Population structure and some growth properties of chub *Squalius cephalus* (Linnaeus, 1758) in Devres Stream of Kızılırmak River, Turkey

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Abstract

This study describes the population structure, growth and condition factor of chub (*Squalius cephalus*) in Devres Stream of Kızılırmak River caught between June 2010 and June 2011. *S. cephalus* individuals ranging between I and VI years old were caught from Devres Stream. Studied individuals were between I and VI years old and their sex was determined as 51.67% male and 48.33% female. The fork length and body weight ranged from 8.79 – 19.64 cm and 9.73 – 126.60 g respectively. The von Bertalanffy growth equations were found: L_t = 27.163 $[1 - e^{-0.159\ (t+1.47)}]$ for females and L_t = 27.078$[1 - e^{-0.160\ (t+1.46)}]$ for males; W_t = 286.14 $[1 - e^{-0.159\ (t+1.47)}]^{3.1049}$ for females and W_t = 284.43 $[1 - e^{-0.160\ (t+1.46)}]^{2.9692}$ for males. The condition factor was calculated as 1.432 and 1.378 for females and males respectively.

Keywords: *Squalius cephalus*; chub; growth; von Bertalanffy's parameters; Devres Stream; Kızılırmak River.

1 | INTRODUCTION

The chub *Squalius cephalus* (Linnaeus, 1758), members of the family Cyprinidae, are common and widely distributed in Europe and Asia. One of the possible reasons for that is the high environmental tolerance of the chub (Arlinghaus and Wolter 2003). This species is usually investigated as an unpretentious species which occurs commonly in localities with different conditions, both natural and artificial ones (Arlinghaus and Wolter 2003). Since it is consumed as food by the locals, the *S. cephalus* has economic value; therefore, in order to take better advantage of the populations of this species, it is important to understand its growth and reproduction characteristics. Some authors have worked on its growth in connection with its usual occurrence of fish species. Many studies have been carried out on age and growth properties of the *S. cephalus*

(Lelek 1959; Vostradovský 1961; Leontovyč 1974; Habasby 1974; Leontovyč 1980; Hanel 1982 1984; Švátora and Pivnička 1986 1989; Altındağ 1996; Ünver 1998, Türkmen *et al.* 1999; Geldiay and Balık 1999; Vlach and Švátora 2000; Vlach and Švátora 2000; Sası and Balik 2003; Kara and Solak 2004; Balık *et al.* 2004; Karatas and Can 2005, Koc *et. al.* 2006; Kirankaya and Ekmekçi 2007, Stefanova *et al.* 2008; Şen and Saygın 2008; Bostancı and Polat 2009; İnnal 2010; Pompei *et al.* 2011; Dirican and Çilek 2012; Bulut *et al.* 2012; Sedaghat *et al.* 2012; Ünver and Erk'akan 2012; Raikova-Petrova *et al.* 2012; Özay 2014; Kaptan 2014; Çicek *et al.* 2016; Kılıç and Becer 2017).

The aim of this study is to determine the age composition, sex ratio, length and weight growth, the length-weight relationship, and the condition factor of *S. cephalus* in Devres Stream, Kızılırmak River. This study is very

important in determining the growth characteristics of the *S. cephalus* which is very common in the domestic waters of this water system which is rich in biodiversity.

2 | METHODOLOGY

Devres Stream is a branch of the Kızılırmak River, geographically located in the Western Black Sea Region of Turkey. Devres Stream is located about 70 km south of Kastamonu, and lies within the coordinates of 35°49′00″ N to 42°35′00″ N latitudes and 25°00′00″ E to 44°51′00″ E longitudes. A total of 329 *S. cephalus* (159 females and 170 males) were collected between June 2010 and June 2011 from the Devres Stream, Kızılırmak River by using a gill net (18–55 mm mesh). Collected specimens were transported to the laboratory to record the fork length (FL) to the nearest 0.1 cm and body weight (BW) to the nearest 0.1 g. Scales were sampled from each specimen for age determination according to Lagler (1966).

Growth was estimated using the von Bertalanffy growth curve model (Sparre and Venema 1992) $L_t = L_\infty[1-e^{-K(t-t0)}]$ and weight $W_t = W_\infty[1-e^{-K(t-t0)}]^b$ where L_t = the fork length (cm) at age t, L_∞ = the asymptotic length (theoretical maximum length), k = the Brody growth coefficient (proportional to rate at which L_∞ is reached), t = the age (years), t_0 = the age at zero length, e is the base of natural log (2.71828), W_t is the weight of the fish in g at age t, W_∞ is the asymptotic weight of (theoretical maximum weight) the fish in g and b is the constant in the length–weight relationship. The von Bertalanffy growth parameters were estimated for males and females separately as well as for both sexes combined. The relationship between FL and

BW was calculated separately for each sex with $\log_{10}$-transformed data (Le Cren 1951). The condition factors (CF) of fish was determined using the formula $(W\ L^{-3}) \times 100$ (Ricker 1975) where W = body weight and L = body length. t-test was performed to test if there were significant differences between the length, weight and condition factor of females and males. Statistical analysis of the data was carried out using SPSS statistical package program for Windows (Version 20.0).

3 | RESULTS

Collected specimens of *S. cephalus* were aged from I to VI years and dominated by the first and second year classes. There were 48.33% females and 51.67% males (ratio 1 : 1.07), and differences in their numbers among different age groups was insignificant (t = 2.509; P > 0.05).

The mean FL, mean W and CF of male and female fish in different age groups are presented in Table 1. Males in all age groups were longer than females. The differences between the sexes were insignificant in all groups (t = 2.215; P > 0.05). Age–length relationships of females and males were plotted in Figure 1 with the respective equations indicated and differences between sexes were insignificant in all age groups (t = −1.963; P > 0.05). Male and female age–weight relationships were drawn in Figure 2. While the weight of the females was higher than that of the males in age groups III and V, the weight of the males was higher than that of the females in age groups I, II, IV and VI. Females grew to a greater asymptotic (W_∞) weight than the males (Figure 3).

TABLE 1 Fork length, weight and condition factor of *Squalius cephalus* in Devres Stream

Age	N	Male			N	Female		
		FL ± SE	W ± SE	CF ± SE		FL ± SE	W ± SE	CF ± SE
I	43	8.90±0.84	10.18±2.66	1.42±0.16	27	8.79±0.99	9.73±3.24	1.40±0.29
II	84	11.33±0.94	20.03±6.66	1.35±0.26	65	11.21±0.83	19.95±4.78	1.40±0.15
III	27	13.49±1.22	32.44±6.43	1.34±0.33	41	13.56±1.54	36.42±14.39	1.41±0.18
IV	7	16.57±1.24	55.43±8.98	1.33±0.24	13	15.93±0.90	61.42±18.70	1.37±0.22
V	4	17.95±0.29	91.62±31.62	1.57±0.47	7	18.00±0.28	100.85±22.03	1.72±0.30
VI	5	19.64±0.86	121.83±19.88	1.68±0.26	6	18.82±0.82	126.60±18.77	1.85±0.37

N, number of fish; *FL*, Fork length (cm), *W*, Weight (g) and *CF*, Condition factor (all *P* > 0.05)

Length–weight relationships (Figure 3) were calculated using the data of all fish samples. The relationship was W = 0.01463008 $L^{2.9692}$ (R^2 = 0.900) for the males and W = 0.01089046 $L^{3.1049}$ (R^2 = 0.913) for the females. The b value for the females was higher than that of the males. While CF of the females was higher than that of the males

in age groups II, III, IV, V and VI, CF of the males was higher than that of the females in age group I. The differences between sexes were insignificant (t = 2.215, P > 0.05; Table 1). The condition factor was calculated as 1.432 and 1.378 for the females and males respectively.
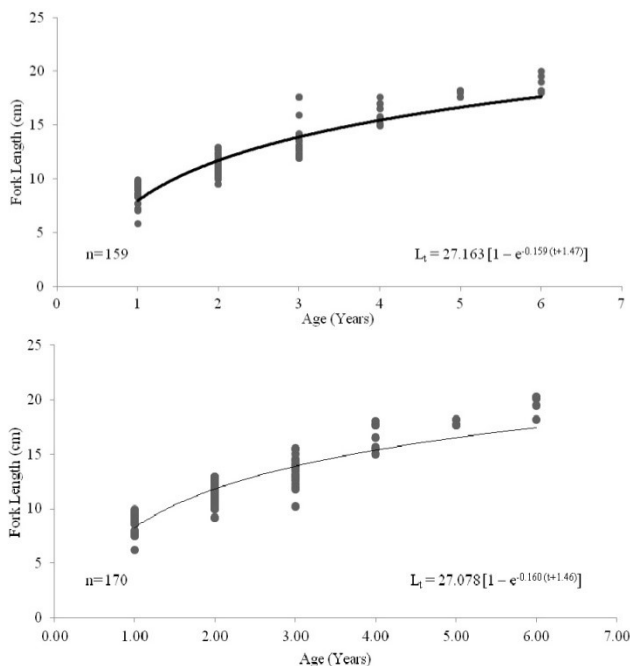
FIGURE 1 Age–length relationships in female (above) and male (below) *Squalius cephalus*
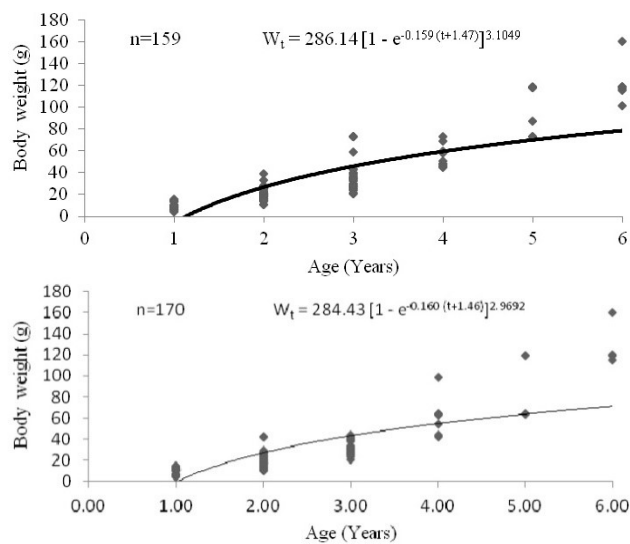

FIGURE 2 Age–weight relationships in female (above) and male (below) *Squalius cephalus*

4| DISCUSSION

The female male sex ratio (F : M) of the chub in Devres Stream was 1 : 1.07, and similar to the 1 : 1 ratio expected for most fish species (Bagenal and Tesch 1978). The sex ratios for this species from different habitats in the world and Turkey were determined as 1 : 2.85 in the Istranca Stream (Kaptan 2014), 1.6 : 1 in the Akçay/Muğla (Özay 2014), 2.98 : 1 in Yeniçağa Lake (Kılıç and Becer 2017), 1.5 : 1 in the River Inny (Caffrey *et al.* 2008). 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. At early life stages the ratio of males is higher, but at later stages the female ratio is higher (Nikolsky 1963) and the results are in agreement with the findings of (Koç *et al.* 2006; Kaptan 2014; Özay 2014; Kılıç and Becer 2017). Some of the research found that the number of female is higher than males in all age groups (Ünver and Erk'akan 2012). Most of the samples studied in the present study belonged to the III year age group. Koç *et al.* (2006); Ünver and Erk'akan (2012); Özay (2014) reported a similar situation for İkizcetepeler Dam Lake, Tödürge Lake and the Akçay Stream populations. Majority of the specimens were in the II year age group for the Devres Creek and Istranca Stream (Balık *et al.* 2004; Kaptan 2014). The number of the individuals was in the age group III in this study.
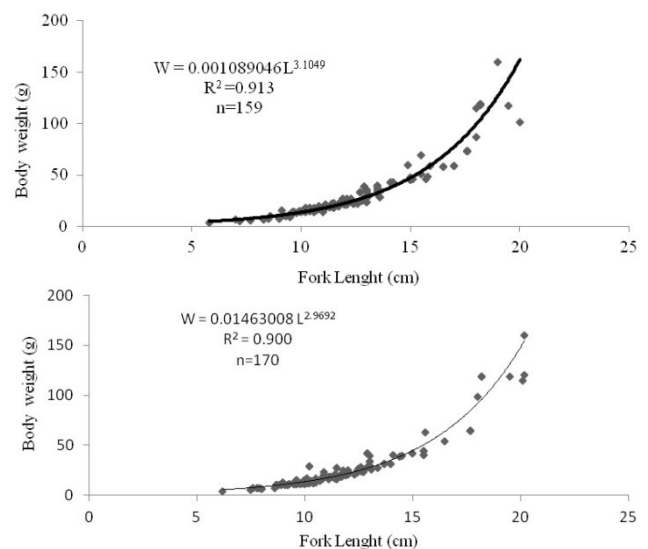

FIGURE 3 Length–weight relationships in female (above) and male (below) *Squalius cephalus*

The males were longer than the females in all the age groups in this research. The females of III, IV, V and VI year age groups were found heavier than the males, while in other age groups, the males were found heavier than the females. The males were longer and heavier at earlier life stages, while the females were longer and heavier at later stages (Koç *et al.* 2006; Ünver and Erk'akan 2012, Özay 2014). Kaptan (2014) found that females were heavier than males in all ages according to this study. Variations in fish growth in terms of length and weight can be explained as an adaptive response to different ecological conditions (Nikolsky 1963). The von Bertalanffy growth equations were: $L_t = 27.163 [1 − e^{−0.159 (t+1.47)}]$ for females and $L_t = 27.078 [1 − e^{−0.160 (t+1.46)}]$ for males; $W_t = 286.14 [1 − e^{−0.159 (t+1.47)}]^{3.1049}$ for females and $W_t = 284.43 [1 - e^{−0.160 (t+1.46)}]^{2.9692}$ for males.

Male individuals were longer than females at I, II, IV and VI, while females were longer than males at III and V. When weights were examined, it was determined that male individual at I and II ages were heavier than female individual while females were heavier than males at other ages (Table 2). While some earlier studies have reported similar theoretical maximum length (Koç *et al.* 2006), other studies were different (Bulut *et al.* 2012; Sedaghat *et al.* 2012; Özay 2014; Kaptan 2014). This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex and gonadal development of fish (Ricker 1975). Geographic location and some environmental conditions such as temperature, organic matter, and quality of food, time of capture, stomach fullness, disease, parasitic loads (Bagenal and Tesch 1978) affect growth.

TABLE 2 Length–weight relationship (*a* and *b*), growth (L_∞, K, t_0).

Study area	Weight range	Length range	N	a	b	r^2	L_∞	k	t_0	Ref.
İkizce tepeler	18.6-243.6[a]	11.1-24.8[a]	172[a]	0.0227[a]	2.87[a]	0.90[a]	26.7[a]	0.26[a]	-1.55[a]	Koç *et al.* (2006)
Dam Lake	29.3-173.9[b]	12.2-24.1[b]	242[b]	0.0194[b]	2.92[b]	0.89[b]	28.9[b]	0.22[b]	-1.55[b]	
Maritza River	41-290	-	161	0.015	3.06	0.99	48.8	0.15	-0.05	Stefanova *et al.* (2008)
Assino Creek	-	-	-	-	-	-	63.91	0.123	-0.160	Pompei *et al.* (2011)
Gamasiab River	31.4-271.12	13.82-29.51	60	0.006	3.97	0.97				Sedaghat *et al.* (2012)
Tödürge Lake	3.8-120.5[a]	6.6-20.1[a]	93[a]	0.012[a]	3.03[a]					Ünver and Erk'akan (2012)
	1.5-320.8[b]	5.3-27.9[b]	373[b]	0.010[b]	3.10[b]					
Akçay Stream	3.78-73.52[a]	6.8-18.2[a]	168[a]	0.078[a]	3.16[a]	0.97[a]	26.09[a]	0.281[a]	-0.393[a]	Özay (2014)
	2.76-124.6[b]	6.7-24.6[b]	145[b]	0.0116[b]	2.97[b]	0.96[b]	36.27[b]	0.102[b]	-1.372[b]	
Istranca Stream	0.70-132.50[a]	3.9-23[a]	488[a]	0.0093[a]	3.08[a]	0.99[a]	39.51[a]	0.137[a]	-0.682[a]	Kaptan
	0.23-357.50[b]	3.2-30.1[b]	171[b]	0.0071[b]	3.18[b]	0.99[b]	49.13[b]	0.127[b]	-0.488[b]	(2014)
Yeniçağa Lake	-	-	729	-	-	-	36.88	0.248	-1.278	Kılıç and Becer (2017)
Devres Stream	4.0-164[a]	5.9-20.2[a]	159[a]	0.0146[a]	2.97[a]	0.90[a]	27.1[a]	0.160[a]	-1.46[a]	Present study
	4.2-168[b]	5.6-20.1[b]	170[b]	0.0108[b]	3.11[b]	0.91[b]	27.1[b]	0.159[b]	-1.47[b]	

[a] male, [b] female; N, number of fish, W (g), L (cm).

Condition factor of chub varied from 1.01 to 2.75 in male; from 1.04 to 2.35 in female. Maximum CF was found as 2.75. The results are in agreement with some earlier reports (Koç *et al.* 2006), while it differs from the studies carried out by (Balık *et al.* 2004; Bostanci and Polat 2009; Ünver and Erk'akan 2012). CF of *S. cephalus* differed in terms of age and gender of fish (Table 1). CF values of *S. cephalus* in the Devres Stream was recorded to be lower than 3.

The slope (*b*) values of the length–weight relationship in both gender was found as a 3.049. Similar b values for *S. cephalus* were reported earlier (Bostancı and Polat 2009; Ünver and Erk'akan 2012, Bulut *et al.* 2012), but it differed from those found several studies (e.g. Koç *et al.* 2006; Sedaghat *et al.* 2012; Özay 2014; Kaptan 2014).

The *b* value is often 3.0 and generally between 2.5 and 3.5. As the fish grows, changes in weight are relatively greater than the changes in length, due to approximately cubic relationships between fish length and weight. The b values in fish is species specific and varies with sex, age, seasons, physiological conditions, growth increment and nutritional status of fish (Ricker 1975; Bagenal and Tesch 1978).

In conclusion, this is the study presenting the age composition, sex ratio, length and weight growth, the length-weight relationship, and the condition factor of *S. cephalus* in the Devres Stream, Kızılırmak River. In addition, it is recommended that the necessary steps should be taken as soon as possible to protect the *S. cephalus* population in the Devres Stream, Kızılırmak River after investigating its stock situation, breeding and feeding behaviors.

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SB & AG primary data collection;
SB data processing, manuscript preparation