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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Growth and reproduction properties of endemic *Capoeta kosswigi* and *Barbus ercisianus* in the Deliçay Stream (Van, Turkey)

Deliçay (Van, Türkiye)'da yaşayan endemik *Capoeta kosswigi* ve *Barbus ercisianus*'un büyüme ve üreme özellikleri

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Abstract: In this study, the growth and reproductive characteristics of *Capoeta kosswigi* Karaman, 1969 and *Barbus ercisianus* Karaman, 1971, which are endemic to the Lake Van Basin, in Deliçay (Van) were investigated. A total of 309 *C. kosswigi* and 288 *B. ercisianus* specimens were caught by electrofishing between April and August 2018. The fork length of *C. kosswigi and B. ercisianus* ranged from 3.7-26.1 cm and from 4.3-22.7 cm, and the total weights ranged from 0.6-227.4 g and from 1.2-140.0 g, respectively. The most intensive catching was in *C. kosswigi* population of 5.0-6.9 (27.5%) cm and 0-19.9 (67.0%) g in the groups, and 12.0-13.9 (24.7%) cm and 0-9.9 (23.3%) g groups in *B. ercisianus.* Condition factor was determined as 1.305±0.008 (0.798-1.886) in *C. kosswigi* and 1.158±0.006 (0.864-1.559) in *B. ercisianus.* The length-weight relationships were calculated as $W = 0.01435 \times L^{2.952}$ ($r^2 = 0.996$) for *C. kosswigi* and $W = 0.01276 \times L^{2.959}$ ($r^2 = 0.994$) for *B. ercisianus.* The M:F ratio was calculated as 1:0.15 in *C. kosswigi* and 1:0.64 in *B. ercisianus.* It was established that *C. kosswigi* attained sexual maturity when they reached to 11 cm fork length for males, 18 cm fork length for females. Maturation of *B.ercisianus* individuals occurred at 9 cm fork length in males and 12 cm fork length in females. The spawning in *C. kosswigi* was observed from 1st week of May to 2nd week of July, and in *B. ercisianus* from 1st week of May to 1st week of August. It may be suggested that minimum catching size must be 20 cm fork length for *C. kosswigi* and 15 cm fork length for *B. ercisianus.*

***Keywords*:** *Barbus ercisianus, Capoeta kosswigi*, growth, length–weight relationships, reproduction

Öz: Bu çalışmada Van Gölü Havzası'na endemik olan *Capoeta kosswigi* Karaman, 1969 ve *Barbus ercisianus* Karaman, 1971 türlerinin Deliçay (Van)'da büyüme ve üreme özellikleri araştırılmıştır. Nisan 2018 - Ağustos 2018 tarihleri arasında toplam 309 adet *C. kosswigi* ve 288 adet *B. ercisianus* elektrikle avcılık yolu ile yakalanmıştır. Çatal boylar *C. kosswigi*'de 3,7-26,1 cm, *B. ercisianus*'ta 4,3-22,7 cm; ağırlık ise *C. kosswigi*'de 0,6-227,4 ve *B. ercisianus*'ta 1,2-140,0 g arasında belirlenmiştir. En yoğun avcılık *C. kosswigi* populasyonunda 5.0-6,9 (%27,5) cm ve 0-19,9 (%67,0) g'lık gruplarda, *B. ercisianus*'ta ise 12,0-13,9 (%24,7) cm ve 0-9,9 (%23,3) g'lık gruplarda gerçekleşmiştir. Kondisyon faktörü *C. kosswigi*'de 1,305±0,008 (0,798-1,886), *B. ercisianus*'ta 1,158±0,006 (0,864-1,559) olarak belirlenmiştir. Boy-ağırlık ilişkisi *C. kosswigi*'de $W = 0,01435 \times L^{2.952}$ ($r^2 = 0,996$), *B. ercisianus*'ta ise $W = 0,01276 \times L^{2.959}$ ($r^2 = 0,994$) olarak hesaplanmıştır. Erkek:dişi oranı *C. kosswigi*'de 1:0,15 ile *B. ercisianus*'ta 1:0,64 olarak hesaplanmıştır. *C. kosswigi'nin* cinsel olgunluğa erkeklerde 11 cm, dişilerde ise 18 cm çatal boyda ulaştığı tespit edilmiştir. *B. ercisianus*'ta cinsel olgunluk boyu erkeklerde 9 cm, dişilerde ise 12 cm çatal boyda gerçekleşmiştir. *C. kosswigi*'de üremenin Mayıs ayının 1. haftası ile Temmuz ayının 2. haftası arasında, *B. ercisianus*'ta ise Mayıs ayının 1. haftası ile Ağustos ayının ilk haftası arasında gerçekleştiği belirlenmiştir. Türlerin devamlılığı için avlanma boyunun *C. kosswigi* için 20 cm çatal boy, *B.* ercisianus için ise 15 cm çatal boy altında olmaması gerekmektedir.

***Anahtar kelimeler*:** *Barbus ercisianus, Capoeta kosswigi*, büyüme, boy-ağırlık ilişkisi, üreme

INTRODUCTION

Determination of the population dynamics parameters such as reproduction, growth, mortality, and length weight relationships (LWRs) in monitoring natural fish populations and using them efficiently and sustainably is the main subject of fisheries biology (Haimovici and Velasco, 2000).

LWRs provide a quick effective method for assessing the weight of a particular fish species by estimating the weight from length observations obtained on the field and the equations can be used to estimate fish stock biomass from limited data (Kimmerer et al., 2005; Froese et al., 2011). LWRs can be used to measure changes in the health of a fish population, determine the relative condition of small fish compared to large fish and compare the condition of a fish population (Froose, 2006). Fish can show either isometric or allometric growth (Sakar et al., 2013). Isometric growth (b=3) indicates that both length and weight of the fish are increasing at the same rate. Allometric growth can be either positive or negative. Positive allometric (b > 3) implies that the fish becomes stouter, or heavier or deeper-bodied as its length increases. Negative allometric (b<3) implies the fish becomes slender or lighter as its length increases (Wootton, 1998).

Fulton's Condition factor (K) is an estimation of general well being of fish and a useful index for estimating growth rate and age and for assessing environmental quality (Ricker,

1975). The Fulton condition factor of 1.0 or greater shows the good condition of fish while less than 1.0 indicates poor condition (Abobi, 2015). The condition factor may differ due to one or more factors such as season, sex, type of food organism consumed by fish, age of fish, amount of fat reserved and environmental conditions (Bagenal and Tesch, 1978; Sakar et al., 2013).

Reproduction is an important physiological system that is crucial in the life cycle of fish and has many characters unique to aquatic life (Bagenal and Tesch, 1978). The reproductive success of a species is determined by its genetic capacities depending on ecological conditions. Reproduction is of vital importance in fish, as in other living things, to ensure the continuity of species. Although a fish can grow and develop in a water source or its environment, it is not considered to have adapted to that environment if it does not have reproductive characteristics. Therefore, it is necessary to determine the growth and reproductive biology of the species to develop successful fisheries management. The gonadosomatic index (GSI), is described as gonad mass as a percentage of total body weight. This index is widely used as a simple measure of the extent of reproductive investment, gonadal development and maturity of fish in relation to spawning. GSI of fish increases with maturity and abruptly declines after spawning. Thus, GSI is particularly helpful in identifying season of spawning (Wootton, 1992; Çetinkaya et al., 2005; Karataş et al., 2005).

Capoeta and *Barbus* genera (Familia: Cyprinidae) shows a widespread distribution in Asia and the Middle East, while the *Barbus* genus shows a distribution in Europe. The different species live in many water sources (Geldiay and Balık, 2009; Türkmen et al., 2002).

Located at the east of Turkey, which features a closed basin, the Lake Van Basin is very rich in terms of diversity of fish species. Five of 9 fish species in the basin are endemic (Şen et al., 2018). *C. kosswigi* and *B. ercisianus* are among the endemic fish of the basin (Elp et al., 2016; Elp, 2017).

C. kosswigi and *B. ercisianus* are firstly recorded by Karaman et al, (1969) and (1971) in Erciş, Karasu and Hoşap streams which are flow into the Lake Van. While *C. kosswigi* has a couple of short barbels, *B. ercisianus* has two pairs of barbels. The body of both species are long and covered with a large number of small scales, and reproductive tubercles are observed on the body, especially in the head, during the reproductive period. They prefer sandy and pebbly bottoms and with flowing, clean, cold and high oxygen content water (Geldiay and Balık, 2009).

This study was carried out for the purpose of determination of growth and reproduction properties and evaluate the current situation of *C. kosswigi* and *B. ercisianus* populations in Deliçay Stream.

MATERIAL AND METHODS

Study area

The present study was carried out in Deliçay Stream, which flows into the Lake Van. Deliçay Stream is formed by the rain and small waters coming from the Morgedik Dam and the hills around it and the melted snow waters. It has approximately 45-50 km length and an average annual flow rate of 2.8 m^3 (Çetinkaya, 1993). There is also a regulator on the river (Figure 1).

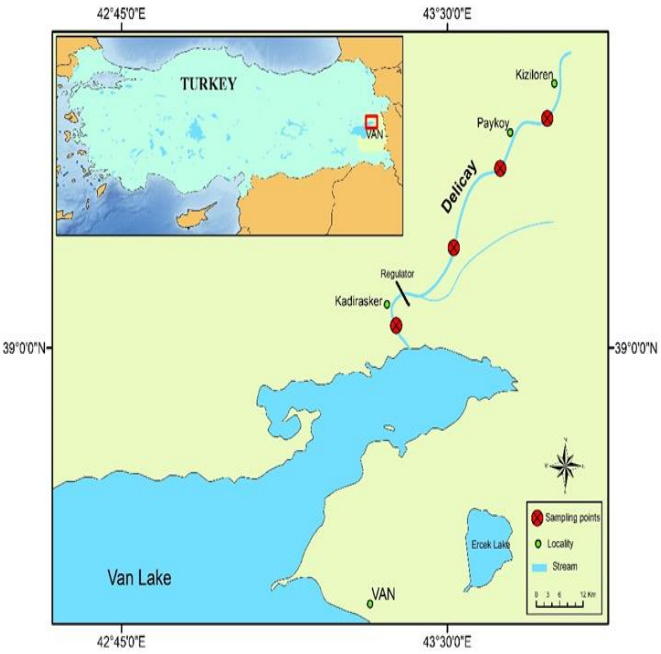

Figure 1. Sampling sites at Deliçay Stream

Fish collection

An electrofishing method (SAMUS 725 MS) was used to catch fish samples with the permission of the Van Yüzüncü Yıl University (Turkey) Animal Researches Local Ethic Committee. During the study, a total of 309 *C. kosswigi* and 288 *B. ercisianus* were monthly collected from April 2018 to August 2018 at four stations: Kadirasker, Deliçay, Payköy and Kızılören (Figure 1).

Laboratory procedures

Fish samples were measured to the nearest 0.1 cm for fork length (FL) and to the nearest 0.1 g for total weight (W). Total length-weight relationships were determined using the equation: $W = a \times L^b$, where W is weight (W), L is length (L), a is the intercept, and b is the slope (Le Cren, 1951). Fulton's Condition Factor was calculated using $K = (W / L^3) \times 100$, where W= weight of fish (g), L= total length of fish (cm) (Ricker, 1975).

The gonads were removed and observed morphologically. Sex was recorded for each fish. The sex of the fish was categorized as male, female, or juvenile. The first

reproduction length and weight of the fish were determined according to the maturity status of the gonads (Crim and Glebe, 1990). Gonadosomatic Index value was calculated using the formula GSI= (Gw / W) × 100, where Gw= gonad weight of fish (g), W= total weight of fish (g) (Karataş et al., 2005).

Statistical analysis

The growth types for the specimens were determined using the Student t-test. The t-test statistics values were calculated and compared with critical values from the T-Table to check if the growth type is isometric (b =3) or allometric (b ≠ 3) (Pajuelo and Lorenzo, 1998). The sex ratio was tested by the chi-square test (χ^2) to indicate whether there was a deviation from a 1:1 ratio (Zar, 1999). The means, variance, standard error, regression, correlation values, and the comparisons of population parameters obtained from the study were performed with SPSS 21.0 and Microsoft Excel 2016.

RESULTS

Growth in length

Fork length values of 309 *C. kosswigi* specimens in the population were ranged from 3.7 to 26.1 cm (n = 309) for all population, 4.8 to 21.8 cm (n = 113) for males, 18.0 to 26.1 cm (n = 17) for females, and 3.7 to 11.4 cm (n =179) for juveniles. The lengths were grouped into 2 cm and the length frequency distributions were examined. It was determined that the most dominant groups were found as 5.0-6.9 cm (27.5%) for all samples, 13.0-14.9 cm (9.7%) for males, 19.0-20.9 cm (1.9%) for females, and 5.0-6.9 cm (26.9%) for juveniles (Table 1).

Table 1. Length groups of *Capoeta kosswigi* in the Deliçay Stream

Fork length groups (cm)	Male		Famale		Juvenil		Total	
	n	%n	n	%n	n	%n	n	%n
3.0-4.9	2	0.6	0	0.0	64	20.7	67	21.7
5.0-6.9	2	0.6	0	0.0	83	26.9	85	27.5
7.0-8.9	7	2.3	0	0.0	27	8.7	34	11.0
9.0-10.9	9	2.9	0	0.0	4	1.3	13	4.2
11.0-12.9	17	5.5	0	0.0	1	0.3	18	5.8
13.0-14.9	30	9.7	0	0.0	0	0.0	30	9.7
15.0-16.9	23	7.4	0	0.0	0	0.0	23	7.4
17.0-18.9	15	4.9	2	0.6	0	0.0	17	5.5
19.0-20.9	6	1.9	6	1.9	0	0.0	12	3.9
21.0-22.9	2	0.6	5	1.6	0	0.0	7	2.3
23.0≤	0	0.0	4	1.3	0	0.0	4	1.3
Total	**113**	**36.6**	**17**	**5.5**	**179**	**57.9**	**309**	**100.0**

The fork lengths for *B. ercisianus* were varied from 4.3-22.7 cm (n = 288) for all samples, 8.0-15.9 cm (n =145) for males, 12.4-22.7 cm (n = 92) for females and 4.3-7.8 cm (n = 51) for juveniles. According to 2 cm length groups, it was observed that the largest length groups were found as 12.0-13.9 cm-group (24.7%) for all samples, 12.0-13.9 cm-group (23.0%) for males, 16.0-17.9 cm-group (12.5%) for females, and 6.0-7.9 cm-group (9.4%) for juveniles (Table 2).

Table 2. Length groups of *Barbus ercisianus* in the Deliçay Stream

Fork length groups (cm)	Male		Famale		Juvenil		Total	
	n	%n	n	%n	n	%n	n	%n
4.0-5.9	0	0.0	0	0.0	24	8.3	24	8.3
6.0-7.9	0	0.0	0	0.0	27	9.4	27	9.4
8.0-9.9	23	8.0	0	0.0	0	0.0	23	8.0
10.0-11.9	40	13.9	0	0.0	0	0.0	40	13.9
12.0-13.9	66	23.0	5	1.7	0	0.0	71	24.7
14.0-15.9	16	5.5	8	2.8	0	0.0	24	8.3
16.0-17.9	0	0.0	36	12.5	0	0.0	36	12.5
18.0-19.9	0	0.0	34	11.8	0	0.0	34	11.8
20.0≤	0	0.0	9	3.1	0	0.0	9	3.1
Total	**145**	**50.3**	**92**	**31.9**	**51**	**17.7**	**288**	**100.0**

Growth in weight

The ranges of total weight in *C. kosswigi* population were found between 0.6-227.4 g (n = 309) for all the samples, 1.2-134.2 g (n = 113) for males, 78.5-227.4 g (n = 17) for females, and 0.6-17.6 g (n = 179) for juveniles.

The weights were grouped into 20 g sample groups and the weight-frequencies were investigated. It was determined that the dominant weight groups were found as 0.0-19.9 g (67.0%) for all samples, 20.0-39.9 g (10.4%) for males, 100.0-119.9 g (1.9%) for females, and 0.0-19.9 g (57.9%) for juveniles (Table 3).

The total weight values of *B. ercisianus* were ranged from 1.2 to 140.0 g (n = 288) for all samples, 5.6 to 44.6 g (n = 145) for males, 23.9 to 140.0 g (n = 92) for females, and 1.2 to 5.6 g (n = 51) for juveniles. According to 10 g weight groups, it was determined that the largest weight groups were found as 0-9.9 g (23.3%) for all samples, 20.0-29.9 g (19.8%) for males, 70.0-79.9 g (6.6%) for females, and 0-9.9 g (17.7%) for juveniles (Table 4).

Table 3. Weight groups of *Capoeta kosswigi* in the Deliçay Stream

Weight groups (g)	Male		Famale		Juvenile		Total	
	n	%n	n	%n	n	%n	n	%n
0-19.9	28	9.1	0	0.0	179	57.9	207	67.0
20.0-39.9	32	10.4	0	0.0	0	0.00	32	10.4
40.0-59.9	28	9.1	0	0.0	0	0.00	28	9.1
60.0-79.9	17	5.5	2	0.6	0	0.00	19	6.1
80.0-99.9	4	1.3	1	0.3	0	0.00	5	1.6
100.0-119.9	3	1.0	6	1.9	0	0.00	9	2.9
120.0-139.9	1	0.3	3	1.0	0	0.00	4	1.3
140.0≤	0	0.0	5	1.6	0	0.00	5	1.6
Total	113	36.6	17	5.5	179	57.9	309	100.0

Table 4. Weight groups of *Barbus ercisianus* in the Deliçay Stream

Weight groups (g)	Male		Famale		Juvenile		Total	
	n	%n	n	%n	n	%n	n	%n
0-9.9	16	5.6	0	0.0	51	17.7	67	23.3
10.0-19.9	52	18.1	0	0.0	0	0.0	52	18.1
20.0-29.9	57	19.8	5	1.7	0	0.0	62	21.5
30.0-39.9	15	5.2	4	1.4	0	0.0	19	6.6
40.0-49.9	5	1.7	9	3.1	0	0.0	14	4.9
50.0-59.9	0	0.0	18	6.3	0	0.0	18	6.3
60.0-69.9	0	0.0	18	6.3	0	0.0	18	6.3
70.0-79.9	0	0.0	19	6.6	0	0.0	19	6.6
80.0-89.9	0	0.0	9	3.1	0	0.0	9	3.1
90.0-99.9	0	0.0	5	1.7	0	0.0	5	1.7
100≤	0	0.0	5	1.7	0	0.0	5	1.7
Total	**145**	**50.3**	**92**	**31.9**	**51**	**17.7**	**288**	**100.0**

Length-weight relationships

Length-weight relationships for both species are shown in Table 5. Strong relationships were found between length and weight for these species in the study (r^2 = 0.948 to 0.996).

The length-weight relationships of *C. kosswigi* were calculated as $W = 0.01435 \times L^{2.952}$ (r^2 = 0.996) for all samples, $W = 0.01854 \times L^{2.858}$ (r^2 = 0.987) for males, $W = 0.02079 \times L^{2.843}$ (r^2 = 0.952) for females, and $W = 0.01574 \times L^{2.895}$ (r^2 = 0.980) for juvenile. The isometric growth pattern was observed for all the samples, females and juveniles ($p>0.05$), whereas the growth pattern for males was negative allometric ($p<0.05$) (Table 5).

The length-weight relationship equations for *B. ercisianus* were calculated as $W = 0.01276 \times L^{2.959}$ (r^2 = 0.994) for all samples, $W = 0.01476 \times L^{2.901}$ (r^2 = 0.962) for males, $W = 0.01949 \times L^{2.813}$ (r^2 = 0.948) for females, and $W = 0.01343 \times L^{2.927}$ (r^2 = 0.960) for juveniles. It was determined that the growth pattern for *B. ercisianus* for all groups was found as isometric ($p>0.05$) (Table 5).

Table 5. The descriptive statistics and estimated parameters of length-weight relationships of *C. kosswigi* and *B. ercisianus* populations in the Deliçay Stream

Species	Sex	n	Regression parameters				Student's t-test	p	Growth type
			a	b	SE_b	r^2			
C. kosswigi	Male	113	0.01854	2.858	0.031	0.987	-2.190	0.044*	A (-)
	Female	17	0.02079	2.843	0.166	0.952	-0.422	0.746	I
	Juvenil	179	0.01574	2.895	0.031	0.980	-0.493	0.656	I
	Total	309	0.01435	2.952	0.011	0.996	-0.380	0.723	I
B. ercisianus	Male	145	0.01476	2.901	0.048	0.962	-0.762	0.489	I
	Female	92	0.01949	2.813	0.069	0.948	-1.905	0.129	I
	Juvenil	51	0.01343	2.927	0.085	0.960	-0.771	0.521	I
	Total	288	0.01276	2.959	0.013	0.994	-1.958	0.122	I

n = number of individuals, a = proportionality constant, b = slope of the relationship; SE_b, standard error of b; r^2 = coefficient of determination; I = isometric growth; A = allometric growth.
* Statistically different ($p<0.05$).

Fulton's condition factor

Fulton's condition factor, K, was used to assess the degree of well-being of *C. kosswigi* and *B. ercisianus* in the Deliçay Stream which provides information on the environmental quality and suitability.

Fulton's condition factor of *C. kosswigi* was calculated as 1.305±0.008 (0.798-1.886) for all samples, 1.287±0.013 (0.798-1.870) for males, 1.288±0.022 (1.154-1.470) for females, and 1.319±0.010 (0.911-1.886) for juveniles. The mean lowest condition value was determined in August (1.272±0.012), whereas the highest in May (1.364±0.074) (Figure 2).

Fulton's condition factor for *B. ercisianus* was determined as 1.158±0.006 (0.864-1.559) for overall, 1.159±0.008 (0.884-1.491) for males, 1.143±0.010 (0.890-1.559) for females, and 1.180±0.016 (0.864-1.509) for juveniles. The mean condition factor ranged from 1.125±0.010 in July to 1.236±0.042 in May (Figure 2).

Reproduction

In the population of *C. kosswigi*, 113 (86.9%) of the specimens collected were male and 17 (13.1%) were female. Male:female ratio was calculated as 1:0.15. The chi-square analysis showed that the sex ratio was significantly different from the expected ratio (χ^2 test, $p<0.05$) (Table 6).

Sex was determined on 237 specimens for *B. ercisianus*. 145 (61.2%) samples were male and 92 (38.8%) samples were female. The M:F ratio was determined as 1:0.64. The sex ratio was found to be significantly different from equality 1:1 (χ^2 test, $p<0.05$) (Table 6).

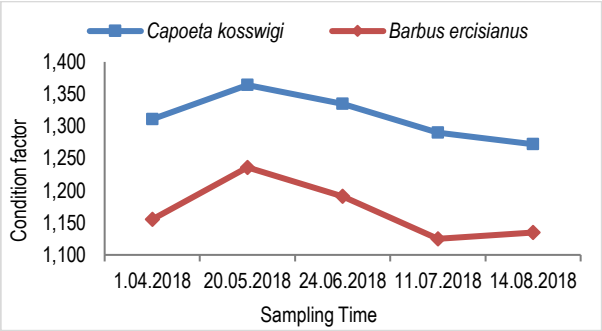

Figure 2. Fulton's condition factor changes for *Capoeta kosswigi* and *Barbus ercisianus* in the Deliçay Stream

Table 6. M:F ratio of the *Capoeta kosswigi* and *Barbus ercisianus* populations in the Deliçay Stream

Species	Male		Female		M+F	M:F	χ^2	Result
	n	%n	n	%n				
C. kosswigi	113	86.9	17	13.1	130	1:0.15	70.89	p<0.05
B. ercisianus	145	61.2	92	38.8	237	1:0.64	12.30	p<0.05

The sexual maturity for *C. kosswigi* was determined on 130 samples. Total 116 of the overall samples was mature and 14 was immature. Of the 113 males, 99 were identified as mature, while all the females were found as mature. When the sexual maturation was examined according to 1 cm length groups, it was determined that maturation occurred at 11 cm (100%) FL for males and 18 cm (100.0%) FL for females (Table 7).

The sexual maturity for *B. ercisianus* was determined on 237 samples. Total 216 of the overall samples was mature and 21 was immature. Of the 145 males, 124 were identified as mature, while all the females were found as mature.

According to 1 cm length groups, males matured at 9 cm (85.7%) fork length and females at 12 cm (100.0%) fork length (Table 8).

Table 7. Sexual maturity groups of *Capoeta kosswigi* in the Deliçay Stream

Fork length groups (cm)	Male		Female	
	Mature (+) (%n)	Mature (-) n (%n)	Mature (+) n (%n)	Mature (-) n (%n)
≤10	6 (30.0)	14 (70.0)	0	0
11	11 (100.0)	0	0	0
12	6 (100.0)	0	0	0
13	9 (100.0)	0	0	0
14	21 (100.0)	0	0	0
15	15 (100.0)	0	0	0
16	8 (100.0)	0	0	0
17	7 (100.0)	0	0	0
18	8 (100.0)	0	2 (100.0)	0
19	4 (100.0)	0	2 (100.0)	0
20	2 (100.0)	0	4 (100.0)	0
21	2 (100.0)	0	2 (100.0)	0
22≤	0	0	7 (100.0)	0
Total	99	14	17	0

Table 8. Sexual maturity groups of *Barbus ercisianus* in the Deliçay Stream

Fork length groups (cm)	Male		Female	
	Mature (+) (%n)	Mature (-) n (%n)	Mature (+) n (%n)	Mature (-) n (%n)
≤8.9	3 (33.3)	6 (66.7)	0	0
9	12 (85.7)	2 (14.3)	0	0
10	13 (86.7)	2 (13.3)	0	0
11	21 (84.0)	4 (16.0)	0	0
12	37 (84.1)	7 (15.9)	2 (100.0)	0
13	22 (100.0)	0	3 (100.0)	0
14	10 (100.0)	0	4 (100.0)	0
15	6 (100.0)	0	4 (100.0)	0
16	0	0	14 (100.0)	0
17	0	0	22 (100.0)	0
18	0	0	19 (100.0)	0
19	0	0	15 (100.0)	0
20	0	0	5 (100.0)	0
21	0	0	3 (100.0)	0
22≤	0	0	1 (100.0)	0
Total	**124**	**21**	**92**	**0**

The GSI values were calculated to determine the reproduction for both populations. The total GSI for *C. kosswigi* was calculated between 0.389 and 16.000 with an average of 2.392±0.243. This value was determined as 2.059±0.252 (0.389-16.000) for males and 3.880±0.605 (1.259-9.776) for females. The mean GSI for all samples peaked in May (5.621±2.930), whereas the lowest in July (1.227±0.162) (Figure 3). The total GSI value for *B. ercisianus* ranged from 0.282 to 16.924 with an average of 4.184±0.212. This value was calculated as 4.032±0.265 (0.282-15.441) for males and 4.388±0.346 (0.540-16.924) for females. The highest GSI for all samples was in May (6.877±1.084), while the lowest in August (1.429±0.091) (Figure 3).

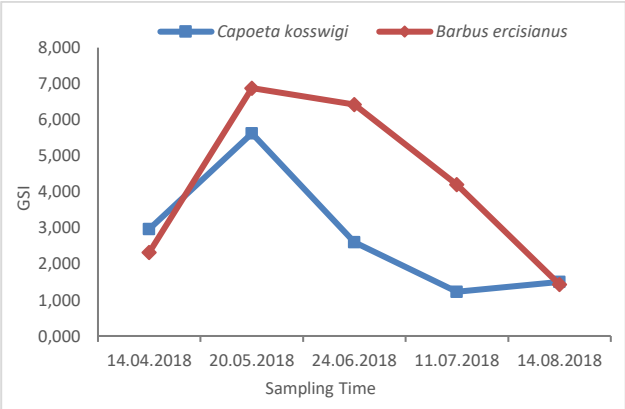

Figure 3. GSI changes for *Capoeta kosswigi* and *Barbus ercisianus* in the Deliçay Stream

DISCUSSION

In this study, the sample size ranged from 309 specimens for *C. kosswigi* to 288 specimens for *B. ercisianus*. The lenght and weight ranges for males was lower than for females in both species.

The maximum length and weight values for *C. kosswigi* were smaller than the previous studies in Lake Van Basin (Table 9). The b value is considered as an indicator showing the nutritional status and growth of the fish. It is affected by the water temperature, the abundance of nutrients in the environment, and other properties. In practice, values of b smaller, equal and larger than 3 indicate isometry, negative allometry and positive allometry respectively (Wootton, 1998). The growth types of *C. kosswigi* for all the samples, females, and juveniles were isometric growth ($p>0.05$), while the growth type for males was negative allometric growth ($p<0.05$). On the other hand, the b values for *C. kosswigi* in our study were within the values (2.5-3.5) reported by Froese (2006). Population characteristics of *C. kosswigi* presented different studies are given in Table 9.

Fulton's condition factor value is related to the body shape of the fish. It is used as an indicator of long-term changing nutritional balance in comparison of fish populations of the same species living under similar or different conditions such as condition factor, nutrient density, climatic conditions, determination of gonad maturity time and duration and nutritional activity (Bogler and Connolly, 1989; Yılmaz et al., 2003; Çetinkaya et al., 2005). Wootton (1992) reported that fish with higher K values (> 1) are in a better condition than fish with lower K values (< 1). In this study, K values ranged from 0.798 to 1.886 with a mean value of 1.305 (Table 9) which indicates that fish were in good condition during the study period in the aquatic ecosystem. Fulton's condition factor values of the *Capoeta* species are shown in Table 9. In the previous studies conducted in our study, the condition factor ranged between 1.234 (Nazik Lake) and 1.452 (Karasu River).

The sex ratio was close to 1:1 in many species, and it sometimes can vary from species to species, even from different sources of the same species in different years or different populations (Nikolsky, 1963). In the present study, the overall M:F ratio of the population was 1:0.15, for all of the investigated samples in *C. kosswigi.* The chi-square analysis showed that the sex ratio was significantly different from the expected 1:1 ratio (χ^2= 70.89, $p<0.05$). In this study, the males were found to be dominant. Due to the large size of females, prey pressure is thought to be more intense on females. It was reported in Table 9 that the males were dominant in Nazik Lake (1:0.77), Karasu River (1:0.85) and Çığlı Stream (1:0.77), whereas females were dominant in Koçköprü (1:1.43) and Zernek Dam Lakes (1:1.72).

Sexual maturation for *C. kosswigi* was occured at 11 cm FL for males and 18 cm FL for females in this study. In Lake Van Basin, females reach sexual maturity for *C. kosswigi* at a larger size than males. These sexual maturity sizes were observed at 15 cm for males and 22 cm for females from Nazik Lake (Şen et al., 1999), 23 cm for males and 33 cm for females from Koçköprü Dam Lake (Elp and Karabatak, 2007), 14 cm for males and 22 cm for females from Zernek Dam Lake (Şen et al., 2008), 11 cm for males and 23 cm for females from Karasu River (Elp and Şen, 2009), 10 cm for males and 18 cm for females from Çığlı Stream (Şen et al., 2014). In addition, it was determined that the *C. kosswigi* population in Deliçay Stream had reached sexual maturity size before the population of *C. kosswigi* from Nazik Lake, Zernek Dam Lake and Koçköprü Dam Lake. The water temperature and nutrition may be effective in this result.

Reproduction in fish is a very complex vital activity, and reproduction has vital importance to ensure species survival in fish as in other living things. (Karataş et al., 2005). The mean GSI value for *C. kosswigi* piked in May (5.621±2.930) and then declined. The lowest GSI value was determined in July (1.227±0.162). Spawning season of *C. kosswigi* took place intensively from 1st week of May to 2nd week of July in Deliçay Stream. Spawning season of *C. kosswigi* was reported in Lake Van Basin between May and July from Nazik Lake (Şen et al., 1999), May and June from Koçköprü Dam Lake (Elp and Karabatak, 2007), June and July from Zernek Dam Lake (Şen et al., 2008) and May and July from Çığlı Stream (Şen et al., 2014). It has been observed that *C. kosswigi* population reproduced at similar periods from various regions in Lake Van Basin

Table 9. Population characteristics of *Capoeta kosswigi* genus presented different studies in Lake Van Basin

Locality	Species*	N	M	F	J	M:F	FL (min-max)	W (min-max)	a	b	r^2	Mean K (min-max)	GSI (min-max)	Reference
Deliçay Stream	*C. kosswigi*	309	113	17	179	1:0.15	3.7-26.1	0.6-227.4	0.01435	2.952	0.996	1.305 (0.798-1.886)	0.39-16.00	The present study
Nazik Lake	*C. capoeta*	603	331	254	18	1:0.77	1.9-48.3	0.1-1379.5	0.01349	2.960	0.993	1.234 (0.494-1.514)	1.16-8.65	Şen et al. (1999)
Koçköprü Dam Lake	*C. capoeta*	1234	507	727	-	1:1.43	3.2-39.8	0.4-755.6	0.01262	2.999	0.998	1.275 (1.078-1.434)	1.05-10.10	Elp and Karabatak (2007)
Zernek Dam Lake	*C. capoeta*	586	158	272	156	1:1.72	4-41	0.7-1060.4	0.0137	2.992	0.990	1.314 (0.997-1.793)	0.23-7.85	Şen et al. (2008)
Karasu Stream	*C. capoeta*	427	216	183	28	1:0.85	4-37.5	0.7-676.2	0.0129	3.039	0.989	1.452 (1.069-2.135)	-	Elp and Şen (2009)
Çığlı Stream	*C. capoeta*	535	254	196	85	1:0.77	3.8-33.2	0.8-432.3	0.0170	2.887	0.985	1.280 (0.665-1.866)	1.33-11.33	Şen et al. (2014)

*In binomial nomenclature, *C. capoeta* was used as the synonym of *C. kosswigi*.

The maximum size for *B. ercisianus* was found as 22.7 cm and 140.0 g. These values are very higher than Çığlı Stream (Table 10). Bilici et al. (2017) explained the size differences in the populations with the selectivity of the sampling nets used, fishing pressure and moreover, ecological differences between lakes and streams. In Deliçay Stream, weight increased isometric with size since the values of b had not a significant difference from the value 3.0 ($p>0.05$). The regression equation for length-weight relationship of *B. ercisianus* shows that the species exhibited an isometric growth pattern. This indicates that there was dimensional proportionality (in body weight and total length) at the same rate. Froese (2006) reported that if b = 3, then small number of specimens in the fish sample have the same form and condition as large specimens. The b value in our study is similar to the value reported for Koçköprü Dam Lake and Çığlı Stream (Table 10). According to their results, the growth type of population was isometric in Çığlı Stream.

The mean Fulton's condition factor values for *B. ercisianus* in present study were lower than Koçköprü Dam Lake and Çığlı Stream (Table 10). In present study, the highest value was reached in May, being higher in the feding months and just prior to spawning. These results were similar with Koçköprü Dam Lake and Çığlı Stream.

The sex ratio of male to female for *B. ercisianus* was 1:0.64 and the difference was statistically significant (χ^2= 12.30, $p<0.05$). In other studies, the male:female ratio has been presented in Table 10. The similar studies showed that the males were dominant. Generally, it is reported that the ability of males to hatch is higher than females in freshwater, but the proportion of males gradually decreases in the upper age classes and the proportion of females becomes quiet dominant in a population (Yıldırım et al., 2001).

The first sexual maturity size for *B. ercisianus* individuals in Deliçay was observed at 9 cm in males, and 12 cm in females. It was reported as 7.0-7.9 cm for males and 15.0-15.9 cm for females from Koçköprü Dam Lake (Elp et al., 2006) and 6.0-6.9 cm for males and 10.0-10.9 cm for females from Çığlı Stream (Şen and Kara, 2016). Our results were close to the values reported for Koçköprü Dam Lake and Çığlı Stream. Moreover, males may grow slower than the females or males may mature earlier than the females in Lake Van Basin.

The GSI peak for *B. ercisianus* was observed on May (6.877±1.084), whereas the lowest GSI was in August (1.429±0.091). Spawning took place intensively from 1st week of May to 1st week of August. Şen and Kara (2016) determined that spawning period for *B. ercisianus* was happened between May and August in Çığlı Stream. The results of the present study are similar to the results given for *B. ercisianus* population in Çığlı Stream.

In conclusion, from these measurements and calculations, it can be argued that growth and condition in the population had suitable values. It was established that *C. kosswigi* attained sexual maturity when they reached to 11 cm (100%) for males and 18 cm (100.0%) for females. The individuals maturation for *B. ercisianus* occurred at 9 cm (85.7%) for males and 12 cm (100.0%) for females. The spawning period for *C. kosswigi* was observed from 1st week of May to 2nd week of July, and for *B. ercisianus* from 1st week of May to 1st week of August. It is expected that the results of the presently reported study will contribute to the sustainable fishery for *C. kosswigi* and *B. ercisianus* in the Deliçay Stream. It may be suggested that fishing should be forbidden between April and August and minimum catching size must be 20 cm fork length for *C. kosswigi* and 15 cm fork length for *B. ercisianus*.

Table 10. Population characteristics of *Barbus ercisianus* presented different studies

Locality	Species*	N	M	F	J	M:F	FL (min-max)	W (min-max)	a	b	r^2	Mean K (min-max)	GSI	Reference
Deliçay Stream	*B. ercisianus*	288	145	92	51	1:0.64	4.3-22.7	1.2-140.0	0.01276	2.959	0.994	1.158 (0.864-1.559)	4.184	The present study
Koçköprü Dam Lake	*B. ercisianus*	204	85	68	51	1:0.80	3-33.8	0.1-428	0.014	2.934	0.992	1.242 (0.790-2.226)	-	Elp et al. (2006)
Çığlı Stream	*B. plebejus*	196	119	76	1	1:0.64	4.3-16.6	1.2-65.8	0.0146	2.934	0.976	1.260 (0.954-1.632)	1.71-10.03	Şen and Kara (2016)

*In binomial nomenclature, *B. plebejus* was used as the synonym of *B. ercisianus*.

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