Population Structure and Some Growth Properties of Gibel Carp (Carassius gibelio) in a Mesotrophic Lake

Hakki DERELİ*, Ezgi DİNÇTÜRK

Abstract

The hereby study investigated gibel carp (Carassius gibelio) in a mesotrophic lake (Lake Beyşehir, Turkey) from April 2013 to March 2014, in order to outline population structure and some growth properties of the species. Two water quality variables (Chlorophyll-a, Trophic State Index (TSI)) were detected seasonally to define trophic status of the lake. Length and weight distributions, length - weight relationship, sex ratio, gonadosomatic index (GSI), condition factor (CF) and von Bertalanffy equation were calculated for C. gibelio sampled monthly. Trophic status of the lake was defined as mesotrophic. Total length and weight of C. gibelio samples was determined in the range of 8.5 and 28.4 cm and 15 and 408 g, respectively. Mean total length and weight of individuals were calculated as 17.5 ± 2.37 cm and 88.6 ± 39.02 g, respectively. There was a negative allometry between length and weight for C. gibelio. The fish samples were composed of 52% females and 48% males, between II and VII years old. Spawning period of the species occurred between April and June after GSI values reached their maximum in March. The CF values were validated between 1.5-1.7 besides the mean rate of females and males were 1.6 and 1.5, respectively. The parameters of von Bertalanffy equation were calculated as L∞: 19.8 cm, W∞: 652.9 gr, k: 0.934. In conclusion, C. gibelio has almost lost the economic value since the individuals are smaller than market size (≥ 250 g), probably due to lack of nutrients/mesotrophic situation of Lake Beyşehir.

Keywords: Beyşehir Lake, eutrophication, gonadosomatic index (GSI), length - weight relationship, von Bertalanffy equation

Introduction

The Beyşehir Lake, which is the biggest freshwater lake in Turkey, has some serious problems about sustainability of indigenous fish populations in recent years (Tekinay et al., 2013). Total production in the lake by commercial fishing has been decreasing since 2005 due to several reasons such as changes in bio-ecological conditions of the lake and uncontrolled fishing (Anonymous, 2013).

Eleven species (Cyprinus carpio, Chondrostoma regium, Leuciscus lepidus, Pseudophoxinus anatolicus anatolicus, Knipowitschia caucasica, Apianius anatolice anatolice, Gambusia affinis, Sander lucioperca, Tinca tinca, Athorina boyeri, Carassius gibelio) belonging to 6 families were reported in the Beyşehir Lake (Cubuk et al., 2006; Yegen et al., 2006). The last four of these species were introduced to the lake and apparently caused some impacts on the lake ecosystem, although this has not been proven yet. Gibel carp, which was introduced into Lake Beyşehir at the end of 1990s, was adapted to the local conditions (Gınar et al., 2007) and become the dominant species (Tekinay et al., 2013).

C. gibelio displays fast growth until sexual maturation and high survival rates. It is an omnivorous fish (Kottelat and Freyhof, 2007), reproduces gynogenetically and has extensive tolerance to different environmental conditions (Ekmekçi, 2013). The reason for the intense reproductive success of introduced C. gibelio is its capacity for gynogenetic reproduction, whereby females are able to use sperm of other cyprinid fishes and salmonids to fertilize their eggs (Penaz et al., 1979; Tarkan et al., 2012). Consequently, this species easily becomes a dominant species in stagnant and slow running waters (Tsoumani et al., 2006).

Since body weight does not reach to market size (≥ 250 g) in Beyşehir Lake, plenty of uneconomical fish cause labor and time loss. This condition situation of species has been probably affected from the trophic status of lake. Also, biological characteristics of the species need to be determined in the lake to obtain useful information in order to prevent the invasion of C. gibelio, as well as for determining population sustainability of natural species and consequently sustainable fisheries in the lake. Therefore, the present study was designed to determine trophic status of lake and investigate population structure and some growth properties of C. gibelio.

Materials and Methods

Fish and water sampling

A monthly-sampling-study was carried out in 5 different areas (Tolca, Yeşildağ, Beyşehir Centre, Göl yak and Çiftlik) in...
Lake Beyşehir (Konya, Turkey) (Fig. 1) between April 2013 and March 2014.

Water samples from each location were taken to determine chlorophyll-a and Trophic State Index (TSI) values. Chlorophyll-a measurements were carried out according to Stirling et al. (1985). Based on chlorophyll-a variance, TSI was detected. According to this procedure lakes are classified as low productive (TSI < 30), medium productive (TSI: 40-50) and high productive (TSI: 50-70) (Carlson, 1977; Carlson and Simpson, 1996).

Monofilament gill nets with the mesh sizes of 30, 40, 50, 60, 70, 80, 100, 110 and 120 mm and monofilament trammel nets with 130 mm mesh size, which received occupancy permission from the Republic of Turkey, Ministry of Food, Agriculture and Livestock, were layed within Lake Beyşehir Ecosystem Rehabilitation Project. Also, multi-filament gill nets with the mesh sizes of 30, 40 and 50 mm and multi-filament trammel nets with 70 and 110 mm mesh sizes were used for C. gibelio sampling. Monthly samples were taken, thus 59 to 346 (mean 156) individuals of species from five stations were investigated.

Fish samples were immediately transferred to Izmir Katip Çelebi University, Faculty of Fisheries Laboratories in cooler boxes.

Qualitative analysis and statistical procedures

For each sample, the total length (TL) was measured to the nearest 0.1 cm and the total weight (W) to the nearest 0.1 g. 20 scales were collected from each sample for age determination according to Lagler (1966) and Nikolsky (1963). After dissection, sex was determined by macroscopic observation, and gonad weights were weighed. Sex ratios, length and weight distribution and length - weight relationship were determined. Condition factor (as formulated CF = (W / L^3) × 100 by Ricker (1975)) and gonadosomatic index (GSI) (as formulated GSI = (W_G / W_T) × 100 by Wootton (1990)) were calculated. Water temperatures were also determined on monthly basis with Hach HQ40d Water Quality Multiparameter, in order to associate with GSI values. Also von Bertalanffy equation data were estimated according to L(t) = L∞(1 – e^(-K(t – t_0))) in length and W∞ = a * L∞ in weight.

Statistical analyses were used to assess if the parameters (total length, weight, condition factor, gonadosomatic index) differed between seasons and sexes. The homogeneity of variances was tested (the Kolmogorov-Smirnov and Levene’s test) and, whenever necessary, the log-transformation log(x + 1) was used.

One way analysis of variance (ANOVA) was used at the 5% significance level to determine differences among the mean results (p ≤ 0.05). The Tukey-HSD test was applied when it was significant. A regression analysis was used to examine morphometric relations (length and weight) (Zar, 1999). All statistical analyses were carried out using Microsoft Excel and the IBM SPSS 21 Software package.

Results

The results of chlorophyll-a and TSI parameters were shown in Table 1. In autumn, both of these parameters have the highest values than during other seasons. The chlorophyll-a and TSI were determined as 26.19 ± 3.59 and 62.26 ± 1.28, respectively. The mean values were calculated as 9.26 ± 2.19 (chlorophyll-a) and 47.20 ± 2.25 (TSI) (Table 1).

Total length of 1,868 C. gibelio samples caught from Lake Beyşehir was determined in the range of 8.5 and 28.4 cm. Minimum and maximum total lengths for female, male and unidentified individuals were detected as 11.0, 8.5 and 10.2 cm and 28.4, 25.9 and 27.1, respectively. The weight parameters varied between 15.0 and 408.0 g; which minimum and maximum values for females as 21.0 and 408.0 g, whereas for males these were 15.0 and 278.0 g and for unidentified individuals, they were 14.0 and 238.0 g, respectively. Mean total length and weight of individuals were measured as 17.5 ± 2.37 cm and 88.6 ± 39.02 g, respectively. Mean total length and weight of females were calculated as 18.4 ± 2.46 cm and 105.8 ± 44.29 g, respectively. Also mean total length and weight of male individuals were determined as 17.1 ± 2.04 cm and 79.0 ± 29.51 g, respectively. In addition, a, b and R^2 rates were estimated as length-weight relationship values 0.017, 2.959 and 0.924, respectively. A negative allometry (b: 2.959) was obtained length - weight relation (Fig. 2).

Research on the range of the age indicated that the fish in the Lake Beyşehir showed an alteration between II and VII years of age (Table 3).
Table 1. Seasonal and mean chlorophyll-α (Chl-α) and Trophic State Index (TSI) values of Beyşehir Lake

<table>
<thead>
<tr>
<th>Season</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chl-α (µg/lt)</td>
<td>6.01 ± 0.61</td>
<td>3.36± 0.88</td>
<td>5.30± 1.06</td>
<td>26.19± 3.59</td>
<td>9.26 ± 2.19</td>
</tr>
<tr>
<td>TSI</td>
<td>48.07± 1.05</td>
<td>3.36± 0.88</td>
<td>46.33± 1.95</td>
<td>62.26± 1.28</td>
<td>47.20 ± 2.25</td>
</tr>
</tbody>
</table>

Table 2. Total length and weight parameters of *C. gibelio* by sexes

<table>
<thead>
<tr>
<th>Total length (cm)</th>
<th>Female</th>
<th>Male</th>
<th>Unidentified</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>Unidentified</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>708</td>
<td>780</td>
<td>380</td>
<td>1868</td>
<td>708</td>
<td>780</td>
<td>380</td>
<td>1868</td>
</tr>
<tr>
<td>Min - Max</td>
<td>11.0 - 28.4</td>
<td>8.5 - 25.9</td>
<td>10.2 - 27.1</td>
<td>28.4 - 8.5</td>
<td>21.0 - 408.0</td>
<td>15.0 - 278.0</td>
<td>21.0 - 408.0</td>
<td>14.0 - 278.0</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>18.4 ± 2.5</td>
<td>17.1 ± 2.0</td>
<td>16.7 ± 2.3</td>
<td>17.5 ± 2.4</td>
<td>105.7 ± 44.29</td>
<td>79.0 ± 29.5</td>
<td>76.6 ± 34.3</td>
<td>88.6 ± 39.2</td>
</tr>
</tbody>
</table>

Table 3. Sex ratio, total length (cm) and weight (g) for different ages of *C. gibelio*

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>%</th>
<th>Mean TL ± SD</th>
<th>Mean W ± SD</th>
<th>Female n</th>
<th>Male n</th>
<th>Female %</th>
<th>Male %</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>14</td>
<td>13.3</td>
<td>14.0 ± 2.3</td>
<td>45.3 ± 26.2</td>
<td>1</td>
<td>8</td>
<td>2.5</td>
<td>21.6</td>
</tr>
<tr>
<td>III</td>
<td>34</td>
<td>32.4</td>
<td>16.8 ± 2.2</td>
<td>80.7 ± 34.5</td>
<td>9</td>
<td>14</td>
<td>22.5</td>
<td>37.8</td>
</tr>
<tr>
<td>IV</td>
<td>26</td>
<td>24.8</td>
<td>19.2 ± 2.7</td>
<td>113.9 ± 49.8</td>
<td>14</td>
<td>7</td>
<td>35.0</td>
<td>10.8</td>
</tr>
<tr>
<td>V</td>
<td>19</td>
<td>18.1</td>
<td>19.0 ± 2.6</td>
<td>118.1 ± 58.8</td>
<td>7</td>
<td>1</td>
<td>17.5</td>
<td>24.3</td>
</tr>
<tr>
<td>VI</td>
<td>9</td>
<td>8.6</td>
<td>21.3 ± 2.3</td>
<td>167.7 ± 60.5</td>
<td>2</td>
<td>1</td>
<td>17.5</td>
<td>2.7</td>
</tr>
<tr>
<td>VII</td>
<td>3</td>
<td>2.9</td>
<td>21.9 ± 2.2</td>
<td>151.5 ± 55.4</td>
<td>2</td>
<td>1</td>
<td>5.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Discussion

Total length of 1,868 *C. gibelio* samples caught from Lake Beyşehir was in a range of 9.9-28.4 cm and it was detected that the individuals in Lake Beyşehir were smaller than the ones reported in other studies. For example, it was reported a total length distribution of 12.5-35.7 cm in Ömerli Dam Lake (Turkey) (Tarkan et al., 2006); 5.2-30.2 cm in Lake Iznik (Turkey) (Tarkan et al., 2006); 8.5-33.3 cm in Lake Uluabat (Turkey) (Emiroğlu, 2008); 10.3-30.5 cm in Aksu River (Turkey) (İnnal, 2012); 21.9-37.0 cm in Chimaïditis Lake (Greece) (Leonardos et al., 2008).

The same finding also applies to the value of maximum theoretical length (L∞) (19.8 cm) calculated for the species. For example, the value of L∞ was reported as 36.2 cm for the same lake (Çınar et al., 2007); 31.7 cm for Buldan Lake (Sarı et al., 2008); 33.3 cm for Lake Eğirdir (Balık et al., 2004); 48.1 cm for Seyitler Dam Lake (Bulut et al., 2013) and 36.0 cm (female) and 32.2 (male) for Gelingüllü Dam Lake (Bulut et al., 2004). Differences in total lengths could be attributed to sampling time, sampling method and ecological properties of the working areas.

Mean total length for female and male individuals was detected as 18.4 ± 2.46 and 17.1 ± 2.04 cm respectively, whereas mean weight was detected as 105.8 ± 44.29 and 79.0 ± 29.51 g. It was determined that the values of mean total length and weight for female individuals were higher in all seasons than those of male individuals. Said length and weight difference between female and male individuals was found statistically significant (except for winter season for total length). Different researchers (Balık et al., 2004; Kirankaya...
and Ekmekçi, 2013) reported that female individuals were longer and heavier compared to male individuals, and b values in the length-weight relationship were calculated higher for females than males.

It was determined that the species showed a negative allometric growth in Lake Beyşehir. In other studies, similar to the hereby investigation, a negative allometry (Bulut et al., 2013; Kazma, 1986; Leonarodos et al., 2008; San et al., 2008) as well as a positive allometry (Balık et al., 2004; Bostancı et al., 2007; Çinar et al., 2007; İnnal, 2012; Özkök et al., 2007; Tarkan et al., 2006) were detected. Differences in b value can be caused by age and maturity (Bulut et al., 2013); geographical location and environmental conditions (Bagenal and Tesch, 1978), season and nutrition (Tesch, 1968) and trophic state of the lake (Tsoumani et al., 2006). It was reported the relationship that as b value was reduced when the concentration of phosphate phosphorus (PO₄³⁻ – P), which trophic level indicator increased, the species exhibited better growth in mesotrophic and oligotrophic lakes, whereas the growth was affected negatively in eutrophic and hypertrophic lakes. On the other hand, Tarkan et al. (2012) reported that total phosphorus was not correlated with growth features of C. gibelio in a mesotrophic reservoir.

In the present study, Beyşehir Lake was classified as medium productive (mesotrophic lake) (TSI: 40-50) according to TSI values, since it has 47.20 ± 2.25 mean TSI value as stated in previous studies (Nas et al., 2008; Kazancı et al., 2009; Fakoğlu and Demir, 2011). It is thought that negative allometric growth of the species is correlated with the trophic state of Lake Beyşehir.

In Lake Beyşehir, the condition factor values for males and females of the species ranged between 1.5 to 1.7 and it was found to be lower than the values recorded within other studies (Balk et al., 2004; Bostancı et al., 2007; Çinar et al., 2007; Özkök et al., 2007; İnnal, 2012; Bulut et al., 2013; Kirankaya and Ekmekçi, 2013). The condition factor varies by the age of species, season, maturity, spawning period, nutritional status and environmental conditions (Çetinkaya et al., 2005). Balk et al. described that the condition factor values increased based on age. On the contrary, condition factor values did not increase based on age in Lake Beyşehir. This situation showed that the species does not exhibit the expected growth.

In the current study, the age range of the caught fish was determined as II-VII. In a previous study upon Lake Beyşehir, the age range was determined as 0-V (Çınar et al., 2007). In the study, the age group, III and IV constituted approximately half of the population (57.2%). The same
sustainable fisheries in mesotrophic lake. It was significantly correlated with an increase in C. gibelio population. Thus, further studies are required in order to reveal the impacts of C. gibelio on native fish stocks and sustainable fisheries in mesotrophic lake.

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Conclusions

In conclusion, Carassius gibelio has almost lost the economic value since the individuals are smaller than market size, probably due to lack of nutrients/mesotrophic situation of Lake Beyşehir. In addition, this species is able to reproduce gynogenetically, which involves the use of sperm from males of other species to activate egg development, so reproductive competition is a likely, but virtually unstudied, impact of gibel carp on native populations. It has been reported that a dramatic decrease in the relative stocks of native fish species was significantly correlated with an increase in C. gibelio population. Thus, further studies are required in order to reveal the impacts of C. gibelio on native fish stocks and sustainable fisheries in mesotrophic lake.

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