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Research article

Length-weight and length-length relationships of *Chlorophthalmus agassizi* Bonaparte, 1840 in İskenderun Bay, Türkiye

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Abstract: The present study was carried out to gain some knowledge on length-weight, length-length relationships and some growth parameters of male and female individuals of *Chlorophthalmus agassizi.* The knowledge of the length-weight relationship has numerous practical applications in fishery biology and is needed in fishery management and conservation. Length-weight and length-length regression equations were estimated for male and female *C. agassizi* caught from the İskenderun Bay, the eastern Mediterranean Sea. Regression coefficients were estimated by using the logarithms of the total lengths and the corresponding weights. The curvilinear relationships of length-weight for all individuals, male and female were given as $W = 0.0117*L^{3.55}$, $W = 0.0013*L^{3.65}$, and $W = 0.0025*L^{3.42}$, respectively. The estimated values of parameter b ranged from 3.42 to 3.65. The r^2 was estimated as 0.94, indicating a high degree of the positive relationship between the length and weight of the population in the İskenderun Bay. Additionally, the relationships among total length, standard length, fork length were also estimated for all specimens. The length-length relationships were determined to show highly correlated (r^2>0.96) and statistically significant. Condition factor (CF) is used for comparing the fish's health or the fatness of the fish. In this study, the mean values of Fulton's CF were in the ranges of 0.673 to 0.736 for *C. agassizi* population. Therefore, these data will be a precious background for further biological studies and local fisheries managements in İskenderun Bay.

Keywords: *Chlorophthalmus agassizi,* growth, İskenderun Bay

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Introduction

Chlorophthalmus agassizi is distributed from the eastern Atlantic (Spain and Canary Islands, including the Mediterranean) to the western Atlantic (Mexico and northern-south America) and is also an abundant by-catch species of trawl fishing in the central and eastern basin of the Mediterranean (Whitehead et al., 1986). It lives marine and brackish waters as bathydemersal species at the depth of 50 - 1000 m and in water temperatures of 5-13°C' (Sulak, 1984; Figueiredo vd., 2002). The shortnose green eye feeds mainly on bottom-living invertebrates and plays an important role in the Mediterranean deep-sea fish populations (D'Onghia et al., 2006).

Length-weight relationships (LWRs) are used in the analysis of fishery data (growth, ondition incidences, mortality, etc.). According to Safran (1992), King (1996), Martin-Smith (1996) and Froese

(2016), LWRs was expressed that there is a cubic relationship between length and weight of fishes, representing as $W=aL^b$. The "b" value is the indicator of the growth pattern of fishes whereas the "a" value represents the condition of the fish. LWRs are also originally used to provide information on the condition of fish and may help determine whether somatic growth is isometric (b=3), positive allometric (b>3) or negative allometric (b<3) (Ricker, 1975; Spiegel, 1991). Moreover, LWRs help to estimate ecosystem parameters, e.g., calculating species biomass from the length-frequency of a given sample. Additionally, length-length relationships (LLRs) are useful for standardization of length type when data are summarized (Froese & Pauly, 2016) and are also functional for comparative growth studies (Moutopoulos & Stergiou, 2002).

Although some studies on LWRs of C. *agassizi* have been carried out in different parts of the Mediterranean Sea, so far (Petrakis & Stergio, 1995; Filiz & Bilge, 2004; Anastosopulou et al., 2006; Innal et al., 2012; Başusta et al., 2015), knowledge on the LLRs has been scarce.

The aim of this study was to point out length and weight distributions, sex ratio, LWRs, LLRs, and condition factor of *C. agassizi* in the northern Mediterranean Sea. Examining the LWRs and LLRs is important for the conservation and management of fish populations. It is thought that our data will contribute to the decisions to be taken for fisheries in İskenderun Bay.

Materials and Methods

İskenderun Bay is located in the northeastern region of the Eastern Mediterranean Sea, about 70 km long and 35 km wide and maximum depth is approximately 100 m in the entrance to the Mediterranean Sea (36°37'23"N 35°53'17"E). The average depth is 55-90 m (Yücesoy-Eryılmaz, 2003), and it is known to have the largest continental shelf area after the Nile Delta in the Eastern Mediterranean Sea.

The samples were caught by commercial trawl hauls at the depths of 10-30 m from İskenderun Bay (eastern Mediterranean, Türkiye) in February 2018. Haul duration was about 15 min and boat speed 2 mph. The trawl was equipped with a 44 mm stretched mesh size at the cod-end. After catching the samples, specimens were transported in iced styrofoam boxes to Hydrobiology laboratory at Faculty of Science and Arts of Balikesir University. The samples were identified at species level according to Merrett (1990).

For each fish, the total length (TL), standard length (SL), and fork length (FL) were measured to the nearest millimeter (mm) and the total weight (TW) was also recorded to the nearest gram (±0.1 g). Sex was determined by macroscopic observation of the gonads in all individuals (Avşar, 2016). The chi-square test ($\chi 2$) was used to examine the differences between the observed and the expected ratio of 1:1 (Zar, 1996).

Length-weight relationships (LWRs) were determined by applying the equation $W=\alpha L^b$, where W is the total body weight (g), L is the total body length (cm), α is the intercept and b is the slope (Ricker, 1975; Froese et al., 2011; Froese & Pauly, 2016). The length-length relationship (LLR) was estimated by linear regression analysis: $TL=\alpha+b*SL$ and $SL=\alpha+b*FL$, where α parameter is the intercept and b parameter is the slope of the linear regression (Cao et al., 2016; Keivany & Zamani-Faradonbe, 2016). Significant variations of in the estimates of b for *C. agassizi* from the expected value for the ideal fish (3.0) were tested by Student's t-test (Jayaprakash, 2001), dividing difference between b and 3 to standard error of b (Zar, 1996; Froese et al., 2011).

Fulton's condition factor (CF) was estimated using the formula as $CF=(W/L^3) \times 100$ (Ricker, 1975; Froese, 2006). All statistical analyses were performed in Jamovi 1.6.23, Excel 2013 and Past 4.03 software.

Results and Discussion

This study increases the information related to size distributions, sex ratio, LWRs, LLRs, and condition for *C. agassazi* inhabit in the İskenderun Bay. The total lengths varied in 8.4-17. 2 cm with length of 11.5 cm being the most dominant in the sample (Figure 1). The weights ranged from 4.33 to 40.06 g. for all individuals with weight of 9.0 g, being the most dominant n the sample (Figure 2)

A total of 209 samples including 124(59.33.%) female and 85 (40.67%) males were examined in this study, The overall sex ratio was significantly different from the expected value of 1:1 (F:M = 1.46:1, $\chi 2 = 7.28$, $p < 0.05$). Although the sex ratio in most of the species was close to 1, this may vary from species to species, differing from one population to another of the same species, and may vary year after year within the same population (Nikolsky, 1980).

The significance of variation in the estimates of b for C. agassizi from the expected value for the ideal fish (3.0) was tested by Students' t-test. Students' t-test was employed by dividing the difference between "b" and "3" by standard error of b (Zar, 1996). The results are as follows:

Combined (C): (3.5519-3)/0.0614=8.9885 ($t_{\alpha(2),0.05,\ 208}$ >1.97)
Female (F): (3.4192-3)/0.0751=5.5819 ($t_{\alpha(2),0.05,\ 123}$ >1.98)
Male (M): (3.6532-3)/0.1008=6.4802 ($t_{\alpha(2),0.05,\ 84}$ >1.99)

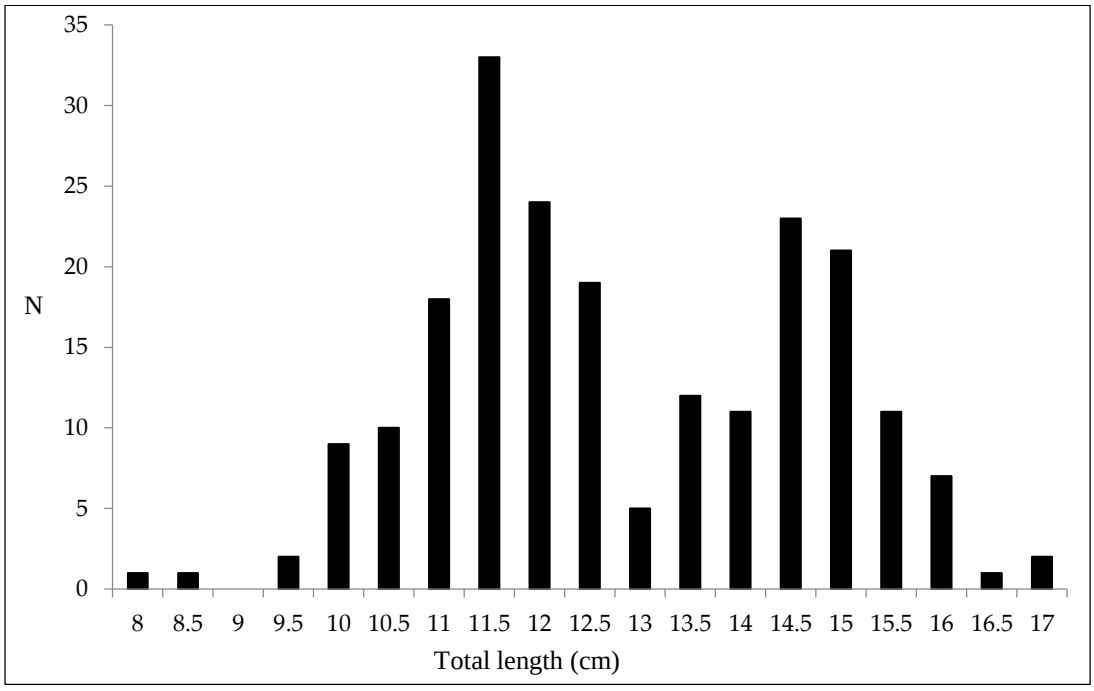

Figure 1. Total length frequency distribution of all *Chlorophthalmus agassizi* specimens from İskenderun Bay

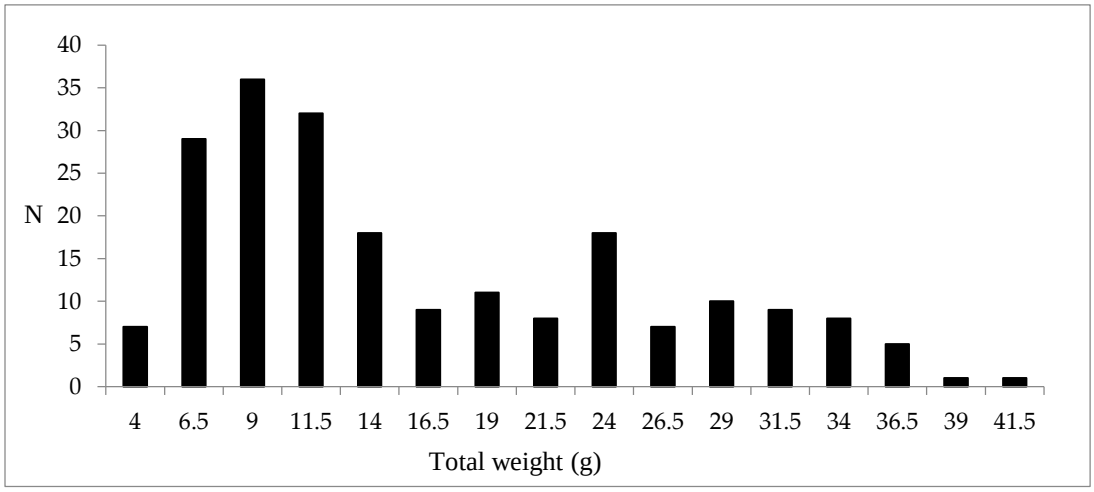

Figure 2. Total weight frequency distribution of all *Chlorophthalmus agassizi* specimens from İskenderun Bay

The number of samples, minimum and maximum of total length (cm), minimum and maximum of weight (g), length-weight relationships parameters (α, 95%CI-α, b and 95%CI-b) and the coefficient of

determination (r^2) and growth types of the species are presented according to the results (Table 1).

Froese (2016) expressed that the parameter b should normally range between 2.5 to 3.5. According to Tesch (1968), if the b values were close to 3, it indicates isometric growth of fish and if the b value different from 3.0 it indicates allometric growth (>3 positive allometric and <3 negative allometric). In this study, the minimum and maximum values for b parameter in LWRs varied from 3.42 to 3.65 for *C. agassazi* (Table 1). In this study, linear regressions on data are highly significant ($P<0.01$) with all $r^2>0.90$. The b values of LWRs that indicated positive allometric growth pattern and the α parameters were close to 0.001, which is suggested for fusiform fish species as normal by Froese (2006). While Claro & GarcíaArteaga, (1994), Merella et al. (1997), Filiz & Bilge (2004), Anastopoulos et al. (2006), Edelist et al. (2011), Innal et al. (2012), Başusta et al. (2015) reported the b parameters were between 2.91-3.28, for the species in Aegean Sea, Hatay, Mexico, Mediterranean Sea, northern Aegean Sea, Antalya Bay, and Balear Islands, respectively, b parameters in our study were slightly high. The variances observed in values of the length-weight relationship parameters in fishes are affected by a number of factors, including season, habitat, population, gonad maturity, sex, diet, stomach fullness, health, sample size, preservation techniques and locality (Moutopoulos & Stergiou, 2002; Froese & Pauly, 2012).

Table 1: Length-weight relationships parameters for *Chlorophthalmus agassizi* caught from İskenderun Bay. (N: number of samples, TL: total length, TW: total weight, a: intersection, b: slope, r^2: correlation coefficient).

		Length parameters		Weight parameters		Relationship parameters							
Sex	N	TL Range (cm)	Mean TL (±SD)	TW Range (g)	Mean TW (±SD)	a	SE of a	95% Cl of a	b	SE of b	95% Cl of b	r^2	GT
C	209	8.4-17.2	13.02±1.80	4.33-40.06	17.11±8.58	0.0017	0.0682	0.0011-0.0026	3.5519	0.0614	3.394-3.725	0.9418	A+
F	124	8.4-17.2	13.31±1.81	5.08-38.04	18.73±8.61	0.0025	0.0842	0.0013-0.0044	3.4192	0.0751	3.194-3.658	0.9444	A+
M	85	9.6-17.0	12.60±1.71	4.33-40.06	14.75±8.01	0.0013	0.1107	0.0008-0.0019	3.6532	0.1008	3.491-3.827	0.9405	A+

Note. C: Combined; F: Female; M: Male

As to length-length relationships parameters, (α and b) and the coefficient of determination (r^2) are presented in Table 2. Values of exponent b in LLRs for *C. agassizi*, remained 1.00 or very close to 1.00 (Anastasopoulou & Papaconstantinou, 2007) representing that total length (TL), standard length (SL) and fork length (FL) also showed isometric growth in this study. In LLRs, all regressions were also highly significant ($p < 0.01$), with the coefficient of determination (r^2) ranging from 0.96 to 0.98.

When the literature is examined, studies on the length- weight relationships of *C. agassizi* are very limited. LLRs for the species are determined as TL=0+1.113FL and TL=0+1.151SL in FishBase (Froese & Pauly, 2016). Anastasopoulou & Papaconstantinou (2007) and Innal et al. (2012) reported isometric and allometric growths for relationships of TL-SL from the Ionian Sea and Mediterranean Sea, respectively. Differences between geographic regions, sample size, genetic structure or environmental conditions may also cause these values to change (Bagenal & Tesch, 1978).

Table 2. Length-length relationship for *Chlorophthalmus agassizi* collected from İskenderun Bay. (N: number of samples, TL: total length, SL: standard length, FL: fork length, a: intersection, b: slope, r^2: correlation coefficient).

N	Sex	Equation	α	b	r^2
209	C	TL = a + bSL	0.8459	1.118	0.96
124	F	TL = a + bSL	1.1011	1.096	0.96
85	M	TL = a + bSL	0.4563	1.154	0.96
209	C	SL = a + bFL	0.0591	0.918	0.98
124	F	SL = a + bFL	0.0761	0.916	0.98
85	M	SL = a + bFL	-0.0247	0.927	0.97

Note. C: Combined; F: Female; M: Male

Fulton's minimum, maximum and mean condition factors were calculated for the 209 specimens (Table 3). The mean values of CF were in the ranges of 0.673 to 0.736 with a minimum and maximum of 0.388 and 1.088, respectively. While condition values ranged from 0.46 to 1.25 with a mean of 0.72±0.07 from Antalya Bay (Innal et al.,

2012), Cabiddu et al. (2010) mentioned condition factor values as 0.70 - 1.45 from Sardinian waters. The condition factors of fish populations may show variations due to physico-chemical factors of environment, food supply that have great influence on the growth of the fish. Condition of fishes also fluctuate with feeding, parasitic infections, sex, size, season, and physiological factors as gonad development (Le Cren, 1951). Froese & Pauly (2016), and Khalid et al. (2020) declared that CF values greater than 1 showed the good condition of the fish whereas a value <1 is an indicator of reverse nature. Khalid et al. (2020) also mentioned the mean condition factor value that fish is in good condition as overall fitness for fish species is assumed when condition factor (K) value is equal or close to 1. Perry et al. (1996) reported that fishes with a low condition index are presumably believed to have experienced adverse physical environment or insufficient nutrition. The present results revealed that *C. agassizi* population may not be in good condition in İskenderun Bay.

Table 3. Condition factor for *Chlorophthalmus agassizi* collected from İskenderun Bay. (N: number of samples, Min: minimum, Max: maximum, SE: standart error).

N	Sex	Mean±SE	Max.	Min.
209	C	0.710±0.10	1.088	0.388
124	F	0.736±0.09	1.088	0.493
85	M	0.673±0.10	0.953	0.388

Note. C: Combined; F: Female; M: Male

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Ethical Approval

The samples were taken by fishermen**.** Therefore, there is no need to ethicall approve.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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