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Length-Weight Relationships of 10 Fish Species from the Southern Black Sea, Turkey

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Abstract: In this study, the length-weight relationships of 10 fish species collected with gill and trammel nets during June 2010 and June 2011 from the Eastern Black Sea coasts of Turkey, were investigated. The b values of the length-weight relationships for 10 fish species ranged from 2.549 to 3.301 with a mean value of 3.070 ± 0.039 (S.E.). Five, four and one species showed isometric, positive allometric and negative allometric growth, respectively. The differences in b values of male and female of *Engraulis encrasicolus, Merlangius merlangus, Mullus barbatus, Scorpaena porcus, Solea solea, Spicara maena and Uranoscopus scaber* were significant. (ANCOVA, $P < 0.05$).

Keywords: Length-weight relationship, fish species, growth type, Southern Black Sea.

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Introduction

Length-weight data are widely used to gather information on biology of fishes. In general, this and other different kind of analysis have become one of the standard methods used in fisheries biology (Le Cren, 1951; Kohler et al., 1995). These data are necessary in estimation of the growth rates, age and length composition of fish populations (Kohler et al., 1995). In fish, size is generally more biologically relevant than age, mainly because several ecological and physiological factors are more size-dependent than age. Consequently, variability in size has important implications in diverse aspects of fisheries science and population dynamics (Erzini, 1994). A length- weight relationship (LWR) presents useful information for understanding the relative condition of fish stocks. In addition, LWR is used in various important applications for evaluation of fish stocks (Ricker, 1968; Pauly, 1993; Garcia et al., 1998; Haimovici and Velasco, 2000). Some of these applications include assessment of available fish stock and comparison of fish populations existing in different regions (Petrakis and Stergiou, 1995). Furthermore, length-weight (L-W) relationships have special importance in fisheries research because they (a) are used to convert growth-in-length equations to growth-in-weight in stock assessment models, (b) allow the estimation of the biomass of a species from length frequency distributions, (c) the condition of fish; and (d) are useful for between region comparisons of life histories of a certain species (Gonçalves et al., 1997; Binohlan and Pauly, 2000).

The aim of this study is to determine the length-weight relationships of 10 fish species, most of which are demersal species caught by gill and trammel nets in the Eastern Black Sea of Turkey. The reported results may contribute to management of fisheries resources in the area.

Materials and Methods

Samples were collected from the monthly fishing trials performed between June 2010 and June 2011 in the Eastern Black

Table 1. Descriptive statistics and estimated parameters of length-weight relationship of 10 fish species caught by gillnet and trammel nets in the Eastern Black Sea, Turkey.

Species			Length and weight characteristics		Parameters of the relationship				Growth (*t*-test)	p
	Sex	N	Length (cm) min-max	Weight (g) min-max	a	b	S.E. (b)	r^2		
Alosa fallax pontica	M	17	16.1-22.7	26.57-77.52	0.0032	3.279	0.228	0.933	Allometric +	ns
	F	23	16.2-23.5	31.57-104.72	0.0056	3.092	0.125	0.967	Isometric	
	All	42	16.1-23.5	26.57-104.72	0.0046	3.163	0.107	0.958	Isometric	
Engraulis encrasicolus	All	19	6.2-13.5	1.72-13.64	0.0182	2.549	0.102	0.974	Allometric -	*
Merlangius merlangus	M	1314	8.0-23.6	4.08-111.54	0.0042	3.226	0.021	0.946	Allometric +	*
	F	1331	7.6-24.2	3.33-106.91	0.0049	3.168	0.020	0.949	Allometric +	
	All	2705	7.6-24.2	3.33-111.54	0.0046	3.195	0.014	0.947	Allometric +	
Mullus barbatus	M	212	9.4-19.8	8.49-66.21	0.0090	2.993	0.073	0.889	Isometric	*
	F	433	11.1-21.4	12.41-96.22	0.0064	3.134	0.043	0.924	Allometric +	
	All	672	7.4-22.6	2.68-102.50	0.0066	3.119	0.034	0.925	Allometric +	
Ophidion barbatum	M	14	16.9-22.2	24.70-55.83	0.0141	2.648	0.196	0.938	Isometric	ns
	F	19	18.0- 21.4	29.20-50.52	0.0047	3.026	0.257	0.891	Isometric	
	All	34	16.9-22.2	24.70-55.83	0.0096	2.777	0.146	0.918	Isometric	
Parablennius gattorugine	All	11	12.6-16.8	26.80-60.78	0.0125	3.021	0.224	0.953	Isometric	ns
Scorpaena porcus	M	458	9.1-22.8	12.92-280.03	0.0112	3.214	0.040	0.935	Allometric +	*
	F	345	8.2-27.9	11.69-470.00	0.0119	3.215	0.031	0.969	Allometric +	
	All	943	8.2-27.9	9.19-470.00	0.0091	3.301	0.021	0.962	Allometric +	
Solea solea	M	117	11.7-19.0	14.44-60.31	0.0105	2.909	0.118	0.840	Isometric	*
	F	183	12.2-22.2	13.25-104.71	0.0055	3.154	0.073	0.913	Allometric +	
	All	309	11.7-22.2	13.25-104.71	0.0062	3.111	0.059	0.901	Isometric	
Spicara maena	All	12	12.1-19.4	4.34-77.52	0.0124	2.942	0.185	0.962	Isometric	*
Uranoscopus scaber	M	244	9.1-20.8	10.81-147.85	0.0143	3.053	0.057	0.921	Isometric	*
	F	271	7.3-25.5	6.03-326.66	0.0097	3.206	0.036	0.967	Allometric +	
	All	606	6.9-25.5	5.46-326.66	0.0103	3.176	0.024	0.967	Allometric +	

* = Significant ($P < 0.05$), ns = not significant ($P > 0.05$); F = Female; M = Male

N = number of samples; min = minimum, max = maximum; a and b are the parameters of relationship; S.E. = standard error; r^2 = coefficient of determination

Sea coasts of Turkey. Fish specimens were collected using gill and trammel nets at depths ranging from 8 m to 95 m. The length of gill and trammel nets consisting of five different mesh sizes (16, 17, 18, 20, 22 mm bar length) were 639 m and 590 m, respectively. The total length (TL) and weight (W) of each fish were measured to the nearest 0.1 cm and 0.01 g, respectively. The relationships between length and weight is expressed by $W = a \times L^b$, which was converted to linear form as $\ln W = \ln a + b \ln L$, where W is total body weight (g), L is the total length (cm), a = intercept and b = slope regression coefficients (Ricker, 1973; King, 2007). When b values equal to 3, less than and higher than 3, then fish species in questions is said to show isometric, negative allometric and positive allometric growth, respectively. (Bagenal and Tesch, 1978; Santos et al., 2002). The b value for each species was tested with a t-test at the 0.05 level of significance to verify whether it was significantly different from the predicted values for isometric growth (Morey et al., 2003). For this test, the following equation was used (Sokal and Rohlf, 1987);

$$t_s = (b - 3) / s_b,$$

Where t_s is the value of t test, b is the slope and s_b is the standard error of b. Analysis of covariance (ANCOVA) was used to determine whether there was significant difference in slopes between sexes (Zar, 1999).

Results and Discussion

A total of 5353 individuals belonging to 10 fish species sampled during in the study. The sample size ranged from 11 individuals for *Parablennius gattorugine* to 2705 for *Merlangius merlangus euxinus*. Table 1 presents the sample sizes, the minimum and maximum L-W values, the coefficients of determination (r^2), regression coefficients and the growth types of each species. In order to compare the results of the present study with those of other length-weight relationship studies in different areas were presented in Table 2. The length-weight relationship parameter, b value, generally ranges between 2 and 4 (Bagenal and Tesch, 1978), often close to 3 (Jobling, 2002). The b values ranged from 2.549 for *E. encrasicolus* to 3.301 for *S. porcus* with mean value of 3.070 ± 0.039 (S.E.). The coefficient of determination (r^2) value

Table 2: Some study results of length-weight relationship for the fish species in different areas.

Species	Length (cm) min-max	a	b	Location	References
A. fallax pontica	11.6-31.6	0.0021	3.390	Middle Black Sea	Samsun, 1995
	17.6-24.6	0.0102	2.926	N. Aegean Sea	Karakulak et al., 2006
	11.9-27.6	0.0046	3.124	Middle Black Sea	Kalaycı et al., 2007
E. encrasicolus	6.0-15.0	0.0076	2.919	Middle Black Sea	Samsun et al., 2004
	8.0-14.7	0.0174	2.601	Middle Black Sea	Kalaycı et al., 2007
	10.3-15.7	0.0240	2.507	Black Sea	Yankova et al., 2011
M. merlangus	9.0-24.0	0.0039	3.240	Middle Black Sea	İşmen, 2002
	5.0-40.0	0.0052	3.140	Middle Black Sea	Kalaycı et al., 2007
	5.5-22.5	0.0040	3.151	East Black Sea	Ak et al., 2009
	10.6-24.5	0.0120	2.836	Sea of Marmara	Demirel and Dalkara, 2012
M. barbatus	12.5-22.3	0.0049	3.273	N. Aegean Sea	Karakulak et al., 2006
	6.6-18.4	0.0111	2.963	Middle Black Sea	Kalaycı et al., 2007
	6.8-14.6	0.0051	3.240	S. Black Sea	Demirhan and Can, 2007
	6.1-21.9	0.0070	3.139	East Black Sea	Ak et al., 2009
O. barbatum	10.1-24.0	0.0027	3.183	N. Aegean Sea	Lamprakis et al., 2003
	19.7-25.4	0.0762	2.081	N. Aegean Sea	Karakulak et al., 2006
	7.3-17.7	0.0029	3.240	Marmara region	Ozen et al., 2009
P. gattorugine	5.2-16.1	0.0084	3.241	N. Aegean Sea	Koutrakis and Tsikliras, 2003
	3.2-11.8	0.0217	3.010	Eastern Ionian Sea	Liousia et al., 2012
S. porcus	8.5-29.2	0.0173	3.034	Middle Black Sea	Kalaycı et al., 2007
	5.0-34.2	0.0090	3.272	East Black Sea	Ak et al., 2009
	7.5-27.2	0.2090	2.987	Aegean Sea	Akalın et al., 2011
S. solea	6.9-16.0	0.0043	3.171	Sea of Marmara	Bok et al., 2011
	15.0-45.0	0.1130	2.960	France C. coasts	Crec'hriou et al., 2012
20.0-33.2	0.0060	3.055	Sea of Marmara	Demirel and Dalkara, 2012	
11.0-22.0	0.0028	3.505	N. Aegean Sea	Karakulak et al., 2006	
7.5-20.0	0.0110	3.020	Aegean Sea	Soykan et al., 2010	
10.4-18.0	0.0100	3.025	Sea of Marmara	Demirel and Dalkara, 2012	
5.3-21.8	0.0150	3.050	S. Black Sea	Demirhan and Can, 2007	
1.8-56.4	0.0080	3.226	East Black Sea	Ak et al., 2009	
10.7-24.6	0.0109	3.154	Sea of Marmara	Bok et al., 2011	

was calculated 0.901 for *S. solea* and 0.974 for *E. encrasicolus* with mean value of 0.935 ± 0,007 (S.E.). Five, four and one species showed isometric, positive allometric and negative allometric growth, respectively. Analysis of covariance (ANCOVA) showed that the differences in slopes(b values) between the sexes for *E. encrasicolus, M. merlangus, M. barbatus, S. porcus, S. solea, S. maena* and *U. scaber* were significant ($P < 0.05$).

The length-weight relationship varies among species according to genetically body shape and to the condition of individuals of a fish species. The condition sometimes reflects the presence of nutrients and the growth before in the sampling week, but condition is variable and dynamic. Individuals within the same sampling considerably vary, however, the average condition of individuals in each population differs according to years and seasons. For some species, sex and gonad development are important variables (Schneider et al., 2000). Also, many factors such as habitat, diet, locality, and stomach fullness are the other important variables that affect the length–weight relationship in fishes (Esmaeili and Ebrahimi, 2006).

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