

The Reproduction Biology of Chub (*Leuciscus cephalus* L. 1758) in Topçam Dam Lake (Aydın, Turkey)

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Abstract: In this study, the reproduction biology of 332 chub (*Leuciscus cephalus* L. 1758) was studied from June, 1999, to June, 2000, on a monthly basis in Topçam Dam Lake. Egg numbers were estimated in 65 females caught just prior to spawning. The sex and age compositions of chub were determined. The specimens were composed of 27.11% males and 72.89% females. Male and female chub become sexually mature in the second year of their life spans. Spawning is in March and April. The fecundity of chub varies from 2100-66,400 per female. The average egg diameter was between 0.391 and 0.744 mm in various age groups.

Key Words: *Leuciscus cephalus*, reproduction, sex ratio, Topçam Dam Lake

Topçam Baraj Gölü'ndeki (Aydın, Türkiye) Tatlısu Kefalinin (*Leuciscus cephalus* L. 1758) Üreme Biyolojisi

Özet: Bu çalışmada, Topçam Baraj Gölü'nden Haziran 1999 ve Haziran 2000 arasında her ay yakalanan 332 tatlısu kefalinin (*Leuciscus cephalus* L. 1758) üreme biyolojisi çalışılmıştır. Yumurta sayısının tahmininde üreme döneminde yakalanan 65 dişiden yararlanılmıştır. Araştırmada balıkların yaş ve cinsiyet kompozisyonu tespit edilmiştir. İncelenen örneklerin % 27,11'ini erkek, % 72,89'unu ise dişi bireyler oluşturmuştur. Bu türe ait erkek ve dişi balıklar 2. yaşta cinsi olgunluğa ulaşmışlardır. Tatlısu kefalisi Mart – Nisan aylarında üremektedirler. Yumurta verimi 2100-66,400 adet/dişi tespit edilmiştir. Ortalama yumurta çapı ise 0,391-0,744 mm arasında değişim göstermiştir.

Anahtar Sözcükler: *Leuciscus cephalus*, üreme, eşey oranları, Topçam Baraj Gölü

Introduction

Chub (*Leuciscus cephalus* L. 1758) are members of the family Cyprinidae, and are common and widely distributed throughout European waters, the Black Sea Basin, the Caspian Sea Basin, the Azov Sea Basin and most Turkish waters (1-3). The age, the growth characteristics of the different species and subspecies of the genus *Leuciscus* inhabiting European and Turkish inland waters vary. There is some information on their reproduction and fecundity in natural habitats (4-9).

The present study was therefore carried out to investigate the reproduction of the *L. cephalus* population in Topçam Dam Lake, in the south-western Anatolia region of Turkey.

Topçam Dam Lake, which is fed by Madran Stream and precipitation, was constructed in 1984 for irrigation and flood prevention. The dam lake is located in the

Büyük Menderes River Basin, in south-western Turkey. The water level decreases in the late spring and summer every year because of irrigation. When the rainfall begins in winter, the water level increases again.

The lake is 49.5 m deep, and the region has a warm climate. During the study water temperatures varied from 7.42 to 28.90 °C. Turbidity was between 65 and 300 cm, pH was 7.20-7.98, dissolved oxygen levels were 5.00-10.54 mg/l, and conductivity levels were 118.10-151.50 µmhos/cm.

Ecological factors affect the biological and reproduction characteristics of fish populations, and so these kinds of investigations should be carried out periodically. The main purpose of the present investigation was to study reproduction biology in *L. cephalus*. This is the first such study of *L. cephalus* in Topçam Dam Lake.

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Materials and Methods

The study was carried out on the reproduction of the *L. cephalus* population in Topçam Dam Lake of south-western Anatolia. The study area is shown in Figure 1.

Specimens were caught monthly with gill-nets of various mesh sizes (18, 22, 25, 28, 35 and 55 mm) between June, 1999, and June, 2000. The caught fish were transported to the laboratory in a 4% formalin solution (10). After the fish samples were brought to the laboratory, the fork length (FL \pm 0.1 mm), weight, and gonad weight (W \pm 0.1 g) were recorded. Sex was determined by examination of the gonad tissue, either by eye in bigger fish or with the aid of a microscope in smaller fish (10). Scales were used for age determination. For this purpose, 10 or 12 scales were taken from between the dorsal fin and lateral line region of the side of the body and examined under a binocular microscope. Scales were kept in 4% NaOH solution for 16 h and then were washed in distilled water and treated with 70% and 96% ethyl alcohol (10,11). After cleaning, the scales were examined under a stereomicroscope for age determination.

The spawning period was estimated from gonad development, direct observation of the gonads and monthly variations in egg diameters of the samples (12). Gonado-somatic index (GSI) was calculated from the equation

$GSI \% = (Wg/Wt).100$; where Wg and Wt are gonad weight and total weight in grams of fish, respectively (12,13).

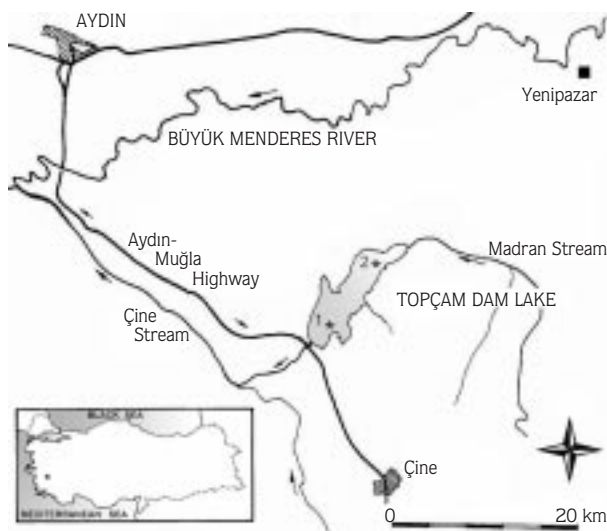


Figure 1. Study area.

Fecundity was studied by the gravimetric method (13). The procedure was as follows: sub-samples of 1 or 2 g according to the size of the eggs were taken from the front, middle and back parts of the ovaries. The number in the sub-samples was multiplied up to the weight of the ovary. The diameters of various size eggs from different parts of the ovary were measured with an object micrometer between January and April. Sexual maturity was confirmed by noting macroscopically the presence of “yolked eggs” or sperm in the gonads (10,14). Fecundity (F)-fork length (FL), fecundity-body weight (W), fecundity-gonad weight (Gw) and fecundity-age (Xt) were calculated with regression analyses. Fecundity (F) was calculated from the equations (15)

$$\log F = \log a + b \log FL \quad \text{or} \quad F = a.FL^b$$

$$\log F = \log a + b \log W \quad \text{or} \quad F = a.W^b$$

$$\log F = \log a + b \log Gw \quad \text{or} \quad F = a.Gw^b$$

$$\log F = \log a + b \log Xt \quad \text{or} \quad F = a.Xt^b$$

Results

The sex and age composition

The age and sex distribution of specimens caught during this study is given Table 1. Females were more numerous than males in all age groups. This suggests that males mature earlier than females and expend more energy and time than do females during the spawning period.

The ages of the captured fish ranged from I to VII years and the 3rd group was dominant in the population. The fish population was 72.89% female and 27.11% male.

Age at sexual maturity

The females and males first attained sexual maturity in their second years. The age of attaining sexual maturity was determined by observing the point at which 50% in the age of groups was exceeded. The ages of these specimens were determined and are summarised in Table 2. 65.52% of females and 73.33% of males attained sexual maturity in their second year. At first sexual maturity the minimum length (FL) and weight (W) were calculated as 14.40 cm and 41.60 g and 14.50 cm and 54.40 g for females and males, respectively.

Table 1. The age and sex composition of *L. cephalus* in Topçam Dam Lake, (N = Number of fish).

| Age | Female | | Male | | Female + Male | |
|-------|--------|-------|------|-------|---------------|--------|
| | N | %N | N | %N | N | %N |
| I | 3 | 0.90 | 2 | 0.60 | 5 | 1.50 |
| II | 29 | 8.74 | 15 | 4.52 | 44 | 13.26 |
| III | 121 | 36.45 | 57 | 17.17 | 178 | 53.62 |
| IV | 68 | 20.48 | 13 | 3.92 | 81 | 24.40 |
| V | 16 | 4.82 | 3 | 0.90 | 19 | 5.72 |
| VI | 3 | 0.90 | - | - | 3 | 0.90 |
| VII | 2 | 0.60 | - | - | 2 | 0.60 |
| Total | 242 | 72.89 | 90 | 27.11 | 332 | 100.00 |

Table 2. The percentage of immature and mature individuals in age groups I-VII of chub (*L. cephalus*) in Topçam Dam Lake. (N = Number of fish).

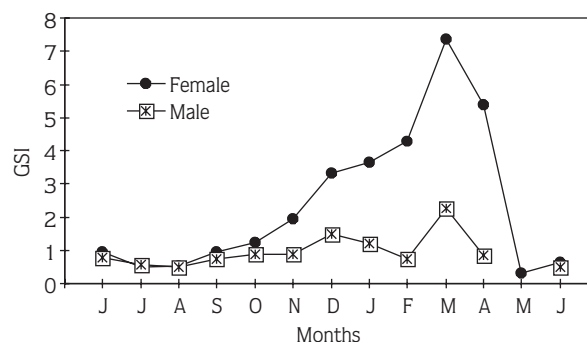
| Age | N | Female | | N | Male | |
|-----|-----|--------------|------------|----|--------------|------------|
| | | Immature (%) | Mature (%) | | Immature (%) | Mature (%) |
| I | 3 | 100.00 | - | 2 | 100.00 | - |
| II | 29 | 34.48 | 65.52 | 15 | 26.67 | 73.33 |
| III | 121 | 5.79 | 94.21 | 57 | 8.77 | 91.23 |
| IV | 68 | - | 100.00 | 13 | - | 100.00 |
| V | 16 | - | 100.00 | 3 | - | 100.00 |
| VI | 3 | - | 100.00 | | | |
| VII | 2 | - | 100.00 | | | |

Spawning

Assessment of the spawning time of *L. cephalus* in Topçam Dam Lake was based on the GSI and analysis of seasonal development in mean egg diameter (Figure 2).

Ovary development began in December. According to the averages, the highest GSI values were determined in the March samples of both females (7.37%) and males (2.29%). There was a decrease in the mean GSI values in May, when spawning was almost finished and the highest water temperature was recorded at 23.2 °C. Spawning occurred between March and April when the water temperature was between 13.5 and 20.6 °C.

We observed oocytes in ovaries in all seasons. Egg diameters are given in Table 3. The mean egg diameter was highest in April (0.707 mm), while the lowest was measured in December (0.379 mm). The maximum egg

Figure 2. Monthly variations in the GSI of *L. cephalus*.

diameters in March and April were 1.350 and 1.275 mm, respectively. Egg diameters increased as fish length, weight and age increased, and larger fish had larger eggs.

Spawning took place between March and April. We observed that all eggs were spawned in May.

Table 3. The average egg diameters (Y) (mm) in chub (*L. cephalus*) during the year (N = Number of eggs).

| Month | N | Min. | Max. | Y ± SD |
|---------------|-----|-------|-------|---------------|
| December 1999 | 151 | 0.100 | 0.755 | 0.379 ± 0.152 |
| January 2000 | 669 | 0.080 | 1.225 | 0.451 ± 0.208 |
| February 2000 | 84 | 0.160 | 1.250 | 0.598 ± 0.258 |
| March 2000 | 466 | 0.100 | 1.350 | 0.682 ± 0.262 |
| April 2000 | 98 | 0.230 | 1.275 | 0.707 ± 0.254 |

Fecundity

Fecundity was estimated in 65 females caught just prior to spawning. The number of eggs ranged from 7595 (April) to 23,434 (January). Fish had different egg sizes. Fecundity was highest in populations with the smallest eggs. Female *L. cephalus* maturing at age II produced a mean of 9142 eggs each. At age VII, fecundity rose to a mean of 53,100 per female.

In the spawning period, the fecundity of female chub was determined according to their age groups as shown in Table 4.

As shown in Table 4, egg production increased with age. Fecundity was determined as 9142, 10,959, 27,197, 41,333, 23,850, and 53,100 in the ages II-VII, respectively. Fecundity was correlated with fish length and weight, and fecundity and egg diameter increased as fish length, weight, gonad weight and age increased (Table 4).

The growth curve of egg diameter related to fecundity in various parts of the ovaries is given in Figure 3.

There were significant correlations between fish length (FL), fish weight (WT), gonad weight (Gw), age (Xt) and fecundity (F) (Figures 4-7). These relationships were:

$$F = 0.1279 FL^{4.0526} \quad (r = 0.766)$$

$$F = 52.907 WT^{1.2558} \quad (r = 0.794)$$

$$F = 4829.1 Gw^{0.9301} \quad (r = 0.973)$$

$$F = 3334.5 Xt^{1.3548} \quad (r = 0.896)$$

Discussion

In this study, a total of 332 specimens of *L. cephalus* in Topçam Dam Lake were examined from June, 1999, to June, 2000. The ages of the captured fish ranged between I and VII. The group was 72.89% female and 27.11% male.

Some information is available in the literature regarding the reproduction biology of *L. cephalus* from different habitats (9,16-20).

The first spawning age for females and males was determined as 2 years old, and this situation was similar to that reported in Akşehir Lake by Altındağ (4), Slastenenko (1) in the Black Sea Basin, and Karataş and Akyurt (19) in Almus Dam Lake determined sexual maturity at the 3rd year.

Sexual maturity was reported at 2 years old for females, earlier than for males, at 3 years old, in the Kızılırmak Basin by Erk'akan and Akgül (16), and in the Savur Stream by Ünlü and Balcı (18), and in Karasu River by Erdoğan et al. (20). The spawning ages for Sarıyar Dam Lake (5) and Aras River (7) are different from those previously studied.

Table 4. Mean length (cm), weight (g), gonad weight and fecundity of 65 female chub (*L. cephalus*) from different age groups in Topçam Dam Lake. (N = Number of fish).

| Age | N | FL (cm) ± SD | WT (g) ± SD | WG | F ± SD | F/FL | F/WT |
|-----|----|---------------|-----------------|-------|-----------------|---------|--------|
| II | 5 | 14.74 ± 0.231 | 46.45 ± 1.892 | 1.66 | 9142 ± 6241 | 613.60 | 199.05 |
| III | 38 | 16.51 ± 1.150 | 68.65 ± 1.950 | 3.11 | 10,959 ± 5236 | 669.83 | 160.06 |
| IV | 17 | 19.69 ± 1.050 | 122.64 ± 5.155 | 7.66 | 27,197 ± 15,173 | 1386.87 | 219.78 |
| V | 3 | 22.64 ± 0.232 | 192.08 ± 12.885 | 9.17 | 41,333 ± 17,752 | 1819.07 | 211.74 |
| VI | 1 | 24.40 | 241.93 | 5.30 | 23850 | 965.59 | 109.20 |
| VII | 1 | 26.10 | 326.40 | 11.80 | 53100 | 2026.72 | 154.36 |

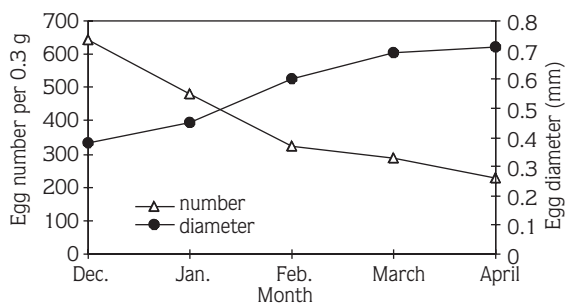
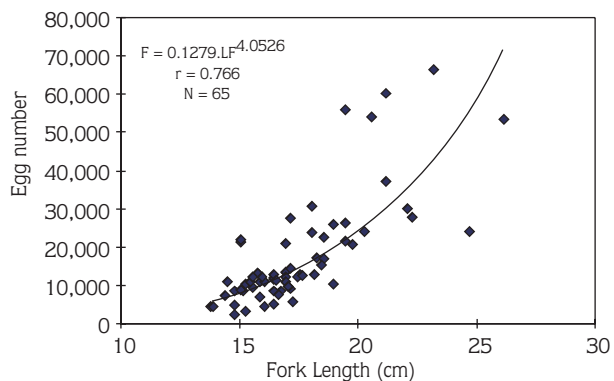
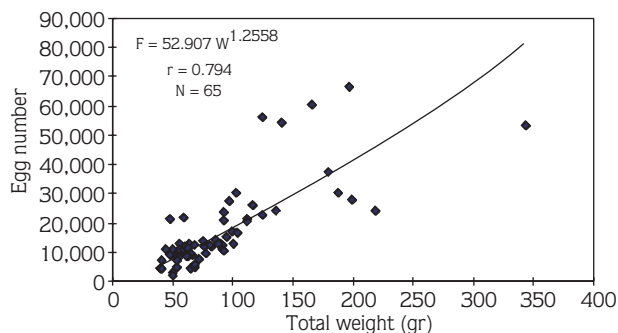
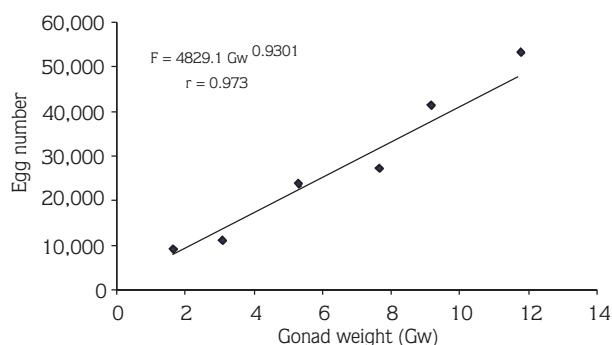
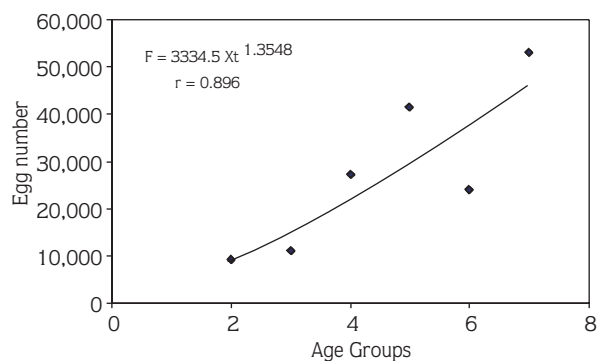


Figure 3. Relationships between fecundity and egg diameter by month.

Figure 4. Relationships between fecundity and fork length of female chub (*L. cephalus*) in Topçam Dam Lake.Figure 5. Relationships between fecundity and total weight of female chub (*L. cephalus*) in Topçam Dam Lake.Figure 6. Relationships between fecundity and gonad weight of female chub (*L. cephalus*) in Topçam Dam Lake.Figure 7. Relationships between fecundity and age of female chub (*L. cephalus*) in Topçam Dam Lake.

In this study, according to GSI values, the investigation of egg diameters and direct observation of gonads of the *L. cephalus* population in Topçam Dam Lake, revealed that the spawning of this species took place in March and April.

Berg (3) reported that the chub population living in the Black Sea Basin laid its eggs between April and June. Erk'akan and Akgül (16) determined that the spawning period of *L. cephalus* in the Kızılırmak Basin

was from May to September. Öztaş (17) determined the spawning time of the *L. cephalus* population in Müceldi Stream (Erzurum, Turkey) to be at the end of May and in June. Altındağ (4) reported that the spawning period of chub in Akşehir Lake was in May and June. Ekmekçi (5) found that the spawning period of *L. cephalus* in Sarıyar Dam Lake was from April to June. However, Karataş and Akyurt (19) and Erdoğan et al. (20) determined that spawning of the chub in Almus Dam Lake and Karasu River took place in May and July, respectively. The spawning time of the chub population in the Topçam Dam Lake begins earlier than that in the other basins because of the warm climate in southern Turkey.

The number of eggs of *L. cephalus* in Topçam Dam Lake ranged between 2100 and 66,400. Fecundity varied from a mean of 9142 eggs per female at age II to a mean of 53,100 eggs per female at age VII. This was correlated significantly with fish length, body weight, age and gonad

weight, and it increased as fish length, weight, gonad weight and age increased. Larger old fish had higher levels of fecundity.

Ünlü and Balcı (18) showed that the number of eggs of *L. cephalus orientalis* in Savur Stream ranged between 2050 and 20,140. However, Libosvasky (21), Öztaş (17); Karataş and Akyurt (19), Ekmekçi (5), Altındağ (4), and Erdoğan et al. (20) reported mean fecundity ranges of 4470-29,780, 4349-51,137, 7056-18,898, 13,269-59,200, 19,162-106,227 and 5012-25,000 eggs per female in their *L. cephalus* populations, respectively. In these investigations it is reported that fecundity increased as fish length, weight, age and gonad weight increased. Fecundity is affected by age, size, species, feeding, season and environmental conditions (15). It also differs between populations of the same species and does not remain constant from year to year.

The diameter of eggs of *L. cephalus* living in the Topçam Dam Lake was determined as 1.350 mm in March and 1.275 mm in April. The diameter varied from a mean of 0.379 mm in December to a mean of 0.707 mm in April. In addition, it was correlated significantly with fish length, weight, age and gonad weight.

One of the most important parameters used to define reproductive potential is the variation of egg diameter in the ovaries. Egg diameter may be related to the amount of food that females can metabolise (10).

Erk'akan and Akgül (16) reported that egg diameters were 0.78-1.20 mm. Öztaş (17) reported that the diameter of eggs of *L. cephalus* living in Müceldi Stream was 0.55-1.38 mm. Libosvasky (21) stated that the mean egg diameter of the *L. cephalus* population in the Rokytna River (Czechoslovakia) ranged between 0.96 and 1.35 mm. Karataş (6) determined that the diameters of eggs were 0.88-1.02 mm in Tozanlı Stream. Libosvasky (21) reported that egg diameters in Klikava Dam were 0.65-1.22 mm.

Based on these results and evaluations, in order to maintain the population in equilibrium it is of great importance to give each fish the chance of reproducing least once in its lifetime, and therefore the minimum fishing size should be 19.70 cm in terms of fork length, because all male and female individuals were mature at age II. It is recommended that fishing be prohibited during the spawning seasons, which last from March to June, and the water temperature also be taken into consideration.

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