Growth Properties of Brown Trout \textit{(Salmo trutta L.)} Living in Different Streams, Upper Coruh River (Turkey).

Ayhan Yıldırım, Murat Arslan, Serdar Bektas Edward J. Peters

Abstract- Growth parameters such as condition factor (K), length-weight relationship, mean length for age classes, and relative growth for brown trout were investigated in different habitats of Coruh river.

Fish were collected from three lakes (Göbekli Lake, Koyun Lake, Kuzu Lake) and the Aksu Stream during August 2002. The b values of the length-weight relationship from Göbekli and Koyun lakes were not statistically different from 3.0 (p>0.05) and indicated isometric growth, while those of Kuzu Lake and the Aksu Stream were significantly different from 3.0 (p<0.05) and indicated negative allometric growth. The b values for the length weight relationships of fish by habitats were significantly different with analyses of covariance (p<0.05). Also, condition factor and relative weight varied among the habitats. These data suggest that Göbekli Lake and Koyun Lake are more suitable habitats for growth than Kuzu Lake and the Aksu Stream.

Keywords- Brown trout, Condition, Coruh basin, Growth, Stream

I. INTRODUCTION

The brown trout, \textit{Salmo trutta} L., which has a natural distribution across Europe including Turkish freshwaters has been introduced successfully into at least 24 countries outside of Europe [1] Therefore, today the brown trout is a global species rather than only a European species [2].

Brown trout are exploited wherever they are found for sport, a commercial purpose and aquaculture [3].

Although biotic and abiotic factors can affect the growth of brown trout, it is generally agreed that water temperature, body size, and level of energy intake are three most important variables. Maximum growth occurs at a water temperature of 13oC which is considered to be the optimum for this species [4]. The amount of food available to the fish changes from time to time and also varies from stream to stream due to factors such as amount of bottom fauna, and other environmental factors [5] - [6] - [7] - [8]. Brown trout may migrate for nutrition and spawning to suitable habitat [9] - [10] - [11].

Our objective was to investigate the effects of habitat on growth parameters such as length weight relation, condition factor and relative weight of brown trout in our study sites.

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II. MATERIALS AND METHODS

This study was carried out in the Göbekli Lake, Koyun Lake, Kuzu Lake, and the Aksu Stream which drains this lake system called Yedigöller. These localities are all situated in the Kaçkar Mountains (İspir, Erzurum, Turkey). Göbekli Lake, Koyun Lake and Kuzu Lake all connect to each other, but the streambed between Göbekli and Koyun Lakes is covered with cobbles and boulders. The streambed between the Koyun and Kuzu Lakes has very small waterfall, about 25 cm high. Water discharging from Kuzu Lake runs into the Aksu Stream by flowing about 250 m through a small waterfall. The streambed at that location has a very steep slope and is covered by big boulders. Fish were caught by electrofishing the stream and by variable mesh gillnets (10x10 mm; 15x15 mm; 20x20 mm) in the lakes during August 2002. In field specimens were measured to the nearest 1 mm (total length) and weighed to the nearest 0.01 g with a portable electronic balance before being frozen and transported to the laboratory. Prior to dissection, all fish were thawed, rinsed and blotted dry. Age was determined by reading the otoliths which were examined in alcohol under a stereomicroscope and ages were determined by counting the number of opaque bands from the nucleus to the margin [12]. A length-weight relationship was developed using \( W=aFL^b \) where FL equals fork length and W equals weight. The constants, a and b were calculated by least-squares regression. To identify growth pattern, the value of the length-weight relationships was tested for deviation from 3.0 by a t-test [13] - [14]. Relative Weight \( (W_r) \) was calculated using: \( \frac{W}{Ws} \) x100, where W is total weight (g), \( W_s \) is length-specific standard weight. The standard weight functions are of the form \( W_s=-4.867+2.960 \log TL \) [Milewski and Brown, 1994]. Condition factor \( (KF) \) was calculated using \( KL=\frac{W}{TL} \) x100, where W is total weight (g) and TL is the total length (cm) [15] One way analysis of variance was used to compare the length in age, condition factor (KF) and relative weight (Wr) after logarithmic transformation. Weight-length relationship curves were compared using analysis of covariance. All statistical significance was based on p=0.05. Statistica software was used for all analyses.

III. RESULTS AND DISCUSSION

Average total lengths by age classes are shown in Table 1. Age classes 1 and 5 for Göbekli Lake, age class 7 for Koyun Lake, age classes 6, 7, and 8 for Aksu Upstream were excluded from the
calculations because of the limited number of fish. Although differences among age class 1 were not statistically significant among sites (p≥0.05), all other age classes tested were statistically significant among the sites (p<0.05). Moreover, fish from Göbekli and Koyun Lakes were determined to be similar to each other until age class 3, and Kuzu Lake and the Aksu Stream had different average lengths from the other populations (Table 1).

Water temperature, fish size, and level of energy intake are three most of important variables for brown trout and optimum water temperature for maximum growth rate for brown trout was 13 °C [4]. Water temperature was measured as 13 °C for the Aksu Stream and 12-13 °C for the lakes during August, which is the warmest month throughout the year. This suggests that water temperatures in Aksu Stream rarely reach the optimum temperature for maximum growth anytime throughout the year. In addition, since water flow in the Aksu Stream is low during summer and fall months, this makes it unsuitable for invertebrates, which are prey for brown trout [3].

Condition factor for brown trout from Göbekli, Koyun, Kuzu Lakes and the Aksu Stream were calculated as 1.336, 1.338, 1.298 and 1.267, respectively, while relative weight was 108.8, 116.6, 108.5 and 98.2, respectively. The one-way analysis of variance condition factor (F=8.875 and p=0.000) defined two homogeneous groups, of which one included Göbekli, Koyun and Kuzu Lakes, and the other group included Kuzu Lake and the Aksu Stream (Table 2). One-way Analysis of variance of relative weight (F=34.444, p=0.000) defined two homogeneous groups, of which one included Göbekli, Koyun and Kuzu Lakes and the other included only the Aksu Stream.

Table 1. Number of fish (N), average total length (TL±SE) with standard error and average total weight (W±SE) with standard error at each age classes for brown trout from Göbekli Lake, Koyun Lake, Kuzu Lake and upstream of Aksu, upper Çoruh River, Turkey.

<table>
<thead>
<tr>
<th></th>
<th>1**</th>
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<th>4**</th>
<th>5**</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>Göbekli Lake</td>
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<td>N</td>
<td>1</td>
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<td>9</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Total Length (cm) (TL±SE)</td>
<td>9.5</td>
<td>15.6±0.37 a</td>
<td>25.1±1.07 a</td>
<td>28.9±0.56</td>
<td>37.9</td>
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<tr>
<td>Total Weight (g) (W±SE)</td>
<td>10.0</td>
<td>50.7±4.25</td>
<td>225.38±26.96</td>
<td>333.44±16.2</td>
<td>670.30</td>
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<td>Koyun Lake</td>
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<td>11</td>
<td>6</td>
<td>2</td>
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<tr>
<td>Total Length (cm) (TL±SE)</td>
<td>16.5±0.75 a</td>
<td>23.9±0.85 a</td>
<td>32.9±1.32</td>
<td>37.4±2.14 a</td>
<td>42.2±0.15</td>
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<tr>
<td>Total Weight (g) (W±SE)</td>
<td>62.7±8.91</td>
<td>189.32±20.38</td>
<td>504.67±67.5</td>
<td>744.8±105.2</td>
<td>1,004.8±39.2</td>
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<td>Kuzu Lake</td>
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<td></td>
</tr>
<tr>
<td>N</td>
<td>4</td>
<td>1</td>
<td>27</td>
<td>18</td>
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<tr>
<td>Total Length (cm) (TL±SE)</td>
<td>8.1±0.62 a</td>
<td>14.9</td>
<td>20.6±0.36 b</td>
<td>23.4±0.42</td>
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<tr>
<td>Total Weight (g) (W±SE)</td>
<td>46.60</td>
<td>118.71±5.84</td>
<td>164.68±8.31</td>
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<td>Aksu Stream</td>
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<tr>
<td>N</td>
<td>4</td>
<td>40</td>
<td>56</td>
<td>31</td>
<td>16</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Total Length (cm) (TL±SE)</td>
<td>6.6±0.38 a</td>
<td>9.3±0.13 b</td>
<td>11.6±0.16 c</td>
<td>14.5±0.27</td>
<td>16.9±0.31 b</td>
<td>17.7±0.62</td>
<td>19.1±1.23</td>
<td>21.7±0.61</td>
</tr>
<tr>
<td>Total Weight (g) (W±SE)</td>
<td>3.9±0.41</td>
<td>10.5±0.45</td>
<td>20.65±0.83</td>
<td>39.80±2.21</td>
<td>63.09±3.96</td>
<td>69.00±6.97</td>
<td>82.28±15.15</td>
<td>122.07±15.89</td>
</tr>
<tr>
<td>One-Way analysis of variance for each age classes</td>
<td>F=3.845</td>
<td>F=125.52</td>
<td>F=311.95</td>
<td>F=223.82</td>
<td>F=129.73</td>
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<td></td>
<td>p=0.084</td>
<td>p=0.000</td>
<td>p=0.000</td>
<td>p=0.000</td>
<td>p=0.000</td>
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</tbody>
</table>

One-way analysis of variance was calculated only total length. Difference among the age classes indicated same letter was not statistically significant (p>0.05).
By contrast those for Kuzu Lake and the Aksu Stream were statistically lower than 3.0 and which suggests negative allometric growth ($t=-2.231$ and $t=-3.157$) ($p<0.05$) (Table 3). Analysis of covariance ($F_{3, 273}= 48.236$ $p<0.05$) bears out these observations and defined two homogeneous groups; one group included Kuzu Lake and the Aksu Stream, while the other group included Göbekli Lake and Koyun Lake.


In the present study, value of $b$, condition factor and relative weight showed similar fluctuations by habitats. The highest values were always in Göbekli Lake and the lowest values were always in the Aksu Stream with Koyun Lake and Kuzu Lake having intermediate values for these measures of fish condition. This suggests that Göbekli Lake had the best habitat for brown trout while the Aksu Stream had the poorest habitat. Koyun Lake was most similar to Göbekli Lake, Kuzu Lake showed condition characteristics that were different from the other lakes. However, the important result is that Kuzu Lake has different physical habitat characteristics like small wet area and shallow water that is unsuitable habitat for larger brown trout that prefer deeper water habitat [18] or migration reported by some researchers can occur from the Aksu Stream to Kuzu Lake for spawning [9] – [11].

Differences in the characteristics of the Aksu Stream population is normal due to the lower temperatures and low discharge which limits the quality of the habitat. Other studies have also assessed the habitats and evaluated differences in brown trout populations living in lentic and lotic systems [9] – [6] – [7] – [19] – [20]. Our data add to the body of evidence that growth and condition of brown trout are linked to aquatic habitats they inhabit. Brown trout inhabiting lotic systems have entirely different growth characteristics from those inhabiting lentic systems. In addition differences in growth and condition of brown trout among the lentic systems shows that variation of the growth parameters can occur between lake in close proximity to each other.

### Table III. Length-weight parameters for brown trout from Göbekli, Koyun, Kuzu lakes and Aksu stream, upper Çoruh River, Turkey.

<table>
<thead>
<tr>
<th>Location</th>
<th>N</th>
<th>$\bar{K}F\pmSE$</th>
<th>95% Conf. Interval</th>
<th>Mean (Wr ±SE)</th>
<th>95% Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Göbekli L.</td>
<td>25</td>
<td>1.34±0.016</td>
<td>1.28-1.38</td>
<td>108.8±1.99</td>
<td>104.7-112.9</td>
</tr>
<tr>
<td>Koyun L.</td>
<td>38</td>
<td>1.34±0.016</td>
<td>1.33-1.37</td>
<td>111.6±1.54</td>
<td>108.5-114.7</td>
</tr>
<tr>
<td>Kuzu L.</td>
<td>50</td>
<td>1.29±0.011</td>
<td>1.27-1.32</td>
<td>108.5±2.05</td>
<td>104.4-112.6</td>
</tr>
<tr>
<td>Aksu S.</td>
<td>163</td>
<td>1.27±0.008</td>
<td>1.25-1.28</td>
<td>98.2±0.57</td>
<td>97.1-99.4</td>
</tr>
</tbody>
</table>

1 Analyses of covariance for “b” values: F=48.236 > F$_{0.05,3,273}=3.314$, difference among the b values indicated same letter was not statistically significant ($p>0.05$).

2 Difference was statistically significant from of 3 ($p<0.05$) and negative allometric growth.

### REFERENCES


