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Age, growth and reproductive properties of an invasive species *Carassius gibelio* (Bloch, 1782) (Cyprinidae) in the Ikizcetepeler Dam Lake (Balikesir), Turkey

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Abstract

Background and Purpose: *The Prussian carp Carassius gibelio is well known as a hazardous fish species for native fish communities. Ikizcetepeler Dam Lake inhabits some fish species as Cyprinus carpio, Leuciscus cephalus, and Barbus species. The dam lake has major economic importance to the area for both fisheries and drinking water. The reason to select C. gibelio was due to the dominant species in stagnant and slow running waters and possible harmful interactions with native species.*

Materials and methods: *A total of 480 specimens of C. gibelio were monthly collected by gill nets during a 1-year period from Ikizcetepeler Dam Lake. Age was determined from scales. Length-weight relationships, von Bertalanffy equation were used to estimated for growth. Sex were determined by macroscopic observation of gonads. Spawning period of this species was determined according to gonado-somatic index (%).*

Results: *Females and males reached a maximum age groups of VI. Total length was 23.6–31.3 cm in females and 23.0–31.4 cm in males. The male and female ratio was 1:3.52 (M:F) in the favor of females. The Von Bertalanffy growth equations (in length) were found as* $L_t = 34.89.(1\text{-}e^{-0.11(t+7.66)})$, $L_t = 32.09\ (1\text{-}e^{-0.23(t+5.83)})$ *for females and males, respectively. The estimated b values were given as 2.886 and 2.981 for females and males, respectively (b<3). The condition of the fish increased during early summer. Spawning period of this species occured between April and July.*

Conclusions: *With a comparison of the relevant literature, the studied Prussian carp population was characterized by a shorter life span and more rapid growth during the first years of life. These can be considered as typical features of invasive species.*

INTRODUCTION

The introduction of a non-native species in an ecosystem is always likely to present an ecological risk if the species is able to integrate itself successfully into the ecosystem (*1, 2*), through predation (*3, 4*), competition (*5, 6*), hybridization (*7*), habitat modification *(8, 9).*

The prussian carp *Carassius gibelio* inhabits Europe and Asia, usually considered as native from central Europe to Siberia or introduced to European waters from eastern Asia according to Fishbase *(10).* The prus-

sian carp is a benthopelagic, nonmigratory and omnivore one as a hazardous fish species for native fish communities in stagnant and slow running waters *C.gibelio* is one of the most common and widely distributed Cyprinid species in ponds, lakes, dam lakes, and rivers in Thrace and Marmara Region of Turkey *(11, 12, 13, 14)*. The prussian carp was first introduced to Turkish waters in the late 1980's *(15)* where it developed extensive populations *(11,16)*. It is known that this species which was reported to exist in Meriç River with a natural distribution inThrace Region of Turkey as Gala Lake in 1988 *(12,13)* and in Iznik Lake in 2004 with increasing density *(11, 14, 17, 18, 19, 20)*. In Lake Mikri Prespa, turbidity increased following the introduction of *C.gibelio (21)*. The prussian carp is able to reproduce from unfertilized eggs (gynogenesis) *(22, 23)*.

Its sexual and gynogenetic reproduction and vast ecological tolerance including its resistance to unfavourable conditions have resulted in the becoming the most successful invasive fish form in the waters of Central and Eastern Europe *(24)* and also Turkey. The expansion of the prussian carp populations in Turkish lakes and reservoirs is worthy of concern *(25, 26, 27)*. Although there are no indications yet to demonstrate that the invasion of the prussian carp has had a direct or indirect adverse impacts on the Ikizcetepeler Dam Lake ecosystem or on its fisheries (due to the competition with *Cyprinus carpio) (28),* the high abundance of the prussian carp in Ikizcetepeler Dam Lake (Personal communication with fisherman) is thought of being a threat for the native fish populations in the future.

To prevent the distribution and establishment of new populations of prussian carp, its biological characteristics should be determined in different lakes and reservoirs of Turkey. The aim of the present study was point out the growth and reproduction of the prussian carp population in Ikizcetepeler Dam Lake. The clarification of the some biological parameters of such a invasive species is essential for management in reservoirs.

MATERIAL AND METHODS

The study area

The Ikizcetepeler Dam Lake is situated approximately 15 km from the city center of Balikesir Geographical coordinates are (27° 56' 42" N, 39º 29' 32" E). It was constructed between 1986 – 1992 and opened 2003 by 25th State Water Systems Services for water supply and commercial fishery. The lake has a surface area of 9.6 km ^{2} and lies at an altitute of 49.75 m. The maximum depth of the lake is 47.0 m *(28)*. The Ikizcetepeler Dam Lake is fed by the Kille Stream and its creeks. During the time of this study, water temperatures varied from 8.0 to 21.0°C, pH was between7.3–8.9, turbidity 130–450 cm and dissolved oxygen 6.4–9.6 ppm, using thermometer, pH-Meter, Secchi disc, and oxygen-Meter.

Sample collection and analyses

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). In total 480 specimens were analysed. Morhological identification and systematic status of *C.gibelio* were made, using characters given by Ozuluğ *(13)* and Kalous *et al. (29)*. Specimens were measured to the nearerst 0.1 cm (total length, TL in cm) and weighed to the nearest 0.1 g. (W. in g.). Scales were used for age determination. Ten to twenty scales from the left side of the body between the lateral line and dorsal fin were removed and dry mounted between two slides for binocular microscopic study *(30, 31, 32)*.

The relationship between total length TL and total weight W was calculated for males and females separately using the allometric model: $W = a*TL^b$, *(33)*, where W is fish total body mass in grams, TL is total length in cm, a is a constant and b the allometric coefficient.

Length-at-age data were used to estimate the parameters of the Von Bertalanffy (1938) growth equation VBGF: $L_t = L_\infty[1-e^{-k(t-t_0)}]$ *(34, 35)*. where L_T is the total length of the fish at time t, L∞ is the ultimate length an average fish could achieve, k is the growth constant which determines how fast the fish approach L∞ and t_0 is the hypothetical time at which the length of the fish is zero. Phi'-prime (?') index was calculated to compare the growth performance of the Prussian carp as: ? =Log (k) 2 Log (L_∞) where k and L∞ are parameters of VBGF *(36)*.

Condition coefficients (CF) were calculated for both sexes using the equation CF=(Body weight/Total Length^3)*100 *(34)*.

Sex was determined by macroscopic observation of the gonads. The overall sex ratio and stages of sexual maturity were also determined. Deviations from 1:1 null hypothesis were statistically tested by Chi-square ($\chi 2$) analysis *(37)*. The spawning period was determined by means of the monthly changes in the gonadosomatic index (GSI%) calculated by using the following equation, GSI=Gonad weight/(Body weight-gonad weight)*100 *(33, 38)*. Statistical analyses were carried out with SPSS, STATISTICA for Windows V 11.0.

The total instantaneous mortality (Z) was calculated by the linearized catch curve *(35)* using fish captured with multimesh gillnet. The natural mortality coefficient (M) was estimated from tentative Pauly formula *(39)*:

Log (M)=−0.0066−0.279log(L∞)+0.6543log(K)+ 0.4634 log (T), where T is the water average annual temperature of fish habitat. In this study, T was 12 ºC. Fishing mortality coefficient (F) was calculated using the below formula: Z = M + F, exploitation rate was calculated using the formula *(35)*: E= F/F+M

RESULTS AND DISCUSSION

In total, 480 prussian carp individuals were caught during the study period. It was found that 77.92% of the

TABLE 1

Total length (TL, cm), and weight (W, g), standard error (SE) for different age groups of *Carassius gibelio* males and females.

Age	N	Male+Female		N	Male		N	Female	
		TL±SE (cm)	W±SE (g)		TL±SE (cm)	W±SE (g)		TL±SE (cm)	W±SE (g)
III	31	25.22±0.18 (23.0-25.0)	245.50±8.61 (150.88-299.14)	14	25.25±0,30 (23.0-27.3)	245.48±14.32 (150.88-299.4)	17	25.20±0.23 (23.6-27.5)	245.52±10.80 (165.58-295.58)
IV	172	26.58±0.07 (24.5-28.3)	302.31±2.21 (209.55-359.21)	51	26.80±0.12 (25.0-28.3)	304.85±3.08 (242.25-353.04)	121	26.58±0,07 (24.5-28.0)	301.24±2.86 (209.55-359.21)
V	184	27.50±0.006 (26.1-29.5)	355.82±2.33 (280.48-420.53)	27	28.02±0,37 (26.3-29.5)	358.42±6,92 (299.48-405.07)	157	28.95±0.24 (26.1-29.4)	391.07±8.82 (280.48-420.53)
VI	93	28.81±0.022 (26.1-31.4)	386.50±7.73 (255.69-622.02)	14	28.02±0.37 (26.3-31.4)	360.73±10,09 (309.32-440.41)	79	28.95±0.24 (26.4-31.3)	391.07±8.82 (255.69-622.02)
	480			106			374		

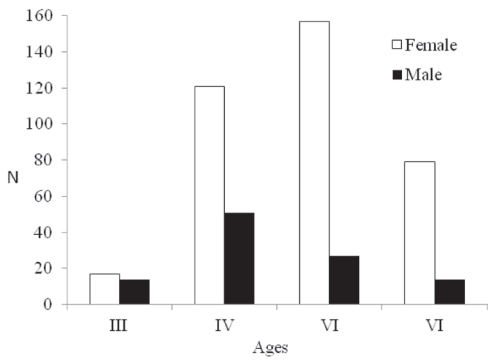

Figure 1. *Age and sex distribution of C. gibelio in Ikizcetepeler Dam Lake*

C.gibelio population in Ikizcetepeler Dame Lake consisted of females and 22.08% of males. This fact can be explained by gynogenesis *(40, 41)*.The sex ratio was 1:3.52 (male) to 1 (female) and significantly different from 1:1 (Chi-square test, P<0.05). Nikolsky *(38)* indicated different sexual dispersions of the same species in different populations. It is well known that the sex ratio in most species is close to one, but it may vary from species to species, differing from one population to another of same species and may vary year to year in the same population. Some researchers confirm our findings *(17, 18, 42,43, 44, 45)*.

Four age groups were found (III to VI), and IV and V age groups were dominant for males and females in the Gibelio population, representing 36% and 38% of all specimens, respectively (Table 1, Figure 1).

In other investigations on this species, age distribution was reported to be I–IV and I–VI in Iznik and Omerli

TABLE 2

Length values (total length TL, fork length FL) at age for *Carassius gibelio* populations in natural lakes and reservoirs in Turkey.

Reference	Mean lengths at ages											Locality
	Length	0	I	II	III	IV	V	VI	VII	VIII	IX	
Balık et al. 2004	FL		11.9	18.1	22.9	25.5	27.4	29.6				Lake Egirdir
Cınar et al. 2007	FL	9.2	12.0	19.6	22.1	24.3	26.7					Lake Beyşehir
Özkök et al. 2007	FL	9.46	11.9	18.6	21.82	24.41	26.86	28.67	30.6	31.0	32.6	Lake Egirdir
Sarı et al. 2008	FL		11.7	14.1	16.98	18.89	20.26	22.03				Buldan Reservoir
Sası 2008	FL				23.8	25.48	27.01	28.38				Topcam Reservoir
Emiroglu et al.2012	TL		17.6	23.1	25.87	28.87	31.25	31.93	33.2			Lake Uluabat
Kırankaya and Ekmekçi 2013	FL	6.4	12.6	15.8	18.4	22.3	26.6					Gelingüllü Reservoir
This study	TL				25.2	26.6	27.5	28.8				Ikizcetepeler

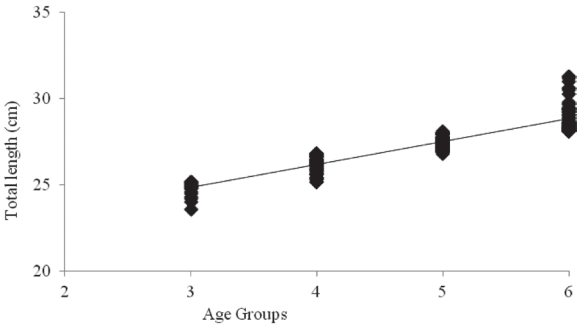

Figure 2. *Age-length relationship in females of C.gibelio in Ikizcetepeler Dam Lake*

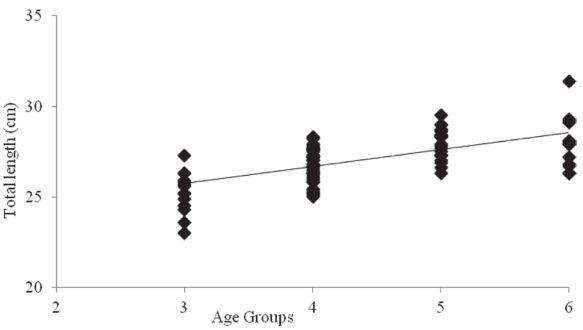

Figure 3. *Age-length relationship in males of C.gibelio in Ikizcetepeler Dam Lake*

Lake (26), I–VI in Egirdir Lake (18), III–VI in Topcam Dam Lake (42),(I–VI) in Buldan Dam Lake (25), VI–VIII in Israel (46), II–VIII in Estonya (47), II–VIII in waters of the Czech Republic (24). The age groups in this study were similiar to those found in Gelingüllü Dam Lake population (48) and by Szczerbowski (49), but different from those reported by Sarı *et al.* (25) and Balık *et al.* (18). These differences in the age distribution of the populations may be due to gill net selectivity, fishing activity, feeding habits and the ecological characteristics of the lakes and reservoirs (38, 50) (Table 2).

TL in the Prussian carp ranged from 23.0 to 31.4 cm 23.6 to 31.3 cm for males and females, respectively (Table 1). There were no significant differences in mean lengths between sexes in any of the age groups were not statistically significant ($p>0.05$).

The von Bertalanffy growth equations (age-length relationships) calculated with mean lengths at different ages were found as $L_t = 34.89\ (1\text{-}e^{-0.11(t+7.66)})$ and $L_t = 32.09\ (1\text{-}e^{-0.23(t+5.83)})$ for females and males, respectively (Figure 2 and 3).

The theoretical maximum lenghts for prussian carp individuals from Ikizcetepeler Dam Lake are close to that estimated for Egirdir Lake (18) and Buldan Dam Lake (25). The maximum recorded lenghts prior to our study were: 28.4 and 36.6 cm for males and females, respectively (47), 34.46 cm (51), 37.7 cm (52), 21.4 cm and 20.0 cm in Miliç Stream and Cakmak Dam Lake (53), 30.2.5cm (26), and 30.2 cm (54). According to Sparre & Venema (35), Ø' is the best index of overall growth performance, in the sense that it has minimum variance. For prussian carp from Ikizcetepeler Dam Lake, the Ø' value of combined sexes was found as 2.55. This value was similiar to the calculated growth performance of the prussian carp in Lake Eğirdir (18), but higher than the 2.47 reported for the same species in Lake Balaton (55). This difference in growth performance between the lakes can be attributed to the difference in size of the largest individuals sampled.

The length-weight relationships were pooled for females (n =374, b=2.886, r^2 = 0.609) and for males (n = 106, b=2.981, r^2 =0.70) in Figure 4 and 5. The low b values (<3) indicated a negative allometric growth with deviation from b=3 (b<3).

The *b* value in length-weight relationship equation is an indicator of the body shape of the fish, affected directly by the habitat in which the fish lives (56). The slope (b) values of the length-weight relationships in both sexes (*b*=2.981 for males *b*=2.483 for females) showed that weight increased negative allometrically with length. For

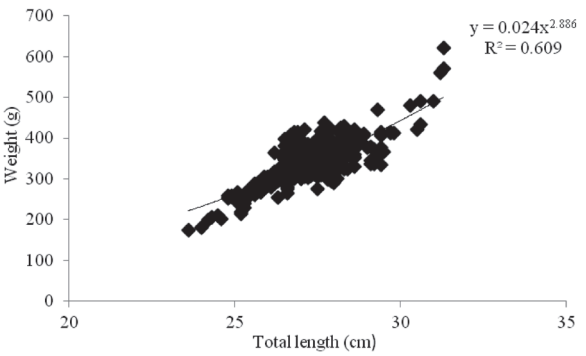

Figure 4. *Length-weight relationship in females of C.gibelio in Ikizcetepeler Dam Lake*

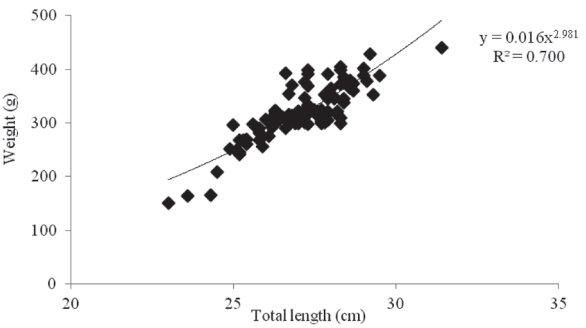

Figure 5. *Length-weight relationship in males of C.gibelio in Ikizcetepeler Dam Lake*

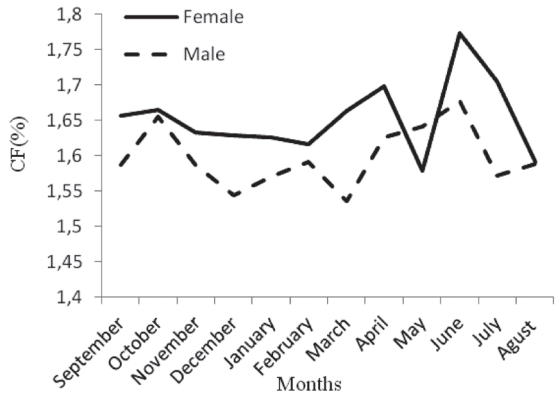

Figure 6. *Monthly variations in CF of females and males of C.gibelio in Ikizcetepeler Dam Lake.*

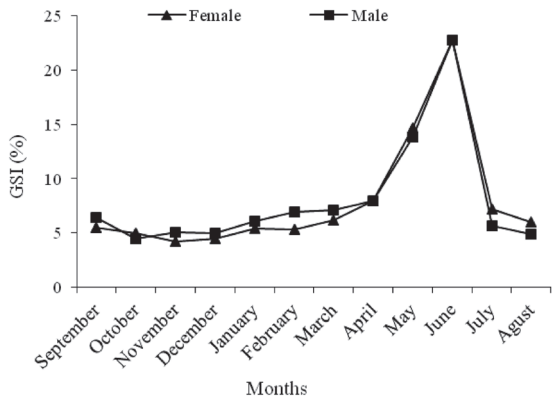

Figure 7. *Monthly variations in GSI% of females and males of C.gibelio in Ikizcetepeler Dam Lake.*

the same species, the b value was reported to be 3.11 in Lake Volvi (Macedonia) by Kleanthidis *et al.* (57) and 2.98 in China by Sifa (58). The *b* value was also reported to be 2.58 for Lyscmia, 3.06 and 3.23 for Pamvotis, 2.33 for Mlkri Prespa 2.40 for Doirani, 2.36 for Koronia Lakes, 2.81 for Lake Chimatditis, 2.87 for Buldan Dam Lake, 2.978 for Bafra Dam Lake, 3.088 for Ömerli Dam Lake, 3.25 For Iznik Dam Lake, 3.152 for Egirdir Lake (18, 25, 26, 51, 52, 59, 60). The values b are often 3.0 and generally between 2.5 and 3.5. As a fish grows, changes in weight and relatively greater than changes in length, due to approximately cubic relationhip between fish length and weight. The values *b* in fish differ according to species, sex, age, seasons, feding, disease, and parasite loads (53).

In both sexes, there was a tendency for the condition factor to increase the last period of spring to summer (Figure 6). The minimum mean CF was in December in males and in May in females. The condition in females was higher than that in males throughout the year.

The gonad development was followed using the GSI% and monthly changes are plotted in Figure 7. Spawning occured between April and July, showing a peak in June.

During spring and early of summer, an obviously rapid growth of gonads occured untill the next spawning. Kırankaya *(48)* found that both values of condition and gonadosomatic index high in spring and the early summer as similiar as our findings (Figure 6, 7). In this study, spawning period is compared to the relevant studies (Table 3).

Because the ecological and climatical conditions are different, the starting and finishing time of reproduction may include different months. As mentioned by Sası *(42),* the spawning cycle is closely to related temperature. Spawning periods of fish vary with respect to their species; the ecological characteristics of fish are determined by such ecological differences as stagnant or running water, as well as altitude, temperature and quality of food *(38).* European freshwater populations of prussian carp seem

TABLE 3

Spawning seasons of *Carassius gibelio* at various localities and average temperatures according to the previous studies.

References	Months												Locality	Tem. (°C)
	J	F	M	A	M	J	J	A	S	O	N	D		
Balık et al. (2004)				■	■	■	■	■	■				Eğirdir Lake	Low tem.
Kırankaya (2007)			■	■	■	■							Gelingüllü Dam Lake	
Sası (2008)			■	■	■	■	■	■	■				Topçam Dam Lake	
Berg (1964)					■	■							Lake Khanka	
Paschos et al. (2004)			■	■									Lake Pamvotis	12.0–14.0°C
Leonardos et al. 2001			■	■	■	■	■	■					Lake Lysimachia	
Leonardos et al. 2008			■	■	■	■	■	■					Lake Chimaditida	
Our study				■	■	■	■	■					İkizcetepeler Dam	8.0–21.0°C

to be predominantly gynogenetic *(22, 41, 47, 61).* Indeed, the Turkish freshwater populations of prussian carp consisted exclusively of females, or the proportion of males was very low *(20, 25, 26, 42, 44).* Our finding (22.08% of males) confirms the relevant literature and also the proportion of males in the populations of the Morava and Dyje Rivers *(24).*

The exploitation rate of the prussian carp has been estimated up to 0.22 which shows the undesirable exploitation amount (E< 0.5). In 2008–2009, overall mortality, rate the natural mortality and fishing mortality of the prussian carp have been estimated up 0.14 $year^{-1}$, 0.11yr^{-1}, 0.031 yr^{-1}, respectively. It was found that natural mortality was higher than fishing mortality, because of insufficient fishing. The E rate is an index of fishing levels, and it should be E = 0.50 for maximum sustainable fishing (35). However, the E rate for the prussian carp population in Ikizcetepeler Dam Lake is rather low (E = 0.22). As there is no fishing pressure on the population, the population exhibits a natural developmental process.

CONCLUSION

Prussian carps are able to expand their range of distribution by having ecological plasticity, and a high tolerance for unfavourable enviromental conditions. In this sense, the establishment of a new prussian carp population was observed in Ikizcetepeler Dam Lake. Thus, to prevent its distribution and influence on the native species, its biological characteristics should be monitored at regular intervals in the locality.

To preserve biodiversity and protect native freshwater fish species, it should prevent to distribute alien and invasive species as the prussian carp uncontrolled. In the light of many negative impacts of introduced fish species, any stocking should generally be restricted to the minimum or completely avoided.

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