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Investigation of Some Biological Characteristics of the Silver Crucian Carp, *Carassius gibelio* (Bloch 1782) Population in Lake Eğirdir

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Abstract: Biological characteristics such as sex, age and length compositions, growth, condition factor, reproduction, mortality and exploitation rates of the silver crucian carp, *Carassius gibelio* (Bloch 1782), population in Lake Eğirdir were investigated between March 2001 and February 2002. According to the 616 specimens ranged in age groups from I to VI, the percentages of male and female individuals in the population were 53.4% and 46.6%, respectively. The fork lengths of the samples ranged from 9 to 33 cm. Allometric growth was also determined among the lengths and weights of both sexes. Incremental growth rates in length and weight for both males and females showed a significant decrease after the age of 2. It was estimated that females had higher L_∞ (L_∞ = 34.2 cm) and lower K (K = 0.316) values than males (L_∞ = 29.5 cm and K = 0.470). Mean condition factors of males, females and the combined sexes were calculated as 2.401, 2.594 and 2.498, respectively. It was determined that the condition factor of both males and females increased with fish size. First maturity length (L_m) was estimated at 9.7 cm for males and 10.3 cm for females. The most intensive period for reproduction was from April to July, although reproduction lasted until August.

Total (Z), natural (M) and fishing mortality (F) and exploitation (E) rates were estimated at Z = 1.01 year^{-1}, M = 0.63 year^{-1}, F = 0.38 year^{-1} and E = 0.38, respectively.

Key Words: Lake Eğirdir, silver crucian carp, *Carassius gibelio*, population structure, growth, condition factor, reproduction, mortality and exploitation

Eğirdir Gölü'ndeki Gümüşi Havuz Balığı, *Carassius gibelio* (Bloch 1782) Populasyonunun Bazı Biyolojik Özelliklerinin İncelenmesi

Özet: Mart 2001 ile Şubat 2002 tarihleri arasında yapılan bu çalışmada Eğirdir Gölü'ndeki gümüşi havuz balığı, *Carassius gibelio* (Bloch 1782) populasyonunun sex, yaş ve boy kompozisyonları, büyüme, kondisyon faktörü, üreme, ölüm ve sömürülme oranları gibi bazı biyolojik özellikleri incelenmiştir. Yaşları I-VI arasında değişen 616 örneğe göre, erkek ve dişi bireylerin populasyondaki oranları sırasıyla % 53,4 ve % 46,6'dır. Örneklerin çatal boyları 9 ile 33 cm arasında değişmiştir. Her iki eşeyin boy ve ağırlıkları arasında da allometrik büyüme saptanmıştır. Hem erkeklerin hem de dişilerin boyca ve ağırlıkça büyüme oranları artışı, iki yaşından sonra önemli bir azalma göstermiştir. Dişilerin, erkeklere (L_∞ = 29,5 cm ve K = 0,470) göre daha yüksek L_∞ (L_∞ = 34,2 cm), daha düşük K (K = 0,316)' ya sahip oldukları belirlenmiştir. Erkek, dişi ve her iki eşeyin ortak kondisyon faktörleri sırasıyla 2,401, 2,594 ve 2,498 olarak hesaplanmıştır. Hem erkek hem de dişilerin kondisyon faktörünün balık büyüklüğü ile arttığı belirlenmiştir. İlk eşeysel olgunluk boyu (L_m) erkekler için 9,7 cm, dişiler için 10,3 cm olarak hesaplanmıştır. Üremenin en yoğun olduğu dönem Nisan ve Temmuz ayları arası olarak belirlenmiş, fakat Ağustos ayına kadar sürdüğü saptanmıştır.

Toplam (Z), doğal (M), ve balıkçılık ölümü (F) ile sömürülme (E) oranları sırasıyla Z = 1,01 yıl^{-1}, M = 0,63 yıl^{-1}, F = 0,38 yıl^{-1} ve E = 0,38 olarak hesaplanmıştır.

Anahtar Sözcükler: Eğirdir Gölü, gümüşi havuz balığı, *Carassius gibelio*, populasyon yapısı, büyüme, kondisyon faktörü, üreme, ölüm ve sömürülme

Introduction

Silver crucian carp, *Carassius gibelio* (Bloch 1782), were distributed in East Asia-Siberia, and are now widely spread throughout Europe (Kottelat, 1997). This species is an omnivorous freshwater fish feeding on plants, detritus and animals (Specziar et al., 1997). The silver crucian carp was introduced into Lake Eğirdir at the beginning of the 1990s (Balık and Çubuk, 1998-1999). The population increased rapidly in the lake, and during this study it was the dominant fish species. This species has a commercial importance for fishing in Lake Eğirdir. Despite its importance, there is inadequate published

information about the size and sex compositions, growth, condition factor, reproduction and mortality and exploitation ratios. Knowledge of the life history of a species is an essential prerequisite for effective fishing management. The present study fills that gap with information about these features of the silver crucian carp population in Lake Eğirdir.

Materials and Methods

A total of 616 specimens of silver crucian carp were collected with 28, 40, 50, 60 and 70 mm mesh-size trammel nets and 18, 20, 22, 25 and 32 mm mesh-size gill nets in 4 different fishing areas (Köprü, Sarıkamış, Soğula and Hoyran) of Lake Eğirdir (Figure 1) between March 2001 and February 2002. For each sample, the fork length (L) was measured to 0.1 cm and the total weight (W) to 0.1 g. Reproductive state was assessed macroscopically and the weight of the gonads was recorded to 0.1 g. In addition, 10-20 scales from each fish were taken and the ages of specimens were determined according to Lagler's method (1966) by checking the scales. The increases in length and weight were determined by formulas given by Chugunova (1963): $RL = (L_t-L_{t-1})/L_{t-1}$ and $RW = (W_t-W_{t-1})/W_{t-1}$ where RL and RW are the increases in length and weight, respectively. L_t is the fork length (cm) at age t, L_{t-1} is the fork length (cm) at age t-1, W_t is the total body weight (g) at age t and W_{t-1} is the total body weight (g) at age t-1.

Growth was assumed to be described by the Von Bertalanffy growth curve model (Sparre and Venema, 1992): $L_t = L_\infty*[1-e^{-K(t-t_0)}]$ and $W_t = W_\infty*[1-e^{-K(t-t_0)}]^b$ where L_t is the fork length (cm) at age t, L_∞ is the theoretical maximum length (cm), K is a constant expressing the rate of approach to L_∞ and t_0 is the theoretical age at which $L_t = 0$. Overall growth performance (∅', phi prime) was calculated to compare growth parameters to other growth parameters reported for the same species from different lakes. This equation is ∅' (phi prime) = Log K + 2*Log L_∞ (Sparre and Venema, 1992). The length-weight equation was carried out by the least squares method on logarithmic transformed data by the equation $W = aL^b$ (Le Cren, 1951) where W is the total body weight (g), L is the fork length (cm) and a and b are parameters of regression. Confidence intervals of 95% were calculated for the slopes (b) to see if these were statistically different from 3 (Sparre and Venema, 1992). In the calculation of condition factor (C) we used the formula of Fulton's coefficient of condition factors $C = (W*100)/L^3$ (Ricker, 1975).

Total mortality rate (Z) was calculated by the linearized catch curve method based on the length composition of the catch (Sparre and Venema, 1992; Alp and Balık, 2000). With this aim, first the length (L1-L2)-

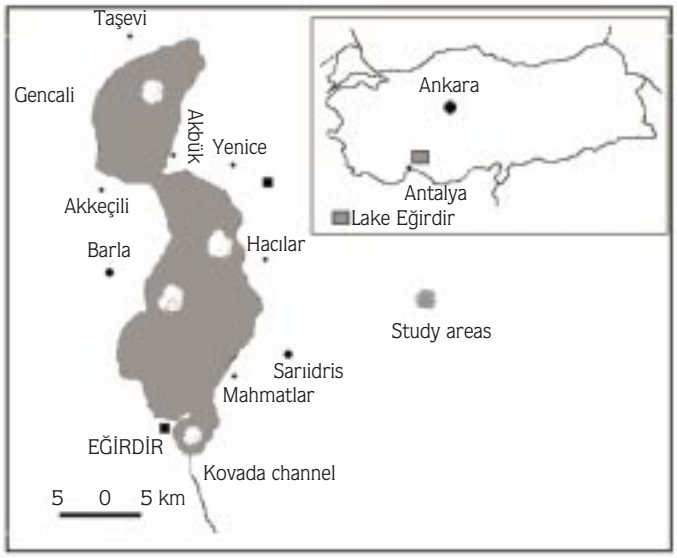

Figure 1. Map of Lake Eğirdir showing the study areas.

frequency ($N_{(L1,L2)}$) distribution of commercial catches was determined. Secondly, the relative ages ($t_{(L1)}$) per length class were calculated from the equation $t_{(L1)} = \{t_0-(1/K)*\ln [1-(L1- L_\infty)]\}$. Then Δt (Δt is the time it takes for an average fish to grow from length L1 to length L2) per length class was estimated using the equation $\Delta t = t_{(L2)}-t_{(L1)}$. After that a linear regression analysis was applied for $x = t((L1+L2)/2)$ and $y = \ln(N_{(L1,L2)}/\Delta t)$, and the slope (b) was determined to be Z. The M rate was calculated from Pauly (1980)'s empirical equation ($\ln M = -0.0152-0.279*\ln L_\infty + 0.6543*\ln K + 0.463*\ln T$) based on the parameters of the Von Bertalanffy growth functions (L_∞ and K) and on the mean annual water temperature (T). The F and exploitation (E) rates were calculated from the equations F = Z-M and E = F/Z.

The relationship between length and maturity was established by using a natural log transformation of the equation $P_L = 1/[1+e^{-r(L-Lm)}]$ (Gulderson et al., 1980 from Love and Johnson, 1998; King, 1996 from Turkmen, 2003) to yield $\ln [(1-P_L)/P_L] = aL + b$ where P_L is the proportion of mature individuals at length L, and a and b (r) are regression parameters. Then, L was plotted against $\ln [(1-P_L)/P_L]$ using simple linear regression to estimate values for a and b. The mean lengths at 50% maturity were calculated by Lm = a/r where a is intercept and r is -b (slope). The spawning season was determined to quantify changes in gonad size with season. With this aim, the gonado-somatic index (GSI) was computed by the equation $GSI = (W_g*100)/W$ (Le Cren, 1951) where W_g is the gonad weight (g) and W is the total body weight (g). The egg number was determined by the gravimetric method (Nikolsky, 1963). The relation between fecundity and fork length was described by the function $Fecundity = aL^b$.

We tested differences between growth and condition factor in males and females within the same age groups by t-test and differences among measured and theoretical values of length and weight by χ^2 -test (Yurtsever, 1984; Elbek et al., 2002).

Results

Sex, age and length compositions

The sex and age distributions of the 616 silver crucian carp from Lake Eğirdir are given in Table 1.

As seen in Table 1, 53.4% of the samples were male and 46.6% female. The sex ratio was 0.87 females to 1 male. This ratio was significantly different from the 1:1 (χ^2, $P < 0.05$) in the samples observed. Age groups ranged from I to V for males and from I to VI for females. Fish samples in age group III were the most common (34.7%). The majority of the specimens were in age groups II, III and IV (78.1%). The fork lengths of the silver crucian carp population ranged from 9 to 33 cm, the majority being 20-26 cm (Figure 2).

Table 1. The sex and age compositions of silver crucian carp from Lake Eğirdir during the study.

Age Groups	Male		Female		Combined Sexes	
	N	%	N	%	N	%
I	48	7.8	31	5.0	79	12.8
II	103	16.7	49	8.0	152	24.7
III	137	22.2	77	12.5	214	34.7
IV	38	6.2	77	12.5	115	18.7
V	3	0.5	41	6.7	44	7.1
VI	0	0.0	12	1.9	12	1.9
Total	329	53.4	287	46.6	616	100

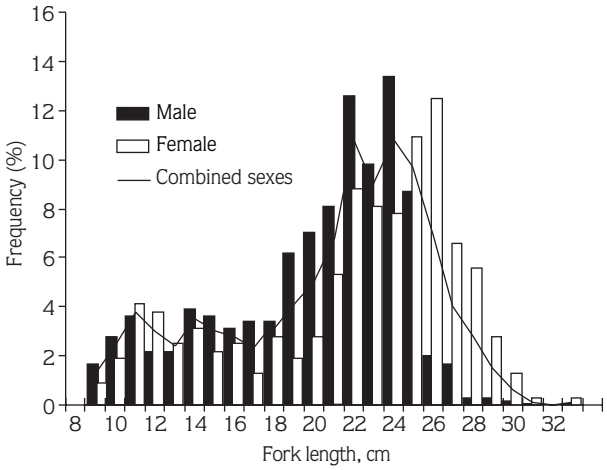

Figure 2. Length distribution of silver crucian carp samples from Lake Eğirdir.

Growth

Increase in length

The mean lengths with confidence intervals (CI) at 95% significance levels and standard deviations (s) for male, female and combined sexes of each age group are given in Table 2. The difference in length between males and females was statistically significant only in age group II.

Table 2. The mean lengths of the different age groups of silver crucian carp from Lake Eğirdir.

Age groups	Male		Female			Combined Sexes	
	$\bar{L}$ ± CI	s	$\bar{L}$ ± CI	s	P = 0.05	$\bar{L}$ ± CI	s
I	12.1 ± 0.650	2.242	11.7 ± 0.542	1.480	>	11.9 ± 0.446	1.990
II	18.5 ± 0.531	2.724	17.4 ± 0.894	3.112	<	18.1 ± 0.452	2.814
III	22.9 ± 0.277	1.636	22.8 ± 0.364	1.603	>	22.9 ± 0.217	1.623
IV	25.2 ± 0.437	1.334	25.6 ± 0.321	1.416	>	25.5 ± 0.261	1.414
V	26.7 ±		27.5 ± 0.388	1.231	>	27.4 ± 0.388	1.274
VI	-	-	29.6 ± 1.042	1.656		29.6 ± 1.042	1.656

The relative increases in length among all age groups except for age group I were higher for females than males, although the rate showed a gradual decrease with age (Table 3).

Lengths based on the Von Bertalanffy growth equations for sex groups and combined sexes were estimated as in Table 4. Growth parameters showed that females grew to a greater theoretical maximum length (L_∞) than males, but the rate at which this was achieved (K) was less than in males (Table 4 and Figure 3). No significant differences were found among observed and calculated lengths for both sexes (χ^2, P > 0.05).

The ∅' values of male, female and combined sexes were calculated as 2.61, 2.57 and 2.58, respectively.

Growth in weight

The mean weights in age groups I and II were higher for males, and in the older age groups for females (Table 5). However, only the difference in age group IV was statistically significant (P < 0.05).

Table 3. The relative increase in length of silver crucian carp for male, female and combined sexes.

Age Groups	Male		Female		Combined Sexes	
	$\bar{L}$	RL	$\bar{L}$	RL	$\bar{L}$	RL
I	12.1		11.7		11.9	
		0.529		0.487		0.521
II	18.5		17.4		18.1	
		0.238		0.310		0.265
III	22.9		22.8		22.9	
		0.100		0.118		0.114
IV	25.2		25.6		25.5	
				0.078		
V	26.7		27.5		27.4	

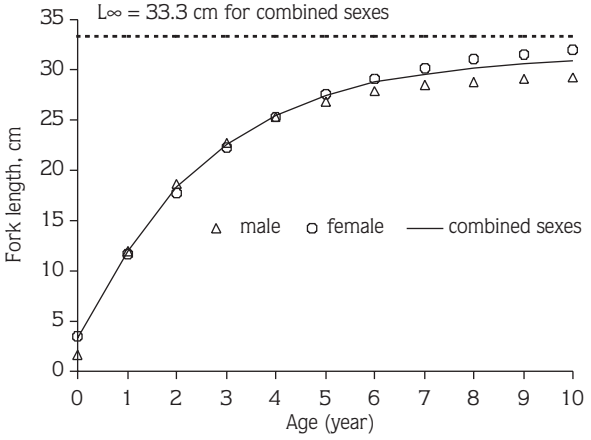

Figure 3. Age-length relationship curves of silver crucian carp from Lake Eğirdir.

Table 4. The growth parameters and Von Bertalanffy growth equations in length for male, female and combined sexes.

Sex	L_∞	K	t_0	Von Bertalanffy growth equations
Male	29.5	0.470	-0.1241	$L_t = 29.5*[1-e^{-0.470\ (t + 0.1241)}]$
Female	34.2	0.316	-0.3474	$L_t = 34.2*[1-e^{-0.316\ (t + 0.3474)}]$
Combined Sexes	33.3	0.346	-0.3026	$L_t = 33.3*[1-e^{-0.346\ (t + 0.3026)}]$

Table 5. The mean weights of the different age groups of silver crucian carp from Lake Eğirdir.

Age groups	Male		Female			Combined Sexes	
	$\bar{W} \pm CI$	s	$\bar{W} \pm CI$	s	P = 0.05	$\bar{W} \pm CI$	s
I	44.9 ± 9.615	33.141	37.5 ± 5.863	16.002	>	42.0 ± 6.276	28.033
II	150.7 ± 12.608	64.623	133.7 ± 18.714	65.174	>	145.2 ± 10.600	66.002
III	295.6 ± 11.441	67.636	299.5 ± 13.640	60.146	>	297.0 ± 8.794	65.637
IV	421.6 ± 23.648	72.166	466.1 ± 18.514	81.636	<	451.4 ± 14.905	80.725
V	546.7 ±		606.2 ± 23.916	75.809	>	602.1 ± 24.287	79.754
VI	-	-	857.5 ± 56.863	90.358		857.5 ± 56.863	90.358

The relative increase in weight was higher for females than males in all age groups. As can be seen in Table 6, its level decreased gradually with age.

Growth parameters and Von Bertalanffy growth equations for male, female and combined sexes are given in Table 7. As shown in Table 7 and Figure 4, females had a higher theoretical maximum weight (W_∞) than males. Differences between observed and calculated weights were statistically significant (χ^2, $P < 0.05$) for females and the combined sexes, but not for males.

Length-weight relationship

The equations of the length-weight relationship were determined by using the lengths and weight of the samples as follows:

For males $W = 0.0185\ L^{3.109}$ $r = 0.998$

For females $W = 0.0134\ L^{3.223}$ $r = 0.999$

For the combined sexes $W = 0.0165\ L^{3.152}$ $r = 0.999$

Table 6. The relative growth in weight of silver crucian carp for male, female and combined sexes.

Age Groups	Male		Female		Combined Sexes	
	$\bar{W}$	RW	$\bar{W}$	RW	$\bar{W}$	RW
I	44.9		37.5		42.0	
		2.356		2.565		2.457
II	150.7		133.7		145.2	
		0.962		1.240		1.045
III	295.6		299.5		297.0	
		0.426		0.556		0.520
IV	421.6		466.1		451.4	
				0.301		
V	546.7		606.2			

Figure 4. Age-weight relationship curves of silver crucian carp from Lake Eğirdir.

Table 7. The growth parameters and Von Bertalanffy growth equations in length for male, female and combined sexes.

Sex	W_∞	K	t_0	b	Von Bertalanffy growth equations
Male	686.8	0.470	-0.1241	3.109	$W_t = 686.8*[1-e^{-0.470\ (t + 0.1241)}]^{3.109}$
Female	1178.3	0.316	-0.3474	3.223	$W_t = 1178.3*[1-e^{-0.316\ (t + 0.3474)}]^{3.223}$
Combined Sexes	1038.1	0.346	-0.3026	3.152	$W_t = 1038.1*[1-e^{-0.346\ (t + 0.3026)}]^{3.152}$

The slope (b) values of the length-weight regression of both sexes were significantly different from 3. These results showed that the silver crucian carp population in Lake Eğirdir grows allometrically.

The curves of the length-weight relationship obtained from the equations of the length-weight relationship are shown in Figure 5.

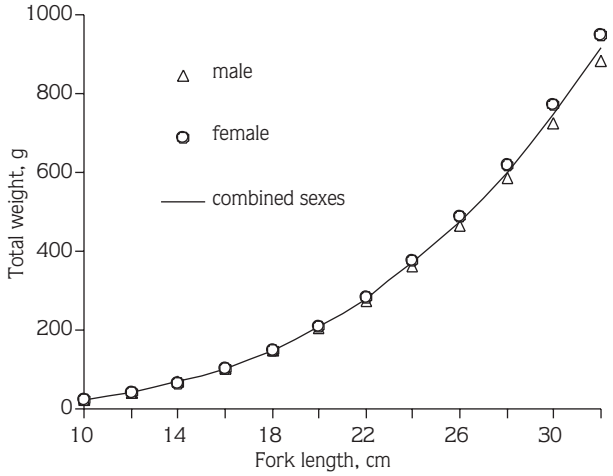

Figure 5. Length-weight relationship curves for males, females and combined sexes of silver crucian carp from Lake Eğirdir.

Condition factor

The mean condition factor ($\bar{C}$) was calculated as 2.401 for males and 2.594 for females. The condition factors of females in all age groups except for age group I were higher than those of males (Table 8). However, the differences in the condition factors between males and females in the same age groups were statistically significant only for age groups III and IV ($P < 0.05$). Differences in mean condition factors of males and females were also statistically significant ($P < 0.05$).

Reproduction

Sexual maturity began at about 8 cm for males and 9 cm for females. Fifty percent of males and females were mature at about 9.7 cm and 10.3 cm, respectively (Table 9 and Figure 6).

Table 9. Maximum-likelihood estimates for the parameters of the logistic equation relating the proportion of mature individuals to lengths of silver crucian carp.

Sex	a	b	$L_{50\%}$, cm	r^2
Male	9.2310	0.9511	9.7	0.978
Female	7.4647	0.7245	10.3	0.980

The GSI values of females were usually higher than those of males during the study. As can be seen in Figure 7, the highest GSI values of both sexes were observed in April, when water temperature was 13 °C. There was a gradual decrease in the mean GSI values of females from April to August, and this was similar in August and September.

The fecundity of silver crucian carp ranged from about 42,000 to 141,000 for individuals weighing 224-555 g captured just prior to spawning. Relative fecundity was 204 eggs g^{-1} of total body weight. A positive correlation was found between the length and weight of the specimens and their egg numbers. The relationship

Table 8. Mean condition factor ($\bar{C}$) values with confidence intervals (CI) and their standard deviations (s) for different age groups of silver crucian carp samples from Lake Eğirdir.

Age groups	Male		Female			Combined Sexes	
	$\bar{C}$ ± CI	s	$\bar{C}$ ± CI	s	P = 0.05	$\bar{C}$ ± CI	s
I	2.249 ± 0.087	0.299	2.231 ± 0.080	0.217	>	2.239 ± 0.060	0.269
II	2.257 ± 0.050	0.256	2.343 ± 0.125	0.435	>	2.288 ± 0.049	0.302
III	2.437 ± 0.043	0.252	2.533 ± 0.071	0.312	<	2.455 ± 0.037	0.273
IV	2.619 ± 0.082	0.250	2.766 ± 0.066	0.292	<	2.719 ± 0.053	0.288
V	2.878 ±		2.932 ± 0.074	0.235	>	2.921 ± 0.077	0.254
VI	-		3.326 ± 0.245	0.390	-	3.326 ± 0.245	0.390
Mean	2.386 ± 0.032	0.293	2.629 ± 0.048	0.419	<	2.486 ± 0.030	0.381

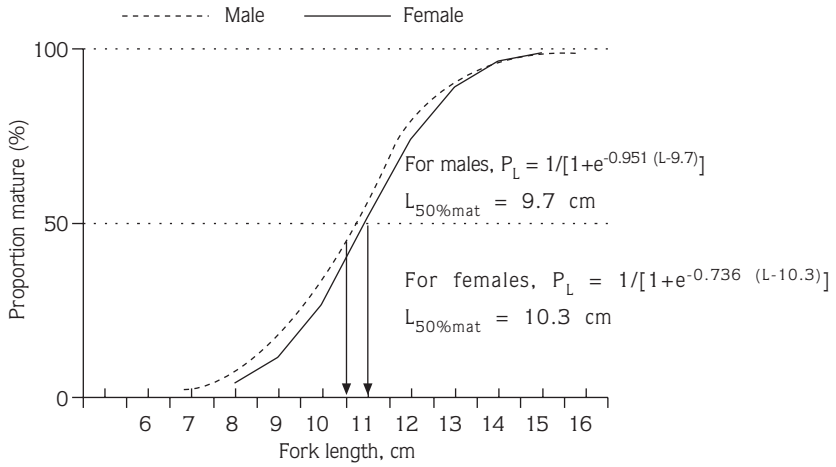

Figure 6. Length-maturity relationship for male and female silver crucian carp from Lake Eğirdir.

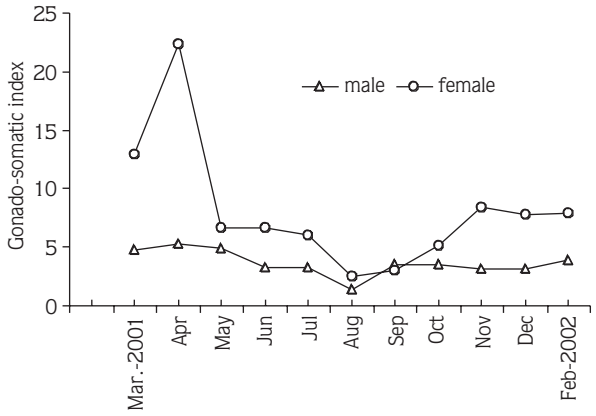

Figure 7. Gonado-somatic index cycles of silver crucian carp from Lake Eğirdir.

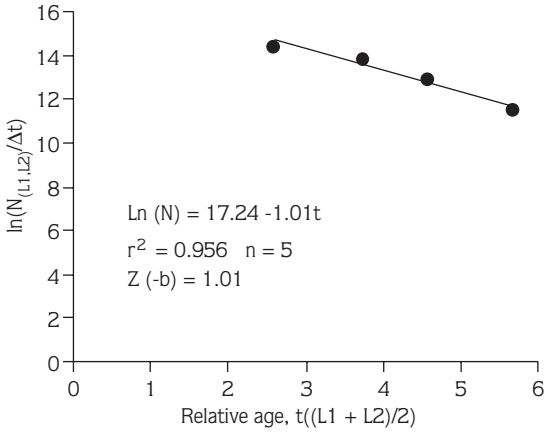

Figure 8. Linearized catch curve based on length composition data for the silver crucian carp population from Lake Eğirdir during the study.

equations between the fecundity of the female silver crucian carp population and their lengths and weights are:

Fecundity = 0.657 $L^{3.694}$ r = 0.876

Fecundity = 208.86 $W^{0.991}$ r = 0.870

Mortality and exploitation rates

The M rate of silver crucian carp stock in Lake Eğirdir was calculated at M = 0.63 $year^{-1}$. In determining the natural mortality rate, L_∞ and K values from Von Bertalanffy growth parameters, and the mean water temperature value (T) of Lake Eğirdir were used. The total mortality rate was estimated at Z(-b) = 1.01 ± 0.4 (±CI) using the length based linearized catch curve method as seen in Figure 8.

Discussion and Conclusion

The silver crucian carp is an exotic fish species for Lake Eğirdir. It was introduced into the lake at the beginning of the 1990s (Balık and Çubuk, 1998-1999).

The sex ratio in most species is close to 1 (Bagenal, 1978). However, it was 0.87 females to 1 male in our study, and this ratio was significantly different from 1:1. The age and length distributions of the silver crucian carp population ranged from ages I to VI, and from 9 to 33 cm. Males were more numerous in the younger age groups and females in age groups IV and above. Ekmekçi and Erk'akan (1992), Çalışkan et al. (1999), Türkmen and Akyurt (2000), Oymak et al. (2001) and Canbolat et

al. (1999) reported similar results regarding the sex compositions of different age groups of some fish species. It can be stated from these results that male individuals of the silver crucian carp population are shorter-lived than females.

Growth in fish continues during their natural life-period, but decreases with age (Atay, 1989). In our study, similar results were found for silver crucian carp. The highest relative increases in length and weight were in age group I. However, these decreased gradually with age. Similar results were reported by Altındağ et al.(1998) for tench, *Tinca tinca* (L., 1758) in Kesikköprü Dam Lake, Canbolat et al. (1999) for *Capoeta capoeta capoeta* (Guldenstant, 1773) in Lake Çıldır, Çalışkan et al. (1999) for *Barbus plebejus* Heckel, 1843 in Lake Çıldır, Altındağ et al. (1999) for pike, *Esox lucius* L., 1758 in Kesikköprü Dam Lake, Türkmen and Akyurt (2000) for *Chalcalburnus mosullensis* (Heckel, 1843) in the Aşkale region of the River Karasu and Altındağ et al. (2002) for tench in Bayındır Dam Lake. The relative increase in length between age groups I and II was higher for males, and in older age groups for females. However, the relative increases in weight among all age groups were higher for females than males. This variation can be attributed to differences in the GSI values of males and females.

The theoretical maximum length and weight values of males and females (L_∞ = 29.5 cm and W_∞ = 686.8 g for males, L_∞ = 34.2 cm and W_∞ = 1178.3 g for females) were close to those of the largest fish samples (29.1 cm and 671 g for males and 33.3 cm and 1018 g for females). The theoretical maximum length and weight of females were higher than those of males. However, the Brody growth coefficient of males (K = 0.470 $year^{-1}$) was higher than that of females (K = 0.316 $year^{-1}$), depending on the theoretical maximum length and weight. In some studies similar results were also found for different species (Altındağ et al., 1998; Türkmen and Akyurt, 2000; Oymak et al., 2001). This may be related to growth rates and life-spans of the sex groups. According to Moreau et al. (1986) and Sparre and Venema (1992) ∅' is the best index of overall growth performance, in the sense that it has minimum variance. Therefore, Sparre and Venema (1992) proposed that growth parameters (L_∞, K and t_0) should not be compared one by one to the results of other studies. The ∅' values calculated from the growth parameters and annual mean temperature of the lake water should be compared to other growth studies on the same species if such work exists. For silver crucian carp from Lake Eğirdir, the ∅' values of male, female and combined sexes were 2.61, 2.57 and 2.58, respectively. These values were higher than the 2.47 reported for the same species in Lake Balaton (Specziar et al., 1997). This difference in growth performance between the lakes can be attributed to the difference in size of the largest individuals sampled. In addition, it is possible that growth is affected by ecological factors such as food abundance and temperature in different areas.

The slope (b) values of the length-weight relationship in both sexes (b = 3.109 for males, b = 3.223 for females and b = 3.152 for combined sexes) showed that weight increased allometrically with length. For the same species, the b value was reported to be 3.11 in Lake Volvi (Macedonia) by Kleanthidis et al. (2000) and 2.98 in China by Sifa (1998). These (b) values in fish differ according to species, sex, age, season and feeding (Tesch, 1968). In addition, it may be related to the size composition of sex groups. Altındağ et al. (1998) found that the b value for tench in Kesikköprü Dam Lake for individuals having reached sexual maturity was greater than that for those that had not reached sexual maturity yet, and that the b value increased with age. In the silver crucian carp population in Lake Eğidir, males were more numerous in the younger age groups, and females in the older age groups. Thus, the b value of females may be higher.

It was determined that the condition factor of both sexes increased gradually with age. This increase was usually higher for females than males. In addition, the condition factor of females in all age groups except for age group I was higher than that of males. The mean condition factor of females was significantly higher than that of males. The condition factor exhibits changes depending on gonad development, age, seasonal changes in growth and net mesh size (Ricker, 1975; Le Cren, 1951). This difference in our study could be also attributed to the different GSI values of males and females. For instance, prior to spawning the GSI values of females were approximately 20, while this value was about 5 for males.

The L_m was 9.7 cm for males and 10.3 cm for females. For this species, the first maturity length was reported to be 11 cm for males and 13 cm for females in the floodplain lakes in the middle of Selenga by Dulmaa

(1999), and 14.5 cm for unsexed fish in Lake Sevan by Gabrielyan (2001). The first maturity size of the silver crucian carp population in Lake Eğirdir was lower than those of Lake Sevan and the floodplain lakes in the middle of Selenga. It has been observed that cool waters produce larger, older and later maturing individuals of a species than warm waters (Bagenal, 1978). Therefore, the first maturity size of the same species may vary for different lakes in various parts of the world. The reproductive activity of silver crucian carp in Lake Eğirdir takes place between April and August, reaching a peak in April. However, this period may change more or less year by year, depending on the ecological characteristics of the water system, such as the temperature of the water in which they live.

The M, F and Z rates were estimated at M = 0.63 $year^{-1}$, F = 0.38 $year^{-1}$ and Z = 1.01 $year^{-1}$. The M rate was rather high, although the F rate was very low because of insufficient fishing. This situation was also observed from fishing activity during the study. The E rate is an index of fishing levels, and it should be E = 0.50 for maximum sustainable fishing (Atay, 1989). However, the E rate for the silver crucian carp population in Lake Eğirdir is rather low (E = 0.38).

Consequently, the present fishing regulations in Lake Eğirdir (Tarım ve Köyişleri Bakanlığı, 2002) are suitable for the silver crucian carp population. However, fishing pressure on this species is insufficient. For optimal fishing and for more yield to be obtained from this species, fishing should be supported under control for 1 or 2 years. Otherwise, both the silver crucian carp population and those of other cyprinids such as the common carp, *Cyprinus carpio* L., 1758 and zahnte, *Vimba vimba* L., 1758 in the lake may be negatively affected in the future.

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