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Length-Weight Relationships of Four *Symphodus* Species (Perciformes: Labridae) off Gökçeada Island (Northern Aegean Sea, Turkey)

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ABSTRACT

The present work provides length-weight relationships (LWRs) of four *Symphodus* species off Gökçeada Island (Northern Aegean Sea, Turkey). The sampling was ensured between November 2013 and December 2014 from commercial fishmongers. This study presents the most recent and the broadest analysis of the LWRs for the following studied species: *Symphodus ocellatus*, *Symphodus tinca*, *Symphodus mediterraneus*, *Symphodus rostratus*. The *b* value varied between 2.81 and 3.37, whereas r^2 aligned from 0.89 to 0.95.

INTRODUCTION

Some morphometric relationships such as length-weight relationships (LWRs), maximum size and length-girth relationships (LGRs) are important to grasp the fishes' condition in their environmental conditions such as history of life, growth pattern, fish fatness, habitat conditions, and general health, (Froese, 2006; Paruğ & Cengiz, 2020; Cengiz 2021). LWRs have been commonly used by fisheries managers and aquatic biologists to appraise the fish stocks, the fisheries ecology and the population dynamics in aquatic ecosystems, and semi-controlled aquatic environments (Ricker, 1968). Over and above, the productivity level and ecological health of aquatic ecosystems could be assessed via length-weight models (Deekae & Abowei, 2010). These models help to evaluate the well-being and the growth patterns of fishes (Muchlisin et al., 2010; Ndiaye et al., 2015).

Labridae has 504 species in the world (Parenti & Randall, 2011), there are 20 species in Turkish coasts (Bilecenoğlu et al., 2014). *Symphodus* species distributed in the Eastern Atlantic, Black Sea and Mediterranean with a depth of 1-50 m, near rocks and eel-grass beds (İlhan et al., 2008). In addition, the sex reversal and the sexual dimorphism could monitor in some species (Whitehead et al., 1986; İlhan et al., 2008). The studies on *Symphodus* fishes have been carried out in assorted areas of the world (Nival, 1966; Stergiou & Moutopoulos, 2001; Pallaoro & Jardas, 2003; Kalaycı et al., 2007; İlhan et al., 2008; Raposeiro & Azevedo, 2009; Škeljo et al., 2015; Kasapoglu et al., 2016; Aydın, 2020; Onay, 2021), in epitome. Torres et al. (2012) underlined that LWRs could change spatially and/or temporarily, therefore these works must be regularly renewed for each discrete population. From this point of view, this study provides new values concerning the relationship between the length and weight of four *Symphodus* species (*S. ocellatus*, *S. tinca*, *S. mediterraneus*, *S. rostratus*) captured from Gökçeada Island (Northern Aegean Sea, Turkey).

MATERIAL AND METHODS

The northern Aegean coasts of Turkey are divided into sub-regions as Saros Bay, Gallipoli Peninsula, Gökçeada Island, Bozcaada Island, and Edremit Bay (Cengiz & Paruğ,

2020, 2021). The northern Aegean areas are described to be an extended continental shelf, smooth muddy/sandy bases and upper nutrient concentrations (Maravelias & Papaconstantinou, 2006) and have higher phytoplankton and zooplankton abundance compared with the southern Aegean Sea (Theocharis et al., 1999). Therewithal, upwellings significantly affected the northern Aegean Sea. It happens in the Aegean Sea (Metaxas, 1973) by virtue of strong northerly winds in summers between August and September, generally. On the ground of the subsurface cool water upwellings, surface temperature changes form a thermal front between the western and eastern regions of the northern Aegean Sea (Zodiatis & Balopoulos, 1993). In addition, The Black Sea inlet is possibly a significant element within the variations in environmental conditions. The Black Sea water led to strong stratification, which facilitates free communication to the shallow waters (Olson et al., 2007). For these reasons, Gökçeada Island (Figure 1) displays the diversity in terms of the species' composition (Keskin & Ünsal, 1998; Karakulak et al., 2006; Altın et al., 2015) and the fishing activity is rather vital for the Island (Cengiz, 2020).

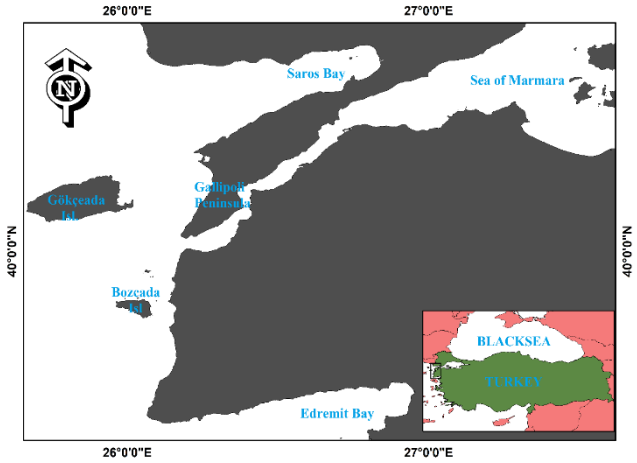

Figure 1. Gökçeada Island and the northern Aegean coasts of Turkey

Four *Symphodus* species were obtained, monthly, from commercial fishmongers around Gökçeada Island between November 2013 and December 2014. Fish were identified according to Mater et al. (2003). Checking the scientific name for each species has been performed in accordance with Froese & Pauly (2021). The individuals were measured to the nearest 1 mm (total length), weighed to the nearest 0.01 g (total weight). The length-weight relationship was uncovered by fitting an exponential curve, $W = aL^b$ (Le Cren, 1951). In this equation, the parameters a and b of the exponential curve were predicted by linear regression analysis over log-transformed data by using the logarithmic transformation equation, $\log W = \log a + b \log L$. In this equation, L is the total length (cm), W is the total weight (g), a is the intercept, and b is the slope or allometric coefficient, using the least-squares method. Growth types of these species were determined using t-test at significance level of 5% according to $t_s = \frac{b-3}{SE_b}$, where t_s is a t-test value, b is a slope, and SE_b is the standard error of the slope (Dutta et al., 2012). Hereby, $b > 3$ indicates a positive allometric growth, while value $b < 3$ displays a negative allometric growth. It is isometric growth when value b is equal to 3 (Bagenal & Tesch, 1978).

RESULTS

In the present study, LWRs of four *Symphodus* species [(*S. mediterraneus* (n=23), *S. ocellatus* (n=23), *S. rostratus* (n=34), *S. tinca* (n=22)] were analyzed. The sample size, minimum and maximum lengths and weights, estimated parameters of LWR (a and b), 95% confidence intervals of b and coefficient (r^2) are given in Table 1 for each species, respectively.

All regressions were highly significant ($p < 0.01$), with the coefficient of determination (r^2) ranging from 0.89 to 0.95. About the type of growth, while one species (*S. rostratus*) showed positive allometry growth, two species (*S. ocellatus, S. tinca*) displayed negative allometry growth. In addition, one species (*S. mediterraneus*) indicated isometric growth. The b values ranged between 2.81 and 3.37, whereas a values varied between 0.0061 to 0.0342 (Figure 2).

Table 1. Length-weight relationships of four *Symphodus* species off Gökçeada Island (Northern Aegean Sea, Turkey)

Species	N	Length range (cm)		Weight range(g)		*a*	*b*	*95% CI of b*	r^2
		L_{min}	L_{max}	W_{min}	W_{max}				
S. mediterraneus	23	10.1	13.7	17.18	44.00	0.0148	3.05	2.36 – 3.72	0.89
S. ocellatus	23	10.5	15.1	18.46	54.61	0.0342	2.68	2.42 – 2.94	0.95
S. rostratus	34	8.8	14.7	8.91	47.78	0.0061	3.37	2.95 – 3.79	0.90
S. tinca	22	10.5	17.1	20.26	80.57	0.0261	2.81	2.54 – 3.08	0.95

Note: *N*: Sample size; L_{min}: minimum length; L_{max}: maximum length; W_{min}: minimum weight; W_{max}: maximum weight; a and b: intercept and slope of length-weight relationships; *CI*: confidence interval; r^2: the coefficient of determination.

Table 2. LWRs of four *Sympodus* species from different areas

Species	References	Area	N	Length range (cm)	*a*	*b*
S. mediterraneus	Petrakis & Stergiou (1995)	South Euboikos Gulf (Greece)	19	6.3 – 13.6	0.000014	3.01
	Valle et al. (2003)	Western Mediterranean (Spain)	41	4.8 – 12.3	0.0212	2.87
	Karakulak et al. (2006)	Gökçeada Island (Turkey)	39	9.8 – 16.4	0.0173	2.90
	Özaydın et al. (2007)	İzmir Bay (Turkey)	39	4.9 – 20.2	0.0127	3.08
	İlhan et al. (2008)	İzmir Bay (Turkey)	62	4.9 – 20.2	0.0147	3.00
	Bilge et al. (2014)	Southern Aegean (Turkey)	38	4.7 – 16.6	0.0139	3.00
	Altın et al. (2015)	Gökçeada Island (Turkey)	72	2.0 – 12.2	0.0100	3.15
	This study	Gökçeada Island (Turkey)	23	10.1 – 13.7	0.0148	3.05
S. ocellatus	Petrakis & Stergiou (1995)	South Euboikos Gulf (Greece)	31	4.4 – 9.9	0.000005	3.22
	Valle et al. (2003)	Western Mediterranean (Spain)	456	3.0 – 9.0	0.0091	3.17
	Özaydın et al. (2007)	İzmir Bay (Turkey)	216	4.7 – 9.2	0.0085	3.22
	İlhan et al. (2008)	İzmir Bay (Turkey)	328	4.7 – 9.2	0.0091	3.18
	Gürkan et al. (2010)	Candarlı Bay (Turkey)	10	4.3 – 6.6	0.0041	3.47
	Keskin & Gaygusuz (2010)	Erdek Bay (Turkey)	575	1.8 – 10.7	0.0102	3.10
	Bilge et al. (2014)	Southern Aegean (Turkey)	274	4.6 – 9.0	0.0102	3.13
	Altın et al. (2015)	Gökçeada Island (Turkey)	1922	1.4 – 18.5	0.0070	3.22
	Onay (2021)	Eastern Black Sea (Turkey)	384	8.2 – 16.4	0.0100	3.21
	This study	Gökçeada Island (Turkey)	23	10.5 – 15.1	0.0342	2.68
S. rostratus	Petrakis & Stergiou (1995)	South Euboikos Gulf (Greece)	70	8.0 – 12.0	0.000001	3.48
	Valle et al. (2003)	Western Mediterranean (Spain)	1156	1.5 – 14.3	0.0176	2.80
	Karakulak et al. (2006)	Gökçeada Island (Turkey)	19	9.6 – 12.7	0.0177	2.83
	Özaydın et al. (2007)	İzmir Bay (Turkey)	36	7.1 – 10.9	0.0049	3.46
	İlhan et al. (2008)	İzmir Bay (Turkey)	167	7.0 – 11.4	0.0070	3.29
	Bilge et al. (2014)	Southern Aegean (Turkey)	42	6.7 – 12.5	0.0048	3.41
	Altın et al. (2015)	Gökçeada Island (Turkey)	1016	1.2 – 17.7	0.0070	3.19
	This study	Gökçeada Island (Turkey)	34	8.8 – 14.7	0.0061	3.37
S. tinca	Petrakis & Stergiou (1995)	South Euboikos Gulf (Greece)	31	12.7 – 20.8	0.000011	3.06
	Pallaoro & Jardas (2003)	Adriatic Sea (Croatia)	1443	8.6 – 42.5	0.0220	2.81
	Valle et al. (2003)	Western Mediterranean (Spain)	56	11.4 – 30.4	0.02584	2.78
	Karakulak et al. (2006)	Gökçeada Island (Turkey)	248	10.0 – 26.8	0.0109	3.04
	Özaydın et al. (2007)	İzmir Bay (Turkey)	89	6.7 – 23.0	0.0183	2.90
	İlhan et al. (2008)	İzmir Bay (Turkey)	277	6.7 – 24.3	0.0184	2.90
	Keskin & Gaygusuz (2010)	Erdek Bay (Turkey)	41	2.5 – 15.5	0.0111	3.09
	Bilge et al. (2014)	Southern Aegean (Turkey)	110	6.6 – 22.0	0.0180	2.92
	Altın et al. (2015)	Gökçeada Island (Turkey)	27	3.0 – 18.5	0.0070	3.26
	Dimitriadis & Fournari-Konstantinidou (2018)	Southern Ionian Sea (Greece)	83	12.4 – 25.3	0.0260	2.76
	Miled-Fathalli et al. (2019)	Gulf of Tunis (Tunusia)	60	11.6 – 25.0	0.0190	2.84
	Onay (2021)	Eastern Black Sea (Turkey)	17	6.5 – 12.8	0.0160	2.99
	This study	Gökçeada Island (Turkey)	22	10.5 – 17.1	0.0261	2.81

Note: *N*: Sample size; *a* and *b*: intercept and slope of length-weight relationships.

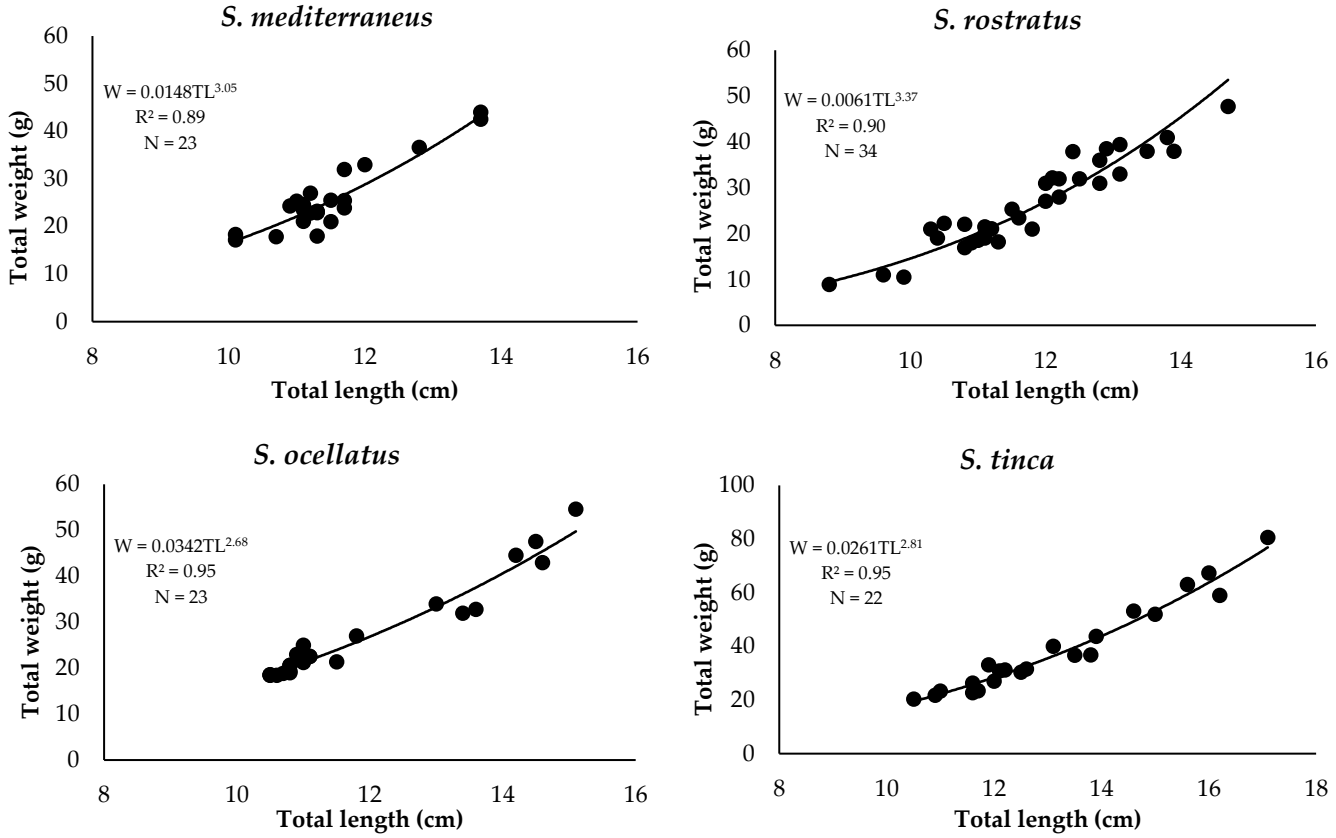

Figure 2. The curves of length-weight relationships for four *Symphodus* species off Gökçeada Island (Northern Aegean Sea, Turkey)

DISCUSSION

In the present study, 102 individuals belonging to four species were examined. Table 2 summarizes the previous studies on LWRs for four *Sympodus* species. The *b* values in LWRs fall between 2.5 and 3.5 (Froese, 2006) or 2 to 4 (Tesch, 1971). In this study, *b* values of the studied fish species were within these expected ranges. The *b* value for *S. mediterraneus* varied between 2.87 and 3.15 in other studies, whereas this value ranged from 3.10 to 3.47 for *S. ocellatus*. The b value for *S. rostratus* was calculated as 3.37. While this value differs from the studies of Valle et al. (2003) and Karakulak et al. (2006), it is similar to other researches. The *b* value for *S. tinca* was estimated to be 2.81. While the ones differ from Petrakis & Stergiou (1995), Karakulak et al. (2006), Keskin & Gaygusuz (2010), Altın et al. (2015) and Onay (2021), it shows similarity with some related works (Table 2).

The length-weight relationships may be changed between different seasons and are affected by factors such as size, temperature, maturity, salinity and food availability. Furthermore, the degree of sexual maturity, diet, fullness or emptying gut and sampling techniques, number and duration of sampling can affect its value (Yıldırım et al., 1999; Wootton, 2003; Abbasi et al., 2019; Eagderi et al., 2020).

Altın et al. (2015) reported the LWRs of seven *Symphodus* species from shallow waters of Gökçeada Island using a beach seine and beam trawl. Cengiz et al. (2011, 2012) underlined that the diversity of species within an area and/or among areas could be relevant to environmental conditions and sundry fishing gears in the sampling. The likely reason for differences in the variety of species between Altın et al. (2015) with this study is presumably by virtue of diversified fishing gears that the commercial fishermen used.

CONCLUSION

In conclusion, this study provided new information about LWRs for four *Sympodus* species from Gökçeada Island (Northern Aegean Sea, Turkey) and added further data to those previously reported species, which will be helpful in biological studies.

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Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

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

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