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HATCHERY AND GROWTH PERFORMANCE OF TWO TROUT PURE BREEDS, *SALVELINUS ALPINUS* AND *SALMO TRUTTA FARIO*, AND THEIR HYBRID

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Abstract

An allelic cross between *Salmo trutta fario* and *Salvelinus alpinus* was carried out under controlled hatchery conditions. Survival to the eyed stage was significantly lower for the hybrid than for both purebreds. There were significant differences in survival in the eyed and yolk sac stages and from fertilization to the first feeding ($p<0.05$) between the hybrid and the purebreds, while the differences between the purebreds were not significant ($p>0.05$). The hybrid did not display heterosis with respect to any hatchery property. During the first 45 days of nursing, there were significant differences between the purebreds and the hybrid in terms of weight gain, survival, feed conversion ratio and specific growth rate ($p<0.05$) with no significant differences between the purebreds ($p>0.05$). The hybrid was slightly heterotic (+1.69) with respect to survival however no heterosis was observed in any other property to the first feeding stage.

Introduction

The high market value of salmonids has generated substantial interest among fish farmers. However, Turkish customers prefer wild salmonid species due to their taste and color. The lack of good-quality seed is one of the

major constraints to the development and expansion of farmed salmonid species. Wild fish such as *Salvelinus* spp. and *Salmo trutta* spp. could partially replace farmed rainbow trout on Turkish markets (Memis et al., 2002)

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and intraspecific cross-breeding of selected salmonid populations, i.e., *S. trutta fario* and *S. alpinus*, may produce a faster growing breed with a higher survival rate for aquaculture.

To produce an alternative and productive strain of salmonid, an allelic cross between *S. trutta fario* and *S. alpinus* was carried out under controlled hatchery conditions. Early development, growth and heterosis of the hybrid to the first exogenous feeding stage were examined.

Materials and Methods

Two experiments were conducted. In experiment 1, two species of salmonids, brown trout (*S. trutta fario*) and arctic charr (*S. alpinus*), were hybridized under controlled hatchery conditions at the Fishery Department Research and Extension Center of the Agricultural Faculty of Ataturk University in Erzurum, Turkey.

The brown trout were captured from the Green River, a cold river in the village of Yesilyayla, Dumlupınar Province, near Erzurum (39.55°N, 42.31°E), in October 1998. Arctic charr were obtained from a local fish farm in Erzurum. Mature fish were kept separately in four fiberglass tanks (1 m diameter, 1 m depth); each tank contained ten mature fish, either male or female, of one of the species. The fish were fed a commercial diet of 45% protein and 12% fat at a daily ration of 1% of their wet body weight. Milt and eggs were obtained from three randomly chosen females and males of each species by applying gentle pressure to the abdominal wall. Dry fertilization was done in bowls to produce purebred *S. alpinus* (Sa♀ x Sa♂), purebred *S. trutta fario* (St♀ x St♂) and an allelic hybrid (St♀ x Sa♂).

The eggs were incubated in three hatching trays containing 1500-3500 eggs, each. At the eye stage, the exact number of eggs in each tray was counted. After that, the trays were observed daily. Dead eggs and deformed and dead fry were recorded and discarded. Survival rates to the first feeding stage were determined by counting the fry remaining in each tray (Yanik et al., 2002). Survival was calculated according to formulas used by

Kötzner (1978), Refstie (1978) and Yanik and Aras (1994):

- survival to eyed stage (%) = (number of eyed eggs/total number of incubated eggs) x 100;
- survival in eyed stage (%) = (number of hatched fry/total number of eyed eggs) x 100;
- survival in yolk sac stage (%) = (number of swim-up fry/total number of yolk sac fry) x 100;
- survival to first feeding (%) = (number of swim-up fry/total number of incubated eggs) x 100.

The eggs were treated according to Jonsson and Svavarsson (2000). Aerated artesian water was provided at 1 l/min, 8.5°C, 7.5 pH and 10.2 mg/l dissolved oxygen.

In experiment 2, the growth, feed conversion, weight gain and survival of alevins was compared when the first exogenous feeding stage (yolk sac absorbed) was reached, using formulas provided by Steffens (1989). Initially, fry were acclimatized for four days in tanks. Ninety fry of each species and hybrid (a total of 270) were stocked randomly in nine disinfected circular fiberglass tanks (50 cm diameter, 40 cm water depth) with a water inflow of 1.2 l/min. The experiment was carried out in three replicates with 30 fry per tank. Fry were fed a diet of 51% protein, 17.15% fat, 93.93% dry matter, and 9.3% ash to satiation, three times a day. The quantity of given feed was recorded. The experiment lasted 45 days during which mortality was recorded. Fish were weighed collectively twice a month to the nearest 0.01 g and were not fed during these days. Heterosis of the hybrid was determined based on the formula of Nguenga et al. (2000): heterosis (%) = $\{H - [(P_1 + P_2)/2] / [(P_1 + P_2)/2]\} \times 100$, where H is the mean weight (or survival rate) of the hybrid and P_1 and P_2 are the mean weights (or survival rates) of the two purebreeds.

Statistical analysis. Fertilization, hatching and survival to first feeding rates were compared using the Chi square test. A one way analysis of variance (ANOVA) followed by Duncan's multiple range test was used to determine significant differences among means at first feeding ($p < 0.05$).

Results

In experiment 1, the survival rate in all stages was significantly lower for the hybrid than the purebreds while the differences between the purebreds were not significant (Table 1). No heterosis was observed in the hybrid compared to either purebred species for any hatchery property.

In experiment 2, there were differences between the purebreds and the hybrid in all parameters (Table 2). Although, the difference in survival was not significant, the hybrid displayed a slight heterosis (+1.69) in this parameter. Growth is shown in Fig. 1.

Discussion

Survival at all stages was significantly lower in the hybrid than in the purebred in experiment 1. Survival can be affected by environmental factors and genotype (Huet, 1971; Akyurt, 1992) or maternal effects on the early development of salmonids (Guo et al., 1990; Poxton, 1991). Maternal effects include differences among females in egg size or quality (Gjedrem, 1992). It is important to know whether or not a genotype-environment interaction affected results. No interaction means that the ranking of animals or strains according to breeding value is the same for different environments. If there is a genotype-environment interaction, strains should be developed for each environment. In the present study, this interaction was negligible since all fish were treated in the same controlled environment. Therefore, the differences likely derived from egg quality, which can vary greatly among salmonids (Hershberger, 1992), or genotype (Huet, 1971).

Survival in all stages differed from earlier studies. For instance, Kötzner (1978) reported lower survival of 68% for the hybrid (Sa♀ x Sa♂), 53% for *S. trutta fario* and 75% for *S. alpinus*, heterosis to the eyed stage and 25%, 45% and 58% survival in the eyed stage, respectively. Refstie and Gjerdem (1975) reported a higher (72%) survival for the hybrid. No heterosis was reported for the hybrids (Sa♀ x Sa♂) with respect to hatchery traits by either Kötzner (1978) or Refstie (1978). Possible reasons for the contradictory

results regarding survival may be differences in breeding history, age of breeders, domesticated and wild strains. These properties may vary according to the initial quality of the gametes (Kjørsvik and Lønning, 1983) or seasonal climatic changes (Richter et al, 1987; Freund et al., 1995).

The survival, weight gain, specific growth rate and feed conversion rate of the hybrids were significantly lower than those of the purebreds at the first feeding stage. The reason may be maternal effects (Guo et al., 1990; Blanc et al., 2000). It has been reported that heterotic effects may not always occur in hybridization studies (Klupp, 1979; Ayles and Baker, 1983; Hörstgen-Schwark et al., 1986).

In terms of feed consumption and in contrast to the findings of the present study, Fricke et al. (1984) reported that hybrid trout utilized more feed than purebred. Similarly, in rainbow trout, feed consumption of hybrids was better (Gjerde, 1988).

Ayles and Baker (1983) observed heterosis among only six of 24 groups of rainbow trout strains and hybrids in terms of live weight gain. On the other hand, Hörstgen-Schwark et al. (1986) found no differences between hybrid and purebred rainbow trout. Gall (1975) and Gjerde (1988) reported higher live weight gains in hybrid than in purebred rainbow trout. In the present study, although hybrids had low hatchery performance, they could compete with arctic charr in terms of growth (Fig. 1). Further work should be conducted to elucidate this point.

Although no significant differences were observed with respect to survival at the first exogenous feeding stage, the hybrids exhibited a slight heterosis (+1.69). Similarly, a higher survival rate in hybrids was reported by Piggins (1970) and Suzuki and Fukuda (1971).

The findings of this study show that the alevin yield at the start of first feeding was poor in the hybrid, mainly because of an abnormally low fertilization rate (egg quality may be suspected) compared to the fertilization rate of the purebreds. The hybrid appears to be a valuable candidate from the fish culture perspective. The economic value of such

Table 1. Productivity of two purebred trout and their hybrid from fertilization to first feeding.

<i>Experiment I</i>	<i>Hybrid (S. trutta fario ♀ x S. alpinus ♂)</i>	<i>Brown trout purebred (Salmo trutta fario)</i>	<i>Arctic charr purebred (Salvelinus alpinus)</i>
Incubation period (days)	44-52	44-48	45-54
Survival to eyed stage (%)	75.36 ^a	99.35 ^b	99.50 ^b
Survival in eyed stage (%)	35.56 ^a	97.23 ^b	97.76 ^b
Yolk sac stage (days)	17	15	18
Survival in yolk sac stage (%)	72.79 ^a	98.84 ^b	98.85 ^b
Survival to first feeding (%)	19.50 ^a	95.45 ^b	95.17 ^b

Within a row, values with different superscripts differ significantly ($p < 0.05$).

Table 2. Means±standard deviations for productivity of two purebred trout and their hybrid after 45 days (in the first exogenous stage).

<i>Experiment II</i>	<i>Hybrid (S. trutta fario ♀ x S. alpinus ♂)</i>	<i>Brown trout purebred (Salmo trutta fario)</i>	<i>Arctic charr purebred (Salvelinus alpinus)</i>
Initial weight (g)	0.78±0.04 ^a	0.47±0.02 ^b	0.79±0.07 ^a
Final weight (g)	2.71±0.25 ^a	1.90±0.04 ^b	3.52±0.31 ^c
Weight gain (%)	245.56±15.24 ^a	308.16±11.11 ^b	348.07±10.45 ^b
Feed conversion ratio	1.26±0.06 ^a	1.06±0.04 ^b	0.98±0.02 ^b
Survival (%)	100 ^a	96.67±3.34 ^a	100 ^a
Specific growth rate (%)	2.75±0.10 ^a	3.13±0.07 ^b	3.21±0.26 ^b

Within a row, values with different superscripts differ significantly ($p < 0.05$).

hybrids will depend largely on genetic improvement of embryonic and fry survival to the first feeding stage. Further research should be conducted to test crossings of various strains of *S. trutta fario* and *S. alpinus* and

improve hybridization success. Since no successful production of fertile gametes has ever been reported in hybrids among salmonids, implementation of selection programs in both species should also progress.

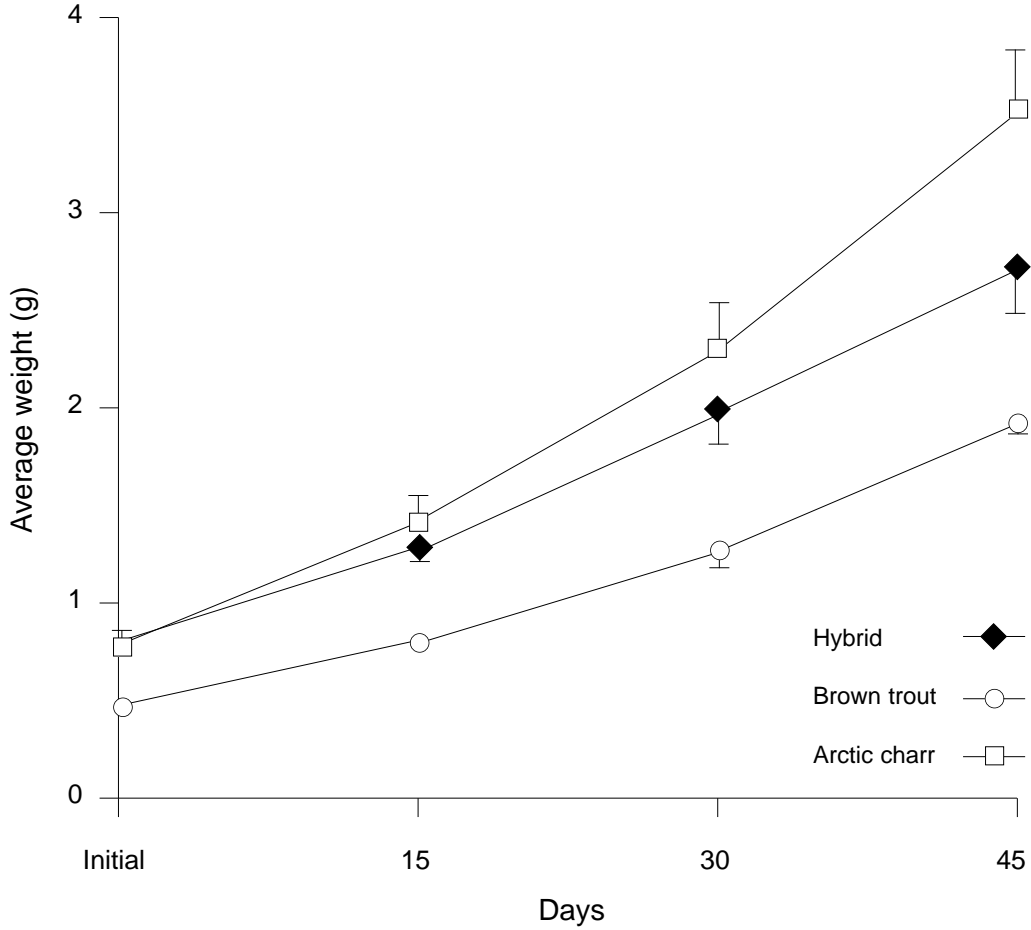


Fig. 1. Average weight (mean±SD) of two purebred trout and their hybrid (*Salmo trutta fario* ♀ x *Salvelinus alpinus* ♂) at the beginning of the first feeding stage (45 days).

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