

The Variation of Several Biological Characteristics of the Chub, *Squalius cephalus* (L., 1758), in the Orenler Dam Lake, Northwest Anatolia, Turkey

Sait BULUT¹, Ramazan MERT^{2*}, Muhsin KONUK¹, Beklan ALGAN³, Ali ALAŞ⁴, Kemal SOLAK⁵

¹Afyonkocatepe University, Faculty of Science and Letters, Department of Biology, 03200, Afyonkarahisar, Turkey

²Neuşehir University, Faculty of Science and Letters, Department of Biology, 50300, Neuşehir, Turkey; rmert20@gmail.com (*corresponding author)

³Afyonkocatepe University, Institute of Science and Tecnology, TR-03200, Afyonkarahisar, Turkey

⁴Necmettin Erbakan University, A.K. Education Faculty, Department of Biology, 42090, Konya, Turkey

⁵Gazi University, Gazi Education Faculty, Department of Biology, TR-06500, Ankara, Turkey

Abstract

In the present study, several growth parameters of 338 *Squalius cephalus* (L., 1758) specimens collected from the Orenler dam lake (Turkey) between July 2005 and June 2006 were studied. The population comprised 50.74% males, 46.29% females, and 2.97% males+females. In the examined samples, the age of females and males ranged from I to VII and I to VI, respectively. The fork length and weight of females were 14.7-38.0 cm and 40.68-27.0 g, respectively; these values were 16.3-33.7 cm and 57.7-560.0 g, respectively, for males. The age-length and age-weight relationships at time t were calculated by the von Bertalanffy equation for females, and the following results were obtained: $L_t = 37.12[1 - e^{-0.36(t-(-0.96))}]$, $W_t = 775.6[1 - e^{-0.36(t-(-0.96))}]^{3.27}$, $L_t = 43.59[1 - e^{-0.3356(t-(-0.719))}]$, and $W_t = 1123.2[1 - e^{-0.3356(t-(-0.719))}]^{3.08}$. The calculated length-weight relationship was $W = 0.36L^{3.27}$ for females and $W = 0.03356L^{3.08}$ for males. The average condition factor was 1.412 for females and 1.284 for males. Consequently, in the Orenler dam lake, *S. cephalus* grows very well according to the study's results.

Keywords: Afyonkarahisar, chub, length-weight relationship, *Squalius cephalus*, von Bertalanffy

Introduction

The chub, *Squalius cephalus* is distributed in the whole of Europe, the Black Sea, the Azov Sea, the Caspian Sea, and Anatolian inland waters. It belongs to Cyprinidae family and prefers fresh, clean, and fast-flowing waters, as well as dam lakes (Kottelat and Freyhof, 2007). Efforts have been made to increase its population artificially in inland waters, such as dam lakes (Geldiay and Balik, 1999).

A number of studies on the chub's population in different parts of Turkey have been previously reported: Biology of the species in the Pinarbasi (İzmir) water spring (Geldiay and Balik, 1972), Bioecology of the species in the Kapulukaya dam lake (Gul, 1994), Bioecology of the species in the Kayabogazi dam lake in Kutahya (Alas, 1998), Some population characteristics of the species in Aksehir Lake (Altindag, 1996), Age, growth, and sex distribution of the species in the Topcam dam lake (Sasi and Balik, 2003), Growth characteristics of the species in the Sir dam lake (Kara and Solak, 2004), Age, growth, and reproduction characteristics of the species in the İkizcetepeler dam lake (Koc *et al.*, 2004), Growth, development, and mortality rates in the Almus dam lake (Karatas and Can, 2005), Changes in growth characteristics of the species in the Gelingullu dam lake (Kirankaya and Ekmekci, 2007) and

Biological characteristics of the species in Karasu River (Sen and Saygin, 2008).

Climatic, geographic, and ecological conditions affect the growth and reproductive features of living creatures differently. The Orenler dam lake contains fish that provide a large proportion of the protein supply for the region (Northwest Anatolia, Turkey). Despite its economic importance, few studies have focused on various aspects of the biology of the *S. cephalus* in the region (Karacali, 2007; Kurupinar and Ozturk, 2009; Yegen *et al.*, 2009).

There is no study on the growth properties of the chub in the Orenler dam lake. Therefore, the aim of the study is to determine the age composition, sex ratio, length and weight growth, the length-weight relationship, and the condition factor of a chub sample and compared these with performance data obtained of the species from other regions.

Materials and methods

Study area

The Orenler dam lake is situated in the Sandikli borough of the Afyonkarahisar province, Turkey (38°36'20.98" N, 30°13'46.74" E), and was constructed on the Karadirek creek for irrigation purposes (Fig. 1) in 1993. It is also fed

by the Ketenli, Nuh, Bilaci, Koru, and Kocadere creeks. Its coverage area is 3.23 km², altitude is 1171 m above sea level, and depth is a maximum of 26 m (Fig. 1; Kurupinar and Ozturk, 2009).

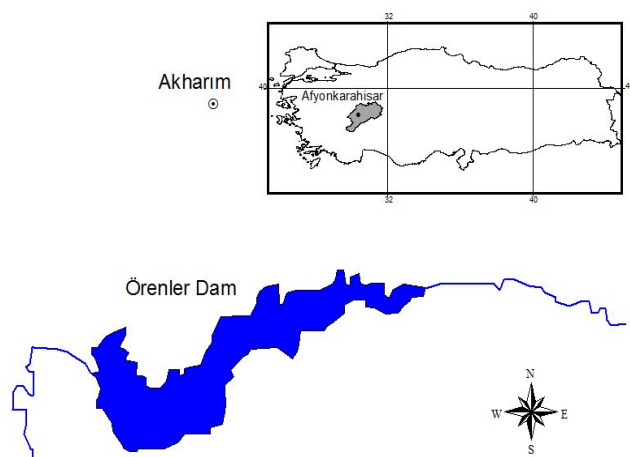


Fig. 1. Orenler dam lake, the studied site

Sample collection

For this study, 338 specimens were captured monthly from July 2005 to June 2006 using nets of 18-60 mm mesh size. Fish samples were transported to the laboratory for analyses of fork length (FL) to the nearest 0.1 cm and weight to the nearest 0.1 g.

Sex and age determination

Sex was determined by macroscopic observation of the gonads. Age was determined from microscopic examination of scales. Ten to fifteen scales from the left side of the body between the lateral line and the dorsal fin were removed and dry-mounted between two slides for binocular microscopy (Lagler, 1966).

Growth analysis

The age-length relationship ($L_t = L_{\infty}[1 - e^{-k(t-t_0)}]$) and age-weight relationship ($W_t = W_{\infty}[1 - e^{-k(t-t_0)}]^b$), were determined using the von Bertalanffy growth equations (Bertalanffy, 1938). The length-weight relationship was calculated using Le Cren's allometric growth formula: $W = aL^b$ (1951). Condition coefficients were calculated for both sexes using the equation $K = (W/L^3) \times 100$ (Bagenal, 1978).

Statistical analysis

To compare growth and condition factor values of the same age group, the *T*-test was used and $p < 0.05$ was accepted as the significant value (Duzgunes, 1975). Statistical analyses were carried out with the Statistical Package for the Social Sciences (SPSS) software.

Results

Age composition and sex ratio

Age and sex distribution data is summarized in Tab. 1 and Fig. 2. Age of the captured fish ranged between I and VII years, and the year II class was dominant. Because of selectivity of the nets, the 0 age group was not represented in the samples.

There were about 50.59% males and 46.45% females, and differences between sexes according to age were not significant ($p < 0.05$). The sex ratio (F:M) was 1:1.09.

Tab. 1. The age and gender distribution of *S. cephalus* in Orenler dam lake

Age	Female		Male		Female+Male	
	N	N%	N	N%	N	N%
I	-	-	-	-	10	2.96
II	45	13.31	124	36.69	169	50.00
III	44	13.02	22	6.51	66	19.53
IV	31	9.17	12	3.55	43	12.72
V	16	4.73	8	2.37	24	7.10
VI	16	4.73	5	1.48	21	6.21
VII	5	1.48	-	-	5	1.48
Total	157	46.45	171	50.59	338	100

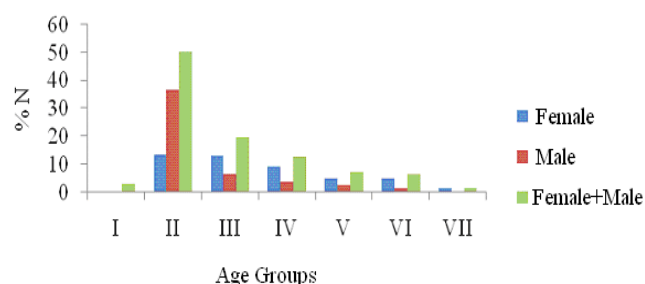


Fig. 2. The length distribution for *S. cephalus* in accordance to age and gender in Orenler dam lake

Length-frequency distribution

Of the 338 specimens measured, the FL of males ranged from 16.3 to 33.7 cm; the range for females was higher (14.7 to 38.0 cm) (Tab. 2). However, the difference between the mean FL of females and males for all years (except VI) was significant ($p < 0.05$, *T*-test).

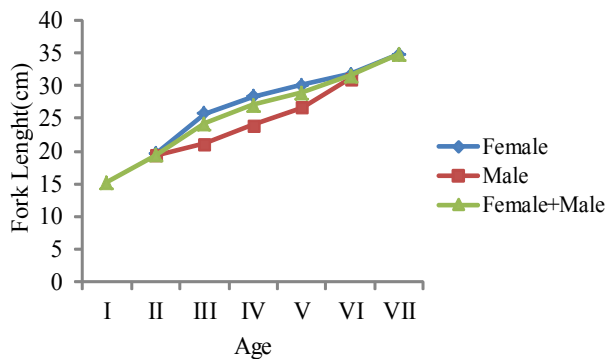
Growth

Data on the mean FL and mean total weight for different ages in males, females, and males+females is summarized in Tab. 2 and 3. The number and percentage of males in year II were higher than females. But females were dominant for other years (III-VI).

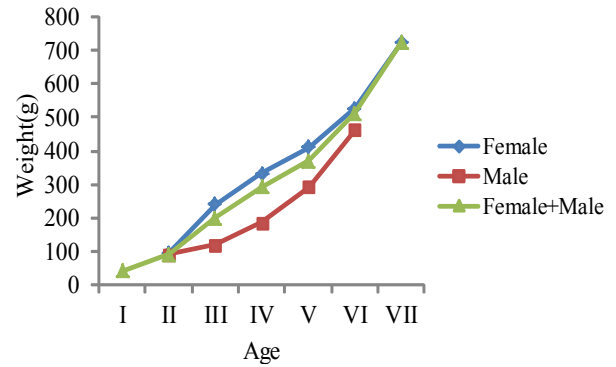
Age-length and age-weight relationships of females and males are plotted in Fig. 3 and 4, respectively. Age-weight relationships are given in Tab. 4. Females grew

Tab. 2. The fork length statistics for age and gender of *S. cephalus* Orenler dam lake

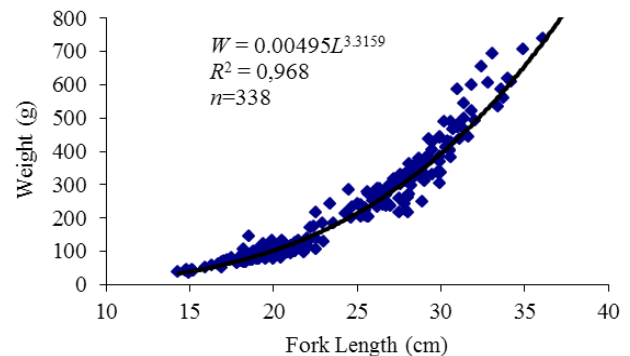
Age	Female FL (cm)±SD (min-max)	Male FL (cm)±SD (min-max)	T-test	Female+Male FL (cm)±SD (min-max)
I	-	-	-	15.2±0.7 (14.3-16.9)
II	19.6±1.3 (14.7-21.4)	19.3±1.0 (16.3-22.5)	$p<0.05$ significant	19.4±1.1 (14.7-22.5)
III	25.7±2.4 (19.4-28.9)	21.1±0.8 (19.6-23.0)	$p<0.05$ significant	24.1±2.9 (19.4-28.9)
IV	28.4±1.1 (25.0-30.0)	24.1±2.8 (18.5-27.9)	$p<0.05$ significant	27.2±2.6 (18.5-30.0)
V	30.1±0.8 (28.5-31.6)	26.6±2.6 (22.5-29.3)	$p<0.05$ significant	28.9±2.2 (22.5-31.6)
VI	31.8±1.4 (29.9-34.2)	31.1±2.2 (27.5-33.7)	$p<0.05$ insignificant	31.6±1.6 (27.5-34.2)
VII	34.9±2.3 (32.4-38.0)	-	-	34.9±2.2 (32.4-38.0)

Fig. 3. The age-length relations for *S. cephalus* in Orenler dam lakeTab. 3. The weight statistics for age and gender of *S. cephalus* in Orenler dam lake

Age	Female W (g)±SD (min-max)	Male W (g)±SD (min-max)	T-test	Female+Male W (g)±SD (min-max)
I	-	-	-	42.6±4.4 (36.5-50.7)
II	95.0±16.9 (40.6-125)	90.3±11.6 (57.5-109.9)	$p<0.05$ significant	91.6±13.3 (40.6-125)
III	241.0±62.6 (105.2-328.1)	120.5±9.1 (110.4-140.4)	$p<0.05$ significant	200.8±76.7 (105.2-328.1)
IV	333.3±32.0 (240.5-377.5)	186.6±36.1 (116.3-222.6)	$p<0.05$ significant	292.4±74.2 (116.3-377.5)
V	411.0±31.0 (347-468)	293.0±78.0 (216.7-436.1)	$p<0.05$ significant	371.7±75.5 (216.7-468)
VI	527.0±67.3 (413.5-618.5)	462.1±118.7 (257.7-560.2)	$p<0.05$ significant	511.5±83.7 (257.7-618.5)
VII	724.1±65.1 (654.5-827)	-	-	724.1±65.1 (654.5-827)

Fig. 4. The age-weight relations for *S. cephalus* in Orenler dam lakeTab. 4. von Bertalanffy length increase parameters for *S. cephalus* in Orenler dam lake

Sex	L_{∞}	t_0	k	b	Equations
Female	43.59	-0.719	-0.3356	3.2756	$L_t = 43.59 [1 - e^{-0.3356(t+0.719)}]$
Male	37.12	-0.96	-0.36	3.0807	$L_t = 37.12 [1 - e^{-0.36(t+0.96)}]$
Female+Male	42.04	-1.88	-0.127	3.159	$L_t = 42.04 [1 - e^{-0.127(t+1.88)}]$

Fig. 5. Length-weight relationship of *S. cephalus* in Orenler dam lake

to a greater asymptotic (L_{∞}) length than males (Tab. 5). Females grew to a greater asymptotic (W_{∞}) weight than males and weighed more than males (Fig. 4). Differences between the sexes according to age group for total weight were statistically significant in all age groups ($p<0.05$).

Length-weight relationships

According to the present findings the b value for females was higher than that for males (Tab. 6). The length-weight curves for males and females are plotted in Fig. 5.

Condition factors

The mean condition factor for females was higher than that for males, but the differences between sexes were not significant ($p<0.05$, T -test; Tab. 7 and Fig. 6).

Tab. 5. von Bertalanffy weight increase parameters for *S. cephalus* in Orenler dam lake

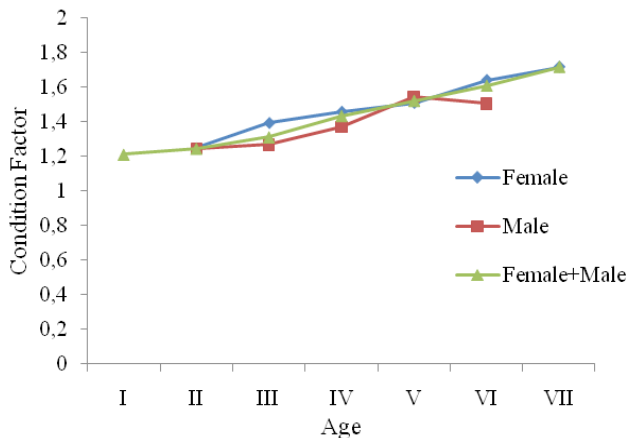
Sex	W_{∞}	t_0	k	b	Equations
Female	1123.2	-0.719	-0.3356	3.2756	$W_t: 1123.2 [1 - e^{-0.3356(t - (-0.719))}]^{3.2756}$
Male	775.6	-0.96	-0.36	3.0807	$W_t: 775.6 [1 - e^{-0.36(t - (-0.96))}]^{3.0807}$
Female+Male	1198.4	-1.88	-0.127	3.159	$W_t: 1198.4 [1 - e^{-0.127(t - (-1.88))}]^{3.3159}$

Tab. 6. The equations of length-weight relation for *S. cephalus* in Orenler dam lake

Sex	N	A	B	Growth Equations	r
Female	157	0.0056	3.2756	$\log W = -2.2518 + 3.2756 \log L$	0.963
Male	171	0.0100	3.0807	$\log W = -2 + 3.0807 \log L$	0.906
Female+Male	338	0.0049	3.3159	$\log W = -2.3053 + 3.3159 \log L$	0.968

Tab. 7. Mean condition factor according to age and sex of *S. cephalus* in Orenler dam lake

Age	Female CF \pm SD (min-max)	Male CF \pm SD (min-max)	T-test	Female+Male CF \pm SD (min-max)
I	-	-	-	1.2112 \pm 0.0997 (1.0503-1.3634)
II	1.2475 \pm 0.1231 (1.0474-1.5004)	1.2441 \pm 0.1044 (0.9550-1.4945)	$p < 0.05$ insignificant	1.2454 \pm 0.1050 (0.9550-1.5004)
III	1.3928 \pm 0.1884 (0.9917-1.9270)	1.2663 \pm 0.1421 (0.9437-1.7417)	$p < 0.05$ insignificant	1.3115 \pm 0.1707 (0.9437-1.9270)
IV	1.4572 \pm 1.1115 (1.1368-1.6324)	1.3700 \pm 0.3497 (1.0249-1.6788)	$p < 0.05$ insignificant	1.4329 \pm 0.2061 (1.0249-1.6788)
V	1.5087 \pm 0.0968 (1.4055-1.6609)	1.5433 \pm 0.2672 (1.2324-1.9024)	$p < 0.05$ insignificant	1.5202 \pm 0.1677 (1.2324-1.9024)
VI	1.6395 \pm 0.1473 (1.4390-1.9690)	1.5042 \pm 0.1611 (1.2391-1.6223)	$p < 0.05$ insignificant	1.6073 \pm 0.1580 (1.2391-1.9690)
VII	1.7152 \pm 0.1922 (1.4121-1.9243)	-	-	1.7152 \pm 0.1922 (1.4121-1.9243)

Fig. 6. Mean condition factor according to age and sex of *S. cephalus*

Discussion

In this research, a total of 338 specimens of *S. cephalus* from the Orenler dam lake were examined from July 2005 to June 2006. The age of the specimens ranged between years I and VII. Of the specimens 72.42% were between years I and III, indicating that the population comprised mostly young individuals.

According to the present findings, the *S. cephalus* population in the Orenler dam lake consisted of 50.59% males and 46.45% females. In this study, the sex ratio was 1:1.09 (F:M) and not significantly different from 1:1 (χ^2 -test). Although the sex ratio in most of the species was close to 1, this may vary from species to species, from one population to another of the same species, and 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). Some early studies verify the present findings (Altindag, 1996; Balik *et al.*, 2004; Ekmekci, 1996; Erdogan *et al.*, 2002; Kalkan *et al.*, 2005; Karatas, 1997; Koc *et al.*, 2007; Oztas and Solak, 1988).

In this study, the year II group was dominant. Like the present findings, most of the samples were in the year II age group for Akşehir Lake, Muceldi Stream, and Isıklı Lake (Altindag, 1996; Balik *et al.*, 2004; Oztas and Solak, 1988). On the other hand, findings at Kirmir Stream (Solak *et al.*, 1995) and the Sariyar dam lake (Ekmekci, 1996) are different from the present findings.

The calculated L_{∞} values of females of the *S. cephalus* population were found to be greater than that of males in this study. The present results indicate that $L_{\infty} = 43.59$ for females and $L_{\infty} = 37.12$ for males, which are higher than the values reported by Altindag (1996), Erdogan *et*

al. (2002), and Koc et al. (2007). On the other hand, the L_{∞} values are lower than the result of Unver and Tanyolac (1999). Differences noted in growth may be attributed to variations in habitat, temperature, and possibly differences in feeding habits (Yildirim et al., 2002). Geographic location and some environmental conditions, such as water temperature, organic matter, quality of food, date and time of capture, stomach fullness, disease, and parasite load, can also affect weight-at-age estimates (Bagenal and Tesch, 1978).

The length-weight relationship in fishes is affected by a number of factors, including season, habitat, gonad maturity, sex, diet and stomach fullness, health, and preservation techniques (Tesch, 1968). Results of the present study indicated that the b value was 3.27 for females and 3.08 for males. So it could be concluded that the growth of *S. cephalus* in the Orenler dam lake is isometric, meaning that the shape does not change as the fish grows. In general, the value of b lies between 2.5 and 4 and can vary as a result of changes in fish shape, season, age, and food availability (Ricker, 1979). In the present study, the value of b remained within the expected range.

Conclusions

Consequently, the present study provides some important information on the age and growth of *S. cephalus* that would be useful for fishery biologists to propose adequate regulations for sustainable fishery management and conservation of this economically important fish species in the Orenler dam lake. As no studies have been done on the age composition, sex ratio, length and weight growth, length-weight relationship, and condition factor of *S. cephalus* living in the Orenler dam lake, there is no comparison.

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