



**Full Length Article**

# Population Characteristics of Carp from Tödürge Lake in Sivas, Turkey

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## ABSTRACT

The study investigates certain fishery biology data including age and sex distributions, growth in length and weight, length-weight relationship and condition coefficient of *C. carpio* population, which is one of the biologically and economically the most important species in view of population density in the ichthyofauna of Tödürge Lake. A total of 211 samples (96 females, 115 males) were caught with monthly periods between May-November 2007. Female: male ratio of population was calculated as 1.00:1.20. Age of the samples was between 1-7 years. Dominant age group was II for female samples and III for male samples in stock. Representation rate of the samples within the population was 39.8% for the first two age groups, while it was 5.7% for the last two age groups. This result indicates that the *C. carpio* population was composed of young individuals and may be exposed to intensive fishing pressure. Fork length ranged between 83-405 mm and body weight was between 10.2 and 1049.8 g. 28.13% of the female individuals were included in 110-159 mm length group, while 22.61% of males were in 160-209 mm length group. Females with 0-100 g body weight accounted for 61.46% of population, while it was determined as 38.26% for males. Representation rate of individuals in stock, which were taller than the smallest prey size (35 cm, in SL), in other words, fishable stock amount constituted around 15-20% of the stock. Fishing of individuals smaller than 35 cm in Tödürge Lake should be banned. Mean fork length changed between 90.7 and 389.0 mm and body weight was between 14.9 and 939.7 g. Mean length and weight values of the individuals in the first four age groups have significantly reduced for the last 20 years. Allometric growth equations was  $W=0.0103L^{2.8497}$  for females and  $W=0.0085L^{2.8534}$  for males. Both the female and male individuals were determined to follow allometric growth. Condition factor changed between 1.57-2.01 for female individuals and 1.47-2.01 for male individuals. It was determined that the condition level and growth performance of the population in length and weight have significantly reduced for the last 20 years. © 2011 Friends Science Publishers

**Key Words:** Common carp; Growth properties; Tödürge lake

## INTRODUCTION

Fishery production could only be increased by using scientific methods, determining ecological conditions in the habitat of fish species, obtaining data of population dynamics and different studies on fishery biology. Especially age and sex distributions of the individuals in population, growth performance in length and weight, relations between age-length, age-weight and length-weight, and seasonal changes in condition coefficient are the necessary parameters for the productive and sustainable use of population (Yerli, 1997; Özyurt & Avşar, 2001).

Origin of the species is Southeast Asia (especially China); however, it is distributed to all Europe (except Siberia), England and even America in time due to its significant place in artificial fish production. It is commonly present in many lakes and calm-flowing deep zones of some big rivers in Anatolia except for highly cold high mountain lakes. Carp population planted in many lakes, lakelets and dam lakes or produced in fish production farms has a

significant role in inland water fishery of Turkey (Geldiay & Balık, 1988). Carp accounted for 27.5% of the freshwater production hunted in 2006 in Turkey (Anonymous, 2007).

Economic value of the species is increased by high growth speed of length and weight, high meat yield, non-selective habitat use, easy production availability in fish farms and tasty meat (Demirkalp, 1992).

The species was first investigated by Numann in 1958 in Turkey (Numann, 1958). He determined different biological and ecological characteristics of carp population inhabiting Akşehir, Beyşehir, Eğirdir, İznik, Apolyont, Manyas and Süleymaniye Lakes. Certain biological characteristics of *C. carpio* were determined by Tanyolaç and Karabatak (1974) in Mogan Lake, Karabatak (1977) in Hirfanlı Dam Lake, Tanyolaç (1979) in Eymir Lake, Cengizler (1987) in Hafik Lake (Sivas), Çetinkaya (1992) in Akşehir Lake (Konya), Demirkalp (1992) in Bafra Balık Lakes (Samsun), Yerli (1997) in Çıldır Lake, Alp and Balık (2000) in Gölhisar Lake (Burdur), Karataş (2000) in Kaz Lake (Tokat), and Özeren (2008) in İznik Lake (Bursa).

Carp population has a highly significant place among the species in the ichthyofauna of Tödürge Lake in view of both its stock amount and fishing productivity (Erdem, 1988; Ünver, 1998). The first study on the carp population in Lake was carried out by Erdem (1988) between 1985 and 1986. In this study performed 20 years later, age and sex distributions of the population, growth rates of length and weight, relation between length-weight and condition coefficient were determined. Changes in the structure, productivity and biological characteristics of the population in 20 years were analyzed based on these current data on fishing biology.

## MATERIALS AND METHODS

**General characteristics of Tödürge lake:** The lake is located approximately 56 km to provincial center within the boundaries of Zara County of Sivas Province. It is the biggest natural reservoir of Sivas Province with 1295 m elevation from sea level and 350 ha surface area (Erdem, 1988; Ünver, 1998). Its mean depth is 2 m, while the maximum depth was measured 44.5 m in the study. Tödürge is one of the karstic lakes in Turkey and limnologically open (Tanyolaç, 1993). The lake water is rich for sulfate salts and has alkali character. It is a eutrophic lake considering its nutrition salt content, and oligotrophic lake considering its phytoplankton composition (Kasaka, 2003).

There are 8 fish species in Lake. Carp and Danube bleak were densely fished by local people. Wide and shallow region located in the eastern part of Tödürge Lake, which is one of the significant bird areas in Turkey, provides a feeding and reproduction area for aquatic birds (Yarar & Magnin, 1997; Ünver, 1998).

**Collection and evaluation of samples:** A total of 211 *C. carpio* samples were monthly collected between May and November 2007. Monofilament and multifilament gill and trammel nets of different lengths and heights with 15x15, 18x18, 20x20, 24x24, 32x32 and 50x50 mm of mesh sizes were used for fish catching. Sampling could not be performed between December-April as the lake surface was partially or completely covered with ice.

Each of the carp sampled was measured to the nearest 0.1 mm in fork length (FL) and weighed to the nearest 0.1 g. Fish scales were used to determine the ages of the samples (Bagenal, 1974). Sex and sexual maturity of the collected samples were determined by macroscopically examination of gonads.

All samples were classified according to age and sex; subsequently, mean length and weight values of each group were determined and the significance of the differences between the sexes was investigated. Growth rates of length and weight of male and female individuals in each age group were evaluated as both annually and proportionally.

Length-weight relationship and condition factor were calculated according to equations  $W = aL^b$  and  $C =$

$W/L^3 \times 100$ , respectively (Lagler, 1956; Moyle & Cech, 1996). Condition values of samples in each age group were separately calculated; in addition, the differences in mean values between age groups and sexes were statistically investigated.

Some physical and chemical characteristics (water temperature, dissolved oxygen, pH, electrical conductivity, total dissolved solids) of the species habitat and air temperature were measured and the monthly changes of all parameters were analyzed.

The evaluation and statistical analysis of data were performed using by SPSS software for Windows (version 15.0, SPSS Inc., Chicago).

## RESULTS

**Some ecological properties of carp in Tödürge lake:** Temperature of the lake water was measured as 3.8°C at the end of November, and 27.1°C in July. Oxygen solubility changed between 3.33 and 9.11 mg/L. pH value of alkali lake water was around 8.

The young carp individuals were observed in small groups composing of 5-30 individuals in coastal regions with 30-50 cm of depth and rich vegetation. These small groups with 5-12 cm of total length were composed of the individuals in 0-I age groups in general. Few individuals shorter than 15 cm of length were fished in sampling performed in regions with over 80 cm of depth, and the samples caught were generally in II-III age groups. On the other hand, fish longer than 20 cm were found in regions deeper than 100 cm in small groups composed of 2 or 3 individuals. Mature individuals were observed to migrate to shallow regions with 5-20 cm of depth and rich macrophytes or meadow regions in order to lay eggs during reproductive period. No individual freely strolling in observable depths was encountered in December when the water temperature decreased below 4°C.

**Sex, age, length and weight distributions:** 45.5% of the samples were composed of female, while 54.5% were of male individuals. Sex ratio of the population was calculated as 1.00:1.20. Carp ranged in age from 1-7 years. Dominant age group was II for female samples and III for male samples in stock. 33.3% of the female individuals were in II age group, and 30.4% of male individuals were in III age group. Representation rate of the first two age groups was 39.8%, while it was 5.7% for the last two age groups. The least number of samples were obtained in VII age group for both sexes (Table I).

Fork length of females was measured between 83-405 mm, while it was between 85-389 mm for male individuals. The maximum number of individuals among the collected samples belonged to 110-159 mm length group in females and 160-209 mm length group in males. In Turkey, according to the 37/1 numbered circular of 2006-2008 Fishing Periods, proportion of individuals at fishable length (taller than 300 mm) in population was determined as 20% (Fig. 1).

**Table I: Age and sex composition of carp specimens collected between May-Nov. 2007 from Tödürge Lake**

Age Groups	Female		Male		Female+Male	
	N	N%	N	N%	N	N%
I	16	16.7	9	7.8	25	11.8
II	32	33.3	27	23.5	59	28.0
III	22	23.0	35	30.4	57	27.0
IV	6	6.2	30	26.1	36	17.1
V	13	13.5	9	7.8	22	10.4
VI	5	5.2	4	3.5	9	4.3
VII	2	2.1	1	0.9	3	1.4
Total	96	45.5	115	54.5	211	100

N: individual number

**Table II: Mean, minimum and maximum fork lengths of male and female individuals of carp in each age class**

Age Groups	Female		Male		t-test	Female+Male	
	N	FL±SE	N	FL±SE		N	FL±SE
I	16	90.7±0.13 (83-100)	9	91.1±0.11 (85-96)	p>0.05	25	91.4±0.11 (83-105)
II	32	141.9±0.33 (117-188)	27	132.4±0.31 (105-162)	p>0.05	59	140.6±0.29 (90-188)
III	22	189.8±0.86 (120-276)	35	194.5±0.33 (163-226)	p>0.05	57	194.0±0.51 (120-276)
IV	6	253.8±1.43 (205-295)	30	275.6±0.55 (230-330)	p>0.05	36	265.2±0.66 (204-346)
V	13	349.7±0.51 (324-379)	9	357.6±0.43 (334-370)	p>0.05	22	352.9±0.35 (324-379)
VI	5	369.4±0.58 (350-380)	4	374.2±1.25 (365-387)	p>0.05	9	366.6±0.61 (331-389)
VII	2	386.0±1.90 (367-405)	1	389.0	-	3	386.3±1.09 (367-405)

N: individual number, FL: mean fork length; mm, SE: standard error, (min.-max. fork length)

**Table III: Mean, minimum and maximum body weights of male and female individuals of carp in each age class**

Age Groups	Female		Male		t-test	Female+Male	
	N	W±SE	N	W±SE		N	W±SE
I	16	14.9±0.52 (10.2-19.2)	9	16.1±0.98 (13.2-22.9)	p>0.05	25	15.4±0.48 (10.2-22.9)
II	32	53.6±3.87 (27.7-107.6)	27	54.0±5.86 (13.8-119.6)	p>0.05	59	53.8±3.38 (13.8-119.6)
III	22	133.8±16.38 (31.1-312.3)	35	149.3±13.48 (40.8-331.7)	p>0.05	57	143.3±10.37 (31.1-331.7)
IV	6	286.5±41.92 (165.8-407.0)	30	346.1±27.21 (141.3-730.4)	p>0.05	36	336.1±23.82 (141.3-730.4)
V	13	692.3±23.25 (557.4-827.5)	9	690.4±27.33 (588.5-850.0)	p>0.05	22	691.5±17.29 (557.4-850.0)
VI	5	795.3±42.70 (643.8-890.0)	4	776.5±45.61 (690.2-870.7)	p>0.05	9	795.3±28.46 (643.8-890.0)
VII	2	939.7±110.10 (829.6-1049.8)	1	854.7	-	3	911.4±69.59 (829.6-1049.8)

N: individual number, W: mean body weight, SE: standard error, (min.-max. body weight)

**Table IV: Growth parameters and equations of male and female individuals of carp from Tödürge Lake**

Sex	N	a	n	Growth equation
Female	96	0.0103	2.8497	$W = 0.0103L^{2.8497}$
Male	115	0.0085	2.8534	$W = 0.0085L^{2.8534}$
Female+male	211	0.0096	2.8523	$W = 0.0096L^{2.8523}$

N: individual number

**Table V: Mean, minimum and maximum condition factor values of male and female individuals of carp in each age class**

Age Groups	Female		Male		t-test	Female+Male	
	N	C±SE	N	C±SE		N	C±SE
I	16	2.01±0.054 (1.61-2.39)	9	2.01±0.069 (1.72-2.37)	p>0.05	25	2.01±0.042 (1.61-2.39)
II	32	1.79±0.034 (1.44-2.32)	27	1.82±0.033 (1.47-2.22)	p>0.05	59	1.80±0.024 (1.44-2.32)
III	22	1.80±0.034 (1.49-2.15)	35	1.79±0.024 (1.57-2.11)	p>0.05	57	1.79±0.019 (1.49-2.15)
IV	6	1.85±0.052 (1.72-2.03)	30	1.71±0.023 (1.45-1.95)	p>0.05	36	1.73±0.022 (1.45-2.03)
V	13	1.62±0.034 (1.41-1.82)	9	1.52±0.075 (1.16-1.79)	p>0.05	22	1.58±0.037 (1.16-1.82)
VI	5	1.57±0.028 (1.50-1.65)	4	1.63±0.093 (1.48-1.90)	p>0.05	9	1.60±0.042 (1.48-1.90)
VII	2	1.63±0.050 (1.58-1.68)	1	1.47	-	3	1.58±0.061 (1.47-1.68)

N: individual number, C: mean condition value, SE: standard error, (min.-max. condition)

Minimum and maximum body weights of all samples changed between 10.2 and 1049.8 g. 61.46% of females and 38.26% of males had body weights between 0-100 g. Proportion of females over 500 g was 20.83%, while the proportion of males was 14.79% (Fig. 2).

**Growth in length:** Mean, minimum and maximum fork lengths of male and female individuals in all age groups were determined and given in Table II. Mean fork length of female individuals was between 90.7-386.0 mm, while it was between 91.1-389.0 mm for male individuals. No

significant difference was found between mean fork lengths of male and female individuals in all age groups ( $p>0.05$ ).

Proportional length growth was high in young individuals; however, it slowed down with age. The biggest increase was 56.4% for females in II. age group, and 46.9% for males in 3<sup>rd</sup> year age group.

**Growth in weight:** Mean body weight of female individuals was between 14.9-939.7 g. Minimum and maximum body weights of male individuals were 16.1 and 854.7 g, respectively (Table III). There was no statistically significant difference between the mean body weights of female and male individuals ( $p>0.05$ ).

The highest relative increase was determined in II. age group for both female and male individuals (259.7% & 235.4%). Relative increase of body weight was high in young individuals, however, slowed down with age.

**Length-weight relationship:** Relations between mean fork lengths and body weights of *C. carpio* for both sexes are seen in Fig. 3. Both female and male individuals displayed an allometric growth. Growth parameters and equations of male and female individuals are given in Table IV. “a” and “n” values of females and males were very close to each other. “n” was determined as 2.8 for females and 2.7 for males.

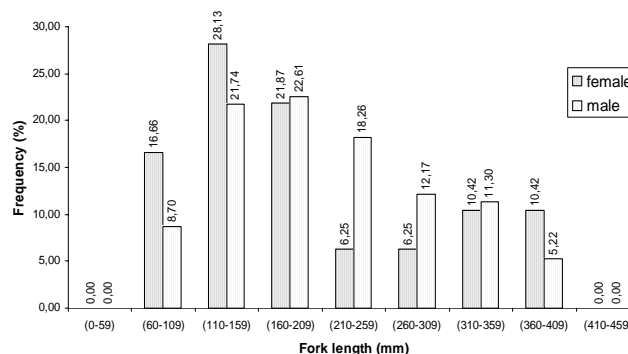
**Condition factor:** Mean, minimum and maximum condition values of male and female individuals are given in Table V. Mean condition values of females changed between 1.57 and 2.01. Minimum and maximum condition values of males were 1.45 and 2.37, respectively. There was no statistically significant difference between mean condition values of males and females in all age groups ( $p>0.05$ ).

## DISCUSSION

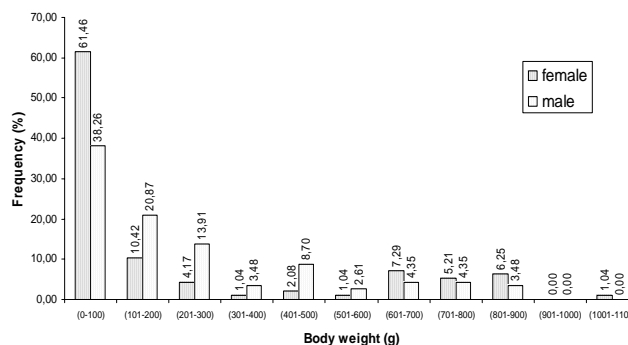
It was determined that the changes in population in last 20 years by comparing the data obtained in the present study with the findings of the study carried out by Erdem (1988) on the same population in 1987.

Erdem (1988) determined that 53.4% of 610 individuals were composed of females and 46.6% were males; in addition, Erdem found female:male ratio as 1.00:0.88 and the age distribution of the population as I-VII. Age distribution was similarly found as I-VII in the present study. Sex ratio and age distribution of carp populations were determined as 1.00:1.47 and I-VII age in Hafik Lake; Hafik/Sivas (Cengizler, 1987), 1.19:1.00 and II-IX age in Eymir Lake; Ankara (Tanyolaç, 1979), 1.00:1.01 and I-VIII age in Bafra Balık Lakes; Samsun (Demirkalp, 1992), 1.16:1.00 and I-IV age in Akşehir Lake; Konya (Çetinkaya, 1992), 1.00:2.24 and II-IX age in Çıldır Lake; Kars (Yerli, 1997), 1.00:0.84 and I-XII age in Kaz Lake; Tokat (Karataş, 2000), 1.14:1.00 and I-VI age in Gölhisar Lake; Burdur (Alp & Balık, 2000), and 1.70:1.00 and I-VII age in İznik Lake; Bursa (Özeren, 2008) which had similar geographic and limnological properties with Tödürge Lake.

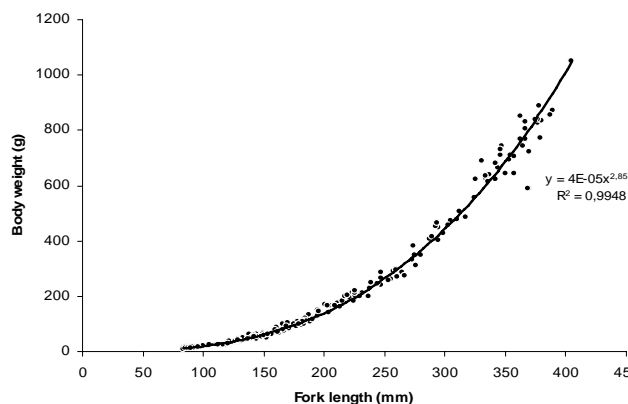
**Fig. 1: Fork length distribution for carp in Tödürge Lake**



**Fig. 2: Body weight distribution for carp in Tödürge Lake**



**Fig. 3: Fork length-body weight relationship of carp for both sexes**



Female:male rate is rarely equal to each other in natural populations, and one of the sexes is represented with a greater proportion (Geldiay & Kocataş, 1975). Nikolsky (1963) expressed that male individuals could be in larger number than females within the first years of age. Male individuals tend to stay in the reproduction area for longer times than females; in addition, death rates of sexes caused by fishing, differences in lifespan and physiological activities, different maturity ages and size of sexes, and the gillnet selectivity are among the factors that could lead to

the inequality between the numbers of males and females caught (Lagler, 1956; Nikolsky, 1963; Sarıhan, 1993).

Age distribution is an important biological indicator for its effect on death rate of population. Proportions of different age groups in population provide information on the productivity and the future of population. It should be taken into account that overfishing and natural deaths are common in population composed of young individuals. As in many other natural lake populations in Turkey, *C. carpio* population in Tödürge Lake has 7 different age groups (I-VII). In addition, age distribution should be expected to be wide in healthy and balanced stocks, which have biological and ecological potentials for the development and reproduction (Nikolsky, 1963). Young individuals are more dominant than old ones in stocks with high reproduction capability; however, old individuals become more dominant in stocks with low fishing activities (Geldiay & Kocataş, 1975; Sarıhan, 1993). In the study carried out on the same stock 20 years earlier, dominant age group was determined as III for both female and male individuals (Erdem, 1988). It was determined that individuals of II. age group in Gölhisar Lakes (Alp & Balık, 2000) and Kaz Lake (Karataş, 2000), IV. age group in Çıldır Lake (Yerli, 1997), and V. age group in İznik Lakes (Özeren, 2008) were represented in the highest percentage. Obtained data may indicate that fishing pressure on carp population in Tödürge Lake, and the regeneration potential of the population did not change much in the last 20 years.

Representation rate of individuals in stock, which were taller than the smallest prey size, 35 cm, accounted for 15-20% of the stock. It was reported that the species could reach maximum 100 cm in length and 30 kg in weight (Slattenenko, 1955). Fork length and body weight of *C. carpio* populations were recorded as 200-536 mm and 179-2220 g in Çıldır Lake (Yerli, 1997), 105-494 mm and 20.1-1628.4 g in Gölhisar Lake (Alp & Balık, 2000) and 56-810 mm and 4.0-9075 g in İznik Lake (Özeren, 2008). On the other hand, Erdem (1988) stated that fork length changed between 95-428 mm; while body weight was between 15-1210 g. Fork length and body weight values of carp population in the first three age groups in Hafik and Akşehir Lakes, in the last three age groups in İznik Lake and in all age groups in Eymir, Bafra, Çıldır and Gölhisar Lakes were higher than the values recorded for the population in Tödürge Lake. There are statistically significant differences between the mean values of length and body weight of the first four age groups determined in the present study and the study carried out on the same stock in Tödürge Lake in 1988. Growth performances of carp population in Tödürge Lake in length and weight were found lower compared to other Turkish populations.

Climate and geographic properties of the habitat where the populations live, trophic levels of the environment, where the stock lives, interspecies and intraspecies competition, biotic and abiotic factors like water temperature and oxygen solubility could control the growth

performance and productivity of a fish stock (Lagler, 1956; Nikolsky, 1963). Water temperature was measured between 3.8-27.1°C, and dissolved oxygen was between 3.33-9.11 mg/L in Tödürge Lake, which has oligotrophic characteristics. pH level of the lake water was around 8. Low growth performance of carp population in Tödürge Lake in length and weight should be considered within this respect.

It can be seen in the graph of relations between length-weight of *C. carpio* samples that length increase was higher in individuals with up to 250 mm of length, while weight increase was higher with sexual maturity in individuals with over 250 mm of length (Fig. 3). “a” value which indicates the plumpness of fish is a significant parameter that demonstrates feeding level of different populations of a species, and amount and variety of food items (Lagler, 1956; Moyle & Cech, 1996). On the other hand, “n” value provides information on body shape of fish in general. As the body height increases in fish at the same length, n value increases (Carlander, 1969). This parameter was determined for female and male individuals as 2.5185 and 2.3058 in Tödürge Lake (Erdem, 1988), 2.9619 (sexes combined) in Eymir Lake (Tanyolaç, 1979), 2.3078 and 2.8213 in Akşehir Lake (Çetinkaya, 1992), and 2.8676 and 2.8847 in Gölhisar Lake (Alp & Balık, 2000).

The condition factor “C” is frequently used by fisheries biologists as an indicator of the health of a fish population. If the fish in a stock have high “C” values, then there is probably plenty of food available to support both somatic and gonadal growth (Moyle & Cech, 1996). In present study, mean condition factor for age groups was determined to change between 1.57-2.01 for females and 1.47-2.01 for males (Table V). Condition factors of females and males changed between 1.74-2.57 and 1.75-2.39 in Hafik Lake (Cengizler, 1987), 1.00-2.72 and 1.05-2.39 in Bafra Balık Lakes (Demirkalp, 1992), and 1.58-2.24 and 1.11-2.13 in İznik Lake (Özeren, 2008). Mean condition factor was reduced from 1.813 to 1.752 for females and from 1.947 to 1.707 for males in last 20 years. Condition factor was also reduced in *C. carpio* population of Tödürge Lake in parallel with the growth performance in length and weight.

It was determined that condition values of the population were inclined to decrease with age in general (Table V). It is generally expected for fish stocks that growth speed of length is higher than the speed of weight increase in the initial ages, and the speed of weight increase is higher than the speed of length increase upon reaching sexual maturity (Lagler, 1956; Moyle & Cech, 1996). However, growth performance of length in female and male individuals in V, VI and VII age groups was higher than the performance of weight increase, which could be caused by the low condition values of old individuals compared to young individuals. In addition, the number of samples in the last three age groups was low, which could be another reason for the irregular relation between age-condition.

It was concluded from the obtained data that the length and weight growth performances and condition levels of carp population in Tödürge Lake were reduced in the last 20 years. Fishing activities in lake should be controlled with scientific methods and constantly observed for the protection of the current stock as well as for the economical and sustainable fishing. As the female and male individuals of population reach sexual maturity after III-IV ages, length and weight values of the subsequent age group should be used for the smallest prey size. For this reason, individuals smaller than 35 cm should be protected from fishing. Changes in water temperature should be taken into consideration when deciding the period of fishing banned.

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