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Age and Growth Properties of Prussian Carp, *Carassius gibelio* (Bloch, 1782) Living in the Middle Basin of Seyhan River in Adana, Turkey

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Abstract.- In this study, 317 prussian carp (*Carassius gibelio*) were examined after being captured during monthly samplings in the middle basin of Seyhan River over the period of April 2013 to March 2014 in order to investigate and determine their age and growth parameters. The total distribution varied from 10.7 to 31.0 cm in length and 26.0 to 450.0 g in weight. Length-weight relationship was calculated as $W = 0.0673 \times L^{2.571}$ for all individuals. The parameters of von Bertalanffy growth fit the mean observed total lengths-at-age for each sex separately and were estimated as $L_\infty = 33.27$ cm, $k = 0.301$ year $^{-1}$, $t_0 = -0.531$ year for females, $L_\infty = 31.96$ cm, $k = 0.294$ year^{-1}, $t_0 = -0.515$ year for males, and as $L_\infty = 32.30$ cm, $k = 0.307$ year $^{-1}$, $t_0 = -0.526$ year for combined sexes.

Key-words: *Carassius gibelio*, growth properties, length-weight relationship, Seyhan River.

INTRODUCTION

Carassius gibelio (Bloch, 1782) is an invasive species seen in inland waters of Turkey. It is a member of the Cyprinidae family and its natural distribution areas are Korea, Northeast China, and Russia in Asia (Berg, 1964; Kottelat and Freyhof, 2007; Froese and Pauly, 2015). *C. gibelio* was reported for the first time in 1986 in Gala Lake in the Thrace Region (Baran and Ongan, 1988). Later on, it was reported to have shown rapid distribution throughout the Marmara Region and Anatolia over the past 20 years (Baran and Ongan, 1988; Özuluğ *et al*., 2004; Özuluğ, 1999; Özuluğ *et al*., 2005a,b; Şaşı and Balık, 2003; Balık *et al*., 2004; Özcan, 2007; Ergüden Alagöz and Göksu, 2012; Emiroğlu *et al*., 2012; Innal, 2012; Kırankaya and Ekmekçi, 2013).

C. gibelio was introduced into Europe from Asia in the 17th century and has since become widely distributed throughout Europe (Lever, 1996). The species was accidentally introduced in southern European countries (Leonardos *et al.*, 2008) and then it was reported from several lakes, reservoirs and ponds in Turkey (Özuluğ *et al*., 2004; Tarkan *et al*., 2006; Kırankaya and Ekmekçi, 2013). For this reason, *C. gibelio* does not allow growth of native fish populations. It is dominating in stagnant and slow-flowing waters, and inhibit reproductive activity of other Cypriniformes. It also changes nutrients-flow in the aquatic environment, and hence is introduced as an invasive species (Tarkan *et al*., 2012a,b; Kırankaya and Ekmekçi, 2013). In addition, *C. gibelio* is gonochoristic and has gynogenetic reproductive properties, because of which *C. gibelio* number increases rapidly (Fan and Shen, 1990; Zou, *et al.*, 2001; Tarkan *et al*., 2006; Bostancı, 2007).

There is no information available on *C. gibelio* inhabiting the middle Seyhan River basin. Data about age, growth properties and length-weight relationship of *C. gibelio* has been determined in this study for the first time.

MATERIALS AND METHODS

Seyhan River Basin is the second largest river basin in the eastern Mediterranean Sea following the Nile River. There are four dams on Seyhan River and its important tributaries. It is determined that because of these dams, water quality and quantity changes at every step. Moreover, the sub-basin permanently contains industrial waste and domestic waste with agricultural drainage water (Talu and Özüt, 2011; Davutoğlu *et al*., 2011).

A total of 317 samples of *C. gibelio* captured on monthly basis between April 2013 and March 2014, by native fisherman having gill nets casting net, and electro-shocker or provided by sport fishermen. The total weight ±0.1 g and total length ±0.1 mm of samples were measured precisely. Sex

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ratio (male number per female; M:F) was calculated.

Length-weight relationship

$W = a*L^b$ formula was used in the calculation of length-weight relationship for all individuals (Ricker, 1975), where a and b are the parameters of regression analysis. The length-weight relationship regression was performed separately for all male and female individuals. t-test was used for determining whether or not b values are different from 3 (Zar, 1999; Yılmaz *et al*., 2010).

Age and growth

For age determination, scales rings were counted under a binocular microscope. The growth was determined according to von Bertalanffy (1938). The least square technique, which was propounded by Avşar (2005) for calculating values of (L_∞), (k) and (t_0) growth fixed, was utilized.

$$L_t = L_\infty [1 - e^{-k(t - t_0)}];$$

where L_t shows age t (year), L_∞ shows theoretical fish length (a theoretical asymptotic length), k shows the growth ratio coefficient, t_0 is the theoretical age the fish would have at a length of zero.

RESULTS

Length and weight relationship

The total length of fish ranged between 10.7 and 31.0 cm, and weight ranged between 26.0 and 450.0 g (Fig. 1). It was observed that the length was at the most 20-22 cm (60.5%) for all individuals (Fig.1). The male: female ratio was found to be 0.06:1. It was confirmed that there wasn't a significant difference among sexes in terms of length and weight (*t*-test, P>0.05) (Table I).

The length and weight relationship was calculated as $W = 0.0603\ TL^{2.606}$ ($r^2 = 0.912$) for female, $W = 0.1085TL^{2.400}$ ($r^2 = 0.961$) for male and $W = 0.0673TL^{2.571}$ ($r^2 = 0.927$) for all individuals. In this study, it was specified that when the b value of *C. gibelio* was examined, *C. gibelio* showed a negative allometric growth (Table I, Fig.2).

Age and growth

The average length of all individuals varies between 10.7 and 31.0 cm depending on age (Table II). It is emphasized that individuals show distribution between II and V age groups, and also the dominant ages are III and IV in population (Table II). According to growth in the length model of population in the von Bertalanffy equations, it is found that $L_t = 33.27\ [1\text{-}e^{-0.301\ (t+0.531)}]$ is for female $L_t = 31.96\ [1\text{-}e^{-0.294\ (t+0.515)}]$ is for male, and $L_t = 32.30\ [1\text{-}e^{-0.307\ (t+526)}]$ is for all individuals.

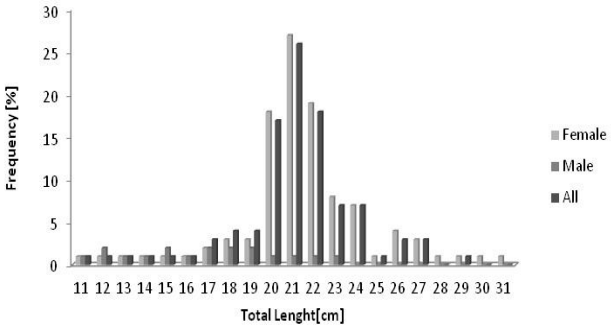

Fig. 1. Length–frequency distribution of females, males, and combined sexes of *C. gibelio* collected in the middle basin of Seyhan River; Number of fish studied = 317

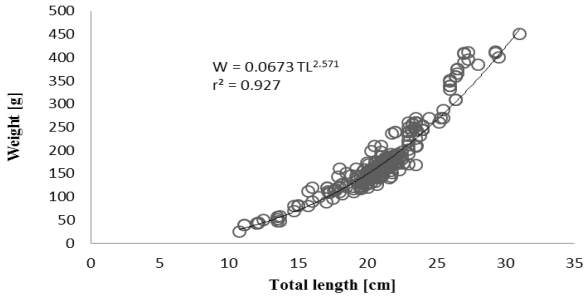

Fig 2. Length-weight relations combined sexes of *C. gibelio* from the middle basin of Seyhan River.

DISCUSSION

It was determined that the age distribution of *C. gibelio* population varies between I and V in the middle basin of Seyhan River. However, it is observed that the age distribution of this species in other regions varies generally between 0 and VII (Table III). Leonardos *et al*. (2008) indicated in their study on Chimaditis Lake that the age distribution of

Table I.- Descriptive statistics and length–weight relationships for *C. gibelio*, the middle basin of Seyhan River.

Sex	n	L_{min}-L_{max}	W_{min}-W_{max}	$W=a\ L^b$		
				a	b±95%CI	r^2
Male	18	11.1-22.5	40.1-136.3	0.1085	2.400±0.014	0.961
Female	299	10.7-31.0	26.0-450.0	0.0603	2.606±0.021	0.912
Combined	317	10.7-31.0	26.0-450.0	0.0673	2.571±0.020	0.927

n, sample size; L, length (cm); W, weight (g); SE, standard error; CI, confidence interval; a, intercept of the relationship; b, slope of the relationship; r^2, coefficient of determination.

Table II.- Age-length key of *C. gibelio* caught in middle basin of Seyhan River.

Length intervals (cm)	Age groups (in years)				
	I	II	III	IV	V
10.5-11.4	3				
11.5-12.4	4				
12.5-13.4	1				
13.5-14.4	5				
14.5-15.4	2	2			
15.5-16.4		5			
16.5-17.4		7			
17.5-18.4		12			
18.5-19.4		12			
19.5-20.4		15	19	2	
20.5-21.4		1	73	26	
21.5-22.4			17	39	
22.5-23.4			1	22	
23.5-24.4				21	
24.5-25.4				3	
25.5-26.4				7	4
26.5-27.4				2	7
27.5-28.4					1
28.5-29.4					2
29.5-30.4					1
30.5-31.4					1
n	15	54	110	122	16
Mean TL ± SD	12.45±1.11	18.40±1.38	20.68±0.58	22.55±1.45	27.53±1.47
Mean TW ± SD	41.41±6.81	127.71±19.11	159.19±20.08	205.68±51.60	385.43±34.89
Males (% n)	7(38.88)	7(38.88)	4(22.22)	0	0
Females (% n)	8(2.67)	47(15.72)	106(35.45)	122(40.80)	16(5.35)
M : F	0.88:1	0.14:1	0.03:1	0.00	0.00

C. gIibelio is between I-VI. Rogozin *et al*. (2011) stated in their study on Shira Lake that the age distribution alters between I-XV. As some records indicate, *C. gibelio* has a long life such as X to XI inland water of Europe (Szczerbowski, 2001; Kırankaya and Ekmekçi, 2013). Bulut *et al*. (2013) report that male individuals have a shorter life span than female individuals. At the same time, it is thought that differences in age composition in studies on *C. gibelio* may occur due to different sampling times and fishing methods.

Tsoumani *et al*. (2006) has revealed in their study on 12 lakes of Greece that the total length values of *C. gibelio* alter between 14.5-37.7cm. Leonardos *et al*. (2008) report total length values of *C. gibelio* which inhabits inland areas of northern Greece are determined as 21.9-37.0cm. It is observed that the data about length values in our study are close to obtained data in studies from other countries. Studies in our country reveal that

Table III.- Comparisons of *C. gibelio* age, length and weight parameters in the different areas of Turkey.

Author	n	Sex	L_{min}-$L_{max(cm)}$	Length	W_{min}-$W_{max(g)}$	Age	Locality
Balık *et al*., 2004	903	M+F	11.9-29.6	FL	37.5-606.2*	I-VI	Egirdir Lake
Tarkan *et al*., 2006	366	M+F	5.2-30.2	TL	1.98-565.2	I-IV	İznik Lake
Tarkan *et al*., 2006	258	M+F	12.5-35.7	TL	40.5-860.6	I-VI	Ömerli Reservoir
Çınar *et al*. 2007	482	M+F	7.1-27.4	FL	6.0-495	0-V	Beyşehir Lake
Bostancı *et al*., 2007	283	M+F	8.2-28.1	FL	12.5-730	**	Egirdir Lake
Özkök, 2007	1717	M+F	7.5-33.3		8.0-1703	0-IX	Egirdir Lake
Sarı *et al*., 2008	2325	M+F	9.7-25.5	FL	23.6-269	I-VI	Buldan Reservoir
Şaşı, 2008	172	M+F	23.8-28.4	FL	35.63-572	III-VI	Topçam Reservoir
İnnal, 2012	128	M+F	10.3-30.5	TL	25.0-607	I-VI	Aksu River Estuary
Güngör, 2012	480	M+F	23.0-34.3	TL	15.8-622	II-V	İkizcetepeler Reservoir
Kırankaya and Ekmekçi, 2013	332	M+F	5.6-27.0	FL	3.8-597	0+-V+	Gelingüllü Reservoir
Bulut *et al*., 2013	149	M+F	14.8-32.5	FL	43.1-807.3	I-VII	Seyitler Reservoir
Ergüden, 2015	142	M+F	11.1-29.5	TL	40.1-412.9	I-V	Seyhan Reservoir
Uysal *et al*., 2015	3114	M+F	7.8-32.2	ÇL	5.0-829	I-VI	İznik Lake
This study	317	M+F	10.7-31.0	TL	26.0-450	I-V	Seyhan River (middle basin)

*Mean value **No data in paper

Table IV.- Growth performance comparisons of *C. gibelio* species in the different locality of Turkey.

Author	Sex	L_{∞}	k	t_0	Locality
Balık *et al*., 2004	M+F	33.30	0.346	-0.302	Egirdir Lake
Çınar *et al*., 2007	M+F	36.20	0.206	-1.270	Beyşehir Lake
Sarı *et al*., 2008	M+F	31.66	0.146	-2.146	Buldan Reservoir
Innal, 2012	M+F	36.86	0.244	-0.791	Aksu River Estuary
Kırankaya and Ekmekçi, 2013	M	32.17	0.232	-0.094	Gelingüllü Reservoir
	F	36.03	0.212	-0.205	Gelingüllü Reservoir
Bulut *et al*., 2013	M+F	48.09	0.290	-0.093	Seyitler Reservoir
Uysal et al., 2015	M+F	40.00	0.204	-1.179	İznik Lake
This study	M+F	32.30	0.307	-0.526	Seyhan River (middle basin)

total length values of *C. gibelio* are similar to length values in our study (Table III). It is confirmed that the closest length values to our study are from the study made in Aksu River by Innal (2012) (Table III).

Tarkan *et al*. (2006) informed in their study on Ömerli Dam Lake that female individuals of *C. gibelio* are between 40.5-860.6g and male individuals of *C. gibelio* are between 43.3-452.6g. It is reported in other a study on İznik Lake that female individuals are between 3.3-565.2g and male individuals are between 1.98-313.3g. Güngör (2012) indicated in a study on İkizcetepeler Dam Lake that the weight measurement of this species are between 15.8-622g for all individuals; between 16.5-622g for female individuals; between 15.0-440.4g for male individuals. In our study, the weight values of *C. gibelio* show distribution between 26.0-450.0g for all individuals. It is shown that the obtained values resemble other studies with similarities to studies in our country (Table III).

C. gibelio fish have two different reproductive activities including gynogenetic and bisexual (Bostancı *et al.*, 2007). Thereby the female individuals interact with the sperm of different species like *C. carpio* so they generate a population which is comprised of entirely females. Thus, they form a crowd of undesirable degree and unisexual culture (Fan and Shen 1990; Bostancı *et al.*, 2007). In our findings, female-male ratio is calculated as 1:0.06. Güngör (2012) has reported that the *C. gibelio* female individual-male individual ratio for the population is 3.52:1 in İkizcetepeler Dam Lake. Kırankaya and Ekmekçi (2013) have found the

male-female ratio as 1:0.73 in Gelingüllü Dam Lake. Uysal *et al.* (2015) has also indicated female-male ratio as 1:0.51 in İznik Lake. Bostancı *et al*. (2007) have stated that in their study on Bafra Fish Lake 2.89 percent of the population are male individuals. In addition, Sarı *et al.* (2008) reported that 0.56 percent of the population consists of male individuals in Buldan Dam Lake and this population can show bisexual reproductive traits.

As a result of the obtained findings and the findings of previous studies, it can be thought that *C. gibelio* species in middle basin of Seyhan River show gynogenetic reproductive traits. It is observed in this study that b value (2.57) denotes negative allometric growth for females, males and all *C. gibelio* individuals. In their study, Kırankaya and Ekmekçi (2013) have observed isometric growth with b=3.05 value in female and negative allometric growth with b=2.80 value in male. b values for all indivudials are notified respectively: b=2.97 for Bafra Fish Lake (Bostancı *et al*., 2007), b=2.87 for Buldan Dam Lake (Sarı *et al*., 2008), b=2.59 for İkizcetepe Dam Lake (Güngör, 2012), b=2.65 for Seyhan Dam Lake (Ergüden, 2015). At same time, it is reported that there is a negative allometric growth between length and weight for all individuals. It is observed that our findings are similar with the findings from studies in previous years. Seasonally, isometric and allometric structuring of a fish species are significant. Variable sample sizes and length ranges among populations also give raise to a change in b values (Froese, 2006). The length–weight relationships of fish are considerably related to season and affected from some factors like stress, reproductive activity, environment and nutrition (Le Cren, 1951; Froese, 2006; Leonardos *et al*., 2008; Saylar and Benzer 2014).

It is observed that when the results of von Bertalanffy growth parameters in studies on *C. gibelio* in our country are scrutinised (Table IV), they have nearly the similar growth ratio with the population of *C. gibelio* in Turkey. The alteration in fish growth (length and weight) can be explained by means of adjusting to different ecological conditions (Nikolsky, 1963).

It is known that as a result of introducing invasive species, consciously or unconsciously within the environment which contains native fish species which are inhabiting their natural environment, the life cycle of native species is affected. These species, which have very wide ecologic tolerance, increase in inland waters rapidly. The effects that take place include both food competition and reproductive force between invasive species and native species. As a consequence of these effects, native species may vanish. This invasive species inhabits different habitats in our inland waters, so we need to be monitoring their life histories and undergo further studies devoted to this population.

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