Turkish Journal of Zoology

Volume 23 | Number 4 Article 6

1-1-1999

The Growth and Reproduction Characteristics of Chub Leuciscus cephalus orientalis (Nordmann, 1840) Living in the River Aras

MUSTAFA TÜRKMEN

H. İBRAHİM HALİLOĞLU

ORHAN ERDOĞAN

AYHAN YILDIRIM

Tr. J. of Zoology
23 (1999) 355–364

The Growth and Reproduction Characteristics of Chub *Leuciscus cephalus orientalis* (Nordmann, 1840) Living in the River Aras

Mustafa TÜRKMEN
Faculty of Fisheries, Mustafa Kemal University, İskenderun-TURKEY
H. İbrahim HALİLOĞLU, Orhan ERDOĞAN
Department of Fisheries, Faculty of Agriculture, Atatürk University, Erzurum-TURKEY
Ayhan YILDIRIM
Department of Fisheries, Vocational School, Atatürk University, İspir, Erzurum-TURKEY

Received: 19.10.1998

Abstract: In this study, the populations structure, growth and reproduction characteristics of 1091 *Leuciscus cephalus orientalis* from the Yağan Region of River Aras between December 1995 and November 1997 were investigated monthly. The age composition of this species ranged between I and VIII. Individuals were composed of 48.85% males and 51.15% females. Female individuals attained greater size and age than males. The largest Female captured was 27.5 cm FL and age VIII, while the largest male was 24.1 cm FL and age VIII. Von Bertalanffy growth equations (in length and weight) and length-weight relationships were found as $Lt=32.47(1-e^{-0.1217(t+1.63)})$, $Wt=502.10(1-e^{-0.1217(t+1.63)})^{3.113}$, $W=0.0099L^{3.113}$ in males and $Lt=36.66(1-e^{-0.1114(t+1.39)})$, $Wt=745.31(1-e^{-0.1114(t+1.39)})^{3.135}$, $W=0.0093L^{3.135}$ in females. Mean condition coefficients of males and females were calculated as 1.326 and 1.333 respectively. Males matured at ages II-III and females at ages III-IV. Spawning in the both years of study occurred between May and July. Fecundity ranged between 3391-17187 eggs/female and was correlated significantly with fish length, weight, age and gonad weight. The minimum fishing size for this species in the River Aras is suggested to be 20.0 cm in terms of total length and it is recommended that fishing be prohibited between May and July.

Key Words: Population Structure, Growth, Spawning Age and Season, *Leuciscus cephalus orientalis,* River Aras.

Aras Nehri'nde Yaşayan Tatlısu Kefali (*Leuciscus cephalus orientalis,* Nordmann 1840)'nin Büyüme ve Üreme Özellikleri Üzerine Bir Araştırma

Özet: Bu çalışmada, Aralık 1995 ve Kasım 1997 tarihleri arasında Aras Nehri'nden yakalanan 1091 adet tatlısu kefalinin (*Leuciscus cephalus orientalis*) populasyon yapısı ile büyüme ve üreme özellikleri incelenmiştir. Örneklerin I-VIII yaşlar arasında dağılım gösterdiği belirlenmiştir. İncelenen örneklerin %48.85'ini erkek, %51.15'ini ise dişi bireyler oluşturmuştur. Yakalanan en büyük erkek birey 24.1 cm çatal boy ve VIII yaş, dişi birey ise 27.5 cm çatal boy ve VIII yaş olarak saptanmıştır. Boyca ve ağırlıkça Von Bertalanffy büyüme denklemleri erkek ve dişi bireyler için sırasıyla $Lt=32.47(1-e^{-0.1217(t+1.63)})$, $Wt=502.10(1-e^{-1.1217(t+1.63)})^{3.113}$ ve $Lt=36.66(1-e^{-0.1114(t+1.39)})$, $Wt=745.31(1-e^{-0.1114(t+1.39)})^{3.135}$ olarak bulunmuştur. Boy ağırlık ilişkisi ve kondisyon katsayısı erkeklerde $W=0.0099L^{3.113}$ ve 1.326, dişilerde ise $W=0.0093L^{3.135}$, 1.333 olarak hesaplanmıştır. Erkeklerin 2-3, dişilerin ise 3-4 yaşlarında cinsi olgunluğa ulaştıkları, üremenin Mayıs ve Temmuz ayları arasında, ortalama yumurta veriminin ise 3391-17187 adet/dişi olduğu tespit edilmiştir.

Bu sonuçlara göre, Aras Nehri'nde yaşayan bu tür için en küçük av büyüklüğünün 20 cm olması ve av yasağının Mayıs-Temmuz aylarını kapsaması önerilmektedir.

Anahtar Sözcükler: Populasyon Yapısı, Büyüme, Üreme Yaşı ve Mevsimi, *Leuciscus cephalus orientalis,* Aras Nehri.

Introduction

The *Leuciscus cephalus orientalis* (Nordmann, 1840) being a subspecies of *Leuciscus cephalus,* the most common and widely distributed throughout European waters, the Black Sea Basin, the Caspian Sea Basin, the Sea of Azov Basin, Caucasian Region and most of Turkey waters is widely distributed in Dicle, Aras, Murat, Aras, the Çoruh River Basins and branches of them, the Lake Van Basin, all of the rivers of East Anatolia, all of the streams flowing to the Black Sea, Munzur Stream and other bodies of in Turkey (1, 2). Although the age, growth and reproduction characteristics of the different species and subspecies of the genus *Leuciscus* inhabiting European and turkish waters have been studied by many researchers (3-32), the subspecies *Leuciscus cephalus orientalis* has studied by comparitively few researchers (33-40). This species inhabiting River Aras is caught for consumption so it has economical importance. Ecological

factors affect the basic biological characteristics of fish populations, so this kind investigation should be carried out periodically. This study is the first on basic biological characteristics such as age, growth and reproduction of the subspecies *Leuciscus cephalus orientalis* inhabiting River Aras. Additionally, this paper is a contribution to the age growth and reproduction of this species from River Aras, and the results of this study will be the basis of other studies on this species.

Material and Methods

This study was performed in an approximately 20 km long section of the River Aras in the East Anatolian region of Turkey (Figure 1). Specimens were captured monthly by means of cast nets with 12-22 mm mesh sizes between December, 1995, and November, 1997. Captured fish were frozen immediately and transported to the laboratory where, once thawed, their size (FL±mm), weight, gonad weight (W±0.1 g) and sexes were necorded. Age was determined from microscopic examination of scales. Ten to fifteen scales from the left side of the body between the lateral line and dorsal fine were removed and dry mounted between two slides for binocular microscopic study (41). Von Bertalanffy growth equations were calculated aacording 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, where Lt is the length of fish in cm at age t, L_∞ the asymptotic length of the fish in cm, e the base of natural log (2.71828) t the fish age (year), t_o the hypothetical time at which the length of the fish is zero, K the rate at which growth curve approaches the asymptote, W_t the weight of the fish in grams at age t, W_∞ the asymptotic weight of the fish in grams and b the constant in the length-weight relationship (42).

Relative growth (R) in weight and length were calculated from the equations and $RW=(W_{t+1}-W_t/W_t)x100$, $RFL=(FL_{t+1}-FL_t)x100$ respectively, where W_{t+1} are the weight in grams and length in cm at age t+1, Wt is weight in grams and FLt is length in cm at age t (42).

Sex was determined by examination of the gonad tissue either by eye for bigger fish or with the aid of a microscope for smaller fish. The sexual maturity and spawning period were estimated from the gonad development (GSI), direct observation of the gonads and monthly variations in egg diameters of samples (43). Gonads were removed, weighed to the nearest to 0.1g and ovaries preserved in 7% formaldehyde solution. Gonadosomatic index (GSI) was calculated from the equation $GSI=(W_g/W_t)x100$, where W_g and W_t are gonad weight and total weight in grams of fish respectively. Fecundity was estimated by gravimetry. 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 sizes. The eggs in the sub-samples were counted by eye or under a lens. The number in the sub-samples was then multiplied up to the weight up of the ovary. The diameters of eggs taken from the font, middle and back parts of ovaries of females of various sizes captured just prior to the spawning period were measured by means of a Polaris caliper compass (1/20) (43). Statistical analyses were done according to Yıldız & Bircan (44), with Minitab 8.2 statistical software.

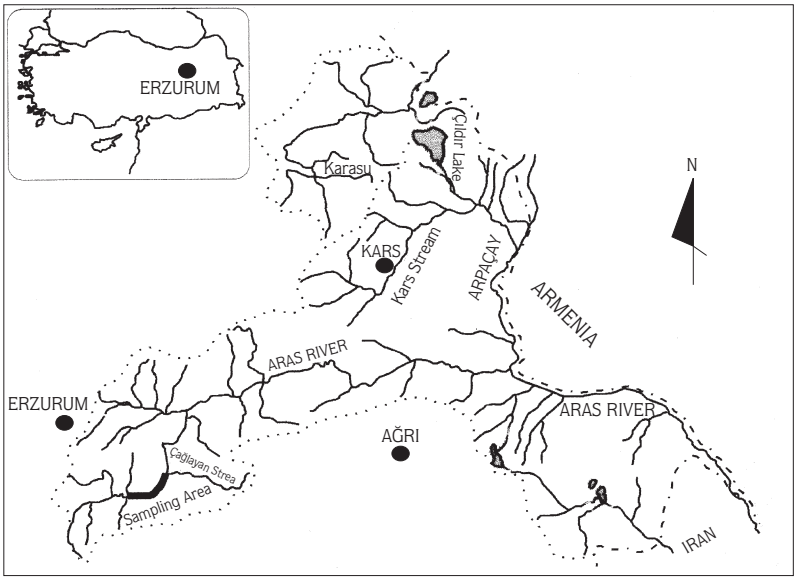

Figure 1. The map of the study area

Results

Age and Sex Distribution

The age and sex distribution of specimens caught during this study are summarized in Table 1 and Figure 2. The ages of captured fish ranged between I and VIII, and the 2nd group was dominant in the population. Because of the large mesh size (12-22 mm) the "0" age group fish were not represented in the specimens. The oldest male and female were age VIII. However, older fish may exist in the river, but were probably not captured because of mesh sizes and natural obstacles. There were 48.85% males and 51.15% females, and the differences between sexes according to age were not significant ($p>0.05$). The sex ratio (M:F) was 0.96:1.0, and was not significantly different from 1:1. Males up to the third age and females after this age were dominant in the population.

Growth in Weight and Age-Weight Relationship

The mean weight (W±Sx) and relative growth (RW) for samples according to age and sex and the significance levels of differences between sexes within the same age groups of *L. c. orientalis* are summarized in Figure 3. Although males weighed more until age II. differences between sexes were not significant, but after this age females were more weight in population. A difference between sexes according to ages for total weight were statistically significant in the 4th, 5th, 6th, 7th and 8th ages. Relative growth in both sexes was minimal in the 8th age and maximum in the 2nd age. The age-weight relationships of samples are plotted in Figure 4.

Von Bertalanffy growth equations (age-weight relationships) calculated with mean weights at different ages were found as $W_t=502.10(1-e^{-0.1217(t+1.63)})^{3.113}$ for males and $W_t=745.31(1-e^{-0.1114(t+1.39)})^{3.135}$ for females.

Table 1. The age and sex distribution of *L. c. orientalis*

	Male+Female		Male		Female		
Age	N	%N	N	%N	N	%N	p=0.05
I	55	5.04	31	2.84	24	2.20	p>0.05
II	346	31.71	184	16.87	162	14.85	p>0.05
III	258	23.65	132	12.10	126	11.55	p>0.05
IV	199	18.24	92	8.43	107	9.81	p>0.05
V	113	10.36	49	4.49	64	5.87	p>0.05
VI	65	5.96	24	2.20	41	3.76	p>0.05
VII	36	3.30	14	1.28	22	2.02	p>0.05
VIII	19	1.74	7	0.64	12	1.10	p>0.05
Total	1091	100.00	533	48.85	558	51.15	p>0.05

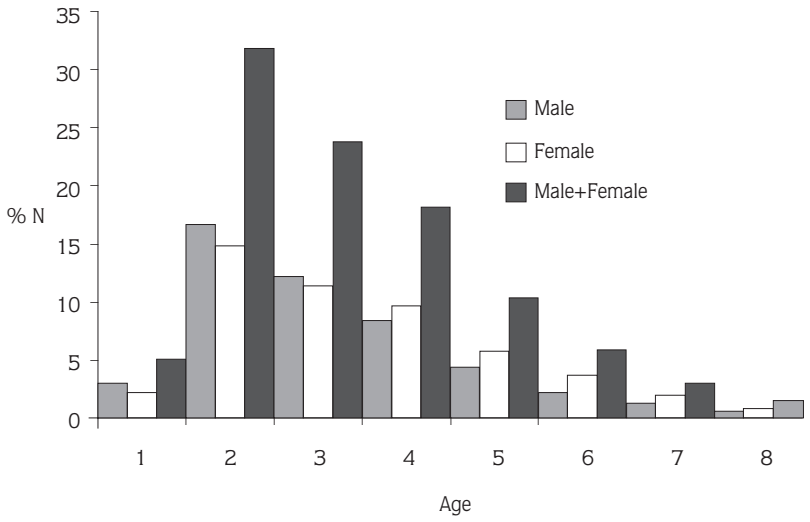

Figure 2. The age and sex distribution of *L. c. orientalis*

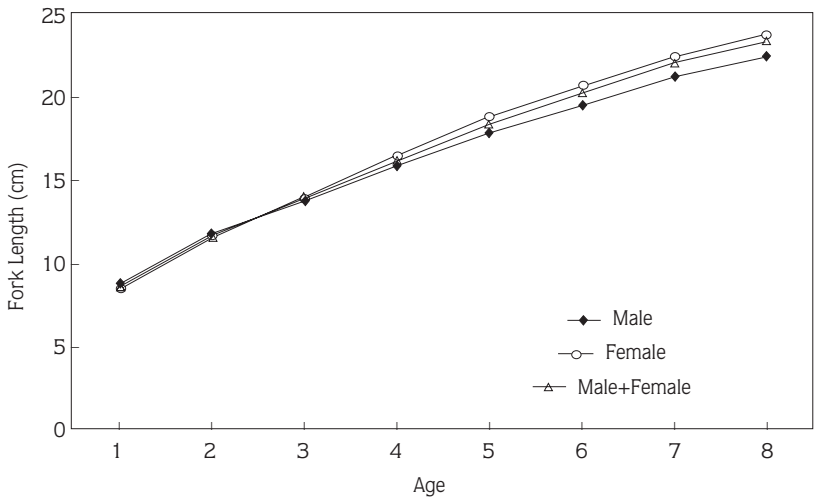

Figure 3. Age-length relationship of *L. c. orientalis*

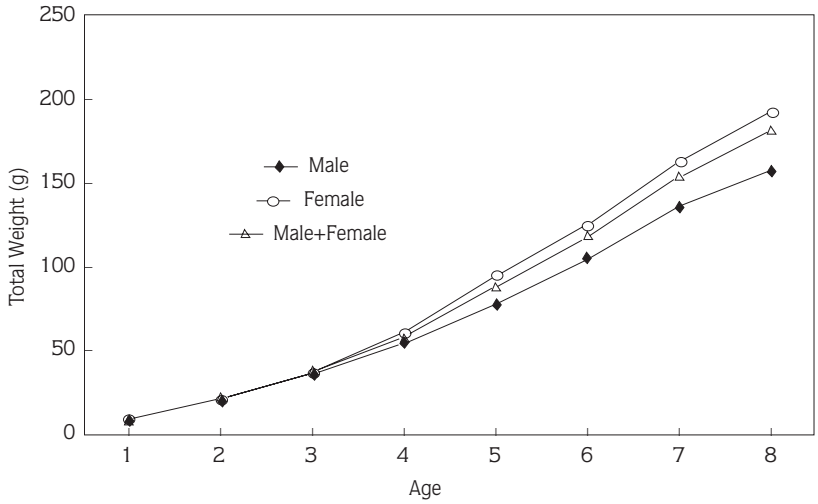

Figure 4. Age-weight relationship of *L. c. orientalis*

Females grew to a greater asymptotic weight (W_∞) than males.

Growth in Length and Age-Length Relationship

The mean fork length (FL)±Sx) and relative (RFL) growth for males and females according to age, and the significance levels of differences between females and males in the same age groups of *L. c. orientalis* are summarized in Table 2. Males were longer until the 4th age, but after that females were longer in the population. Differences between sexes according to age for fork length were statistically significant only in the 4th,5th and 6 th ages. Relative growth in both sexes was minimum in the eighth age and maximum in the second age. The age-length relationships of the samples were plotted in Figure 3.

Von Bertalanffy growth equations (age-length relationships), calculated by using mean fork lengths at different ages, were found as $L_t=32.47(1-e^{-0.1217(t+1.63)})$ for males and $L_t=36.66(1-e^{-0.1114(t+1.39)})$ for females. Females grew to a greater asymptotic length (L_∞) than the males.

Length-Weight Relationships

Length-weight relationships calculated by using the lengths and weights of the 1091 *L. c. orientalis* specimens were found as $W=0.0099L^{3.113}$ for males and $W=0.0093L^{3.135}$ for females. The b value of females was higher than that of males. The correlation coefficients of these relationships for males (r=0.982) and females (r=0.993) were always close to one and significant ($p<0.05$). The length-weight curves for males and females are plotted in Figure 5.

Table 2. The mean fork length (FL), standard error (Sx) and relative (RFL) growth in length of different age groups in *L. c. orientalis*

Age	Male+Female FL±Sx(cm)	RFL	Male FL±Sx(cm)	RFL	Female FL±Sx(cm)	RFL	p=0.05
I	8.83±0.16		8.92±0.15		8.67±0.34		p>0.05
	(6.3-11.0)	0.33	(6.7-10.1)	0.33	(6.3-11.0)	0.34	
II	11.77±0.05		11.85±0.07		11.65±0.07		p>0.05
	(9.2-13.2)	0.19	(9.5-13.2)	0.17	(9.2-12.8)	0.21	
III	13.98±0.06		13.91±0.09		14.05±0.07		p>0.05
	(12.2-16.5)	0.16	(12.3-16.5)	0.15	(12.2-15.8)	0.18	
IV	16.28±0.07		15.95±0.10		16.55±0.10		p<0.05
	(13.5-19.0)	0.13	(13.5-17.3)	0.12	(14.5-19.0)	0.14	
V	18.48±0.07		17.88±0.10		18.85±0.07		p<0.05
	(16.9-19.7)	0.10	(16.9-19.0)	0.09	(17.6-19.7)	0.10	
VI	20.30±0.13		19.54±0.14		20.73±0.16		p<0.05
	(18.3-23.0)	0.09	(18.3-20.7)	0.09	(18.6-23.0)	0.08	
VII	22.07±0.26		21.27±0.32		22.47±0.35		p>0.05
	(19.8-26.0)	0.06	(20.0-23.2)	0.05	(19.8-26.0)	0.06	
VIII	23.36±0.44		22.43±0.64		23.82±0.57		p>0.05
	(20.7-27.5)		(20.7-24.1)		(22.3-27.5)		

Table 3. The mean weight (W), standard error (Sx) and relative (RW) growth in weight of different age groups in *L. c. orientalis*

Age	Male+Female W±Sx(cm)	RW	Male W±Sx(cm)	RW	Female W±Sx(cm)	RW	p=0.05
I	9.14±0.46		9.06±0.45		9.29±0.98		p>0.05
	(2.96-16.76)	1.33	(4.22-15.50)	1.42	(2.96-16.76)	1.21	
II	21.28±0.29		21.89±0.41		20.50±0.41		p>0.05
	(8.41-37.50)	0.74	(10.50-37.50)	0.69	(8.41±31.14)	0.82	
III	37.10±0.57		36.92±0.88		37.29±0.71		p>0.05
	(21.00-69.20)	0.58	(21.00-69.20)	0.49	(24.93-65.50)	0.66	
IV	58.80±0.90		55.11±1.29		61.79±1.19		p<0.05
	(28.43-100.60)	0.51	(28.43-89.30)	0.43	(32.43-100.60)	0.55	
V	89.04±1.33		78.71±1.64		95.50±1.45		p<0.05
	(65.00-115.3)	0.34	(65.00-106.90)	0.34	(68.60-115.34)	0.32	
VI	119.09±2.92		105.72±4.45		126.52±3.36		p<0.05
	(68.14-176.00)	0.30	(68.14-151.00)	0.30	(93.00-176.00)	0.30	
VII	155.25±5.98		137.44±6.80		164.15±8.07		p<0.05
	(97.64-255.60)	0.17	(97.64-169.00)	0.15	(104.53-255.60)	0.18	
VIII	182.07±11.27		158.50±8.79		193.86±16.19		p<0.05
	(135.00-302.50)		(135.00-181.50)		(157.00-302.50)		

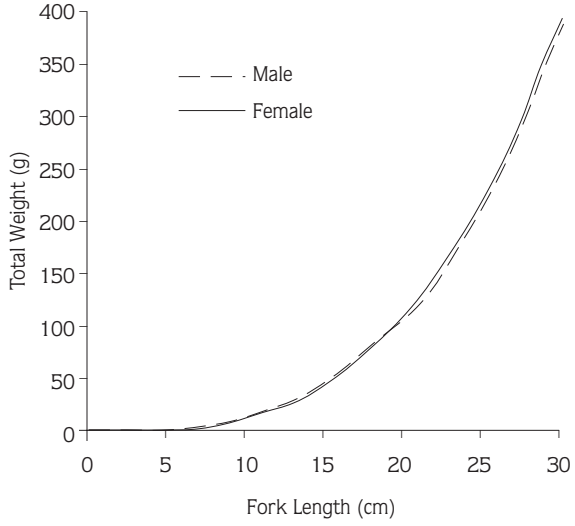

Figure 5. Length-weight curves of *L. c. orientalis*

Condition Coefficients

The mean condition coefficient of females (1.333) was higher than that of males (1.326), but the differences between sexes were not statistically significant ($p<0.05$) (Table 4, Figure 6). Table 4 and Figure 6 show that the condition coefficient increases as age increases. Seasonal variations in condition coefficients were determined for both sexes (Figure 7). In general, monthly conditions showed a similar pattern in both sexes, and it was higher in the spawning period, but lower after the spawning period and during the winter period.

Age at Spawning

Age and length at spawning were studied in 558 females and 533 males. Males matured at between 2 and 3 years of age, and females between 3 and 4 years of age. There were differences between males and females

Age	Male+Female K±Sx (Min-Max)	Male K±Sx (Min-Max)	Female K±Sx (Min-Max)	p=0.05
I	1.270±0.018 (1.050-1.504)	1.253±0.024 (1.050-1.504)	1.300±0.026 (1.078-1.484)	p>0.05
II	1.282±0.008 (1.032-1.902)	1.291±0.011 (1.047-1.682)	1.271±0.012 (1.032-1.902)	p>0.05
III	1.338±0.009 (1.025-1.820)	1.347±0.014 (1.025-1.820)	1.329±0.010 (1.129-1.661)	p>0.05
IV	1.345-0.011 (1.021-1.804)	1.340±0.018 (1.084-1.804)	1.349±0.014 (1.021-1.660)	p>0.05
V	1.403±0.013 (1.115-1.679)	1.376±0.024 (1.226-1.679)	1.421±0.014 (1.115-1.559)	p>0.05
VI	1.407±0.016 (1.112-1.702)	1.401±0.033 (1.112-1.702)	1.411±0.018 (1.243-1.652)	p>0.05
VII	1.423±0.016 (1.221-1.703)	1.419±0.042 (1.221-1.703)	1.425±0.013 (1.291-1.500)	p>0.05
VIII	1.406±0.016 (1.297-1.522)	1.405±0.0432 (1.297-1.522)	1.406±0.015 (1.315-1.455)	p>0.05
Total	1.330±0.005 (1.021-1.902)	1.26±0.007 (1.025-1.820)	1.333±0.006 (1.021-1.902)	p>0.05

Table 4. The condition coefficient (K) and standard error (Sx) of different age groups in *L. c. orientalis*

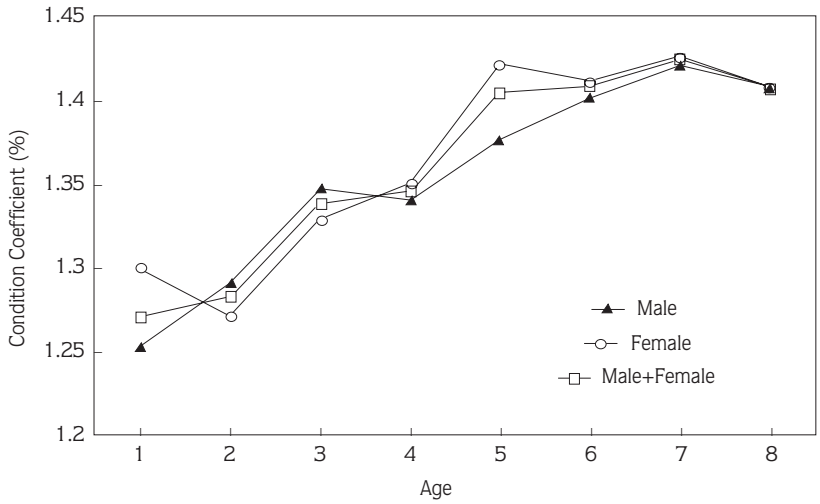

Figure 6. Condition coefficient according to ages and sexes of *L. c. orientalis*

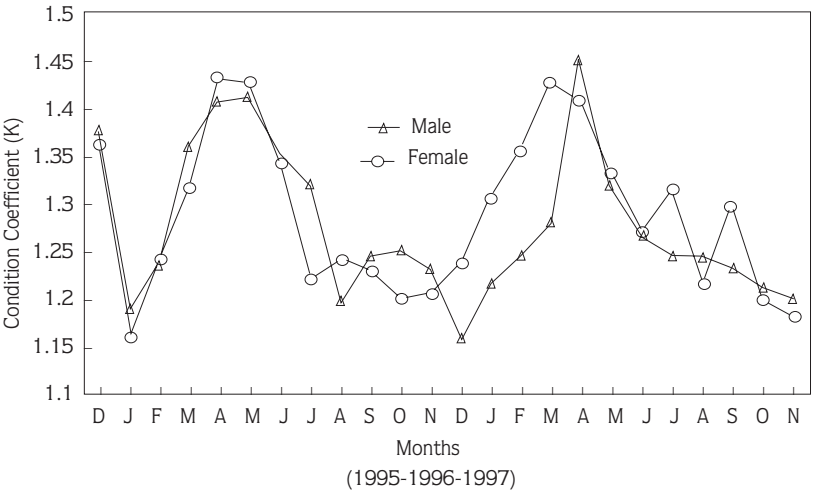

Figure 7. Seasonal variations in condition coefficient of *L. c. orientalis*

in length and age at first spawning. In addition, the maturity according to age of these specimens was determined, and 64% of males were found mature in their second age, 91% in their third age and 100% in their 4th age and after; 59% of females were mature in their third age, 96% in their 4th age and 100% in their 5th age and after.

Gonad Development and Spawning Period

The gonad development was studied by using gnodosomatic index (GSI). Its monthly change was plotted in Figure 8. Spawning in both years of the study occurred between May and July when water temperatures were between 16 and 23°C. In the 1st year, after spawning, there seemed to be 7-month quiescent period (Aug 1996-Feb 1997), and during spring (March-May), a rapid growth of the gonads occurred until the next spawning. Also, in the 2nd year of study, the cycle of GSI was similar to that in the 1st year. (Figure 8).

Fecundity and Egg Diameter

Fecundity was estimated in 56 females captured just prior to spawning. Female *L. c. orientalis* maturing at age III produced a mean of 3391 eggs per female. At age VIII, this figure rose to a mean of 17.187 eggs per female. Fecundity was correlated with fish length, weight, and fecundity and egg diameters increased as fish length, weight, gonad weight and age increased. In general, larger and older fish had a higher fecundity and larger eggs. Egg diameters in females captured just prior to the spawning period varied from 0.92 to 1.45 mm, and increased as the fish length, weight and age increased, and larger and older fish had larger eggs.

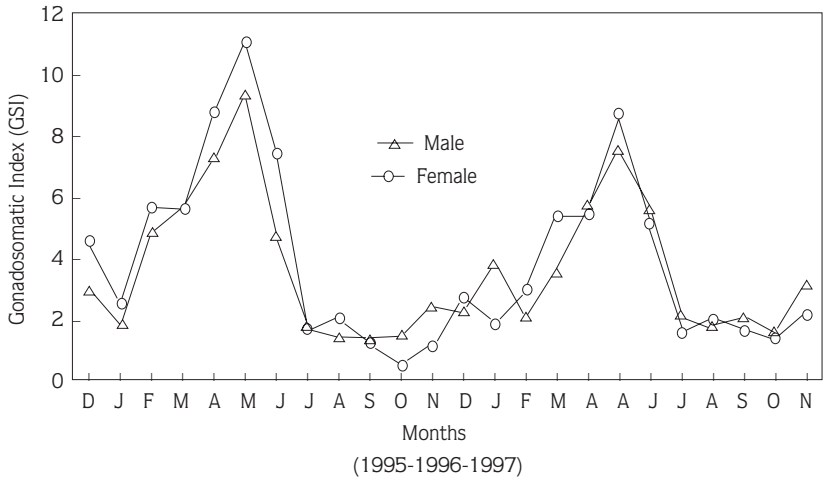

Figure 8. Monthly variations in the GSI of *L. c. orientalis*

Discussion

In this study, a total of 1091 specimens of *L. c. orientalis* from River Aras were examined from November 1995 to October 1997. The age of captured fish ranged between I and VIII. The group was 48.85% male and 51.15% female. The sex ratio of captured specimens was 0.96/1.0 (M/F) and not significantly different from 1:1. 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 same species and may vary year to year in the same population (43). 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. Several investigators have also reported similar patterns in their studies (30, 35, 36, 40). It is reported that in freshwater fish, the ability of hatching out is generally higher for males than females, but in upper age classes the rate of males gets lower and lower, and also the rate of females becomes quite dominant in a population (43). The fact that 78.64% of the samples is between ages I and IV indicates that there is a young population of *L. c. orientalis* in the River Aras. Most samples in the population were in the second age group. Several other investigators (31, 35) have also reported this model.

Males were longer and heavier than females in the early life stages, but in later stages females were longer and heavier than males. This situation was similar to that reported by Altındağ (31), but it was different environmental conditions (43, 45). The L_{∞} and W_{∞} values of females were higher than those of males. A similar pattern was reported by Çolak (18) and Altındağ (31).

The reason this may be that females grow faster than males, and the life span of females is longer than that of males (46). Relative growth in length and weight for both sexes was lowest in the 8th highest in the second age. This stiuation was reported by Nikolsky (43). The condition coefficient increased as age increased. Several investigators (31, 34, 40) have reported similar results. In general, seasonal conditions showed a similar pattern in both sexes. In the both years of the study, seasonal conditions were maximum in April, being higher in general in the feeding months and in the months just prior to spawning season, but it lower in other months. Several investigators (30, 36, 40) have reported similar patterns. Variations in condition coefficients may be explained by differences in environmental conditions and between species (47).

The b value in length-weight of males (3.113) was lower than that of females (3.135). This pattern has been reported by many investigators; they are often 3.0 and generally fall between 2.5 and 4.0 Values of this range are generally erroneous. As a fish grows, changes in weight are relatively gerater than changes in length, due to the approximately cubic relatinship between fish length and wegiht. The b values in fish differ according to species, sex, age, sexual maturity of fish, season and fish feeding (42). The first spawning age for males was age II and this stiuation was similar to that reported by several investigators (7, 13, 23, 29, 38), but was different from that reported by others (5, 25, 30, 36, 37, 40) in their studies. The spawning age for females was age III, years old, and this stiuation was similar to that reported by many investigators (5, 7, 25, 30, 36, 37, 40), .ut was different from that reported by Philippart (13) and Özdemir (38). The reason for these differences is that the first spawning age is affected by age, species, size of fish and environmental factors such as temperature, turbidity, organic matter, pH and hardness of the water (48). Spawning in the both years of study occurred between May and July. Several investigators have reported that spawning occurred in May and June (3, 5, 17, 39). In addition, Bircan & Ağırağaç (29), Karataş (30) and Ekmekçi (40) reported that spawning occurred in June, April-June, June-July, April-July and April-June respectively. The spawning characteristics of fishes transferred a different place were observed to vary. It was also observed that the spawning characteristics of fishes of the same length living in areas with different ecological features, but belonging the same species, had some variations (43).

Fecundity varied from a mean of 3391 eggs per female age III to a mean of 17.187 eggs per female age VIII, and it was correlated significantly with fish length, weight, age and gonad weight. It increased as fish length, weight, gonad weight and age increased, and larger and older fish had higher fecundity. Many investigators have reported that fecundity increased as fish length, weight, age and gonad weight increased (49). Libosvarsky (8), Erk'akan & Akgül (23), Öztaş (37), Ünal & Balcı (39), Bircan & Ağırağaç (29), Karataş (30) and Ekmekçi (40) reported that fecundity was 4470-29780, 1909-15680, 4349-51137, 2050-20140, 25125-63044, 5895-28072 and 13300-59200 eggs/female in their *Leuciscus cephalus* populations respectively. Fecundity is affected by age, size, species, feeding of fish, season and environmental conditions. Additionally, it differs between populations of same species and does not remain constant from year to year. A major feature of 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 (47). Egg diameters in females captured just prior to the spawning period varied from 0.92 to 1.45 mm. It incerased as fish length, weight and age increased, and larger and older fish had larger eggs. Libosvarsky (8), Erk'akan & Akgül (23), Şen (36), Öztaş (37) and Ekmekçi (40) reported that egg diameters were between 0.96-1.35, 0.78-1.20, 0.70-1.50, 0.55-1.38 and 0.69-1.65 mm respectively.

In light of these results and evaluations, in order to maintain the population in equilibrium, it is of great importance to give each fish the chance of reproduction at least once in its lifetime and therefore the minimum fishing size should be 20.0 cm in terms of total length that is equal to 19.0 cm fork length, because all male and female individuals were mature at age IV and had a 19.0 cm fork length at age V. It is recommended that fishing be prohibited during the spawning season, which lasts from May to July, and that water temperature also be taken into consideration.

Acknowledgements

The authors wish to thank the Atatürk University Research Fund for supporting this study. We are also grateful to Prof. Dr. İhsan AKYURT for his technical assistance.

References

1. Kuru, M., The Freshwater Fish Fauna of Eastern Anatolia: İst. Üniv. Fen Fak. Mec., Seri. B, 36, 137-147, 1971.
2. Geldiay, R. & Balık, S., Türkiye Tatlısu Balıkları, Ders Kitabı, Ege Üniv., Su Ürün., Fak., Yay., No: 46, İzmir, 532 s., 1996.
3. Berg, L. S., Freshwater fishes of the U.S.S.R. and adjacent countries: Academy of sciences of the U.S.S.R. (Translated from Russian, Israel Program for Scientific Translations, Jerusalem. 1963) Vol. 2, 496 p., 1949.
4. Kosswig, C., Türkiye Tatlısu Balıklarının Zoocoğrafyası, Hidrobiyoloji Mec., A, II (1) 3-20, 1954.
5. Slastenenko, E., Karadeniz Havzası Balıkları (Çev. H. Altan): EBK Yayınları İstanbul 711 p., 1955-56.
6. Numann, W., Anadolunun Muhtelif Göllerinde Limnolojik ve Balıkçılık İlmi bakımından Araştırmalar ve Bu Göllerde Yaşayan Sazanları Hakkında özel bir Etüd: İstanbul Üniv. Fen Fak. Hidrobiyoloji Arş. Enst. Yay. Mografi, 7, 1958.
7. Lelek, A., The Age, Growth and Sex Ratio in the Chub (Leuciscus cephalus L.) from the Rockytna River: Zoologcke Listy., Floia Zool., Rocnik VIII, XXII, 4, 365-376, 1959.
8. Libovarsky, J., After Geschelehterver Höltnis und Grewichtsschwankurgen Beim Döbel (Leuciscus cephalus L.) in Svrakta-Fluβ: CSR. Z. Fish. 8 NF. (4-6). 279-293, 1959.
9. Libovarsky, J., Gonad Weight and Egg Number in Chub (Leuciscus cephalus) from the Rokytna Stream: Floia Zoologica, 28 (1) 35-42, 1979.
10. Kirka, A., Age and Growth of Chub Leuciscus cephalus (L.) from the Orava Reservoir: Zool. Listy., 14 (3) 235-250, 1965.
11. Holcik, J., Some Data on the Biology of Chub Leuciscus cephalus (Linnaeus 1758) in the Kilcava Reservoir. Acta Rerum Natur. Mus. Nat. Slov., 13: 113-125, Bratiblava, 1967.
12. Tnayolaç, J., Some Aspects of Local Population of Freshwater Fishes in the surroundings of Ankara: Communications, 3 (13) 65-100, 1968.
13. Philippart, J.C., Age and Growth İn the Chub Leuciscus cephalus (L.) from the O urthe and the Berwine: Ann. Soc. R. Zool. Belg. (1-2) 47-81, 1972.
14. Geldiay, R & Balık, S., The biological investigations of chub (Leuciscus cephalus L.), inhabiting the stream originated from springs of Pınarbaşı, İzmir Region (Turkey): Ichthyologia, 5 (1) 21-33, 1973.
15. Habashy, A.P., Age Growth, Spawning and Some Biochemical Data in The Chub (Leuciscus cephalus L.) in The Rouchovanka Creek, Zoll. Listy, 13: 71-83, 1974.
16. Peel, K. and Tandon, T.T., The Abundance, Growth and Production of the Chub Population in the Klicava Reservoir During the Years 1967-1975: Vestnic Ceskolovenske Spolecnosti Zoologicke Svazek 1, 52-59, 1978.
17. Penaz, M., Prokes, M. and Wohlgemuth, E., The Community of Fish Fry of Jihlava River Near Mohelno: Acte Sc. Nat. 12 (5) 1-36, 1978.
18. Çolak, A., Keban Baraj Gölü'nde bulunan balık stoklarının populasyon dinamiği: Doğa Bilim Dergisi, Vet. Hay./Tar. Orm., 6, 1-14, 1982.
19. Hanel, L., Note on the Length Growth of the Chub (Leuciscus cephalus Pisces, Cyprinidae) in the Reservoir Klièava and The River Berounka: Vest. ès. Spoleè. Zool., 46: 241-256, 1982.
20. Hickley, P. & Bailey, R.G., OBservation on the growth and production of chub Leuciscus cephalus and dace Leuciscus leuciscus in a small lowland river in Southeast Enagland: Freshwater Biology, 12, 167-178, 1982.
21. Vitali, R. and Braghieri, L., Population Dynamic of Barbus barbus plebejus (Valenciennes) and Leuciscus cephalus cabeda (Risso) in the Middle River po Italy: Hydrobiologia, 109, 105-124, Netherlands, 1984.
22. Erk'akan, F., Sakarya Havzası'ndaki bazı ekonomik balık türlerinin kondisyon faktörleri: Doğa A2. 9 (3) 525-530, 1985.
23. Erk'akan F. & Akgül, M., Kızılırmak Havzası ekonomik balık stoklarının incelenmesi: Doğa Tr. Vet. ve Hay. D. 10 (3) 239-250, 1986.
24. Akbay, N., Cip Baraj Gölü Limnolojisi: D.S.İ. Gn. Müd. İşletme ve Basım Dairesi, 43s, 1987.
25. Erdem, I. S., Sürgü Gölü limnolojisi. D.S.İ. basım vei fotofilm işl. müd. mat. 35 s., 1987.
26. Bıanco, P.G., Leuciscus cephasu (Linnaeus), with records of fingerling adult males, Leuciscus pleurobipunctatus (Stephanidis) and their hybrids from western Greece: J. Fish Biol. 32, 1-16, 1988.
27. Neophitou, C., Autecology of Chub, Leuciscus cephalus (L.), in A Greek Stream, and the Use of the Pharyngeal Bone in Fish Predator-Prey Studies, Aquaculture and Fisheries Management, 19: 179-190, Greece. 1988.
28. Gül, A., Kapulukaya Baraj Gölü'nde Yaşayan Stizostedion luicopreca (Linnaeus, 1758) ve Leuciscus cephalus (Linnaeus, 1758)'un Biyo-Ekolojileri Üzerine Bir Araştırma: Doktora Tezi, G.Ü. Gen Bil. Ens. (Yayınlanmamış), Ankara, 1994.
29. Bircan, R. & Ağırağaç, A., Altınkaya Baraj Gölü tatlısu kefalinin (Leuciscus cephalus L., 1758) üreme biyolojisi: Doğu Anadolu Bölgesi I. (1993) ve II. (1995) Su Ürünleri Sempozyomu, Erzurum, 631-650, 1995.

30. Karataş, M., Almus Baraj Gölü'nde Yaşayan Tatlısu Kefali (Leuciscus cephalus) ve Bıyıklı Balığın (Barbus plebejus) Biyo-Ekolojik Özelliklerinin Araştırılması. Doktora Tezi, Ata. Üniv. Fen Bil. Enst. Zootekni Anabilim Dalı, (Yalınlanmamış), Erzurum 1995.

31. Altındağ, A., Akşehir Gölü'ndeki (Konya) tatlısu kefalinin (Leuciscus cephalus) L., 1758) bazı populasyon özellikleri, büyüme ve kondisyonu: Tr. J. of Zoology 20, 53-65, 1996.

32. Yerli, S.V., Canbolat, A.F. and Çalışkan, M., Çıldır Gölü (Ardahan, Kars)'ndeki Leuciscus cephalus (Nordmann, 1840)'un Kondisyon Faktörü Üzerine Bir Araştırma: Tr. J. of Veterinary and Animal Sciences 20, 303-305, 1996.

33. Yanar, M., Karasu IrmağınınMenba Kısmını Oluşturan Derelerde Yaşayan Leuciscus cephalus orientalis (Nordmann, 1840) ile Capoeta capoeta umbla (Heckel, 1843)'nın Biyo-ekolojisi Üzerinde Araştırmalar: Ata. Üniv. Fen Bil. Ens. Zootekni Anabilim Dalı, Yük. Lis. Tezi (Yayınlanmamış), Erzurrum, 1984.

34. Öztaş, H., Müceldi Suyu'nda (Doğu Anadolu) Yaşayan Tatlısu Kefali (Leuciscus cephalus, L., 1758) Populasyonunda Mevsimsel Kondisyon Faktörü Değişmeleri Üzerine Araştırmalar: Doğa TU Zooloji D. 12 (3) 256-261, 1988.

35. Öztaş, H. and Solak, K., Müceldi Suyu'nda (Doğu Anadolu) Yaşayan Tatlısu Kefali (Leuciscus cephalus, L., 1758) Büyüme Özellikleri ve Eşem Oranları: Doğa TU Zooloji D. 12 (3) 262-271, 1988.

36. Şen, D., Kalecik (Karakoçan-Elazığ) Gölet'inin ve Su Ürünlerinin İncelenmesi: Doğa TU Biyol. 12, 69-85, 1988.

37. Öztaş, H., A Study the Reproduction Biology of Chub Leuciscus cephalus (L., 1758) in Müceldi Stream in East Anatolien: Doğa TÜ J. Vet. and Animal Sci 13 (2) 1989.

38. Özdemir, N., Çıldır Gölünün Balık Türleri Üzerinde Bir Araştırma: İstanbul Üniv. Su Ürünleri Dergisi 1 (2) 71-84, 1991.

39. Ünlü, E. and Balcı, K., Savur Çayı'nda Yaşayan Bazı Cprinidae (Pisces) Eşeysel Olgunluk Yaşı, Yumurtlama Dönemi ve Yumurta Verimi Üzerine Bir Araştırma: Eğitiminin 10, Yılında Su Ürünleri Sempozyumu, İzmir, 347-356, 1991.

40. EKmekçi, F.G., Sarıyar Gölü'nde yaşayan tatlısu kefali'nin (Leuciscus cephalus, Linnaeus 1758) büyüme ve üreme özellikleri: Tr. J. of Zoology, 20, 95-106, 1996.

41. Lagler, K.F., Freshwater Fishery Biology: W.M.C. Brown Company, Lowa, 421 p. 1966.

42. Ricker, W.E., Computation and Interpretation of Biological Statistics of Fish Populations: Bull. Fish. Res. Bd. Can. 191, 382 p., 1975.

43. Nikolsky, G.W., The Ecology of Fishes (Translated by L. Birkett): Academic Press. 352 p. London and New York, 1963.

44. Yıldız, N. and Bircan, H., Uygulamalı İstatistik: Ata. Üniv. Yayınları No: 704, 218 pp., Erzurum, 1994.

45. Wootton, R.S., Fish Ecology: Printed in Great Britain by Thomson Litho Ltd. 203 pp., Scotland, 1992.

46. Weatherly, A.H., Growth and Ecology of Fish Populations: Academic Press., 293 pp., London, 1972.

47. Nikolsky, G.V., Theory of Fish Population Dynamics (in Russian): Printed in Great Britain by T. and A. Constable Ltd., 321 p. Edinburgh, 1969.

48. Lagler, K.F., Bardach, J.E. and Miller, R.R., Ichthyology: John Wiley & Sons, Inc., New York, 288-289, 1962.

49. Blaxter, J.H.S., Development: Eggs and larvae. Fish physiology (Edt. W.S. Hoar and D.J. randal). Reproduction growth, bioluminescence, pigments and poisons: Academic Press, New York and London, 3, 180-184, 1969.