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Evaluating the Growth Performance of Native Stream Trout (*Salmo trutta*) in North Firat under Culture Conditions

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Abstract: In this study, stream trout (*Salmo trutta*), caught from the Northern Firat river basin in province of Erzurum were fed trout feed after a week long adaptation period. After 2 months adaptation period, they were fed commercial trout feed regularly for 3 month trial period. Individually tagged fish were categorized as small (20-50 g), medium (50-100 g) and big size (100-400 g). Growth performances of groups were compared according to this classification. The trial lasted end of the 3 months (91 days). The trial concluded that the group classified as big size had the highest specific growth rate with 0.31±0.210%. Groups classified as medium (0.10±0.170) and small size (0.19±0.180) had the lowest specific growth rate. The difference in specific growth rate was statistically significant ($p<0.05$) and in favor of the big size group. As a result, adaptation studies conducted on the culture of these types of trout conclude that fish weighing >100 g should be cultured as breeding candidate as they have better adaptation capacity under culture conditions.

Key words: Stream trout (*Salmo trutta*), individual tagging, growth performance, brood adaptation, breeding Turkey

INTRODUCTION

The nutrition problem, caused by the rapid population increase has made utilizing natural resources maximally mandatory. As a result, every country feels obliged to utilize their natural resources, protect and increase the food supply of these natural resources. Fresh waters are one of the most important natural resources that can be used in producing food supply. Developed countries started conducting studies to culture economically valuable fish species many years ago, after identifying the biological and ecological characteristics of fresh water fish. The increased demand for cultured fish has forced fishing businesses into fish farming and increased the importance of aquaculture (Turan, 2003).

The purpose of aquaculture is to produce a certain species in a rapid, economic and appealing fashion. Brown trout is considered good material for aquaculture. In the future the food quality of cultured species will be an important criterion that influences the choice of consumers (Pigott and Tucker, 1990).

In comparison to rainbow trout and other salmonoids, information available in literature about culture performance of brown trout (*Salmo trutta*) is significantly inadequate. The majority of studies conducted regarding natural trout species are systematic studies; the number of studies regarding bio-ecological and growth properties are next to none (Lelek, 1988; Imamoglu, 1996; Arslan, 2003; Turan *et al*., 2009). However, in recent years, there are some studies on the subject of cultivating natural trout species that stand out (Tatar, 1983; Tabak *et al*., 2001; Uysal and Alpbaz, 2003; Bascinar *et al*., 2007; Kocabas, 2009; Karabulut and Yandi, 2010). Tatar (1983) investigated the breeding possibilities of producing juvenile Munzur trout, becoming extinct due to uncontrolled fishing in Anatolia under culture conditions. Serious studies have been conducted to culture Black sea trout (*Salmo trutta labrax*) by the Trabzon Central Research Institute of Aquaculture a Ministry of Agriculture institute (Tabak *et al*., 2001).

Kocabas (2009) investigated the breeding and reproduction efficiency properties, growth performances under culture conditions and certain phenotypic properties of stream trout (*Salmo trutta*) ecotypes an ever-spreading species in the Turkey. Another study reports data regarding the adaptation of stream trout (*Salmo trutta*) belonging to population in the Northern Firat, to a culture environment (Karabulut and Yandi, 2010).

Stream trout are prone to uncontrolled fishing because they are the most favored species for sporting purposes of in land waters due to their meat quality and appeal. In recent years, the effects of erosion that have increased due to hydroelectric power plants and stream improvement works, sand-gravel mining, agricultural pest control, domestic and industrial waste disposal and

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destruction of forestlands have caused an increase in water pollution, resulting in a decrease in the number of valuable trout species living in inland waters and extinction of valuable trout species living in inland waters (Kurtoglu, 2002; Kocabas, 2009). As a result now a days, culturing endangered natural trout under intensive conditions is extremely important. If stocks are not too exhausted, stocks can be increased in natural waters by implementing preventative measures. However if the total amount of fish left in the water source are inadequate for stock rehabilitation, their numbers can be increased by breeding them under culture conditions and releasing back into the wild (Tabak *et al.*, 2001).

Under these circumstances stocks should be supported by producing cultured fry and reproduction properties and culturing these species should be researched. In general, small fish are caught during the fishing process of studies conducted to increase stock. The called as small fish come with numerous issues such as slow growth during their adaptation to culture conditions and the poor level of feed conversion ratio (Karabulut and Yandi, 2010). Besides being a waste of labor and time this situation puts a strain on natural stocks for no good reason by catching small trout on the verge of extinction. The purpose of culture studies is to select brood fish by choosing brood fish from those that have a higher growth performance under culture conditions and identifying their reproduction efficiency properties. Observing fish individually is easier when fish are labeled during the process of choosing brood fish; ultimately this helps to determine hatching and reproduction efficiency.

A tag is something that is placed on or inside an animal's skin to help identify the animal. Tagging has been intensively used for many years in estimating population size, determining survival rates, measuring population parameters, determining unit stock, exploitation rate, movement and migration, determining the growth and age, conducting behavior research and measuring physiological parameters of fish by individual identification (Jones, 1979; Akyol and Ceyhan, 2003).

The purpose of this study was to choose and assess brood fish that display good adaptation and growth performance by catching trout in their natural habitat, separating them into groups under culture conditions and tagging them individually.

MATERIALS AND METHODS

The adaptation and culture study was conducted at Rize University, Faculty of Aquaculture, Iyidere Aquaculture Production, Education and Research Unit

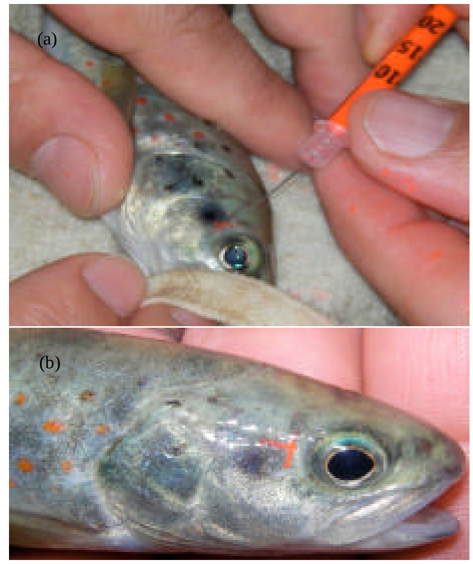

Fig. 1: a) individually tagging the brood fish candidate with the Visible Implant Elastomer tag; b) the tagged fish

(Turkey). For the experiments we caught 76 stream trout (*Salmo trutta*) from Rizekent stream within the borders of Ilica district (40°9'48.16"N, 40°59'43.90"E) of Erzurum (The basin of Upper Firat river) in November 2009. The trout were caught by using a 220 V and a 650 W electro shock device. The fish were marked individually once they were adapted to the tank environment. Elastomer tag were injected into the skin of the fish with different shapes (Fig. 1).

Fish, individually tagged with a Visible Implant Elastomer, were placed into 1.1×1.1×0.6 m fiberglass tanks. The temperature of the water and the level of oxygen in the tank was measured daily throughout the trial. We estimate that average water temperature over the experimental period was 11°C. There is a ±1°C variation due to seasonal changes but in general day time water temperature was fairly constant over the experimental period and dissolved oxygen content of incoming water was the highest (over 10.9 mg L^{-1}) in winter but dropped to a minimum value of 9.2 mg L^{-1} in April. Fish were given daily feed which is 2% (Celikkale, 2002) of their daily live weight, taking into consideration water temperature and feed tables, twice a day (09:00-17:00), everyday for the duration of 91 days. A time-controlled fully automatic feeder (Eheim, Germany) was used for feeding and stress caused by hand-feeding was not allowed. Fish were fed a commercial extruder trout feed containing 46% crude protein and 20% crude fat.

Fish were anaesthetized with benzocaine (30 mg L^{-1}) and taken weights and lengths individually every 14 days throughout the trial period. A 0.01 g accurate scale was used to measure live weight of the fish and a ruler was used to measure their length after their water and secretion was dried with a clean dry cloth. The equations stated were used to calculate the weight gain, specific growth rate and the condition factor for he each three groups.

$$\text{Weight gain (g)} = \text{Final weight (g)} - \text{Initial weight (g)}$$
(Steffens, 1989)

$$\text{Specific growth rate (\%)} = \frac{\text{In final weight (g)} - \text{In initial weight (g)}}{\text{Feeding period (Day)}} \times 100, \text{ (Fowler, 1991)}$$

$$\text{Condition factor (\%)} = \frac{\text{(W) Weight (g)}}{\text{(L3) Total length (cm)}} \times 100, \text{ (Avsar, 2005)}$$

A SigmaPlot (SigmaPlot 11.0, Systat Software Inc., and San Jose, CA, USA) program was used to conduct data analysis and draw graphs. Kolmogorov-Smirnov and Shapiro-Wilke tests were used to conduct intra group normality tests. ANOVA was used to conduct inter group variance tests. The one-way-ANOVA Tukey test was used to determine the difference between groups with normal distribution and co-variance the non-parametric ANOVA (Kruskal Wallis test) test was used to determine the difference between groups without normal distribution and co-variance. The significance level for all data sets was $p<0.05$.

RESULTS AND DISCUSSION

The fish, caught in their natural habitat were put in an adaptation environment in research unit. After a 1 week adaptation period without feeding, the fish were fed different feed types (Dried tubifex, granule foie gras, semi wet feed (Anchovy+commercial feed), extruder commercial feed). Wild fish newly caught from river does not take commercial feed immediately. It takes some time for fish to get accustomed to taking commercial feed. While some of the fish started taking commercial feed in first 45 days, all of them started taking commercial feed after 2 months (60 days). After all fish started taking commercial feed, the study started on 08 January 2010 and ended on 07 April 2011 daily measurements and weighing were conducted during seven periods throughout the 3 months (One period is 14-15 days including the first measurement on the 1st day and six measurements over the 3 months it is total seven measurements). At the end of the study the individually tagged fish were categorized under three groups; 20-50 g (Small size), 50-100 g (Medium size) and 100-400 g (Big size). Growth and the condition factor were

Table 1: Data obtained in the study

	Groups		
Parameters evaluated	Small size 20-50 g	Medium size 50-100 g	Big size 100-400 g
Initial length (cm)	16.31±1.250	19.94±1.590	28.50±3.6600
Final length (cm)	19.33±1.770	23.48±1.200	34.43±5.2800
Initial weight (g)	38.57±10.61	69.60±18.67	220.00±76.540
Final weight (g)	46.43±8.180	76.20±19.61	289.66±107.03
Weight gain per period (g)	0.66±1.210[a]	1.10±1.900[ab]	11.30±8.1000[c]
Specific growth rate (%)	0.19±0.180[a]	0.10±0.170[a]	0.31±0.2100[b]
Condition factor (%)	0.700±0.09[a]	0.798±0.09[ab]	0.879±0.140[b]

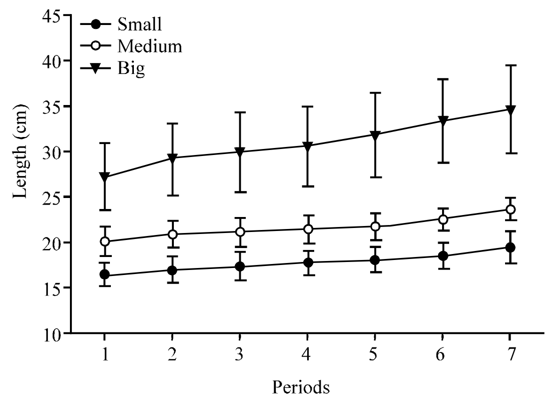

Fig. 2: The average change in length for the small, medium and big size groups during the trial

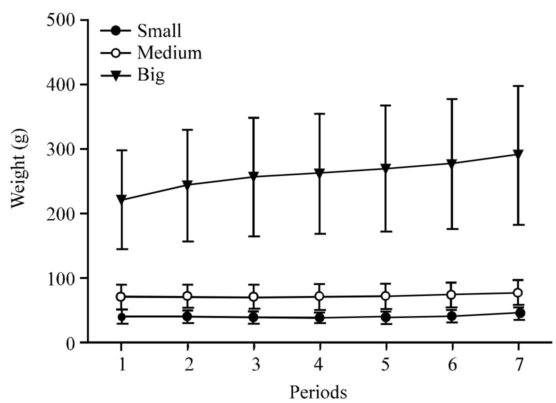

Fig. 3: The average change in weight change for the small, medium and big size groups during the trial

analyzed according to groups. Variance analysis was conducted on all results and they were exposed to a test with a probability level of $p<0.01$ and $p<0.05$ according to results obtained from the study. Table 1 shows the obtained results.

Trial results concluded that the tagged fish in the small size group had the shortest length (19.33±1.77 cm) and the lowest weight (46.43±8.18 g) the big size group had the highest increase in length (34.43±5.28 cm) and the highest weight gain (289.66±107.03 g) (Fig. 2 and 3).

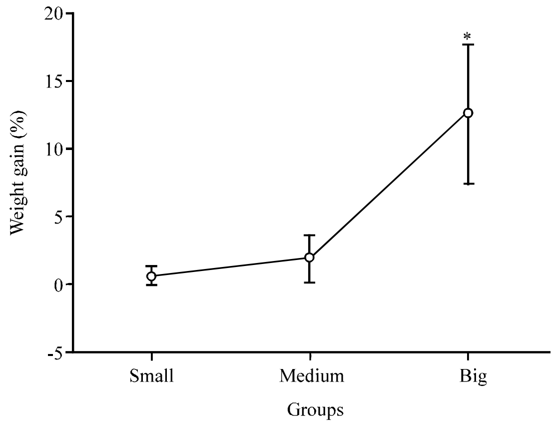

Fig. 4: The difference in weight gain per period between the test groups according to the Kruskal-Wallis test (*$p<0.05$)

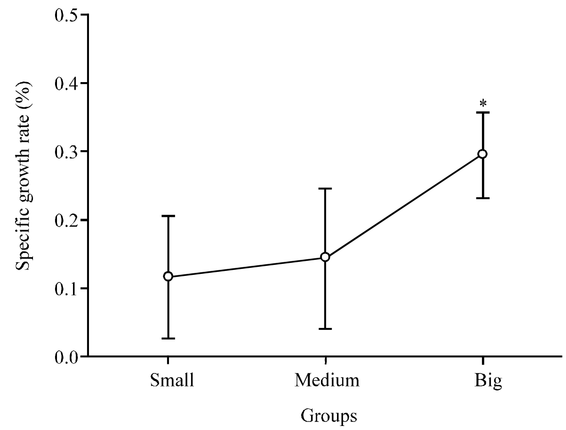

Fig. 5: One-way ANOVA Tukey test results between groups based on measurements recorded during the study (*$p<0.05$)

Not many studies or results are available regarding culture of trout species in rivers of Turkey as they have only recently started being cultured. In general, studies to culture natural trout focus on Black sea trout (*Salmo trutta labrax*), Abant trout (*Salmo trutta abanticus*), stream trout (*Salmo trutta fario*) and Brook trout (*Salvelinus fontinalis*). Kurtoglu (2002) reported that Black sea trout grew from an average of 11-15.8±2.79 cm in sea water and from an average of 11-16.1±2.05 cm in fresh water in terms of weight, the Black sea trout reached a weight of 36.2±17.57 g from its initial weight of 11.6 g in sea water and a weight of 40.1±17.33 g in fresh water. According to the absolute growth in weight in Kurtoglu's study, the increase for fish in sea water was 24.6 and 28.4 g for those in fresh water. The increases recorded in this study (Table 1) were 7.86 g for the small size group, 6.6 g for the medium size group and 69.7 g for the big size group. In comparison to the study conducted on Black sea trout, the absolute growth was lower for the first two groups in this study and higher for the last group.

Upon completion of the study, the weight gain was compared between groups; the big size tagged group had the highest weight gain per period with 11.30±8.10 g and the small size group had the lowest weight gain with 0.66±1.21 g. The difference between groups was significant according to Kruskal-Wallis results ($p<0.05$) (Fig. 4). The best indicator of growth in intensive breeding of fish is the specific growth rate. The specific growth rate is the percentage fish grow on a daily basis. Study results concluded that the big size group had the highest specific growth rate with 0.31±0.21 while the small size group (0.19±0.18) and the medium size group (0.10±0.17) had the lowest values. Covariance was identified between groups using variance analysis. Groups displayed normal distribution ($p<0.05$). The one-way ANOVA Tukey test was conducted between groups (Fig. 5).

Galbreath and Torgaard (1997) investigated the sea water performances of triploid Atlantic salmon and brown trout hybrids; they concluded that the specific growth rate for the diploid group was 0.42 and 0.41 for the triploid group. Kocabas (2009) concluded (at the end of day 228) that the specific growth rate for natural trout (*Salmo trutta*) ecotypes in Turkey changed on the average between 0.43 and 0.62.

The results obtained by Galbreath and Torgaard (1997) and Kocabas (2009) differ from those of this study. In their study, conducted on the growth of Black sea trout, Bascinar *et al.* (2007) concluded that specific growth rates changed between 0.14 and 0.40 from the start of the study to the end. They also concluded that the group fed on average, 3 times a day had the highest specific growth rate (On average 0.36%). Results obtained by researchers are similar to that of this study.

Throughout the trial, the condition factor was 0.700±0.09 for the small size group and 0.879±0.14 for the big size group. There was a statistically significant difference between the condition factor of the small size group and that of the big size group ($p<0.05$) (Fig. 6). While the best condition factor was between 0.87 and 1.24 for the big size group at the start of the study, the best condition factor for the same group at the end of the study was between 0.67 and 0.90. The reason behind the decrease in their condition may be the fact that the fish, caught in their natural habitat have yet to adapt to their culture environment are not taking feed and are suffering from stress caused by the tagging process (All of which are reasons that cause weight loss).

Karabulut and Yandi (2010) conducted a study in which they tried to make Northern Firat originated trout adapt to culture conditions; they concluded that the condition factor that was 1.08 at the start of the study

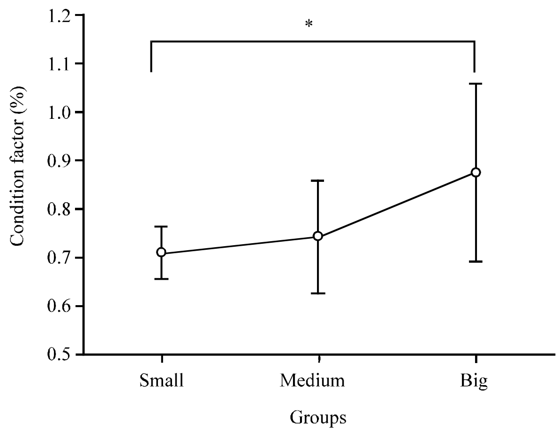

Fig. 6: The condition factor of experimental groups (*$p<0.05$)

decreased to 0.89 as a result of weight loss caused by not taking feed, stripping, stress and illnesses and that it increased to 1.00 after the fish adapted to the environment and started eating. Their trial results regarding the condition factor are higher than those of this study; the reason being that they recorded measurements on a monthly basis and the adaptation period was 9 months.

Heinimaa *et al.* (1998) assessed natural brown trout in three different types of fresh water. They reported that the condition factor changed between 0.64 and 0.69. The results of the study were lower than those of this study. Landergren (1999) reported that the condition factor of brood *Salmo trutta* from the wild was 1.16±0.15. Tabak *et al.* (2001) reported that broodstock candidates of Black sea trout had a condition factor of 1.02±0.01 after 15 months.

Kocabas (2009) reported that the condition factor of *Salmo trutta* ecotypes changed between 0.94 and 1.13 during growth trial conducted in fresh water environment in conclusion of investigating the growth performance of natural trout (*Salmo trutta*) ecotypes under culture conditions in Turkey. Condition factor results of the stated studies differ from those obtained in this study as they are higher. The condition of fish change in accordance with some factors like the size of the fish, the time they were caught, their reproduction period, the season and the contagiousness of their bacterial, parasitary or fungal disease (Welcomme, 2001).

CONCLUSION

Culturing and having economical expectations regarding *Salmo trutta* is extremely new in the country. There are two ways to culture fish; the first is to catch them in their natural habitat and place them under culture conditions till they reach their breeding age and the second is to determine their reproduction period and obtain fertilized eggs from the broodstock fish in their natural habitat.

Another alternative is to catch candidate fish near their breeding weight, strip and fertilize them under culture conditions as a result, stocks of endangered trout are not pushed by catching different small, medium and big size fish randomly from their natural habitat, labor and time is not wasted. In fact, stripping in natural habitats preserves the quality and prevents loss of eggs brought from incubation units.

Fish caught in natural habitat were included in this study. Results are data belonging to natural and wild fish. Data belonging to the aquaculture of species will be obtained by new generations of fish obtained from their eggs under culture conditions. This data enables them to be compared to Rainbow trout, other Pasific salmon, Atlantic salmon, Brook salmon and Alp trout as stated in literature (Comparing data from wild fish and cultured fish does not make sense). Assessment of the performance of new generations, obtained from wild fish will determine their culture potential.

Although, production and release works are proposed in order to restore corrupted natural ecosystems, there should also be some additional protection measures to accelerate the recovery of stocks when the positive arrangements in spawning, feeding and migration areas are considered.

For reinforcement of the corrupted stocks, female and male brood stock numbers belonging to the target water source should be taken into consideration in hatchery works aiming intensive production in order to not give rise to genetic contraction. It is important to create long term healthy stock despite changing environmental conditions of species belonging to the target water source. Researchers should be careful about not doing more harm than good when interfering with nature.

In this study, a preliminary investigation was performed to determine how much the fish, to be caught in their natural environment, should weight in selecting the breeding candidate. It was concluded that when bigger (100-400 g) members of this trout species were taken from their natural habitat, they adapted better and grew more under culture conditions. Fish of this size also have the capacity to participate in the production cycle quicker. This prevents small members from being taken from their natural habitat and placed at risk for the purpose of uncertain production.

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