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EARLY DEVELOPMENT AND GROWTH OF ARCTIC CHARR
(SALVELINUS ALPINUS) AND RAINBOW TROUT
(ONCORHYNCHUS MYKISS) AT A LOW WATER TEMPERATURE

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Key words: arctic charr, growth, low water temperature, rainbow trout, survival

Abstract
Hatchery traits and growth of eggs and fry of rainbow trout, Oncorhynchus mykiss, and arctic charr, Salvelinus alpinus, were tested in fresh water of a low temperature. There were significant differences (p<0.05) between the survival rates from fertilization through the eyed stage and the first exogenous feeding. No significant differences were observed between species with regard to feed conversion or survival of fry at the end of the 154-day trial, but weight gain and specific growth rate differed significantly (p<0.05). These results suggest that the arctic charr could be considered an alternative to rainbow trout, particularly in coldwater farms.

Introduction
Rainbow trout, Oncorhynchus mykiss, is the most extensively cultured fish in Turkey as well as globally. Nevertheless, other low-priced cultured salmonids are available year-round and a steady supply of these fish can be guaranteed. The arctic charr, Salvelinus alpinus, is not endemic in Turkey. However, in countries such as Canada it has been cultured for many decades both to enhance sport fisheries and as food fish (Guillou et al., 1995). Turkish customers seem to prefer wild species because of their taste and color. Consequently, chances are that wild fish such as Salvelinus spp. can partially replace rainbow trout in Turkish markets.

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cold freshwater fish cultured for food consumption. It is sold at competitive prices ranging from $2.14 to $2.50 per kg live weight in Turkey (Yanik and Aras, 1999) and at $2.47-2.72 in the USA (Johnson, 1998). Yet, many rainbow trout farmers believe that if wild species such as the arctic charr could be cultured, they would eventually occupy a category of their own and obtain higher retail prices.

Salvelinus spp. have a higher tolerance to low dissolved oxygen concentrations and to a greater range in pH (4.0 to 9.8) than rainbow trout (McClane, 1974). The optimum temperature for rearing Salvelinus spp. is 7.5-12.5°C. Rainbow trout grow best at 15-16°C and growth declines when temperatures reach the vicinity of 4°C (Piper et al., 1982; Stevenson, 1987). Hatching, growth, survival and feed efficiency of salmonids, from the egg stage to the table stage, have already been studied (Okutan, 1972; Canyurt, 1977; Özdemir, 1980; Karatas, 1991; Yanik and Aras, 1991; Bromage et al., 1992; Yanik and Aras, 1994). In some studies, wild fish performed better than rainbow trout. For instance, a winter production trial at Virginia State University revealed that brook trout consumed feed better in cold water conditions than rainbow trout (Newton, 1997). In Canada, brook trout had better growth rates and less size variability than other salmonids (Dumas et al., 1995). Rainbow trout does not actively feed at temperatures below 8°C. Therefore, rainbow trout culture in temperate zones may be limited during winter, when low water temperatures prevent feeding some 60-90 days per year (Tidwell et al., 1991).

This research was conducted to demonstrate to farmers the potential of culturing arctic charr instead of rainbow trout from the viewpoint of fertilization, hatching, survival and growth.

Materials and Methods

Experiment 1. Arctic charr, shipped from France, were reared intensively on a local farm. Rainbow trout of the same age were reared intensively in our farm, located in the Research and Extension Center of the Fishery Department at the College of Agriculture of the University of Atatürk in Erzurum.

The fish were used to produce eggs and milt for induced spawning. Experiments were done in three replicates. Eggs were treated as in Jonsson and Svavarsson (2000). Aerated artesian water with 1 l/min inflow, 8.5°C temperature, 7.5 pH and 10.2 mg/l dissolved oxygen was used. The eggs were incubated in the hatchery of the Research and Extension Center in six hatching trays with approximately 1000 eggs each. At the eyed stage, the exact number of eggs in each tray was counted. After that, 500 eggs from each tray were monitored to determine hatching properties. Trays were observed daily and dead eggs as well as deformed and dead fry were discarded. Survival rates to the first feeding stage were determined by counting the fry remaining in each tray (Yanik and Aras, 1994).

Experiment 2. Growth, feed conversion and survival of fry from the two species were compared. Fry were acclimatized for four days in tanks. Ninety fry from each species (a total of 180) were stocked randomly into six circular fiberglass tanks (three replicates containing 30 fry per tank). The tanks were 50 cm (diameter) by 40 cm (water depth) and received 1.2 l/min of disinfected water. The fry received a pelleted diet containing 51% protein, 17.15% fat, 93.93% dry matter and 9.3% ash. They were fed to satiation three times a day and the quantity of feed was recorded. Fish were weighed collectively twice a month on a scale with an accuracy of 0.01 g and were not fed on those days. The experiment lasted 154 days (140 feeding days) during which mortality was recorded.

Statistical analysis. In experiment 1, the rates of fertilization, hatching and survival to first feeding were calculated. In experiment 2, the specific growth, feed conversion and survival rates were calculated. All data were analyzed using a one-way analysis of variance with the SAS Statistics Package Program, version 6.11, followed by the Duncan’s multiple range test to determine significant differences among means at the α = 0.05 level (Duncan, 1971).
Results

Experiment 1. Mean survival (Table 1) to the eyed stage of the arctic charr was significantly (F=28.75, p<0.05) higher (98.4%) than that of the rainbow trout (94.93%). However, there were no significant differences in average survival during the eyed (F=0.09) and yolk sac (F=0.71, p>0.05) stages. The cumulative survival from fertilization to first feeding differed significantly (F=28.75, p<0.05) between arctic charr (97.07%) and rainbow trout (93.27%). The duration of incubation for the rainbow trout was 30-36 days and for the arctic charr 39-49 days. The yolk sac stage for the rainbow trout was 19-21 days and for the arctic charr 25-28 days.

Experiment 2. The weight gain and feed conversion, specific growth and survival rates of the rainbow trout and the arctic charr are presented in Table 2. Growth is shown in Fig. 1. The initial average weights of the rainbow trout and arctic charr were 1.54 and 0.79 g, respectively, and significantly differed (F=297.86, p<0.05) from each other. So did the final average weights, 20.22 and 14.82 g (F=9.88, p<0.05), and weight gains, 1211.35 and 1786.72 (F=21.93, p<0.05). The mean survival rate of both species was high, 92.22% for the rainbow trout and 97.78% for the arctic charr. Survival did not differ significantly between the species (F=1.47, p>0.05). The average specific growth rate of the rainbow trout was 1.67, significantly different (F=18.62, p<0.05) from that of the arctic charr which was 1.91.

Discussion

Temperature is a vital factor for incubation and hatching. It was suggested that the optimal temperature range for rainbow trout is 10-12°C (Stevenson, 1987). However, Bardach et al. (1972) reported successful hatching results with water temperatures of 8-13°C and a dissolved oxygen concentration of at least 7 ppm. Therefore, the low water temperature used in this study may have caused the slightly lower survival of eggs and fry of the rainbow trout as compared to the arctic charr. The difference in egg size between the two species might also have caused the difference in survival rate from fertilization to the eyed stage. However, previous works indicate controversial results between egg size and early survival rate in salmonids (Gall, 1974) and arctic charr (Wallace and Aasjord, 1984; Jonsson and Svavarsson, 2000). No correlation was found between egg size and embryonic survival to hatching in brook trout (Hutchings, 1991).

Table 1. Comparison of survival of rainbow trout and arctic charr from fertilization to first feeding.

<table>
<thead>
<tr>
<th></th>
<th>Rainbow trout</th>
<th>Arctic charr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubation duration (days)</td>
<td>30-36</td>
<td>39-49</td>
</tr>
<tr>
<td>Survival to eyed stage (%)</td>
<td>94.93±1.10a</td>
<td>98.4±0.40b</td>
</tr>
<tr>
<td>Survival during eyed stage (%)</td>
<td>98.91±1.03a</td>
<td>99.05±0.92a</td>
</tr>
<tr>
<td>Yolk sac stage (days)</td>
<td>19-21</td>
<td>25-28</td>
</tr>
<tr>
<td>Survival in yolk sac stage (%)</td>
<td>99.43±0.25a</td>
<td>99.59±0.21a</td>
</tr>
<tr>
<td>Survival to first feeding (%)</td>
<td>93.27±0.81a</td>
<td>97.07±0.92b</td>
</tr>
</tbody>
</table>

Means in a row with different superscripts differ significantly (p<0.05).
The survival rates of the rainbow trout to the eyed stage were in accordance with the work of Jonsson and Svavarsson (2000). The values were higher than those reported by Yanık and Aras (1994) although their research was conducted in the same research center, with the same water temperature. However, Yanık and Aras (1994) used rectangular concrete troughs of 145 x 45 x 35 cm instead of fiberglass tanks. Perhaps, the tank form and dimensions affected the early survival rates of these fish. On the other hand, the survival rates of the arctic charr to the first feeding stage in this study and in the findings of Jonsson and Svavarsson (2000) were higher than those of the rainbow trout and those reported by Yanık and Aras (1994). This could suggest that, in low temperatures, arctic charr eggs have a better hatchability than do those of the rainbow trout.

In experiment 2, the average weight gain of the arctic charr was higher than that of the rainbow trout and statistically different. This can be explained by the low water temperature. The temperature averaged 8.5°C throughout the investigation and, therefore, was below the optimum for rainbow trout but quite adequate for Salvelinus species (Piper et al., 1982). The average growth rates were in accordance with the findings of Yanık and Aras (1999) and Coyle and Tidwell (2000).

The feed conversion ratio of the arctic charr was better than that of the rainbow trout but not statistically different. Average survival rates were similar to those reported by Coyle and Tidwell (2000), but higher than those reported by Yanık and Aras (1994).

The specific growth rates in this study (1.91% for arctic charr and 1.67% for rainbow trout) were in accordance with the findings of Arndt et al. (1998) but higher than reported by Tidwell et al. (1991) for rainbow trout (0.7%) and by Coyle and Tidwell (2000) for brook trout (1.4%). The controversial results may be attributed to the growing stage that was studied.

This study indicates that, under the same environmental conditions, the early growth rates of rainbow trout and arctic charr are similar and that the latter could eventually substitute rainbow trout in culture. Nevertheless, further investigation on the growth rates of later stages is required before final conclusions can be drawn. Further investigations are also required to establish the hatchery properties of salmonids.

### References
Growth of arctic charr and rainbow trout at low temperature

Fig. 1. Average weight (mean±SD) of rainbow trout and arctic charr during 154 day trial at a constant temperature of 8.5°C.


Karatas M., 1991. Gürüz su ürünleri istasyonuında yetiştirilen gökkusagi alabalıklarının (O. mykiss) yumurta verimi ve çıısı gücü