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

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 \( L_t = 34.89\left(1-e^{-0.11(t+7.66)}\right) \), \( L_t = 32.09\left(1-e^{-0.23(t+5.83)}\right) \) 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 occurred 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 in Thrace Region of Turkey as Gala Lake in 1988 (12,13) and in İznil 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 İkizcetepeler Dam Lake ecosystem or on its fisheries (due to the competition with Cyprinus carpio) (28), the high abundance of the prussian carp in İkizcetepeler Dam Lake (Personal communication with fishermen) 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 biological parameters of such a invasive species is essential for management in reservoirs.

**MATERIAL AND METHODS**

**The study area**

The İkizcetepeler Dam Lake is situated approximately 15 km from the city center of Balıkesir Geographical coordinates are (27° 56’ 42” N, 39° 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 km² and lies at an altitude of 49.75 m. The maximum depth of the lake is 47.0 m (28). The İkizcetepeler 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 between 7.3–8.9, 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. Morphological 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 nearest 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 \( LVBG: L_t = L_\infty [1-e^{-k(T-t_0)}] \) (34, 35), where \( L_t \) is the total length of the fish at time t, \( L_\infty \) is the ultimate length an average fish could achieve, k is the growth constant which determines how fast the fish approach \( L_\infty \) 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: \( E = \frac{F}{F+M} \) (35).

**RESULTS AND DISCUSSION**

In total, 480 prussian carp individuals were caught during the study period. It was found that 77.92% of the...
C. gibelio population in Ikizcetepeler Dam 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).

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 lakes.

### TABLE 1
Total length (TL, cm), and weight (W, g), standard error (SE) for different age groups of Carassius gibelio males and females.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Male+Female</th>
<th>N</th>
<th>Male</th>
<th>N</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TL±SE (cm)</td>
<td>W±SE (g)</td>
<td>TL±SE (cm)</td>
<td>W±SE (g)</td>
<td>TL±SE (cm)</td>
</tr>
<tr>
<td>III</td>
<td>31</td>
<td>25.22±0.18</td>
<td>245.50±8.61</td>
<td>25.25±0.30</td>
<td>245.48±14.32</td>
<td>25.20±0.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(23.0-25.0)</td>
<td>(150.88-299.14)</td>
<td>(23.0-27.3)</td>
<td>(150.88-299.4)</td>
<td>(23.6-275)</td>
</tr>
<tr>
<td>IV</td>
<td>172</td>
<td>26.58±0.07</td>
<td>302.31±2.21</td>
<td>26.80±0.12</td>
<td>304.85±3.08</td>
<td>121</td>
</tr>
<tr>
<td>V</td>
<td>184</td>
<td>27.50±0.006</td>
<td>355.82±2.33</td>
<td>28.02±0.37</td>
<td>358.42±6.92</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(26.1-29.5)</td>
<td>(280.48-420.53)</td>
<td>(26.3-29.5)</td>
<td>(299.48-405.07)</td>
<td>(26.1-29.4)</td>
</tr>
<tr>
<td>VI</td>
<td>93</td>
<td>28.81±0.022</td>
<td>386.50±7.73</td>
<td>28.02±0.37</td>
<td>360.73±10.09</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(26.1-31.4)</td>
<td>(255.69-622.02)</td>
<td>(26.3-31.4)</td>
<td>(309.32-440.41)</td>
<td>(26.4-31.3)</td>
</tr>
<tr>
<td></td>
<td>480</td>
<td>106</td>
<td>374</td>
<td></td>
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<td></td>
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</tbody>
</table>

### TABLE 2
Length values (total length TL, fork length FL) at age for Carassius gibelio populations in natural lakes and reservoirs in Turkey.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Mean lengths at ages</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length 0 I II III IV V VI VII VIII IX</td>
<td></td>
</tr>
<tr>
<td>Balik et al. 2004</td>
<td>FL</td>
<td>11.9</td>
</tr>
<tr>
<td>Cınar et al. 2007</td>
<td>FL</td>
<td>9.2</td>
</tr>
<tr>
<td>Özkök et al. 2007</td>
<td>FL</td>
<td>9.46</td>
</tr>
<tr>
<td>Sari et al. 2008</td>
<td>FL</td>
<td>11.7</td>
</tr>
<tr>
<td>Sassi 2008</td>
<td>FL</td>
<td>23.8</td>
</tr>
<tr>
<td>Emiroğlu et al. 2012</td>
<td>TL</td>
<td>17.6</td>
</tr>
<tr>
<td>Krankaya and Ekmekçi 2013</td>
<td>FL</td>
<td>6.4</td>
</tr>
<tr>
<td>This study</td>
<td>TL</td>
<td>25.2</td>
</tr>
</tbody>
</table>
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 Estonia (47), II–VIII in waters of the Czech Republic (24). The age groups in this study were similar 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 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 \( L_t = 34.89 \left(1-e^{-0.11t+7.66}\right) \) and \( L_t = 32.09 \left(1-e^{-0.23t+5.83}\right) \) for females and males, respectively (Figure 2 and 3).

The theoretical maximum lengths 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 lengths 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), \( \Phi^* \) is the best index of overall growth performance, in the sense that it has minimum variance. For prussian carp from Ikizcetepeler Dam Lake, the \( \Phi^* \) value of combined sexes was found as 2.55. This value was similar 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 \( b=3 \). 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 \((b=2.981 \text{ for males } b=2.483 \text{ for females})\) showed that weight increased negative allometrically with length. For Figure 2.

**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**

**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**
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 Lysmcia, 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 Chimadittis, 2.87 for Buldan Dam Lake, 2.978 for Bafra Dam Lake, 3.088 for Ömerli 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 relationship between fish length and weight. The values $b$ in fish differ according to species, sex, age, seasons, feeding, 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 occurred between April and July, showing a peak in June.

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

Because the ecological and climatic conditions are different, the starting and finishing time of reproduction may include different months. As mentioned by Sasi (42), the spawning cycle is closely related to 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.

<table>
<thead>
<tr>
<th>References</th>
<th>Months</th>
<th>Locality</th>
<th>Tem. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kırankaya (2007)</td>
<td></td>
<td>Gelingüllü Dam Lake</td>
<td></td>
</tr>
<tr>
<td>Sasi (2008)</td>
<td></td>
<td>Topçam Dam Lake</td>
<td></td>
</tr>
<tr>
<td>Berg (1964)</td>
<td></td>
<td>Lake Khanka</td>
<td></td>
</tr>
<tr>
<td>Paschos et al. (2004)</td>
<td></td>
<td>Lake Pamvotis</td>
<td>12.0–14.0°C</td>
</tr>
<tr>
<td>Leonardos et al. 2001</td>
<td></td>
<td>Lake Lysimachia</td>
<td></td>
</tr>
<tr>
<td>Leonardos et al. 2008</td>
<td></td>
<td>Lake Chimaditida</td>
<td></td>
</tr>
<tr>
<td>Our study</td>
<td></td>
<td>İkizcetepeler Dam</td>
<td>8.0–21.0°C</td>
</tr>
</tbody>
</table>
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, estimated up to 0.22 which shows the undesirable exploitation amount, was observed in Ikizcetepeler Dam Lake. Thus, 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.

**CONCLUSION**

Prussian carps are able to expand their range of distribution by having ecological plasticity, and a high tolerance for unfavourable environmental 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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