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Observations on biological properties of the chub, *Leuciscus cephalus* and environment conditions in the Çaparlıpatlak Pond (Balikesir), Southern Marmara Region, Turkey

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This investigation was conducted in the Çaparlıpatlak Pond, based on a 1-year study involving 431 specimen. The age composition of this species ranged between I and VI with the dominance of fourth age group in the population. Individuals were composed of 36.60% males and 63.40% females. The male and female ratio was 1:1.71 (M:F). Female individuals attained greater size than males. The largest female captured was 21.5 cm FL while the largest male was 20.2 cm FL at the same age, VI. The length–weight relationship was given by $W = 0.0648 \cdot L^{2.44}$ (where W= weight in g; FL = fork length in mm). Age at length data were inferred by modal analysis of the length–frequency distributions. The parameters of the fitted Von Bertalanffy growth equation were $L\infty = 23.66$ cm; $K = 0.30$ yr^{-1}; $to = -0.95$ yr. Macroscopic examination of the gonads, and analysis of the monthly values of the gonadosomatic index indicated that reproduction occurs in spring and early summer, with a maximum between April and June, when water temperatures are high.

Key words: *Leuciscus cephalus*, age, growth, condition, spawning

INTRODUCTION

The chub *Leuciscus cephalus* (L.) is widely distributed in Europe, Anatolia, Black and Azov Sea basins (Geldiay and Balik, 2007; Kuru, 2000). The chub is an opportunistic and mobile species and is common in almost all running waters in Turkey (Bogutskaya, 1997). Although age, growth, feeding, length–weight relationships and reproduction features of the chub inhabiting Europen and Turkish waters have been reported (Karataş and Akyurt, 1997; Gül and Yılmaz, 2002; Saşı and Balık, 2003; Balık et al., 2004; Kalkan et al., 2005; Hamwi et al., 2005; Koc et al., 2007), little is known as to biology in Turkish reservoirs such as the Ēaparlżpatlak Pond, where chub is mainly caught for consumption and thus has an economic value. It is also a popular game fish. This paper describes various aspects of the biology of a Çaparlıpatlak Pond population of *L. cephalus* in the vicinity of Balikesir (Turkey).

Boron accumulation is not often studied for aquatic and semi-aquatic organisms except in a

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few papers (Emiroglu et al., 2010). In the future, we also aim to investigate boron concentration of Çaparlıpatlak Pond, its sediment and *L. cephalus* and different organisms from surrounding county of Balikesir.

MATERIALS AND METHODS

Çaparlıpatlak Pond (the surface area 637 decares, depth 6.2–19.16 m) is being fed by Salkım and Agu Creeks of Koca River, situated at forthy-five km from Balikesir city center and at 233 m above sea level. It was built in 1992 by 17th Regional Directorate of Rural Services to supply irrigation water for the city of Balikesir (Fig. 1).

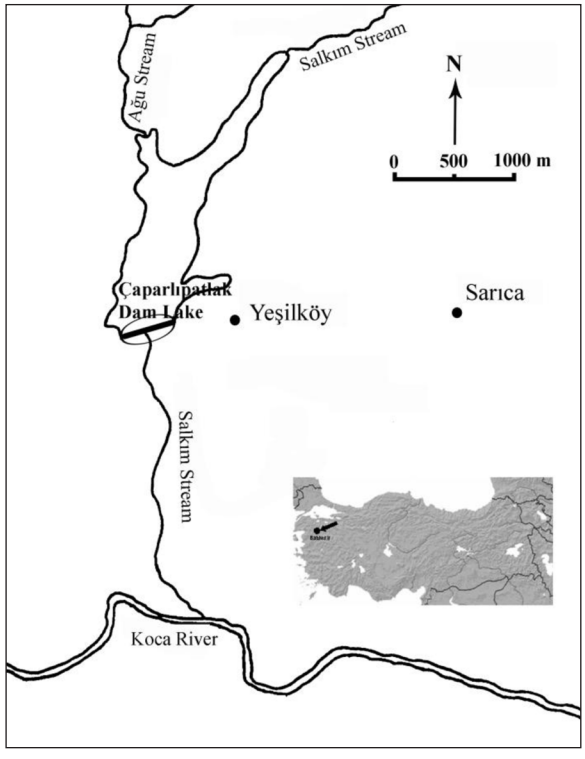

Fig. 1. The studying area

A total of 431 chub (272 females and 159 males) were monthly caught with various mesh gillnets during the period from January 2005 to December 2005. Each specimen was measured (fork length, FL, to the nearest mm below), weighed (total wet weight, TW, in g) at the laboratory at Balikesir University. Scales which were taken from the left side of the fish above the lateral line were used for determining age, especially due to difficulty of otolith interpretation (Bagliniere and Le Louarn, 1987). Von Bertalanffy growth equations were calculated according to: $L_t = L_\infty[1-e^{-k(t-t)_0}]$ in the length and $W_t = W_\infty[1-e^{-k(t-t)_0}]^b$ in weight (Sparre and Venema, 1992). The fork length–weight relationships were calculated for male, female and all individuals:

$$W = a\ FL^b.$$

Condition coefficients (CF) were calculated for both sexes using the equation CF = (Body weight/Fork Length^3 · 100) (Ricker, 1975). Each of these was sexed by macroscopic observation of the gonads, which were removed and weighed (gonad weight, GW, in g). The overall sex ratio and stages of sexual maturity were also determined. The spawning period was determined by means of the monthly changes in the gonadosomatic index (GSI), the gonadosomatic index was calculated using the following equation: GSI = Gonad weight/(Body weight–gonad weight) · 100 (Avsar, 2005).

RESULTS AND DISCUSSION

Table 1 shows the length–weight distributions of male, female and sexed individuals. There is not a statistically significant difference in average fork length and weight between males and females. The length–weight relationships were calculated for each sex separately as given below:

$W = 0.0765 \cdot L^{2.38}$ ($n = 272$; $r^2 = 0.85$) for females and $W = 0.04442 \cdot L^{2.58}$ ($n = 159$; $r^2 = 0.80$) for males and showed a negative allometric growth with in the length range of 8.0–21.5 cm (Figs. 2 and 3). The ages of captured fish ranged between I and VI, and III age group was dominant in the population (Table 1). Because of selectivity of nets, the fish of 0 age group was not represented in the specimens. There were 36.60% males and 63.40% females, the sex ratio (M:F) (1:1.71) was significantly different from 1.1 ($p < 0.05$) (Fig. 4).

Table 1. Mean fork length (FL, cm) and mean weight (W, g), standard error (SE) for different age groups of *Leuciscus cephalus* males, females, and combined sexes

Age	N	Male + Female		N	Male		N	Female	
		FL ± SE (cm)	W ± SE (g)		FL ± SE (cm)	W ± SE (g)		FL ± SE (cm)	W ± SE (g)
I	35	9.63 ± 0.13 (8.0–10,8)	16.20 ± 0.67 (9.98–27.57)	11	9.82 ± 0.25 (8.1–10.8)	15.75 ± 1.33 (9.98–23.21)	24	9.55 ± 0.15 (8.2–10.6)	16.40 ± 0.8 (11.47–27.57)
II	84	13.62 ± 0,07 (12.1–15.0)	38.47 ± 0.73 (14.72–51.32)	33	13.71 ± 0,10 (12.2–14.9)	38.82 ± 1,17 (14.72–51.32)	51	13.57 ± 0.09 (12.1–15.0)	38.23 ± 0.94 (18.79–50.33)
III	166	14.41 ± 0.04 (13.4–15.4)	45.69 ± 0.6 (29.00–73.04)	75	14.42 ± 0.07 (13.5–15.4)	44.85 ± 0.81 (33.52–68.38)	91	14.41 ± 0.05 (13.4–15.3)	46.31 ± 0.85 (29.00–73.04)
IV	94	15.46 ± 0.05 (14.5–16.0)	51.45 ± 0.6 (15.41–66.50)	30	15.38 ± 0.08 (14.5–16.4)	51.36 ± 1.05 (35.60–63.82)	64	15.51 ± 0.06 (14.5–16.6)	51.51 ± 0.76 (15.41–66.50)
V	38	17.19 ± 0.17 (16.5–18.2)	66.49 ± 2.53 (46,37–100,9)	10	17.03 ± 0.10 (16.7–17.6)	64.60 ± 3.61 (49.01–85.52)	28	17.05 ± 0.10 (16.5–18.2)	67.99 ± 2.57 (46.37–100.90)
VI	14	19.51 ± 0.30 (18.0–21.5)	100.92 ± 2.98 (84.36–120.9)	5	19.60 ± 0.20 (19.0–20.2)	99.21 ± 4.56 (84.36–110.00)	9	19.46 ± 0.47 (18.0–21.5)	101.86 ± 4.04 (86.83–120.9)
	431			159			272		

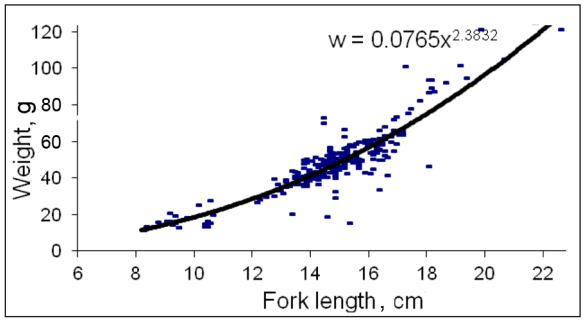

Fig. 2. Length–weight relationship of *L. cephalus* (female)

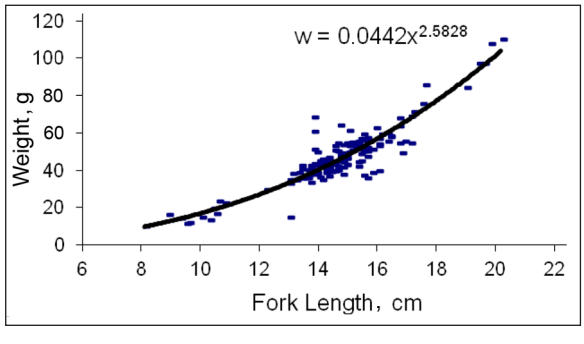

Fig. 3. Length-weight relationship of *L. cephalus* (male)

The equation of theoretical growth in length of the chub in the Çaparlıpatlak Pond is as follows: $L\infty = 23.66\ (1-e^{-0.301\ (t+0.953)})$. The seasonal variations in the condition coefficients were determined for both sexes (Fig. 5). In general, monthly conditions showed a similiar pattern for both sexes, showing higher in the spawning period, but lower after the spawning period and during the the winter period. Monthly changes in gonadosomatic index for all individuals are shown in Fig. 6. Spawning

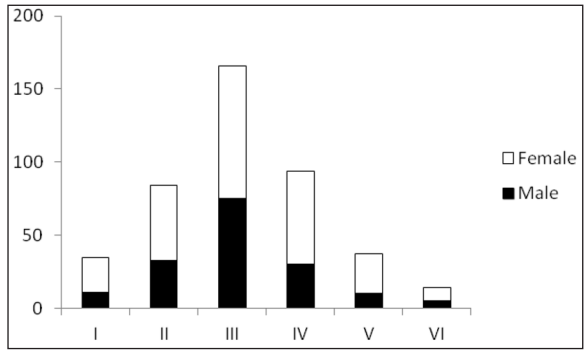

Fig. 4. Sex and age composition *of L. cephalus*

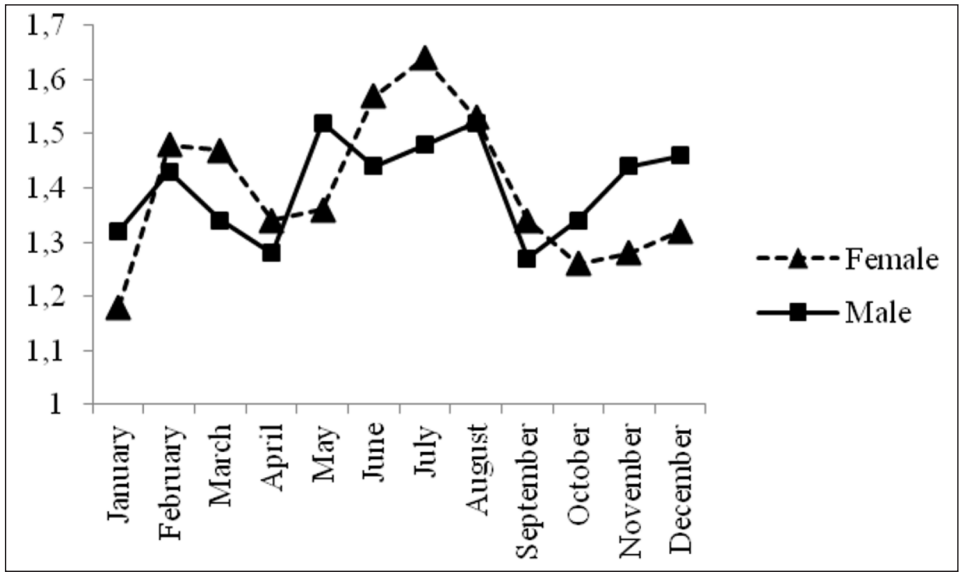

Fig. 5. Monthly variations in condition coefficient (CF) *of L. cephalus*

occurred between March and May, showing a peak in April. During spring (March–May) an obviously rapid growth of gonads occurred until next spawning.

A total of 431 chub individual was collected from Çaparlıpatlak Pond during the study period. In this study, among the specimens, female / male ratio was larger than 1, as confirmed by the relevant literature (Türkmen et al., 1999; Saşı and Balık, 2003; Kara and Solak, 2004; Koc et al., 2007; Bostancı and Polat, 2009). Nikolsky (1963) indicates different sexual dispersions of the same species in different populations. It is well known that the sex ratio in most species is close to one, but it may vary from species to species, differing from one population to another of the same species and may vary year to year in the same population. The age of the chub caught in Çaparlıpatlak Pond was between ages I and VI (Table 1). The fact that 60.55% of the specimens were in age III indicated that the population was

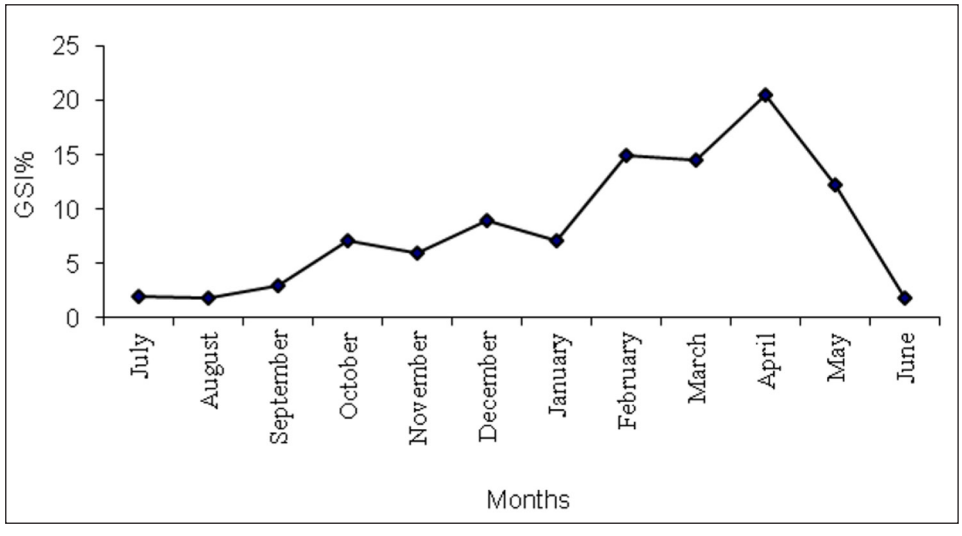

Fig. 6. Monthly variations in the GSI% of *L. cephalus*

Table 2. Age structure, parameters of the length–weight relationship (a, b), the growth (L_∞, K, t_0) and CF of *Leuciscus cephalus* in this study and previous studies (-indicates absence of data). * values belong to female; ** values belong to male

Investigators	Area	Age	Weight range	Length range	N	a	b	r^2	L¥	K	t_0	CF
Prokes et al., 78	Rokytna River	–	–	–	–	–1.873	3.20	–	–	–	–	–
Öztaş and Solak, 88	Müceldi Stream	6	9.1–324.0* 7.9–245.0**	8.5–26.8* 8.0–24.8**	588* 717**	–4.706* –4.958**	2.97* 3.04**	–	–	–	–	–
Şen, 88	Kalecik Lake	–	–	–	–	–4.440	3.02	–	–	–	–	–
Solak et al., 95	Kirmir Stream	7	15.0–379.0* 19.0–378.0**	9.8–30.9* 10.7–30.7**	192* 203**	–4.63* –4.71**	2.87* 3.01**	–	–	–	–	1.09–2.02* 1.12–2.01**
Altındağ, 96	Aksehir Lake	7	41.0–176.6* 52.0–557.0**	13.0–44.0* 15.0–31.0**	–	–1.980* –1.801**	3.135* 3.001 **	–	40.5* 32.3**	0.21* 0.40**	–1.36* –0.61**	1.60* 1.56**
Ekmekçi, 96	Sarıyar Dam Lake	10	94.0–924.0* 72.0–457.0**	18.3–37.3* 17.3–31.8**	234	–	–	–	–	–	–	1.04–1.88
Treer et al., 97	Crotia	–	–	–	–	–	–	–	31.8	0.28	0.04	–
Treer et al., 99	Lika River	5	–	–	24	0.027	2.67	0.990	–	–	–	0.99
Treer et al., 99	Kupa River	5	–	–	20	0.006	3.24	0.998	–	–	–	1.10
Treer et al., 99	Lonja River	5	–	–	13	0.017	2.88	0.998	–	–	–	1.21
Türkmen et al., 99	Aras River	8	3.0–302.5* 4.2–181.5**	6.3–27.5* 6.7–24.1**	558* 533**	0.009* 0.010**	3.14* 3.11**	0.98* 096**	36.7* 32.5**	0.11* 0.12**	–1.39* –1.63**	1.08–1.46* 1.25–1.52**
Unver and Tanyolaç, 99	Tödürge Lake	7	1.5–347.1	5.3–28.7* 5.4–23.3**	460* 214**	0.010* 0.012**	3.10* 3.04**	–	47.4* 54.5**	0.11* 0.08**	–0.38* –0.76**	0.81* 107**
Erdogan et al., 02	Karasu River	9	14.0–322.5* 17.0–176.3**	10.0–29.0* 10.8–24.0**	376* 383**	0.014* 0.015**	2.98* 2.95**	0.976* 0.951**	41.4* 35.9**	0.12* 0.12**	–1.32* –1.17**	1.35* 1.32**
Gül and Yılmaz, 02	Kızılırmak River	6	6.0–353.0	4.7–31.0	–	–	–	–	–	–	–	–
Şaşı and Balık, 03	Topçam Dam Lake	7	19.8–344.0* 16.2–203.1**	10.8–26.2* 9.7–23.5**	242* 90**	0.009* 0.023**	3.19* 2.85**	0.955* 0.947**	40.2* 27.1**	0.12* 0.30**	–1.58* –0.46**	1.41–1.91* 1.78–1.74**
Georgiev, 03	Vardar River	–	–	–	229	–	2.88	–	–	–	–	–

Table 2. Continued

Investigators	Area	Age	Weight range	Length range	N	a	b	r^2	L¥	K	t_0	CF
Koutrakis and Tsikliras, 03	Strymon Estuary (Greece)	–	–	–	627	–	3.856	–	–	–	–	–
Balık et al., 04	Işıklı Lake	5	44.6–247.0* 41.7–260.1**	13.5–23.1* 13.5–23.0**	215* 313**	0.014* 0.016**	3.08* 3.03**	0.949* 0.943**	28.6* 31.6**	0.17* 0.13**	–3.32* –3.84**	1.40–2.00* 1.57–2.14**
Kara and Solak, 04	Sır Dam Lake		20.51–2242* 26.18–1556**	11.6–51.3* 11.2–46.2**	234* 191**	0.0074* 0.0063	3.17* 3.21**	– –	74.0* 54.0*	0.17* 0.30**	–0.82* –0.49**	1.25–1.60* 1.18–1.51**
Kalkan et al., 05	Karakaya Dam Lake	6	123.8–721.5* 115.4–584.2**	17.0–36.2* 17.0–34.4**	49* 28**	0.013* 0.082 **	3.03* 2.49**	–	37.8* 35.5**	0.41* 0.60**	–1.00* –0.19**	1.42* 1.43**
Vlach et al., 05	Upon Stream	–	–	–	379	–	3.066	–	–	–	–	1.49
Koç et al., 2007	İkizcetepeler Dam Lake	6	18.6–243.6* 29.3–173.9**	11.1–24.8* 12.2–24.1**	172* 242**	0.0227* 0.0194**	2.87* 2.92**	0.90* 0.889**	26.71* 28.89**	0.26* 0.22**	–1.55* –1.55**	0.77–2.40* 1.30–2.03**
Kırankaya and Ekmekçi, 07	Gelingüllü Dam Lake	4	32–600	11.9–31.2	267	0.0248	2.8751	0.91	–	–	–	0.68–1.98
Bostancı and Polat, 09	Çamlıdere Dam lake	6	21.5–35.3* 20.0–31.2**	151.9–667.6* 124.4–462.6**	72* 29**	0.013* 0.014**	3.04* 3.01**	0.90* 0.93**	38.51* 34.12**	0.328* 0.371**	–1.67* –1.07**	1.38–1.99* 1.27–1.91**
Ünver and Kkekil-li, 2010	Hafik Lake	8	22.5–553.0	114–332	242	0.00002* 0.00002**	2.97* 2.97**	0.98* 0.97**	–	–	–	0.91–1.91
Innal, 2010	Çamkoru pond	10	11.3–38.4* 11–34.8**	18.2–845* 18.9–498**	188* 94**	0.0144	3.0126					

mostly made of young individuals, confirming the relevant study by Innal (2010). Age distributions in other investigations on this species are reported in Table 2. The majority of samples in the population were in the third age group. This situation was also reported for Kirmir Stream population (Solak et al., 1995), while most of the samples were in the second age group (Altindag, 1996), were in the third age group (Ekmekçi, 1996) and in the second and third age groups (Kalkan et al., 2005). It is reported that most of the samples were in the third age group for Topçam, Karakaya, Almus and İkizcetepeler Dam Lake populations (Saşı and Balık, 2003; Kalkan et al., 2005; Koc et al., 2007). These differences in the age distribution of the populations may be due to gill net selectivity, fishing activity, feeding habits and the ecological characteristics of the lakes and reservoirs (Nikolsky, 1963). While males were longer and heavier in the earlier life stages than females, but in later stages females were longer and heavier than males. This situation was similiar to that reported by Altındag (1996), but it was different from that reported by some investigators in *L. cephalus* from Sarıyer Dam Lake (Ekmekçi, 1996), Kirmir Stream (Solak et al., 1995), and Karakaya Dam Lake (Kalkan et al., 2005). L∞ and k values in Von Bertalanffy's growth equation can be used as indicators for making comparisons of growth (Sparre and Venema, 1992). A theoretical maximum length of 23.66 cm is realistic because the largest specimen sampled during the survey was 21.5 cm. The theoretical maximum length and k value are close to those estimated for Dobra River in Crotia (Treer et al., 1997), Topçam Dam Lake (Saşı and Balık, 2003), and Upor Stream (Czech Republic) (Vlach et al., 2005). In contrast, Lobón-Cerviá (1982) finds that computed infinite lengths are smaller than sizes attained by the population. In our case, this is not so. Weight-at-age estimates were more valuable as a measure of growth length estimates. 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 enviromental coditions such as temperature, organic matter, quality of food, data and time of capture, stomach fullness, disease, parasitic loads (Wooton, 1998) can also affect weight-at-age estimates. The condition coefficient changed according to months, age groups, and sexes (Türkmen et al., 1999; Bostanci and Polat, 2009; Altindag, 1996; Ekmekçi, 1996). In general, seasonal conditions showed a smiliar pattern in both sexes. Several investigators have reported similar patterns (Unver and Tanyolac, 1999; Erdogan et al., 2002). The slope (b) values of the length-weight relationships in female and male (b = 2.38, 2.58) showed that weight increased negative allometrically with length. Our values of b for Çaparlıpatlak Pond were found to be close to those estimated in Warta River, Karakaya Dam Lake and Apa Dam Lake by Przyby (1996), Kalkan et al. (2005), but was different from those found by Altındag (1996), Türkmen et al. (1999), Erdogan et al. (2002), Solak et al. (1995), Balık et al. (2004), Bostancı and Polat (2009). The values b are often 3.0 and generally between 2.5 and 3.5. The values b in fish differ according to species, sex, age, seasons (Ricker, 1975). In addition, changes in fish shape, physiological conditions, during life span, growth increment or break can all affect the growth exponent b (Froese, 2006). Spawning occurred between March and May, showing a peak in April in Çaparlıpatlak Pond population (Fig. 6). These are compared to the relevant studies (Table 3). In general, monthly conditions exhibited a similar pattern for both sexes, showing a peak before the spawning season, but indicating somewhat lower values after the spawning period and during winter (Fig. 6). Because the ecological and climatic conditions are different, the starting and finishing time of reproduction may include different months. As has been mentioned by a number of investigators, the spawning cycle is closely related to temperature. 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).

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

References	Months												Locality	Tem. (°C)
	J	F	M	A	M	J	J	A	S	O	N	D		
Hellawel (1971)					■	■							Afon Llynfi River	Low tem.
Penaz et al., (1978)					■	■	■						Jihlava River	
Erk'akan and Akgül (1986)					■	■	■	■	■				Kızılırmak River	
Poncin et al., (1987)					■	■							–	
Neophitou (1988)				■	■								Rentina River	
Şen (1988)				■	■	■	■						Kalecik Reservoir	
Öztaş (1989)					■	■							Müceldi Stream	12–28 °C
Unlü and Balcı (1993)					■	■							Savur Stream	15–23 °C
Ekmekci (1996)				■	■	■							Sarıyar Dam Lake	
Altındağ (1997)					■	■							Akşehir Lake	
Karatas (1997)					■	■							Tozanlı Stream	
Karataş and Akyurt, 1997					■	■	■						Almus Dam Lake	
Yerli et al., (1997)					■	■	■	■	■	■			Çıldır Lake	
Unver (1998)					■	■	■						Tödürge Lake	
Türkmen et al., (1999)					■	■	■						Aras River	16–23 °C
Yıldırım et al., (2001)					■	■							Oltu Stream	14–19 °C
Erdogan et al., (2002)					■	■							Karasu River	
Fredrich et al., 2003					■	■	■	■					Spree River	
Kalkan et al., (2005)					■	■							Karakaya Dam Lake	
Koc TH et al., 2007				▒	▒								İkizcetepeler Dam	16–18 °C
Lorenzoni et al., (2011)				▒	▒	▒	▒						Assino Creek	
Unver and Saraydın (2012)					▒	▒	▒						Tödürge Lake	
This study (2005)				▒	▒	▒	▒						Çaparlıpatlak Pond	7–27 °C

CONCLUSION

The discharge of wastewater and sewage from the Bigadiē Boron Works, reorganized as one of the subsidiaries of the Eti Mine Works in 2008, time to time into Çaparlıpatlak Pond has caused irreversible damage to all life forms in the pond (Etimaden, 2014; Görmez, 1997). Therefore, necessary precautions and studies such as remediating wastewater to be discharded and the scheduling of the fishing seasons should be taken.

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EUROPINIO ŠAPALO (*LEUCISCUS CEPHALUS*) BIOLOGINIŲ SAVYBIŲ STEBĖJIMAS IR APLINKOS SĄLYGŲ ĮTAKA ÇAPARLIPATLAK TVENKINYJE (BALIKESYRAS, PIETŲ MARMARIO REGIONAS, TURKIJA)

Santrauka

Tyrimas atliktas su 431 Çaparlıpatlak tvenkinio individu, kurių amžius svyravo nuo I iki VI. Populiacijoje dominuojanti buvo IV amžiaus grupė. Patinėlių aptikta 36,60 %, patelių – 63,40 % (santykis 1:1.71). Patelės stambesnės nei patinėliai. Didžiausia pagauta patelė – 21,5 cm FL, didžiausias patinėlis – 20,2 cm FL (abu priklausė VI amžiaus grupei). Ilgio ir svorio santykis siekė $W = 0{,}0648 \cdot L^{2{,}44}$ (W – masė g, FL – ilgis mm). Nustatytas Von Bertalanffy augimo lygis buvo $L\infty = 23{,}66$ cm; $K = 0{,}30\ yr^{-1}$; $to = -0{,}95$ yr. Makroskopinis lytinių liaukų tyrimas ir gonadosomatinio indekso analizė parodė, kad šapalai neršia pavasarį bei ankstyvą vasarą – balandžio ir liepos mėn., kai vandens temperatūra yra aukšta.

Raktažodžiai: *Leuciscus cephalus*, amžius, augimas, būklė, nerštas