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Research Article

Studies on the Age, Growth and Reproduction Characteristics of the Chub, *Leuciscus cephalus orientalis*, (Nordmann, 1840) in Karasu River, Turkey

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Abstract: This study is based on the examination of 759 chubs from Karasu River (40° 45′ 33″ E, 39° 56′ 16″ N) between November 1995 and October 1997. This population comprised seven age groups of males and nine of females. The second age group was dominant in the population. Individuals were composed of 50.46% males and 49.54% females. The male and female ratio was 1:1.019 (M:F). The Von Bertalanffy growth parameters and length-weight relationships were; $L_t = 35.8765\ (1\text{-}e^{-0.1241(t+1.16660)})$, $W_t = 583.2981\ (1\text{-}e^{-0.1241(t+1.16660)})^{2.952}$, $W = 0.0150\ FL^{2.952}$ in males and $L_t = 41.4154\ (1\text{-}e^{-0.1160(t+1.3207)})$, $W_t = 936.3338\ (1\text{-}e^{-0.1160(t+1.3207)})^{2.980}$, $W = 0.0142\ FL^{2.980}$ in females, respectively. The condition coefficients of male, female and all specimens were; 1.32, 1.35 and 1.33, respectively. The relationships between fecundity (F) and fish length (FL), fish weight (W), gonad weight (W_o), and fish age (t) were; $F = 1.699\ FL^{2.847}$ (r = 0.813), $F = 969.424\ W_o^{1.019}$ (r = 0.953), $F = 95.669\ W^{0.955}$ (r = 0.843) and $F = 862.017\ t^{1.589}$ (r = 0.814), respectively. In addition, the relationships between gonad weight and total weight, fork length of samples were; $W_o = 0.394 + 0.723\ W$ (r = 0.763) and $W_o = -8.953 + 0.894\ FL$ (r = 0.714) in females (in 119 samples), $W_t = 1.598 + 0.037\ W$ (r = 0.660) and $W_t = -2.965 + 0.429\ FL$ (r = 0.643) in males (in 117 samples), respectively. Fecundity varied from a mean of 5012 eggs per female (III years old) to a mean of 25,000 eggs per female (VIII years old). Egg diameter varied between 100 µm and 137 µm with a mean of 119 µm. The reproduction period of this species inhabiting Karasu River was between May and July, and the first reproduction ages were; age II (for males) and age III (for females).

Key Words: Chub, *Leuciscus cephalus orientalis*, Age, Growth, Reproduction, Karasu River.

Karasu Nehri-Türkiye, Tatlı Su Kefali (*Leuciscus cephalus orientalis*, Nordmann 1840)' nin Yaş, Büyüme ve Üreme Karakterlerinin İncelenmesi

Özet: Kasım 1995 ile Ekim 1997 tarihleri arasında Karasu Nehri (40° 45′ 33″ E, 39° 56′ 16″ N)' nda yürütülen bu çalışmada toplam 759 adet tatlı su kefali incelenmiştir. Populasyonda erkeklerin I-VII, dişilerin ise I-IX yaşlar arasında dağılım gösterdiği ve ikinci yaş grubunun dominant olduğu belirlenmiştir. Örneklerin % 50,46' sı erkek % 49,54' ü ise dişi bireylerden oluşmakta olup, erkek ve dişi oranı 1:1,019 olarak hesaplanmıştır. Von Bertalanffy büyüme parametreleri ve boy ağırlık ilişkisi sırasıyla erkeklerde $L_t = 35{,}8765\ (1\text{-}e^{-0{,}1241(t+1{,}16660)})$, $W_t = 583{,}2981\ (1\text{-}e^{-0{,}1241(t+1{,}16660)})^{2{,}952}$ ve $W = 0{,}0150\ FL^{2{,}952}$, dişilerde ise $L_t = 41{,}4154\ (1\text{-}e^{-0{,}1160(t+1{,}3207)})$, $W_t = 936{,}3338\ (1\text{-}e^{-0{,}1160(t+1{,}3207)})^{2{,}980}$ ve $W = 0{,}0142\ FL^{2{,}980}$ olarak hesaplanmıştır. Kondisyon faktörü erkek, dişi ve erkek+dişi karışımında sırasıyla 1,32, 1,35 ve 1,33 olarak bulunmuştur. Fekundite (F) ile boy (FL), ağırlık (W), gonad ağırlığı (W_o) ve yaş (t) arasındaki ilişkiler sırasıyla $F = 1{,}699\ FL^{2{,}847}$ (r = 0,813), $F = 969{,}424\ W_o^{1{,}019}$ (r = 0,953), $F = 95{,}669\ W^{0{,}955}$ (r = 0,843) ve $F = 862{,}017\ t^{1{,}589}$ (r = 0,814) olarak hesaplanmıştır. Ayrıca, gonad ağırlığı ile çatal boy ve toplam ağırlık arasındaki ilişkiler sırasıyla dişilerde (119 örnek) $W_o = 0{,}394 + 0{,}723\ W$ (r = 0,763) ve $W_o = -8{,}953 + 0{,}894\ FL$ (r = 0,714), erkeklerde ise (117 örnek), $W_t = 1{,}598 + 0{,}037\ W$ (r = 0,660) ve $W_t = -2{,}965 + 0{,}429\ FL$ (r = 0,643) olarak belirlenmiştir. Ortalama fekundite III. yaşta 5012 adet/dişi, VIII. yaşta ise 25000 adet/dişi olarak bulunmuştur. Ortalama 119 µm olan yumurta çapı 100 ile 137 µm arasında değişmektedir. İlk cinsi olgunluk yaşı erkeklerde II dişiler ise III. yaş olarak belirlenmiş olup, yumurtlama Mayıs ve Temmuz ayları arasında gerçekleşmektedir.

Anahtar Sözcükler: Tatlı su Kefali, *Leuciscus cephalus orientalis*, Yaş, Büyüme, Üreme, Karasu Nehri

Introduction

The chub (*Leuciscus cephalus orientalis*) is a member of the *Cyprinidae* or carp family. The *Leuciscus cephalus orientalis* is the most common and widely distributed subspecies throughout European freshwaters, in the Black Sea Basin, Caspian Sea Basin, Azov Basin, Caucasia freshwaters and most freshwaters in Turkey. These especially include all of the rivers and branches in the East and Southeast Anatolia region of Turkey, and all of the streams flowing into the Black Sea (1,2). This subspecies' meat is delicious and is consumed by local people, and so has economic importance.

Although there is a lot of information concerning the species and different subspecies of the genus *Leuciscus* inhabiting European and Turkish waters (1-28), there is little information about the subspecies *Leuciscus cephalus orientalis* (29-37).

Ecological factors affect the basic biological characteristics of fish population, and so these kinds of investigations should be carried out periodically. The purpose of the present investigation was to follow seasonal changes in biological parameters in *Leuciscus cephalus orientalis*. Additionally, this study is the first record of the age, growth and reproduction characteristics of the subspecies *Leuciscus cephalus orientalis* in Karasu River.

Materials and Methods

This study was performed in Karasu River (40° 45´ 33´´ E, 39° 56´ 16´´ N), one of the most important branches of the Euphrates. The river studied is about 45-65 km from Erzurum city center and is about 15 km long, 10-30 m wide and 50-200 cm deep. The origin of the river is located in the East Anatolia region of Turkey (Figure 1).

A total of 759 chubs were captured monthly by cast nets of 12-22 mm mesh sizes between November 1995 and October 1997. The captured fish were transported to the laboratory for analysis. Then total lengths and wet weights were recorded to the nearest 1.0 mm and 0.1 g, respectively. Sexes were determined by examination of the gonad tissue either by eye for larger fish or with the aid of a microscope for smaller fish. Ten to 15 scales used for age determination were removed from above the lateral line below the anterior extent of the dorsal fin on

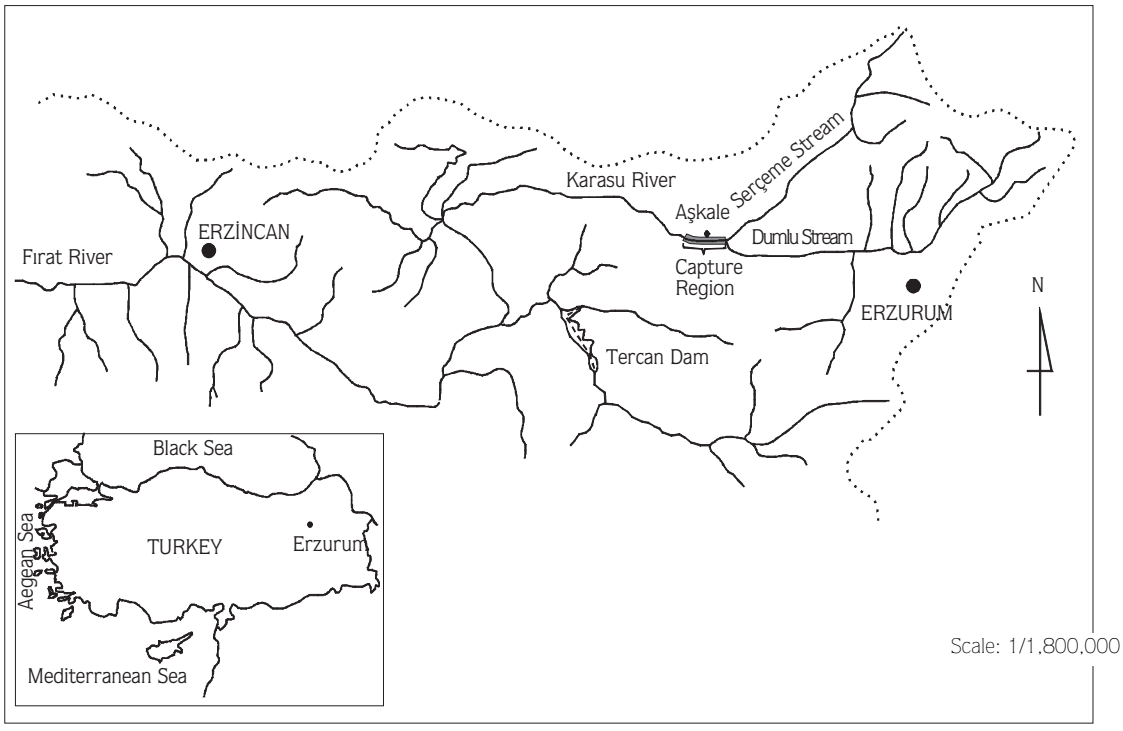

Figure 1. Map of the capture region.

the left side of the fish and were mounted dry between two slides for binocular microscopic study (38).

Von Bertalanffy growth parameters, length-weight relationships and relative growth rate in length and weight of samples were calculated according to $L_t = L_\infty(1-e^{-K(t-to)})$ in length and $W_t = W_\infty(1-e^{-K(t-to)})^b$ in weight, $W = a.FL^b$, $RFL = [(FL_{t+1}-FL_t)/FL_t]x100$ and $RW = [(W_{t+1}-W_t)/W_t] \times 100$, respectively. Condition coefficients were calculated for both sexes using the equation $K = (W/FL^3) \times 100$ (39).

The age of sexual maturity and spawning period were estimated from the gonad development and monthly variations in egg diameters of the samples (40). Gonads were removed, weighed to the nearest 0.1 g and the ovaries were preserved in 7% formaldehyde solution. The gonadosomatic index (GSI) was calculated from the equation $GSI = (W_g /W_t) \times 100$. Fecundity was estimated by the gravimetric method. The procedure was as follows: after two to three hours of washing, the 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, which contained various eggs. The eggs in sub-samples were counted under a lens or by means of a special apparatus. Then the number in the sub-samples was multiplied up to the weight of the ovary. The diameters of eggs taken from the front, middle and back parts of ovaries from females of various sizes caught just prior to spawning were measured by means of a Polaris caliper compass (1/20) (40,41). The relationships between fecundity and fork length, total weight, gonad weight and age were calculated from the equations $F = aFL^b$, $F = aW^b$, $F = aG_W{}^b$ and $F = at^b$, respectively (42). All calculations were done using Statistica 5.0 for Windows 95.

Results

Age Composition and Sex Ratio

The age and sex distributions of examined samples during this study are given in Table 1. The age of fish varied between I and IX. The second age group was dominant in the population. Since the mesh size was large (12-22 mm) the "0" age group fish were not represented in the samples. The sex rate of the population was 1:1.019 (F/M). Although the rate of males up to age II was higher than the rate of females in the population, the differences between sexes according to ages were not statistically significant ($p > 0.05$).

Growth in Length and Von Bertalanffy Curves

The mean fork lengths ($\overline{FL} \pm S_{\bar{x}}$) in cm and relative growth (RFL) for males and females according to ages, and the significance levels of differences between sexes in the same age groups of *Leuciscus cephalus orientalis* are summarized in Table 2. The males until age II were longer than females; after this age the females were longer than males, and the differences between sexes were not statistically significant ($p > 0.05$) in the others except age groups III and VI. Relative growth in males and females was highest in the first and second ages, respectively.

Von Bertalanffy growth parameters calculated by using the mean fork lengths at ages were; $L_t = 35.8765$

Table 1. Age and sex distribution of Leuciscus cephalus orientalis from Karasu River.

Age Groups	All Samples		Male		Female		
	N	% N	N	% N	N	% N	p = 0.05
I	176	23.19	94	12.38	82	10.80	p > 0.05
II	251	33.07	133	17.52	118	15.55	p > 0.05
III	212	27.93	105	13.83	107	14.10	p > 0.05
IV	52	6.85	26	3.43	26	3.43	p > 0.05
V	44	5.80	19	2.50	25	3.29	p > 0.05
VI	13	1.71	4	0.53	8	1.05	p > 0.05
VII	6	0.79	2	0.26	5	0.66	p > 0.05
VIII	3	0.40	-	-	3	0.40	-
Ix	2	0.26	-	-	2	0.26	-
All Groups	759	100	383	50.46	376	49.54	p > 0.05

Table 2. The mean fork length ($\overline{FL} \pm S_{\bar{x}}$ (cm)), relative growth (RFL) in length of different ages and significance levels of differences between sexes in the same ages of *Leuciscus cephalus orientalis* from Karasu River.

Age Groups	N	Male $\overline{FL} \pm S_{\bar{x}}$ (cm)	RFL (%)	N	Female $\overline{FL} \pm S_{\bar{x}}$ (cm)	RFL (%)	p = 0.05
I	94	10.82 ± 0.07	23.12	82	9.95 ± 0.13	26.05	p < 0.05
II	133	13.32 ± 0.07	20.46	118	12.54 ± 0.08	28.53	p < 0.05
III	105	16.04 ± 0.09	12.96	107	16.11 ± 0.13	21.31	p > 0.05
IV	26	18.12 ± 0.15	15.96	26	19.55 ± 0.16	13.82	p < 0.05
V	19	21.01 ± 0.27	11.85	25	22.25 ± 0.26	10.57	p < 0.05
VI	4	23.50 ± 0.58	1.91	8	24.60 ± 0.28	3.50	p > 0.05
VII	2	23.95 ± 0.45		5	25.46 ± 0.24	7.75	p < 0.05
VIII		-		3	27.43 ± 0.30	5.53	-
IX		-		2	28.95 ± 0.55		-

$(1-e^{-0.1241(t+1.16660)})$ in males and $L_t = 41.4154\ (1-e^{-0.1160(t+1.3207)})$ in females, and the curves are plotted in Figure 2.

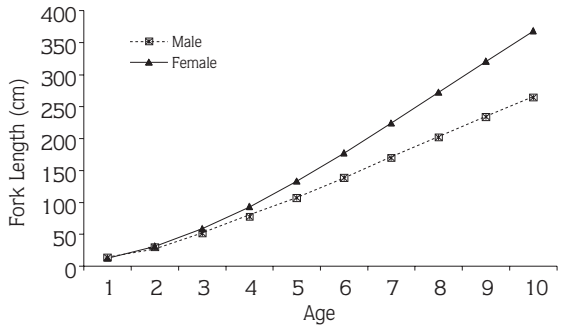

Figure 2. Von Bertalanffy growth curves in length of *Leuciscus cephalus orientalis* from Karasu River (November 1995-October 1997).

Growth in Weight and Von Bertalanffy Growth Curves

The mean weight ($\overline{W} \pm S_{\bar{x}}$), relative growth (RFL) in weight of different ages and significant levels of differences between sexes in the same ages of *Leuciscus cephalus orientalis* are summarized in Table 3. The males until age II were heavier than females; after this age females were heavier than males, and the differences between sexes were not statistically significant ($p > 0.05$) in the others except age groups III and VI. Relative growth in males and females was highest in the first and second age groups, respectively.

Von Bertalanffy growth parameters calculated using the mean total weight at ages were; $W_t = 583.2981\ (1-e^{-0.1241(t+1.16660)})^{2.952}$ in males and $W_t = 936.3338\ (1-e^{-0.1160(t+1.3207)})^{2.980}$ in females, and the curves are plotted in Figure 3.

Table 3. The mean total weight ($\overline{WL} \pm S_{\bar{x}}$), relative growth (RW) in weight of different ages and significance levels of differences between sexes in the same ages of *Leuciscus cephalus orientalis* from Karasu River.

Age Groups	N	Male $\overline{WL} \pm S_{\bar{x}}$ (g)	RW (%)	N	Female $\overline{WL} \pm S_{\bar{x}}$ (g)	RW	p = 0.05
I	94	17.00 ± 0.37	83.52	82	13.97 ± 0.50	91.16	p < 0.05
II	133	31.20 ± 0.56	74.99	118	26.70 ± 0.56	114.23	p < 0.05
III	105	54.60 ± 1.00	50.02	107	57.20 ± 1.42	80.97	p > 0.05
IV	26	81.91 ± 3.23	46.95	26	103.52 ± 3.19	43.83	p < 0.05
V	19	120.37 ± 4.86	43.14	25	148.89 ± 5.33	31.55	p < 0.05
VI	4	172.30 ± 4.67	2.29	8	195.87 ± 8.11	14.23	p > 0.05
VII	2	176.25 ± 1.75	-	5	223.73 ± 9.27	21.66	p < 0.05
VIII	-	-	-	3	272.20 ± 0 .35	18.48	-
IX	-	-	-	2	322.50 ± 0.50		-

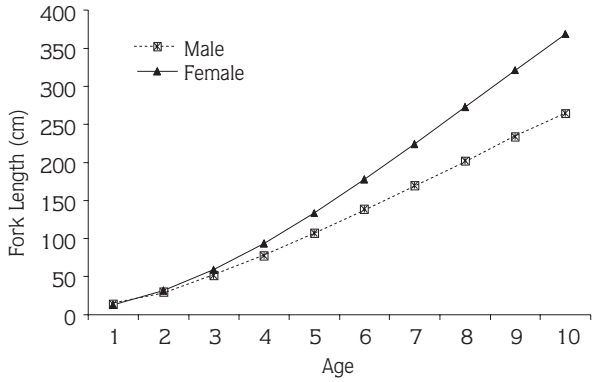

Figure 3. Von Bertalanffy growth curves in weight of *Leuciscus cephalus orientalis* from Karasu River (November 1995-October 1997).

Length-Weight Relationships

Length-weight relationships were calculated using the lengths and weights of the 759 *Leuciscus cephalus orientalis* specimens, and these equations for males and females were; $W = 0.0150\ FL^{2.952}$ and $W = 0.0142\ FL^{2.980}$, respectively. The correlation coefficients of the length-weight relationships for males (r = 0.975) and females (r = 0.988) were close to one, and significant ($p < 0.01$). The value "b" of females was higher than that of males. The length-weight curves for males and females are plotted in Figure 4.

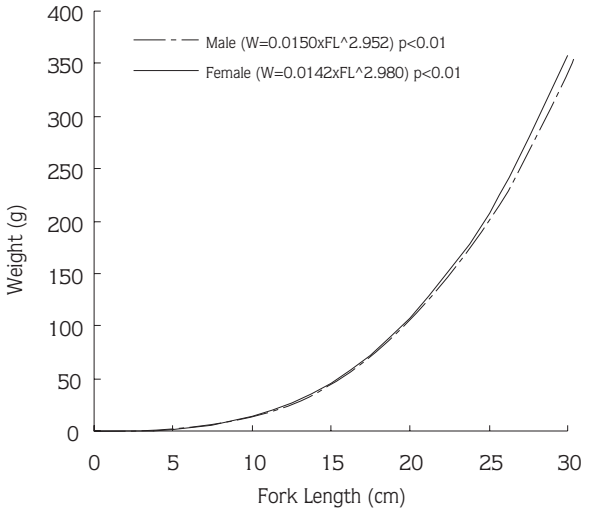

Figure 4. The length-weight relationship of *Leuciscus cephalus orientalis* from Karasu River (November 1995-October 1997).

Condition Coefficient

The mean condition coefficients according to sexes at different ages are summarized in Table 4. The mean condition coefficient of females (1.35) was higher than that of males (1.32), but the differences between sexes were not statistically significant ($p > 0.05$).

Table 4. Condition coefficients ($\overline{K} \pm S_{\overline{x}}$) in different age groups of Leuciscus cephalus orientalis from Karasu River.

Age Groups	All Samples $\overline{K} \pm S_{\overline{x}}$	Male $\overline{K} \pm S_{\overline{x}}$	Female $\overline{K} \pm S_{\overline{x}}$	p = 0.05
I	1.35 ± 0.01	1.33 ± 0.02	1.37 ± 0 .02	p > 0.05
II	1.32 ± 0.01	1.31 ± 0.01	1.33 ± 0.01	p > 0.05
III	1.33 ± 0.01	1.31 ± 0.01	1.35 ± 0.01	p > 0.05
IV	1.37 ± 0.02	1.36 ± 0.03	1.38 ± 0.02	p > 0.05
V	1.32 ± 0.01	1.29 ± 0.02	1.34 ± 0.02	p > 0.05
VI	1.32 ± 0.03	1.34 ± 0.07	1.31 ± 0.03	p > 0.05
VII	1.33 ± 0.03	1.29 ± 0.09	1.35 ± 0.02	p > 0.05
VIII	1.31 ± 0.09	-	1.31 ± 0.09	-
IX	1.33 ± 0.03	-	1.33 ± 0.03	-
All Groups	1.33 ± 0.01	1.32 ± 0.01	1.35 ± 0.06	p > 0.05

Additionally, seasonal variations in condition coefficients were examined for both sexes (Figure 5). In general, seasonal condition showed a similar pattern in both sexes. In both years of the study, it was maximum in May. In general, condition was higher during spawning and feeding months, but it was lower during other months.

Age at Spawning

Age at spawning was studied in 205 males and 188 females. Males matured sexually during their second-

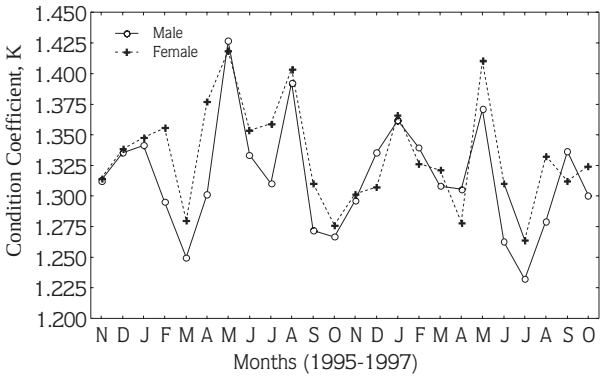

Figure 5. Seasonal variations in condition coefficient of *Leuciscus cephalus orientalis* from Karasu River (November 1995-October 1997).

fourth year of life (between 13 and 18 cm fork length). With the exception of a small proportion of females (2.23% which mature in their second year), all females matured sexually during their third-fifth year of life (between 16 and 19 cm fork length). The ages of these specimens were determined and the results may be summarized as 47.07% of males were mature in their second year, 85.71% in their third year, 96.2% in their fourth year and 100% in their fifth year and after; 2.23% of females were mature in their second year, 80.22% in their third year, 90.5% in their fourth year, 96.5% in their fifth year and 100% in their sixth year and after.

Gonad Development and Spawning Period

Gonad development was examined by using the gonadosomatic index (GSI) values of 383 males and 376 females individuals and the results are plotted in Figure 6. In both years of the study, fish began to spawn on May 15 and the spawning continued to the end of July when water temperatures were between 15 and 22 °C. In females in both years of this study, gonad development started in December, being particularly intense from April to May when the GSI reached its maximum value. In June, the GSI diminished because of spawning and continued to do so to the end of July. In males, the cycle of GSI was similar to that of females although the GSI had lower values.

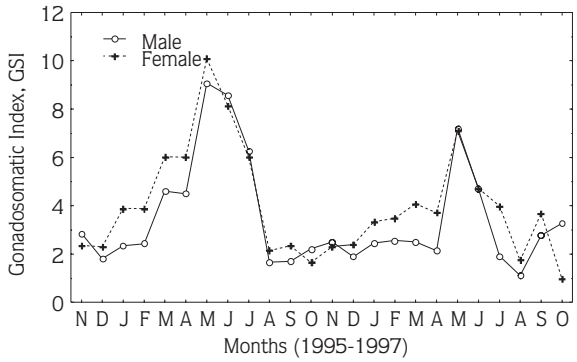

Figure 6. Gonad cycle of male and female of *Leuciscus cephalus orientalis* from Karasu River (November 1995-October 1997).

Fecundity

Fecundity was studied in 31 females caught just prior to the spawning period. Fecundity varied from a mean of 5012 eggs per female (III years old) to a mean of 25,000 eggs per female (VIII years old). Fecundity was correlated with fish length, weight, age and gonad weight, and it increased as fish length, weight, gonad weight and age increased. Larger and older fishes showed a higher fecundity and larger eggs. In addition, the relationships between fecundity (F) and fish length (FL), fish weight (W), gonad weight (W_o), and fish age (t) were; $F = 1.699\ FL^{2.847}$ ($r = 0.813$), $F = 969.424\ W_o^{1.019}$ ($r = 0.953$), $F = 95.669\ W^{0.955}$ ($r = 0.843$) and $F = 862.017\ t^{1.589}$ ($r = 0.814$), respectively. Egg diameter varied between 100 µm and 137 µm with a mean of 119 µm.

Additionally, the relationships between gonad weight with total weight and fork length of samples were; $W_o = 0.394 + 0.723\ W$ ($r = 0.763$) and $W_o = -8.953 + 0.894\ FL$ ($r = 0.714$) in females (in 119 samples), and $W_t = 1.598 + 0.037\ W$ ($r = 0.660$) and $W_t = -2.965 + 0.429\ FL$ ($r = 0.643$) in males (in 117 samples), respectively. As seen from the present data, the relationship between gonad weight and total weight was higher than that between gonad weight and fork length.

Discussion

This study is based on the examination of 759 chubs from Karasu River between November 1995 and October 1997. The age of the fish ranged from I to IX. The fact that 84.19% of the specimens were between ages I and III indicates that there is a young *Leuciscus cephalus orientalis* population in Karasu River. Individuals were composed of 50.46% males and 49.54% females. The male and female ratio was 1:1.019 (M:F). It is well known that the sex ratio in the majority of species is close to one, but it varies considerably from species to species, differs from one population to another of the same species and may vary from year to year in the same population (40). In the early life stages, the rate of males was higher than that of females, but in later stages the rate of females was higher than that of males. This situation was similar to that reported by some investigators in their *Leuciscus cephalus* (26,32,36) and *Leuciscus cephalus orientalis* populations (33). Generally, it is reported that in freshwater fish the ability of hatching out for males is higher than that for females, but in upper age classes the rate of males is becoming lower and lower, and the rate of females becomes quite dominant in a population (40). The majority of samples in the population were in the second age group. This situation was also reported by some investigators in their *Leuciscus cephalus* populations (27,32).

Males were longer and heavier in the early life stages than females, but in later stages females were longer and heavier than males. This situation was similar to that reported by Altındağ (27), but it was different from that reported by some investigators in *Leuciscus cephalus orientalis* (33), *Leuciscus cephalus* (36) and *Leuciscus lepidus* (43). Variations in fish growth in terms of length and weight can be explained as an adaptive response to different environmental conditions (40,44). The values of L_{∞} and W_{∞} of females were higher than those of males. The findings of this study were similar to Çolak's (18) and Altındağ's (27). The reason for this is that the first spawning age of males was earlier than that of females, and consequently, females grow better than males, and the life of females is also longer than that of males (40,45). Relative growth in length and weight for males and females were higher in the early life stages, but in later stages it was lower. This situation was also reported by Nikolsky (40).

In general, seasonal condition showed a similar pattern in both sexes. In both years of the study, it was maximum in May. In general, the condition was better in spawning and feeding months, but lower in other months. Similar patterns were reported by other investigators (26,33,36).

The value "b" in the length-weight of males (2.952) was higher than that of females (2.980). The values found in this study were close to those found by Şen (33) in *Leuciscus cephalus orientalis*, and Karataş (26) and Altındağ (27) in *Leuciscus cephalus*, but were different from those found by Çolak (18) and Erdem and Erdem (43) in *Leuciscus lepidus*, and Özdemir (34) in *Leuciscus cephalus.* The values "b" are often 3.0 and generally fall between 2.5 and 3.5. As a fish grows, changes in weight are relatively greater than changes in length, due to the approximately cubic relationship between fish length and weight. Additionally, the values "b" in fish vary according to species, sex, age and sexual maturity of fish, season and fish feeding (39).

The first spawning age for males was II years old, and this situation was similar to that reported by many investigators (7,14,22,46), but was different from that reported by Çolak (18) in *Leuciscus lepidus* and Öztaş (31), Karataş (26), and Ekmekçi (36) in their *Leuciscus cephalus* populations. The first spawning age for females was III years old, and this situation was similar to that reported by many investigators in *Leuciscus cephalus* (7,22,26,31,36,46) and in *Leuciscus lepidus* (18), but was different from that reported by Philippart (14) in *Leuciscus cephalus*. The reason for these differences is that first spawning age is affected by age, species, size of fish and environmental factors (47). Spawning in both years of the study occurred between May and July. The spawning characteristics of fish vary in respect of their species and the ecological characteristic of the water system in which they live. These characteristics of fish are determined by environmental factors. Fish transferred to a different place were observed to have varying spawning characteristics. It was also observed that the spawning characteristics of fish of the same length living in parts with different ecological features, but belonging the same species, had some variations (40). The cycle of GSI was approximately similar in both years of the study (Figure VI).

Fecundity varied from a mean of 5012 eggs per female (III years old) to a mean of 25,000 eggs per female (VIII years old). Libovarsky (9), Öztaş (31), Bircan and Ağırağaç (46), Karataş (26), and Ekmekçi (36) in *Leuciscus cephalus* and Ünlü and Balcı (35) in *Leuciscus cephalu orientalis* reported similar results. It is well known that fecundity is affected by age, size, species, feeding of fish, season and environmental conditions. Additionally, it differs between populations of the same species and does not remain constant from year to year. A major feature of the fecundity is its increase (within certain limits) during the growth of fish. A large fish lays more eggs than a small one, and the correlation of fecundity with weight in most fish is higher than that with length, which in turn is higher than that with age (48). Fecundity was correlated significantly with fish length, weight, age and gonad weight. It increased when the fish length, weight, gonad weight and age increased, and larger and older fish showed a higher fecundity. This pattern was similar to that found by many investigators in other studies on *Leuciscus cephalus* (9,22,26,36,46) and *Leuciscus cephalus orientalis* (5,35). In this study, the egg diameters varied between 100 µm and 137 µm with a mean of 119 µm, and it increased when the fish length, weight and age increased, and larger and older fish had larger eggs. Erk'akan and Akgül (22), Öztaş (31), Bircan and Ağırağaç (46), Karataş (26), and Ekmekçi (36) reported similar results in *Leuciscus cephalus* and Şen (33) also reported in *Leuciscus cephalus orientalis*.

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 to reproduce at least once in its lifetime and therefore the recommended minimum fishing size for this species in Karasu River is 27.0 cm in terms of total length, which is equal to 25.5 cm fork length. It is recommended that fishing be prohibited during the spawning season, which extends between May and July, also taking the temperature into consideration.

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