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Several Growth Characteristics of an Invasive Cyprinid Fish (*Carassius gibelio* Bloch, 1782)

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Abstract

Age composition, length-weight relationships, growth, and condition factors of the gibel carp (*Carassius gibelio* Bloch, 1782) were determined using specimens collected from Seyitler Reservoir between July 2005 to June 2006. A total of 149 gibel carp were observed and examined. The age composition of the samples ranged between I and VII years of age. It has been determined than 82.55% of the obtained samples are comprised of females, 16.11% is comprised of males and 1.34% is comprised of immature. The population is dominated by females able to reproduce gynogenetically. The mean fork lengths and mean weights of the population were 14.8-32.5 cm and 43.1-807.3 g respectively. The length-weight relation were calculated as $W = 0.0696\ L^{2.132}$, r=0.838 for females, for males $W = 0.2942\ L^{2.6417}$ r=0.784 and $W = 0.0274\ L^{2.9382}$, r=0.813 for all samples. The mean Fulton Condition Factor was calculated as 2.342 for females, 2.064 for males and 2.276 for all samples. Age-length and age-weight relations were determined according to von Bertalanffy growth equation formula. Growth parameters of the population were $Lt = 48.09\ [1\text{-}e^{-0.093(t+0.29)}]$, and $Wt=2323.62\ [1\text{-}e^{-0.093(t+0.29)}]^{2.9382}$. The growth performance index value (Ø′) was computed as 5.37 for all specimens.

Keywords: *Carassius gibelio*, condition factor, invasive species, length-weight relation, Seyitler Reservoir

Introduction

Introduction of fish in freshwater ecosystems is frequently considered a practical application of fisheries management in many countries. However, these introduction initiatives can cause ecologic undesirable consequences due to intentional or unintentional introduction of invasive fish, as well as cultivation of the species targeted. Currently, *C. gibelio* (Kırankaya and Ekmekçi, 2013) is a typical example of introduced species. It is an omnivorous fish species which feeds on detritus, zooplankton, zoobenthos and macrophyta (Specziar *et al.,* 1997) and continues to expand its distribution area in fresh water environments. Small specimens feed on plankton and detritus, while large specimens prefer benthos and relatively large plankton and has lived in freshwater and lagoon lakes, ponds and streams.

C. gibelio was introduced to Europe from Asia in the 17th century. It has been already established in at least 12 European countries and range expansion of the freshwater system of Turkey (Özuluğ *et al.,* 2004; Vetemaa *et al.,* 2005; Özcan, 2007). The presence of gibel carp in the Turkey was not recognized until the 1980s (Baran and Ongan, 1988), probably due to its strong ppheotypicalotypical resemblance to the *Carassius* species introduced to Turkey: crucian carp *Carassius carassius* (L., 1758), and goldfish *Carassius auratus* (L., 1758). With developments in the identification of *Carassius* species, distribution of crucian carp in Turkey is presently thought to include both the Thrace region and the entire Anatolian Peninsula (Gaygusuz *et al*., 2007).

Invasive alien fish species have reduced the abundance of native inland water species through predation, hybridization, parasitism or competition for resources, and may alter population size, structure and ecosystem processes, such as food webs, energy flow or the hydrodynamic properties of a particular inland water ecosystem (Gurevitch and Padilla, 2004). The results of these impacts are manifested both directly and indirectly, with economic costs and risks posed to non-market goods and services as well as to public health have raised concern (Andersen *et al.*, 2004).

Interestingly, gibel carp is one of the few fish species where the population is almost exclusively composed of females, some reproducing gynogenetically using the sperm of other species (Riehl and Baensch, 1991; Zhou *et al*., 2000). In addition, some even exhibit gynogenetic reproduces by the sperm of other species to activate (but not fertilize) their own eggs (Saat, 1990). Gynogenetic reproduction has some potential benefits: it allows the biomass of a population to be mainly composed of females,

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and available ecological resources can be solely used for egg production (Paschos *et al*., 2004).

C. gibelio has been reported in 1988, for the first time, in Gala Lake of Turkey (Baran and Ongan, 1988). Later on, reports from the Thrace Region (Özuluğ and Meriç, 1996; Özuluğ *et al*., 2004; 2005 a, b; İlhan *et al*., 2005; Tarkan *et al*., 2006; Gaygusuz *et al*., 2007) and the Anatolian Peninsula (İznik Lake-Tarkan *et al*., 2006; İznik Lake (Van)-Özuluğ *et al*., 2004; Büyük Menderes River Basin (Şaşı and Balık, 2003; İlhan *et al*., 2005; Özcan, 2007; Sarı *et al*., 2008; Şaşı, 2008), Kızılırmak and Yeşilırmak Basins (İlhan *et al*., 2005; Yılmaz *et al*., 2007; Uğurlu and Polat, 2007; Bostancı *et al*., 2007 b; Kırankaya and Ekmekçi, 2013) and the Mediterranean region: the Lyca basin (Çıldır, 2001; Balık *et al*., 2005; Balık *et al*., 2003; Bostancı *et al*., 2007 a; Çınar *et al*., 2007) and Clicia Basin (Alagöz *et al*., 2006) has followed.

According to Yeğen *et al*. (2009), the indigenous species of Seyitler Reservoir are: *Capoeta tinca* (Heckel, 1843), *Alburnus* sp.*, Squalius cephalus* (Linnaeus, 1758), *Cobitis simplicispina* (Hanko, 1925), *Knipowitschia caucasica* (Kawrajsky, 1899). The introduced species are: *C. gibelio* (Bloch, 1782) and *Cyprinus carpio* (Linnaeus, 1758).

Population sustainability must be maintained with natural sources/species. Therefore, management of natural sources based on scientific principles are needed. However, there are no studies, in the literature, on the growth properties of *C. gibelio* in Seyitler Reservoir. Therefore, the aim of this study is to examine the age composition, sex ratio, length and weight distributions, length-weight relationship and codition factor of *C. gibelio* samples which are eligible for fishing in Seyitler Reservoir. The results of the present study will be the basis of future research on this species and provide the necessary knowledge for fisheries and environmental management approaches.

Materials and methods

This study was carried out on a monthly basis between July 2005 to June 2006 in Seyitler Reservoir, in the Inner Aegean Region (38°47'30.57" N, 30°47'30.95" E). The Dam lake was built in 1964 for irrigation, and is fed by Seyitler Creek (Bulut, 2010). The sampling was performed using gill nets of various mesh sizes (25 x 25, 30 x 30, 35 x 35, 40 x 40, 45 x 45 mm). Collected fish were placed on ice in a cooler box and immediately transported to the laboratory. The fork lengths and weights were measured and weighted to the nearest 1 mm and 0.01 g. Scales were used for age determination. Twenty to 25 scales were taken from each fish and used for age determination according to Lagler's method (Lagler, 1956). The scales were taken from the area between the dorsal fin and a lateral line region of the body side and examined under a binocular microscope. Sex was determined by macroscopic observation of the gonads.

To calculate length-weight relationships the equation of the Le Cren (1951),

$W = a.L^b$, was used,

where W is the total weight of the fish (g), L is the fork length (cm), 'a' and 'b' are the parameters of the equation. The parameters 'a' and 'b' were estimated by linear regression of the transformed equation:

$\text{Log } W = \log a + b \log FL.$

The determination coefficient (r^2) was used as an indicator of the quality of the linear regression (Bagenal and Tesch, 1978).

The von Bertalanffy growth equations were determined:

$L_t = L_\infty [1 - e^{-k(t-to)}]$ and $W_t = W_\infty [1 - e^{-k(t-to)}]b$,

where L_t and W_t = fork length (cm) and weight (g) at age t, L_∞ and W_∞ = asymptotic length and weight (the length and weight of the fish would reach at an infinity age), k = the growth coefficient, t= age of fish and t_0 is the theoretical age the fish would have at length zero (Pauly, 1979).

Condition factors were computed for each sex as follows:

$CF=(W/L^3) \times 100$

where W is weight (g), L is fork length (cm), and 'b' is the exponent of the length-weight relationship for females, males, and overall (Bagenal, 1978).

The growth performance index (phi-prime index) Ø' was computed from the equation:

$Ø' = \text{Ln } k + 2 \times \text{Ln } L_\infty$

where 'k' and L_∞ are von Bertalanffy growth equation parameters (Sparre and Venema, 1992).

Differences between mean growth in males and females within the same age group were tested by Student's t test. Statistical significance was set at 0.05.

Results

In this study, a total of 149 *C. gibelio* specimens were investigated. Sex composition was 82.55% female, 16.11% male and 3.52% undetermined. Females were aged between II and VII; males between II and IV. It was observed that the dominant age was III (84.56%) in all specimens and this was followed by ages II and IV (5.37%) majority of the population consisted of females and it is possible that it is a monosexual, triploid and gynogenetic form (Tab. 1).

Tab. 1. Age and sex distribution of *C. gibelio* from Seyitler Reservoir

Age	Female		Male		Female+Male	
	N	%	N	%	N	%
I	-	-	-	-	2	1.34
II	5	3.36	1	0.67	6	4.03
III	104	69.8	22	14.77	126	84.56
IV	7	4.70	1	0.67	8	5.37
V	5	3.36	-	-	5	3.36
VII	2	1.34	-	-	2	1.34

As seen in Tab. 2, mean fork-lengths of *C. gibelio* varied between 14.8 and 32.5 cm. Eighty percent of the population was over 20 cm length. The longest individual was a female. This was obviously observed since the population's dominant length was between 20-21.9 cm (53.64%) (Fig. 1).

Tab. 2. Average fork lengths of *C. gibelio* and its relation with age (cm)

Age	N	Min	Max	Mean±SD
I	2	14.8	15.9	15.35±0.77
II	6	17.0	20.1	17.74±1.72
III	126	17.6	24.3	21.02±1.14
IV	8	23.4	25.4	23.79±0.69
V	5	25	27.3	25.56±1.08
VII	2	31	32.5	31.75±1.06

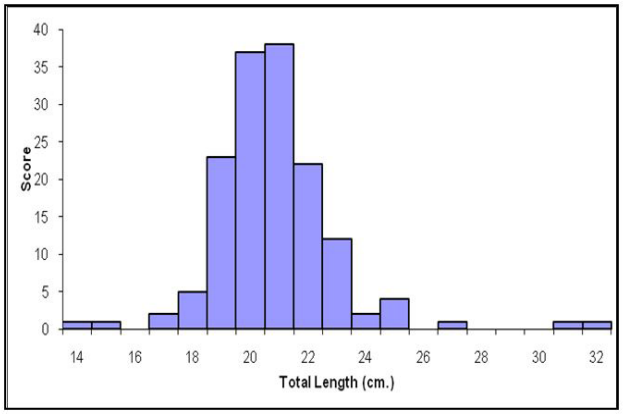

Fig. 1. Length-score distribution of *C. gibelio*

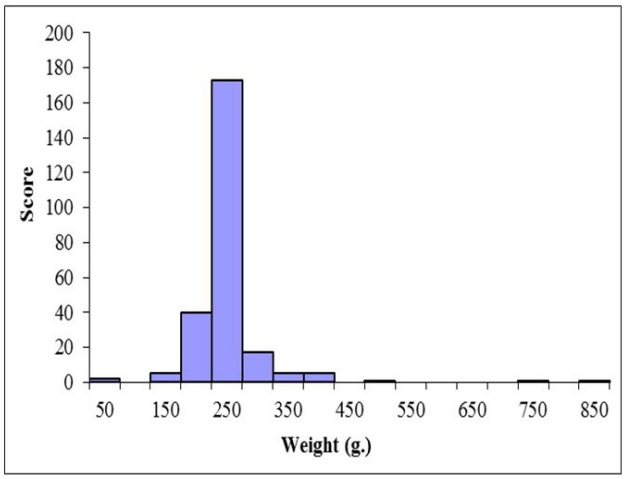

Fig. 2. Weight-score distribution of *C. gibelio*

As seen in Tab. 3, the weights of the individuals varied between 43.1 and 807.3 g, and over 95% of the population were of 150 g weight. Most of the observed population was within the 200-249 g weight group (Fig. 2). Both length and weight increased with old age (Fig. 3, Fig. 4).

Tab. 3. Average weight and relationships with age groups of *C. gibelio* (g)

Age	N	Min	Max	Mean±SD
I	2	43.1	49.2	46.15±4.31
II	6	115.2	205.5	130.6±58.56
III	126	121.6	360.4	214.11±35.47
IV	8	236.9	361.9	300.38±47.71
V	5	284.6	451.5	348.46±68.01
VII	2	703.5	807.3	755.4±73.39

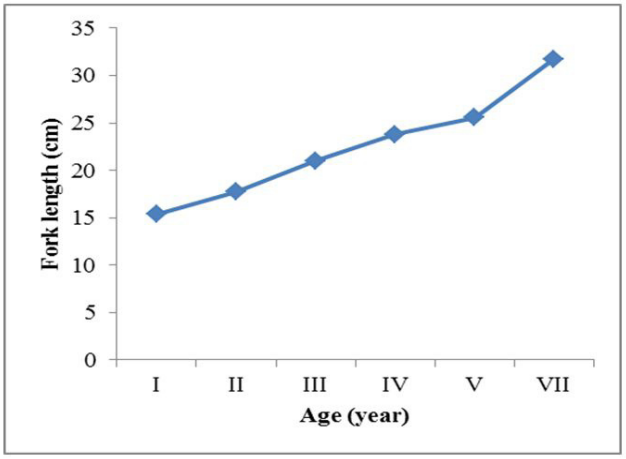

Fig. 3. Age-weight relationship of *C. gibelio*

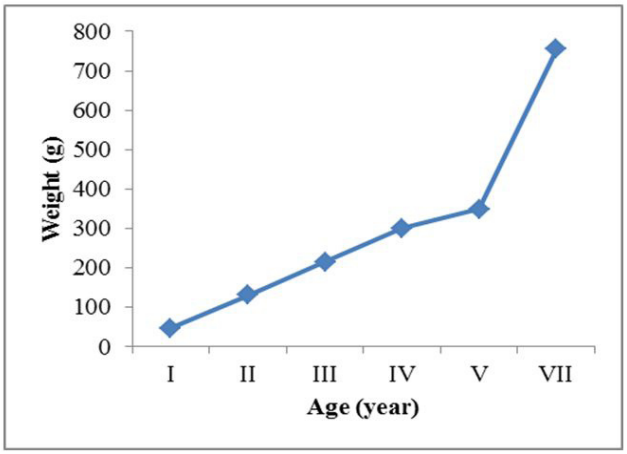

Fig. 4. Age-fork length relationship of *C. gibelio*

Results of statistical analysis (t-test) showed that there were no statistically significant differences between both lengths, weight and sexes ($p>0.05$).

The mean condition factor was calculated as 2.064 for males, 2.342 for females, and 2.276 for female + male. The minimum and maximum range values were 1.223 and 2.974, respectively (Tab. 4).

Analysis of the average condition factor showed the highest level to be in the group VII age (2.359), and at the lowest level in the V age group (2.11) (Tab. 4). There was a statistically significant difference between average condition factors of the sexes ($p<0.05$).

The von Bertalanffy length growth and weight equations for all individuals of *C. gibelio* living in Seyitler Reservoir were found to be $L_t = 48.09\ [1\text{-}e^{-0.093(t+0.29)}]$, and $W_t=2323.62\ [1\text{-}e^{-0.093(t+0.29)}]^{2.9382}$, respectively. The Ø' value was calculated as 5.37 using L_∞ and k values. The relationship between length-weight, was calculated by using their length and weight, and was found at: and was found at: $W = 0.0696\ L^{2.132}$, r=0.838 for females, for males $W = 0.2942\ L^{2.6417}$ r=0. 784 and $W = 0.0274\ L^{2.9382}$, r=0. 813 for female + male and related graph was given in Fig. 5. A negative allometric growth was detected in the population.

Tab. 4. Average condition factors with the relation of age groups of *C. gibelio*

Age	N	Female	N	Male	N	Female+ Male
I	-	-	-	-	2	1.28
II	5	2.47	1	2.37	6	2.46
III	104	2.36	22	2.05	126	2.31
IV	7	2.14	1	2.06	8	2.13
V	5	2.11	-	-	5	2.11
VII	2	2.36	-	-	2	2.36
Total	123	2.34	24	2.07	149	2.28

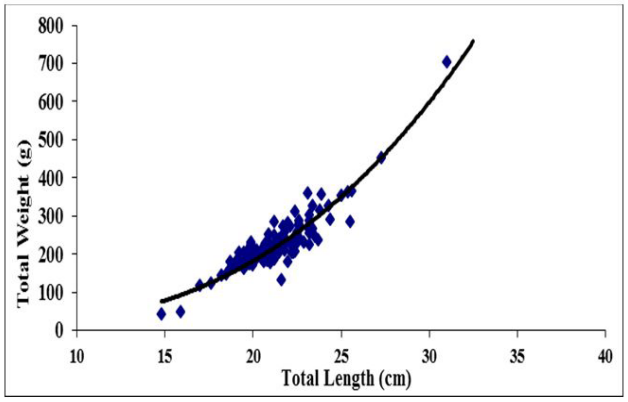

Fig. 5. Length-weight relationship of *C. gibelio*

Discussion

The introduction of invasive alien species is considered to be a leading cause of species endangerment and extinction in freshwater systems. Inland water ecosystems are particularly vulnerable to invasive alien species. The understanding of population biology of invaders and the effect of introduced species is necessary for constructing a robust theory of invasion biology that would provide a basis for rational decisions about species introduction and eradication efforts (Simberloff, 2003). The gibel carp is an invasive fish species for Seyitler Reservoir, Turkey.

Studies on *C. gibelio* have reported the following age groups: I-IV in Eğirdir Lake (Balık *et al.,* 2004) III-VI in Menderes Lake (Şaşı, 2008); II-VII in Bafra Fish Lake (Bostancı *et al.,* 2007a); 0-V in Beyşehir Lake (Çınar *et al.,* 2007); 0-V in Gelingüllü Reservoir (Kırankaya and Ekmekçi, 2013); I-VI in Buldan Reservoir (Sarı *et al.,* 2008); I-VI in Ömerli Reservoir I-IV, in İznik Lake (Tarkan *et al.,* 2008); I-VII shore and inner side waters of Estonia (Vetemaa *et al.,* 2005).

The results of the present study have shown that individuals of *C. gibelio* population is between I-VII ages old. This age range is similar to those reported for Bafra Fish Lake (Bostancı *et al.,* 2007b) and Ulubat Lake (Emiroğlu, 2008). In addition it is similar to the case of the Eğirdir Lake (Özkök *et al.,* 2007) except for the 0±IX age range. Oldest age is IV in male individuals and VII in females. Similar results were reported by Balık *et al.* (2004), Özkök *et al*. (2007), Sarı *et al.* (2008) and Emiroğlu (2008). According to these results it is obvious that male individuals have shorter life spans that females.

In previous reports, the male/female ratios for Turkish fresh water systems were 1.14/1 in Eğirdir Lake (Balık *et al.,* 2004); 0.03/1 Bafra Fish Lake (Bostancı *et al.,* 2007b); 1.46/1 in Eğirdir Lake (Bostancı *et al.,* 2007a); 0.92/1 in Beyşehir Lake (Çınar *et al.,* 2007); 1.08/1 in Eğirdir Lake (Özkök *et al.,* 2007) 0.52/1 in Ulubat Lake (Emiroğlu, 2008); 0.005/1 in Buldan Reservoir (Sarı *et al.,* 2008); 0.07 in Ömerli Reservoir, 0.63/1 in İznik Lake (Tarkan *et al.,* 2008); 0.026/1 in Pomvotis Lake (Tsoumani *et al.,* 2006). In our study it is 0.19/1. In other studies this ratio was reported to be close to 1/1. The studies on *C. gibelio* introduced into Eğirdir Lake in the early 1990s, and dominated the Lake immediately, have shown that the male/female ratio was high in the beginning; however later it recessed close to 1/1. The ratio of 0.19/1 in Seyitler Reservoir shows that female individuals dominate due to gynogenetic reproduction of *C. gibelio* (Buth *et al.,* 1991). Gynogenetic reproduction which may be undesirable for other species in the same habitat may have caused an increase in the number of female individuals in the *C. gibelio* population of Eğirdir Lake. This trend continues in Eğirdir Lake and Seyitler Reservoir should be monitored for economic benefits.

In this study, mean condition factor of males, females and the combined sex were calculated as 2.342, 2.064 and 2.276, respectively. The condition values were similar to other published results in Turkey (Özkök *et al.,* 2007; Çınar *et al*., 2007) and were lower than those reported by Bostancı *et al*. (2007b), Balık *et al.* (2004), Kırankaya and Ekmekçi (2013). Differences in condition coefficients may change within the same species depending on age, season, sexual maturity, spawning period, feeding condition and environmental conditions (Çetinkaya *et al.,* 2005).

The phi-prime test (Ø′) which reflects the overall growth performance was used to evaluate the reliability of the growth parameter (Pauly and Munro, 1984). The growth performance value of the *C. gibelio* population in the Seyitler Reservoir was 5.37. This value is also close to the ones obtained in Beyşehir Lake (Ø′=5.59), (Çınar

et al., 2007) and Eğirdir Lake (Ø′=5.91), (Balık *et al.,* 2004). The growth performance of *C. gibelio* population in Seyitler Reservoir was found to be lower than other lakes except for Buldan Reservoir (Ø′=4.8), (Sarı *et al.,* 2008) among the Turkish lakes studied. This is probably related to the homogeneity of ecological situations such as food abundance and water temperature of the habitats (Alp *et al.,* 2005)

The length-weight relationship of the crucian carp population in Seyitler Reservoir was $W=0.0274 \times L^{2.938}$. The slope value of the length-weight relationship showed that body weight negative allometric growth was detected in with fork length. Similar results were reported by Kızına (1986), Bostancı *et al.* (2007b), Kırankaya and Ekmekçi (2013) and Sarı *et al.* (2008) as 2.87, 2.97, 2.90 and 2.87, respectively. However, different results were also reported by Bostancı *et al.* (2007a), Balık *et al.* (2004), Tarkan *et al.* (2006), Tsoumani *et al.* (2006) and Özkök *et al.* (2007) as 3.177, 3.152, 3.237, 3.28 and 3.128, 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 mean fork lengths and weights of the specimens from the study area were14.8-32.5 cm, and 43.1-807.3 g. These values were reported from Bafra Fish Lake as 16.9-30 cm and 125-730 g (Bostancı *et al.,* 2007 b); 7.1-27.4 cm and 6-495 g from Beyşehir Lake (Çınar *et al.,* 2007); 9.7-25.5 cm and 23.6-269.1 g from Buldan Reservoir (Sarı *et al.,* 2008); and 8.2-28.1 cm and 17-732 g from Eğirdir Lake (Bostancı *et al.,* 2007 a). These values show Seyitler Reservoir specimens to be larger than *C. gibelio* from other lakes.

The maximum length (L_{∞}) and maximum weight (W_{∞}) of *C. gibelio* were reported as follows: 36.2 cm and 1285.6 g for Beyşehir Lake, 31.66 cm and 627.18 g for Buldan Reservoir, 33.3 cm and 1038.1 g for Eğirdir Lake (Balık *et al.,* 2004). These values were expected to be 48.09 cm and 2323.62 g for the study area's fish specimens in regards to the calculation of von Bertalanffy. The results show our fish to have much higher value than others, and this could be explained by ecological differences among the localities mentioned.

Based on these results and extrapolations, it is obvious that *C. gibelio* are in competition for food with the highly economically valued *C. carpio* and other local fish (*C. tinca* (endemic), *Alburnus* sp.*, S. cephalus, C. simplicispina* (endemic), *K. caucasica*) due to its omnivorous feeding behavior. To control population density, fishing should be allowed in all seasons and a long-term continuous monitoring program for the species is highly recommended. Although present no risk is foreseen on native fish stocks yet; the monitoring of fish stocks, especially on protected fauna species, should be made periodically to sustainable exploitation and to protect biodiversity.

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