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Research Article

An Investigation on the Reproduction Properties of Chub (*Leuciscus cephalus* L., 1758) in Lake Tödürge (Zara/Sivas)*

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Abstract: In this study, the reproductive properties of the chub population (*Leuciscus cephalus* L., 1758) in lake Tödürge, Zara/Sivas, were investigated. A total of 674 specimens were caught between April and November 1994. The age and sex distributions and the age of sexual maturity were determined. The reproduction period of the population was determined. Fecundity was determined and the relationships between the fecundity and body weight, length and age were investigated.

The age composition of specimens of the population consisting of 68.25% female and 31.75% male, was found to be between I and VII. Males reached maturity in their second or third year of life, whereas females matured in their third or fourth year of life. The reproduction period of the chub population in lake Tödürge was determined to be between May and July. The mean diameter of eggs and fecundity were found as 0.65 mm and 14.500, respectively.

Key Words: Chub, *Leuciscus cephalus*, Reproduction, Lake Tödürge

Tödürge Gölündeki (Zara/Sivas) Tatlısu Kefali (*Leuciscus cephalus* L., 1758)'nin Üreme Özellikleri

Özet: Bu çalışmada Tödürge Gölünde (Zara/Sivas) yaşayan tatlısu kefali (*Leucisus cephalus* L., 1758) populasyonunun üreme özellikleri incelenmiştir. Nisan-Kasım 1994 tarihleri arasında toplam 674 adet örnek yakalanmış, yaş ve eşey dağılımı, eşeysel olgunluğa erişme yaşları bulunmuş, populasyonun üreme zamanı saptanmıştır. Ayrıca, yumurta sayısı (fekondite) belirlenmiş ve yumurta sayısının vücut ağırlığı, boy ve yaşa göre değişimleri incelenmiştir.

%68.25'ini dişi, %31.75'ini erkek bireylerin oluşturduğu populasyon örneklerinin yaş dağılımı I-VII arasında bulunmuştur. Erkeklerin II-III, dişilerin III-IV yaşlarında eşeysel olgunluğa eriştikleri saptanmıştır. Tödürge Gölü tatlısu kefali populasyonunun üreme periyodunun Mayıs-Temmuz ayları arasında olduğu belirlenmiştir. Ortalama yumurta çapı 0.65 mm ve yumurta sayısı 14.500 olarak bulunmuştur.

Anahtar Sözcükler: Tatlısu Kefali, *Leuciscus cephalus,* Üreme, Tödürge Gölü.

Introduction

Unfortunately, biological data regarding growth parameters and reproduction properties of economically important species which live in freshwater bodies or lakes in Turkey have not been obtained. Because of this, researchers need to study the same or different species from different areas. Lake Tödürge has fish that provide a great proportion of the protein needed for the region (1). There is only one study, by Erdem (2), on the fish of Lake Tödürge.

Chub (*Leuciscus cephalus* L., 1758) are widely distributed in Europe, Anatolia, Caucasia, basins of the Black Sea, Caspian Sea and Azov Sea (3). *L. cephalus* is abundant in Lake Tödürge. Many investigations have been made to determine the various biological properties of chub (4-15).

This study has been carried out to investigate some reproductive properties such as age of sexual maturity, reproductive period and fecundity of the population of chub in Lake Tödürge.

General features of study area

Lake Tödürge, which is of karstic origin (16), is approximately fifty-six km. from Sivas (Figure 1). The lake is located north of the E-23 highway (39°53'N, 37°36'E).

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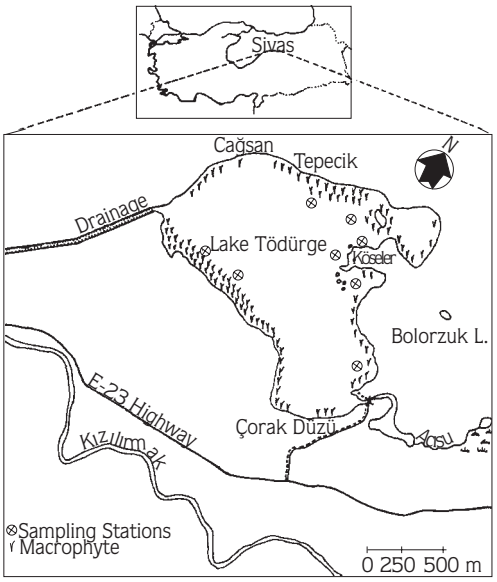

Figure 1. Lake Tödürge and Sampling Stations (1/25000).

The lake has a surface area of 350 hectares and is at an altitude of 1,295 meters. It is roughly triangular in shape. The maximum depth of the lake is 30 meters. A great proportion of lake water is supplied by underground water which percolates through karstic rocks. The outlet of the lake to the west discharges lake water into the Kızılırmak by means of a drainage canal around Yarhisar village. The lake is surrounded by flat and wide grasslands, arid regions and fields. The most widespread species of macrophyte in the lake are *Phragmites* sp. and *Thypa* sp..

In addition to chub, many other species live in the lake including: *Cyprinus carpio, Capoeta capoeta, Capoeta tinca, Chalcalburnus chalcoides, Chondrostoma nasus* and *Orthrias angorae, Silurus glanis* (1). Fishing has been carrying out by cooperatives.

Materials and Methods

A total of 674 specimens were obtained from weekly collections during the prereproductive and reproductive periods (April-July) and monthly collections during the rest of the year. Many gillnets of various mesh sizes (15x15, 18x18, 20x20, 24x24 and 32x32 mm) were used to collect fish between April 1994 and November 1994. After being caught, the fish samples were transported to the laboratory where their size (fork length; mm, referred to as L in the text) and weight (g) were measured and weighed to the nearest 1.0 mm and 0.1 g, respectively. Age determination was carried out according to the method of Lagler (17).

Sex (immature, male, female) was determined by macroscopic observation of the gonads. The overall sex ratio and stages of sexual maturity were also determined. The gonads were removed and weighed to the nearest 0.1 gram.

The spawning period was determined by means of the monthly changes in the gonadosomatic index (GSI), ovarium weight, egg diameter and egg number in per gram ovarium. A total of 234 specimens belonging to different age and length groups were used to determine the ranges of percentage of individuals which had laid and which had not which were caught between April and August. The gonadosomatic index was calculated using the following equation:

$$GSI = \frac{wo}{W_t} \times 100; \quad (1)$$

where wo is gonad weight and Wt is body weight (18).

Egg diameter was measured under a binocular stereo microscope using an eye piece graticule.

Fecundity was estimated by the gravimetric method. Randomly chosen specimens from each age group of different lengths, caught during the spawning period were used to determine fecundity. The relationships between egg number and body weight, length and age were calculated by the least-squares method.

The increment of percentage of the mean number of eggs (nm) according to the age groups (1, 2, 3...) was calculated using following equation.

$$\%I.P. = \frac{nm_2 - nm_1}{nm_1} \times 100 \quad (2)$$

Table 1. The states of sexual maturity according to age groups of specimens of *L. cephalus* (%)

Age Groups		I	II	III	IV	V	VI	VII
Immature	(female)	100	83.3	16.6	8.1	6.6	-	-
Mature	(female)	-	16.7	83.4	91.9	93.4	100	100
Immature	(male)	86.4	23.7	14.3	14.2	-	-	-
Mature	(male)	13.6	76.3	85.7	85.8	100	-	-

Results

Age and Sex Composition

Studies have shown that the age composition of the fish samples, caught in Lake Tödürge were found to be between I and VII. The specimens of the population were 68.25% (460) female and 31.75% (214) male. Maximum ages observed were VI in males and VII in females. In age group IV females were dominant and in age group II males were dominant. The sex distribution frequency shows a marked deviation from the 1:1 expected sex ratio. There were more females than males; the observed sex ratio was 1 female: 0.47 male in the specimens of the population. When the monthly distribution of caught individuals was investigated, it was seen that, most samples were obtained in August whereas the fewest samples were obtained in November.

The Age of Sexual Maturity

The age of sexual maturity of specimens, 138 females and 91 males, caught in Lake Tödürge in April, May and June, was determined by directly observing the gonads and the results are shown in Table 1.

According to these values, none of the females in age class I had matured, whereas 13.6% of males in age class I had attained sexual maturity. In age group IV 91.9% of females and 85.8% of males had reached sexual maturity.

According to these values, it was determined that males reached maturity between their first and fourth year of life, whereas females matured between their second and fifth year of life. The smallest mature female was 74 mm and the smallest male was 67 mm.

Reproduction Period

Gonadosomatic Index (GSI)

GSI, used to determine the reproduction period, was calculated using equation 1 and the mean monthly GSI values of the males and females are shown in Table 2.

The maximum values for both males and females in May were calculated to be 5.2 and 9.1, respectively. In the males, the minimum value was in August (0.4) whereas in the females it was in July (1.2). After August the gonads began to develop and the values of GSI again started to increase gradually until November.

Egg Diameter and Ovarium Weight

The values of the egg diameter, ovarium weight and egg number per gram ovarium and also the monthly changes of these values are shown in Table 3.

Table 2. The monthly changes in the values of gonadosomatic index (GSI) SD:Standard deviation

	Female			Male		
Months	N	(GSI(min.-max.)	SD	N	GSI(min.-max.)	SD
		8.2			4.3	
April	43	(0.9-11.3)	4.7	28	(0.4-7.2)	3.3
		9.1			5.2	
May	39	(1.6-12.8)	3.9	31	(0.4-8.6)	4.0
		1.9			1.0	
June	56	(0.7-7.2)	4.2	32	(0.6-1.9)	0.6
		1.2			0.6	
July	63	(0.4-2.6)	1.8	31	(0.4-0.7)	0.3
		1.6			0.4	
August	97	(0.6-3.4)	1.2	33	(0.2-0.7)	0.2
		3.4			0.9	
September	69	(1.3-5.3)	0.9	35	(0.6-1.3)	1.2
		5.6			2.0	
October	60	(1.5-9.4)	2.2	16	(1.2-2.8)	0.7
		6.4			3.3	
November	33	(4.4-9.7)	1.3	8	(2.5-4.2)	1.5

As shown in Table 3, the mean ovarium weight was at its maximum in May (10.8) and at its minimum in July (2.0). In May, when the mean egg diameter was at its maximum, the mean value of egg number per gram ovarium was found to be at its minimum. In addition, according to the macroscopic observation of the gonads, the specimens of *L. cephalus* commenced laying in May and in July 98% of the investigated individuals had laid (Table 4).

According to the monthly changes in the values of the gonadosomatic index, egg diameter, ovarium weight and egg number per gram ovarium of the specimens in Lake Tödürge, the spawning period was determined to be between May and July inclusively.

Fecundity

The fecundity and the increments of percentage of its value to the age groups, calculated using equation 2, are shown in Table 5. As shown in Table 5, the mean fecundity was found to be 1158 in age group II and 28664 in age group VII. The values of the proportional increments in percentage of fecundity were high at early ages whereas these values decreased gradually with age.

To determine the relationships between fecundity and age, length and weight, the graphs of fecundity-age, fecundity-length, fecundity-weight were drawn and are shown in Figure 2, 3 and 4, respectively. In all the graphs positive correlations were found.

There was a linear increase between fecundity and age; n=-10014 + 5455.1 x age; r^2=0.993 (Figure 2). The correlation coefficient was very high.

As shown in Figures 3 and 4 there was also a linear increase both between fecundity and length; n=-17782+173.85 x L;r^2=0.958; and between fecundity and weight; n=1588.6+120.53 x W;r^2=0.959.

Discussion and Conclusion

In a population, if the age composition has a wide range, it indicates that this region has a sufficient food supply for the fish population. Because of the age distribution in Lake Tödürge is very high (I-VII), it can be said that the lake has a high breeding capacity. The age composition of the chub was determined by different researchers such as Geldiay and Balık (5) 0-VI, Erk'akan (6) I-V and Ekmekçi (9) I-X. The difference seen between the age distribution values may be related to the kind of nets or mesh-size of the nets or may be explained as an adaptative response to the different ecological conditions of the study areas.

Table 3. The monthly changes of the gonadal values (OW:ovarium weight, n:egg number in per gram ovarium, d:egg diameter, SD:standard deviation)

		OW(g)		d (mm)		n	
Months	N	(min.-max.)	SD	(min.-max.)	SD	(min.-max.)	SD
		8.7		0.76		1652	
April	43	(0.7-9.6)	1.1	(0.74-0.85)	0.7	(1423-1813)	40.3
		10.8		1.04		1132	
May	39	(1.5-11.6)	0.9	(0.86-1.68)	1.0	(1010-1270)	23.6
		2.7		0.57		2053	
June	56	(0.6-3.3)	1.7	(0.52-0.61)	0.3	(1891-2196)	36.0
		2.0		0.46		2471	
July	63	(1.0-2.9)	0.8	(0.35-0.57)	0.7	(2307-2544)	47.2
		2.6		0.53		2112	
August	97	(1.8-3.4)	2.2	(0.46-0.69)	0.4	(1947-2213)	19.8
		3.7		0.62		1748	
September	69	(2.6-4.7)	1.6	(0.55-0.64)	0.2	(1684-1805)	53.4
		3.5		0.56		1970	
October	60	(0.8-4.2)	2.0	(0.53-0.59)	0.2	(1843-2024)	31.5
		4.3		0.66		1650	
November	33	(1.4-5.7)	1.3	(0.62-0.85)	0.3	(1477-1781)	30.5

Table 4. The ranges of percentage of individuals which had laid and which had not between April-August

Months	N	İndividuals which had not laid	İndividuals which had laid
April	31	100.0	-
May	25	72.0	28.0
June	46	10.9	89.1
July	49	2.0	98.0
August	83	-	100.0

It was determined, in Lake Tödürge's *L. cephalus* population, the females reached maturity between their second and fifth year of life and the males between their first and fourth (Table 1). According to Slastenenko (11) the sexual maturity age in the chub population of the Black Sea basin is III. The maturity age of chub was found to be III in the females and II in the males by Erk'akan and Akgül (7), however it was determined to be IV in the females and III in the males by Ekmekçi (9). According to Nikolskii (19), the age of sexual maturity can change in relation to water temperature, breeding, growth rate and population density. In addition, because the growth rate in males is higher than in females at early ages, it causes the maturation to start earlier (one or two years) in males than in females.

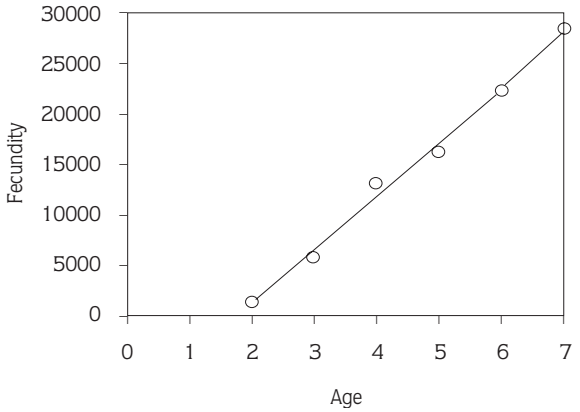

Figure 2. The relationship between fecundity and age.

When the monthly changes of the gonadosomatic index values were examined (Table 2), it could be seen that the highest values was attained by both males (5.2) and females (9.1) in May. According to the gonadosomatic index values of the males and females in July, it may be said that spawning finished in this month.

The highest mean egg diameter was found in May (1.04 mm) and the lowest value was found in July (0.46 mm) (Tablo 3). Egg diameters were determined by Erk'akan and Akgül (7) to be 0.78-1.20 mm, by Öztaş (15) to be 0.55-1.38 mm, by Ekmekçi (9) to be 1.03 mm, and by Ünlü and Balcı (14) to be 0.83-1.50 mm.

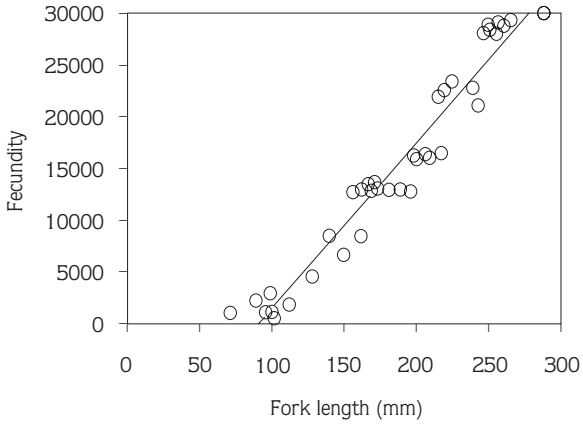

Figure 3. The relationship between fecundity and length.

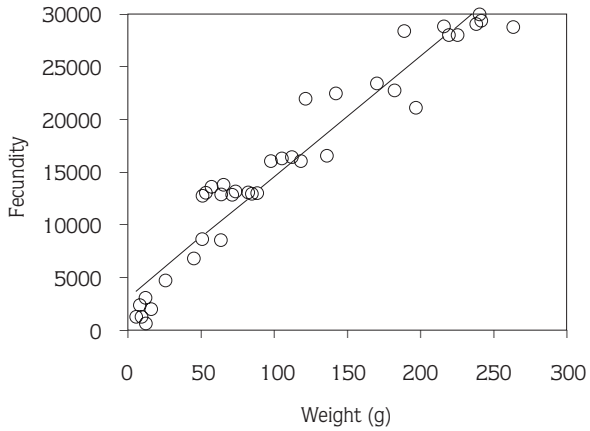

Figure 4. The relationship between fecundity and weight.

Age	N	Fork length (mm)	Weight (g)	nm	(% I.P.)
II	7	95.6	11.44	1158	
III	4	153.1	47.05	5624	385.7
IV	11	175.9	71.15	13113	133.2
V	5	206.0	114.60	16278	24.1
VI	6	226.2	159.90	22368	37.4
VII	8	258.5	240.30	28664	28.1

Table 5. The mean number of eggs (nm) and the increments of percentage of this value (% I.P.)

The period when the mean egg diameter is highest indicates that laying has started and in this period the mean egg number per gram ovarium is the lowest. In this study, these values varied between 1132.2 and 2471.1. In May when the egg diameter was the highest, the egg number per gram ovarium was found to be the lowest (Table 3).

At the end of the observation of gonads, it was determined that the fish had laid from May to the end of June. It was observed that the gonads of all the individuals in July were empty. Herzig and Winkler reported that the spawning period for chub is between April and May and if the altitude is more than 1000 meters, then spawning occurs in June (9).

At the end of the gonadal investigations, it may be said that the reproduction period of chub in Lake Tödürge was between May and July inclusively. This period has been determined to be, by Erk'akan and Akgül (7) between May and September, Ekmekçi (9) between April and June and Ünlü and Balcı (14) between May and June. Because the ecological and climatical conditions were different, the starting and finishing time of the reproduction period may include different months.

In this study, the mean egg number varied between 1158 and 28664. This value was determined by Erk'akan and Akgül (7), Öztaş (15), Ekmekçi (9) and Ünlü and Balcı (14) to be 1909-15680, 1960-61808, 13269-59200 and 2050-20140, respectively. It has been reported that fecundity can change in relation to fish age, length and weight (19) and especially, temperature, which is the most important ecological factor affecting the egg number (20). A linear increase was found between fecundity and age. However a logarithmical increase was found between fecundity and length and weight. As we known the older individuals are more productive than the younger (19).

According to the results, it may be proposed that fishing must be forbidden between March and July to ensure maximum productivity from *L. cephalus* population in Lake Tödürge. While the prohibition of fishing has been decided, climatical factors and also water temperature must be taken into consideration. In addition, until the limit of the smallest prey size allowed for commercial fishing is determined, it may be suggested that, the fourth age group must be used, in which mean length (176 mm-fork length) and weight (72 g) values result in the number of individuals that have reached maturity being at its maximum. This will be more economic for both the population and prey production.

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References

1. Tanyolaç, J., Erdem, Ü., Akpınar, M.A., Bardakçı, F., Sivas İli İçsularında yaşayan ekonomik balık türlerinin incelenmesi. XII. Ulusal Biyo. Kong., Edirne, 1994.
2. Erdem, Ü., Tödürge Gölü'ndeki sazan (Cyprinus carpio L., 1758) populasyonunun bazı biyolojik özelliklerinin incelenmesi. Doğa TU Zoooloji D. 12:1,32-47, 1988.
3. Geldiay, R., Balık, S., Türkiye Tatlısu Balıkları. Ege Üni., Fen Fak. No:97, 1988.
4. Tanyolaç, J., Some aspects of local populations of freshwater fishes in the surroundings of Ankara. Communications, 3:13, 65-100, 1968.
5. Geldiay, R., Balık, S., Pınarbaşı Kaynak Suları'nda yaşayan tatlısu kefalinin biyolojisi üzerine araştırmalar. E.Ü. Fen Fak. İlmi Raporlar Serisi, Rapor no: 139, 1997.
6. Erk'akan, F., Sakarya Havzası balıklarının (Pisces) sistematiği ve biyo-ekolojik ilişkileri üzerine araştırmalar. Doktora Tezi H.Ü. Beytepe, Ankara, 1981.
7. Erk'akan, F., Akgül, M., Kızılırmak Havzası ekonomik balık stoklarının incelenmesi. TÜBİTAK Proje No:VHAG-584, Ankara, 1985.
8. Öztaş, H., Solak, K., Müceldi Suyu (Doğu Anadolu)'nda yaşayan tatlısu kefalinin büyüme özellikleri ve eşem oranları. Doğu TU Zooloji D. 12:3, 262-271, 1988.
9. Ekmekçi, F.G., Sarıyar Baraj Gölü'ndeki ekonomik öneme sahip balık stoklarının incelenmesi. Doktora Tezi H.Ü. Fen Bil. Enst. Beytepe, Ankara, 1989.
10. Berg, L.S., Freshwater Fishes of The U.S.S.R. and adjacent countries. Academy of Sciences of the U.S.S.R. 2, 1949.
11. Slastenenko, E., Karadeniz Havzası Balıkları. Et ve Balık Kur. Yayını, 1956.
12. Libosvarsky, J., Gonad weight and egg numbers in chub (Leuciscus cephalus L., 1758) from the Rokytna Stream. Folia Zoologica 28:35-42, 1979.

13. Hickley, P., and Bailey, R.G., Observation on the growth and production of chub, L. cephalus and dace, L. leuciscus in a small lowland river in Southeast England. Freshwater Biology 12, 167-178, 1982.

14. Ünlü, E., Balcı, K., Savur Çayı'ndaki L. cephalus orientalis (Nordm., 1840)'in üreme özellikleri üzerine bir araştırma. Doğa-Tr. J. of Zoology 17, 91-102, 1993.

15. Öztaş, H., Müceldi Suyu (Doğu Anadolu)'nda yaşayan tatlısu kefali (Leuciscus cephalus L., 1758)'nin üreme özellikleri. Doğa -TUJ. Vet. Animal Sci. 13:2, 171-179, 1989.

16. Tanyolaç, J., Limnoloji. Hatipoğlu Yay. No:67, 263, 1993.

17. Lagler, E.D., Freshwater Fishery Biology. W.M.C. Brown Company. p. 317, 1967.

18. Le-Cren, E.D., The length-weight relationship and seasonal cycle in gonad weight and condition in the perch. J. Anim. Ecol. 20:2, 201-219 (abst. from Lagler, E.D., 1967), 1951.

19. Nikolsky, G.V., The Ecology of Fishes. Academic Press, London, p. 352, 1963.

20. Bardakçı, F., Cyprinion macrostomus Heckel, 1843'ün bazı biyolojik özellikleri üzerine sıcaklığın etkisi. Yüksek Lisans Tezi C.Ü. Fen Bil. Enst., Sivas, 1989.