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Full Length Research Paper

Length-weight and length-length relationships of the Mediterranean shad *Alosa agone* (Scopoli, 1786) from the Northeastern Mediterranean coast of Turkey

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The relationships between total length (TL), fork length (FL) and standard length (SL), and between TL and weight were investigated for Mediterranenan shad, *Alosa agone,* from two estuary localities (Karaduvar and Samandag), North-eastern Mediterranean coast of Turkey. A total of 297 specimens, 150 males and 147 females, were captured by gill net and trammel net between September 2006 and May 2007 from the NE Mediterranean Sea coast of Turkey. The values of the exponent b of the length-weight relationships (LWRs) were 3.50 for female and 3.49 for male. The length-length relationship (LLRs) between the three length measurements (TL-FL-SL) were highly correlated (r^2>0.99, P<0.001). This study presented the first reference on LWRs and LLRs for Mediterranean shad species from NE Mediterranean coast of Turkey.

Key words: *Alosa agone,* Mediterranean shad, length-weight relationship, length-length relationship, NE Mediterranean Sea.

INTRODUCTION

Shad species (Clupeidae) have only one represantative, *Alosa agone* (Scopoli, 1786), in the Mediterranean Sea. Mediterranean shad *A. agone* are primarily anadromous clupeids that occur in the Adriatic and Mediterranean basins (Whitehead, 1984). This species is locally found mainly in the marine, estuarine sites, along Mediterranean coast of Turkey. *A. agone* is a large species, reaching over 55 cm fork length and 1500 g body weight (Whitehead, 1985; Turan et al., 2007).

Length-weight relationships (LWRs) of fishes are useful in determining the weight and biomass when only length measurements are available and allow comparisons of species growth between different habitats or regions, and also are required in fishery management and conservation (Froese, 1998; Koutrakis and Tsikliras, 2003, Oscoz et al., 2005). The length-length relationship (LLRs) is also of great importance for comparative growth studies (Moutopoulos and Stergiou, 2002).

To the best of our knowledge, there is no information on LWRs and LLRs for *A. agone*. This study paper provides the first comprehensive description of LWRs and LLRs of *A. agone* from the Northeastern Mediterranean coast of Turkey according to their sexes.

MATERIALS AND METHODS

A. agone specimens were collected between September 2006 and May 2007 from two estuary localities, Karaduvar and Samandag (36° 02´ N 35° 57' E-36° 48´ N 34° 42' E), North-eastern coast of Turkey. A total of 297 specimens were captured by gill net and trammel net. After capture, all the fishes were immediately transported on crushed ice to laboratory for analysis. This species have complex taxonomic relationships that are presently unclear, and researchers are not in full agreement on their taxonomic status. For this reason, the nomenclatural assignments of Kottellat (1997) and Fishbase (Froese and Pauly, 2010) were used. Total length (TL), fork length (FL) and standard length (SL) of each fish obtained specimen was measured to the nearest cm and total weight (W) to

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Abbreviations: TL, Total length; **FL,** fork length; **SL,** standard length; **W,** total weight; **LWRs,** length-weight relationships; **LLRs,** length-length relationships.

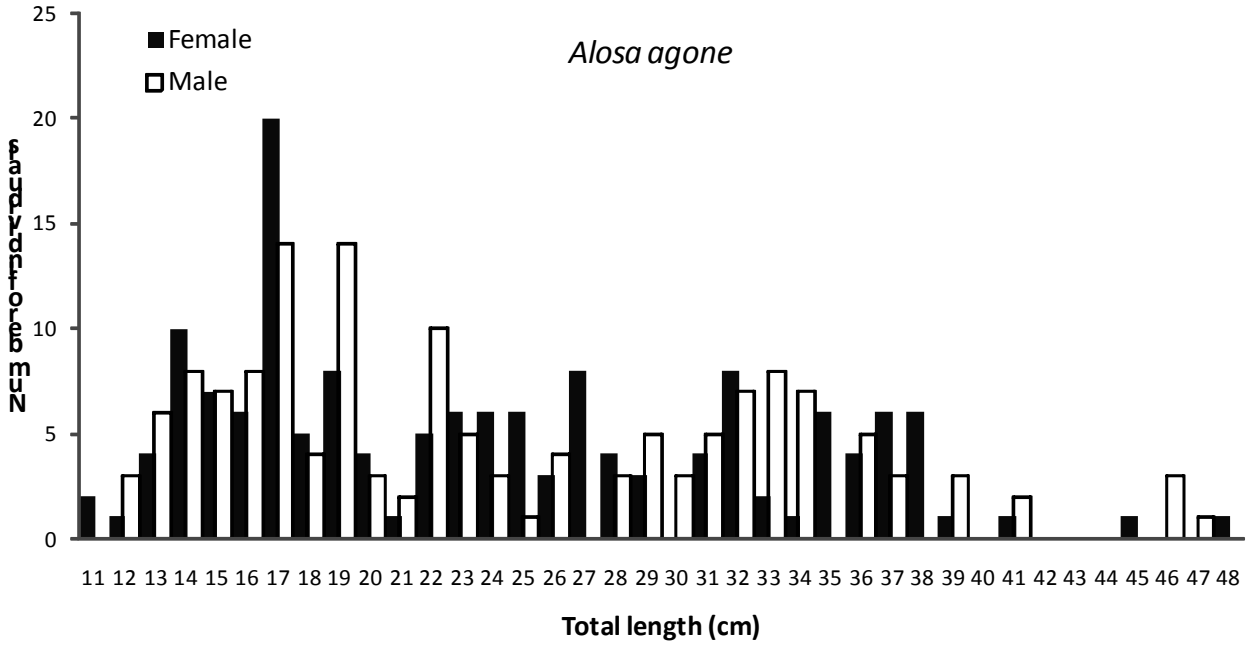

Figure 1. Total length (cm) frequency of females and males specimens of Mediterranean shad, *A. agone* from the NE Mediterranean coast of Turkey

Table 1. Descriptive statistic and estimated parameters of length-weight relationships for Mediterranean shad species from NE Mediterranean coast of Turkey.

Specie	Sex	n	Length		Weight		Relationship parameter			
			TL Range (cm)	Mean TL (±SE)	Range W (g)	Mean W (±SE)	a	b	SE(b)	r^2
A. agone[1]	Female	150	11.50-48.00	24.30±0.68	10.31-1576.32	206.39±20.73	0.0011	3.50	0.34	0.987
	Male	147	12.50-47.00	24.42±0.71	13.52-1531.60	212.26±23.37	0.0010	3.49	0.31	0.989
	Both	297	11.50-48.00	24.36±0.49	10.31-1576.32	214.57±15.57	0.0010	3.49	0.23	0.988

n, Sample size; TL, total length; W, total weight; a, intercept; b, slope; SE, standard error; r^2, determination coefficients; [1]Length-weight relationship not previously reported for Turkish NE Mediterranean Sea.

the nearest 0.01 g. The LWRs was $W = TL^b$ (Ricker, 1973), the statistical significance level of r^2 was estimated, and the parameters a and b estimated by least square linear regressions were performed by the log-transformed equation, log W = log a + b log TL, where, W is the weight of the fish in grams; TL is the total length in centimeters and a and b are the intercept and the slope of the regression line, respectively. LLRs were established using linear regression analysis: TL–SL, SL–FL and FL–TL. LWRs for Mediterranean shad species were calculated separately according to the sex. The significance of regression was assessed by analysis of variance (ANOVA), and the b value was determined by Student's t-test using the SPSS computer package program.

RESULTS AND DISCUSSION

Of the 297 specimens ranging from 11.5 to 48.0 cm TL, 150 were males and 147 were females. Length-frequency indicated that the 17.0 cm length classes had the highest number of male and female specimens, respectively (Figure 1). The sample size, size range (cm, TL), mean TL and standard error (SE) of TL, total weight range (g, W), mean W and SE of W, the estimated parameters of the LWR (a and b), SE of b and the determination coefficients (r^2) are given in Table 1. Linear regression was significant (P<0.001). According to Froese (2006), the values of the parameter *b* varies between 2.5 and 3.5. In this study, b (based on TL) was 3.50 for females and 3.49 for males. The LWRs indicated a positive allometric growth in Mediterranean shad for all sexes. The determination coefficients (r^2) for LWRs were greater than 0.98 for all sexes. The slopes (b) of the length–weight regressions were significantly between the sexes (t = 15.769, P<0.05). Length–weight curves for males and females are plotted in Figure 2. Conversions among length measurements are given in Table 2. The LLRs were significant (P<0.001) for all shad specimens with all r^2 values greater than 0.99. Although, there are no data

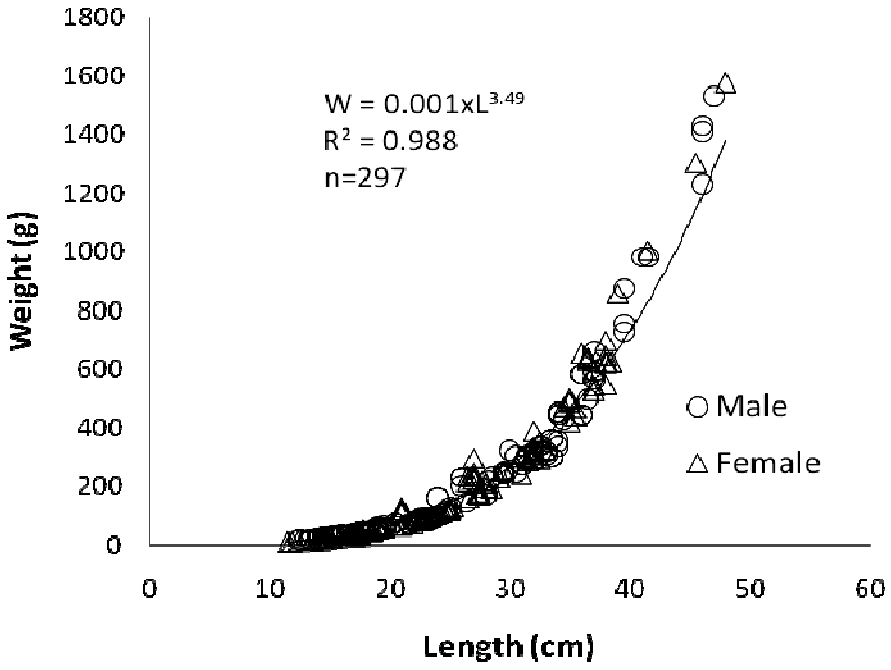

Figure 2. Length–weight relationships for Mediterranean shad species from NE Mediterranean coast of Turkey.

Table 2. Estimated parameters for the conversion between the length measurements (TL, FL and SL in cm) for Mediterranean shad species of the NE Mediterranean coast of Turkey.

Species	Sex	n	Equation	Constant a	Slope b	SE (b)	r^2
A. agone[a]	Female	150	TL = a + bSL	-1.186	1.295	0.005	0.997
			SL = a + bFL	0.238	0.939	0.001	0.999
			FL = a + bTL	0.725	0.821	0.003	0.999
	Male	147	TL = a + bSL	-1.167	1.288	0.005	0.998
			SL = a + bFL	0.234	0.940	0.001	0.999
			FL = a + bTL	-0.717	0.824	0.002	0.999
	Both	297	TL = a + bSL	-1.177	1.291	0.004	0.998
			SL = a + bFL	0.236	0.940	0.001	0.999
			FL = a + bTL	0.721	0.822	0.002	0.999

n, Number of individuals; a: intercept; b: slop; r^2: coefficient of determination; [a] For *A. agone*, no length–weight relationship information was available in FishBase (Froese and Pauly, 2010).

available on LLRs of Mediterranean shad, we could compare our results with published LWRs studies in Turkish Coast (northern Aegean Sea) and the other different geographic areas (D'ancona, 1927; Quignard and Douchement, 1991; Dulcic and Glamuzina, 2006; Karakulak et al., 2006; Volta and Giussani, 2010), which are presented in Table 3. Length and weight data collected throughout the sampling period are not representative of a particular season or time of the year; therefore estimated parameters *a* and *b* should be considered to be mean annual values. Several factors are known to influence the LWRs in fish, they include gonad maturity, stomach fullness, season, health and preservation techniques (Bagenal and Tesch, 1978), all of which were not observed in this study.

To the best of our knowledge, no information is available on the LLRs and LWRs of *A. agone* in the NE Mediterranean Sea coast of Turkey. In conclusion, this

Table 3. Biogeographic comparison of LWRs parameters for *A. agone.*

Study	Locality	Country	Sex	n	Length type	L_{min}-L_{max}	a	b	r^2
D'Ancona (1927)[a]	Tiber River	Italy	Male	14	FL	-	0.0062	3.469	0.960
D'Ancona (1927)[a]	Tiber River	Italy	Female	19	FL	-	0.0030	3.600	0.960
Dulcic and Glamuzina (2006)	middle Adriatic Sea (River Neretva estuary)	Crotia	Both	44	TL	26.00-40.50	0.0122	2.930	0.980
Dulcic and Glamuzina (2006)	middle Adriatic Sea (River Setina estuary)	Crotia	Both	32	TL	26.40-42.60	0.0144	2.950	0.978
Karakulak et al. (2006)[b]	Gökceada Island (northern Aegean Sea)	Turkey	Both	32	TL	17.60-24.60	0.0102	2.926	0.880
Volta and Giussani (2010)	Lago Maggiore	Italy	Both	1110	TL	10.10-38.10	0.0050	2.916	0.956
This study	NE Mediterranean Sea	Turkey	Both	297	TL	11.50-48.00	0.0011	3.499	0.987
This study	NE Mediterranean Sea	Turkey	Male	147	TL	12.50-47.00	0.0010	3.498	0.989
This study	NE Mediterranean Sea	Turkey	Female	150	TL	11.50-48.00	0.0010	3.500	0.988

[a] Taken from Quignard and Douchement (1991);[b] LWRs reported for *Alosa fallax* in FishBase.

study provides first information on LLRs and LWRs which are useful for fishery biologist, sustainable fishery management and conservation.

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