Satılmış et al., 2014; Gündoğdu et al., 2016; Çalık & Sağlam, 2017; Samsun et al., 2017; Türker & Bal, 2018; Yıldız et al., 2018). However, there is no data on the length-weight relationships of wrasse species in these studies. There are two studies on Lapin species in the Eastern Black Sea Region. Kalaycı et al. (2007) studied the meat productivity of the species, Kasapoğlu et al. (2016) studied some biological characteristics of the species *S. tinca*. There are some length-weight relationship studies conducted in other seas and involving wrasse species (Valle et al., 2003; Pallaoro & Jardas, 2003; Verdiell-Cubedo et al., 2006; Özaydın et al., 2007; İlkyaz et al, 2008; İlhan et al., 2008; Keskin & Gaygusuz, 2010; Gürkan

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et al., 2010; Bilge et al., 2014; Dimitriadis & Fournari-Konstantinidou, 2018).

This study aimed to provide data on the relationship between the length and weight of four wrasse fish species captured from the coastal waters of the Eastern Black Sea, Turkey. This research is the first study to determine the LWR of wrasse species in the Eastern Black Sea.

Material and Methods

Study Area and Fish Sampling

This study was carried out on four fish species belonging to the Labridae family, which were caught as discard fish during red mullet fishing in Rize region of the Eastern Black Sea between June 2015 and May 2016 (Figure 1). In this region, fishes were obtained monthly from the fishermen and they were transferred to the laboratory. The fishing was carried out at a depth of 10-40 m with trammel nets (20-24 mm in mesh size).

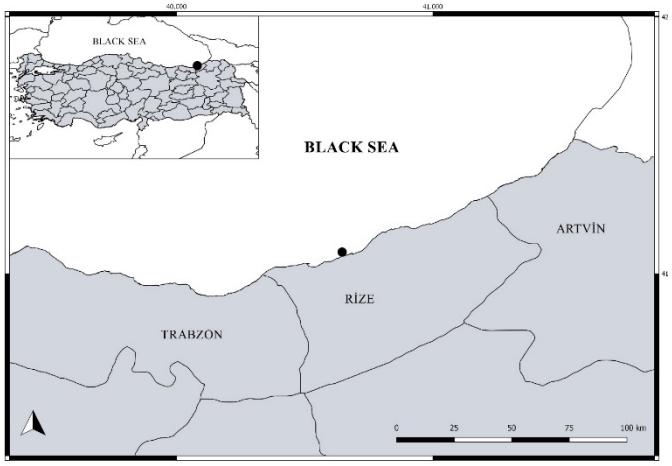

Figure 1. Study area

Length- Weight Relationship (LWR)

Fish species were identified at species level and verified with reference to the Fish Base (Froese & Pauly, 2017). The weight (W) was determined to the nearest 0.01 g and the total length (TL) was measured to the nearest 0.1 cm. The parameters *a* and *b* of relationships of the Equation (1) (Ricker, 1973, 1975) were estimated through logarithmic transformation (Equation 2);

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

$$\log W = \log a + b \log TL \quad (2)$$

where *W* is weight (g), *TL* is total length (cm), *a* is the intercept and *b* is the slope of the linear regression. Parameters *a* and *b* were calculated by least-squares regression, as was the coefficient of determination (r^2). Additionally, 95% confidence limits of the parameter b were estimated. The growth type was identified according to Equation (3):

$$ts = \frac{b-3}{SE(b)} \quad (3)$$

where *ts* is a t-test value, *b* is a slope, and SE(*b*) is a standard error of the slope. According to t-test value of *b*, the growth type was determined as isometric (*b*=3), negative allometric (*b*<3), and positive allometric (*b*>3) (Dutta et al., 2012). All the statistical analyses were evaluated at a 5% significance level ($p<0.05$) (Zar, 1999).

Results

In this research, LWR for 4 species (*S. ocellatus* (n=384), *S. cinereus* (n=321), *S. tinca* (n=17) and *S. roissali* (n=18)) were examined (Figure 2). For all species, sample sizes, length ranges (minimum-maximum), parameters of length-weight relationships (*a* and *b*), 95% confidence intervals of *b* and the coefficient of determination (r^2) and growth types were given in Table 1.

The total length for *S. ocellatus* was between 6.9 and 16.4 cm (11.56 ± 0.050 cm) and the total weight was between 4.77 and 79.97 g (23.36 ± 0.35 g). The total length for *S. cinereus* was between 8.2 and 16.4 cm (12.46 ± 0.069 cm) and the total weight was between 8.51 and 77.49 g (35.28 ± 0.65 g). The total length for *S. tinca* was between 6.5 and 12.8 cm (11.56 ± 0.37 cm) and the total weight was between 3.87 and 36.07 g (20.86 ± 1.77 g). The total length for *S. roissali* 7.4 and 12.2 cm (11.56 ± 0.26 cm) and the total weight was between 6.11 and 28.51 g (21.04 ± 1.34 g). The most abundant species were *S. cinereus* (51.89 %), *S. ocellatus* (43.37 %), *S. roissali* (2.43 %) and *S. tinca* (2.31 %).

Table 1. Length-weight relationships of 4 fish species caught from Eastern Black Sea, Turkey

Species	N	$TL_{min-max}$	$W_{min.-max.}$	*a*	*b*	SE(*b*)	95% CL of b	r^2	t-test
S. ocellatus	321	6.9-16.4	4.77-79.97	0.028	2.73	0.0071	2.89-2.56	0.76	2,77
S. cinereus	384	8.2-16.4	8.51-77.49	0.010	3.21	0.0024	3.31-3.12	0.91	1,67
S. tinca	17	6.5-12.8	3.87-36.07	0.016	2.99	0.0561	3.49-2.49	0.91	0,37
S. roissali	18	7.4-12.2	6.11-28.51	0.014	3.06	0.0535	3.55-2.57	0.91	0,37

Note: *N*: sample size; *TL*: length type: *W*: weight; *min*: minimum; *max*: maximum; *CI*: Confidence interval; *a* and *b* relationship parameters; *SE(b)*: Standard error of b; *r*: Coefficient of determination.

Table 2. LWR parameters fish species estimated from other areas

Species	N	$L_{min-max}$	$W_{min.-max.}$	a	b	r	Region	Reference
S. ocellatus	216	4.7-9.7	-	0.009	3.22	0.96	Aegean	Özaydın et al., 2007
	328	4.7-9.2	1.10-10.56	0.009	3.19	0.97	Aegean	İlhan et al., 2008
	575	1.8-10.7	0.0093	0.010	3.08	0.97	Marmara	Keskin & Gaygusuz, 2010
	10	4.30-6.60	0.59-2.79	0.004	3.48	0.98	Aegean	Gürkan et al., 2010
	456	3-9	-	0.009	3.17	0.96	Mediterranean	Valle et al., 2003
	1922	1.4-18.5	0.01-81.69	0.01	3.2	0.98	Aegean	Altın et al., 2015
	274	4.6-9	-	0.010	3.13	0.95	Aegean	Bilge et al., 2014
S. cinereus	8	6.6-8.6	-	0.008	3.26	0.99	Aegean	İlkyaz et al., 2008
	20	4-7	-	0.011	3.07	0.95	Aegean	Özaydın et al., 2007
	58	22-106	-	0.011	3.11	0.99	Mediterranean	Verdiell-Cubedo et al., 2006
	92	4.5-10.1	2.19-25.35	0.023	3.03	0.86	Aegean	İlhan et al., 2008
	173	2.3-11.3	-	0.009	3.18	0.99	Marmara	Keskin & Gaygusuz, 2010
	4	5.90-7.60	2.9-6.03	0.007	3.24	0.96	Aegean	Gürkan et al., 2010
	665	3.6-15.4	-	0.010	3.13	0.97	Mediterranean	Valle et al., 2003
	61	4.7-9.7	-	0.005	3.51	0.91	Aegean	Bilge et al., 2014
	536	1.5-15.8	0.02-56.32	0.01	3.2	0.96	Aegean	Altın et al., 2015
S. tinca	89	6.7-23	-	0.018	2.91	0.98	Aegean	Özaydın et al., 2007
	277	6.7-24.3	4.28-185.16	0.018	2.91	0.98	Aegean	İlhan et al., 2008
	41	2.1-15.5	-	0.011	3.10	0.99	Marmara	Keskin & Gaygusuz, 2010
	10	4.70-10.50	1-12.09	0.013	2.89	0.96	Aegean	Gürkan et al., 2010
	56	11.4-30.4	-	0.026	2.79	0.97	Mediterranean	Valle et al., 2003
	1443	8.6-42.5	7.9-679.8	0.022	2.81	0.98	Adriatic	Pallaoro & Jardas, 2003
	83	12.4-25.3	30-205	0.026	2.76	0.97	Ionian sea	Dimitriadis & Fournari-Konstantinidou, 2018
	110	6.6-22	-	0.018	2.92	0.96	Aegean	Bilge et al., 2014
	60	11.6-25	22-186	0.019	2.84	0.99	Mediterranean	Miled-Fathalli et al., 2019
	27	3-18.5	0.23-77.22	0.010	3.30	0.99	Aegean	Altın et al., 2015
	248	10-26.8	-	0.010	3.04	0.97	Aegean	Karakulak et al., 2006
S. roissali	22	2.4-14.1	-	0.007	3.39	0.98	Marmara	Keskin & Gaygusuz, 2010
	120	-	-	0.035	2.67	0.95	Mediterranean	Gordoa et al., 2000

Regarding the type of growth, two species (*S. ocellatus*, and *S. tinca*) showed positive allometry, two species (*S. cinereus* and *S. rossali*) showed negative allometry. In the findings of this study, the "*a*" values ranged from 0.0010 to 0.028 while the "*b*" parameters varied between 2.73 and 3.21. The determination coefficients (r^2) ranged between 0.76 (for *S. ocellatus)* and 0.91 (for other species).

Discussion

In this research, 740 fish samples belonging to the Labridae family and to four species were caught and examined. Due to the lack of other studies in the region, the study was compared with some studies conducted in other seas.

While the b value for *S. ocellatus* ranged between 3.08 and 3.48 in other studies (Valle et al., 2003; Özaydın et al, 2007; İlhan et al, 2008; Keskin & Gaygusuz, 2010; Gürkan et al, 2010; Bilge et al., 2014; Altın et al., 2015). It was found to be 2.73 in our study. In addition, the r value for *S. ocellatus* was calculated as 0.76. This value is low, this may be related to the nutrition of individuals. The b value for *S. cinereus* ranged from 3.03 to 3.51 in other studies. In this study, the b value was determined to be 3.22, similar to other studies (Table 2). The b value for *S. tinca* was calculated as 2.99. While this value differs with the work of Keskin & Gaygusuz (2010), it is similar to other studies (Table 2). The b value for *S. roissali* was determined to be 3.06. While this value differs from the work of Gordo et al. (2000), it is similar to Keskin & Gaygusuz (2010).

The LWR is affected by some factors such as stomach fullness sex, preservation techniques, feeding habits, health, maturity, season, and habitat (Tesch, 1968), and annual differences in environmental conditions (Froese, 2006). In addition, differences in the period and size composition of the sampling might affect *b* values of the LWR (Table 2). Furthermore, some authors used the standard length (SL) while others used the total length (TL).

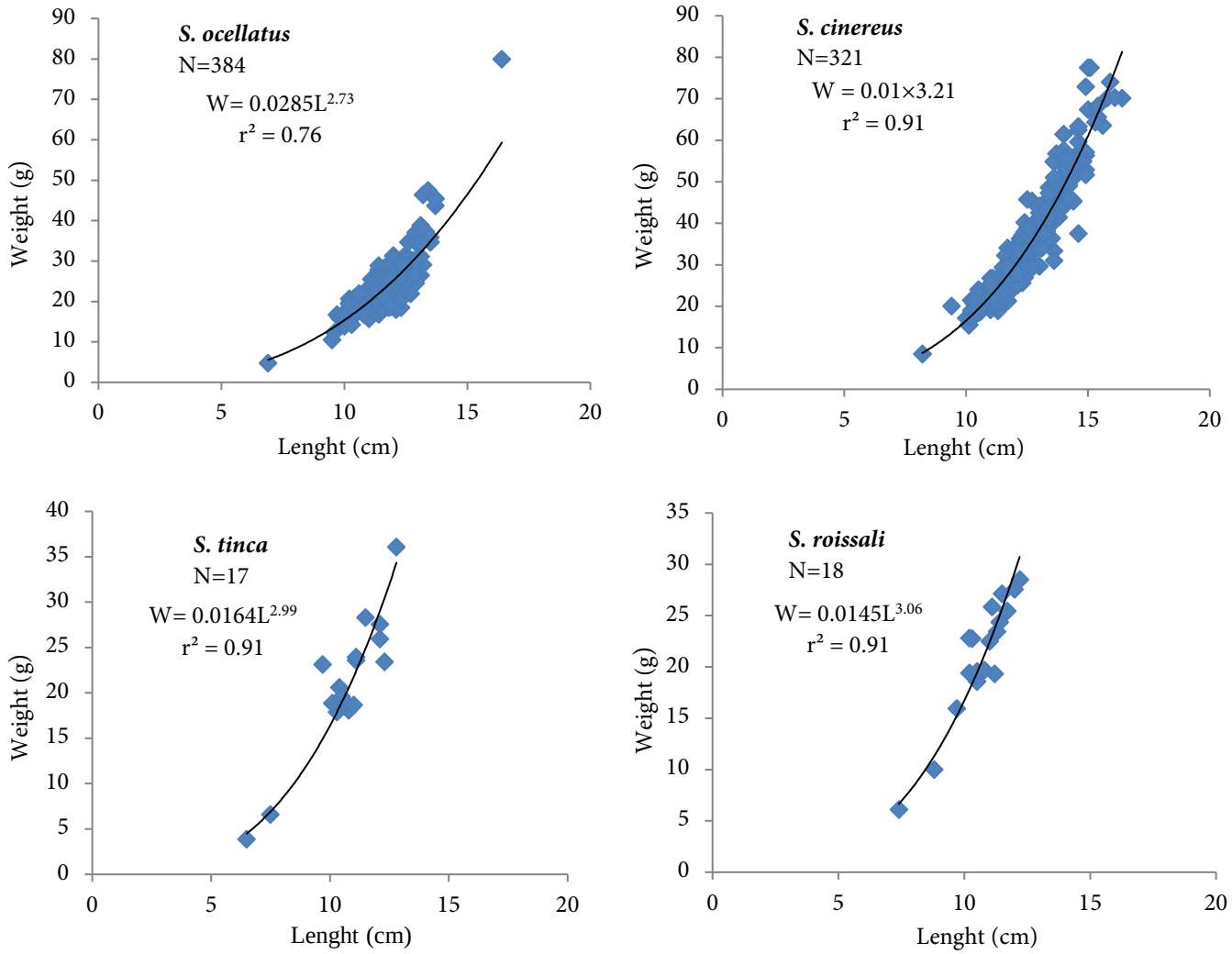

Figure 2. The curves of length-weight relationships for four *Symphodus* species from the Rize coast in the south-eastern Black Sea, Turkey

Indeed, the estimation of LWR is needed and important as it provides information on population conditions. It is also a widely applied approach in the study of the dynamics of exploited stocks and an effective tool used for basic research and management strategies in fisheries. Moreover, the parameters of length-weight relationships allow other authors to make comparisons between different populations of the same living species in similar or different ecosystems (Pauly, 1993; Petrakis & Stergiou, 1995; Gongalves et al., 1997).

Conclusion

With this study, new findings on the wrasse fish in the Black Sea basin were determined. The data related to the fish on the coast of Turkey will contribute to future works. In addition, these data can be used in the assessment of fish stocks of species that have not yet been exploited and have no economic value. Moreover, the increasing need for protein is important in terms of bringing these species to the economy and consuming them as human food. Further studies of this species are required to expand our knowledge of life cycles in the conditions of the Black Sea basin.

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Compliance with Ethical Standards

Conflict of Interest

The author confirms that no conflicts of interest exist and the funders had no role in study design, data collection, analysis, and decisions.

Ethical Approval

For this type of study, formal consent is not required.

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