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Research Article

Some biological parameters of the Pontic shad (*Alosa immaculata* Bennet, 1835) from the Southeastern Black Sea

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Abstract – The present study investigates some basic biological parameters (size and sex composition, LWRs and condition factor) of Pontic shad, *Alosa immaculata* from the Southeastern Black Sea. Fish samples were monthly caught from Rize coasts in the Northeastern Black Sea of Türkiye from October 2021 to May 2022 and totally 270 Pontic shad (147 females and 123 males) ranging from 12.5 cm to 32.6 cm TL were sampled during the sampling period. The sex ratio of female to male was calculated as 1.20:1.00 ($\chi 2$ test; $p>0.05$). The total length-weight relationships were determined as $W=0.0047TL^{3.157}$ for females, as $W=0.0058TL^{3.088}$ for males and as $W=0.005TL^{3.135}$ for over all individuals with the b-values were significantly different from isometric growth (Pauly's t-test; $p<0.05$) indicating (+) allometric growth for females and over all individuals, while males showed isometric growth pattern(Pauly's t-test; $p>0.05$). The regression analysis revealed that $r^2>0.9$ showing a highly significant correlation between total length and weight. Fulton's condition factor (K) values ranged from 0.611 to 0.943 (mean 0.763±0.075) in females and from 0.588 to 0.948 (mean 0.740± 0.080) in males indicating a poor growth condition in this habitat throughout the sampling period. This study will provide a baseline on some biological parameters of Pontic shad to provide a guideline for the fisheries management authority and fisheries scientists for further research. Furthermore, the reported results may contribute to the conservation and sustainability of this species in the area.

Keywords – Alosa Immaculata, Black Sea, Condition, Growth Type, Pontic Shad.

I. INTRODUCTION

The length and weight data of fishes have commonly been studied to get biological information and has been used one of the standard methods in fisheries biology [1,2,3,4]. Length-weight relationships (LWRs) and condition factor are important parameters in fishery assessment studies due to providing information about the growth of the fish, its general wellbeing, and fitness in the existing habitat [2,3,5]. Hereby, the LWRs and condition factor are very important parameters that commonly used in researching the population characteristics of the fish species [6,7].

The length-weight relationships (LWRs) in fish also provide significant information about the general health, growth pattern, life history, habitat conditions, fish fatness and condition, as well as morphological characteristics of the fish [7, 8]. In addition, by using these parameters the life history, and more generally population ecology of fish species can be revealed by making comparisons between regions [9,10].

Alosa immaculata (Bennet, 1835) also known as the Pontic shad, is the largest species of the family Clupeidae in the Black Sea. The Pontic shad is a migratory species that is distributed in the Black Sea and Sea of Azov [11], as well as in the Sea of Marmara [12]. It migrates for spawning into the Danube, Don, Dnieper, and other major rivers of the Black Sea River basin [13, 14]. Pontic shad is an endemic fish species for the Black Sea [15] and it is found off the coasts of the Black and the Marmara Sea in Türkiye [16].

The Pontic shad, *Alosa immaculata* is one of the commercially important pelagic fish species in Türkiye. This species is mainly caugth by the fishing gears such as midwater trawl, purse seine and gillnets. According to TurkStat fisheries data, the total catch amount of *Alosa* species caught from Turkish waters in 2022 is 3146.8 tons and 31.5% (990.1 tons) of this amount was landed from the Black Sea [17]. In the communiqué regulating the commercial fishing activities, there is not any fishing restriction or ban on the Pontic shad such as minimum landing size, fishing gear, area, or period [18].

According to the International Union for Conservation of Nature (IUCN) criteria, the Pontic shad, *Alosa immaculata* (Bennet, 1835) is one of the vulnerable (VU) species globally due to reasons such as impoundment of main rivers (all happened more than 10 years ago) which has significantly reduced available spawning sites and migration routes. The current threat to the species is overfishing, at sea and in the rivers during the migration runs, which is causing a population decline of unknown levels [19] and its population status is decreasing [20].

The knowledge of some biological parameters of fish such as size values (i.e. minimum, maximum, and mean), and size relationships (i.e. length-weight) helps for the sustainable exploitation of fisheries resources in the Black Sea [21]. For this aim in this study, some basic biological aspects such as the size and sex composition, length-weight relationships, growth type and Fulton's condition factor of Pontic shad caught from Rize coasts in the south-eastern Black Sea were investigated. This study will provide a baseline on some biological parameters of Pontic shad to provide a guideline for the fisheries management authority and fisheries scientists for further research. Furthermore, the reported results may contribute to the conservation and sustainability of this species in the area.

II. Materials and Method

This study was carried out in Rize coasts in the south-eastern Black Sea, Türkiye. Pontic shad specimens were monthly collected by using multifilament gillnets with various mesh sizes and hand lines with different hook sizes from October 2021 to May 2022. During the sampling period, each fish specimen was measured in total length (TL) to the nearest 1 mm and weighed to the nearest 0.01 g body weight (W). Sex was determined via macroscopic observation of the gonads using the morphological differences such as structure, shape, and color [4].

The length-weight relationship (LWR) in fishes is generally expressed by $W = aTL^b$, which was converted to logarithmic form as $\log W = \log a + b \log TL$, where W is total body weight (g), TL is the total length (cm), a: intercept and b: slope regression coefficients. Then the LWR parameters were estimated by the linear regression using the log-transformed values of this equation [22, 23]. ANCOVA was used to determine if there was significant difference in slopes (b values) between the sexes (24). Fulton's condition factor (K) was calculated using the following formula: $K = (W/TL^3) \times 100$, where W is total body weight (g) and TL is total length (cm) [1]. The differences in mean Fulton's condition factor between sexes were tested by t-test. To compare the slopes to confirm whether the b value was different from the isometric growth (b=3) for both sexes and combined sex, Pauly's t-test [25] was performed using the formula as:

$$t = \frac{Sd_{logTL}}{Sd_{logW}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2}$$

where, Sd_{logTL} is the standard deviation of the log TL values, Sd_{logW} is the standard deviation of the log W values, r^2 is correlation coefficient, n is the number of specimens used in the calculation. If calculated t value is greater than the table t values for n-2 degrees of freedom the value of b is different from isometric growth (b=3) [3, 25]. All tests applied in the study were performed at the 0.05 level of significance. Statistical analyses were performed using the SPSS and Microsoft Office Excel software.

III. RESULTS

Length and weight distribution

A total of 270 Pontic shad individuals were sampled during the study. The total lengths (TL) of all samples examined were between 12.5 cm and 32.6 cm (mean 21.7±0.388 cm) and their body weight ranged from 13.40 g to 298.54 g (mean 100.95 ± 5.253). Total length (TL) and weight (W) characteristics of the Pontic shad by sexes were presented in Table 1.

Table 1. Total length (TL) and weight (W) characteristics of Pontic shad by sexes (S.E.: Standard Error)

Sex	N	Total Length (cm)		Weight (g)	
		Range	Mean±S.E	Range	Mean±S.E
Female	147	12.5-32.6	22.7±0.557	13.78-298.54	117.52±7.818
Male	123	12.7-30.9	20.5±0.514	13.40-261.07	80.99±6.328
Combined	270	12.5-32.6	21.7±0.388	13.40-298.54	100.95±5.253

The total length - frequency distribution of 270 Pontic shad samples ranging from 12.5 cm to 32.6 cm TL was plotted based on 1 cm class intervals for female and male individuals (Fig. 1).

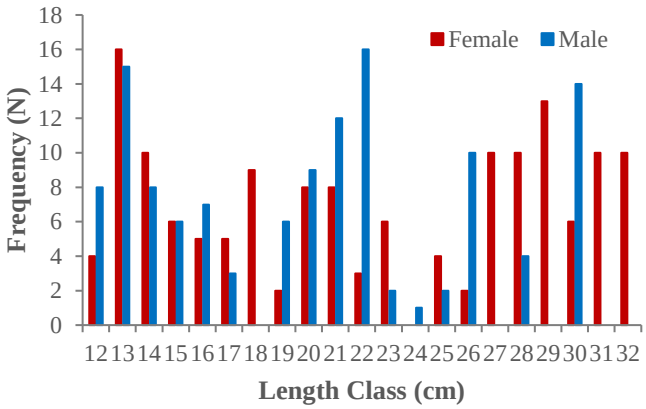

Figure 1. The total length - frequency distribution of Pontic shad by sexes.

Length-weight relationship (LWR)

The total length-weight relationships were determined as $W=0.0047TL^{3.157}$ ($r^2=0.982$, N=147, $p<0.05$) for females, as $W=0.0058TL^{3.088}$ ($r^2=0.952$, N=123, $p>0.05$) for males and as $W=0.005TL^{3.135}$ ($r^2=0.994$, N=270, $p<0.05$) for combined sex (Fig. 2.) with the b-values were significantly different from isometric growth indicating (+) allometric growth for females and over all individuals (Pauly's t-test; $p<0.05$), while males showed isometric growth (Pauly's t-test; $p>0.05$). The slopes (b value) of the length-weight relationships were statistically significant for both sexes (ANCOVA, $p<0.05$).

The length-weight relationships (LWR) for Pontic shad by sexes are presented in Figure 2. The correlation coefficient (r^2) for regression analysis indicated that the Pontic shad has a high correlation ($r^2>0.9$) between the total length and weight for both sexes and all individuals. Descriptive statistics and estimated parameters of the length-weight relationship (LWR) of Pontic shad by sexes from the Southeastern Black Sea, NE Türkiye were presented in Table 2.

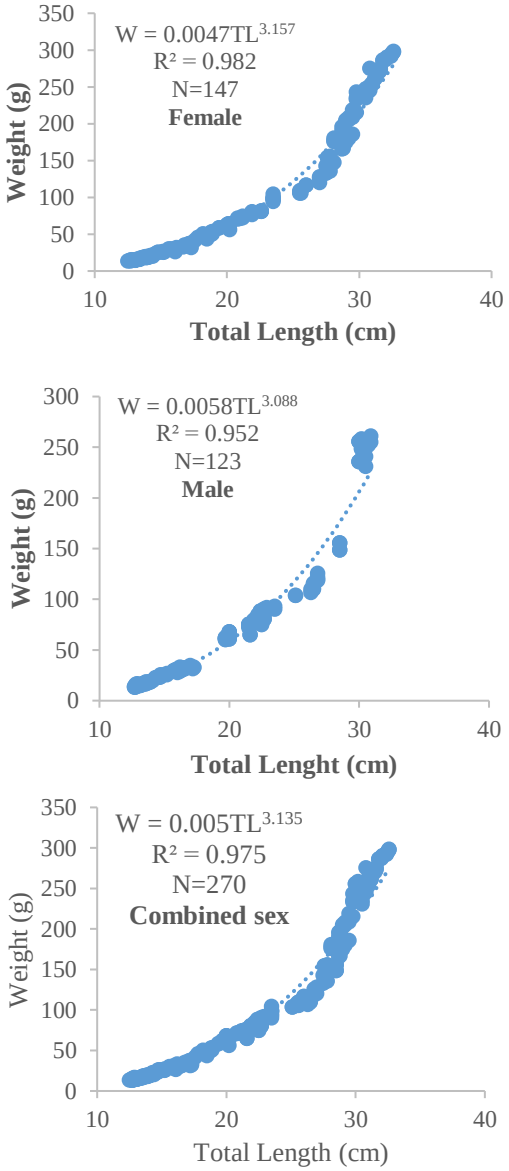

Figure 2. Length-weight relationships (LWRs) of Pontic shad by sexes.

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships (LWRs) of Pontic shad by sexes. (F: Female, M: Male, S.E.: Standard Error, C: Combined, C. I.: Confidence Interval, G.T.: Growth Type, A+: Positive Allometric, I: Isometric)

Sex	N	Parameters of LWR						
		a	b	S.E. (b)	95% CI of b	R^2	G. T.	Pauly's t-test
F	147	0.005	3.157	0.022	3.113-3.202	0.982	A+	p<0.05
M	123	0.006	3.088	0.034	3.021-3.155	0.952	I	p>0.05
C	270	0.005	3.135	0.019	3.097-3.172	0.975	A+	p<0.05

Fulton's condition factor (K)

Fulton's condition factor (K) values of the Pontic shad ranged from 0.611 to 0.943 (mean 0.763±0.075) in females and from 0.588 to 0.948 (mean 0.740± 0.080) in males indicating a poor growth condition in this habitat. No significant difference was observed in mean K values between females and males (t-test, p>0.05).

Sex composition

During the study, of the sampled 270 Pontic shad individuals, 54% (N= 147) were females and 46% (N=123) were males, accordingly the ratio of female to male was calculated as 1.20:1.00 which did not deviate from the expected ratio of 1:1 (χ^2 test, p>0.05).

IV. DISCUSSION

Descriptive statistics and estimated parameters of the LWRs of Pontic shad by sexes were given in Table 2. It was seen that there are strong relationships between the lengths and weights of the fish (r^2>0.9, P<0.05). The values of the parameter b which reflects the growth type of the fish in this study were within the expected range of 2.5 - 3.5 [6], but also can vary between 2 and 4 [26].

The result of the current study and some of the previous results of LWR parameters estimated in different localities of the Black Sea for the Pontic shad, *Alosa immaculata*, were also presented in Table 3 for comparison. The results of this study are consistent with those of the previous studies carried out in the Black Sea with some differences that can be mainly attributed to the ecological characteristics of the studied areas. Besides, the LWR in fish is influenced by many factors such as presence of food, feeding ratio, gonad development, spawning period, season, sex, and habitat [26]. The LWRS may also be influenced by geographical location and environmental conditions in given year [3, 27].

Table 3. Some of the previous results of LWR parameters estimated in different localities of the Black Sea for the Pontic shad, *Alosa immaculata.*

Locality	Sex	N	TL range	a	b	R^2	Reference
Western Black Sea	Female	294	14.0–34.2	0.0100	2.970	0.955	31
	Male	273	13.2–34.1	0.0070	3.070	0.951	
	Combined	567	13.2–34.2	0.0078	3.040	0.952	
Mid. Black Sea	Female	1039	11.6–31.2	0.0209	3.390	0.984	28
	Male	851	11.0–31.6	0.0246	3.340	0.979	
	Combined	1890	11.6–31.6	0.0212	3.380	0.983	
SE Black Sea	Female	438	10.2 38.8	0.0030	3.303	0.993	32
	Male	292	11.4 35.5	0.0035	3.249	0.990	
	Combined	730	10.2-38.8	0.0032	3.285	0.992	
Central Black Sea	Combined	1312	11.5-34.9	0.0280	3.320	0.980	33
Bulgarian Black Sea	Combined	191	24.2-37.7	0.071	2.490	0.780	21
Middle Black Sea,	Combined	227	11.9-27.6	0.0050	3.120	0.940	34
SE Black Sea	Combined	42	16.1-23.5	0.0046	3.163	0.958	2
SE Black Sea	Female	147	12.5-32.6	0.0047	3.157	0.982	This study
	Male	123	12.7-30.9	0.0058	3.088	0.952	
	Combined	270	12.5-32.6	0.0050	3.135	0.975	

The Fulton's condition factor (K) values calculated for the Pontic shad, *A. immaculata* in the current study varied from 0.611 to 0.943 (mean 0.763±0.075) in females and from 0.588 to 0.948 (mean 0.740± 0.080) in males indicating that the species is in a poor growth condition in this habitat throughout the sampling period. The mean K values for females, males, and all individuals of Pontic shad from the Turkish coast of the Black Sea were reported as 1.21, 1.02 and 1.12 [28] and 0.68, 0.71 and 0.78 [29], respectively. These values were estimated as 1.10 for females, 1.05 for males and 1.08 for overall specimens of *A. immaculata* in the Sea of Marmara [12]. The differences in K values among the present study and other studies previously reported above may be explained by the factors such as habitat conditions, sampling period, year, and techniques, feeding level, food presence and utilisation, age of the fish, season, sex, and state of sexual maturity [3, 30]. Additionally, overfishing, pollution, and changes in ecological conditions against of the fish may have significantly caused these differences over the years.

V. CONCLUSION

This study representing some basic biological characteristics (size composition, sex ratio, length-weight relationships, and condition factor) of Pontic shad, *Alosa immaculata* in Rize coasts from the Southeastern Black Sea. Information on basic biological data of a fish population is of great importance to understand how fishes react under anthropogenic pressure or other environmental conditions. Consequently, the reported results in this study would be useful for fishery management authority and biologists in Türkiye. Potential conservation and management plans need much more data on the bio-ecology of the species. The results of the present study will provide a useful dataset to fisheries management authority and fisheries scientists for further research to fully understand the bio-ecological characteristics of this species in addition to take conservation measures and to ensure sustainability of the species in the Black Sea.

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