The Open Access Israeli Journal of Aquaculture – Bamidgeh

As from **January 2010** The Israeli Journal of Aquaculture - Bamidgeh (IJA) will be published exclusively as **an on-line Open Access (OA)** quarterly accessible by all AquacultureHub (http://www.aquaculturehub.org) members and registered individuals and institutions. Please visit our website (http://siamb.org.il) for free registration form, further information and instructions.

This transformation from a subscription printed version to an on-line OA journal, aims at supporting the concept that scientific peer-reviewed publications should be made available to all, including those with limited resources. The OA IJA does not enforce author or subscription fees and will endeavor to obtain alternative sources of income to support this policy for as long as possible.

Published under auspices of
The Society of Israeli Aquaculture and Marine Biotechnology (SIAMB),
University of Hawaii at Manoa Library
and
University of Hawaii Aquaculture Program in association with
AquacultureHub
http://www.aquaculturehub.org

ISSN 0792 - 156X

PUBLISHER:
Israeli Journal of Aquaculture - BAMIGDEH -
Kibbutz Ein Hamifratz, Mobile Post 25210,
ISRAEL
Phone: + 972 52 3965809
http://siamb.org.il

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

Telat Yanik* and Sükriye Aras Hisar

Fisheries Department, Agricultural Faculty, Atatürk University, 25240 Erzurum, Turkey

Canan Bölükbasi

Animal Sciences Department, Agricultural Faculty, Atatürk University, 25240 Erzurum, Turkey

(Received 17.2.02, Accepted 25.4.02)

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.

In Turkey, rainbow trout is the principal

* Corresponding author. E-mail: telatyanik@yahoo.com

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.

S*alvelinus* 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;Yanık and Aras, 1991; Bromage et al., 1992; Yanık 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 $\alpha = 0.05$ 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.

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

Means in a row with different superscripts differ significantly ($p<0.05$).

Table 2. Weight gain, feed conversion ratio, survival and specific growth rate of rainbow and arctic charr after 154 days of trial (140 feeding days).

	Rainbow trout	*Arctic charr*
Initial weight (g)	1.54±0.02[a]	0.79±0.07[b]
Final weight (g)	20.22±2.76[a]	14.82±1.11[b]
Weight gain (%)	1211.35±189.47[a]	1786.72±96.94[b]
Feed conversion ratio	1.63±0.05[a]	1.53±0.05[a]
Survival (%)	92.22±6.94[a]	97.78±3.85[a]
Specific growth rate (%)	1.67±0.09[a]	1.91±0.03[b]

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

Arndt R.E., Wagner E.J., Routledge M.D. and Q.A. Bradwisch, 1998. Hatchery performance and fish health of cutthroat rainbow trout hand-fed or demand-fed a floating feed. *J. Appl. Aquacult.*, 8(3):41-49.

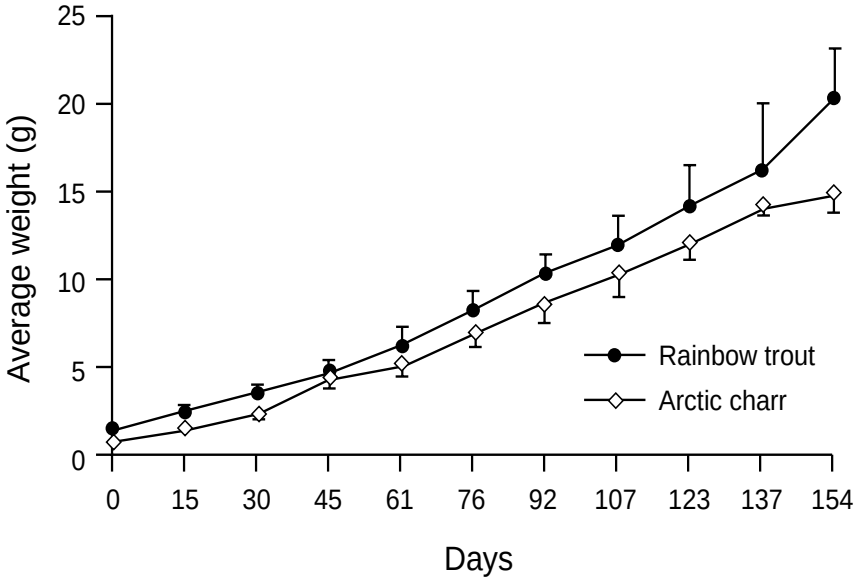

Fig. 1. Average weight (mean±SD) of rainbow trout and arctic charr during 154 day trial at a constant temperature of 8.5°C.

Bardach J.E., Ryther J.H. and W.O. McLarney, 1972. *Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley, New York. 868 pp.

Bromage N., Jones J., Randall C., Thrush M., Davies B., Springate J., Duston J. and M. Baker, 1992. Brood stock management, fecundity, egg quality and the timing of egg production in rainbow trout (*O. mykiss*) *Aquaculture*, 100:141-166.

Canyurt M.A., 1977. Yavru som balıgı (*Salmo salar* L.) yetistiriciligi ile ilgili bazı parametreler üzerine arastırmalar. *TÜBITAK VI. Bilim Kongresi, Tebligi.* 17-21 Ekim, Ankara.

Coyle S.D. and J.H. Tidwell, 2000. Production characteristics of rainbow trout, (*Oncorhynchus mykiss*), and brook trout (*Salvelinus fontinalis*) under seasonal pond conditions. *J. Appl. Aquacult*., 10(1):37-43.

Dumas S., Blanc J.M., Audet C. and J. de la Noue, 1995. Variation in yolk absorption and early growth of brook charr (*Salvelinus fontinalis,* Mitchill), arctic charr, (*Salvelinus alpinus*, L.), and their hybrids. *Aquacult. Res.,* 26:759-764.

Duncan D.B., 1971. Multiple range and multiple F-tests. *Biometrics*, 11:313-323.

Gall G.A.E., 1974. Influence of size of eggs and age of female on hatchability and growth in rainbow trout. *Calif. Fish Game*, 6:26-35.

Guillou A., Soucy J., Khalil M. and L. Adambounou, 1995. Effects of dietary vegetable and marine lipid on growth, muscle fatty acid composition and organoleptic quality of flesh of brook charr (*Salvelinus fontinalis*). *Aquaculture*, 136:351-362.

Hutchings J.A., 1991. Fitness consequences of variation in egg size and food abundance in brook trout (*Salvelinus fontinalis*). *Evolution,* 45:1162-1168.

Johnson H.M., 1998. *Annual Report on the United States Seafood Industry.* H.M. Johnson & Assoc., Bellevue, Washington.

Jonsson B. and E. Svavarsson, 2000. Connection between egg size and early mortality in arctic charr (*Salvelinus alpinus*). *Aquaculture*, 187(3-4):315-317.

Karatas M., 1991. Gürüz su ürünleri istasyonunda yetistirilen gökkusagı alabalıklarının (*O. mykiss*) yumurta verimi ve çıkıs gücü

üzerine bir arastırma. *Tokat Ziraat Fak. Derg.,* 1(2):179-184.

McClane A.J., 1974. *McClane's New Standard Fishing Encyclopedia*. Holt, Rinehart and Winston Inc., New York.

Newton S.H., 1997. 1996-97 winter trout production. *Aquaculture Mag*., 23:25-26.

Okutan C., 1972. Soguk su balıkları üretimi. *Balık ve Balıkçılık Derg.*, 20(2):17-22.

Özdemir N., 1980. Gökkusagı (*O. mykiss*), ve dere alabalıklarının (*S. fontinalis*) bazı verim özellikleri üzerine arastırmalar. *TÜBITAK VII. Bilim Kongresi, Vet. ve Hay. Arastırma Grubu Tebligleri* 29 Eylül-3 Ekim, Istanbul.

Piper R.G., McElwain I.B., Orme L.E., McCraren J.P., Fowler L.G. and J.R. Leonard, 1982. *Fish Hatchery Management*. US Department of the Interior, Fish and Wildlife Service, Washington, DC.

Stevenson J.P., 1987. *Trout Farming Manual, 2nd Ed.* Fishing New Books, Farnham, Surrey. 259 pp.

Tidwell J.H., Webster C.D. and R.S. Knaub, 1991. Seasonal production of rainbow trout (*Oncorhynchus mykiss,* Walbaum) in ponds using different feeding practices. *Aquacult. Fish. Management*, 22:335-341.

Yanık T. and M.S. Aras, 1991. Erzurum ve Van gökkusagı alabalıgı (*O. mykiss*) yavru hatlarının aynı sartlarda yasama gücü yem degerlendirme ve büyüme bakımından karsılastırılmaları üzerine arastırmalar. pp. 249-261. In: *Egitiminin 10. Yılında Su Ürünleri Sempozyumu*. 12-14 Kasım, Izmir.

Yanık T. and M.S. Aras, 1994. Comparison between some traits of eggs stripped from Erzurum and Van rainbow trout *(Oncorhynchus mykiss)* broodstock strains. *J. Agric. College at Atatürk Univ.*, 25(4):599-608.

Yanık T. and M.S. Aras, 1999. Economical analyzes of replacing slaughterhouse by-product meals in salmonid (*Oncorhynchus mykiss*) fry diets. *Turkish J. Vet. Animal Sci.*, 23(1):155-160.

Wallace J.C. and D. Aasjord, 1984. An investigation of the consequences of egg size for the culture of arctic charr (*Salvelinus alpinus* L.). *J. Fish Biol.*, 24:427-435.