Age and Growth Features of *Chondrostoma regium* (Heckel, 1843) from Almus Dam Lake, Turkey

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Abstract: *Chondrostoma regium* (Heckel, 1843) samples (n=359) were collected from Almus Dam Lake (Tokat) between March 2006 and April 2007 in order to estimate age and growth properties. Total lengths of specimens ranged from 13.7 cm to 28.1 cm and weights ranged from 19 g to 240 g. The overall ratio of females to males was 1:0.66. Ages of fish varied between 1-6 years. The von Bertalanffy growth parameters were L_∞ = 33.50 cm, k = 0.219 year^{-1} and t_0 = -2.369 year for females, and L_∞ = 27.50 cm, k = 0.397 year^{-1} and t_0 = -1.455 year for males. The length-weight relationship was found as W = 0.0036 $TL^{3.316}$ in females and W = 0.0038 $TL^{3.269}$ in males. The growth performance index (Φ') values of females, males and entire samples were 2.391, 2.477 and 2.407, respectively. The relative condition factor value was 1.006 for entire population.

Key words: Almus Dam Lake, Age and growth interactions, *Chondrostoma regium*, Turkey

Almus Baraj Gölü (Tokat, Türkiye)'ndeki *Chondrostoma regium* (Heckel, 1843)'un Yaş ve Büyüme Özellikleri

Özet: *Chondrostoma regium* örnekleri (n=359), yaş ve büyüme özelliklerinin tespit edilmesi amacıyla Mart 2006-Nisan 2007 tarihleri arasında Almus Baraj Gölü (Tokat)'den toplanmıştır. Örneklerin toplam boyları 13,7-28,1 cm ve ağırlıkları 19-240 g arasında dağılım göstermiştir. Tüm örnekler için dişi-erkek oranı 1: 0,66 olarak belirlenmiştir. Yaş dağılımı 1-6 yıl arasında değişmiştir. Von Bertalanffy büyüme denklemi parametreleri dişiler için L_∞ = 33,50 cm, k = 0,219 yıl^{-1} ve t_0 = -2,369 yıl, erkekler için L_∞ = 27,50 cm, k = 0,397 yıl^{-1} ve t_0 = -1,455 yıl olarak hesaplanmıştır. Boy-ağırlık ilişkisi dişilerde W = 0,0036 $TL^{3.316}$ ve erkeklerde W = 0.0038 $TL^{3.269}$ şeklinde bulunmuştur. Büyüme performans katsayısı (Φ') dişi, erkek ve tüm bireylerde sırasıyla 2,391, 2,477 ve 2,407 olarak tespit edilmiştir. Nispi kondisyon faktörü değeri tüm bireylerde 1.006 olarak hesaplanmıştır.

Anahtar kelimeler: Almus Baraj Gölü, yaş ve büyüme etkileşmeleri, *Chondrostoma regium*, Türkiye

1. Introduction

Chondrostoma regium (Heckel, 1843), is a member of the family Cyprinidae and has a wide distribution including whole Anatolia except northwest Anatolia and Thrace. It is commonly known as "kababurun" in Turkey. It is a benthopelagic species inhabiting both lentic and lotic environment [1]. *C. regium* is a planktivorous fish due to mainly feeding on Bacillariophyta [2,3]. Although this species has not economical value as commercial fish, it is consumed as food by local people.

There are several studies on biology of *C. regium* from different water bodies in Turkey. Şen [4], Polat and Gümüş [5], and Polat et al. [6] studied its age determination methods. Growth features were investigated in the Savur Stream [7], Euphrates between Atatürk Dam and Syrian border [8], Atatürk Dam Lake [9], Seyhan Dam Lake [10]. Kalkan and Erdemli [11], Kara and Solak [12], and Çoban and Şen [13] reported on age, growth and reproduction properties of this species living Karakaya, Sır and Keban dam lakes, respectively. Aydın et al. [14] examined the relationships between fish length and otolith length of *C. regium* in Keban Dam Lake. Özcan [15] has reported its length-weight relationship from Hatay province. No study has previously been conducted, however, concerning *C. regium* inhabiting Almus Dam Lake. The objective of present study was to determine age and sex compositions, length and weight distributions, growth parameters, length-weight relationship, and condition of *C. regium* population in this reservoir.

2. Materials and Methods

The Almus Dam is located in the borders of Almus district ($40°22'$ N-$36°55'$ E) of Tokat province in the central Black Sea region of Turkey. It was built to irrigate and produce of energy on Yeşilırmak River by DSI (State Hydraulic Works General Management) and came into operation in 1966. The dam lake is fed on Karadere and Muhad streams constantly running besides small streams drying in summer. The area, volume, length, wide, depth and average deep of reservoir are 3130 ha, 10^8 m^3, 22 km, 2 km, 74 m, and 30 m, respectively [16]. The water temperature ranges from 5 °C to 24 °C throughout the year [17]. Although the lake has been classified as oligotrophic, there are many fish species present, including *Cyprinus carpio*, *Barbus plebejus*, *Capoeta capoeta*, *Capoeta tinca*, *Carassius carassius*, *Chondrostoma regium*, *Alburnus orontis*, *Alburnus chalcoides*, *Squalius cephalus*, *Silurus glanis* and *Oncorhynchus mykiss* [18].

Fish samples were monthly collected from commercial fishermen in Almus Dam Lake between March 2006 and April 2007. However, no specimens were obtained between May and July due to legal fishing ban. A total of 359 individuals (194 females, 128 males and 37 undetermined sexes) were sampled. The total lengths (±0.1 cm) and weight (±1 g) of fish were recorded. Sex was macroscopically determined from gonad examination. The chi-squared test was used to show whether the sex proportions deviated significantly from 1:1 [19]. Age was estimated by scales removed from the left anteriodorsal of fish. Scale preparation for ageing was done according to method of Chugunova [20].

The von Bertalanffy growth function (VBGF) was used to determine age-length relationship. The VBGF is described by the following equation, $L_t = L_\infty [1-e^{-k(t-t_0)}]$ [21], where L_t is the total length at age t; L_∞ is the asymptotic length (cm), k is the body growth coefficient (year^{-1}) and t_0 is the theoretical age at zero length (year). Growth performance index, $\Phi' = \log k + 2 \log L_\infty$ [22] was used to compare growth of fish.

The length-weight relationship (LWR) was calculated via the formula $W = aL^b$ [23], where W is the weight of fish (g), L is the total length (cm), a is the constant and b is the

slope. The parameters a and b of LWR were determined through the linear regression analysis based on logarithms, log W = log a + b log L. The strength of LWR was evaluated by means of regression coefficient (r^2). Whether the growth of fish was isometric (b=3) or allometric (b<3, b>3) was determined by the student's t-test [19].

The relative condition factor (CF) was computed using the equation CF = W / W' [24], where W is the weight of fish and W' is the weight calculated by aL^b. CF values were separately determined according to sexes. Differences between CF values of females and males were tested by the student's t-test [19].

3. Results

Of the 359 *C. regium* specimens examined, 54.04% were female, 35.65% were male, and 10.31% were undetermined sexes. The female: male ratio was 1:0.66, which deviated from 1:1 ($X^2 = 13.53 > X^2_{0.05,1} = 3.84$, P<0.05). Age of fish ranged from 1 to 6 in females and from 1 to 5 in males. Samples of undetermined sexes were in I age group. Age group I was dominant for females, males and all individuals (Table 1).

Table 1. Age and sex composition of *C. regium* from Almus Dam Lake

Age groups	Female		Male		Undetermined sexes		All samples	
	n	%	n	%	n	%	n	%
I	90	25.07	69	19.22	37	10.31	196	65.60
II	24	6.69	17	4.73	-	-	41	11.42
III	43	11.98	27	7.52	-	-	70	19.50
IV	29	8.08	13	3.62	-	-	42	11.70
V	7	1.94	2	0.56	-	-	9	2.50
VI	1	0.28	-	-	-	-	1	0.28
Total	194	54.04	128	35.65	37	10.31	359	100.00

n, sample size

The total lengths of obtained fish varied between 13.7 cm and 28.1 cm. The majority of specimens were found in 16 cm, 18 cm and 24 cm length groups (Fig. 1a). It was observed that there were two samples the total lengths of which were bigger than 27 cm. The weights of fish ranged from 19 g to 240 g. The 61.28% of individuals were weighted between 25 g and 75 g (Fig. 1b). It was determined that there were four specimens the weights of which were over 200 g.
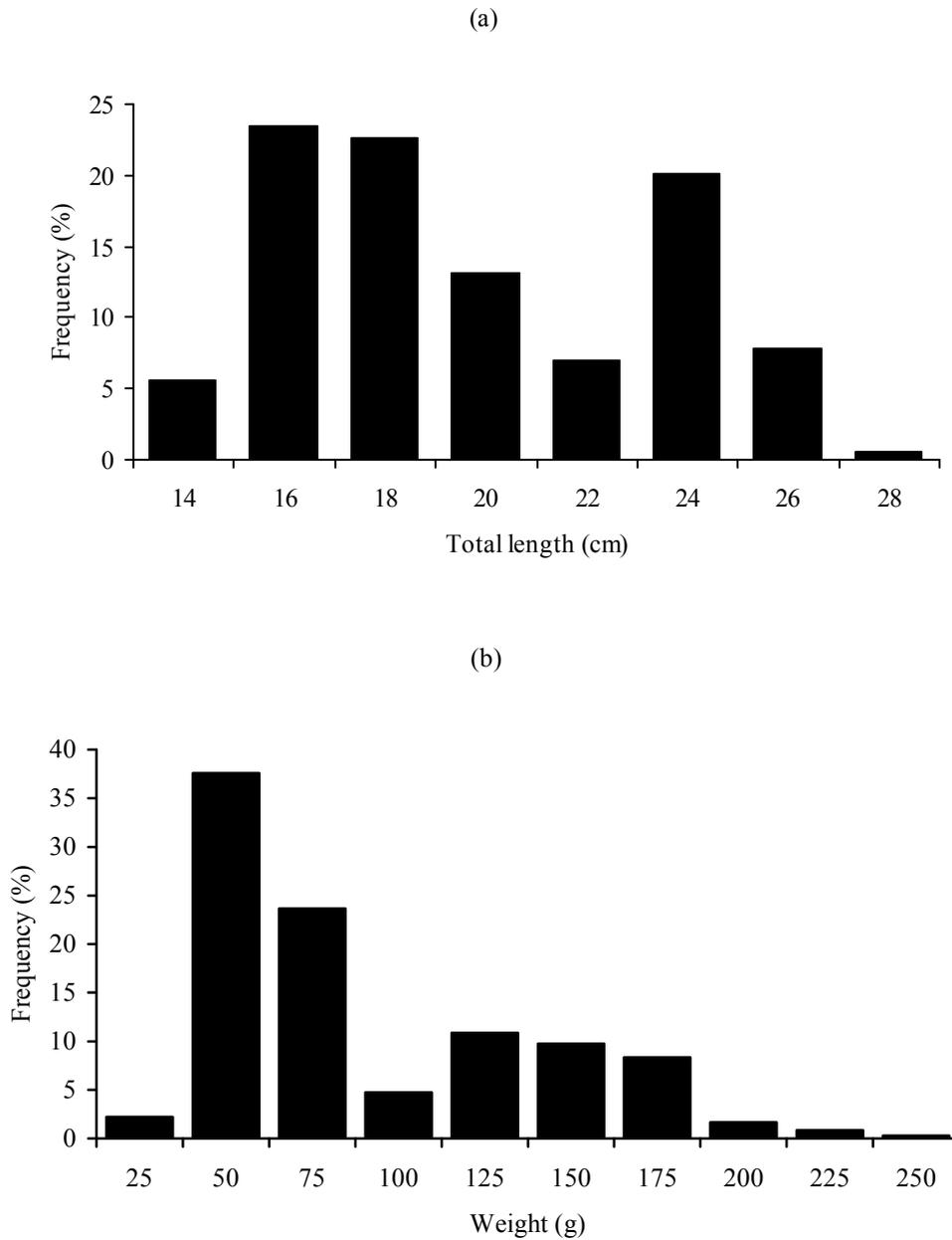
(a)

(b)

Fig. 1. Length (a) and weight (b) distributions of *C. regium* from Almus Dam Lake

The parameters of von Bertalanffy growth equation calculated for females, males, and overall samples of *C. regium* are given in Table 2. The growth performance index (Φ') value was computed as 2.391 for females, 2.477 for males, and 2.407 for entire population.

Table 2. The parameters of the von Bertalanffy growth equation and growth performance index values of *C. regium* from Almus Dam Lake.

Sex	n	L_∞ (cm)	t_0 (year)	k (year^{-1})	Φ'
Female	194	33.50	-2.369	0.219	2.391
Male	128	27.50	-1.455	0.397	2.477
All samples	359	32.89	-1.577	0.236	2.407

n, sample size; L_∞, asymptotic length; t_0, theoretical age; k, body growth coefficient; Φ', growth performance index

The LWRs were calculated as W = 0.0036 TL$^{3.316}$ (n=194, length range=14.2-28.1 cm, r^2=0.989) for females, W = 0.0038 TL$^{3.269}$ (n=128, length range=13.7-25.8 cm, r^2=0.984) for males, and W = 0.0039 TL$^{3.281}$ (n=359, length range=13.7-28.1 cm, r^2=0.983) for all specimens. Positive allometric growth (b>3) was observed for females (95% confidence intervals of b=3.267-3.367, P<0.001), males (95% confidence intervals of b=3.196–3.342, P<0.001), and all individuals (95% confidence intervals of b=3.236-3.327, P<0.001).

The relative condition factor (CF) ranged from 0.866 to 1.205 with mean 1.005±0.005 for females, from 0.843 to 1.225 with mean 1.022±0.006 for males, and from 0.788 to 1.246 with mean 1.006±0.004 for overall specimens. There was significant difference in mean CF between sexes (t-test, P<0.05).

4. Discussion and Conclusion

Age distribution and the overall sex proportion of *C. regium* in the present study were I-VI years and 1:0.66, respectively. Age ranges and the sex ratios for this species from different habitats in Turkey were determined as I-VI years and 1:0.53 in the Savur Stream [7], I-VI years and 1:1.06 in the Euphrates [8], I-VIII years and 1: 0.71 in the Atatürk Dam Lake [9], II-V years and 1:1.23 in the Karakaya Dam Lake [11], I-V years and 1:0.82 in the Sır Dam Lake [12], and I-IV years and 1:0.83 in the Seyhan Dam Lake [10], respectively. Our results are in accordance with the previous ones.

Total lengths and weights of the samples examined varied 13.7-28.1 cm and 19-240 g, respectively. These ranges were compared with those reported by Ünlü et al. [7] for Savur Stream (2.8-29.0 cm and 11-296 g), Şevik [8] for Euphrates (11.5-29.2 cm and 17-283 g), Oymak [9] for Atatürk Dam Lake (13.0-30.5 cm and 23-385 g), Kalkan and Erdemli [1] for Karakaya Dam Lake (20.4-31.8 cm and 109-314 g), Kara and Solak [12] for Sır Dam Lake (15.5-26.0 cm and 42-243 g), Ergüden et al. [10] for Seyhan Dam Lake (14.3-24.5 cm and 33-128 g). The variations in the length and weight compositions can be attributed to differences in sampling time and method, sample size, type of length measured, and the ecological properties of studied areas.

The von Bertalanffy growth parameters and growth performance index values of *C. regium* calculated in various studies are shown in Table 3. In present study, while asymptotic length estimated for females (L_∞=33.50 cm) is the higher than males, the growth coefficient for females (k=0.219) is the lower than males. The similar result was

reported by Ünlü et al. [7], Oymak [9], and Kalkan and Erdemli [11] for populations inhabiting different habitats of *C. regium*. This situation may be linked to the faster growing and the longer life of females than males [25]. The Φ' values of current study are not statistically different from other studies (Table 3). This means that the growth of *C. regium* in Almus Dam Lake is similar to population in other localities (t-test, P>0.05).

Table 3. The von Bertalanffy growth parameters and growth performance index values of *C. regium* reported from different studies

Locality	Sex	n	L_∞ (cm)	t_0 (year)	k (year^{-1})	Φ'
	F	188	28.35[*]	-3.303	0.430	2.539
Savur Stream [7]	M	101	23.76	-3.088	0.670	2.578
	T	289	26.74	-3.208	0.510	2.562
	F	422	38.67[*]	-3.074	0.136	2.308
Atatürk Dam Lake [9]	M	303	35.01	-2.754	0.168	2.314
	T	725	34.81	-2.958	0.170	2.314
Karakaya Dam Lake [11]	F	64	39.59[*]	-0.325	0.210	2.517
	M	79	34.96	-0.389	0.326	2.600
	F	252	31.89[*]	-3.445	0.178	2.258
Sır Dam Lake [12]	M	209	38.13	-4.037	0.117	2.231
	T	461	31.98	-3.367	0.178	2.260
	F	89	29.83	-1.984	0.262	2.368
Seyhan Dam Lake [10]	M	75	26.85	-1.630	0.255	2.264
	T	164	28.06	-1.863	0.245	2.286
	F	194	33.50	-2.369	0.219	2.391
Almus Dam Lake	M	128	27.50	-1.455	0.397	2.477
	T	359	32.89	-1.577	0.236	2.407

n, sample size; F, female; M, male; T, total specimens; L_∞, asymptotic length; t_0, theoretical age; k, body growth coefficient; Φ', growth performance index; *fork length

The LWRs of *C. regium* from Almus Dam Lake were highly significant (P<0.001), with r^2>0.982. The parameter b values of LWRs in this study were within the expected range of 2.5-3.5, but they can vary between 2 and 4 [23]. The coefficient b of LWR was calculated as 3.317 for female, 3.269 for male and 3.282 for total specimens. All estimated b values were different from 3 (b>3, P<0.05), and this result shown a positive allometric growth for *C. regium*. Table 4 demonstrates the parameters of LWRs of this species reported from different study areas. Our findings were in agreement with data of Şevik [8], Oymak [9], Kara and Solak [12] and Özcan [15] while they were higher than results of Ünlü et al. [7], Kalkan and Erdemli [11] and Ergüden et al. [10]. Differences in LWRs can be referred to many factors including habitat, area, season, the number of samples, degree of stomach fullness, gonad maturity, sex, health, preservation techniques, and variations in observed length ranges of the specimen examined [26,27].

Table 4. The parameters of length-weight relationship of *C. regium* reported from different studies

Locality	Sex	n	L_{min}-L_{max}	W_{min}-W_{max}	a	b	r^2
Savur Stream [7]	T	289	2.8-29.0[*]	11-296	0.0057	1.844	0.980
Euphrates [8]	T	281	11.5-29.2[*]	17-283	0.000008	3.038	-
Atatürk Dam Lake [9]	F	422	13.0-29.7[*]	23-351	3.8432	3.197	0.917
	M	303	16.8-30.5	29-385	2.3922	3.278	0.944
	T	725	13.0-30.5	23-385	3.0067	3.240	0.927
Karakaya Dam Lake [11]	F	64	20.4-31.8[*]	112-314	0.0590	2.517	-
	M	79	20.6-31.2	109-294	0.5857	1.776	-
	T	143	20.4-31.8	109-314	0.1953	2.124	-
Sır Dam Lake [12]	F	252	15.5-26.0[*]	46-243	0.0082	3.109	0.840
	M	209	16.0-24.3	42-177	0.0115	2.989	0.817
	T	461	15.5-26.0	42-243	0.0092	3.066	0.830
Hatay Province [15]	T	128	18.4-33.8	68-467	0.0010	3.282	0.709
Seyhan Dam Lake [10]	T	164	14.3-24.5	33-128	0.0327	2.640	0.929
Almus Dam Lake	F	194	14.2-28.1	22-240	0.0036	3.317	0.989
	M	128	13.7-25.8	19-168	0.0038	3.269	0.984
	T	359	13.7-28.1	19-240	0.0039	3.282	0.983

n, sample size; F, female; M, male; T, total specimens; L_{min}, minimum length (cm); L_{max}, maximum length (cm); W_{min}, minimum weight (g); W_{max}, maximum weight (g); *Fork length

The relative condition factor of *C. regium* inhabiting Almus Dam Lake showed that the males were in better condition than the females. The similar observation was reported by various authors [28-30]. This may be due to several reason such as feeding activity and gonadal development of females. Moreover, condition of fish can be varied by several factors including state of sexual maturity, feeding regime, fullness rate of the stomach, and age of fish as well as season and sex [31].

Consequently, our study is the first investigation concerning *C. regium* population in Almus Dam Lake and provides some information on the age structure, sex proportion and growth properties of this species. According to results of present research, it is suggested that the growth features of *C. regium* in this dam lake are similar to those of different localities. Further studies are required for biological data such as feeding and reproduction characteristics, sustainable fishery management, and conservation of *C. regium* in Almus Dam Lake.

Acknowledgement

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