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Reproductive Characteristics of Brown Trout (*Salmo trutta fario* L.) Reared in North-Eastern Turkey

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Abstract

Spawning time, fecundity, fertilization rate, and egg size of brown trout (*Salmo trutta fario*) reared in north-eastern Turkey were investigated. Seventeen females were stripped into separate bowls and eggs were fertilized by milt from at least two males. Spawning lasted from mid-November to early January. The mean brood size was 989.4±620.53 g and mean total and relative fecundities were 2029±2051 eggs/individual and 2259±947 eggs/kg body weight, respectively. Mean egg diameters and weights were 5.3±0.40 mm and 93.9±19.37 mg. The mean fertilization and hatching rates were 95.4±4.60% and 83.3±11.79% of the total number of eggs. Correlations were positive between body weight and total (r^2 = 0.8665, p<0.001) and relative (r^2 = 0.1632, p>0.10) fecundity, and negative between egg diameter and body weight (r^2 = -0.002, p>0.10) and total fecundity (r^2 = -0.0865, p>0.05). Our findings suggest that reproductive parameters of brown trout under culture conditions in north-eastern Turkey are similar to those of other salmonid species.

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Introduction

Brown trout (*Salmo trutta fario* L.) belongs to the family Salmonidae and order Salmoniformes. The species has a wide distribution range and naturally lives in Europe, northern Africa, and western Asia including Anatolia (Page and Burr, 1991; Geldiay and Balık, 1996; Behnke, 2002). The brown trout has been transferred outside its natural range for over a century and has become a self-sustaining population in North and South America, New Zealand, Australia, Africa, and the headwaters of the Himalayas in Asia (Elliott, 1994; Behnke, 2002). This species has importance for sport and commercial fishing, and aquaculture (Baglinière and Maisse, 1999).

Studies on the brown trout in Turkey concentrate on bio-ecology (Aras, 1974), morphometric characteristics (Bardakçı et al., 1994), age and growth (Alp et al., 2005; Arslan et al., 2007), and reproduction traits and fecundity in the natural habitat (Karataş, 1997, Tabak et al., 2001; Alp et al., 2003; Bozkurt and Secer, 2006; Arslan and Aras, 2007).

The main aim of hatcheries is to fulfil the demand for good quality eggs and larvae from available broodstock. Biotic (e.g., size, age, genotype, nutritional status of broodfish) and environmental (e.g., water quality, photoperiod) factors influence fecundity and egg size (Peter and Crim, 1979; Rottmann et al., 1991). In practical fish culture, it is important to know the number of eggs, fry, and young produced. Estimation of fecundity can be used to assess the abundance and reproduction potential of spawning stock. Such knowledge provides possibilities for improving reproductive capacities of broodstocks.

Brown trout culture is developing in Turkey. In the present study, reproductive parameters of brown trout broodstock are discussed.

Materials and Methods

Data were collected from the Central Fisheries Research Institute Freshwater Hatchery in Trabzon during the 2002-2003 breeding season. Broodstock consisted of 17 females and 11 males, 3-5 years old. The parental stocks were randomly divided into rectangular fiberglass tanks (2 x 2 x 1.2 m) at a maximum density of 5-6 kg/m^3. The broodstock were fed a 6-mm commercial fishmeal-based pelleted diet containing approximately 45% crude protein and 7% crude lipid. Fish were hand-fed to satiation twice daily during natural daylight hours.

Females were checked weekly during the spawning season to determine the stage of gonadal maturation. Ripe females were anesthetized with a 50 mg/l solution of tricaine methanesulfate (MS-222), stripped into individual dry plastic bowls, and the eggs were fertilized with milt from two males. Dry fertilization was performed Billard (1992) after using 2-3 ml semen for each batch of eggs stripped from a single female. Broodfish were weighed before and after stripping. Fecundity was determined using a gravimetric method (MacGregor, 1957), and calculated in terms of either total (number of eggs per female) or relative (number of eggs/kg body weight) fecundity. Egg size (diameter) was measured with a Von Bayer trough (Piper et al., 1983).

Fertilized eggs from each female were incubated separately in baskets with plastic nets, within a plastic canoe. Water temperature ranged 9-11°C and flowed to each incubator at 1.5 l/min. The fertilization rate was estimated as the percentage of live eggs 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.

Data were recorded to determine the following parameters: spawning season, female weight and length, total fecundity, relative fecundity, egg weight and diameter, fertilization rate, and hatching rate. Data were analyzed using Minitab statistical software.

Results

The spawning season lasted 50 days, from 19 November to 8 January, and peaked on December 12 (Fig. 1). The fertilization and hatching rates were quite high (Table 1). There was a significant positive allometry for the relationship between total fecundity and female body weight (p<0.001, Fig. 2) and a small positive correlation between relative fecundity and female body weight (p>0.10). On the other hand, there were small poorly negative correlations between egg diameter and body weight (r^2 = -0.045, p>0.10) and egg diameter and total fecundity (r = -0.294, p>0.05).

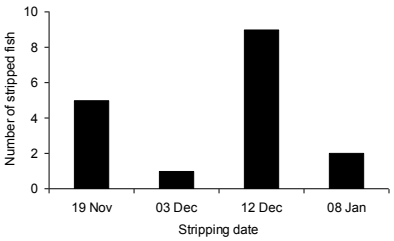

Fig 1. Stripping dates and numbers of stripped brood.

Table 1. Biometrics and reproductive variables of brown trout (*Salmo trutta fario*) broodstock.

	No.	*Min*	*Max*	*Mean*	*±SD*
Fork length (cm)	17	30.8	62.1	42.7	8.43
Wt before stripping (g)	17	438	2725	989.4	620.53
Wt after stripping (g)	17	359	2075	810.8	467.3
Total egg wt (g)	17	78	640	177	157.8
Individual egg wt (mg)	762	64.4	130.6	93.9	19.37
Egg diameter (mm)	762	4.6	6.1	5.3	0.40
Total fecundity (eggs/individual)	17	799	8801	2029	2051
Relative fecundity (eggs/kg)	17	1080	4241	2259	947
Fertilization rate (%)	17	86.8	99.2	95.4	4.60
Hatching rate (%)	17	66.0	97.7	83.3	11.79
Gonadosomatic index	17	3.7	34.4	21.7	7.37

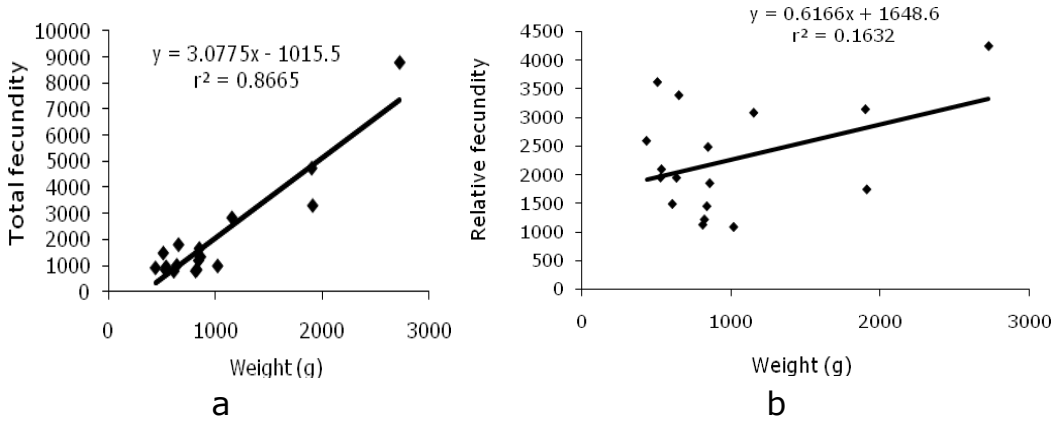

Fig. 2. Relationship between female body weight and (a) total and (b) relative fecundity.

Discussion

The spawning season for brown trout in natural habitats in Turkey is January-March in Atakoy Dam Lake (Karataş, 1997), November-December in the Kapsitre, Cağlayan, Fırtına, İyidere, and Solaklı streams in the eastern Black Sea region (Tabak et al., 2001), and November-January in the Fırnız stream (Alp et al., 2003). Brown trout spawns between October and December (Brown, 1971) and when the water temperature is 8-12°C (Scott and Crossman, 1973). In the culture conditions of the present study, brown trout likewise spawned November-January. The time of spawning for brown trout in north-eastern Turkey is similar to spawning times of rainbow trout and brook trout but seems to begin earlier than in other species (Table 2).

Table 2. Biometrics and reproductive variables of salmonid species broodstock in north-eastern Turkey.

	Salmo salar[1]	*Salvelinus fontinalis*[2]	*Oncorhynchus mykiss*[3]	*Salmo trutta labrax*[4]	
				Wild	*Reared*
Spawning time	Dec 23-Jan 8	Dec 28-Jan 6	Jan 15-Feb 15	Nov 19-Dec 12	Dec 3-Jan 8
Weight (g)	1606.5	888.8	1704	1773.2	869.5
Total egg wt (g)	285.8	179.0	-	307.5	145.9
Egg diameter (mm)	5.8	4.9	5.19	5.2	5.0
Total fecundity	3763	2735	2304	3524.6	1931.3
Relative fecundity	2923	3124	1364	2470.3	2719.8
Fertilization (%)	-	-	75.1	98.4	97.3
Hatching (%)	-	-	96.4	88.1	83.1

[1] Şahin et al. (1998)
[2] Akbulut et al. (1998)
[3] Kurtoğlu et al. (1998)
[4] Şahin et al. (2007)

The study revealed that fecundity increases with fish size. However, while older fish were more fecund, younger fish produced more ova per gram ovary. The mean total and relative fecundity rates in *S. trutta fario* appear to be lower than in other salmonid species. These differences are not inconsistent since broodstock size, age, and genotype, as well as daily and seasonal feeding rates, can influence the number of eggs produced (Bromage, 1996). Fish size is the major determinant of reproductive effort in brown trout females (Nicola and Almodóra, 2002). In this study, total and relative fecundity had a direct relationship with body weight, as described for *S. salar* (Şahin et al., 1998), *S. fontinalis* (Akbulut et al., 1998), and *O. mykiss* (Kurtoğlu et al., 1998 in north-eastern Turkey.

The mean egg size (5.3±0.40 mm) was nearly the same as the average for *O. mykiss* (5.19 mm; Kurtoğlu et al., 1998) and *S. trutta labrax* (5.2 mm; Şahin et al., 2007), but slightly lower than for *S. salar* (5.8 mm; Şahin et al., 1998). Egg size is determined by the size and age of the broodfish, and larger broods produce a greater number of eggs (Leitritz and Lewis, 1980). Further, egg size differs between broods reared in different environmental and/or husbandry conditions.

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

It is concluded that the reproductive parameters of brown trout reared in north-eastern Turkey are similar to those of other salmonid species under culture conditions.

References

Akbulut B., Okumuş İ., Başçınar N., Kurtoğlu İ.Z. and T. Şahin, 1998. Egg production in a brook trout (*Salvelinus fontinalis*) broodstock: fecundity, egg size and correlation of body weight. *Proc. 1st Int. Symp. Fish. Ecol.*, 2-4 Sep., Trabzon, Turkey.

Alp A., Kara C. and M. Büyükçapar, 2003. Reproductive biology of brown trout, *Salmo trutta magrostigma* Dumeril 1858, in a tributary of the Ceyhan river which flows into the eastern Mediterranean sea. *J. Appl. Ichthyol.*, 19:346-351.

Alp A., Kara C. and M. Büyükçapar, 2005. Age, growth and diet composition of the resident brown trout, *Salmo trutta magrostigma* Dumeril 1858, in Fırnız stream of the River Ceyhan, Turkey. *Turk. J. Vet. Anim. Sci.*, 29:285-295.

Aras S., 1974. *Bioecological Studies on Trout Inhabiting the Çoruh and Aras Basins*. Ph.D. Thesis, Fac. Agric., Ataturk Univ., Erzurum (in Turkish).

Arslan M. and N.M. Aras, 2007. Structure and reproductive characteristics of two brown trout (*Salmo trutta*) populations in the Çoruh River basin, Northeastern Anatolia, Turkey. *Turk. J. Zool.*, 31:185-192.

Arslan M., Yıldırım A., Bektaş Ş. and A. Atasever, 2007. Growth and mortality of the brown trout (*Salmo trutta* L.) population from Upper Aksu Stream, Northeastern Anatolia, Turkey. *Turk. J. Zool.*, 31:337-346.

Baglinière J.C. and G. Maisse, 1999. *Biology and Ecology of the Brown and Sea Trout.* Springer-Praxis Publ. Ltd, Heidelberg. 286 pp.

Bardakçı F., Tanyolaç J. and M.A. Akpınar, 1994. Morphological comparison of trout (*Salmo trutta* L., 1766) populations caught from a Sivas stream. *Turk. J. Zool.*, 18:1-6.

Behnke R.J., 2002. *Trout and Salmon of North America*, 1st ed. Free Press, Simon and Schuster Inc., New York. 360 pp.

Billard R., 1992. Reproduction in rainbow trout: sex differentiation, dynamics of gametogenesis, biology and preservation of gametes. *Aquaculture*, 100:263-298.

Bozkurt Y. and S. Secer, 2006. Relationship between spermatozoa motility, egg size, fecundity and fertilization success in brown trout (*Salmo trutta fario*). *Pak. J. Biol. Sci.*, 9(11):2141-2144.

Bromage N.R., 1996. Broodstock management and seed quality: general consideration. pp. 1-24. In: N.R. Bromage, R.J. Roberts (eds.). *Broodstock Management and Egg and Larval Quality*. Blackwell Sci. Ltd., Oxford.

Brown C.J.D., 1971. *Fishes of Montana*. Big Sky Books, Montana State Univ. 207 pp.

Elliott J.M., 1994. *Quantitative Ecology and the Brown Trout*. Oxford Univ. Press, Inc. New York. 286 pp.

Geldiay R. and S. Balık, 1996. *Freshwater Fishes of Turkey*. Fac. Fish. Publ. no. 46, Agean Univ., İzmir. 532 pp. (in Turkish).

Karataş M., 1997. Investigations on the reproduction properties of trouts (*Salmo trutta* L.) inhibiting in Ataköy (Tokat) Dam Lake. *Turk. J. Vet. Anim. Sci.*, 21:439-444.

Kurtoğlu I.Z., Okumus I. and M.S. Celikkale, 1998. Analysis of reproductive performance of rainbow trout (*Oncorhynchus mykiss*) broodstocks in commercial farms in eastern Black Sea region of Turkey. *Turk. J. Vet. Anim. Sci.,* 22:489-496 (in Turkish).

Leitritz E. and R.C. Lewis, 1980. *Trout and Salmon Culture (Hatchery Methods)*. California Fish Bull. no. 164, Div. Agric. Natl. Res. Publ. 4100, Univ. Calif.

MacGregor J.S., 1957. Fecundity of the Pacific sardine (*Sardinops caerulea*). *US Fish Wildl. Serv. Fish. Bull*., 121:427-449.

Nicola G.G. and A. Almodóra, 2002. Reproductive traits of stream-dwelling brown trout *Salmo trutta* in contrasting neighbouring rivers of central Spain. *Freshw. Biol*., 47:1353-1365.

Page L.M. and B.M. Burr, 1991. *A Field Guide to Freshwater Fishes of North America North of Mexico.* Houghton Mifflin Co., New York. 432 pp.

Peter R.E. and L.W. Crim, 1979. Reproductive endocrinology of fishes: gonadal cycles and gonadotropin in teleosts. *Annu. Rev. Physiol.*, 40:323-346.

Piper R.G., McElvain L.B., Orme L.E., McCraden J.P., Fowler L.G. and J.R. Leonard, 1983. *Fish Hatchery Management*. US Fish Wildl. Serv., Washington DC. 517 pp.

Rottmann R.W., Shireman J.V. and F.A. Chapman, 1991. *Introduction to Hormone-Induced Spawning of Fish*. S. Regional Aquac. Center, US Dept. Agric., Publ. no. 421.

Scott W.D. and E.J. Crossman, 1973. *Freshwater Fishes of Canada*. Fish. Res. Board Can. Bull. 184, Ottawa. 966 pp.

Şahin T., Akbulut B. and M. Aksungur, 1998. Analysis of reproductive characteristics of Atlantic salmon (*Salmo salar*). pp. 401-406. In: *Proc. III. Fish. Symp*., June 10-12, Erzurum, Turkey.

Şahin T., Akbulut B., Çakmak E. and Y. Çavdar, 2007. Reproductive performance of wild and hatchery-reared Black Sea salmon. *Isr. J. Aquac. - Bamidgeh*, 59(4):212-216.

Tabak I., Aksungur M., Zengin M., Yılmaz C., Aksungur N., Alkan A., Zengin B. and S. Mısır, 2001. Determination of bioecologic features and culture potential of Black Sea trout (*Salmo trutta labrax* Pallas, 1811). Final Project Rep., Min. Agric. Rural Affairs, Central Fish. Res. Inst., Trabzon. 193 pp. (in Turkish).