

Age, Growth and Sex Ratio of *Cyprinus Carpio* (Linnaeus, 1758) in A Lagoon Lake, Lake Karaboğaz (Samsun, Turkey)

Karaboğaz Lagün Gölündeki (Samsun, Türkiye) *Cyprinus Carpio*'nun Yaş, Büyüme ve Eşey Oranı

Research Article

Seda Macun

Faculty of Science, Department of Biology, Hacettepe University, Ankara, Turkey

ABSTRACT

The present study investigates the age, growth, length-weight relationship and sex ratio of the *Cyprinus carpio* (Linnaeus, 1758) collected in the Lake Karaboğaz. The ages of 250 carps caught between October 2008 and June 2010 ranged from I to IV. The female:male ratio was 1.37:1. The fork length of the females ranged from 150 mm to 570 mm, and of males from 145 mm to 442 mm. The weight of the females ranged from 61 g to 2354 g and of males from 56 g to 1227 g. The length-weight relationship showed an allometric growth ($b=2.88$; $r=0.969$). The data were compared with those obtained from other lakes in the Kızılırmak Delta.

Key words: Lake Karaboğaz, carp, growth characteristics, condition factor.

ÖZET

Bu çalışmada Karaboğaz Gölü'nden avlanan *Cyprinus carpio* (Linnaeus, 1758)'nin yaş, büyüme, boy-ağırlık ilişkisi ve eşey oranı araştırılmıştır. Ekim 2008 ve Haziran 2010 tarihleri arasında yakalanan 250 sazan örneğinin yaş dağılımı I-IV arasında olup eşey oranı (dişi:erkek) 1.37:1'dir. Çatal boy uzunluğunun dişi bireylerde 150-570 mm arasında, erkek bireylerde ise 145-442 mm arasında dağılım gösterdiği tespit edilmiştir. Ağırlık değerleri ise dişi bireylerde 61-2354 g, erkek bireylerde ise 56-1227 g olarak saptanmıştır. Bu çalışmadan elde edilen veriler Kızılırmak Deltası'nda bulunan diğer göllerden elde edilmiş olan verilerle karşılaştırılmıştır.

Anahtar Sözcükler: Karaboğaz Gölü, sazan, büyüme özellikleri, kondisyon faktörü

Article History: Received: Jan 21, 2014; Revised: Jun 22, 2014; Accepted: Aug 18, 2014; Available Online: Sep 15, 2014.

Corresponding author: S. Tunçer, Faculty of Science, Department of Biology, Hacettepe University, Ankara, Turkey

Tel: +903122976218

Fax:+90312 299 2028

E-Mail: seda.hidro@gmail.com

INTRODUCTION

Cyprinus carpio, which belongs to the family Cyprinidae, shows a wide distribution pattern in Turkey and in the world in general. Despite commercial hunting, considerable numbers of *Cyprinus carpio* are produced (78.165 tones/year) in fish farms [30]. Having an important role in the inland fishery, many studies have been conducted on *C. carpio* in Turkey [27, 1, 34, 17-23, 24, 2-3, 5, 7-10, 16, 37, 14, 28, 11-12,35]. However, there have not been any studies on the growth characteristics of *C. carpio* in Lake Karaboğaz which is the current area of study. Therefore, this study investigates the age composition, sex ratio, length-weight relationship and condition factor of *C. carpio*.

Karaboğaz, where this study was conducted, is a lagoon lake located 41° 38' North latitude and 35° 38' East longitude (Figure 1). Covering a surface area of 1500 hectares, the length and the width of the lake is 6 km and about 1 km respectively. Having a shallow structure in general, its deepest point is 2.5 m. The surface salinity of the lake is between 0.24 and 6.40‰ while the base salinity is between 0.24 and 13.19‰. Karaboğaz shows brackish water character due to the inflow of salt water into the lake through a channel connected to the Black Sea, located in the north of the lake. In addition, fresh water inflow is provided by drainage channels surrounding

the lake. Underwater vegetation has increased in the lake due to agricultural pollutant loadings discharged into the lake through the channels from the agricultural lands.

Species of fish densely concentrated in the lake are *C. carpio*, *Carassius gibelio*, *Mugil cephalus*, *Petroleuciscus (Leuciscus) brysthenicus*, *Scardinius erythrophthalmus* and *Neogobius melanostomus*.

MATERIAL AND METHODS

16 field studies were carried out from October 2008 to June 2010. All the samples were caught in nets with a mesh opening of 10-90 mm. All 250 individuals sampled in the lake were weighed with a 1 g precision scale and their lengths were measured with a millimeter ruler. Lagler's (1966) criteria for age determination were taken into account for the preparation of fish scales and the criteria set forth by Crag-Hine and Jones (1969) and Philipart (1972) were taken into consideration for the identification of annual rings. A binocular microscope of the Euromex-Arnheim brand and a Ken-A-Vision Model X-100 microprojection were used for age determination. Condition factor (Cf) was calculated using the equation (Lagler, 1966): $Cf = W/L^3 \times 10^5$, where W is the body weight (g), L is the body length (mm). Individuals were classified in respect of sex in order to determined growth feature. Growth



Figure 1. The study area, Lake Karaboğaz.

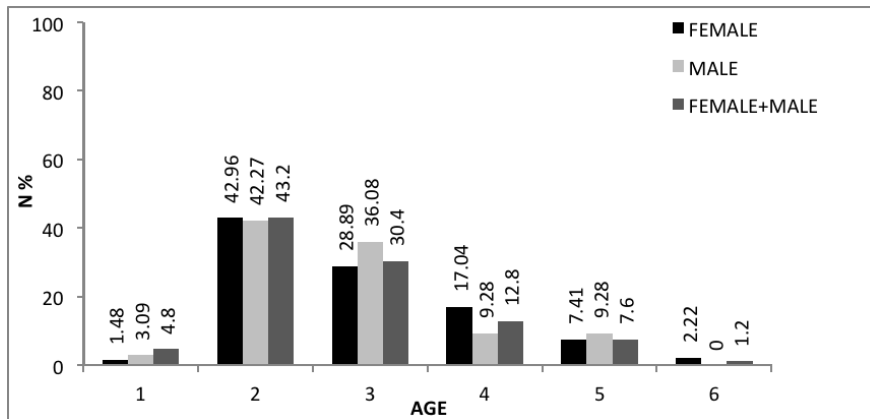


Figure 2. The age distribution of *C. carpio* in Lake Karaboğaz.

in length and weight were examined and Relative Growth in Length (RGL) and Relative Growth in Weight (RGW) were calculated by the following equation [31]: $RGL = [(L_t - L_{t-1}) / L_{t-1}] \times 100$ and $RGW = [(W_t - W_{t-1}) / W_{t-1}] \times 100$, where L_t is the fork length (mm) at age t , L_{t-1} is the fork length (mm) at age $t-1$, W_t is the total body weight (g) at age t , W_{t-1} is the total body weight (g) at age $t-1$. Length-weight relationships were determined according to the allometric equation [32]: $W = aL^b$, where W is the body weight (g), L is the body length (mm), while a and b are constants. Statistical comparison of growth and condition factor between sexes was performed applying the t-test.

RESULTS

The age distribution of the 250 *C. carpio* samples caught in Lake Karaboğaz ranged from I to IV. The predominant age groups in the population were II and III, and the age group with the smallest concentration in the lake was VI (Figure 2). 223 of

250 *C. carpio* individuals were sexed; 135 females and 98 males. The sex ratio was found to be 1.37:1 (female:male).

It was observed that the fork length of the 250 *C. carpio* individuals ranged from 135 to 570 mm and the dominant length (52.4%) in the population varied between 215 and 175 mm (Figure 3). In addition, the individuals with or less than 300 mm (the legal minimum size limit for this species) accounted for 69.4% of the population. When analyzed separately, the results yielded that the shortest and the longest lengths were 150 mm and 570 mm for the female individuals while 145 mm and 442 mm for the male individuals (Table 1).

Examination of a total of 250 *C. carpio* individuals revealed that the weight values ranged from 40 g to 2354 g and taking the weight distribution into account, it was determined that the weight of 62.4% of the fishing population was between 160 g and 400 g (Figure 4). The lowest

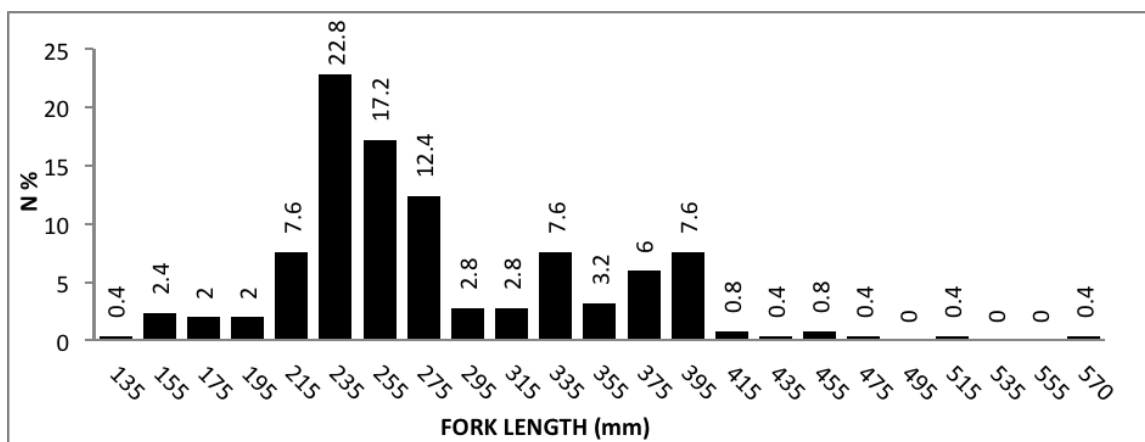


Figure 3. The weight distribution of *Cyprinus carpio* in Lake Karaboğaz (%).

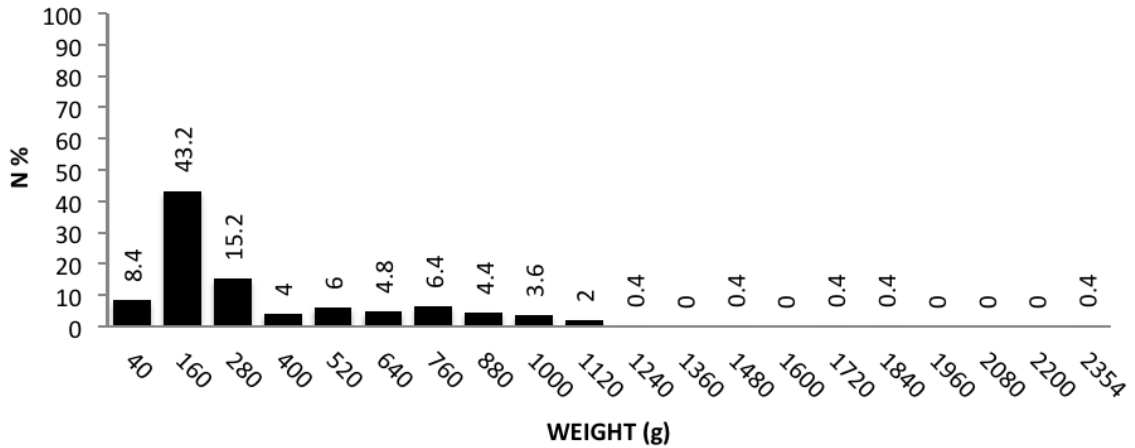


Figure 4. The weight distribution of *Cyprinus carpio* in Lake Karaboğaz (%).

and the highest weights of the female individuals were 61 g and 2354 g while they were 56 g and 1227 g for the male individuals (Table 2).

Table 1 presents the results of the t-test (p 0.05) which reveals the minimum, maximum and mean fork length, the values of the mean length gain and differences between the sexes in terms of growth according to the age groups of male and female individuals of *C. carpio* in Lake Karaboğaz.

Taking the RGL values of the female and male individuals separately, it was observed that the

highest RGL for both sexes was in age group I while the lowest RGL were in age groups V and IV for the females and males, respectively. When comparing the length growth of the females and males, it was detected that the mean fork lengths of the females were higher than those of the males, with an exception for the males in age group I (Table 1). The results of the t-test indicated that the difference between the sexes in terms of length growth was not statistically significant except for age group IV. It was determined that the increase in length growth depends on age in both females and males (Figure 5).

Table 1. Descriptive statistics of length for *Cyprinus carpio* in Lake Karaboğaz according to age and sex.

Age	N	Female			Male			T	Significant	
		FL ± SD (Min-Max)	SE	RGL	N	FL ± SD (Min-Max)	SE			RGL
1	2	157.5±10.61 (150-65)	7.50	0.51	4	164.5±29.29 (145-208)	14.64	0.37	0.31	p>0.05 not significant
2	58	238.6±23.74 (205-330)	3.11	0.18	41	225.7±25.11 (160-270)	3.92	0.19	2.59	p>0.05 not significant
3	39	281.8±51.95 (215-385)	8.32	0.34	35	268.2±30.26 (220-335)	5.12	0.23	1.40	p>0.05 not significant
4	23	377.2±42.17 (315-504)	8.79	0.07	9	329.6±16.37 (305-355)	5.46	0.14	3.27	p<0.05 significant
5	10	402±60.15 (360-570)	19.02	0.05	9	377.3±27.01 (355-442)	9.00	-	1.13	p>0.05 not significant
6	3	421.7±46.19 (395-475)	26.67	-	-	-	-	-	-	-

Table 2. Descriptive statistics of weight for *Cyprinus carpio* in Lake Karaboğaz depending on age and sex

Age	N	Female			Male			T	Significant	
		MW± SD (Min-Max)	SE	RGW	N	MW± SD (Min-Max)	SE			RGW
1	2	76±21.21 (61-91)	15.00	2.27	4	74±24.59 (56-110)	12.30	1.94	0.97	p >0.05 not significant
2	58	248.2±84.95 (149-638)	11.12	0.73	41	217.7±62.64 (75-343)	9.79	0.61	1.95	p ≤0.05 significant
3	39	430.2±242.76 (175-1021)	38.88	1.22	35	351±129.46 (202-666)		0.80	1.78	p >0.05 not significant
4	23	956.3±300.16 (606-1908)	62.59	0.22	9	632.4±109.31 (433-788)	36.44	0.41	3.13	p <0.05 significant
5	10	1164.9±428.69 (872-2354)	135.57	0.14	9	894.7±161.62 (747-1227)	53.87		1.77	p >0.05 not significant
6	3	1333±381.34 (1111-1773)	220.17	-	-					

Table 3 shows the minimum, maximum and mean weight (g) and standard deviation values obtained to determine the growth characteristics of the *C. carpio* population in Lake Karaboğaz. As can be seen in Table 3, the increase in the length growth is dependent on age in both males and females. The comparison of the males and females pointed out that RGW of the females were higher than those of the males in all age groups except IV. A t-test was conducted to detect any difference between the females and the males in terms of mean weights. The test showed that the difference between age groups II and IV were statistically significant. The mean weight gain in all the individuals in the population was the highest in age group I and the lowest in age group V (Table 2).

The analysis of the length-weight relationship of *C. carpio* individuals caught in Lake Karaboğaz revealed that the length growth was much faster at early ages while the weight was observed to increase faster than the length growth at later ages (Figure 6). In addition, there appears to be a positive relationship between length and weight.

The condition factor (*C_f*) values calculated for the 250 individuals are given in Table 4. The mean *C_f* for all the individuals was calculated as 1.78. The highest value of *C_f* for the whole population was in age group I while the value of *C_f* in the other age groups, were similar to one another. When the values of *C_f* for the male and female individuals were compared with each other, they were found to be very close to each other. The t-test

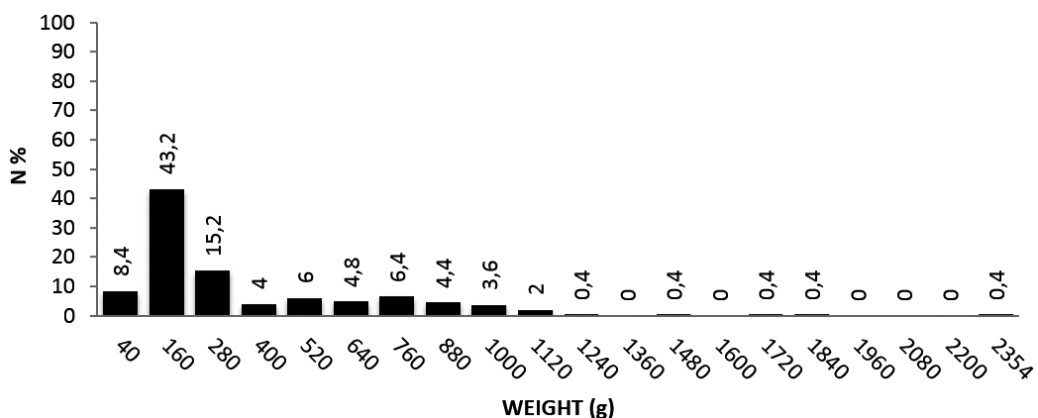
**Figure 5.** The age-length relationship for *Cyprinus carpio* in Lake Karaboğaz according to sex.

Table 3. The distribution of length and weight values for *C. carpio* individuals (female + male) in Lake Karaboğaz according to age groups.

Male+Female			Fork Length (mm)				Weight (g)			
Age	N	%N	Min	Max	Mean±SD	RGL	Min	Max	Mean±SD	RGW
1	12	4.8	135	208	160.75±20.4	0.444	40	110	73.67±20.4	2.138
2	108	43.2	160	330	232.14±24.8	0.184	75	638	231.17±76.5	0.697
3	76	30.4	215	385	274.91±43.2	0.323	175	1021	392.36±199.5	1.205
4	32	12.8	305	504	363.8±42.5	0.073	443	1908	865.25±298.2	0.198
5	19	7.6	355	570	390.32±47.9	0.080	747	2354	1036.89±350.3	0.285
6	3	1.2	395	475	421.67±46.2		1111	1773	1332.67±381.3	

Table 4. Descriptive statistics of condition factor for *Cyprinus carpio* in Lake Karaboğaz according to age and sex.

Age	Female			Male			T	Significant	Female+Male	
	N	Cf±SD (Min-Max)	SE	N	Cf±SD (Min-Max)	SE			N	Cf±SD (Min-Max)
1	2	1.92±0.15 (1.81-2.03)	0.1	4	1.68±0.31 (1.22-1.85)	0.2	0.99	p>0.05 not significant	12	1.77±0.26 (1.22-2.07)
2	58	1.80±0.21 (1.19-2.37)	0	41	1.85±0.20 (1.38-2.37)	0	1.28	p>0.05 not significant	108	1.81±0.22 (1.13-2.37)
3	39	1.76±0.19 (1.20-2.06)	0	35	1.76±0.17 (1.19-2.24)	0	0.20	p>0.05 not significant	76	1.77±0.19 (1.19-2.26)
4	23	1.78±0.38 (1.16-3.22)	0.1	9	1.75±0.08 (1.56-1.81)	0	0.19	p>0.05 not significant	32	1.77±0.32 (1.16-3.22)
5	10	1.78±0.21 (1.27-2.08)	0.1	9	1.66±0.12 (1.42-1.78)	0	1.47	not significant	19	1.72±0.18 (1.27-2.08)
6	3	1.76±0.09 (1.65-1.81)	0.1	-	-	-			3	1.76±0.09 (1.65-1.81)

supported this result and found no statistically significant difference in terms of the value of *Cf* between the sexes.

DISCUSSION

This study investigated the growth characteristics of *C. carpio* in Lake Karaboğaz. For this purpose, firstly the age composition of the *C. carpio* samples was detected by using fish scales. As a result of the age determination, *C. carpio* samples were found to vary between age groups I and VI. The fact that no samples younger than I and older than VI were detected may be due to the selectivity of nets used in fishing. The lack of individuals under the age of I and the scarcity of individuals at the age of I during fishing indicate a disadvantage

in the reproductive capacity of the *C. carpio* population.

Looking at the age distribution of the population in general, the individuals in age groups II and III comprise the dominant age group (73.6%). High numbers of young individuals and rapid decline in the numbers of older individuals in lakes are indications of excessive fishing pressure on the populations in question and higher numbers of young individuals compared to older individuals in the population is indicative of excessive or insufficient fishing activity in the population [4]. In line with this information, the results of the analysis of the age distribution of *C. carpio* individuals in Lake Karaboğaz points to a fishing pressure in the lake. The fact that 95.2%

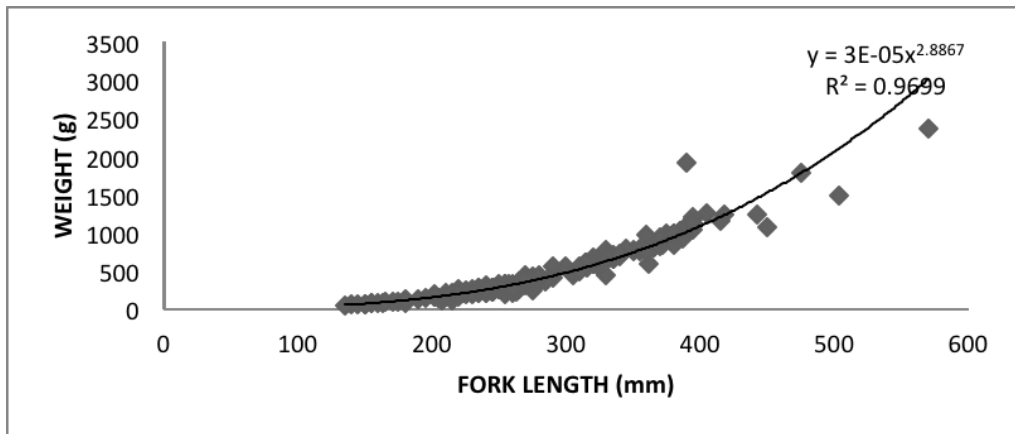


Figure 6. The length-weight relationship for *Cyprinus carpio* in Lake Karaboğaz.

of the sample caught in the lake had reached sexual maturity and that these individuals were predominantly in age groups II and III clearly reveals that there is a fishing pressure on young individuals. In addition, the fishing pressure on age groups II and III explains the reason why the number of individuals in and greater than age group IV is low. According to these results, the distribution of age groups in the population indicates that the *C. carpio* species in Lake Karaboğaz is vulnerable to fishing pressure. This has an adverse effect on the future of the species in the lake.

The sex ratio of *C. carpio* in Lake Karaboğaz was 1.37:1. According to Nikolskii (1963), the sex ratio of many species is close to 1:1 in healthy fish populations. Şişli (1999) states that the expected Mendelian sex ratio in populations is 1:1. The female:male ratio (1.37:1) found in this study indicates that females are slightly more numerous than males. The reason behind this is the fact that *C. carpio* in Lake Karaboğaz shows reproductive capability year round. In addition, it may also result from the fact that females are less active than males and therefore more likely to be caught in fishing nets thrown in vegetation-rich and near-shore areas.

The length distribution of the *C. carpio* population ranges from 135 to 570 mm and 69.6% of the population is less than 300 mm (Figure 3). The minimum specified length limit (total length) is 400 mm [30]. Hence, 81.2% of the *C. carpio* population exceeds the minimum length (Figure 3). In addition to this, taking into account the fact that the reproductive age in both sexes of *C. carpio*

is in age group II and they show reproductive capacities year round, it was determined that a very small proportion of the sample was harvested before they reached sexual maturity while a major proportion of the sample was harvested at reproductive age. All of the above put the future of the *C. carpio* population under threat. A t-test was conducted to see any statistically significant difference in length between the sexes which was detected only in age group IV. However, taking into account the length growth values between male and female individuals, the mean fork lengths of the females were found to be higher than those of the males except for in age group I. This may be due to the small sample size of age group I (6 individuals in total; 2 females and 4 males). The Relative Growth in Length (RGL) of the population of *C. carpio* was the greatest in the transition from age group I to age group II while it declined rapidly after age group II. This result is in accordance with Wootton's proposition (1990). According to this proposition, rapid length growth at earlier ages slows down when the fish reach sexual maturity due to the allocation of the majority of nutrients and energy to reproductive activities, such as the development of gonads and the formation of germ cells. Having a linear relationship between age and length, length growth in natural fish populations depends on age and theoretically, it is expected to be faster at earlier ages than at later ages [26]. The age-length graphs drawn for Lake Karaboğaz are in accordance with what Nikolskii expected it to be in natural populations and reveal that the population is healthy in terms of length growth. Taking into account the weight of both sexes of *C. carpio* individuals, it was determined that the mean

weight in female and male individuals increased depending on age groups and the mean weight of the females was higher than that of the males in all age groups (Table 2). The difference in the mean weight values between the sexes was found to be statistically significant in age groups II and IV.

Looking at the Relative Growth in Weight (RGW), it was detected that the RGW for the female individuals was higher than that for the male individuals in all age groups except IV (Table 2). Taking into account the RGW for the whole population, it was the greatest in the transition from age group I to age group II (Table 3). This results from the fact that both sexes reach sexual maturity at the age of II and their gonad weights increase.

The length-weight relationship of *C. carpio* in Lake Karaboğaz, showed a positive curvilinear relationship between the growth in length and the growth in weight. The mean value of parameter *b* calculated as 2.88 by regression equations was close to 3. This reveals that *C. carpio* in Lake Karaboğaz display an allometric growth pattern. The value of the correlation coefficient (0.969), which determines the length-weight relationship, revealed that there was a strong and a significant relationship between the length and weight (Figure 6).

The condition factor (*Cf*) calculated from both parameters of length and weight reflects the growth characteristics of fish populations. It is also a very important parameter of growth rate which gives information about the feeding activity or the level of stock in a certain environment as well as making the comparison of the same population living in as different localities as possible. In addition, this value provides seasonal and even monthly comparison of different age and sex groups in a given population. The mean *Cf* for the 250 *C. carpio* samples caught in Lake Karaboğaz was 1.78. Looking at the whole population, it was determined that *Cf*, which was supposed to increase in proportion to age groups, increased in the transition from age group I to age group II and increased at an equal rate at later ages (Table 4).

C. carpio is one of the most studied species because it has a wide geographic distribution in

Turkey; it plays an important role in the economy and is widely used in fish releasing activities. For the purpose of comparison, Table 5 shows the fork length and weight values (absolute growth parameters) obtained from studies conducted in different regions by various researchers and those obtained in this study. When the graph values were examined, Bafra Balık Lakes Çernek and Liman Lakes (lagoon lakes in the Kızılırmak Delta) were compared first because they belong to the same system. As a result of the investigation, it was determined that the growth values of *C. carpio* in Lake Karaboğaz were compatible with those in Bafra Balık Lakes and Çernek while the values in Lake Liman were lower. Due to its proximity to the sea and the fresh water input from the drainage canals built by the General Directorate of State Hydraulic Works (DSİ, Turkey), Lake Liman has a different position from hydrological and hydrographic aspect [11-12]. In addition, the growth values in Köyceğiz Lagoon Lakes are greater than in Lake Karaboğaz while lower than in Lake Akşehir, Lake İznik and Lake Hafik especially in age groups I, II, III and IV (Table 5).

In conclusion, the *C. carpio* population in Lake Karaboğaz reflects the growth characteristics expected to be observed in natural fish populations. However, the pressure from fishery and overfishing inhibit the active reproduction and growth of the species. Therefore, the future generations of the *C. carpio* population in Lake Karaboğaz are at risk. Consequently, the minimum length-weight values for fishing should be reconsidered and fishing activities should be continuously monitored.

ACKNOWLEDGEMENTS

The present study was financially supported of TUBITAK 108Y058.

REFERENCES

1. A.G. Alpbaz, H. Hoşsucu, Gölarmara Sazanının (*Cyprinus carpio*, L.) Gelişmesi ve Vücut Yapısı Üzerine Bir Araştırma. EÜ Ziraat Fakül Dergisi 16 (1979) 19.

2. S. Balık, R. Ustaoğlu, Investigations on the biological characteristics of common carp (*Cyprinus carpio* L., 1758) Population in Gölcük Lake (BozdağÖdemiş). VIII. Ulusal Biyoloji Kongresi; 3-5 Eylül 1986; İzmir; Cilt II: 656-671, 1987.
3. S. Balık, R. Ustaoğlu, Investigations on the bioecological characteristics of common carp (*Cyprinus carpio* L., 1758) in Lake Kuş (Bandırma). X. Ulusal Biyoloji Kongresi; Erzurum; pp 271-282, (1990).
4. G.W. Bennet, Management of Lakes and Ponds. Van Nostrand Reinhold Company, 1970.
5. İ. Cengizler, Ü. Erdem, Hafik Gölündeki sazan (*Cyprinus carpio* L., 1758)'ın bazı biyolojik özelliklerinin incelenmesi. IX. Ulusal Biyoloji Kongresi; Sivas, 1988. (In Turkish)
6. D. Crag-Hine, J.W. Jones, The growth of dace *Leuciscus leuciscus* (L.), roach *Rutilus rutilus* (L.) and chub *Squalis cephalus* (L.) in Willow Brook, Northamptonshire. J Fish Biol., 1 (1969) 59.
7. F.Y. Demirkalp (Aksun), Growth characteristics of flathead grey mullet (*Mugil cephalus* L., 1758) in Bafra Balık Lakes (Balıkgözü-Uzungöl). Turk. J. Zool., 16 (1992a) 149.
8. F.Y. Demirkalp (Aksun), Growth characteristics of carp (*Cyprinus carpio* L., 1758) in Bafra Balık Lakes. Turk J Zool., 16 (1992b) 161.
9. F.Y. Demirkalp (Aksun), Growth and growth rates of pikeperch, *Stizostedion lucioperca* (L., 1758) in Bafra Balık Lakes. Turk. J. Zool., 16 (1992c) 177.
10. F.Y. Demirkalp (Aksun), The reproduction biology of *Cyprinus carpio* L. 1758, *Mugil cephalus* L. 1758, *Stizostedion lucioperca* (L. 1758) in Bafra Balık Lakes (Balıkgözü-Uzungöl). Turk. J. Zool., 16 (1992d) 311.
11. F.Y. Demirkalp, Growth characteristics of carp (*Cyprinus carpio* L., 1758) in Liman Lake (Samsun, Turkey). Hacet J. Bio. Chem., 35 (2007a) 1-7.
12. F.Y. Demirkalp, Some growth characteristics of carp (*Cyprinus carpio* L., 1758) in Liman Lake (Samsun, Turkey). Hacet. J. Bio. Chem., 35 (2007b) 1.
13. F.Y. Demirkalp, E. Gündüz, S. Bayarı, S.S. Çağlar, Y. Saygı, S. Kaynaş, Çernek Gölü'nün ekonomik öneme sahip balık popülasyonları ve ekosistem yapısı üzerine bazı araştırmalar. TÜBİTAK TOG-TAG/TARP 2358, 2001 (In Turkish)
14. F.Y. Demirkalp, Y. Saygı, Growth and Nutritional Characteristics of Some Fish Species in Lake Yeniçağa, Hacettepe University Scientific Research Projects Coordination Unit; Report p 158, 2001.
15. F.Y. Demirkalp, E. Gündüz, S.S. Çağlar, Y. Saygı, S. Bayarı, Liman Gölü (Samsun-Bafra) Limnolojisi ve Ekonomik Öneme Sahip Balık Popülasyonları Üzerine Araştırmalar; TÜBİTAK TBAG-2196, 2006. (In Turkish)
16. F.G. Ekmekçi (Atalay), Growth properties of carp (*Cyprinus carpio* L., 1758) population in Sarıyar dam Lake (Ankara). Turk. J. Zool., 20 (1996) 107.
17. Ü. Erdem, Growth ratio of the carp (*Cyprinus carpio* L., 1758) in Akşehir Lake. VII. Bilim Kongresi; 6-10 Ekim 1980; Aydın, Türkiye; pp 261-274, 1980 (In Turkish)
18. Ü. Erdem, Growth rate and some reproductive characteristic of the carp (*Cyprinus carpio* L., 1758) population of Eber Lake. Bull Selcuk Uni Fac Sci, 2 (1982) 91.
19. Ü. Erdem, A comparative study on the carp (*Cyprinus carpio* L., 1758) population in the Eğridir, Beyşehir and Çavuşcu lakes. Turk J Vet Anim Sci, 7 (1983a) 167.
20. Ü. Erdem, Growth length-weight relationship, condition factor and reproduction age, characteristics of the carp (*Cyprinus carpio* L., 1758) population in the Çavuşcu Lake, Cum Uni Fac Sci J, 1(1983b) 9.
21. Ü. Erdem, Growth ratios, length-weight relationship, condition factor and reproduction age, characteristics of the carp (*Cyprinus carpio* L., 1758) in the Beyşehir Lake. Turk J Biol, A2 8 (1984a) 61.
22. Ü. Erdem, Growth, reproduction age, condition factor and meristic characteristics of the carp (*Cyprinus carpio* L., 1758) population in the Apa Dam Lake. Cum Uni Fac Sci J, 2 (1984b) 31.
23. Ü. Erdem, Investigations on the some biological characters of the population of the carp (*Cyprinus carpio* L., 1758) in Tötürge Lake. Turk J Zool, 12 (1988) 32.
24. R. İkiz, Determination of growing and lowest catching size of pike - perch (*Lucioperca lucioperca* L., 1758) population in Mamasin dam Lake. Cum Uni Fac Sci J, 5 (1985).
25. K.F. Lagler, Freshwater Fishery Biology. Iowa: WMC Brown Company, 1966.
26. G.V. Nikolskii, The Ecology of Fishes (Translated by L. Birkett). London: Academic Press, 1963.
27. W. Numann, Anadolu'nun muhtelif göllerinde limnolojik ve balıkçılık ilmi bakımından araştırmalar ve bu göllerde yaşayan sazan hakkında özel bir etüd. İstanbul, Turkey: İstanbul Üniversitesi Fen Fakültesi Hidrobiyoloji Araştırma Enstitüsü Yayınları, 1958 (In Turkish).
28. S.C. Özeren, İznik Gölü Balıklarının Taksonomisi ve *Cyprinus carpio* L. 1758 (Sazan), *Rutilus frisii* Nordmann, 1840 (akbalık) ve *Atherina boyeri* Risso, 1810 (gümüş balığı)'nin Biyo-Ekolojik Yönden İncelenmesi. PhD, Hacettepe University, Ankara, 2004. (In Turkish)
29. J.Ci. Philipart, Age et croissance de chevaine *Leuciscus cephalus* (L.) dans L'Ourthe et la Berwine, Ann. Soc. R. Zool. Bleg., 102 (1972) 47.
30. Republic of Turkey Ministry of Food, Agriculture and Livestock, Marine and Internal Waters Commercial Fisheries Harvesting Circular Number 2008/48, 2008. URL: <http://www.tarim.gov.tr/images/Files/Mevzuat/Sirkuler/DENIZLERDEVEIÇSULARDATICARIAMAÇLI SUURUNLERI AVCILIGINIDUZENLEYEN2006.pdf>

31. W.E. Ricker, Calcul et interpretation des statistiques biologiques des populations de poissons. Ottawa, Canada: Ministere Des Peches et des Oceans, 1980.
32. P. Sparra, E. Ursin, S.C. Venema, Introduction to Tropical Fish Stock Assessment. Part I Manual FAO Fisheries Technical Paper 1. Rome FAO No: 306, 1980.
33. M.N. Şişli, Ekoloji. Ankara, Turkey: Gazi Kitabevi Yayınları, 1999. (In Turkish)
34. J. Tanyolaç, Age and growth of carp *Cyprinus carpio* L. in Lake Eymir-Ankara. Comm Fac Sci Uni Ank 3 (1979) 1.
35. S. Uğurlu, N. Polat, Ş. Kandemir, Fish fauna of lagoons within the Kızılırmak and Yeşilirmak deltas (Samsun-Turkey). J. Fish. Sci., 2 (2008) 475.
36. R.J. Wootton, Ecology of Teleost Fishes. London: Chapman and Hall, 1990.
37. S.V. Yerli, The Investigation of Growth Parameters of *Cyprinus carpio* Linnaeus 1758 in Çıldır Lake (Ardahan, Kars), Turkey. Turk. J. Zool., 21 (1979) 91.