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ISSN 0792 - 156X

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

Reproductive Performance of Wild and Hatchery-Reared Black Sea Salmon

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(Received 28.3.07, Accepted 12.4.07)

Key words: Black Sea salmon, *Salmo trutta labrax*, fertilization, fecundity, egg diameter

Abstract

Spawning period, total fecundity, egg size, and fertilization and hatching rates of wild and hatchery-reared Black Sea salmon (*Salmo trutta labrax* Pallas, 1811) were investigated. Wild broodstock consisted of 15 females (4-5 years old) with a mean weight of 1773.2±1014.4 g. Hatchery-reared broodstock consisted of 28 females (3 years old) with a mean weight of 869.5±319.6 g. The spawning period lasted from mid-November to the beginning of January. Mean total fecundity was 3524.6±2106.9 and 1931.3±915 eggs/female for wild and hatchery-reared broodstock, respectively, and mean egg diameters were 5.2±0.20 and 5.0±0.24 mm. Fertilization and hatching rates were 98.4±1.71% and 88.1±8.78% for wild broodstock and 97.9±1.84% and 83.1±15.77% for hatchery-reared. The reproductive parameters of wild and hatchery-reared Black Sea salmon in northeastern Turkey were similar to those of other salmonid species.

Introduction

Aquaculturists are seeking new species for culture, particularly species with high market prices. The Black Sea salmon, *Salmo trutta labrax*, is receiving much attention as a candidate for aquaculture development in the Black Sea region of Turkey (Celikkale et al., 1999).

The Black Sea salmon, also called the Black Sea trout, is a subspecies of the European trout, *Salmo trutta* (Dorofeeva, 1967). It tends to develop populations with both migratory and permanent freshwater fractions. Black Sea salmon appears to have a high degree of analogy with sea trout and brown trout in northwestern Europe and Scandinavia. It occurs in most rivers that flow into the Black and Azov Seas (Celikkale et al., 1999; Solomon, 2000). Some populations are totally non-migratory and identified as *S. trutta fario*. This may have developed naturally, especially where obstacles or other conditions

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in the lower river make migration difficult or disadvantageous. Where they occur, Black Sea salmon represent a migratory fraction (marine ecotype) of the overall river trout population (Slastenenko, 1955; Solomon, 2000).

Aquaculture of Black Sea salmon is developing in Turkey. In the present study, we discuss reproductive parameters of wild and hatchery-reared broodstock of the Black Sea salmon.

Materials and Methods

Data were collected from the Central Fisheries Research Institute Freshwater Hatchery in Trabzon, Turkey, during the 2002-2003 breeding season. Wild broodstock were captured from the Storm River (41º13'N, 40º58'E) in Rize, Turkey, from April to the end of June 1999. Hatchery-reared broodstock were raised from eggs that hatched in November 2000.

Wild broodstock (4-5 years old) consisted of 15 mature females (mean wt 1773.2± 1014.4 g; range 884-3639 g) and seven males (mean wt 1246.0±145.4 g; range 593-3428 g). Hatchery-reared broodstock (3 years old) consisted of 28 mature females (mean wt 869.5±319.6 g; range 340-1812 g) and 11 males (mean wt 849.3±17.4 g; range 514-1118 g). The broodstocks were randomly divided into rectangular fiberglass tanks (2 x 2 x 1.2 m) at a maximum density of 5-6 kg/m^3 and fed a 4-6 mm commercial fishmeal-based extruded diet containing approximately 45% crude protein and 7% crude lipid. Fish were hand-fed to satiation twice daily during natural daylight hours and considered satiated when they began to ignore the feed. Water temperature was measured three times a day with a mercury thermometer.

Females were checked by hand weekly during the spawning season to determine their stage of gonadal maturation. Ripe females were anesthetized with a 50 mg/l solution of tricaine methanesulfate (MS-222) and their eggs were stripped. Females were weighed before and after stripping.

Fecundity was determined using the gravimetric method (MacGregor, 1957) and calculated in terms of total (number of eggs per female) and relative (number of eggs/kg body weight) fecundity. Egg size (diameter) was measured with a von Bayer trough (Piper et al., 1983).

Dry fertilization was performed by adding 2 ml sperm from two males to the eggs of each female (Billard, 1992). Eggs from each female were incubated separately in individual incubators provided with spring water at a flow of 1.5 l/min. The fertilization rate was calculated as the percentage of eggs that remained alive three days after fertilization. Dead and unfertilized eggs were removed and counted daily. The hatching rate was based on the ratio of hatched-out larvae to the total number of eggs. Hatching times were converted to degree-days by combining the daily mean incubation temperatures from fertilization to hatching.

Data were analyzed using Minitab statistical software. Means and differences at the 5% level were considered significant.

Results

Spawning lasted 24 days for wild broodstock (November 19 to December 12) and 37 days for hatchery-reared broodstock (December 3 to January 8). Spawning peaked between December 3 and 12. The water temperature ranged 9-11°C. The hatching time was 374 degree-days for both broodstocks.

Total fecundity differed significantly between stocks (Table 1) and was linearly related to body weight (Fig. 1). Relative fecundity did not significantly differ between stocks. The correlation between relative fecundity (RF) and body weight (W) was low; it was negative for wild broodstock (RF = 2584.6 - 0.0645 W; $r^2 = 0.014$; $p<0.05$) and positive for hatchery-reared (RF = 2397.8 + 0.3718 W; $r^2 = 0.016$; $p<0.05$).

The difference in egg diameter between the two groups was significant. The correlation between egg diameter and body weight was small but positive for wild broodstock and negative for hatchery-reared broodstock (Fig. 2).

The fertilization and hatching rates were similar in both stocks and did not significantly differ.

Table 1. Reproduction in wild and hatchery-reared Black Sea salmon broodstock.

	Broodstock				
	Wild[1]		*Hatchery-Reared*[2]		
	Means±SD	*Range*	*Means±SD*	*Range*	*t-test*
Wt before stripping (g)	1773.2±1014.4	884-3639	869.5±319.6	340-1812	*
Fork length (cm)	52.9±10.9	39.9-72.2	41.1±4.2	33.2-51.5	*
Wt after stripping (g)	1452.8±823.8	715-2988	712.1±249.2	328-1452	*
Total egg wt (g)	307.5±179.1	141-703	145.9±70.0	12-356	*
Avg egg wt (mg)	87.69±12.90	70.0-119.7	83.1±8.84	63.9-99.3	NS
Egg diameter (mm)	5.2±0.20	4.9-5.7	5.0±0.24	4.6-5.6	*
Total fecundity	3524.6±2106.9	1451-8764	1931.3±915	664-5050	*
Relative fecundity	2470.3±549.5	1762-3280	2719.8±834.3	1319-5774	NS
Fertilization rate (%)	98.4±1.71	93.7-99.9	97.9±1.84	94.1-99.8	NS
Hatching rate (%)	88.1±8.78	64.6-95.8	83.1±15.77	43.0-97.5	NS
Hatching time (degree-days)	374	-	374	-	-

* significantly different at a level of $p<0.05$. NS = not significantly different
[1] Data derived from 15 fish and 583 eggs.
[2] Data derived from 28 fish and 1427 eggs.

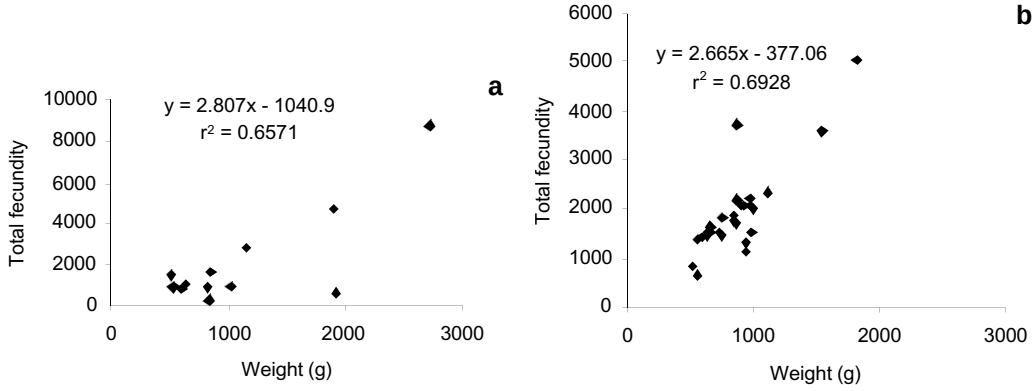

Fig. 1. Relationship between total fecundity and brood weight in (a) wild and (b) hatchery-reared Black Sea salmon.

Discussion

Although the wild broodstock spawned within only 24 days compared to the hatchery-reared broodstock which spawned within 37, the number of degree-days to hatching was the same for both broodstocks. Barach (1962) reported a similar spawning time for Black Sea salmon but a shorter incubation period. The duration of early developmental stages of fish embryos is mainly controlled by genetic make-up (Dumas et al., 1995), and water tem-

perature and its variability during incubation. The spawning time of Black Sea salmon in northeastern Turkey is similar to that of brook trout but shorter than that of rainbow trout (Table 2).

Total fecundity was linearly related to body weight, as reported for rainbow trout (Okumus et al., 1997; Kurtoglu et al., 1998) and brook trout (Akbulut et al., 1999). Fish size was the major determinant of reproductive effort in brown trout females (Nicola and Almodóra, 2002). Judging from our results, fecundity in the Black Sea salmon is also determined by female size. Relative fecundity for both broodstocks was within the reported ranges for other salmonid species. Correlation between relative fecundity and body weight was rather small, negative for wild and positive for hatchery-reared stock. Negative correlations between relative fecundity and body weight were also reported for farmed rainbow trout, coho salmon, and Atlantic salmon (Estay et al., 1999).

The fertilization and hatching rates obtained in the present study were within the ranges reported for other salmonid species.

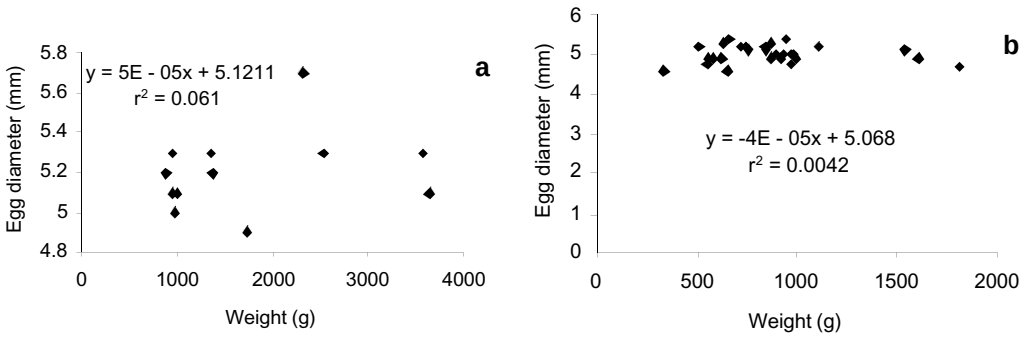

Fig. 2. Relationship between egg diameter and brood weight in (a) wild and (b) hatchery-reared Black Sea salmon.

Table 2. Reproduction in rainbow trout and brook trout.

	Brook trout	*Rainbow trout*	
	Akbulut et al. (1999)	*Okumus et al. (1997)*	*Kurtoglu et al. (1998)*
Spawning period	Dec 28-Jan 6	Jan 11-Feb 8	Jan 15-Feb 15
Fish wt (g)	888.8	2036.7	1704
Total egg wt (g)	179.0	413.4	-
Egg diameter (mm)	4.9	5.01	5.19
Total fecundity	2735	4870	2304
Relative fecundity	3124	2493	1364
Fertilization rate (%)	-	98.4[1]; 95.8[2]	75.1
Hatching rate (%)	-	80.3[1]; 91.7[2]	96.4

[1] in sea cages
[2] in freshwater ponds

In conclusion, the present study suggests that the reproductive parameters of wild and hatchery-reared Black Sea salmon in north-eastern Turkey are similar to those of other salmonid species. Further research on performance during different life stages and in different rearing systems is needed.

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