J. Appl. Ichthyol. (2006), 1–6
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ISSN 0175–8659

Received: July 31, 2005
Accepted: February 9, 2006
doi:10.1111/j.1439-0426.2006.00787.x

Age, growth and reproductive characteristics of chub, *Leuciscus cephalus* (L., 1758) in the İkizcetepeler dam lake (Balikesir), Turkey

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Summary

In this study, the population structure, growth and reproduction characteristics of 414 chub (*Leuciscus cephalus* L., 1758) from the İkizcetepeler dam lake were investigated monthly between January and December 2000. Age groups ranged between I and VI for this species in the reservoir, with the second and third year-classes dominating. Sex ratio was 1 : 1.4 (M : F), corresponding to 58.4% males and 41.6% females. Females attained greater size and age than males. The largest female captured was 24.8 cm FL, the largest male was 24.1 cm FL, both age VI. The von Bertalanffy growth equations and length–weight relationships were found as: $L_t = 28.89[1 - e^{-0.224(t+1.55)}]$ for females, $L_t = 26.71[1 - e^{-0.259(t+1.55)}]$ for males; $W_t = 347.386[1-e^{-0.224h\ (t+1.55)}]^{2.86}$ for females, $W_t = 286.48[1-e^{-0.259\ (t+1.55)}]^{2.92}$ for males; $W = 0.0227 \times L^{2.87}$ for females and $W = 0.0194 \times L^{2.92}$ for males. Significant statistical differences in condition factors between age classes and sexes were not found ($P > 0.05$, *t*-test). Spawning period of this species in the lake was between April and May.

Introduction

Chub (*Leuciscus cephalus* L., 1758) is widely distributed in Europe, Anatolia, and the Black and Azov sea basins (Slastenenko, 1956; Geldiay and Balık, 1972, 1996; Kuru, 2000). Although age, growth and reproduction characteristics of the chub inhabiting European and Turkish waters have been studied extensively (Erk'akan and Akgül, 1986; Neophitou, 1987; Poncin et al., 1987; Altındağ, 1996; Ekmekçi, 1996; Karatas and Akyurt, 1997; Gül and Yılmaz, 2002; Şaşı and Balık, 2003; Balık et al., 2004), little is known as to growth in Turkish reservoirs such as the İkizcetepeler dam lake, where chub is mainly caught for consumption and thus has an economic value. It is also popular as a gamefish. The main aim of the present investigation was to determine seasonal changes in biological characteristics of *L. cephalus*. In addition, the study contributies to the age, growth and reproduction knowledge of this species in the İkizcetepeler dam lake, which in turn is compared to performance data obtained from other regions of the species' range.

Material and methods

Reservoir characteristics

The İkizcetepeler dam lake is located approximately 15 km from the city of Balikesir (27°56′42″N, 39°29′32″E) and was created by a 47.0 m-high dam constructed between 1986 and 1991 by DSI (State Water Systems Services) in order to supply the city with fresh water. The reservoir surface is 9.6 km^2; overall volume totals 164 560 000 m^3. The minimum code (water above sea level) is 49.75 m; the maximum code is 175 m. According to April 2000 measurements, maximum depth was 47.0 m. The largest water supply to the lake is from the Kille Stream, which in turn is connected to other streams, namely, the Akçaköy, the Taşköy and the Kozludere. The İkizcetepeler dam lake contains fish serving a commercial fishery operated by cooperatives.

For this study, 414 specimens were captured monthly from January to December 2000 using a total of 1000 m of gill nets of 18–55 mm mesh sizes. 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. Age determination was carried out from microscopic examination of scales. Ten to 15 scales from the left side of the body between the lateral line and dorsal fin were removed and dry mounted between two slides for binocular microscopy (Lagler, 1966). The von Bertalanffy growth equations were calculated according to: $L_t = L_\infty[1-e^{-K(t-t_0)}]$ for FL and weight $W_t = W_\infty[1-e^{-K(t-t_0)}]^b$, where L_t is the length of fish in cm at age t, L_∞ is the asymptotic fish length in cm, e is the base of natural log (2.71828), t is the fish age (year), t_0 is the hypothetical time at which the length of the fish is zero, K is the rate at which the growth curve approaches the asymptote, W_t is the weight of the fish in g at age t, W_∞ is the asymptotic weight of the fish in g and b is the constant in the length–weight relationship (Ricker, 1975; Sparre and Venema, 1992).

Condition coefficients were calculated for both sexes using the equation $K = (W/FL^3) \times 100$ (Ricker, 1975).

Sex was determined by macroscopic observation of the gonads. The overall sex ratio and stages of sexual maturity were also determined. Gonads were removed and weighed to the nearest 0.1 g. Deviations from 1 : 1 null hypothesis were tested statistically by chi-squared analyses (Sokal and Rohlf, 1981).

The spawning period was determined by identifying monthly changes in the gonadosomatic index (GSI). The GSI was calculated using the equation: GSI = Gonad weight/(Body weight − Gonad weight) × 100 (Nikolsky, 1963; Avsar, 1994). Statistical analyses were carried out with SPSS, STATISTICA for Windows V 11.0.

Results

Length–frequency distribution

Of 414 specimens measured, FL of males ranging from 12.2 to 24.1 cm; the range (11.1–24.8 cm) for females was higher than

for males (Table 1). However, the difference between FL means of female and male fish for all year-classes was not significant (P > 0.05, *t*-test).

Age composition and sex ratio

Age and sex distribution data are summarized in Fig. 1. Age of captured fish ranged between I and VI, while the second and third year classes were dominant. Because of selectivity of the nets, the '0' age group was not represented in the samples. There were about 58% males and 42% females, and differences between sexes according to age were not significant (P > 0.05). Sex ratio (F : M) was 1 : 1.41.

Growth

Data on *L. cephalus* mean FL and mean total weight for different ages in males, females and all individuals are summarized in Table 1. Males up to age II were longer than females; above this age females were longer than males. But the differences between the sexes were not significant in other groups except groups IV and V (P > 0.05). Age–length relationships of females and males are plotted in Fig. 2 with the respective equations indicated. Although females up to age II weighed more, differences between sexes were not significant as above this age males weighed more in the population. Differences between the sexes according to age groups for total weight were statistically significant in age groups IV and V (P < 0.05). Male and female age–weight relationships are plotted in Fig. 3. Females grew to a greater asymptotic (W_∞) weight than the males (Fig. 3a).

Length–weight relationships

Length–weight relationships were calculated by using the data of 414 *L. cephalus* specimens. These were found to be $W = 0.0194 \times L^{2.92}$ ($R^2 = 0.90$) for males and $W = 0.0227 \times L^{2.87}$ ($R^2 = 0.90$) for females. The *b* value for males was somewhat higher than that for females. The length–weight curves for males and females are plotted in Fig. 4.

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; Table 1, Fig. 5). Additionally, seasonal variations in the condition coefficients were determined for each sex (Fig. 6). In general, monthly conditions exhibited a similiar pattern for both sexes, showing a peak during the spawning season, but indicating somewhat lower values after the spawning period and during winter. Differences between values of CF according to months, especially in May, were statistically significant (d.f.: 10.402; *F*: 7.425; P < 0.001; one-way ANOVA), again reflecting the peak spawning season.

Gonad development and spawning period

Gonad development was followed using the GSI. Monthly changes are plotted in Fig. 7. Spawning occurred between April and May. During spring (March–May), an obviously rapid growth of gonads occurred untill the next spawning. Differences between values of GSI according to months,

Table 1
Mean fork length (FL, cm), and mean weight (*W*, g), mean condition factor (CF), standard error (SE) for different age groups of *Leuciscus cephalus* males and females in the İkizcetepeler reservoir as determined by monthly samples taken in the year 2000

	Male						Female							
Age	N	FL ± SE (min–max)	*W* ± SE (min–max)	CF ± SE (min–max)	GSI ± SE (min–max)	N	FL ± SE (min–max)	*W* ± SE (min–max)	CF ± SE (min–max)	GSI ± SE (min–max)	P = 0.05*	P = 0.05**
I	22	12.9 ± 0.1 (12.2–13.9)	34.8 ± 0.1 (29.3–44.2)	1.63 ± 0.21 (1.30–2.01)	1.18 ± 0.10 (0.43–2.41)	19	12.6 ± 0.2 (11.1–13.5)	33.8 ± 2.0 (18.6–57.6)	1.74 ± 0.53 (0.77–2.68)	1.78 ± 0.43 (0.40–6.77)	P > 0.05	P > 0.05
II	64	14.3 ± 0.1 (12.5–16.6)	45.9 ± 1.1 (28.3–69.7)	1.60 ± 0.36 (1.01–2.84)	1.28 ± 0.11 (0.19–3.72)	40	14.5 ± 0.1 (13.0–16.4)	45.1 ± 1.2 (30.9–66.9)	1.53 ± 0.26 (1.03–2.20)	1.42 ± 0.17 (0.19–4.58)	P > 0.05	P > 0.05
III	93	15.3 ± 0.1 (13.5–17.9)	56.8 ± 1.2 (35.8–96.4)	1.62 ± 0.40 (0.88–3.04)	1.80 ± 0.16 (0.27–8.17)	57	15.4 ± 0.1 (13.8–17.5)	58.9 ± 1.6 (40.1–95.1)	2.05 ± 0.42 (1.01–3.05)	2.37 ± 0.28 (0.39–8.74)	P > 0.05	P > 0.05
IV	57	16.9 ± 0.1 (14.7–18.8)	75.6 ± 1.6 (36.0–121.4)	1.61 ± 0.31 (1.02–2.61)	1.80 ± 0.18 (0.13–6.17)	39	17.4 ± 0.2 (14.9–20.4)	77.7 ± 2.2 (48.6–110.4)	1.80 ± 0.31 (1.03–2.91)	3.13 ± 0.43 (0.50–11.18)	P > 0.05	P < 0.05
V	3	19.6 ± 0.17 (17.9–21.5)	97.0 ± 2.2 (92.8–100.1)	1.60 ± 0.07 (1.51–1.66)	3.10 ± 0.32 (2.50–3.61)	8	21.1 ± 0.6 (19.3–22.8)	128.9 ± 10.2 (88.9–162.7)	1.51 ± 0.21 (1.24–1.93)	2.48 ± 0.36 (0.98–3.57)	P > 0.05	P > 0.05
VI	3	23.6 ± 0.1 (18.8–24.1)	137.8 ± 18.8 (110.9–173.9)	1.71 ± 0.36 (1.32–2.03)	2.27 ± 0.84 (0.75–3.64)	9	24.40 ± 0.40 (24.0–24.8)	145.9 ± 19.5 (88.1–243.6)	1.61 ± 0.41 (1.26–2.40)	3.16 ± 0.8 (0.84–7.65)	P > 0.05	P > 0.05
	242					172						

Min–max, minimum and maximum values; n, number of fish; P-value, significance level.
*Significance values belong to CF values.
**Significance values belong to GSI values.

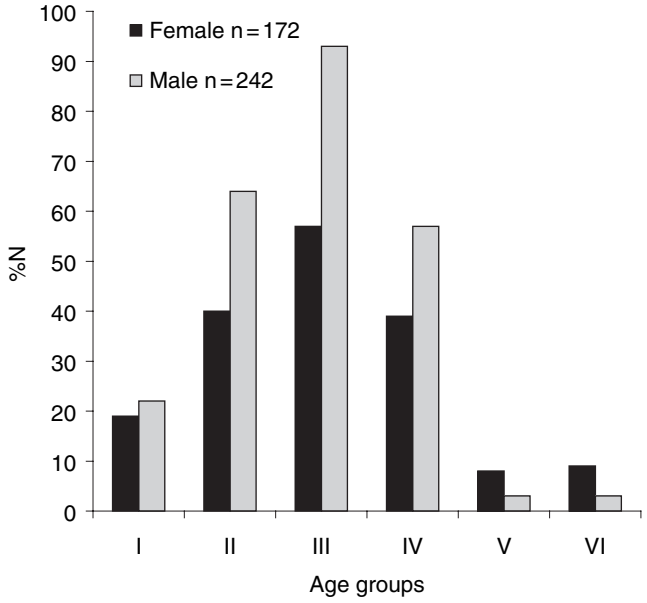

Fig. 1. *Leuciscus cephalus* in İkizcetepeler reservoir. Age and sex distribution as determined from monthly samples taken in the year 2000 and based on scale readings (n = number of fish)

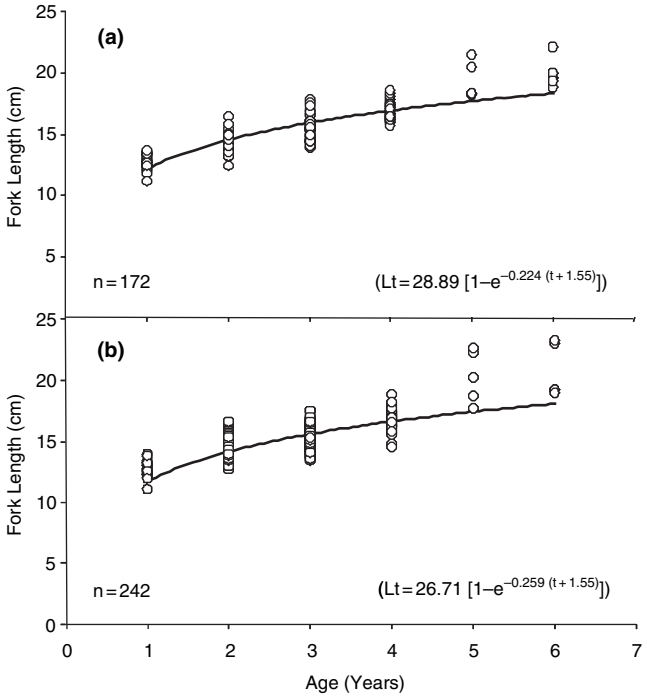

Fig. 2. Age–length relationships in female (a) and male (b) *Leuciscus cephalus* in the İkizcetepeler artificial reservoir as determined from monthly samples taken in year 2000

especially April, are statistically significant (d.f.: 10.403; *F*: 40.434; $P < 0.001$; one-way ANOVA). Differences in GSI between age classes and sexes, especially age-class IV groups, were also found to be statistically significant ($P < 0.05$, *t*-test; Table 1).

To analyse distribution of data, values of mean ± SD were estimated as mean ± 1 SD = 90.91; mean ± 2 SD = 100; mean ± 3 SD = 100. As seen in these values and Fig. 7, the monthly data were not normally distributed.

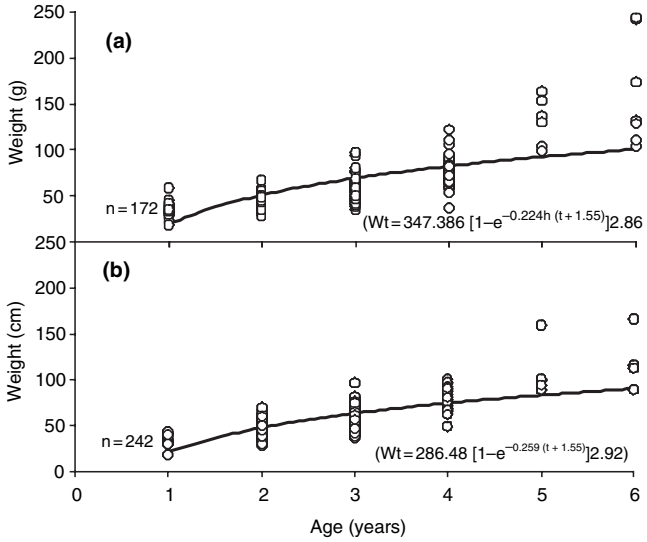

Fig. 3. Age–weight relationships in female (a) and male (b) *Leuciscus cephalus* in the İkizcetepeler artificial reservoir as determined from monthly samples taken in year 2000

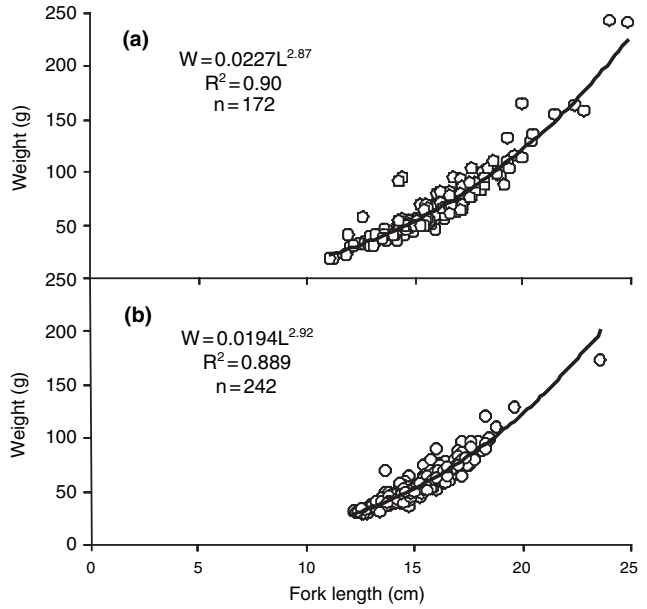

Fig. 4. Length–weight relationships in female (a) and male (b) *Leuciscus cephalus* in the İkizcetepeler artificial reservoir as determined from monthly samples taken in year 2000

Discussion

In this study, a total of 414 specimens of *L. cephalus* from the İkizcetepeler dam lake were examined from January to December 2000. The age of captured fish ranged between groups I and VI. The fact that 71.25% of the specimens were between ages I and III indicates that the population were mostly young individuals. The population consisted of 58.44% males and 41.56% females. In this study, the sex ratio was 1 : 1.41 (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, 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). Some researchers confirm our findings (Öztaş and Solak, 1988; Altındağ, 1996; Ekmekçi, 1996;

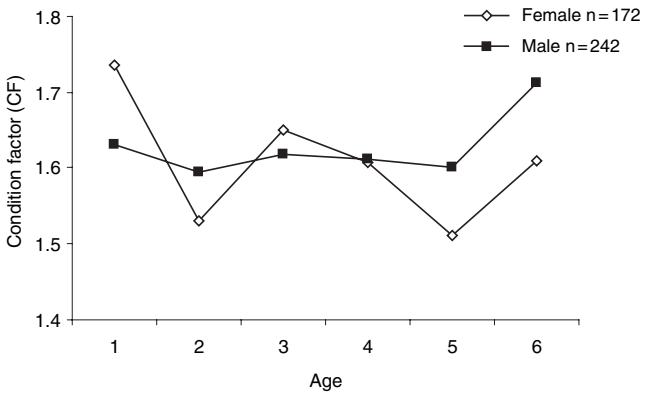

Fig. 5. Mean condition factor according to age and sex of *Leuciscus cephalus*

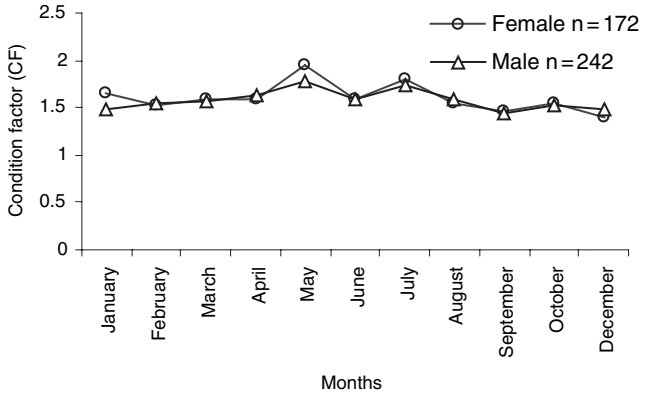

Fig. 6. Monthly variations in condition factor of *Leuciscus cephalus*

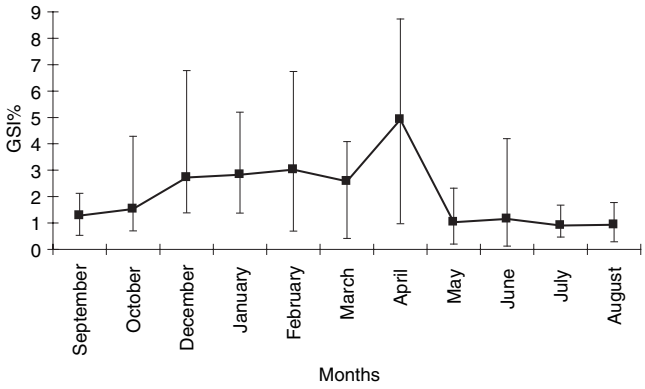

Fig. 7. Gonadosomatic index (GSI) changes in *Leuciscus cephalus* over time as revealed from monthly samples taken in year 2000. N = total number of fish samples; n = number of fish sampled each month. Values represent mean, and bars indicate range

Karatas, 1997; Erdoğan et al., 2002; Şaşı and Balık, 2003; Balık et al., 2004; Kalkan et al., 2005). The majority of samples in the population was in the third age group. This situation was also reported for Kirmir Stream, and the Topçam and Karakaya dam lake populations (Solak et al., 1995; Şaşı and Balık, 2003; Kalkan et al., 2005). While most of the samples were in the second age group for Akşehir Lake, Müceldi Stream and Işıklı Lake populations (Öztas and Solak, 1988; Altındağ, 1996; Balık et al., 2004), there were only a few in the third age group for the Sariyar dam lake (Ekmekçi, 1996). While males were longer and heavier at earlier life stages, females were longer and heavier at later stages. This situation was similiar to that reported by Altındağ (1996), but different from that reported by some investigators of *L. cephalus* from Karakaya dam lake (Kalkan et al., 2005), Kirmir Stream (Solak et al., 1995) and Sarıyar dam lake (Ekmekçi, 1996). Variations in fish growth in terms of length and weight can be explained as an adaptive response to different ecological conditions (Nikolsky, 1963; Wootton, 1992). The von Bertalanffy growth equations were: $L_t = 28.89[1 - e^{-0.224(t+1.55)}]$ for females and $L_t = 26.71[1 - e^{-0.259(t+1.55)}]$ for males; $W_t = 347.39[1 - e^{-0.224(t+1.55)}]^{2.86}$ for females and $W_t = 286.48[1 - e^{-0.259(t+1.55)}]^{2.92}$ for males in the İkizcetepeler dam lake. The theoretical maximum length was close to those estimated for rivers in Croatia, except for the Dobra River, and the Karasu River and the Karakaya dam lake both in Turkey (Table 2). Maximum lengths recorded prior to our study were 23.1 and 44.0 cm (Table 2). This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex and gonadal development (Ricker, 1975). Geographic location and some environmental conditions such as temperature, organic matter, quality of food, time of capture, stomach fullness, disease, parasitic loads (Bagenal and Tesch, 1978), temperature, organic matter, quality of food and the water system in which the fish live (Wootton, 1992; Treer et al., 1998, 1999) can also affect weight-at-age estimates.

In this study, seasonal conditions showed a similar pattern in both sexes. Maximum condition factor was found in May, being generally higher in the feeding months and in the months just prior to the spawning season (Fig. 6). Several investigators have reported similar patterns (Ekmekçi, 1996; Türkmen et al., 1999; Ünver and Tanyolaç, 1999; Erdoğan et al., 2002).

The slope (b) values of the length–weight relationship in both sexes ($b = 2.96$ for males, $b = 2.86$ for females) showed that weight increased with length in negative allometry. For the same species, the b values are shown in Table 2.

As seen in Table 2, b values for the İkizcetepeler dam lake were found to be close to estimates by Treer et al. (1998) and Solak et al. (1995), but also different from those found by Altındağ (1996), Türkmen et al. (1999), Erdoğan et al. (2002) and Kalkan et al. (2005). The b values are often 3.0 and generally between 2.5 and 3.5. As the fish grows, changes in weight are relatively greater than changes in length, due to approximately cubic relationships between fish length and weight. The b values in fish differ according to species, sex, age, seasons and feeding (Ricker, 1975; Bagenal and Tesch, 1978). In addition, changes in fish shape, physiological conditions, different amounts of food available, life span or growth increment can all affect the b growth exponent (Frost, 1945; Treer et al., 1998, 1999). As a result of lower masses of chub in the İkizcetepeler dam lake during their first years (Table 1), the CF during the same period was also low – below 1. Towards the fifth year, the chub gains in mass and attains CF fish values around 1.80 (Table 1, Fig. 5). Values of chub in the İkizcetepeler dam lake lower than 3 CF do not mean that the chub was in poor condition. As seen in Table 2, our findings in CF confirm the previous literature.

In the present study, the mean monthly gonodosomatic index values were the highest in April and decreased in May for the İkizcetepeler population (Fig. 7). Spawning occurred between April and May. These are compared to the relevant studies (Table 3).

Table 2
Age structure, parameters of length–weight relationship (*a* and *b*), growth (L_∞, K, t_0) and CF of *Leuciscus cephalus* in this and previous studies (– indicates absence of data)

References	Area	Age	Weight range	Length range	N	*a*	*b*	r^2	L_∞	K	t_0	CF
Prokes et al. (1978)	Rokytna River	–	–	–	–	−1.873	3.20	–	–	–	–	–
Öztas and Solak (1988)	Müceldi Stream	6	9.1–324.0[a]	8.5–26.8[a]	588[a]	−4.706[a]	2.97[a]	–	–	–	–	–
			7.9–245.0[b]	8.0–24.8[b]	717[b]	−4.958[b]	3.04[b]					
Şen (1988)	Kalecik Lale	–	–	–	–	−4.440	3.02	–	–	–	–	–
Solak et al. (1995)	Kirmir Stream	7	15.0–379.0[a]	9.8–30.9[a]	192[a]	−4.63[a]	2.87[a]	–	–	–	–	1.09–2.02[a]
			19.0–378.0[b]	10.7–30.7[b]	203[b]	−4.71[b]	3.01[b]					1.12–2.01[b]
Altındağ (1996)	Aksehir Lake	7	41.0–176.6[a]	13.0–44.0[a]	–	−1.980[a]	3.135[a]	–	40.5[a]	0.21[a]	−1.36[a]	1.60[a]
			52.0–557.0[b]	15.0–31.0[b]		−1.801[b]	3.001[b]		32.3[b]	0.40[b]	−0.61[b]	1.56[b]
Ekmekçi (Atalay) (1996)	Sarıyar dam lake	10	94.0–924.0[a]	18.3–37.3[a]	234	–	–	–	–	–	–	1.04–1.88
			72.0–457.0[b]	17.3–31.8[b]								
Treer et al. (1997)	Croatia	–	–	–	–	–	–	–	31.8	0.28	0.04	–
Treer et al. (1998)	Dobra River	–	–	–	–	0.003	3.53	–	38.9	0.16	−0.60	1.08
Treer et al. (1998)	Bednja River	–	–	–	–	0.019	2.87	–	32.9	0.26	−0.09	1.29
Treer et al. (1998)	Lika River	–	–	–	–	0.027	2.67	–	27.3	0.38	0.20	0.99
Treer et al. (1998)	Kupa River	–	–	–	–	0.005	3.24	–	29.5	0.36	0.62	1.10
Treer et al. (1998)	Lonja River	–	–	–	–	0.017	2.88	–	32.8	0.34	0.10	1.21
Treer et al. (1999)	Dobra River	6	–	–	87	0.004	3.37	0.998	–	–	–	1.08
Treer et al. (1999)	Bednja River	7	–	–	108	0.019	2.87	0.998	–	–	–	1.29
Treer et al. (1999)	Lika River	5	–	–	24	0.027	2.67	0.990	–	–	–	0.99
Treer et al. (1999)	Kupa River	5	–	–	20	0.006	3.24	0.998	–	–	–	1.10
Treer et al. (1999)	Lonja River	5	–	–	13	0.017	2.88	0.998	–	–	–	1.21
Türkmen et al. (1999)	Aras River	8	3.0–302.5[a]	6.3–27.5[a]	558[a]	0.009[a]	3.14[a]	0.98[a]	36.7[a]	0.11[a]	−1.39[a]	1.08–1.46[a]
			4.2–181.5[b]	6.7–24.1[b]	533[b]	0.010[b]	3.11[b]	0.96[b]	32.5[b]	0.12[b]	−1.63[b]	1.25–1.52[b]
Ünver and Tanyolaç (1999)	Tödürge Lake	7	1.5–347.1	5.3–28.7[a]	460[a]	0.010[a]	3.10[a]	–	47.4[a]	0.11[a]	−0.38[a]	0.81[a]
				5.4–23.3[b]	214[b]	0.012[b]	3.04[b]		54.5[b]	0.08[b]	−0.76[b]	107[b]
Erdoğan et al. (2002)	Karasu River	9	14.0–322.5[a]	10.0–29.0[a]	376[a]	0.014[a]	2.98[a]	0.976[a]	41.4[a]	0.12[a]	−1.32[a]	1.35[a]
			17.0–176.3[b]	10.8–24.0[b]	383[b]	0.015[b]	2.95[b]	0.951[b]	35.9[b]	0.12[b]	−1.17[b]	1.32[b]
Gül and Yilmaz (2002)	Kızılırmak River	6	6.0–353.0	4.7–31.0	–	–	–	–	–	–	–	–
Şaşı and Balık (2003)	Topçam Dam Lake	7	19.8–344.0[a]	10.8–26.2[a]	242[a]	0.009[a]	3.19[a]	0.955[a]	40.2[a]	0.12[a]	−1.58[a]	1.41–1.91[a]
			16.2–203.1[b]	9.7–23.5[b]	90[b]	0.023[b]	2.85[b]	0.947[b]	27.1[b]	0.30[b]	−0.46[b]	1.78–1.74[b]
Balık et al., 2004	Işıklı Lake	5	44.6–247.0[a]	13.5–23.1[a]	215[a]	0.014[a]	3.08[a]	0.949[a]	28.6[a]	0.17[a]	−3.32[a]	1.40–2.00[a]
			41.7–260.1[b]	13.5–23.0[b]	313[b]	3.08[b]	3.03[b]	0.943[b]	31.6[b]	0.13[b]	−3.84[b]	1.57–2.14[b]
Kalkan et al. (2005)	Karakaya dam lake	6	123.8–721.5[a]	17.0–36.2[a]	49[a]	0.013[a]	3.03[a]	–	37.8[a]	0.41[a]	−1.00[a]	1.42[a]
			115.4–584.2[b]	17.0–34.4[b]	28[b]	0.082[b]	2.49[b]		35.5[b]	0.60[b]	−0.19[b]	1.43[b]
This study	İkizcetepeler dam lake	6	18.6–243.6[a]	11.1–24.8[a]	172[a]	0.0227[a]	2.87[a]	0.90[a]	26.71[a]	0.26[a]	−1.55[a]	0.77–2.40[a]
			29.3–173.9[b]	12.2–24.1[b]	242[b]	0.0194[b]	2.92[b]	0.889[b]	28.89[b]	0.22[b]	−1.55[b]	1.30–2.03[b]

[a]Female values.
[b]Male values.

Table 3
Spawning seasons of *Leuciscus cephalus* at various localities and average temperatures according to previous studies

References	Months J	F	M	A	M	J	J	A	S	O	N	D	Locality	Temperature (°C)
Hellawel (1971)													Afon Llynfi Rıver	Low temperature
Penaz et al. (1978)													Jıhlava River	
Erk'akan and Akgül (1986)													Kızılırmak River	
Poncin et al. (1987)													–	
Neophitou (1987)													Rentina River	
Şen (1988)													Kalecik Reservoir	
Öztaş (1989)													Müceldi Stream	12–28
Unlü and Balci (1993)													Savur Stream	15–23
Ekmekçi (1996)													Sarıyar Dam Lake	
Altındağ (1997)													Akşehir Lake	
Karatas (1997)													Tozanlı Stream	
Karatas and Akyurt (1997)													Almus Dam Lake	
Yerli et al. (1997)													Çıldır Lake	
Ünver (1998)													Tödürge Lake	
Türkmen et al. (1999)													Aras River	16–23
Yıldırım et al. (2001)													Oltu Stream	14–19
Erdoğan et al. (2002)													Karasu River	
Kalkan et al. (2005)													Karakaya Dam Lake	
This study													İkizcetepeler Dam Lake	16–18

As seen in Table 3, the spawning period in the İkizcetepeler dam lake is similar to previous investigations, except for those of Yerli et al. (1997) in Çıldır Lake and Erk'akan and Akgül (1986) in the Kızılırmak River. Due to different ecological and climate conditions, the starting and finishing time of reproduction may include different months. Spawning periods of

fish vary with respect to their species; the ecological characteristics of fish are determined by such ecological differences as stagnant or running water, as well as altitude, temperature and quality of food (Nikolsky, 1963).

According to the results it can be proposed that fishing should be prohibited between March and June for maximum productivity from the *L. cephalus* population in the İkizcetepeler dam lake. Also, to maintain a well-balanced population the minimum fishing size should be 22.5 cm TL, which is equal to 21.0 cm FL.

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