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Some Characteristics and Size of Carp (*Cyprinus carpio* L., 1758) Population in the Lake Karamık (Afyonkarahisar/Turkey)

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Abstract

In this study, some population characteristics such as age, length, weight, condition, growth, mortality rates and size of carp (*Cyprinus carpio* L., 1758) population in the Lake Karamık were investigated. The ages, fork lengths and weights of the examined 108 individuals ranged between I-X years, 9-70 cm, and 16-8780 g, respectively. The mean condition factor of the population was calculated as 2.022. The length-weight relationship and von Bertalanffy growth equations were $W = 0.0245*L^{2.952}$ ($r^2 = 0.996$) and $L_t = 130*[1-e^{-0.0754*(t+0.2452)}]$, respectively. The total (Z), natural (M) and fishing mortality (F) rates were Z = 0.40 yr^{-1}, M = 0.16 yr^{-1}, and F = 0.24 yr^{-1}, respectively. The number of fish longer than 25 cm in the population and their respective biomass were estimated as 47,847 individuals and 53,893 kg. In addition, it was determined that the maximum sustainable yield could be obtained with 60% of the present fishing effort.

Key words: Growth, mortality, biomass, maximum sustainable yield.

Introduction

Carp (*Cyprinus carpio* L., 1758) is the main species for the fresh water fisheries in Turkey. The annual total catch of fresh water fish in Turkey during the last 10 years has varied between about 43 000 and 50 000 tonnes. About 30-35% of total catch consisted of the carp (Seçer *et al*., 2005). Carp is widely distributed in nearly all fresh waters of Turkey. This species is also one of two economic fish species in the Lake Karamık. Another economic fish species in the lake is pike (*Esox lucius* L., 1758). Although many studies have already been conducted on carp populations in different habitats of Turkey, there is no study about this species in the Lake Karamık. Carp fishing in this lake has been regulated according to information on the other carp populations in the same region such as the Lakes of Eğirdir, Akşehir and Beyşehir, etc. For effective fisheries management, biological characteristics of a fish species for each habitat should be separately investigated and their stocks should be regularly monitored.

For this reason, some population characteristics of the carp population in the Lake Karamık, such as age, length and weight distributions, condition factors, length-weight relationship and growth parameters, and mortality rates, were investigated. An estimate for its population size was also provided.

Materials and Methods

The Lake Karamık is located in the southwest of Turkey. It has a surface area of 38 km^2 and a mean depth of 2-3 m. Most of the surface area of the lake was covered by vegetation. Fish samples were obtained monthly by gillnets with mesh sizes (stretched mesh) of 36, 40, 44, 50, 60, 70, 80 and 90 mm, and trammel nets with mesh sizes of 100, 120, 140 and 160 mm at three selected sampling sites in the Lake Karamık (Figure 1) from March 2002 to February 2003.

The fork length (L±1 mm) and weight (W±1 g) of each sampled fish were recorded. Scale samples from each fish were taken and their ages were determined according to Lagler's method (Lagler, 1956) by checking the scales. In addition, catch and length-frequency distributions of carp caught by fishermen in year were determined.

The mean lengths and mean weights of different age groups were calculated and Fulton's coefficient of condition factor (K) was computed from the formula $(W/L^3)*100$ (Ricker, 1975). The length - weight relationship was determined from $W = a*L^b$ equation (Pauly, 1983). 95% confidence interval (CI) was calculated for the slope (b) to see if this was statistically different from 3 (Sparre and Venema, 1992). Growth in length was determined using the von Bertalanffy growth equation $L_t = L_\infty * [1-e^{-k*(t-t0)}]$. The parameters of the von Bertalanffy were estimated by using the Ford-Walford plot method (Sparre and Venema, 1992). Where (L_t) is the fork length (cm) at age (t), (L_∞) is the asymptotic length (cm), (k) is a growth coefficient (yr^{-1}), and (t_0) is the hypothetical age of the fish at zero length. In addition, overall growth performance (Ø') was calculated to compare growth parameters with other growth parameters reported for the same species from different lakes. This equation is $Ø' = Ln\ k+2*Ln\ L_\infty$ (Sparre and Venema, 1992).

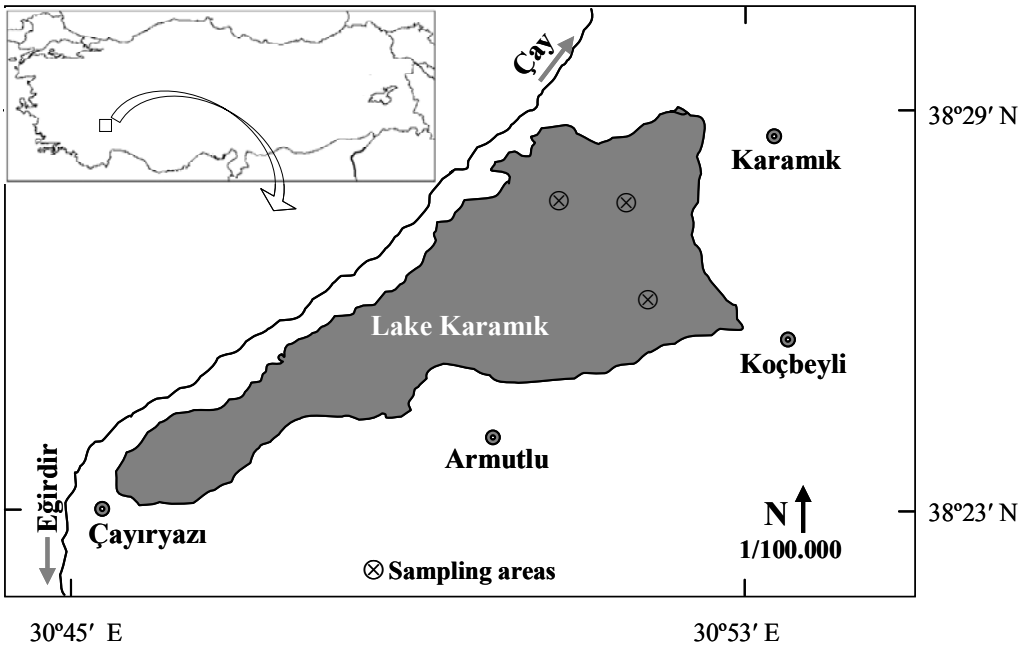

Figure 1. The location of the Lake Karamık and sampling areas.

Total mortality (Z) was determined by the linearized catch curve method based on the length composition of the commercial catch (Pauly, 1983). The natural mortality (M) was estimated by using the calculated L_∞, k and the annual mean water temperature (ºC) based on the empirical equation of Pauly (1980). The fishing mortality (F) and exploitation (E) rates were calculated from the equations F = Z-M and E = F/(F+M).

The carp stock was assessed using Jones' length-based cohort analysis. In the prediction of the yield and biomass of the carp population, the length-based Thompson and Bell Model was applied (Sparre and Venema, 1992). In addition, the optimum effort was determined from predicted biomass-yield relationships in different levels of the present effort for maximum sustainable yield (MSY).

Results

Some Population Parameters

During the study, only 108 carp could be caught with experimental nets. Fishing with gillnets and trammel nets could be carried out only in small part of this lake because of vegetation. Therefore, except for reproduction period catching efficiency of the nets was very low. In addition, it was observed during the study that most of carp were caught by fishermen in reproduction period. The number of male and female carp samples was insufficient to investigate biological characteristics for each sex group separately. Therefore, population parameters of carp were analyzed for only combined sexes. The ages, lengths and weights of the samples ranged between I-X years, 9-70.4 cm and 18-8780 g. The mean condition factor was calculated as 2.022±0.052 (±SE). The mean lengths, weights and condition factors of different ages are given in Table 1.

The length-weight relationship of the carp population in Lake Karamık was $W= 0.0245*L^{2.952}$ (r^2 = 0.996). The slope value of the length-weight regression (b = 2.952±0.031; ± 95% CI) was significantly different from 3. The von Bertalanffy growth equation was $L_t = 130*[1-e^{-0.0754*(t+0.2452)}]$. The Ø' value was calculated as 7.150 using L_∞ and k values.

Mortality Rates

The Z rate of the carp stock for over 25 cm in length was estimated as 0.40±0.003 yr^{-1} (± 95% CI) using the length-based linearized catch curve method as seen in Figure 2.

Using L_∞ = 130 cm, k = 0.0754 yr^{-1} and T = 14ºC values, the M rate of the carp stock was calculated to be 0.16 yr^{-1}. The F and E rates were also calculated as 0.24 yr^{-1} and 0.60 yr^{-1}, respectively.

Stock Size

It was determined that a total of 22,602 carp were recruited to the exploited stock when they were 25 cm in fork length (Table 2). As shown in Figure 3, a part of these individuals was caught by fishermen, another part died because of natural causes, and 115 of them reached 70 cm in fork length. According to length intervals, number of individuals and mean fish

Table 1. The number (n), mean length (L), weight (W) and condition factor (K) of carp samples by age groups [± Standart Error; (Min.-Max.)]

Age groups	n	L	W	K
0	12	10.0±0.2 (9.0-11.2)	22.8±1.6 (16-33)	2.246±0.076 (1.912-2.695)
I	31	13.4±0.5 (9.2-19.5)	58.3±7.0 (18-168)	2.146±0.040 (1.652-2.587)
II	13	21.5±0.4 (18.4-23.6)	224.8±14.8 (144-301)	2.254±0.053 (1.935-2.491)
III	5	26.9±0.8 (25.1-30)	440.5±34.4 (350-558)	2.313±0.055 (2.213-2.493)
IV	4	37.1±2.3 (33-43.2)	1022.8±148.2 (778-1,412)	2.007±0.123 (1.751-2.243)
V	13	43.3±0.9 (37-48.5)	153.5±73.2 (1064-1912)	1.871±0.037 (1.676-2.101)
VI	9	51.1±1.3 (45.8-58.6)	2677±212 (1622-3784)	1.973±0.062 (1.688-2.274)
VII	8	58.1±1.2 (53-63)	4111±257 (3180-5512)	2.086±0.040 (1.928-2.272)
VIII	10	61.1±1.0 (57-67)	4739±220 (3662-5870)	2.079±0.067 (1.795-2.534)
IX	1	69	6585	2.005
X	2	69.7 (69-70.4)	7822 (6865-8780)	2.303 (2.090-2.516

Table 2. The calculation procedure of Jones' length-based cohort analysis (k = 0.0754 yr^{-1}, L_∞ = 130 cm, M = 0.16 yr^{-1}, the asterisk indicates terminal F/Z [assumed to be 0.5)]

Length interval						Catch	Survivor			
L_1-L_2	N	$t_{(L1)}$	Δt	$\overline{W}$	$H_{(L1,L2)}$	$N_{(L1,L2)}$	$N_{(L1)}$	F/Z	F	Z
25-29.9	6	2.833	-	0.435	1.0531	344	22602	0.135	0.025	0.185
30-34.9	32	3.480	0.647	0.712	1.0559	1833	20053	0.482	0.149	0.309
35-39.9	66	4.160	0.680	1.086	1.0590	3780	16249	0.709	0.390	0.550
40-44.9	82	4.877	0.717	1.571	1.0625	4696	10919	0.829	0.774	0.934
45-49.9	46	5.635	0.758	2.182	1.0664	2634	5252	0.849	0.897	1.057
50-54.9	15	6.439	0.804	2.931	1.0709	859	2148	0.798	0.630	0.790
55-59.9	7	7.295	0.856	3.834	1.0759	401	1071	0.773	0.546	0.706
60-64.9	4	8.210	0.915	4.905	1.0818	229	553	0.784	0.581	0.741
65-69.9	2	9.193	0.983	6.156	1.0886	115	260	0.785	0.584	0.744
70-∞	1	10.255	1.062	7.601		57	115	0.500*	0.160	0.320

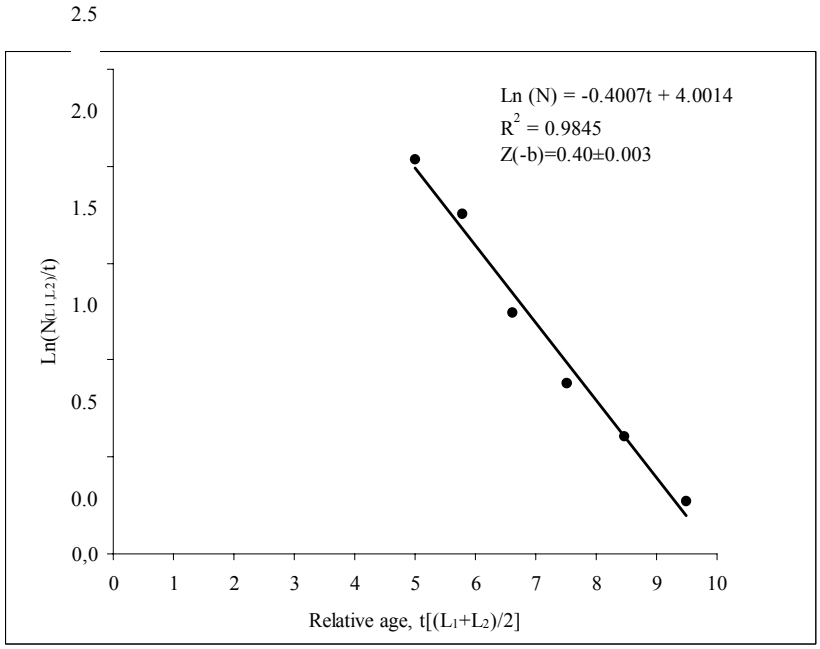

Figure 2. Linearized catch curve based on length composition data for the carp population in the Lake Karamık.

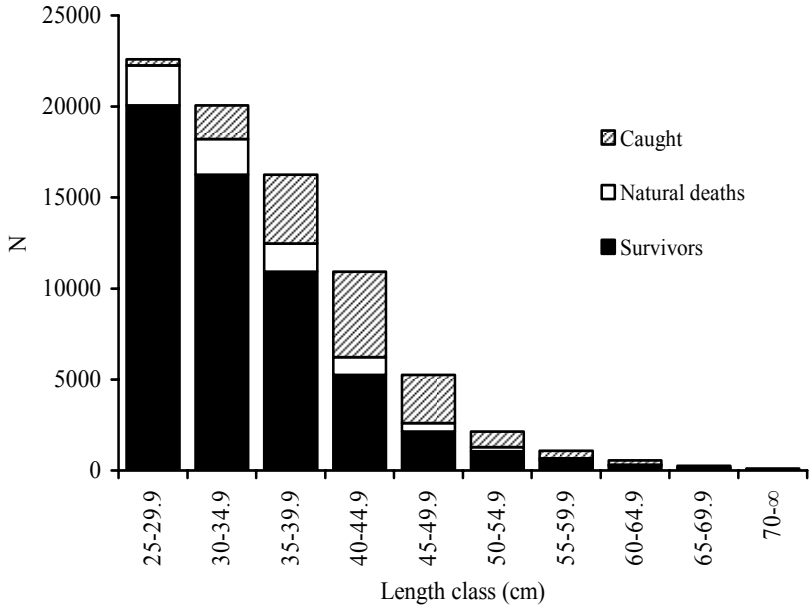

Figure 3. The fate of the carp recruited to the exploited stock.

biomass of carp longer than 25 cm, are given in Table 3. The carp stock was estimated as 47,847 individuals in number and 53,893 kg in biomass.

Stock Analysis for MSY

At present fishing effort, the yield was 25,000 kg and the mean biomass was estimated as 53,893 kg. The yield and biomass were predicted as shown in Figure 4 for different levels of fishing effort. These results showed that maximum sustainable yield could be obtained with 60% level of the present fishing effort.

Discussion

In a fish population, if the age composition has a wide range, it indicates that this habitat has a sufficient food supply (Ünver, 1998). The age, length and weight distributions of the carp captured with experimental nets in the Lake Karamık ranged between I-X years, 9-70 cm and 16-8,780 g, respectively. However, the smallest carp caught in commercial fishing was 25 cm in fork length. Probably, small individuals caught in the nets were released into the lake by fishermen; because small carp are not popular among consumers. Also, fishing circular prohibits catching carp smaller than 30 cm total length in all Turkish lakes (TKB, 2004), which is equal to 28 cm fork length. The maximum age was the same or close to the ages reported in the previous studies on the carp populations in the Lakes Akşehir (Alp *et al*., 1999), Beyşehir (Balık, 1997), Çıldır (Yerli and Zengin, 1996) and the Mamasın Dam Lake (İkiz, 1988). However, it was higher than those of carp populations in the Lakes Tödürge (Erdem, 1988), Gölhisar (Alp and Balık, 2000), Kazova Kaz (Karataş, 2000), the Altınkaya Dam Lake (Bircan and Erdem, 1994) and the Karacaören I Dam Lake (Balık and Çubuk, 1999). Although the maximum age of the carp population in the Lake Karamık was similar to ages reported in the Lakes Akşehir (Alp *et al*., 1999) and Çıldır (Yerli and Zengin, 1996), their the maximum length and weight were higher than those of the Lakes Akşehir (45 cm and 1562 g) and Çıldır (54 cm and 2220 g). These differences may be due to net selectivity, fish activity, fishing pressure, feeding habits and the ecological characteristics of the lakes. The mean condition factor was calculated as 2.022. The mean condition factor of carp population for the Lakes; Çıldır (Yerli and Zengin, 1996), Gölhisar (Alp and Balık, 2000), Akşehir (Alp *et al*., 1999), Tödürge (Erdem, 1988), Beyşehir (Balık, 1997), Hafik (Cengizler and Erdem, 1989), Bafra Balık Lake (Demirkalp, 1992) and for the Karacaören I Dam Lake (Balık and Çubuk, 1999) and the Mamasın Dam Lake (İkiz, 1988) was reported as 1.83, 1.579, 1.668, 1.836, 1.915, 1.96, 1.842, 1.78 and 2.286, respectively. It is clear that the mean condition factor of the carp population in the Lake Karamık is higher than that of many other carp populations in Turkey. The reason may largely be attributed to feeding opportunities.

The length-weight relationship of the carp population in the Lake Karamık was $W=0.0245*L^{2.952}$. The slope value of the length-weight relationship showed that body weight increased allometrically with fork length. Similar

Table 3. Mean number of fish, mean biomass and annual yield of carp over 25 cm

Length Interval	Mean Fish Number	Mean Biomass (kg)	Yield (kg)
L_1-L_2	$\overline{N}_{(L1, L2)}$*Δt	$\overline{B}$ *Δt	$Y_{(L1, L2)}$
25-29.9	13786	5991	149
30-34.9	12319	8766	1304
35-39.9	9691	10552	4104
40-44.9	6068	9533	7378
45-49.9	2937	6407	5747
50-54.9	1363	3995	2518
55-59.9	735	2818	1537
60-64.9	394	1934	1123
65-69.9	196	1206	705
70-∞	358	2721	435
Total	47847	53893	25000

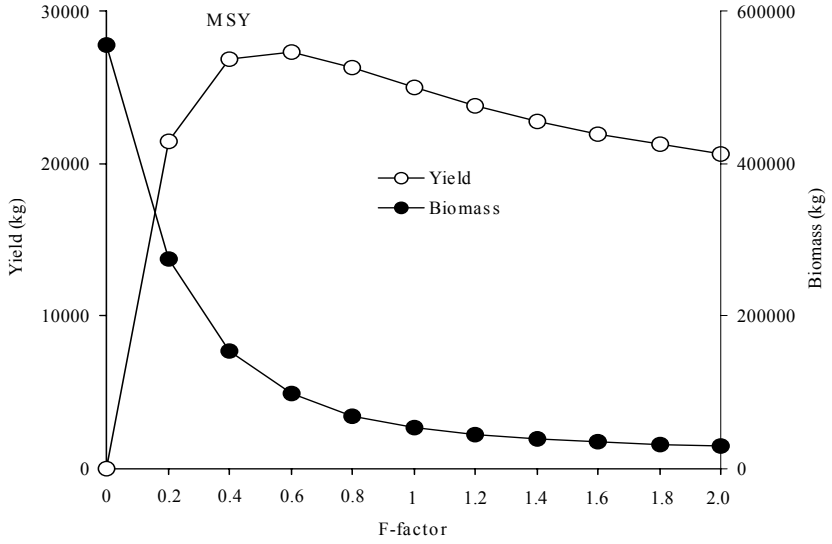

Figure 4. Prediction of yield-biomass relationships at various fishing effort levels.

results were reported by Alp *et al*. (1999) and Alp and Balık (2000) as 2.8438 and 2.8739, respectively. However, different results were also reported by İkiz (1988), Erdem (1988), Cengizler and Erdem (1989) as 2.3828, 2.4887 and 2.71298, respectively. These variations could be attributed to differences in age, maturity and sex. Geographic location and associated environmental conditions, such as seasonality, stomach fullness, disease and parasite loads, can also affect the value of b (Bagenal and Tesh, 1978).

The Ø' value of the carp population in the Lake Karamık was 7.150. This value was calculated as 6.803, 7.090, 6.573, 6.028, 6.897, 5.995, 6.816 and 6.168 using L_∞ and k values reported in the studies of Düzgüneş (1985), Erdem (1982), Erdem (1988), Cengizler and Erdem (1989), İkiz (1988), Alp *et al*. (1999), Alp and Balık (2000) and Özyurt and Avşar (2001), respectively. The growth performance of the carp population in the Lake Karamık was higher than that in other comparable Turkish lakes or reservoirs.

Mortality rates are important for understanding the rate of population decay (Ricker, 1975, Sparre and Venema, 1992). The Z, M and F rates for the carp stock over 25 cm in fork length were estimated as 0.40 yr^{-1}, 0.16 yr^{-1} and 0.24 yr^{-1}, respectively. The exploitation rate was E = 0.60 yr^{-1}. As a rule was suggested by Gulland (1971) that a fish stock is optimally exploited at a level of fishing mortality that generates E = 0.50, where F_{opt} = M, but in the present study F > F_{opt} = M. Although the E rate was found close to 0.50, the F rate should be decreased for sustainable carp fishing.

During the study, the annual yield of the carp was 25,000 kg. The stock of the carp over 25 cm was estimated as 47847 individuals in number and 53893 kg in biomass. It was apparent from the predicted yields and biomass at the different fishing effort levels that the maximum sustainable yield would be obtained with 60% of the present fishing effort for the carp population in the Lake Karamık. At this effort

level, the annual yield may increase from 25,000 kg to 27,307 kg. According to Çubuk *et al*. (2005), the pike population in the same lake was overexploited and fishing effort should be decreased from 145 to about 58-60 fishing boats. Both carp and pike have been fished by nearly all fishing boats. Therefore, the maximum fishing effort should be determined simultaneously for both species. In the light of these results and evaluations, the number of fishing boats should be about 80 boats for the future of both carp and pike populations and their sustainable fisheries.

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