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Research Article

Egg and Larval Growth Performance of Brown Trout (*Salmo trutta sp.*) in Commercial Farm Conditions

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ABSTRACT

The aim of this study is to determine the egg and larval growth performance of brown trout (*Salmo trutta sp.*) at a constant high water temperature under commercial farm conditions. Eggs were taken from 450 female broodstocks with an average weight of 5.09±0.29 kg. The eggs placed in the incubators were observed on the 14th day and kept at a constant temperature of 12.5°C. Then larvae began to hatch on the 29th day and all the eggs were fully hatched by the 31st day. The incubation period was determined as 350 days /°C. In the study, an average survival rate was determined as 21.07%±5.16% until the end of the larval stage. A significant relationship was found between the rate of eggs that hatched and the survival rate after the larval period had ended ($p<0.05$). After 120 days of larval feeding, larvae weighing 0.15 g reached 9.26±1.13 g. During this period, the feed conversion rate (FCR) and specific growth rate (SGR) values were determined as 1.21±0.09 and 1.23±0.72 respectively.

Keywords: *Salmo trutta sp.*, egg, larvae, growth

INTRODUCTION

The *Salmonidae* family has many species of commercial, cultural and environmental value. According to the International Union for Conservation of Nature - Red List of Threatened Species, thirteen species in the family are listed as "endangered", "critically endangered" or "vulnerable" (IUCN 2020). Overfishing, water pollution and wrong water management policies are the main reasons for the decreasing natural populations of the fish. Aquaculture is one of the most widely used methods to increase natural populations after endangered species have adapted to culture conditions (Cabrita et al. 2009).

Salmo trutta sp., also known as Brown (*Salmo trutta sp.* Dumeril, 1858), Mediterranean or Anatolian trout, were studied and recorded at many locations throughout a wide area of Turkiye (Kocaman et al. 2004). Hesthagen & Johnsen (1989) observed that the effects of larvae stocking time in habitats on growth rates were negligible. For this reason, breeding these species in culture conditions will increase the survival rate of larvae.

Freshwater fish species may be even more vulnerable to global climate change as they have limited dispersal abilities within the hydrographic networks in which they currently live. In this context, an important scientific issue is to predict how fish populations will cope with future temperature changes in their natural habitats (Buisson et al. 2008, 2009). Environmental temperature is an important abiotic factor affecting physiological functions in aquatic vertebrates, and many aspects of fish embryonic development are strongly affected by temperature (Mueller et al. 2011). As the temperature increases, embryonic development also increases (Mueller et al. 2015).

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Some information about the embryonic development and larval rearing of different trout species has been provided to date (Grande & Andersen, 1990; Killeen et al. 1999; Halacka, 1995; Bascinar & Okumus, 2004), but this information seems to be limited in the case of brown trout. Moreover, it is seen that the information about the relationship between water temperature, egg hatching and larval development is mostly limited to the information related to fish in the natural environment (Réalis-Doyelle et al. 2016, 2018).

The aim of this study is to provide information on brown trout in terms of egg hatching, survival rate and larval growth performance in a commercial farm environment and to increase the production success based on these new results.

MATERIALS and METHODS

Broodstock stocking and feeding

Brown trout broodstocks used in the experiment, which are expected to be fed up to an average live weight of 5.09 0.29 kg, were first taken into the maturation process in the commercial net cage farm which is located in Keban Dam Lake. Fish were placed in net cages and the volume was kept as 5 kg/cubic meter. The water temperature in which the broodstock was located was 12.5 ± 0.5 °C. Fish were fed twice a day at 2% of their average body weight with feed purchased from a commercial fish feed factory, with nutrient contents given in Table 1. After the maturation period of about 3 months, a total of 500 broodstocks were selected randomly and transferred to the hatchery of the farm. Eggs were taken from 450 female broodstocks with an average weight of 5.09 ± 0.29 kg. The fish were fed at 1% of their average weight for one month, gonad development and egg maturation were continuously controlled and feeding was stopped two days before spawning. The fish, whose eggs were determined to be mature, were gradually spawned within 15 days.

Table 1. Proximate composition of the experimental diet (% dry matter) for trout.

Essential Nutrient	Commercial Feed I (350-500 µ)	Commercial Feed II (800µ - 1 mm)
Dry Matter (max)	88	88
Crude Protein (% - Least)	50	44
Crude Cellulose (% - Most)	1.3	2.5
Crude Ash (% - Most)	12	12
Crude Fat (% - Least)	15	18
Digestible energy (kcal/kg)	4360	4000
Vitamins		
Vit. B_2 (mg / kg)	25	25
Pantothenic acid (mg / kg)	20	20
Vit. B_1 (mg / kg)	10	10
Vit. B_{12} (mg / kg)	0.02	0.02
Niacin (mg / kg)	200	200
Biotin (mg / kg)	0.5	0.5
Folic acid (mg / kg)	5	5
Colin (mg / kg)	1.500	1.000
Vit. A (IU / kg)	12.500	12.500
Vit. E (IU / kg)	250	250
Vit. D3 (IU / kg)	2.500	2.500
Vit. C (mg / kg)	250	200
Vit. K_3 (mg / kg)	5	5

Incubation, Hatching and Larval Feeding

Sperm and eggs were obtained from brown trout provided by the Keban Trout Co. Inc. which is located in Keban Dam Lake, Elazig-Turkiye. Prior to milt extraction, males were anesthetized using 0.2 g/l MS-222. Milt was obtained by abdominal massage and collected from the urogenital papilla using a jug, taking special care to avoid urine and faeces contamination. Females were anesthetized with the same method and eggs were obtained by stripping (female male ratio 1:2). The eggs were stocked with 5000 pieces in each incubator. A total of 4,244,400 eggs were used throughout the study. No manipulation was applied to the eggs that were expected to pass to the observation stage, only 150 ml of formaldehyde was applied to each incubator twice a day to prevent fungal growth. Dead eggs were counted daily and removed from the incubators. The larvae with yolk sac were transferred into 3x1x0.5 m larvae tanks. The first feeding was made with the starter feeds in the form of powder and the content of which is given in Table 2 and given to the fish just before the consumption of the yolk sac. The live weight development of the larvae was measured with a 0.001 g precision digital electronic balance (made by Mettler Toledo), and 100 larvae were randomly selected from each experimental group for this measurement.

Table 2. Nutritional composition of starter feed.

Brut Energy	4.900 max.
Fat	12
Protein	48
Digestible energy	4.360
DP/DE (mg/kj)	29.50

Water quality parameters were measured between 7:00 am and 8:00 am on each sampling day. Water temperature, dissolved oxygen and pH were measured and recorded daily with YSI multi-parametric instrument.

The study was carried out for four months under commercial production conditions. The larvae were fed 8 times a day with extruded trout larvae feed which was produced by Camli Fish Feed Company, Izmir Turkiye. The nutrient content of the feed was "48% crude protein, 12% crude fat, and 1.5% crude fiber and 4360 kcal/kg digestible energy".

Growth performance indicators were calculated using the following formulae according to (Ricker, 1975):

Specific growth rate (SGR,%day-1)= ln (final weight in grams) – ln (initial weight in grams) x100) / t (in days).

Mean daily weight gain (MDWG) = 100 x [(Total final weight – Total initial weight)/Days of experiment]

Survival (%) = 100 x (Total number of harvested fish / Total number of initial stock)

Statistical analysis

The mean and standard deviation values were calculated using Microsoft Excel 2020 version. For the statistical analysis, data from the replicates of each group were pooled for one-way ANOVA analysis and differences at the 5% level were considered significant.

RESULTS AND DISCUSSION

The eggs of Salmo trutta sp. were incubated at 13 ± 0.3 ° C; dissolved oxygen 7 ± 0.8 mg/lt O_2 and pH between 7 ± 0.5 were measured.

This study on the larval growth of brown trout consisted of 2 stages. First, the broodstock were fed for a total of 7 months. 450 female and 226 male broodstocks were used in the study and a total of 400,000 g eggs were obtained from 2280 kg female broodstocks. The eggs placed in the incubators were observed on the 14th day at a constant temperature of 12.5 °C and the larvae began to hatch on the 29th day and all the eggs were fully hatched by the 31st day. The incubation period was determined as 350 days / °C. The weight of the eggs obtained from spawning was measured as 0.095 ± 0.005g. The average weight of female broodstocks throughout the experiment, unfertilized eggs, losses in incubators during the larval period were also calculated and noted (Table 3).

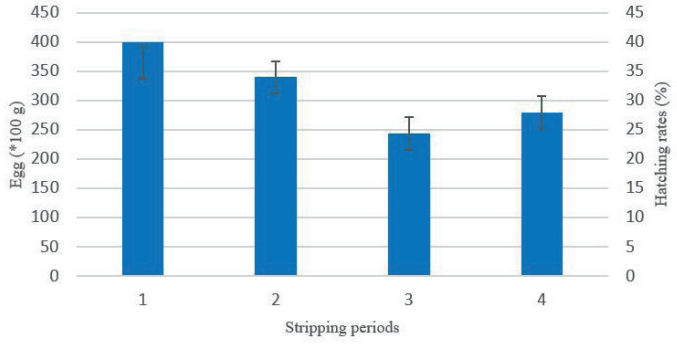

Figure 1. Number of brown trout egg according to spawning period and hatchery success.

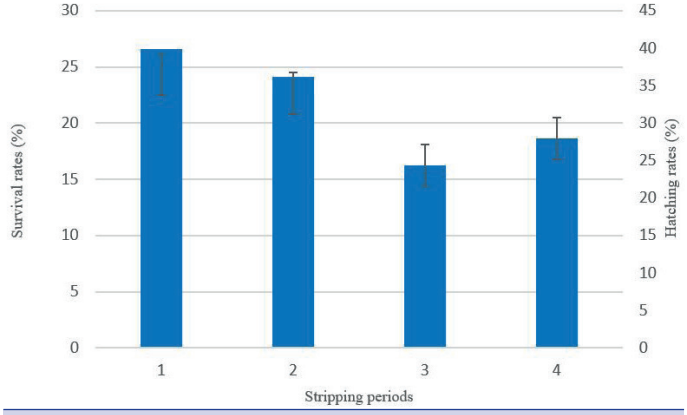

Figure 2. Comparison of hatching rate (%) and larval survival rate (%).

According to the data obtained, the average hatching success was determined as 30.7 ± 5.52% in a study carried out at constant temperature in a commercial enterprise (figure 1).

Figure 1. Figure 1. Number of brown trout egg according to spawning period and hatchery success

During this period, feeding was done 8 times a day until the larvae were satiated. During the experiment, a total of 4,244,400 eggs and 856,280 fish were obtained with an average survival rate of 21.07% ± 5.16% until the end of the larval stage. A significant relationship was found between the rate at which eggs hatched and the survival rate after the larval period ($p<0.05$). (Figure 2). Larval feeding was studied over a period of four months. The mean FCR and SGR values during the study were 1.21 ± 0.09 and 1.23 ± 0.72, respectively. The variation of these values according to the months is given in Figure 3.

From the 12th day following their hatching, the fish were first fed with larvae starter feed with a size of 300 microns. In direct proportion to the size of the fish, 500 and 800 micron sized powder feeds were used. The content of the feed used had 48% crude protein and 12% crude fat content. Larvae weighing 0.15 g were fed in the larvae tanks for 3 months and reached a weight of 3.7 g at the end of the feeding. During this period, fish weighing about 3.7 g were fed in concrete ponds (fry rearing ponds) for one month. At the end, the mean fish weight was determined as 9.26±1.13 g.

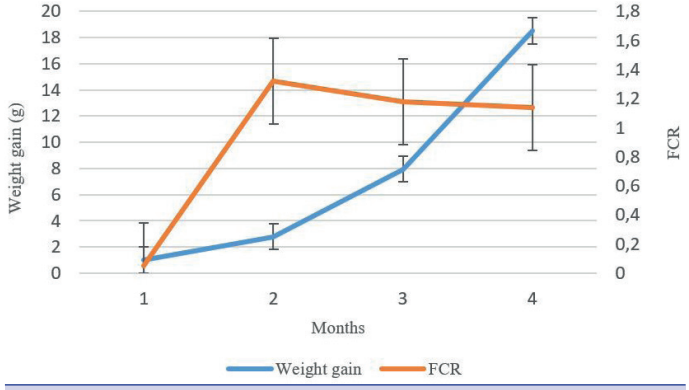

Figure 3. *Salmo trutta sp.* larva feeding on a monthly basis FCR -Weight gain.

Table 3. Number of eggs and hatchery success of brown trout.

Spawning	Number of spawned female broodstock	Obtained number of eggs	Harvesting losses (%)	Number of live eggs	Incubation losses (%)	Hatchery success (%)
1	50	40.000	38.2	24.720	41	36.46
2	150	135.000	37	85.050	46	34.02
3	150	140.000	39	85.400	60	24.40
4	100	85.000	36.5	53.975	56	27.94

This study reveals the egg hatching rate and larval survival rate of brown trout in a commercial farm at 12.5 ± 0.5 °C. These results allow us to gain insight into the larval growth performance of brown trout at constant water temperature in the commercial setting Bascinar and Okumus (2004) reported that factors such as genetic status and broodstock pond water temperature are among the factors controlling the duration of the early developmental stages of fish embryos and larvae. The degree-day value in embryonic development is lower in cold water than in hot water (Grande and Andersen, 1990; Bascinar and Okumus, 2004). The first eye pigmentation time of various trout species is 30-33 days at degree-day for Salmo trutta (Killeen et al., 1999), 220 days at degree-day (Gjerdem and Gunnes, 1978), 195 days at degrees (Grande and Andersen, 1990), and 245 days for *Salvelinus fontinalis*. Alp et al., (2010) observed that Brown trout eggs were incubated at 7.23°C for 244 degree-day (35 days) and at 387 days (56 days), whereas at 8.21°C they were observed for 261 degree-day (31 days). The authors also reported that they hatched at 413 degree-day (50 days). In addition, the effect of temperature on the hatching time of brown trout was investigated in different geographical regions (Spain, [Ojanguren and Braña, 2003], Austria, [Lahnsteiner, 2012], the United States [Embody, 1934], the United Kingdom and [Wood, 1931] The consensus of these researchers revealed a negative curvilinear relationship between egg hatching time and temperature, especially at water temperatures of 6°C, 8°C and 10°C.

In this study, Brown trout eggs reached the eye stage at 12.5°C on the 14th day and all the eggs were hatched by the 31st day. Compared to previous studies, the result of this study shows that the eye period and opening of brown trout eggs is much more advanced. It can be said that this difference is due to the high water temperature.

Doyelle et al., (2016), in their study with Brown trout, found the larval survival rate at low water temperature (6-8°C) to be 75%, and similar results were also revealed in the study by Lahnsteiner, 2012. In this study, the larval survival rate was approximately 30%. This difference was caused by the higher incubation temperature and higher stocking rates in the commercial fish farm environment than in the experimental conditions.

CONCLUSION

This study is probably one of the first studies on egg production, hatching and larval survival of commercial brown trout at a constant high hatchery temperature. After incubation, larval feeding for 90 days followed by 30 days of fry feeding was carried out commercially for this species. In the study, the highest live weight gain was determined in the period when the fish were kept in concrete ponds. In the light of the biological data obtained from this study, it is seen that the production success of brown trout under culture conditions changes depending on hatching temperature and larval feeding regime. More detailed research is needed in suitable habitats for rootstock supply, larval breeding and breeding for the protection of natural stocks.

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Ethics committee approval: No need for the ethical committee approval.

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