Austin Biology

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Research Article

Assessing Stock Reproductive Potential of *Salmorizeensis, Salmo trutta abanticus, Salmo trutta caspius, Salmo trutta fario* and *Salmocoruhensis* with Fecundity

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Received: October 04, 2016; **Accepted:** November 16, 2016; **Published:** November 18, 2016

Abstract

Determination of the annual total egg production of a stock is important due to understanding fluctuations in population size. Therefore, the objective of the present work was to assess and compare the fecundity of *Salmorizeensis, Salmo trutta abanticus, Salmo trutta caspius, Salmo trutta fario* and *Salmocoruhensis*. Sampling was carried out by electro fishing. The results showed that the highest individual fecundity was in *S. Coruhensis* (1476±1043) while the highest relative fecundity was in *S. t. caspius* (4000±1092) ($p<0.05$). Egg sizes and weights of *S. t. abanticus, S. rizeensis, S. t. caspius, S. t. fario* and *S. coruhensis* were 4.91±0.37 mm and 92.21±16.07 mg; 4.52±0.53 mm and 59.42±12.32 mg; 4.23±0.26 mm and 48.92±5.32 mg; 4.59±0.53 mm and 81.54±21.41 mg, and 4.67±0.46 mm and 76.52±17.52 mg, respectively. The relationships between egg size and egg weight of *S. trutta* subspecies were found significantly ($p<0.05$). The results also showed that fecundity significantly increased with fish weight and length ($p<0.05$). Overall fecundity and egg size is affected by fish size and species.

Keywords: Fecundity; *Salmorizeensis*; *Salmo trutta abanticus*; *Salmo trutta caspius*; *Salmo trutta fario; Salmocoruhensis*

Introduction

S. trutta is one of the most important fish species due to its aquaculture potential, economic value and wide consumer demand and *S. trutta* forms resident populations in the upper streams of rivers and occurs in North Africa, Europe, West Asia and Anatolia and is characterized by extensive genetic, morphological and ecological diversity [1,2]. Thus far, based mainly on morphological data, the numerous forms of brown trout *S. trutta* have been classified under different taxonomic groupings [3]. *S. trutta* is represented by five subspecies within the Turkey; *Salmo trutta macrostigma*, *Salmo trutta labrax*, *Salmo trutta caspius*, *Salmo trutta fario* and *Salmo trutta abanticus*. Recently, *S. t. labrax* and *S. t. macrostigma* was described by Turan et al. [4] as *Salmocoruhensis* and *Salmorizeensis*, respectively [5,6].

Fecundity is expressed as one of reproductive traits [7] and it is an important biological parameter for successful fisheries management, to evaluate the commercial potentialities of a fish stock and plan a breeding programme [8]. Estimation of fecundity is essential to assessment the reproductive potential of a stock, fluctuations in reproductive output and population growth rate [8-11]. In addition, a better understanding of reproductive development and associated fecundity is necessary for culture studies. To date, reproduction biology and ecology of *S. trutta* has been intensively studied [3,12-23], but fecundity pattern of subspecies of *S. trutta* was not compared. Therefore, this study was designed to investigate to compare of fecundity of *S. rizeensis, S. t. abanticus, S. t. caspius, S. t. fario* and *S. coruhensis* inhabiting North Anatolia Rivers, Turkey.

Materials and Methods

Sampling of wild fish

A total of 168 individuals caught from sampling sites in North Anatolia rivers (*S. coruhensis*, Camlihemsin-Firtina Stream; *S. t. fario*, Camlihemsin-Firtina Stream-Meryemana Stream; *S. rizeensis*, Caykara-Ipsil-Yedigoller Lake; *S. t. abanticus*, Yedigoller Lake; *S. t. caspius*, Susuz-Cildir Lake) in Turkey, using by electro fishing (SAMUS 725G, 650 W, 5-60 A and 12 V DC). After cessation of oviposition, post-spawning females were removed, anaesthetized with Benzocaine (ethyl 4-aminobenzoate), weighed and measured. Fish were allowed to recover fully before being returned. Total weight, weight of gonads and its subsamples were recorded with an electronic analytical balance to the nearest 0.01 g.

Estimation of fecundity

The number of eggs was estimated by gravimetric method, using three pieces removed from the ovary. They were then counted and mean value calculated from three sub-samples and weighed. The total number of eggs in each sub-sample ovary was determined. This value was proportional to the total ovary weight; the number of eggs ($F1$) for the subsample was estimated using the equation, $F1$= (Gonad weight x number of eggs in the subsample)/subsample weight. Then, by taking the mean number of three subsample fecundities ($F1, F2, F3$), the individual fecundity for each female fish was calculated [$F= (F1 + F2 + F3)/3$]. Relative fecundity index was calculated as RF =

Citation: Kocabas M and Bascinar N. Assessing Stock Reproductive Potential of *Salmorizeensis*, *Salmo trutta abanticus, Salmo trutta caspius, Salmo trutta fario* and *Salmocoruhensis* with Fecundity. Austin Biol. 2016; 1(3): 1015.

Table 1: Mean length (cm) and weight (g) values of female *S. t. abanticus*, *S. rizeensis*, *S. t. caspius*, *S. t. fario* and *S. coruhensis.*

	n	Length (min-max) (cm)	Weight (min-max) (g)
S. t. abanticus	23	31.45±8.54^{b} (15.6-43.0)	482.02±360.44^{b} (41.3-1250.0)
S. rizeensis	22	19.54±4.44^{a} (13.6-29.3)	82.51±61.20^{a} (28.3-298.0)
S. t. caspius	20	21.25±2.05^{a} (18.1-24.5)	123.38±24.83^{a} (87.4-155.0)
S. t. fario	27	34.47±9.30^{c} (26.0-50.8)	628.56±358.50^{c} (228.0-2150.0)
S. coruhensis	73	35.15±7.95^{c} (22.0-54.9)	647.81±502.00^{c} (140.0-2410.0)

^{a,b,c} Different superscripts within the same column demonstrate significant differences. (p<0.05).

AF/*TW*, where *AF* is individual fecundity and *TW* total weight [24].

Fork length, fecundity and body weight, and fecundity relationships were determined from the equations; $F = q \times FL^{b}$ and $F = q \times W^{b}_{B}$, where *F* is the number of eggs (fecundity), *FL* and W_B are the fork length (mm) and body weight (g), respectively. "*a*" and "*b*" are constant parameters in linear regression analysis and $q = e^{a}$. Fecundity was estimated according to Bagenal and Braum [25]. The egg shapes were round and slightly hard when diameters were being measured. The mean fecundities and mean egg diameters for individuals were recorded by length and weight of each examined female fish.

Statistical analysis

The differences in between groups were tested with the one-way ANOVA test and Tukey test. Statistical analyses were performed with SPSS 14.0 software package and significant levels of 0.05, 0.01 and 0.001 were accepted. Relationship between fecundity and length, weight, and also between egg size and egg weight was described by exponential and linear equations: $F= ab^{L}$; $F= ab^{t}$ and $F = a + bW$.

Results

Mean length (cm) and weight (g) values of female *S. rizeensis, S. abanticus, S. t. caspius, S. t. fario* and *S. coruhensis* during spawning period are presented in Table 1. Significant differences were obtained from the statistical comparison of length-weight relationships among subspecies ($p<0.05$).

The relationship of some features [total egg mass (g), egg weight (mg), egg diameter (mm), individual fecundity (egg/individual), relative fecundity] with five ecotypes of brown trout are shown in Table 2. Egg sizes and weights of *S. t. abanticus, S. rizeensis, S. t. caspius, S. t. fario* and *S. Coruhensis* were 4.91±0.37 mm and 92.21±16.07 mg; 4.52±0.53 mm and 59.42±12.32 mg; 4.23±0.26 mm and 48.92±5.32 mg; 4.59±0.53 mm and 81.54±21.41 mg, and 4.67±0.46 mm and 76.52±17.52 mg, respectively. It was determined that the biggest egg was in *S. t. abanticus* and the smallest was *S. t. caspius* in populations ($p<0.05$). During the study period, the highest individual fecundity was in *S. coruhensis* and the lowest was in *S. t. macrostigma* while the most relative fecundity was in *S. t. fario* and the lowest *S. t. abanticus* ($p<0.05$). The highest relative fecundity (egg/kg) was in *S. t. fario* (4000±1092); the lowest relative fecundity was in *S. t. abanticus* (1871±742), beside the highest individual fecundity was in *S. coruhensis* (1476±1043) and the lowest individual fecundity was in *S. rizeensis* (193±123). Differences in the relative fecundity values among ecotypes were significantly ($p<0.05$).

Fecundity significantly increased with fish weight and length ($p < 0.05$). The relationships between egg size and egg weight of *S. t. abanticus, S. rizeensis, S. t. caspius, S. t. fario* and *S. coruhensis* were found significantly ($p<0.05$) (Table 3).

Discussion

Fecundity is important due to assessing potentialities of a fish stock, fisheries management and plans a breeding programme [8]. Thus far, a great deal of past research has focused on fecundity of various finfish species, namely, *Gudusia chapra* [26,27], *Mystus gulio* [28], *Puntius gonionotus* [29], *Mystus bleekeri* [30], *Mastacembelus pancalus* [31], *Liza parsia* [32,33], *Gadus morhua* and *Melanogrammus aeglefinus* [11], *Puntius sophore* [10], *Gadus morhua* [34], *Clarias gariepinus* [35], *Hoplostethus atlanticus* [36,37], *Platichtysflesus* [38], *Thunnus alalunga* [39,40]. Although fecundity is one of the most important biological parameters, there is a lack of information in the literature on comparison of the fecundity of brown trout subspecies. Geldiay and Balık [41] reported the number of eggs produced by brown trout living in Turkish waters as 2000-5000 per kg. Yanar et al. [42], Karatas [13], Cetinkaya [17], Alp et al. [19], Arslan and Aras [20] and Kocabas et al. [23] reported the number of eggs per kg of fish weight ranges of 3230, 3113, 2810, 2340, 2810 and 3122 in their *S. trutta* populations, respectively. In our study, it was determined as 1871-4000 per kg. We obtained a different result from the other brown trout populations. Variation in the number of eggs the populations may largely result from geographic distributions and selectively different environmental factors [43]. Environmental factors (temperature, sunlight, weather etc.) cause changes in fecundity. Especially, temperature is one of selective factor [16]. In addition, the availability of food in the natural and captive condition affect to fecundity.

Egg size and weight are the primary reproductive trait under selection in salmonids and interrelated life history traits, environmental and maternal effects [44-47]. Moreover, egg size is highly variable among species and positively correlated with body size, growth and survival [48,49]. Additionally, it is important due to affect the egg hatchability, juvenile body size and survival [50]. Egg

Table 2: Some features in *S. t. abanticus*, *S. rizeensis*, *S. t. caspius*, *S. t. fario* and *S. coruhensis* (TEW: Total Egg Mass (g), EW: Egg Weight (mg), ED: Egg Diameter (mm), IF: Individual Fecundity (egg/brood), RF: Relative Fecundity (egg/kg), ±: standard deviation) (p<0.05).

	S. t. abanticus	*S. rizeensis*	*S. t. caspius*	*S. t. fario*	*S. coruhensis*
TEW	60.13±56.86^{ab}	11.78±7.87^{a}	24.81±10.06^{a}	106.20±102.31^{bc}	112.02±92.02^{c}
EW	92.21±16.07^{a}	59.42±12.32^{c}	48.92±5.32^{c}	81.54±21.41^{ab}	76.52±17.52^{b}
ED	4.91±0.36^{a}	4.52±0.53^{bc}	4.23±0.26^{c}	4.59±0.53^{abc}	4.67±0.46^{ab}
IF	623±515^{bc}	193 ±123^{c}	505 ±206^{bc}	1179±669^{ab}	1476 ±1043^{a}
RF	1871±742^{b}	2403±953^{b}	4000±1092^{a}	1988±865^{b}	2314±858^{b}

^{a,b,c} Different superscripts within the same raw demonstrate significant differences. (p<0.05).

Table 3: Relationships between fecundity and length, and total weight, and egg size and egg weight in *S. t. abanticus*, *S. rizeensis*, *S. t. caspius*, *S. t. fario* and *S. coruhensis.*

	Model	a	b	r^2	F
Length (x) - Fecundity (y)					
S. t. abanticus	$y = a\,x^b$	0.0706***	2.627095***	0.941	271.57
S. t. caspius	$y = a\,x^b$	0.0107*	3.505514**	0.665	19.81
S. t. fario	$y = a\,x^b$	1.8657 n.s.	1.784433***	0.712	54.38
S. coruhensis	$y = a\,x^b$	0.0463**	2.846369***	0.673	125.34
S. rizeensis	$y = a\,x^b$	0.3189 n.s.	2.082436***	0.629	28.87
Total Weight (x) - Fecundity (y)					
S. t. abanticus	y = a + b x	71.100 n.s.	1.344700***	0.884	130.11
S. t. caspius	y = a + b x	-304.396 n.s.	6.563795**	0.628	16.89
S. t. fario	y = a + b x	541.336***	0.792415***	0.690	55.70
S. coruhensis	y = a + b x	293.476*	1.767080***	0.713	151.80
S. rizeensis	y = a + b x	48.904*	1.792892***	0.755	46.34
Egg size (x) - Egg weight (y)					
S. t. abanticus	y = a + b x	-0.07456*	0.033728***	0.791	41.67
S. t. caspius	y = a + b x	-0.02687*	0.017924***	0.791	37.86
S. t. fario	y = a + b x	-0.09197***	0.037342***	0.882	165.23
S. coruhensis	y = a + b x	-0.07746***	0.032908***	0.798	246.06
S. rizeensis	y = a + b x	-0.03987**	0.023369***	0.740	57.06

*: $p<0.05$
**: $p<0.01$
***: $p<0.001$
n.s.: no significant

diameters of *S. trutta* were reported to be 4.0-4.5 mm in the Coruh River [51], 2.5-3.0 mm in the Catak Stream [17], 3.93 mm in the Gokpinar Stream [12] and 3.0-5.1 mm in the Koprucay Stream [14]. Kocabas et al. [23] determined as 3.2-5.1 mm in *S. t. macrostigma*. Consistent with results of previous studies, the results obtained in the present study indicated that egg diameters varied from 4.23 to 4.91. The observed range of eggs weights (48-92 mg) was different from that of 11-71 mg reported by Alp et al.[19] in Firniz Stream in Turkey and that of 53-63 mg and 65-76 mg found by Crisp et al. [52] and Crisp et al. [53] at northern England and that of 55 mg found by Kocabas et al. [23]. This may be due to size- and age-dependent effects [54].

Fish fecundity varies with body length or weight [43]. In present study, fecundity increased with increasing fish size (length and weight) as also observed by Alp et al. [19], Arslan and Aras [20], Nicola and Almodovar [18]. Lobon-Cervia et al. [15] and Kocabas et al. [23] indicated that trout length was the major determinant of fecundity. The present study confirmed that fecundity was related to both fish length and weight significantly.

Consequently, fecundity increased with increasing fish size (length and weight). To fully understand egg production processes of the respective population, including estimations was realized with fecundity, future studies should focus on timing, now possible by new.

Acknowledgement

This study was carried out with the grant provided by Karadeniz Technical University Scientific Research Foundation (Project no: 2005.117.01.1). We thank to Prof. Dr. Ibrahim OKUMUS, who is our supervisor forever.

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Austin Biol - Volume 1 Issue 3 - 2016
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Citation: Kocabas M and Bascinar N. Assessing Stock Reproductive Potential of *Salmorizeensis*, *Salmo trutta abanticus, Salmo trutta caspius, Salmo trutta fario* and *Salmocoruhensis* with Fecundity. Austin Biol. 2016; 1(3): 1015.