Afyon Kocatepe Üniversitesi *6 (2)* *Afyon Koactepe University*
FEN BİLİMLERİ DERGİSİ 1-12 JOURNAL OF SCIENCE

SOME BIOLOGICAL PROPERTIES OF THE SQUALIUS CEPHALUS (L., 1758) POPULATION INHABITING APA DAM LAKE IN KONYA (TURKEY)

Ramazan Mert[a] Sait Bulut[b] ve Kemal Solak[c]

[a]*Faculty of Science and Art, Nevsehir University, 50300, Nevsehir, Turkey*
[b]*Faculty of Science and Art, Afyonkocatepe University, 03200, Afyonkarahisar, Turkey*
[c]*Faculty of Education, Gazi University, 06500, Ankara, Turkey*
e-posta: mert@nevsehir.edu.tr

Abstract

In the present study, sex and age distribution, growth, reproduction properties and condition factor of *Squalius cephalus* (L., 1758), Inhabiting Apa Dam Lake, were investigated. The ages of *S. cephalus* were determined in the range of I to V. of the investigated samples, 45.36% were female and 43.46% were male. The minimum fork length of this species was 131 mm, the lowest weight was 30 g, the maximum fork length was 307 mm and the highest weight was 438 g. Relation between length and weight was calculated as $W = 0.091 \times L^{2.43}$ (female+male). First sex maturity was attained at the age of II in males and III in females and spawning occurs between may and july. Monthly gonadosomatic index (GSI) values varied from 1.23 to 7.87. Fecundity increased with the age.
Key Words: Squalius cephalus, age and growth, reproduction, Apa Dam Lake

APA BARAJ GÖLÜ'NDE YAŞAYAN *SQUALIUS CEPHALUS* (L., 1758)'UN BAZI BIYOLOJIK ÖZELLIKLERI.

Özet

Bu çalışmada Apa Baraj Gölü'nde yaşayan ve ekonomik öneme sahip Squalius cephalus (L., 1758) populasyonunun eşey dağılımı, yaş dağılımı, büyüme ve üreme özellikleri ile kondisyon faktörü araştırılmış ve S. cephalus'un I-V yaşları arasında dağılım gösterdiği belirlenmiştir. İncelenen örnekler; %45.36 dişi ve %43.46 oranında erkek bireylerden oluşmuştur. Bu türe ait en küçük çatal boy uzunluğu 131 mm, en düşük ağırlık 30 g, en büyük çatal boy uzunluğu 307 mm, en yüksek ağırlık ise 438 g olarak saptanmıştır. Boy-ağırlık ilişkisi W = 0.091 x L 2.43 (dişi+erkek) olarak hesaplanmıştır. Eşeysel olgunluğa ulaşma yaşı, erkeklerde II. ve dişilerde III. yaş olarak belirlenmiştir. Yumurtlama dönemi ise mayıs-temmuz aylarına rastlamaktadır. Aylara göre Gonadosomatik İndeks (GSİ) değerleri 1.23-7.87 arasında değişim göstermiştir. Fekondite, yaş ile beraber artmıştır.
Anahtar Kelimeler: Squalius cephalus, Yaş ve Büyüme, Üreme, Apa Baraj

1.Introduction

S. cephalus is a cyprinid species encountered in the Anatolian inland water bodies as well as the whole Europe, Black sea, Caspian Sea and Azow Sea Basins (Geldiay and Balık 1999).

A vast amount of research by domestic and foreign investigators was conducted on the S. cephalus, an economically important fish species living in the inland waters, in terms of populational studies, elucidation of the potential nutritional value, and the studies of population dynamic changes over time. Some examples of these studies are; the determination of age, growth and sex distribution of the fish in the Rocktyna River (Lelek 1959), age, growth, spawning and certain biochemical data on a species in Rouchovanka River (Habasby 1974), biology of the species in Pinarbaşı water spring (Geldiay and Balık 1999), bio-ecology of the species in Kapulukaya Dam Lake (Gül 1994), some population characteristics of the species in Aksehir Lake (Altindag 1996), age, growth and sex distribution of the species in Topcam Dam Lake (Sası and Balik 2003), growth characteristics of the species in Sir Dam Lake (Kara and Solak 2004), growth, development and mortality rates in the Almus Dam Lake (Karatas and Can 2005), age, growth and reproduction characteristics of the species in the İkizcetepeler Dam Lake (Koc et. al. 2004). 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.

In order to a better management of the fresh water fish populations, certain biological characteristics such as growth, feeding, condition factor and reproduction must be understood thoroughly. These characteristics may vary with the chemical, physical, biological and hydrographic conditions of water ecosystem. Besides, in terms of growth, feeding, condition factor and reproduction characteristics, a variance is observed in a given fish species from different geographical locations (Karatas 1995).

The aim of this study was to determine some biological characteristics such as age and sex composition, growth in length and weight, age-length, age weight and weight relationships, condition factor, spawning time, age of sexual maturity and fecundity of S. cephalus in the Apa Dam Lake and establish a suitable database for future studies.

2. Material and Method

The Konya region is poor in regard to fresh water resources it contains. The Apa Dam Lake in the Konya region is one of the most important inland basin rivers of the region, and is fed from the waters of the highlands of Bozkir county as well as from the Carsamba Creek sourced from the Beysehir Lake (Fig. 1).

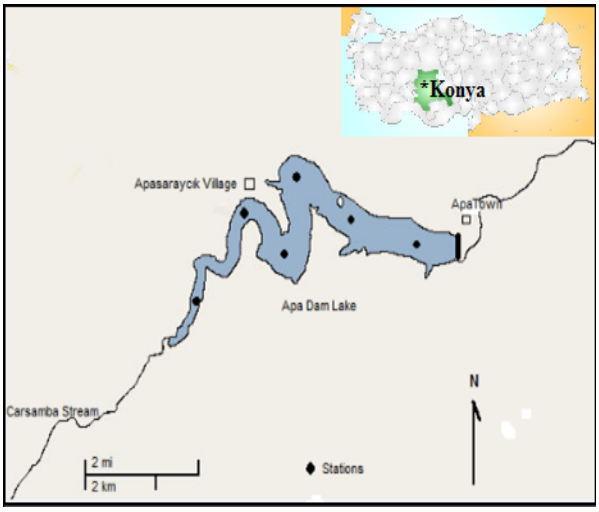

Figure 1. The sampling areas in Apa Dam Lake

Carşamba Creek which is facilitated by the Apa Dam Lake passes through the Cumra meadow and extends to the Hotamis Lake (Saracoğlu 1990). The Apa Dam Lake is located in the country of Cumra at 37° 22' 10.66'' North and 32° 29' 42.26'' West, between the Apasaraycık village and Apa town. It was constructed for irrigation purposes (90%) and to prevent water spills (10%) to be 29.83 meters high, and made with zoned terrain fillings. The dam was first run in 1963 and has a surface area of 12 square kilometers, with an irrigation field of 59704 ha, an altitude of 1013 meters and a depth of 26 meters (Anonymous 1992).

Sampling studies were performed from january 2001 until december 2002 from various stations in the lakes using trammel nets. The fish specimens were brought into the lab, weighed using a scale with a sensitivity of 0.01 g, and their length measured using a special measuring board as mm. The ages of S. cephalus individuals were estimated by inspecting their scales (Lagler 1966), by two researchers independently.

The development of the S. cephalus individuals in the lake was determined both via length and weight measurements. The length/weight ratio was also evaluated using Chugunova equations (Chugunova 1963).

The level of statistical significance ($P<0.05$) of the differences in fork lengths and weights between male and females in all age groups were tested using the "t-test".

In each of the age groups, the proportional length extension (OL) was calculated using the formula of OL = Lt - Lt-1 / Lt-1, and the proportional weight increase (OW) was calculated using the formula of OW = Wt - Wt-1 / Wt-1 (Chugunova 1963).

The length/weight relationships of the female, male and female+male individuals were determined using the growth equations devised by Le Cren (1951):

LogW = Log a+b . Log L, that is the logarithmic expression of the formula:

$W = a.Lb$

The condition factor was estimated using the formula of:

$K = (W / L3) . 105$

The condition factor was estimated independently for each sex and according to the age of the specimen, and the statistical significance ($P>0.05$) was determined using the "t-test". The data obtained for each individualwas evaluated separately and averaged in age and sex groups (Bagenal 1978).

In order to assess the reproductive characteristics of the individuals, their abdomen was incised and their sex was determined by

examining their gonads. Each gonad was removed and weighed. One gram of samples representing the ovary was removed from top, median and bottom parts of the ovary, and egg counts were taken using binocular microscopes. The total number of eggs a female carried was estimated by multiplying the egg count in 1 g of ovary by the total ovary weight. The gonadosomatic index (GSI) value was calculated using the equation of:

GSI = [GW (g) / W (g)] .100 (Bagenal 1978).

To determine the egg diameter, at least 25 eggs collected from different parts of the ovary were measured using a micrometer, and the average egg diameters were determined for each female fish (Lagler 1966).

3. Results

The 474 *S. cephalus* individuals studied were found to be aged from 1 to 5 (Fig. 2). The male female ratio was 43.46% against 45.36%, respectively.

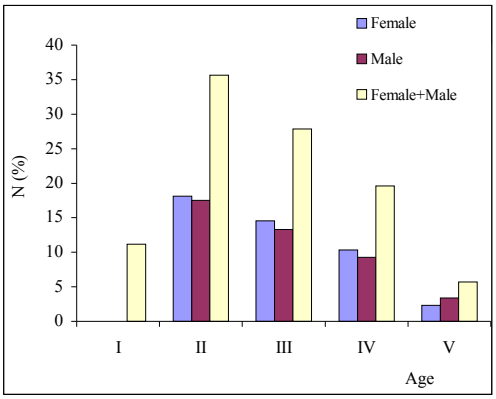

Figure 2. The age and sex distribution of *Squalius cephalus* in Apa Dam Lake

Growth in length

The average fork length distribution of the sampled individuals in respect to their ages was shown in Table 1. The difference fork length in age group II, IV and V were statistically significant ($p<0,05$). This variation can be attributed to differences in the GSI values of males and females.

According to the average fork length, for every age group and sex (female, male, female+male) the growth rate was shown in Table 1. The most pronounced growth in length was found in the individuals that were IV-years old.

The proportional growth increase rates for females, males and female+males according to the age groups and sex were listed in Table 2. The fastest proportional increase in length was in the IV age group.

Table 1. The distribution of length of *Squalius cephalus* in Apa Dam Lake according to age and sex

AGE	FEMALE			MALE				FEMALE + MALE		
	N	FL(mm) ± SD (Min-Max)	S_X	N	FL(mm) ± SD (Min-Max)	S_X	t-test (P < 0.05)	N	FL(mm) ± SD (Min-Max)	S_X
I	-	-		-	-	-	-	53	174.89±22.54 (131-210)	3.10
II	86	201.70±10.97 (182-220)	1.18	83	208.08±19.56 (173-245)	1.15	0.005	169	204.83±16.06 (173-245)	1.24
III	69	237.71± 13.89 (221-264)	1.17	63	239.46±14.43 (216-268)	1.82	0.240	132	238.55±14.12 (216-268)	1.23
IV	49	267.47± 14.78 (244-294)	2.11	44	272.20±10.52 (243-291)	1.59	0.038	93	269.71±13.09 (243-294)	1.36
V	11	289.27±11.31 (272-306)	3.41	16	295.31±8.10 (284-307)	2.02	0.073	27	292.85±9.81 (272-307)	1.89

Table 2. According to age and sex relative increase in lenght of *Squalius cephalus* in Apa Dam Lake

AGE	FEMALE			MALE			FEMALE + MALE		
	N	FL(mm)	O.L.	N	FL(mm)	O.L.	N	FL(mm)	O.L.
I	-	-		-	-	-	53	174.89	0.17
II	86	201.70	0.18	83	208.08	0.15	169	204.83	0.16
III	69	237.71	0.13	63	239.46	0.14	132	238.55	0.13
IV	49	267.47	0.08	44	272.20	0.08	93	269.71	0.09
V	11	289.27	-	16	295.31	-	27	292.85	-

Growth in weight

In Table 3, the average age and weight distributions with respect to sex were shown. As seen in Table 3, the average weights of females was higher than those of the males. The differences in the average weights between males and females in the same age groups were statistically significant only for age groups II and IV ($p<0,05$). The average weights displays changes depending on gonad development, age, seasonal changes in growth.

When the proportional weight increase was determined in respect to the average weight, it was found that the II-years-old females were heavier than the males (Table 4). This increase was more pronounced in the III-year-old fish, yet, was similar to each other in all other ages, and was lowest in the male fish of II-years old..

Table 3. The distribution of weight of *Squalius cephalus* in Apa Dam Lake according to age and sex

AGE	FEMALE			MALE				FEMALE + MALE		
	N	W(g) ± SD (Min-Max)	S_X	N	W(g) ± SD (Min-Max)	S_X	t-test (P<0.05)	N	W(g) ± SD (Min-Max)	S_X
I	-	-		-	-	-	-	53	71.91±23.97 (30-108)	3.29
II	86	133.03±22.85 (99-179)	2.46	83	127.80±20.22 (96-173)	2.22	0.058	169	130.46±21.70 (96-179)	1.67
III	69	209.04±38.54 (147-261)	4.64	63	202.54±35.12 (153-254)	4.44	0.156	132	205.94±36.95 (147-261)	3.22
IV	49	308.00±29.79 (240-352)	4.26	44	297.95±29.45 (236-343)	4.44	0.053	93	303.25±29.90 (236-352)	3.10
V	11	378.55±45.21 (314-438)	13.63	16	374.44±42.98 (305-424)	10.75	0.408	27	376.11±43.08 (305-438)	8.29

Table 4. According to age and sex relative increase in weight of *Squalius cephalus* in Apa Dam Lake

AGE	FEMALE			MALE			FEMALE + MALE		
	N	W (g)	O.W.	N	W (g)	O.W.	N	W (g)	O.W.
I	-	-	-	-	-	-	53	71.91	0.81
II	86	133.03	0.57	83	127.80	0.58	169	130.46	0.58
III	69	209.04	0.47	63	202.54	0.47	132	205.94	0.47
IV	49	308.00	0.23	44	297.95	0.26	93	303.25	0.24
V	11	375.55		16	374.44		27	376.11	

Length-weight relationship

In the *S. cephalus* individuals, length-weight relationship was calculated separately for the females, males and female+males and the equation used for the calculation of this relationship was

$W = 0.017 \times L^{2.88}$ for females,

$W = 0.038 \times L^{2.76}$ for males, and

$W = 0.091 \times L^{2.43}$ for females+males (Table 5).

Table 5. Lenght-weight relationships equations of *Squalius cephalus* in Apa Dam Lake

FEMALE	$W = 0.017 \times L^{2.88}$
	Log W = -1.79+ 2.88 x Log L
MALE	$W = 0.038 \times L^{2.76}$
	Log W = - 1.42 + 2.76 x Log L
FEMALE + MALE	$W = 0.091 \times L^{2.43}$
	Log W = -1.04+2.43 x Log L

Condition factor

For each age group, the average condition factor was estimated separately according to the sex of the fish (Table 6). It was found that the condition factor values were statistically higher in females compared to that of the males ($p>0.05$). The female *S. cephalus* individuals had a condition factor varying between 0.85-2.81 while the male fish had a condition factor of 0.76-2.94.

Table 6. The condition factor values of *Squalius cephalus* in Apa Dam Lake according to age and sex

AGE	FEMALE			MALE				FEMALE + MALE		
	N	CF ± SD (Min-max)	S_x	N	CF± SD (Min-Max)	S_x	t-test (P<0.05)	N	CF ± SD (Min-Max)	S_x
I	-	-		-	-	-	-	53	1.34±0.42 (0.66-2.96)	0.06
II	86	1.62±0.39 (1.07-2.81)	0.04	83	1.42±0.47 (0.76-2.94)	0.05	0.009	169	1.52±0.44 (0.76-2.94)	0.03
III	69	1.56±0.37 (0.85-2.38)	0.04	63	1.48±0.40 (0.79-2.43)	0.05	0.156	132	1.56±0.38 (0.79-2.43)	0.03
IV	49	1.61±0.29 (1.18-2.38)	0.04	44	1.48±0.21 (1.03-2.10)	0.03	0.003	93	1.55±0.26 (1.03-2.38)	0.03
V	11	1.56±0.02 (1.53-1.60)	0.01	16	1.45±0.18 (1.22-1.77)	0.05	0.021	27	1.50±0.15 (1.22-1.77)	0.03

Reproduction

The male-female ratio, the age of maturity, mating periods and fecundity (egg yield) characteristics of the *S. cephalus* from the Apa Dam Lake were investigated.

The sex ratio

Of the 474 specimens of the *S. cephalus*, 215 were females (45.36%), 206 were males (43.46%) and 53 were fingerlings (11.18%), (Fig. 2). Thus, the male-female ratio was 0.96:1.

The first maturity age

The age of reaching maturity was determined by examining the stage of the gonad development in the specimens. It was found that the adolescence was at the age of maturity was at age III in females, and II in males. The smallest of the female was 208 mm, while the smallest male was 180 mm in length.

Reproduction period

The monthly GSI values were calculated in order to determine the mating period of the *S. cephalus.* Moreover, the variation of the egg diameter through the month was monitored. The GSI values were highest in june (7.87), and lowest in july (1.56).

In july and august, the egg diameter and egg count data was not collected, since there was no egg in the ovary of the fish in that period. The monthly variations in egg diameter were in accordance with the GSI values (Fig. 3, Fig. 4). The smallest egg diameter was measured in september as 0.41 mm, and the largest in july, as 0.88 mm. The greatest egg count in 1 g of ovary was obtained in september. As the egg diameter increased, the egg count decreased. This drop in egg count continued until june (Fig. 4).

As is clearly shown in Fig. 3, the egg development in the *S. cephalus* individuals from the Apa Dam Lake continue until june, and they lay eggs mostly during june and july. Taking into consideration the GSI, ovary weight and egg diameter data, it can be concluded that reproduction in *S. cephalus* takes place during may-july.

Fecundity

The egg count-age relationship in the specimens of the *S. cephalus* in Apa Reservoir was shown in Table 7. According to the results, the fecundity value for the group aged III and IV were estimated at 15253 and 22976, respectively.

Table 7. The egg number changes of *Squalius cephalus* in Apa Dam Lake according to age

Age	N	Fork Length (mm)	Weight (g)	Mean Egg Number
III	69	237.71	209.04	15253±3712
IV	49	267.47	308.00	22976±7245

4. Discussion and Conclusion

During the study, the 474 specimens of the *S. cephalus* collected appeared to be between the ages of I to V. In previous reports, individuals as old as VIII were mentioned (Turkmen et al. 1999; Ekmekci 1996). The most common age in the current study group was II, followed by III, IV, I and V. Among the specimens, individuals under the age I have not been encountered, possibly due to the selectivity of the nets employed for collection. While among the specimens, female/male ratio was close to 1, in many other investigations in Turkey, this ratio was generally larger than 1 (Saşı and Balık 2003; Kara and Solak 2004; Turkmen et al. 1999).

Among the specimens studied, the length and weight of the individuals varied between 17.3-30.7 cm, and 96-438 g, respectively. In previous studies, various data were recorded on the same species, i.e., 8.5-26.8 cm and 7.9-324 g in Muceldi Creek (Oztas and Solak 1988), 6.1-14.8 cm and 5.5-73 g in Pınarbası Spring Basin (Geldiay and Balık 1972), 11.6-51.3 cm and 20.51-2242 g in Sır Dam Lake (Kara and Solak 2004), 17.0-36.2 cm and 115.4-721.5 g in the Karakaya Dam Lake (Kalkan et al. 2005), 14.0-34.0 cm and 35.6-668.0 g in the Almus Dam Lake (Karatas and Can 2005) and 13.5-23.1 cm and 41.7-260.1 g in Isıklı Dam Lake (Balık et al. 2004). The measured lengths of the fish collected from Pınarbası Spring Basin and Müceldi Creek are smaller, and the growth is slower. It can be postulated that this difference is due to the lower water temperature in creeks, water current, and thus the scarcity of food. On the contrary, in Sır, Karakaya and Almus Dam Lakes, *S. cephalus* specimen lengths are larger than those obtained in the Apa Dam Lake (Table 8). This could possibly be due to the ecologic changes in the habitats as well as the yearly temperature differences. Moreover the differences in terms of fishery pressures among regions may also cause changes in the population structure (Ricker 1975).

Table 8. Summary of the available parameters of lenght-weight relationship, growth (L_∞, K, t_0) and CF of *Squalius cephalus* in this and previous studies

Area	Sex	N	Weight(g)	Length (mm)	a	b	r^2	L_∞	K	t_0	CF	References
Tödürge Lake	♀	460	-	-	0.010	3.10	-	47.4	0.11	-0.38	0.81	Ünver and Tanyolaç(1999)
	♂	214	1.5-347.1	53-299	0.012	3.04	-	54.5	0.08	-0.75	1.07	
Aras River	♀	558	3.0-302.5	63-275	0.009	3.14	0.98	36.7	0.11	-1.39	1.08-1.46	Türkmen et al.(1999)
	♂	533	4.2-181.5	67-241	0.010	3.11	0.96	32.5	0.12	-1.63	1.25-1.52	
Topçam Dam Lake	♀	242	19.8-344.0	108-262	0.009	3.19	0.955	40.2	0.12	-1.58	1.41-1.91	Şaşı and alık(2003)
	♂	90	16.2-203.1	97-235	0.023	2.85	0.947	27.1	0.30	-0.46	1.78-1.74	
Sır Dam Lake	♀	234	20.51-2242	116-513	0.0074	3.17	-	74.0	0.17	-0.82	1.25-1.60	Kara and Solak(2004)
	♂	191	26.18-1556	112-462	0.0063	3.21	-	54.0	0.30	-0.49	1.18-1.51	
Işıklı Lake	♀	215	44.6-247.0	135-231	0.014	3.08	0.949	28.6	0.17	-3.32	1.40-2.00	Balık et al.(2004)
	♂	313	41.7-260.1	135-230	0.016	3.03	0.943	31.6	0.03	-3.84	1.57-2.14	
Karakaya Dam Lake	♀	49	123.8-721.5	170-362	0.013	3.03	-	37.8	0.41	-1.00	1.42	Kalkan et al.(2005)
	♂	28	115.4-584.2	170-344	0.082	2.49	-	35.5	0.60	-0.19	1.43	
Almus Dam Lake	♀	178	41.0-668.0	147-340	0.005	3.27	-	39.1*	0.16*	-3.05*	-	Karataş and Can(2005)
	♂	127	35.6-408.4	140-310	0.053	3.27	-	-	-	-	-	
İkizcetepeler Dam L.	♀	172	18.6-243.6	111-248	0.023	2.87	0.90	28.9	0.22	-1.55	0.77-2.40	Koç et al.(2004)
	♂	242	29.3-173.9	122-241	0.019	2.92	0.889	26.7	0.26	-1.55	1.30-2.03	
Apa Dam Lake	♀	215	99.0-438.0	182-306	0.016	2.88	-	70.0	0.06	-3.72	0.85-2.81	This study (2002)
	♂	206	96.0-424.0	173-307	0.038	2.76	-	56.6	0.09	-3.87	0.76-2.94	

In the *S. cephalus* population in th Apa Dam Lake, proportional length and weight increase is more pronounced in earlier ages, and thus slows down with aging (Table 2, Table 4). The proportional length increases recorded in the specimens from the Sarıyar Dam Lake (Ekmekci 1996), Aksehir Lake (Altındag 1996) and Kapulukaya Dam Lake (Gül 1995) were in harmony with those obtained from the specimens of Apa Dam Lake. According to the proportional weight increases monitored in the specimens from the same locations, the results appear parallel in the Apa and Karakaya Dam Lakes (Kalkan et al. 2005), and Aksehir Lake, however, it was smaller in Cildir Lake (Yerli et al. 1999). Considering that the seasons and reproduction-feeding relation are important in weight gain, the *S. cephalus*

population in Apa Dam Lake exhibits a good level of weight growth.

The "b" value that takes place in length-weight relationship is an indication of the body shape of the fish, and is affected directly by the habitat in which the fish lives (Karataş 2005). The length-weight relationship has been calculated using the equations of

Log W = -1.79+ 2.88 x Log L in females, and

Log W = - 1.42 + 2.76 x Log L in males.

The "n" value of 3 that was calculated for the *S. cephalus* in Apa Dam Lake indicated that although the fish developed well in length, they did not feed appropriately, thus, the growth was negative "allometric". Besides, it was found that the "n" value estimated for the fish in the Apa Dam Lake is similar to that in the Ikizcetepeler Dam Lake (Koc et al. 2004), but lower than those in other locations. It was proposed by Ricker (Ricker 1975) that the difference that occurred in the length-weight relationship could be due to geographical location, environmental conditions, stomach fullness, diseases and parasites.

The condition factor values for the *S. cephalus* in the Apa Dam Lake varied between 0.76-2.94, and the mean values were 1.59 for females and 1.46 for males (Table 6). These values resemble those obtained in the studies by Koc et al. (2004) and Kalkan et al. (2005), however, they were higher than those by Unver and Tanyolac (1999) and Turkmen et al. (1999). Nevertheless, it should be noted that even among the individuals of the same species, these variations in condition factor might be affected by age, maturity, spawning period, feeding conditions, and environmental conditions (Karataş 2005). Moreover, some of the specimens whose abdomen was incised for sex determination were found to be heavily infested with endoparasites. This also may be a reason for a weaker physical condition in these fish (Ricker 1975).

In the current study, it was found that the mean monthly GSI values were highest in june, and the lowest in july, while the greatest ovary weights and egg diameters were measured in may. Therefore, upon evaluating the GSI, ovary weights and egg diameter data together, reproduction appears to have taken place during may-june. In previous studies, reproduction was reported to take place during the same period by Kalkan et al. (2005), Turkmen et al., Sen and Saygın, and Kara and Solak; during april-june by Ekmekci (1996) and during march-may by Koc et al. (2004). Therefore, regarding the time of mating, a significant similarity was observed between the current study and previous work.

References

Altındağ, A. 1996, Akşehir Gölü'ndeki (Konya) tatlısu kefalinin (*Leuciscus cephalus* L., 1758) bazı populasyon özellikleri, büyüme ve kondisyonu. Turkish Journal of Zoology, 20, 53-65.

Anonymous 1992, Türkiye'deki barajlar ve hidroelektrik santralleri. DSİ, Ankara.

Bagenal, T 1978, Methods for assessment of fish production in freshwaters. Blackwell Scientific Publications, London, pp. 365.

Balık, S., H.M. Sarı., M.R. Ustaoğlu. and A. İlhan 2004, Işıklı Gölü (Çivril, Denizli, Türkiye) tatlısu kefali (*Leuciscus cephalus* L., 1758) populasyonunun yaş ve büyüme özellikleri. Ege Üniversitesi Su Ürünleri Dergisi, 21 (3-4): 257-262.

Chugunova, N.I 1963, Age and growth studies in fish. Washington Israel Program for Scientific Ltd., Washington, pp. 130.

Ekmekçi, F.G 1996, Sarıyar Gölü'nde yaşayan tatlısu kefalinin (*Leuciscus cephalus*, Linnaeus 1758) büyüme ve üreme özellikleri. Turkish Journal of Zoology, 20, 95-106.

Geldiay R., S. Balık 1999, Türkiye tatlısu balıkları, İzmir. Ege Üniversitesi Su Ürünleri

Fakültesi Yayınları, No: 46, Ege Üniversitesi Basımevi, Bornova, s. 532.

Gül, A 1994, Kapulukaya baraj gölü'nde yaşayan *Stizostedion lucioperca* (L., 1758)'un biyo-ekolojileri üzerine bir araştırma. Doktora Tezi, Gazi Üniversitesi Fen Bilimleri Enstitüsü, Ankara.

Habasby, A.P. 1974, Age, growth, spawning and some biochemical data in the Chub (*Leuciscus cephalus* L.) in the Rouchovanka Creek, Zool. Listy. 13:71-83.

Kalkan, E., M. Yılmaz. and Ü. Erdemli 2005, Some biological properties of the *Leuciscus cephalus* (L., 1758) population living in Karakaya Dam Lake in Malatya. Turkish Journal of Veterinary and Animal Sciences., 29: 49-58.

Kara, C., K. Solak 2004, Sır Baraj Gölü (Kahramanmaraş)'nde yaşayan tatlısu kefali (*Leuciscus cephalus* L., 1758)'nin büyüme özellikleri. Kahramanmaraş Sütçü İmam Üniversitesi Fen Mühendislik Dergisi, 7 (2): 1-8.

Karataş, M 1995, Almus Baraj Gölü'nde yasayan tatlısu kefali (*Leiciscus cephalus*) ve bıyıklı balığın (*Barbus plebejus*) üreme özellikleri ile et verimlerinin araştırılması. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.

Karataş, M 2005, Balık biyolojisi araştırma yöntemleri. Nobel Yayınları, No:772, s. 498.

Karataş, M., M.F. Can 2005, Growth, mortality and yield of Chup (*Leuciscus cephalus* L., 1758) population in Almus Dam Lake. Turkey Journal of Biological Sciences, 5(6):729-733.

Koc, H.T., Z, Erdoğan., M, Tinkçi. and T, Treer 2004, Age, growth and reproductive characteristics of Chub, *Leuciscus cephalus* (L., 1758) in İkizcetepeler Dam Lake (Balikesir). Turkish Journal of Applied Ichthyology, 19-24.

Lagler, K.F 1966, Freshwater fishery biology. W.M.C. Brown Company, Iowa, pp. 421.

Le Cren, E.D 1951, The length-weight relationship and seasonal cyclein gonad weight and condition in Perch, *Perca fluviatilis*. Journal of Animal Ecology, 20: 201-219.

Lelek, A. 1959, The age, growth and sex ratio in the Chub (*Leuciscus cephalus* L.) from the Rockytna River. Zoologcke Listy Florida Zool Rocnik ,VIII, XXII, 4: 365-376.

Öztas, H., K, Solak 1988, Müceldi Suyu'nda (Doğu Anadolu) yaşayan tatlısu kefali (*Leuciscus cephalus*, L., 1758) büyüme özellikleri ve eşem oranları. Doğa Türk Zooloji Dergisi, 12 (3): 262-271.

Ricker, W 1975, Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada.191: 203-211.

Saraçoğlu, H 1990, Bitki örtüsü, akarsular ve göller. M.E.B. Basımevi, İstanbul, s. 577.

Şaşı, H., S. Balık 2003, Topçam Baraj Gölü'ndeki (Aydın) tatlısu kefalinin (*Leuciscus cephalus* L., 1758) yaş, büyüme ve cinsiyet oranları. Ege Üniversitesi Su Ürünleri Dergisi, Cilt 20, Sayı (3-4):503-515.

Türkmen, M., H.İ. Haliloğlu., E, Erdoğan. and A. Yıldırım 1999, The growth and reproduction characteristics of Chub *Leuciscus cephalus orientalis* (Nordmann, 1840) living in the River Aras. Turkish Journal of Zoology, 23: 355-364.

Ünver, B., J. Tanyolac 1999, Growth properties of Chub (*Leuciscus cephalus* L., 1758) in Tödürge Lake (Sivas). Doğa Turkish Journal of Zoology, 23, 257-270.

Yerli, S.V., M. Calışkan. and A.F. Canbolat 1999: Çıldır Gölü (Ardahan)'deki *Leuciscus cephalus*'un büyüme ölçütleri üzerine incelemeler. Turkish Journal of Zoology, 23 (Ek sayı 1): 271-278.