Population structure and some growth properties of chub *Squalius cephalus* (Linnaeus, 1758) in Devres Stream of Kızılırmak River, Turkey

Semra Benzer • Ali Gül

Gazi University, Gazi Faculty of Education, Teknikokullar 06500 Ankara, Turkey.

**Abstract**

This study describes the population structure, growth and condition factor of chub (*Squalius cephalus*) in Devres Stream of Kızılırmak River caught between June 2010 and June 2011. *S. cephalus* individuals ranging between I and VI years old were caught from Devres Stream. Studied individuals were between I and VI years old and their sex was determined as 51.67% male and 48.33% female. The fork length and body weight ranged from 8.79 – 19.64 cm and 9.73 – 126.60 g respectively. The von Bertalanffy growth equations were found:

\[
L_t = 27.163 \left[ 1 - e^{-0.159 (t+1.47)} \right] \]

for females and

\[
L_t = 27.078 \left[ 1 - e^{-0.160 (t+1.46)} \right] \]

for males;

\[
W_t = 286.14 \left[ 1 - e^{-0.159 (t+1.47)} \right]^{3.1049} \]

for females and

\[
W_t = 284.43 \left[ 1 - e^{-0.160 (t+1.46)} \right]^{2.9692} \]

for males. The condition factor was calculated as 1.432 and 1.378 for females and males respectively.

**Keywords:** *Squalius cephalus*; chub; growth; von Bertalanffy’s parameters; Devres Stream; Kızılırmak River.

1 | INTRODUCTION

The chub *Squalius cephalus* (Linnaeus, 1758), members of the family Cyprinidae, are common and widely distributed in Europe and Asia. One of the possible reasons for that is the high environmental tolerance of the chub (Arlinghaus and Wolter 2003). This species is usually investigated as an unpretentious species which occurs commonly in localities with different conditions, both natural and artificial ones (Arlinghaus and Wolter 2003). Since it is consumed as food by the locals, the *S. cephalus* has economic value; therefore, in order to take better advantage of the populations of this species, it is important to understand its growth and reproduction characteristics. Some authors have worked on its growth in connection with its usual occurrence of fish species. Many studies have been carried out on age and growth properties of the *S. cephalus* (Lelek 1959; Vostradovský 1961; Leontovyč 1974; Hababyy 1974; Leontovyč 1980; Hanel 1982 1984; Švátora and Pivnička 1986 1989; Altındağ 1996; Ünver 1998, Türkmen et al. 1999; Geldiay and Balık 1999; Smajlović 2000; Vlach and Švátora 2000; Vlach and Švátora 2000; Sasi and Balik 2003; Karatas and Can 2005, Koc et. al. 2006; Kirankaya and Ekmekçi 2007; Stefanova et al. 2008; Şen and Saygın 2008; Bostancı and Polat 2009; Innal 2010; Pompei et al. 2011; Dirican and Çilek 2012; Bulut et al. 2012; Sedaghat et al. 2012; Ünver and Erk’akan 2012; Raikova-Petrova et al. 2012; Özay 2014; Kaptan 2014; Çicek et al. 2016; Kılıç and Becer 2017).

The aim of this study is to determine the age composition, sex ratio, length and weight growth, the length-weight relationship, and the condition factor of *S. cephalus* in Devres Stream, Kızılırmak River. This study is very
important in determining the growth characteristics of the S. cephalus which is very common in the domestic waters of this water system which is rich in biodiversity.

2 | METHODOLOGY

Devres Stream is a branch of the Kızılirmak River, geographically located in the Western Black Sea Region of Turkey. Devres Stream is located about 70 km south of Kastamonu, and lies within the coordinates of 35°49′00″ N to 42°35′00″ N latitudes and 25°00′00″ E to 44°51′00″ E longitudes. A total of 329 S. cephalus (159 females and 170 males) were collected between June 2010 and June 2011 from the Devres Stream, Kızılirmak River by using a gill net (18–55 mm mesh). Collected specimens were transported to the laboratory to record the fork length (FL) to the nearest 0.1 cm and body weight (BW) to the nearest 0.1 g. Scales were sampled from each specimen for age determination according to Lagler (1966).

Growth was estimated using the von Bertalanffy growth curve model (Sparre and Venema 1992) \( L_t = L_{\infty} \times \left(1 - e^{-k(t-t_0)}\right) \) and weight \( W_t = W_{\infty} \times \left(1 - e^{-b(t-t_0)}\right)^{b} \) where \( L_t \) = the fork length (cm) at age \( t \), \( L_{\infty} \) = the asymptotic length (theoretical maximum length), \( k \) = the Brody growth coefficient (proportional to rate at which \( L_{\infty} \) is reached), \( t \) = the age (years), \( t_0 \) = the age at zero length, \( e \) is the base of natural log (2.71828), \( W_t \) = the weight of the fish in g at age \( t \), \( W_{\infty} \) = the asymptotic weight (theoretical maximum weight) the fish in g and \( b \) is the constant in the length–weight relationship. The von Bertalanffy growth parameters were estimated for males and females separately as well as for both sexes combined. The relationship between FL and BW was calculated separately for each sex with log transformed data (Le Cren 1951). The condition factors (CF) of fish was determined using the formula \( \frac{W}{L^{3.1046}} \times 100 \) (Ricker 1975) where \( W \) = body weight and \( L \) = body length. \( t \)-test was performed to test if there were significant differences between the length, weight and condition factor of females and males. Statistical analysis of the data was carried out using SPSS statistical package program for Windows (Version 20.0).

3 | RESULTS

Collected specimens of S. cephalus were aged from I to VI years and dominated by the first and second year classes. There were 48.33% females and 51.67% males (ratio 1 : 1.07), and differences in their numbers among different age groups was insignificant \( (t = 2.215; P > 0.05) \). Male and female age–weight relationships were drawn in Figure 1 with the respective equations indicated and differences between sexes were insignificant in all age groups \( (t = -1.963; P > 0.05) \). Male and female age–weight relationships were drawn in Figure 2. While the weight of the females was higher than that of the males in age groups III and V, the weight of the males was higher than that of the females in age groups I, II, IV and VI. Females grew to a greater asymptotic \( (W_{\infty}) \) weight than the males (Figure 3).

**TABLE 1** Fork length, weight and condition factor of Squalius cephalus in Devres Stream

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Male FL ± SE</th>
<th>Male W ± SE</th>
<th>Male CF ± SE</th>
<th>Female FL ± SE</th>
<th>Female W ± SE</th>
<th>Female CF ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>43</td>
<td>8.90±0.84</td>
<td>10.18±2.66</td>
<td>1.42±0.16</td>
<td>27</td>
<td>8.79±0.99</td>
<td>9.73±3.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.40±0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>84</td>
<td>11.33±0.94</td>
<td>20.03±6.66</td>
<td>1.35±0.26</td>
<td>65</td>
<td>11.21±0.83</td>
<td>19.95±4.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.40±0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>27</td>
<td>13.49±1.22</td>
<td>32.44±6.43</td>
<td>1.34±0.33</td>
<td>41</td>
<td>13.56±1.54</td>
<td>36.42±14.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.41±0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>7</td>
<td>16.57±1.24</td>
<td>55.43±8.98</td>
<td>1.33±0.24</td>
<td>13</td>
<td>15.93±0.90</td>
<td>61.42±18.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.37±0.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>4</td>
<td>17.95±0.29</td>
<td>91.62±31.62</td>
<td>1.57±0.47</td>
<td>7</td>
<td>18.00±0.28</td>
<td>100.85±22.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.72±0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>5</td>
<td>19.64±0.86</td>
<td>121.83±19.88</td>
<td>1.68±0.26</td>
<td>6</td>
<td>18.82±0.82</td>
<td>126.60±18.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.85±0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( N \), number of fish; FL, Fork length (cm), W, Weight (g) and CF, Condition factor (all \( P > 0.05 \))

Length–weight relationships (Figure 3) were calculated using the data of all fish samples. The relationship was \( W = 0.01463008 \times \frac{L}{L^{2.362}} \times 10^{0.900} \) for the males and \( W = 0.01089046 \times \frac{L}{L^{3.046}} \times 10^{0.913} \) for the females. The \( b \) value for the females was higher than that of the males. While CF of the females was higher than that of the males in age groups II, III, IV, V and VI, CF of the males was higher than that of the females in age group I. The differences between sexes were insignificant \( (t = 2.215; P > 0.05) \); Table 1). The condition factor was calculated as 1.432 and 1.378 for the females and males respectively.
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4 | DISCUSSION

The female male sex ratio (F : M) of the chub in Devres Stream was 1 : 1.07, and similar to the 1 : 1 ratio expected for most fish species (Bagenal and Tesch 1978). The sex ratios for this species from different habitats in the world and Turkey were determined as 1 : 2.85 in the Istranca Stream (Kaptan 2014), 1.6 : 1 in the Akçay/Muğla (Özay 2014), 2.98 : 1 in Yeniçağa Lake (Kılıç and Becer 2017), 1.5 : 1 in the River Inny (Caffrey et al. 2008). Although the sex ratio in most of the species was close to 1, this may vary from species to species, differing from one population to another of the same species, and may vary year after year within the same population. At early life stages the ratio of males is higher, but at later stages the female ratio is higher (Nikolsky 1963) and the results are in agreement with the findings of (Koç et al. 2006; Kaptan 2014; Özay 2014; Kılıç and Becer 2017). Some of the research found that the number of female is higher than males in all age groups (Ünver and Erk’akan 2012). Most of the samples studied in the present study belonged to the III year age group. Koç et al. (2006); Ünver and Erk’akan (2012); Özay (2014) reported a similar situation for İkizcetepeler Dam Lake, Tödürge Lake and the Akçay Stream populations. Majority of the specimens were in the II year age group for the Devres Creek and Istranca Stream (Balık et al. 2004; Kaptan 2014). The number of the individuals was in the age group III in this study.

The males were longer than the females in all the age groups in this research. The females of III, IV, V and VI year age groups were found heavier than the males, while in other age groups, the males were found heavier than the females. The males were longer and heavier at earlier life stages, while the females were longer and heavier at later stages (Koç et al. 2006; Ünver and Erk’akan 2012, Özay 2014). Kaptan (2014) found that females were heavier than males in all ages according to this study. Variations in fish growth in terms of length and weight can be explained as an adaptive response to different ecological conditions (Nikolsky 1963). The von Bertalanffy growth equations were: 
\[ L_t = 27.163 \left[ 1 - e^{-0.159 (t+1.47)} \right] \] for females and 
\[ L_t = 27.078 \left[ 1 - e^{-0.160 (t+1.46)} \right] \] for males;
\[ W_t = 286.14 \left[ 1 - e^{-0.159 (t+1.47)} \right]^{3.1049} \] for females and 
\[ W_t = 284.43 \left[ 1 - e^{-0.160 (t+1.46)} \right]^{2.9692} \] for males.
Male individuals were longer than females at I, II, IV and VI, while females were longer than males at III and V. When weights were examined, it was determined that male individual at I and II ages were heavier than female individual while females were heavier than males at other ages (Table 2). While some earlier studies have reported similar theoretical maximum length (Koç et al. 2006), other studies were different (Bulut et al. 2012; Sedaghat et al. 2012; Özay 2014; Kaptan 2014). This variation may be due to different stages in ontogenetic development, as well as differences in condition, length, age, sex and gonadal development of fish (Ricker 1975). Geographic location and some environmental conditions such as temperature, organic matter, and quality of food, time of capture, stomach fullness, disease, parasitic loads (Bagenal and Tesch 1978) affect growth.

TABLE 2 Length–weight relationship (a and b), growth (L∞, K, t₀).

<table>
<thead>
<tr>
<th>Study area</th>
<th>Weight range</th>
<th>Length range</th>
<th>N</th>
<th>a</th>
<th>b</th>
<th>r²</th>
<th>L∞</th>
<th>k</th>
<th>t₀</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>İkizce tepeler</td>
<td>18.6-243.6</td>
<td>11.1-24.8</td>
<td>172</td>
<td>0.0227</td>
<td>2.87</td>
<td>0.90</td>
<td>26.7</td>
<td>0.26</td>
<td>-1.55</td>
<td>Koç et al. (2006)</td>
</tr>
<tr>
<td>Dam Lake</td>
<td>29.3-173.9</td>
<td>12.2-24.1</td>
<td>242</td>
<td>0.0194</td>
<td>2.92</td>
<td>0.89</td>
<td>28.9</td>
<td>0.22</td>
<td>-1.55</td>
<td></td>
</tr>
<tr>
<td>Marıtza River</td>
<td>41-290</td>
<td>-</td>
<td>161</td>
<td>0.015</td>
<td>3.06</td>
<td>0.99</td>
<td>48.8</td>
<td>0.15</td>
<td>-0.05</td>
<td>Stefanova et al. (2008)</td>
</tr>
<tr>
<td>Assino Creek</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>63.91</td>
<td>0.123</td>
<td>-0.160</td>
<td>Pompei et al. (2011)</td>
</tr>
<tr>
<td>Gamasiab River</td>
<td>31.4-271.12</td>
<td>13.8-29.52</td>
<td>60</td>
<td>0.006</td>
<td>3.97</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td>Sedaghat et al. (2012)</td>
</tr>
<tr>
<td>Tödürge Lake</td>
<td>3.8-120.5</td>
<td>6.6-20.1</td>
<td>93</td>
<td>0.012</td>
<td>3.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ünver and Erk’akan (2012)</td>
</tr>
<tr>
<td></td>
<td>1.5-320.8</td>
<td>5.3-27.9</td>
<td>373</td>
<td>0.010</td>
<td>3.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akçay Stream</td>
<td>3.78-75.2</td>
<td>6.8-18.2</td>
<td>168</td>
<td>0.078</td>
<td>3.16</td>
<td>0.97</td>
<td>26.09</td>
<td>0.281</td>
<td>-0.393</td>
<td>Özay (2014)</td>
</tr>
<tr>
<td></td>
<td>2.76-124.6</td>
<td>6.7-24.6</td>
<td>145</td>
<td>0.0116</td>
<td>2.97</td>
<td>0.96</td>
<td>36.27</td>
<td>0.102</td>
<td>-1.372</td>
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</tr>
<tr>
<td>Istranca Stream</td>
<td>0.70-132.50</td>
<td>3.9-23.3</td>
<td>488</td>
<td>0.0093</td>
<td>3.08</td>
<td>0.99</td>
<td>39.51</td>
<td>0.137</td>
<td>-0.684</td>
<td>Kaptan</td>
</tr>
<tr>
<td></td>
<td>0.23-357.50</td>
<td>3.2-30.1</td>
<td>171</td>
<td>0.0071</td>
<td>3.18</td>
<td>0.99</td>
<td>49.13</td>
<td>0.127</td>
<td>-0.488</td>
<td>(2014)</td>
</tr>
<tr>
<td>Yeniçağa Lake</td>
<td>-</td>
<td>729</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36.88</td>
<td>0.248</td>
<td>-1.278</td>
<td>Kliç and Becer (2017)</td>
<td></td>
</tr>
<tr>
<td>Devres Stream</td>
<td>4.0-164.4</td>
<td>5.9-20.2</td>
<td>159</td>
<td>0.0146</td>
<td>2.97</td>
<td>0.90</td>
<td>27.1</td>
<td>0.160</td>
<td>-1.46</td>
<td>Present study</td>
</tr>
<tr>
<td></td>
<td>4.2-168.8</td>
<td>5.6-20.1 i</td>
<td>170</td>
<td>0.0108</td>
<td>3.11</td>
<td>0.91</td>
<td>27.1</td>
<td>0.159</td>
<td>-1.47</td>
<td></td>
</tr>
</tbody>
</table>

² male, ³ female; N, number of fish, W (g), L (cm).

Condition factor of chub varied from 1.01 to 2.75 in male; from 1.04 to 2.35 in female. Maximum CF was found as 2.75. The results are in agreement with some earlier reports (Koç et al. 2006), while it differs from the earlier studies carried out by (Balık et al. 2004; Bostancı and Polat 2009; Ünver and Erk’akan 2012). CF of S. cephalus differed in terms of age and gender of fish (Table 1). CF values of S. cephalus in the Devres Stream was recorded to be lower than 3.

The slope (b) values of the length–weight relationship in both gender was found as a 3.049. Similar b values for S. cephalus were reported earlier (Bostancı and Polat 2009; Ünver and Erk’akan 2012, Bulut et al. 2012), but it differed from those found several studies (e.g. Koç et al. 2006; Sedaghat et al. 2012; Özay 2014; Kaptan 2014).

The b value is often 3.0 and generally between 2.5 and 3.5. As the fish grows, changes in weight are relatively greater than the changes in length, due to approximately cubic relationships between fish length and weight. The b values in fish is species specific and varies with sex, age, seasons, physiological conditions, growth increment and nutritional status of fish (Ricker 1975; Bagenal and Tesch 1978).

In conclusion, this is the study presenting the age composition, sex ratio, length and weight growth, the length-weight relationship, and the condition factor of S. cephalus in the Devres Stream, Kızılırmak River. In addition, it is recommended that the necessary steps should be taken as soon as possible to protect the S. cephalus population in the Devres Stream, Kızılırmak River after investigating its stock situation, breeding and feeding behaviors.

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