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Growth and reproduction of a non-native fish species *Carassius gibelio* (Bloch, 1782) from Büyükçekmece Lake (İstanbul, Turkey)

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Abstract

Büyükçekmece Lake is a lagoon lake located at the mouth of Karasu Stream, which drains into the Sea of Marmara. The sea connection of the lagoon was blocked by the Büyükçekmece Dam in 1985, so the lagoon became a freshwater lake over time. Non–native *Carassius gibelio* (Bloch 1782) was introduced to the lake by a fisherman in early 1990s. By the time, it has become one of the most dominant fish species in the lake despite predators like *Esox lucius*, Linneaeus 1758, *Silurus glanis* Linnaeus, 1758 and also other cyprinids such as *Cyprinus carpio*, Linneaeus 1758, *Scardinius erythrophthalmus* (Linneaeus 1758) which have similar feeding regime. The aim of the current study was to study the growth and reproduction characteristics of gibel carp living in the lake. Field surveys were carried out monthly between March 2009 and April 2010. Fork length and body weight were determined between 4.4–31.4 cm and 1.44–774.4 g, respectively. The female:male ratio of total 487 gibel carp specimens was estimated as 20.1:1.0. The age composition of the population ranged from age class I to XI. The length–weight relationships, condition factor and von Bertalanffy growth parameters were estimated for all individuals as $W=0.0154FL^{3.134}$, K=2.26 (SE=0.02) and $L_t=33.97[1-e^{-0.198(t+0.162)}]$, respectively. Length at first maturity was calculated as 13.23 cm FL for females. Mean absolute fecundity in a mature female was 46,628 eggs (SE = 3,880), ranging from 5,266 eggs (16.7 cm FL) to 78,416 eggs (25.3 cm FL). The relationships between fecundity and fish size (fork length and weight) were calculated by regression analysis and the fecundity increased exponentially with the fish length and weight.

Keywords: Gibel carp, invasive, gynogenesis, age, fecundity.
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Büyükçekmece Gölü (İstanbul, Türkiye)'nde yaşayan egzotik balık türü *Carassius gibelio* (Bloch, 1782)'nun büyümesi ve üremesi

Özet

Büyükçekmece Gölü, Karasu Çayı'nın Marmara Denizi'ne döküldüğü yerde oluşmuş bir lagün gölüdür. 1985 yılında inşa edilen Büyükçekmece Barajı ile deniz bağlantısı kesilmiş ve zamanla tatlı su özelliği kazanmıştır. Yabancı bir tür olan *Carassius gibelio* (Bloch 1782), 1990'ların başında bir balıkçı tarafından göle bırakılmıştır. Göle girişinin ardından, avcı karakterdeki *Esox lucius* Linnaeus, 1758 ve *Silurus glanis* Linnaeus, 1758 ile benzer beslenme özelliği gösterdiği *Cyprinus carpio*, Linneaeus 1758, *Scardinius erythrophthalmus* (Linneaeus 1758) gibi diğer sazangillere rağmen, göldeki baskın balık türlerinden biri olmuştur. Sunulan çalışmanın amacı, gölde yaşayan gümüşi havuz balığının büyüme ve üreme özelliklerini incelemektir. Saha çalışmaları Mart 2009 ile Nisan 2010 tarihleri arasında aylık olarak yapılmıştır. Çatal boy ve vücut ağırlığı sırasıyla 4,4–31,4 cm ile 1,44–774,4 g'dır. Toplam 487 adet gümüşi havuz balığının dişi:erkek oranı 20,1:1,0 olarak hesaplanmıştır. İncelenen örneklerin yaş dağılımı, I ile XI yaş sınıfı arasında dağılım göstermiştir. Boy–ağırlık ilişkisi, kondisyon faktörü ve von Bertalanffy büyüme parametresi tüm bireyler için sırasıyla W=0,0154$FL^{3,134}$, K=2,26 (SH=0,02) ve L_t=33,97[1–$e^{-0,198(t+0,162)}$] olarak hesaplanmıştır. Dişiler için ilk eşeysel olgunluk boyu 13,23 cm olarak hesaplanmıştır. Fekonditesi, 5.266 yumurta (16,7 cm ÇB) ve 78.416 yumurta (25,3 cm ÇB) arasında değişmekle birlikte ortalama 46.628 yumurta (SH=3.880)'dır. Fekondite ile balık büyüklüğü (boy ve ağırlık) arasındaki ilişki regresyon analizi ile hesaplanmış ve fekonditenin balık boyu ve ağırlığı ile birlikte üssel olarak arttığı belirlenmiştir.

Anahtar Kelimeler: Gümüşi havuz balığı, istilacı, ginogenez, yaş, fekondite.

Introduction

Adaptations in life-history characteristics and biogeographical models of growth and habitation are the main themes in the adaptations of invasion and colonization theory for the introduction of fish species into new freshwater ecosystems (Villeneuve et al. 2005). Some of non-native fish species have invasive characteristics and modify local ecological conditions by re-shaping the reproduction, growth, and improvement of native species, as well as by hybridisation and introducing diseases and parasites (Latini and Petrene 2004). A good example of this case is *Carassius gibelio* (Bloch, 1782) gibel carp. It is a non-native fish species of Turkish inland waters, and the first record was given from Gala Lake in Thrace in 1988 (Baran and Ongan 1988). The introduction of gibel carp to new inland water occurred either by the fisherman, or some government sponsored initiatives with the aim of stocking mirror and common carp (*C. carpio*) for aquaculture purposes (Özuluğ et al. 2004; Bostancı et al. 2007). However, it is evident that gibel carp has detrimental effects on the native fish fauna. A monitoring study carried out in Ömerli Reservoir (north-west of Turkey) for 3 years showed that gibel carp abundance (mean CPUE) increased up to 245% and this related significantly with the reduction in the CPUE of large-bodied native species such as Baltic vimba *Vimba vimba* (L. 1758) (52%) and rudd *Scardinius erythropthalmus* (L. 1758) (44%) (Gaygusuz, et al. 2007). The gibel carp was intentionally introduced into Büyükçekmece Lake in the early 1990s by a fisherman for a stocking purpose from Kayalı Reservoir to Büyükçekmece Lake (Özuluğ 1999; İnnal and Erk'akan 2006). For approximately 25 years, it has been reported from numerous areas of Turkey (Özuluğ 1999; Şaşı and Balık 2003; Balık et al. 2003; Özuluğ et al. 2004; İlhan et al. 2005; Mendil et al.

2005; Yeğen et al. 2006; Bostancı et al. 2007; Gaygusuz et al. 2007; Mendil and Uluözlü 2007; Uğurlu and Polat 2007; Emiroğlu et al. 2008; İlhan and Balık 2008; Özcan 2008; Çiçek et al. 2009; Bulut 2010; Emiroğlu et al. 2010; Aydın et al. 2011; Emiroğlu 2011; Emiroğlu et al. 2012; İnnal 2011; Önsoy et al. 2011; Özvarol and Karabacak 2011; Çakmak et al. 2012; Ergüden and Göksu 2012; Tarkan et al. 2012a; Yılmaz et al. 2012; Zengin et al. 2012; Karakuş et al. 2013; Keskin et al. 2013; Kırankaya and Ekmekçi 2013; Gaygusuz et al. 2013; Saç and Özuluğ 2014).

Most of the studies carried out in Büyükçekmece Lake was about the composition and taxonomy of fishes (Balık, 1985; Meriç, 1986; Özuluğ, 1999) and there were only two studies (Erman 1959; Tarkan et al. 2006a) on population parameters of these fishes while there was no study to determine of gibel carp's population dynamics. The aim of the present study was to determine the growth and reproduction properties of gibel carp living in Büyükçekmece Lake and to provide basic information to further studies on the invasion effects of the species on the indigenous species of the lake.

Materials and methods

Study site

Büyükçekmece Lake is a lagoon lake located at the mouth of the Karasu Stream, which drains into the Sea of Marmara. The sea connection of the lagoon was blocked by Büyükçekmece Dam in 1985, and the lagoon became a freshwater lake over time. The surface area of the lake is 28.5 km^2 with the maximum water depth of about 6 m (Aktan et al. 2006). The lake is a shallow lake, which has a dynamical structure due to climatic changes. There are four streams feeding the Büyükçekmece Lake; the biggest one is the Karasu Stream, which is located in northern part of the lake. There are a lot of little streams connecting to Karasu Stream. The other streams feeding the lake are Hamza located in the northern, Keşliçiftliği located in eastern and Çekmece located in western of the lake (Özuluğ, 1999). The specimens were caught in the southern east of the lake at a depth of about 3 meters.

Due to connection with the Sea of Marmara until 1985, marine species such as *Pomatomus saltatrix* (L. 1766), *Syngnathus abaster* Risso, 1827, *Mugil cephalus* L., 1758, *Sardina pilchardus* (Walbaum 1792), *Engraulis encrasicolus* (L. 1758) were common in Büyükçekmece Lake along with some of freshwater fish species such as *Tinca tinca* (L. 1758), *Rutilus rutilus* (L. 1758), *Anguilla anguilla* (L. 1758). But, after the construction of the dam, the fish fauna of the lake has changed rapidly and freshwater species have replaced the marine species due to the decrease in salinity over time (Balık 1985; Meriç 1986) and, a total of 23 freshwater fishes were determined in the lake (Özuluğ 1999).

Sampling and analysis

A total of 487 individuals was captured using gillnets having different mesh sizes (10×10 mm, 20×20 mm, 30×30 mm, 40×40 mm and 50×50 mm) from the lake from March 2009 to April 2010. Water temperature was measured with a digital thermometer during these monthly surveys.

Samples were measured to the nearest 0.1 cm standard length (SL), fork length (FL) and total length (TL) and, weighed to the nearest 0.01 g total body weight (W). For length-length relationships, the following relationships were constituted using linear regression analysis: (a) FL versus TL; (b) FL versus SL; (c) SL versus TL. Scales were used for age determination. For this purpose, scales were taken from the region of the fish between the dorsal and the lateral line, put into small envelopes and preserved as dry. Scales were then placed on polycarbon plastic plates, which were 1 mm in thickness, 3 cm in length and 1.5 cm in width and pressed under a cylinder pressure. After the scales were removed, their marks were left on the polycarbon plastic plate. These preparates were read using a Microfish Reader (Lagler 1969; Gürsoy et al. 2005). To confirm the ages of the population, two independent age determinations were done by two different readers. Only the age of 425 specimens were determined because some scales, which belong to 62 specimens were deformed. Length–weight relationship was analyzed by using the equation: W=aL^b, where W is the total weight (g), L is the fork length (cm), and a and b are the equation parameters (Le Cren 1951; Froese 2006). The condition coefficient was calculated using the Fulton's Condition Factor K=(W/FL^3)x100 (Ricker 1975). Growth in length was determined by the von Bertalanffy equations; $L_t=L_\infty[1-e^{-k(t-to)}]$, where Lt is length at time t, L_∞ is asymptotic length, t is age, t_o is age when the length equals to 0 and k coefficient of development (Cailliet et al. 1986).

Gonad maturation was determined according to Nikolsky (1963) with the naked eye or microscopic examination. To determine the spawning period, gonadosomatic index (GSI) was calculated for females by using the formula GSI=(G/W)x100 where G is gonad weight and W is total body weight (Le Cren, 1951; King 2007). For the estimation of mean length at 50% maturity, a logistic function was performed to the proportion of the mature specimens by size class using non-linear regression. The function used for estimating length at first maturity was $P=1/(1+\exp[-r(L-L_m)])$, where P is the proportion mature in each size class, r (-b slope) is a parameter controlling the slope of the curve and L_m is the size at 50% maturity (King 2007). The absolute fecundity was calculated by gravimetric method. With this method, the subsamples of 1 g were taken from 3 different parts of the ovaries and then, the number of the sub-samples was multiplied up to the weight of the ovary using the formula F=f(G/g) (Le Cren 1951). Relative fecundity was estimated using the equations; RF_W=(F/W) and RF_L=(F/L), where F is absolute fecundity, W total weight and L fork length. The relationships between fecundity and fish size (fork length/weight) were calculated by regression analysis; F=aXb. Where F=fecundity, X=fork length of fish (cm) or weight of fish (g), a=regression constant and b=regression coefficient.

Table 1. The range of fork length (FL, cm), body weight (W, g) and condition factor (K) values in different age classes of *Carassius gibelio*, Büyükçekmece Lake, İstanbul, Turkey (n: number of specimens; SE: standard error)

Age Classes	n	FL (±SE) (min. - max., cm)	W (±SE) (min. - max., g)	K (±SE) (min. - max.)
I	37	7.3 ± 0.3 (4.4 - 9.9)	9.86 ± 1.30 (1.44 - 23.27)	2.14 ± 0.04 (1.83 - 2.40)
II	129	11.8 ± 0.1 (9.9 - 14.7)	38.39 ± 1.52 (20.23 - 78.99)	2.21 ± 0.02 (1.78 - 2.88)
III	41	16.2 ± 0.2 (14.8 - 18.1)	101.45 ± 3.72 (69.01 - 152.12)	2.32 ± 0.02 (2.11 - 2.72)
IV	31	19.6 ± 0.2 (18.2 - 21.0)	179.53 ± 4.70 (135.87 - 226.40)	2.33 ± 0.03 (2.11 - 2.60)
V	70	22.5 ± 0.1 (21.2 - 23.2)	271.92 ± 3.20 (203.70 - 329.50)	2.33 ± 0.02 (1.99 - 2.60)
VI	79	23.9 ± 0.1 (23.2 - 25.0)	311.49 ± 3.70 (215.70 - 373.30)	2.26 ± 0.01 (1.98 - 2.43)
VII	16	25.4 ± 0.1 (25.0 - 26.0)	383.89 ± 9.89 (345.70 - 476.83)	2.24 ± 0.02 (2.13 - 2.40)
VIII	10	26.6 ± 0.1 (26.1 - 27.2)	437.02 ± 9.35 (388.78 - 492.20)	2.32 ± 0.03 (2.16 - 2.41)
IX	7	27.6 ± 0.2 (27.3 - 28.2)	494.88 ± 13.40 (459.40 - 553.10)	2.31± 0.02 (2.21 - 2.37)
X	2	28.6 ± 0.1 (28.5 - 28.7)	538.20 ± 4.20 (534.00 - 542.40)	2.30 ± 0.01 (2.29 - 2.30)
XI	3	30.6 ± 0.4 (30.0 - 31.4)	680.30 ± 50.29 (602.50 - 774.40)	2.28 ± 0.05 (2.23 - 2.34)

Results

The fork length and weight of 487 samples varied between 4.4–31.4 cm and 1.44–774.4 g, respectively. Age distribution of the population ranged between age classes I and XI. Dominant age class was determined as age class II (30.35%), and it was followed by age class VI (18.59%) and V (16.47%). Since the mesh size was not sufficiently small (minimum 10 mm), fish samples in the age class 0 were not captured in surveys (Table 1).

Length-weight relationship of gibel carp was calculated for females, males and all individuals as W=0.014$FL^{3.159}$, W=0.015$FL^{3.107}$, and W=0.015$FL^{3.134}$, respectively. The regression coefficient b indicated positive allometric growth for the population with deviation from b=3 (Table 2).

Table 2. Descriptive statistics and estimated parameters of length-weight relationships of *Carassius gibelio*, Büyükçekmece Lake, İstanbul, Turkey (n: number of individuals; FL: fork length; W: body weight; Min.: minimum; Max.: maximum; *a*: intercept; *b*: slope; CL: confidence limits; r^2: coefficient correlation)

Sexes	n	Fork length (FL, cm)		Body weight (W, g)		Regression parameters		Confidence limits	r^2
		Min.	Max.	Min.	Max.	a	b	95% CL of b	
Female	462	4.4	31.4	1.44	774.40	0.014	3.159	0.002	0.991
Male	23	5.2	30.4	2.62	727.90	0.015	3.107	0.036	0.923
All ind.	487	4.4	31.4	1.44	774.40	0.015	3.134	0.002	0.996

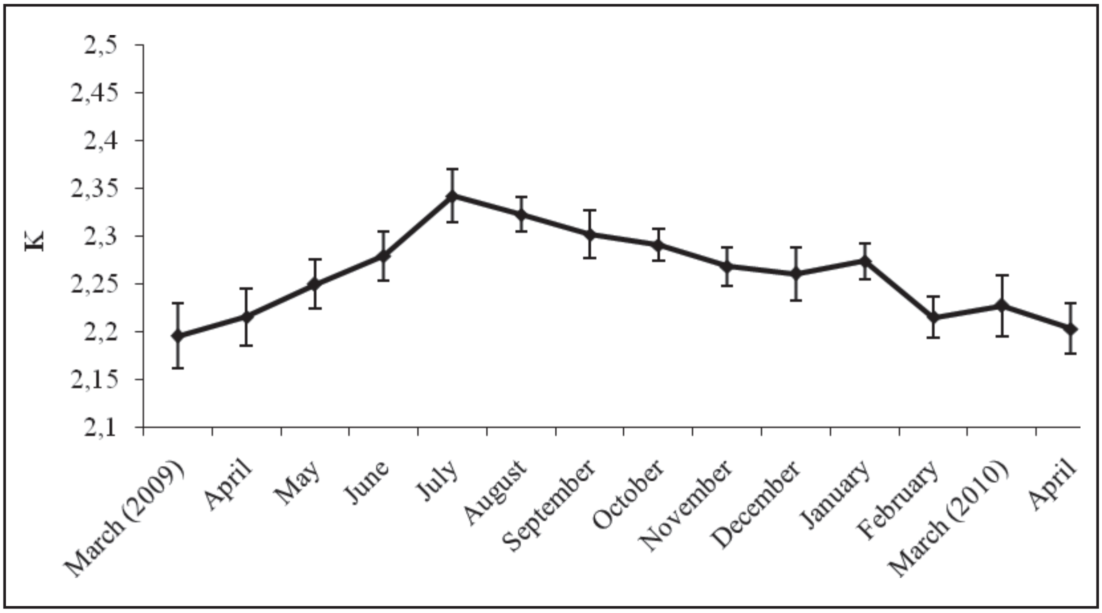

Figure 1. Monthly mean condition factors (K) of *Carassius gibelio* (both sexes combined) in Büyükçekmece Lake, İstanbul, Turkey.

The mean condition factor was calculated as 2.22 (SE=0.01) for females, 2.11 (SE=0.10) for males and 2.26 (SE=0.02) for all individuals. According to the monthly variation of condition factor, the maximum and minimum condition factor values were calculated as 2.34 (SE=0.03) in July 2009 and 2.19 (SE=0.03) in March 2009, respectively (Table 1). Monthly variation of condition factor was shown in Fig. 1. Maximum condition factor values were detected for age class IV and V (Table 1). Von Bertalanffy growth parameters were calculated for all individuals as L_t=33.97(1–$e^{-0.198(t+0.162)}$). Results of length-length relationships are *FL*=0.91*TL*-0.039 (r^2=0.998), *FL*=1.19*SL*+0.220 (r^2=0.997) and *SL*=0.77*TL*-0.179 (r^2=0.996), respectively.

The sex composition of the population was determined as 462 (94.87%) females and 23 (4.72%) males. The ratio of females to males was calculated as 20.1:1.0. According to the monthly variation of GSI (Fig. 2), a prolonged spawning period was observed from April to August. The mean GSI began to increase in March and attained maximum value in April (8.36%) indicating the pre-spawning period. In May, GSI sharply declined (2.61%) and in the following months, it showed a gradual decrease until August. Furthermore, macroscopic investigations of the gonads also showed spawning has begun in May when the prominent temperature increasing happened (20.9°C). However, at the end of June, the spawning ended, and there was no female carrying ripe eggs in July. The size at first maturity where 50% of females were identified as sexually mature was 13.23 cm FL (P=1/(1+$e^{[-0.888(LT-13.23)]}$)), and corresponding age class was II. Mean absolute fecundity in mature female was 46,628 eggs (SE=3,880), ranging from 5,266 eggs (a female of fork length 16.7 cm) to 78,416 eggs (a female of fork length 25.3 cm). Relative fecundity was estimated with 2,025 eggs at fork length (ranged from 315 to 3,180 eggs.FL^{-1}) and 179 eggs at total body weight (ranged from 51 to 250 eggs.W^{-1}). The relationships of absolute fecundity versus body size (length and weight) were calculated as F=1.427$FL^{3.326}$ (r^2=0.61)) and F=95.446$W^{1.203}$ (r^2=0.59), respectively.

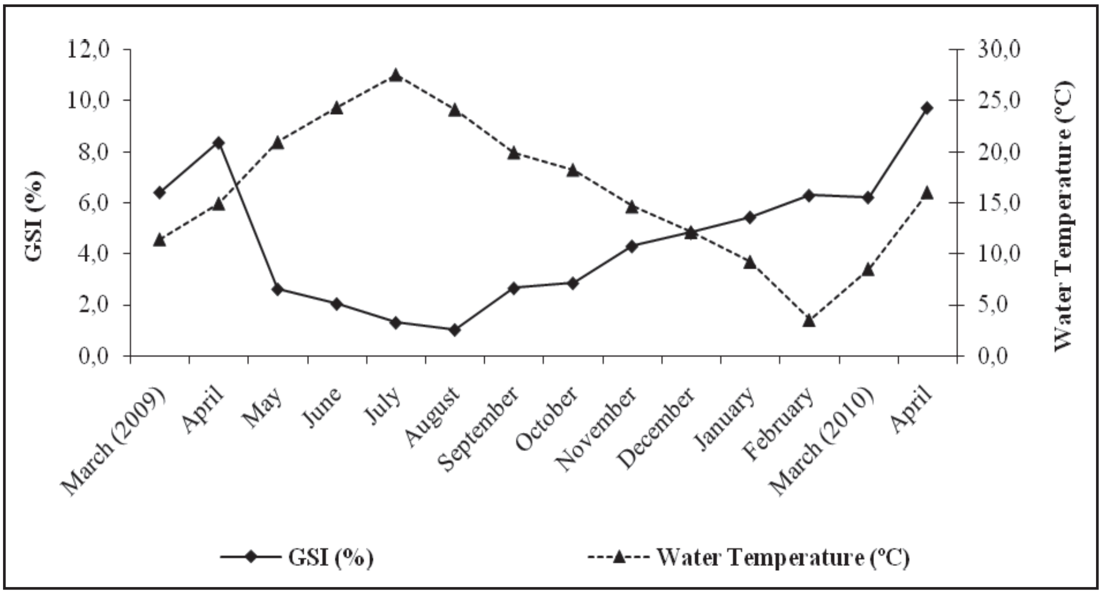

Figure 2. Monthly variations in the gonadosomatic index (GSI) of female *Carassius gibelio* and water temperature (°C) in Büyükçekmece Lake, İstanbul, Turkey.

Discussion

The existence of non-native gibel carp in Büyükçekmece Lake was detected in the 1990s (Özuluğ, 1999) and it became one of the most dominant fish species in due time (personal communication, Arif Paşa, fisherman). The reason for the increase of population density and the strong establishment of the species might be explained with its successful spawning strategy and high ability at colonization in new environments. One of the main factors on reproductive and also invasion success of gibel carp is definitely gynogenesis (Tóth et al. 2005; Vetemaa et al. 2005; Emiroğlu et al. 2011; Tarkan et al. 2012a; Tarkan et al. 2012b).

Gibel carp reproduces bisexually when conspecific sperm are used for fertilization or experiences gynogenesis spontaneously or preternaturally by fertilizing its eggs with heterologous sperm from closely related species such as common carp (Xu et al. 2005). It populates as a bisexual population inclusive of females as the majority and males as the minority (approximately 20%) in natural ecosystems, whereas other gynogenetic species are composed of all-female populations (Zhou et al. 2000). Fan and Shen (1990) has hypothesized that the offspring of gynogenetic populations had been composed of 5% males and 95% females, and if some of the eggs develop into males, gibel carp may be able to reproduce both gynogenetically and bisexually. It was thought that gibel carp living in Turkish inland waters had either bisexual or gynogenetical reproduction characteristics. While female:male rates from Ömerli (14.17:1), Topçam (98.84%:1.16%), Seyitler (82.55%:16.11%), Uluabat (2.7:1.0), İkizcetepeler (77.92%:22.08%), Ladik (93.5%:6.5%) and Buldan (99.44%:0.56%) reservoirs showed that gibel carp may reproduce with gynogenesis, female/male rates from İznik (1.58:1), Eğirdir (46.6%-53.4%), Beyşehir (52.1%:47.9%) and Gelingüllü lakes (1:1.39) showed that it probably may reproduce bisexually (Tarkan et al. 2006b; Şaşı 2008; Sarı et al. 2008; Balık et al. 2004a, Çınar et al. 2007; Emiroğlu et al. 2011; Bulut et al. 2013; Kırankaya and Ekmekçi 2013; Yazıcıoğlu et al. 2013; Erdoğan et al. 2014). The ratio of female:male (20.1:1.0) would indicate gynogenetic reproduction of gibel carp in Büyükçekmece Lake population. Depending on that small percentage (approximately 5%) of males, in addition to gynogenetic reproduction, bisexual reproduction is another option for the population to some extent.

The length distribution in different age classes of gibel carp population living in Büyükçekmece Lake were smaller, and the growth was slower than the other gibel carp populations living in Eğirdir, Beyşehir and Gelingüllü lakes (Balık et al. 2004a; Çınar et al. 2007; Kırankaya and Ekmekçi 2013). Food abundance, which is the most important factor effecting growth, is higher in eutrophic lakes than that in the oligotrophic lakes, and consequently, fish growth is faster in eutrophic lakes (Demir 1996). Compared to the eutrophic Buldan (Balık et al. 2004b), Topçam (Sömek et al. 2005) and Ömerli (Albay and Akçaalan 2003) reservoirs, it was thought that the slower growth of gibel carp could be the result of the nutritional deficiency in oligotrophic Büyükçekmece Lake (Aktan et al. 2006). However, because of high abundance of the other omnivorous cyprinids such as roach (*R. rutilus)* and bitterling (*R. amarus*) (Saç 2010), interspecific food competition might negatively affect gibel carp growth. According to Szczerbowski (2001), the growth rate of gibel carp decreased substantially in areas where common carp intensively were stocked. These changes on age-dependent length values usually depend on population density, food supply, ecological conditions and food interactions (Szczerbowski 2001; Ricker 1975). The age of gibel carp specimens from Büyükçekmece Lake was similar to some records from European inland waters, which have 10 and 11 years lifespan (Szczerbowski 2001). However, the maximum age of gibel carp for Turkish inland waters was observed in Lake Uluabat population to be 12 years, while the common age structure was six years in most populations of the species such as Eğirdir, Buldan, Ömerli and Topçam lakes (Table 3).

Table 3. Length at age values of *Carassius gibelio* populations from various water bodies in Turkey.

Water bodies	Length	The mean lengths of the different age classes													References
		0	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Lake Eğirdir	FL	-	11.9	18.1	22.9	25.5	27.4	29.6	-	-	-	-	-	-	Balık et at. 2004
Lake İznik	TL	-	13.8	19.7	25.3	30.1	-	-	-	-	-	-	-	-	Tarkan et al. 2006b
Ömerli Reservoir	TL	-	12.6	20.4	26.7	30.9	33.1	35.7	-	-	-	-	-	-	Tarkan et al. 2006b
Lake Beyşehir	FL	9.2	12.0	19.6	22.1	24.3	26.7	-	-	-	-	-	-	-	Çınar et al. 2007
Buldan Reservoir	FL	-	11.7	14.7	17.0	18.9	20.3	22.0	-	-	-	-	-	-	Sarı et al. 2008
Lake Uluabat	SL	-	4.8	7.0	9.0	11.2	13.3	15.3	17.2	19.1	21.3	23.4	24.3	27.3	Emiroğlu et al. 2012
Gelingüllü Reservoir	FL	6.4	12.6	15.8	18.4	22.3	26.6	-	-	-	-	-	-	-	Kırankaya and Ekmekçi 2013
Seyitler Reservoir	FL	-	15.4	17.7	21.0	23.8	25.6	31.8	-	-	-	-	-	-	Bulut et al. 2013
İkizcetepeler Reservoir	TL	-	-	-	25.2	26.6	27.5	28.8	-	-	-	-	-	-	Erdoğan et al. 2014
Büyükçekmece Lake	FL	-	7.3	11.8	16.2	19.6	22.5	23.9	25.4	26.6	27.6	28.6	30.6	-	Present study

According to GSI, gibel carp population living in Büyükçekmece Lake spawned only once a year. In spite of that, multiple spawning was reported in some gibel carp populations. Gudkov (1986), Kizina (1987) and Pipoyan and Rukhkyan (1998) mentioned multiple spawning for gibel carp populations at Volga Delta and Armenia inland waters. These differences could be related to environmental conditions such as water temperature, flow regime or the abundance of food (e.g. Tarkan et al. 2007). In its natural distribution area, gibel carp begins to spawn by the end of May and during June at a water temperature of up to 18-19°C (Szczerbowski 2001). In gibel carp population living in Büyükçekmece Lake, the duration of the spawning period was similar to that observed in the natural range; it began in May, when the water temperature in the lake was 20.9°C, and ended at the end of June. In spite of this, the spawning period of non-native gibel carp populations in Turkish inland waters was reported to be longer; in most populations such as Lake Eğirdir, Lake Uluabat and Gelingüllü Reservoir, it started to spawn in April and continued until July or August (Balık et al. 2008; Emiroğlu et al. 2012; Kırankaya and Ekmekçi 2013).

In conclusion, Büyükçekmece Lake is one of the main resources for domestic waters of the İstanbul city and because of this fact, the fishing that continues illegally in the lake is forbidden. However, the abundance of economic fish species living in the lake such as pike and catfish is decreasing due to overfishing so; it is considered that these predator fish species do not have any predation pressure on gibel carp and other species, as well. Gibel carp, due to having many small fishbones, does not have any economic values and is not consumed as human food, but is captured accidentally by the nets (with the mesh size of 50×50 mm and up) used in the fishing of economic species. Its population density in the lake has increased since its introduction, and it has become one of most dominant fish species. The gynogenetic reproductive strategy is thought to be the most important factor for its increasing population density in Büyükçekmece Lake.

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