Research Article

Growth Characteristics of Carp (*Cyprinus carpio* L., 1758) in Liman Lake (Samsun, Turkey)

F. Yıldız Demirkalp
Hacettepe University, Department of Biology, Ankara, TURKEY

Abstract

Age and growth features of 288 specimens of the carp collected during the years 2002-2005 in Liman Lake were studied using the scale method. The age of the carp in Liman Lake was found between I and VI. The observed sex ratio was 1.16 female:1 male in the studied samples. The results of the fork length-weight regression indicated the allometric growth characteristic of the specimens. The mean condition factor for the carp in the study area was 1.87. The data obtained were compared with those of the other populations of the same species in the other regions of Turkey.

Key Words: Liman Lake, carp, growth, condition factor, weight-length relationship

Introduction

Cyprinus carpio has a significant place in Turkey's in fishing activities and it has widespread distribution in our freshwater ecosystems such as lake, pond and dam lake. Moreover, *Cyprinus carpio* has considerable commercial potential in our domestic market.

The production of domestic aquaculture is a total of 44.698 tones and of them, 13.820 tones include carp. It also equals to 32% of domestic production (1). *Cyprinus carpio* that it is very significant for domestic fishing production in terms of its economical value has been regarding its growing features in many lakes and reservoires (2-11).

Liman Lake is a part of Kızılırmak Delta which is valuable wetland system in the northern Turkey and it has been recognized as a "Ramsar Site". Kızılırmak Delta comprises a variety of saline lakes from oligohaline to mesohaline character including Balık, Uzun, Çernek, Liman, Tatlı, Gıcı Lakes and some small marshes with similar origin (12).

Liman Lake is isolated on the north-west side of delta and its coordinates are between 41º 44' north latitude and 35º 40'east latitute. The lake has small size (200 hectare) and its the average depth is 2.5 meter with spatial and seasonal variations.

The lake can be characterized as a mixo-oligohaline brackish water because of salinity of ‰ 1.96-4.06. The lake is connected with Black Sea by a natural strait from north side. The drainage channel which was built by State Water Department (DSI) extends along the south side of lake (13). This channel brings the remaining irrigation water of the regional agriculturel area into the lake. Therefore, there are continuously mixture of sea water and freshwater in the lake. The south, south-west and south-east sections of the lake consist of reed beds (*Phragmites australis*), north side is surrounded with sandy beach. The main fish species living in the lake are *Carassius carassius, Mugil cephalus, Sander lucioperca* and *Cyprinus carpio*.

Up to now growing features of *Cyprinus carpio* has not been studied in Liman Lake. Thus, the study examines the age, length and weight growing, sex ratio and condition factor of *Cyprinus carpio* living in Liman Lake.

Materials and Methods

A total of 288 specimens was caught from October 2002 to June 2005. The sampling was made by gill net of various mesh size (between 40 and 70 mm). Forks length (FL) and weights (W) of 288 specimens were measured to the nearest 0.1 cm and 0.1 gr., respectively. The scales were used for age determination according to Lagler (14), Crag-Hine and Jones (15), Philipart (16). The sex was determined by examination of the gonad tissue in the abdomen. During the scale readings for age determination, Euromex-Arnhem binocular microscope and Ken-A Vision x100 Model microprojection were used.

The formulas $OL = (L_t-L_{t-1})/(L_{t-1}).100$ and $OW = (W_t-W_{t-1})/(W_{t-1}).100$ were employed for relative length increment (RLI) relative weigth increment (RWI), respectively, (17), where L_t = fork length at age t, L_{t-1}= fork length at t-1 age, W_t = weight at age t and W_{t-1}= weight at age t-1. Condition factor was calculated from the equation of $K=W/L^3$ of Lagler (14). The length-weight relationship was computed separately for all female and male specimens by the equation; $W=aL^n$. Determining of growth (length and weight) and condition factor differences at same age between female and male specimens were statistically calculated with "t-test" in the %95 confidence interval (18). Statistical analyses were carried out using SPSS 11.0 programme.

Results

The findings show that 288 specimen caught in Liman Lake have the age distribution between I and VI age groups. Of these age groups, II and III age groups are found to be dominant ones (49.31%). Less common age groups are the first year (5.55 %) and Vi[th] year age group (10.42 %) (Figure 1).

Of 262 specimen of which sex is identified, 141 are female, 121 male. The ratio of female:male is found to be 1.16:1. Fork length values of the population are identified between 145 and 460 mm. The most dominant length interval is found to be 201-300 with 56.24% ratio. The rate of specimen under 300 cm which is to be hunting prohibitionlength is 63.88%. The lowest and highest length values are measured as 190-460 mm for females and 195-410 mm for males (Figure 2 and Table 1).
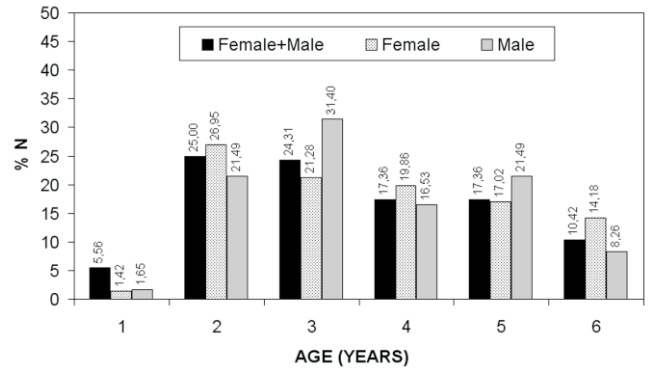

Figure 1. Frequency of age groups and sex ratio of *Cyprinus carpio* caught in Liman Lake.
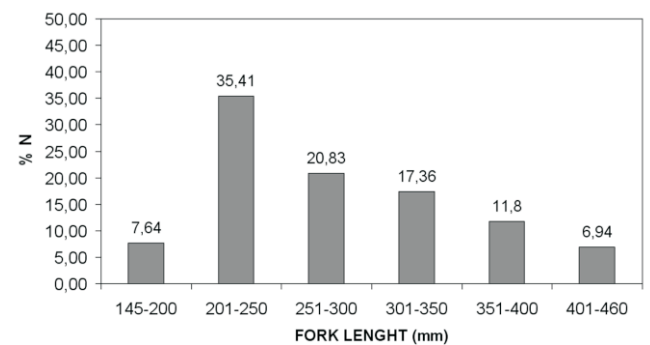

Figure 2. Fork lenght (mm) frequency distribution of *Cyprinus carpio* living in Liman Lake.

Table 1 shows the results of t-test indicating the minimum, maximum and mean fork length (mm), relative length increase and differences in length growth between sexes. Table also indicates that length growth increases depending on age groups for the population as a whole and for both sexes. Lenghth growth between female and male specimen is not statistically significant (p>0.05). It is also found that relative length increase depends on age except for the second age group.

Weight values are determined to change between 42 and 1965 gr. for the population. The most common weight interval for those which are eligible for fishing is between 152 and 586 gr. (70.13%). The rate of those weight is

Table 1. Fork lenght (mm) and relative lenght increment (RLI) of *Cyprinus carpio* caught in Liman Lake.

		Female			Male				Female+Male	
AGE	N	FL ± SD (Min-Max)	RLI %	N	FL ± SD (Min-Max)	RLI %	t-test	N	FL ± SD (Min-Max)	RLI %
I	1	190	17.2%	1	210	8.0%		16	192.2 ± 21.5 (145-215)	15.4%
II	38	222.6 ± 22 (195-275)	10.6%	26	227 ± 36.8 (195-330)	9.7%	p>0.05	72	221.8 ± 28.1 (190-330)	11.5%
III	30	246.3 ± 25.8 (220-315)	18.4%	38	249.1 ± 30.4 (215-330)	20.4%	p>0.05	70	247.4 ± 27.8 (215-330)	15.6%
IV	28	291.8 ± 32.2 (240-375)	14.3%	20	300 ± 11.5 (285-315)	14.8%	p>0.05	50	293.2 ± 26.9 (240-375)	15.7%
V	24	333.8 ± 40.9 (245-390)	23.7%	26	344.6 ± 32.9 (305-400)	14.9%	p>0.05	50	339.4 ± 36.6 (245-400)	16.6%
VI	20	413 ± 36.9 (360-460)		10	396 ± 17.8 (365-410)		p>0.05	30	407.3 ± 32.2 (360-460)	

more than 1 kg is determined as 11 %. The lowest and highest weight for female and male specimens are found to be 117-1965 gr. and 120-1302 gr, respectively (Figure 3 and Table 2).

Table 2 shows minimum, maximum, mean weight, relative weight increase and the results of t-test for eligible population for fishing. Relative weight values are increases is related with age.

Regression curve indicating the relationship between length and weight in *Cyprinus carpio* shows that there is a positive curve relationship between length and weight growth (Figure 4). Weight-length equation is found to
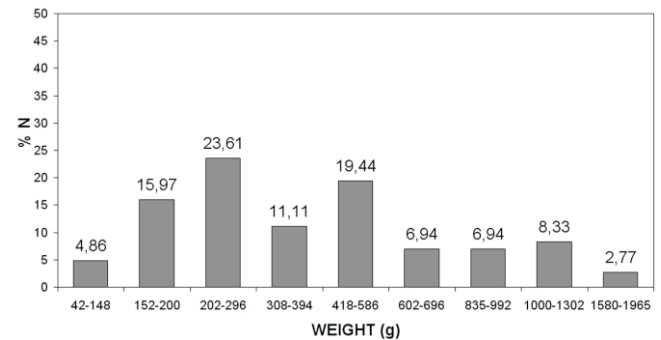

Figure 3. Weight (gr.) frequency distribution of *Cyprinus carpio* living in Liman Lake.

Table 2. Weight (g) and relative weight increment (RWI) of *Cyprinus carpio* caught in Liman Lake.

		Female			Male				Female+Male	
AGE	N	FL ± SD (Min-Max)	RLI %	N	FL ± SD (Min-Max)	RLI %	t-test	N	FL ± SD (Min-Max)	RLI %
I	1	190	17.2%	1	210	8.0%		16	192.2 ± 21.5 (145-215)	15.4%
II	38	222.6 ± 22 (195-275)	10.6%	26	227 ± 36.8 (195-330)	9.7%	p>0.05	72	221.8 ± 28.1 (190-330)	11.5%
III	30	246.3 ± 25.8 (220-315)	18.4%	38	249.1 ± 30.4 (215-330)	20.4%	p>0.05	70	247.4 ± 27.8 (215-330)	15.6%
IV	28	291.8 ± 32.2 (240-375)	14.3%	20	300 ± 11.5 (285-315)	14.8%	p>0.05	50	293.2 ± 26.9 (240-375)	15.7%
V	24	333.8 ± 40.9 (245-390)	23.7%	26	344.6 ± 32.9 (305-400)	14.9%	p>0.05	50	339.4 ± 36.6 (245-400)	16.6%
VI	20	413 ± 36.9 (360-460)		10	396 ± 17.8 (365-410)		p>0.05	30	407.3 ± 32.2 (360-460)	

to be W= 0.0283. L$^{2.871}$ for whole population, and W= 0.0282. L$^{2.874}$ for female and W= 0.0289. L$^{2.863}$ for male.
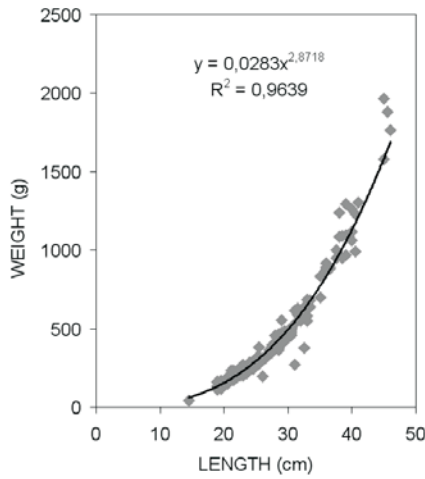

Figure 4. Length and weight relationship of *Cyprinus carpio* (female+male) caught in Liman Lake.

Table 3 provides the results of t-test and standart deviation regarding minimum, maximum and mean condition factor for the whole population and both sexes depending on age groups. Mean K value for the population is found to be 1.876. It is 1.943 for female specimen and 1.868 for male specimen.

Discussion

Since Liman Lake has a special position, it has different ecological structure than the other lakes in Kızılırmak Delta. Its exceptional status is a result of the following characteristics:its being near to sea, rate of salt (1.96-4.06%), and freshwater entrance into the lake and nearby agricultural fields. In this study, growing features of *Cyprinus carpio* that has economic value in Liman Lake are investigated. As a result of the scale analysis of the specimens, it is found that the age of the population changes from I to VI. Those with II and III ages are dominant.

The reason for the unavailability of specimen belonging to 0 age group and fewer specimens from 1 age group is related to size of mesh used by fisherman. On the other hand, the reasons for the unavailability of samples from older age groups (>VI) can be related to natural mortality, past time hunting pressure and to be a young population in the lake. Among the specimen eligible for fishing, the age for sexual maturity is II and III age groups (49.31%). Since they are subject to fishing, it is dangerous for the population. Distribution of sexes across age groups is similar to that for the entire population.

The rate of female:male is found to be 1.16:1 which indicates that the population is healthy in terms of sex ratio. Nikolskii (19) argues that ratio of sexes in many

Table 3. Condition factor results for female, male and combined sexes of *Cyprinus carpio* from The Liman Lake.

		FEMALE			MALE				FEMALE+MALE	
Age	N	K ± SD (Min-Max)	SH	N	K ± SD (Min-Max)	SH	T testi	N		K ± SD (Min-Max)
I	1	2.347		1	1.943			16		1.994 ± 0.327 (1.377-2.347)
II	38	1.928 ± 0.288 (1.109-2.303)	0.066	26	1.995 ± 0.276 (1.613-2.469)	0.0765	p>0.05	72		1.944 ± 0.275 (1.109-2.469)
III	30	1.948 ± 0.169 (1.656-2.221)	0.0437	38	1.873 ± 0.127 (1.658-2.095)	0.0292	p>0.05	70		1.909 ± 0.148 (1.656-2.221)
IV	28	1.739 ± 0.245 (1.098-2.263)	0.0655	20	1.771 ± 0.338 (0.906-2.015)	0.1071	p>0.05	50		1.748 ± 0.276 (0.906-2.263)
V	24	1.854 ± 0.171 (1.530-2.178)	0.0495	26	1.777 ± 0.119 (1.623-1.979)	0.0331	p>0.05	50		1.814 ± 0.149 (1.530-2.178)
VI	20	1.842 ± 0.239 (1.493-2.259)	0.0756	10	1.853 ± 0.083 (1.746-1.968)	0.0371	p>0.05	30		1.846 ± 0.197 (1.493 ± 2.259)
		K=1.943			K= 1.868					K=1.876

species is 1:1. Similarly, Şişli (20) states that expected Mendel sex ratio for populations are 1:1. The values found in the study are consistent with these assumptions. Comparing of male, slightly higher ratio of female specimen can be attributed to less activity of female lead to easy catching of them in the coast line vegetation zone.

Length distribution for the *Cyprinus carpio* samples eligible for fishing is found to be between 145 and 460 mm and 63.88% of the population have the length of less than 300 mm. Circular published by the Ministry of Agriculture and Forest states that minimum length for *Cyprinus carpio* for fishing is 300 mm (21). Therefore, fishing in Liman Lake is found to be dangerous for *Cyprinus carpio* population, since most samples which are caught have this length value or below this. Another threat is hunting of those samples when their reproduction period. Regarding length growth values of both sexes, males have slightly higher values in contrast to females, but this difference is not statistically significant between two sexes in all age groups (p>0.05).

Relative length increase is found to be dependent on the age except for the second age group in Liman Lake. Wootton (22) states that length increase is higher in early ages but it becomes slow because energy is mostly used for reproduction activities such as gonad development, originating of germinative cell. *Cyprinus carpio* population in Liman Lake reaches sexual maturity at the age of two. Therefore, relative length increase of 15.4% at the first age decreases to 11.5% at the age of two and it again shows an increase at older ages. Differences found between sexes in terms of relative length increase is not statistically significant (p>0.05).

Age-length correlation for *Cyprinus carpio* samples in terms of eligible population for fishing and sexes is consistent with the assumptions of Nikolskii (19) concerning natural fish population that length growth increases depending on age and that there is a linear relationship between age lengths.

Weight distribution for the samples eligible for fishing varies between 42 and 1965 gr. Given that ideal weight for commercial value is 1000 gr. (11), the rate of samples having this and more weight is 11% in Liman *Cyprinus carpio* population. Like length values, weight of hunting population is mostly below ideal fishing size. It is an indicator of improper fishing practices in Liman Lake. Differences observed between sexes in terms of weight values are not statistically significant (p>0.05).

Relative weight increase is in parallel to age except for the second age group and differences in this regard between two sexes are not statistically significant (p>0.05). The reason for less weight values at the age of two seems to be that male samples have less weight values. Because females of this age have higher values of weight due to the weight of gonad.

Table 4. Comparing length, weight and condition factor values of *Cyprinus carpio* living in Liman Lake with the other studies results.

	Study Area	Fork Length (mm) Age Groups											Weight (g) Age Groups											K Value
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11	
Alpbaz and Hoşsucu (1979) (2)	Göl Marmara	252	416	513	578	645	800						340	650	2892	4083	5900	9750						1,6
Erdem (1983a) (23)	Eğirdir Lake	141	231	314	361	400	440	501	545	588	639	660	77	233	457	716	976	1313	1886	2228	2660	3320	3987	1,6
Erdem (1983a, 1984) (23, 24)	Beyşehir Lake	150	231	310	355	404	458	499	556	609	651	679	97	276	567	782	1191	1548	2114	2605	3090	3664	4182	1,6
Erdem (1983a, b) (23, 25)	Çavuşçu Lake	141	220	288	349	411	455	501	560	611	680		69	193	417	674	1078	1377	1890	2522	3108	3767		1,8
Balık and Ustaoğlu (1987) (4)	Gölcük Lake	77	103	136	163	172	192	209	232	256	274	314	8	19	38	64	76	98	125	178	238	288	451	1,5
Cengizler and Erdem (1988) (5)	Hafik Lake	128	185	238	269	305	332	365					52	134	263	372	500	655	940					-
Yerli (1992) (6)	Köyceğiz Lagoon	224	308	356	414	475	547	600		662	712		217	496	742	1180	1764	2474	3442					-
Demirkalp (1992) (7)	Bafra Balık Lakes	165	268	319	365	442	516	535	630				116	382	628	905	1625	2561	2824	4050				1,8
Çetinkaya (1992) (8)	Akşehir Lake	143	181	215	239	258	290	322	369	430	465	533	51	98	157	217	271	374	499					-
Yerli (1997) (26)	Çıldır Lake		216	266	297	331	384	469	471	500				206	342	486	715	1028	1431	2073	2180			-
Demirkalp ve Saygı (2001) (9)	Yeniçağa Lake	238	229	266	299	313	404	475	577	568	632		222	229	386	572	652	1260	2093	3135	3503	4875		1,9
Demirkalp et al. (2001) (10)	Çernek Lake	152	205	262	340	396	493						71	161	339	679	1019	1985						-
Özeren (2004) (11)	İznik Lake	61	122	174	248	392	653	810					5	42	110	320	1141	4572	8422					1,9
This study	Liman Lake	192	221	247	293	339	407						148	218	296	448	739	1274						1,8

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Age and weight correlation figure of *Cyprinus carpio* population found in Liman Lake is consistent with the assumptions regarding natural fish population in that weight increases in parallel to age. Regression curves indicating the relationship between length and weight in the sample show a positive curved relationship in all groups. "b" value calculated based on regression equations for the population eligible for fishing is found to be 2.87. Although this value is very close to 3, *Cyprinus carpio* exhibits an allometric growth feature in Liman Lake. Correlation coefficient of 0.96 indicates a significant relationship between length and weight.

Table 4 shows comparisons of the findings of earlier studies with this study regarding fork length, weight and condition factor values of *Cyprinus carpio* in different localities in Turkey.It is seen that values found in Liman Lake are lower than those found in Lake Marmara, Köyceğiz Lagoon and Bafra Balık Lakes and higher than those recorded in Gölcük, Hafik and Akşehir Lakes. Values determined in Liman Lake are also found to be very similar to those observed in Çıldır, Yeniçağa and Çernek Lake. In the early years of fish, the growth values of Liman population are similar to those found in Eğridir, Beyşehir, Çavuşçu ve İznik Lakes. However, the values of later ages in Liman Lake are higher than those recorded in these localities.

Condition factor value (K) is used to get information about feeding status of the fish in its environment and to make comparisons among populations living in different habitat. For *Cyprinus carpio* population eligible for fishing, mean K value is found to be 1.87. It is 1.94 for female samples and it is 1.86 for male samples. The differences between sexes in terms of K values is not statistically significant (p>0.05). K values found in Liman Lake seem to be normal range when compared to those found in different localities (Table 4).

In conclusion it is found that the population of *Cyprinus carpio* reflects the expected and previously observed features of age distribution, growing and condition factor in natural fish populations. Proper fishing techniques and following the fishing restrictions are necessary for the continuation of *Cyprinus carpio* population in Liman Lake as an economical resource. Fishing of samples with small size and lower weight will be a threat for *Cyprinus carpio* population in Liman Lake.

Acknowledgement

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