Journal of Applied Ichthyology

J. Appl. Ichthyol. 27 (2011), 942–944

ISSN 0175–8659

Received: February 15, 2010
Accepted: May 20, 2010
doi: 10.1111/j.1439-0426.2010.01589.x

Short communication

Length–weight and length–length relationships for four shad species along the western Black Sea coast of Turkey

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Summary

This study investigates length–weight and length–length relationships of four shad species (*Alosa caspia caspia, Alosa immaculata, Alosa maeotica, Alosa tanaica*) captured in the western Black Sea coast of Turkey. A total of 686 specimens, 355 females and 331 males, were caught by gill net, trammel net and longline from 2006 through 2007 along the western Black Sea coast of Turkey. The relationships of total length (TL), fork length (FL) and standard length (SL) are presented for inhabiting in the Black Sea four shad species and the relationships between total length (TL) and body weight (BW) from the two localities, Sile and Karasu in the western Black Sea coast of Turkey. The Length–weight relationships generally indicated positive allometric growth in *Alosa* species for both males and females and an isometric growth for *A. immaculata* females. The coefficient *b* ranged from a minimum 2.97 for females of *A. immaculata* to a maximum 3.75 for both sexes *A. c. caspia*. Results indicated that the length–length relationship between the three length measurements were highly correlated ($r^2 > 0.99$, $P < 0.001$).

Introduction

On the Turkish Black Sea coast the genus *Alosa* is represented by four species: Caspian shad *Alosa caspia caspia* (Eichwald, 1838); pontic shad *Alosa immaculata* Bennett, 1835; Black Sea shad *Alosa maeotica* (Grimm, 1901); and Azov shad *Alosa tanaica* (Grimm, 1901) (Whitehead, 1985). This study investigates length–weight and length–length relationships of these four species captured on the western Black Sea coast of Turkey. Some 76% of the shad production in Turkey is from the Black Sea (Zengin et al., 1998), where there is high fishing pressure on marine species. The aim of this study was to obtain comprehensive information on length–weight and length–length relationships for the four species.

Materials and methods

A total of 686 (355 females; 331 males) *Alosa* specimens were collected from 2006 to 2007 by gill net, trammel net and longline in two locations along the western Black Sea coast of Turkey, Sile (29°38′N 41°15′E; 41°15′N 41°35′E) and Karasu (41°07′N, 30°38′E; 41°06′N, 30°42′E). All species were identified according to Whitehead (1985); Aksiray (1987), and Turan et al. (2007) and rechecked against FishBase (http://www.fishbase.org). In total, four species are included in the study: *A. c. caspia*, *A. maeotica*, *A. tanaica*, and *A. immaculata*. Total length (TL), fork length (FL) standard length (SL), and body weight (BW) were measured in the laboratory to the nearest 0.1 cm and 0.01 g, respectively. Sex was macroscopically determined by gonad examination. Specimens were catalogued and deposited in the Fisheries Genetic Laboratory, Faculty of Fisheries, Mustafa Kemal University, Hatay, Turkey.

The length–weight relationships were measured and described using the equation $W = aTL^b$ (Ricker, 1973; Bagenal and Tesch, 1978), the statistical significance level of r^2 was estimated and the parameters a and b were estimated by least square linear regressions performed by the log-transformed equation, $\log BW = \log a + b \log TL$ (Beverton and Holt, 1996). Length–length relationships were estimated by linear regression. Prior to regression analysis of log W on log TL, log–log plots of length and weight values were performed for visual inspection of outliers (Froese, 2006). Only extreme outliers attributed to data error were omitted from analyses.

Results and Discussion

The length–length regressions applied to 686 specimens of the four *Alosa* species are presented in Table 1. Results indicated that the length–length relationships among the three length measurements were highly correlated ($r^2 > 0.99$, $P < 0.001$). Estimated parameters of the length–weight relationship along with descriptive statistics by sex and species are given in Table 2. This study also provides new maximum sizes for *A. tanaica*.

According to Tesch (1971), the value of the parameter b varies between 2 and 4. A value of 3 indicates that the fish grows symmetrically or isometrically; values other than three indicate allometric growth. In the present study, b (based on TL) varied from a minimum of 2.97 for *A. immaculata* females to a maximum 3.75 for both sexes of *A. c. caspia*. The r^2 values ranged from 0.951 for *A. immaculata* males to 0.988 for *A. maeotica* females. All length–weight relationships were significant ($P < 0.001$), with all r^2 values > 0.950.

The length–weight relationships generally indicated positive allometric growth in *Alosa* species for both males and females and an isometric growth for *A. immaculata* females. In addition to the present study, Table 3 gives a comparison of published length–weight relationship parameters in different regions for the *Alosa* species. *A. c. caspia* showed positive allometric growth in the present study in contrast to studies from other geographical areas conducted in the Caspian and

Table 1
Length–length relationship comparisons of total length (TL), fork length (FL) and standard length (SL) of four shad species, western Black Sea coast

Species	Sex	n	Equation	a	b	95% CL of b	r^2
A. caspia	Male	16	TL = a + bSL	−0.905	0.900	0.855–0.943	0.993
			SL = a + bFL	0.425	1.036	1.017–1.056	0.999
			FL = a + bTL	0.675	1.065	1.016–1.115	0.993
	Female	14	TL = a + bSL	−1.139	0.915	0.860–0.970	0.991
			SL = a + bFL	1.315	0.975	0.945–1.005	0.998
			FL = a + bTL	−0.182	1.117	1.048–1.187	0.990
	Both	30	TL = a + bSL	−0.926	0.902	0.872–0.932	0.993
			SL = a + bFL	0.608	1.023	1.006–1.040	0.998
			FL = a + bTL	0.511	1.075	1.039–1.111	0.992
A. immaculata	Male	273	TL = a + bSL	−0.878	0.924	0.918–0.930	0.997
			SL = a + bFL	0.028	1.058	1.055–1.061	0.999
			FL = a + bTL	0.988	1.019	1.013–1.026	0.998
	Female	294	TL = a + bSL	−0.797	0.921	0.914–0.928	0.998
			SL = a + bFL	0.079	1.055	1.051–1.060	0.999
			FL = a + bTL	0.880	1.025	1.019–1.031	0.997
	Both	567	TL = a + bSL	−0.832	0.922	0.918–0.927	0.996
			SL = a + bFL	0.063	1.056	1.054–1.059	0.998
			FL = a + bTL	0.934	1.022	1.018–1.026	0.998
A. maetica	Male	24	TL = a + bSL	−0.433	0.875	0.849–0.902	0.995
			SL = a + bFL	0.243	1.046	1.030–1.063	0.999
			FL = a + bTL	0.323	1.088	1.069–1.107	0.998
	Female	27	TL = a + bSL	−0.261	0.867	0.843–0.892	0.995
			SL = a + bFL	0.031	1.057	1.044–1.069	0.999
			FL = a + bTL	0.368	1.087	1.066–1.108	0.998
	Both	51	TL = a + bSL	−0.294	0.869	0.853–0.886	0.996
			SL = a + bFL	0.113	1.053	1.043–1.062	0.999
			FL = a + bTL	0.309	1.089	1.076–1.102	0.998
A. tanaica	Male	18	TL = a + bSL	−0.499	0.881	0.844–0.918	0.994
			SL = a + bFL	0.316	1.041	1.019–1.064	0.998
			FL = a + bTL	0.337	1.084	1.058–1.111	0.998
	Female	20	TL = a + bSL	0.018	0.857	0.842–0.878	0.999
			SL = a + bFL	0.211	1.048	1.034–1.063	0.999
			FL = a + bTL	−0.227	1.112	1.102–1.121	0.999
	Both	38	TL = a + bSL	−0.150	0.865	0.848–0.882	0.998
			SL = a + bFL	0.236	1.046	1.034–1.058	0.999
			FL = a + bTL	−0.022	1.102	1.090–1.114	0.999

n, number of individuals; a, intercept; b, slope; r^2, coefficient of determination, CL, confidence limits.

Table 2
Descriptive statistics and estimated parameters of length–weight relationships for four shad species caught on western Black Sea coast of Turkey

		Length characteristic		Weight characteristic	$W = aL^b$			
Species	Sex	n	TL Range (cm)	W Range (g)	a	b	95% CL of b	r^2
A. c. caspia[1]	Female	14	16.3–20.0	32.1–112.0	0.0052	3.29	2.921–3.654	0.970
	Male	16	15.0–21.0	32.1–112.0	0.0015	3.69	3.381–4.012	0.978
	Both	30	15.0–21.0	51.0–103.2	0.0013	3.75	3.461–4.116	0.954
A. immaculata	Female	294	14.0–34.2	22.2–343.3	0.0100	2.97	2.904–3.053	0.955
	Male	273	13.2–34.1	19.7–341.1	0.0070	3.07	2.991–3.158	0.951
	Both	567	13.2–34.2	19.7–343.3	0.0078	3.04	2.990–3.104	0.952
A. maeotica[1]	Female	27	17.6–33.8	43.6–347.2	0.0079	3.02	2.887–3.181	0.988
	Male	24	16.0–33.2	29.7–331.7	0.0044	3.19	2.996–3.391	0.980
	Both	51	16.0–33.8	29.7–347.2	0.0062	3.09	2.977–3.214	0.981
A. tanaica[1]	Female	20	16.0–30.0	32.8–275.1	0.0048	3.21	3.072–3.363	0.991
	Male	18	15.5–29.0	29.8–228.4	0.0078	3.03	2.885–3.287	0.976
	Both	38	15.5–30.0	29.8–275.1	0.0051	3.18	3.058–3.327	0.984

n: sample size; a, intercept; b, slope; CL, confidence limits; r^2, coefficient of determination (all significant $P < 0.001$).
[1]Length-weight relationship not previously reported for Turkish Black Sea.

Mediterranean seas (Chumaevskaya-Svetovidova, 1938; Economidis and Sinis, 1991), which reported negative allometric growth for this species. Nevertheless, the other three *Alosa* species (*A. immaculata, A. maeotica*, *A. tanaica*) in the present study showed the b values to be generally in agreement with similar results for *Alosa* species from the same geographical areas (Samsun, 1995; Tarkan et al., 2006). The observed differences could be due to the sampling procedure, sample size, length range, or changing environmental and habitat factors.

Length–weight relationships in fishes can be affected by habitat, seasonal effect, degree of stomach fullness, gonad

Table 3
Comparison of four shad species length-weight relationship parameters in various locations

Shad Species	Author(s)	Location	Country	Sex	n	L_{min}-L_{max}	a	b	r^2
Alosa c. caspia[1]	Chumaevskaya-Svetovidova (1938)	NE Caspian Sea	Russia	Both	316	18.0–22.0	0.6930	1.73	0.998
Alosa c. caspia[1]	Economidis and Sinis (1991)	–	Greece	Female	212	–	0.0343	2.69	0.962
Alosa c. caspia[1]	Economidis and Sinis (1991)	–	Greece	Male	123	–	0.0389	2.66	0.948
Alosa maeotica	Tarkan et al. (2006)	Sapanca Lake	Turkey	Both	18	13.2–32.0	0.0053	3.15	0.971
Alosa tanaica	Tarkan et al. (2006)	Kucukcekmece Lagoon	Turkey	Both	21	9.6–24.6	0.0049	3.23	0.997
Alosa immaculata	Samsun (1995)	Mid. Black Sea Coast	Turkey	Female	1039	11.6–31.2	0.0209	3.39	0.984
Alosa immaculata	Samsun (1995)	Mid. Black Sea Coast	Turkey	Male	851	11.0–31.6	0.0246	3.34	0.979
Alosa immaculata	Samsun (1995)	Mid. Black Sea Coast	Turkey	Both	1890	11.6–31.6	0.0212	3.38	0.983
Alosa immaculata	Ciolac and Patriche (2004)	Black Sea and Danube River	Romania	Both	752	20.4–38.0	–	–	–
Alosa immaculata[1]	Kolarov (1991)	Black Sea and Danube River	Bulgaria	Both	22022	9.0–36.0[2]	0.0062	2.57	–

[1]Length-weight relationship of parameters reported in Fishbase (Froese and Pauly, 2009).
[2]Length measured as fork length (cm).

maturity, health, general fish condition, and preservation techniques (Tesch, 1971; Wootton, 1990), all of which were not considered in the present study.

This study presents the first reference on length–length and length–weight relationships for *A. c. caspia, A. immaculata, A. maeotica* and *A. tanaica* captured on the western Black Sea coast of Turkey.

Acknowledgements

Our thanks to TUBITAK (Project No. 106T149) for financial support.

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