Turk J Zool
26 (2002) 399-403

Research Note

Comparison of the Growth Performance and Mortality in Abant Trout (*Salmo trutta abanticus* Tortonese, 1954) and Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792) under Farming Conditions*

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Received: 26.03.2002

Abstract: This experiment was conducted between 15th February 2000 (day 1) and 31st January 2001 (day 350) at the DSI-Gölköy Fish Production Station, Bolu (Turkey). Abant trout larvae obtained from eggs of wild Abant trout broodstocks in Lake Abant and rainbow trout larvae obtained from eggs of the hatchery broodstocks in Gölköy Fish Production Station were used. Trials I and II involved eight groups (four Abant and rainbow trout experimental groups, and four Abant and rainbow trout parallel groups). A total of 1784 larvae was used in both the trials. At the end of the experiment, although the mean wet weight of Abant trout was found to be around 5 g, the maximum increase in weight was found in rainbow trout (between 116.202 and 173.315 g in trials I and II). Final mean condition factors (CF) differed between the Abant and the rainbow trout groups ($P < 0.001$). The specific growth rate (SGR) exhibited significant differences between trials I and II for the Abant and rainbow trout groups ($P < 0.01$) ($P < 0.05$). It is concluded that the desired level of growth performance of Abant trout was not obtained in tank conditions. In contrast, the growth and survival rate of rainbow trout were clearly better than those of Abant trout.

Key Words: Abant trout (*Salmo trutta abanticus*), Rainbow trout (*Oncorhynchus mykiss*), Growth, Mortality

Çiftlik Koşullarında Abant Alabalığı (*Salmo trutta abanticus* Tortonese, 1954) İle Gökkuşağı Alabalığı (*Oncorhynchus mykiss* Walbaum, 1792)'nın Gelişim Performansı ve Ölüm Oranlarının Karşılaştırılması

Özet: Çalışma, Bolu-DSİ Gölköy Balık Üretme İstasyonu'nda gerçekleştirilmiş ve 15 Şubat 2000 ile 31 Ocak 2001 arasında 350 gün devam etmiştir. Bu çalışmada, Abant Gölü'nden yakalanan Abant alabalığı anaçlarından sağlanan yumurtalardan çıkan larvalar ile Gölköy Balık Üretme İstasyonu'nda yetiştirilen gökkuşağı anaçlarından sağlanan yumurtalardan çıkan larvalar kullanılmıştır. I. ve II. deneme 8 grup (4 adet Abant ve gökkuşağı alabalığı deneme, 4 adet Abant ve gökkuşağı alabalığı paralel grubu) olarak düzenlenmiştir. Her 2 deneme de toplam 1784 adet larva kullanılmıştır. Deneme sonunda, Abant alabalığı ortalama yaş ağırlığı 5 gram civarında bulunmasına karşın, en yüksek ağırlık artışı gökkuşağı alabalıklarında bulunmuştur (I. ve II. deneme de 116,202 ile 173,315 gram arasında). Gökkuşağı ve Abant alabalığı grupları arasında ortalama son kondüsyon faktörü (CF) bakımından farklılığın önemli olduğu bulunmuştur ($P < 0,001$). I. ve II. denemede, türler arasında spesifik büyüme oranı farklıdır ($P < 0,01$) ($P < 0,05$). Sonuç olarak; tank yetiştirme koşullarında Abant alabalığının gelişim performansının arzu edilen seviyede olmadığı görülmüştür. Buna karşın; gökkuşağı alabalığının büyüme ve yaşama oranı Abant alabalığı büyüme ve yaşama oranından daha iyi olduğu tespit edilmiştir.

Anahtar Sözcükler: Abant alabalığı (*Salmo trutta abanticus*), Gökkuşağı alabalığı (*Oncorhynchus mykiss*), Büyüme, Ölüm

Introduction

Aquaculture is a new subject in Turkey and has displayed a tendency to increase in sea and inland waters over the last 20 years. The history of rainbow trout farming in Turkey is less than 30 years old. Rainbow trout were introduced successfully into Turkey in 1969 at the Zonguldak-Seven Lakes National Parks (1). The first rearing attempts were started in 1970. Species of the family Salmonidae are an important international resource, providing food and restocking, and are valuable in commercial and recreational fisheries. Rainbow trout are the most widely cultured species in the world. They tolerate alterations of water temperature, and have been

* Part of a doctorate thesis

transferred around the world as a highly popular fish for both sport and commercial use. Abant trout is native to Lake Abant, Turkey, and the nearest rivers and creeks, and is known to be endemic to Lake Abant, Turkey (2), being reared in natural conditions as well. Abant trout feed only on the natural food it captures. Moreover, it is very popular for sport fishing.

The most important factors controlling the growth of fish are the species, water temperature, body size, food type and access to food. Growth rate increases with increasing temperature until an optimal one, and then declines. It declines with increasing body size (3). The growth rate of Abant and rainbow trout is affected by many factors including the size and metabolic requirements of the fish, the water temperature, and the amount of food eaten by the fish. The rearing period of Abant trout is longer than that of rainbow trout, because they do not accept commercial pellet food and require special environmental conditions involving water temperature, water quality, clean water and dissolved oxygen. Although rainbow trout reaches a weight of over 200 g in 12-18 months (4), it takes Abant trout around 3 years. Because of this, commercial fish farms do not produce Abant trout. It is, however, important for restocking and as a biological gene source for Turkey. Nowadays, Abant trout populations are badly affected by natural phenomena (e.g., droughts and climate change) or human activities (e.g., overfishing, tourism, pollution and industry). Such models are essential tools for the conservation and management of populations of Abant trout such as its rearing under farming conditions. The goal of our experiment was to compare the growth performance and mortality in Abant and rainbow trout in tanks.

Materials and Methods

The experiment was conducted at the DSI-Fish Production Station, Bolu, and lasted for 350 days. It was carried out in hatchery troughs (200 x 40 x 30 cm), and circular fibreglass tanks with a rearing volume of 100 L.

Abant trout larvae obtained from eggs of wild Abant trout broodstocks in Lake Abant and rainbow trout larvae obtained from eggs of the cultured broodstocks in the hatchery were used.

Larvae of Abant trout (n = 892; initial mean live weight = 0.085 ± 0.00 and 115 ± 0.00 g, and initial mean total length = 2.05 ± 0.01 and 2.17 ± 0.01 cm) and larvae of rainbow trout (n = 892; initial mean live weight = 0.093 ± 0.00 and 0.134 ± 0.00 g and initial mean total length = 2.20 ± 0.02 and 2.48 ± 0.09 cm) were used in the experiment with parallel groups in trials I and II. Total water volumes of the hatchery trough and growing tanks were 30 l/min and 25 l/min respectively during the trials. Dissolved oxygen was measured at least weekly, while water temperature was measured twice daily. Mean daily water temperature was 11.90 ºC with a standard deviation of 2.46 (n = 350).

During the experiment, larvae were fed a commercial extruded pelleted diet, containing about 56% crude protein and 8% crude lipid. For large fish, an extruded granule diet, containing about 47% crude protein and 8% crude lipid, was used. Juveniles were fed *ad libitum* by hand, until they weighed 5 g. Large fish were fed twice a day by hand (9:00 AM and 4:00 PM). Each sample of 30 Abant and rainbow trout was randomly selected from the tank. Before weighing and measuring, all fish were fasted for about a day, and the fish handled individually were anaesthetized using MS-222. Larval fish were weighed to the nearest 0.001, and 5 g for large fish individually monthly. Moreover, total lengths of the fish were measured to the nearest 1 mm to calculate condition factors individually monthly. The fish were not fed at over 18 ºC.

The following were calculated: specific growth rates (SGR, %.day^{-1}), the formula used was SGR = 100 x ($\log_e W_f$ - $\log_e W_i$)/t, W_i and W_f are the initial and final body weights (g) and t the time in days between weighings; condition factor (CF) = $(W \cdot 100) \cdot L^{-3}$; W is fish weight (g), L is total length (cm), mortality rate (MR) = (number of dead fish at the end of the trial)/(number of initial fish) · 100. From the weight and length data obtained from each group, population mean specific growth rates, condition factors and mortality rates were calculated and compared. Means were compared using the Tarist statistical program (5).

Results

Daily temperatures ranged from 6.5 to 21 ºC (mean 11.90 ºC; SD 2.46). The maximum temperature was 21 ºC, in July, and the minimum was 6.5 ºC, in December. Dissolved oxygen (DO) concentration varied with season; minimum DO was 8.70 mg l^{-1} and the maximum water

temperature was calculated in July, and maximum DO was 10.70 mg l^{-1} and the minimum water temperature was calculated in December.

Juveniles were fed *ad libitum* until they weighed 5 g. During the study, the growth performance in rainbow trout was higher than that of Abant trout. Rainbow trout reached to 5 g in June (135 days after the beginning of the experiment), but Abant trout reached 5 g at the end of day 350.

The results of ethe xperiment are given in the Table. The initial mean live body weights in rainbow trout varied between 0.081 ± 0.00 and 0.134 ± 0.00 g in both the trials, and in Abant trout between 0.081 ± 0.00 and 0.111 ± 0.00 g. At the end of the experiment, the final mean live body weight of rainbow trout varied between 116.33 and 173.42 g, and that of Abant varied between 4.530 and 5.250 g (Table). During the present study, the weight gain of rainbow trout was higher than that of Abant trout. There was a significant difference between mean live body weight in Abant and rainbow trout ($P < 0.001$).

It is well known that SGRs are not constant but decrease with increasing body size. For Abant and rainbow trout there were significant differences in SGRs between trials I and II ($P < 0.01$), ($P < 0.05$). Although growth rates of rainbow trout in both these trials ranged between 1.87 ± 0.31 and 2.01 ± 0.003, growth rates of Abant trout ranged between 0.88 ± 0.00 and 0.97 ± 0.03. The highest growth rate of 3.87% body weight per day was registered during the 30 days that rainbow trout took to increase their mean weight from 2.34 g to 7.84 g in June in the experimental group in trial I, while the highest growth rate of 2.93% body weight per day was registered during the 30 days that Abant trout took to increase from 0.58 g to 1.47 g in June in the experimental group in trial I (Table).

Final mean CFs were 1.28 ± 0.03, 1.15 ± 0.03, 1.15 ± 0.0 3 and 1.16 ± 0.02 for the experimental and parallel groups of rainbow trout in trials I and II respectively, while final CFs in Abant trout were less than 1, indicating that Abant trout not only had the poorest growth rates but also had the worst nutritional status. Final CFs of rainbow trout were significantly higher than those of Abant trout ($P < 0.001$)(Table).

Fish mortality was found to be rather high for Abant trout throughout the experiment. At the end of day 350, the highest mortality rates varied between 71% and 59% in the Abant trout groups, while the highest mortality ranged between 39% and 19% in the rainbow trout groups.

Generally, the results of this study showed that rainbow trout showed better growth performance and survival rate than did Abant trout under farming conditions.

Discussion

Water temperature is a key factor controlling the rate of growth, i.e., it affects the metabolic rate and growth of fish. High water temperature increases energy

Table. Results of Experiment in Trial I and II.

	Trial I				Trial II			
	RAINBOW Experimental	RAINBOW Parallel	ABANT Experimental	ABANT Parallel	RAINBOW Experimental	RAINBOW Parallel	ABANT Experimental	ABANT Parallel
Number of initial larvae	236	236	236	236	210	210	210	210
Initial mean live weight (g)	0.105 ± 0.00	0.093 ± 0.00	0.081 ± 0.00	0.088 ± 0.00	0.128 ± 0.00	0.134 ± 0.00	0.100 ± 0.00	0.111 ± 0.00
Initial mean tot. length(cm)	2.48 ± 0.09	2.20 ± 0.02	2.05 ± 0.01	2.07 ± 0.01	2.27 ± 0.04	2.30 ± 0.03	2.14 ± 0.02	2.17 ± 0.02
Experiment period (day)	350	350	350	350	350	350	350	350
Final mean live weight (g)	173.42 ± 8.49	133.96 ± 9.24	4.530 ± 0.32	5.250 ± 0.34	116.33 ± 6.25	160.33 ± 9.86	4.950 ± 0.44	4.610 ± 0.31
Final mean tot. length(cm)	23.90 ± 0.36	22.30 ± 0.45	7.89 ± 0.19	8.23 ± 0.18	21.49 ± 0.30	23.66 ± 0.38	7.99 ± 0.19	7.74 ± 0.14
Spec. Growth Rate (SGR)	2.01 ± 0.35	1.95 ± 0.40	1.07 ± 0.27	1.24 ± 0.19	1.87 ± 0.31	1.95 ± 0.31	1.11 ± 0.29	1.05 ± 0.23
Final Condition Factor (CF)	1.28 ± 0.03	1.15 ± 0.03	0.88 ± 0.00	0.90 ± 0.00	1.15 ± 0.03	1.16 ± 0.02	0.91 ± 0.01	0.97 ± 0.03
Mortality Rate (%)	39	35	59	71	19	19	41	67
Total biomass (kg)	15.334	15.626	0.335	0.362	10.318	14.591	0.435	0.322

requirements. In contrast, low water temperature decreases the metabolic rate and food consumption. Each species has a water temperature range for optimum growing (6). Koskela et al. (7) stated that in brown trout (*Salmo trutta* L.) rates of feed and growth were found to increase with increasing temperature. The tolerance temperature for rainbow trout ranges from 1 to 24 ºC and the optimal temperature is 10-15 ºC for the best growth. The tolerance temperature for brown trout ranges from 0.5 to 25.5 ºC and the optimal temperature is 9-15 ºC (8,9). Edward (10) stated that for most other salmonids slightly lower temperatures are preferable. The upper lethal limit is around 24-27 ºC, but at temperatures above about 20 ºC appetite and growth are reduced, leading to attack by disease organisms. The lower lethal limit is around –0.5 ºC but little growth can be expected below 5 ºC. Although annual growth is related to water temperature, growth is faster with water temperature increasing rather than decreasing at 3.5-15 ºC (3). In our experiment, water temperatures were 6.5-21 ºC. Daily mean water temperature (11.90 ± 2.46) was suitable for the growth of rainbow and Abant trout; but the high temperature (21 ºC) calculated in July and August retarded the growth of Abant trout, and the minimum temperature was 6.5 ºC, in December. The fish were not fed at over 18 ºC. Çelikkale (11) stated that at temperatures approaching 20 ºC feeding should be carried out with care, keeping an eye on the oxygen levels and water flow. Above 21 ºC or 22 ºC feeding should stop. Stevenson (12) stated that at temperatures above 18-20 ºC the proteins constituting the enzymes begin to become inactivated, thus inhibiting the metabolism of the fish. In this trial, the fact that at temperatures above 18 ºC feeding stopped depends not only on the appetite of healthy Abant and rainbow trout but also on water temperature for 13 days in July and August. Okumuş et al. (13) stated that even food supply in sufficiently high densities creates stress, inhibits feeding and decreases resistance to disease stress due to reduced space, deteriorating water quality and social organization (dominancy of some individuals). Disagreements among the authors might be due to differences in the behaviour of salmonid species, rearing systems (tank, cage and raceway), environment (fresh water, sea water, water exchange), fish size, season and feeding regime. According to Hepher (14), the growth rate of fish is very high during the larval and juvenile stages of development; reaching 40% or more of the fry weight/day. The growth rate decreases with increasing weight, and fish of 1.0 kg usually grow less than 1% per day. At the end of our experiment, the highest growth rate of 3.87% body weight per day was registered during the 30 days that rainbow trout took to increase their mean weight from 2.34 g to 7.84 g in June in the experimental group in trial I, while that of 2.93% body weight per day was registered during the 30 days that Abant trout took to increase from 0.58 g to 1.47 g in June in the experimental group in trial I.

Goryczko (15) stated that the amount of feed consumed by fish depends, on temperature, size of the fish and food quality. As the temperature increases to the optimal level (16-18 ºC), the fish metabolism accelerates and food demands increase. The appetite of healthy trout therefore depends not only on their size, but also on water temperature. In the present study, before the live weight and total length of fishwere measured, they were starved for about a day. After handling, Abant trout did not accept food for 3 days because of handling stress (16). Rainbow trout reached 5 g in June (135 days after the beginning of the experiment), but Abant trout reached 5 g at the end of day 350. At the end of day 365, the values of total length for Abant trout (7.74 ± 0.14-8.23 ± 0.18 cm in trials I and II) (Table) in the present study are similar to the 6 cm for brown trout (*Salmo trutta*) fed natural food in nature (17), and 8.6-11.2 cm (15). The values, however, are comparable to 16-19 cm after 365 days, in February and March (18).

Rainbow trout showed good growth performance at high temperatures. Abant trout, however, did not display the desired level of growth performance at high water temperatures, i.e., increasing water temperature above 15 ºC had adverse effects on the growth performance of Abant trout. Final mean CFs were 1.28 ± 0.03, 1.15 ± 0.03, 1.15 ± 0.0 3 and 1.16 ± 0.02 for the experimental and parallel groups of rainbow trout in trials I and II respectively, while final CFs in Abant trout were less than 1, indicating that Abant trout not only had the poorest growth rates but also had the worst nutritional status (Table). An increase in CF is generally assumed to reflect an improvement in nutritional status, whereas a decline in CF may be related to malnutrition (19). In our experiment, Abant trout usually accepted commercial pellet diet at the bottom, and rarely actively fed at the surface; no uneaten pellets were found on the bottom of the tanks. This phenomenon is important for waste

removal from intensive aquaculture systems because waste matter changes the water quality. Fish and food type appear to be important factors influencing growth. The growth rates in Abant trout were lower than those in rainbow trout under farming conditions. The effects of feeding frequency upon the food intake and growth of salmonids appear to be highly dependent upon rearing conditions (20). Fish obtained from hatchery-reared Abant trout broodstocks may able to accept pellet diets above the water surface efficiently and consume sufficient food to maintain positive rates of growth and increase the condition factor.

Abant trout (*Salmo trutta abanticus*) experienced the highest mortalities during the experiment. At the end of day 350, the highest mortality rates were varied between 59% and 71% in Abant trout groups, while these were 19% and 39% in rainbow trout groups (Table). The highest mortalities were observed in May and June in Abant trout. Melting snow water may affect water quality negatively, and Abant trout is more sensitive to sudden water change than rainbow trout.

In conclusion, the present study has shown that the desired level of growth performance and survival rate of Abant trout fed commercial pellet food were not obtained in tanks. Rainbow trout, however, showed a better growth performance and survival rate than did Abant trout.

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