

REPRODUCTION BIOLOGY OF *Capoeta trutta* (Heckel, 1843) IN THE SHOUR RIVER, SOUTHWEST IRAN

Mehran Javaheri Baboli¹, Mohsen Taghavi Niya^{2*}

¹Department of Fisheries Science, College of Agricultural Sciences and Natural Resources, Ahvaz branch, Islamic Azad University, Ahvaz, Iran

²Young Researchers Club, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

*Corresponding Author, E-mail: M_taghavi50@yahoo.com

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Reproductive characteristics of tuweni *Capoeta trutta* (Heckel, 1843), a native cyprinid in the Shour River, Iran, were investigated by monthly sampling between July 2010 and June 2011. Among 815 specimens captured, the overall sex ratio was 1:1.96 (males:females). Monthly changes of the gonado-somatic index (GSI) and frequency distribution of egg diameter confirmed that spawning lasted from January to April. Results indicated that the age at first maturity for males is one year and for females two years. Fecundity increased with fish age, averages being 2591 for 1⁺ old females and 11552 eggs in mature 6⁺ old females. Correlation of absolute fecundity and body weight was high ($R=0.85$). The absolute fecundity between all age groups was statistically significant ($p<0.05$).

INTRODUCTION

Capoeta trutta is one of the dominant fishes in the rivers of Khuzestan Province, especially in the Shour River. This subject was chosen for the present research on the one hand because of its abundance, and on the other hand because of its importance in economy and sport, and lack of studies on this species due to its specific regional distribution (Abdoli, 1999; Coad, 2008; Javaheri et al., 2012). This kind of fish has a vast distribution in the south of China, north of India, Turkmenistan, the Aral Sea, the Middle East and Anatolia (Alp, 2005).

It has 7 species and 3 subspecies in Iran (Abdoli, 1999; Coad, 2008). The Shour River is one branch of the Karun River which is an Iranian tributary of the Tigris-Euphrates basin (Afshin, 1994).

Determining the size at first sexual maturity in fish is important for population management in fisheries (Templeman, 1987) and is widely used as an indicator of minimum-permissible capture size (Lucifora et al., 1999). Knowledge about fish fecundity is essential for evaluating the potential of stock recruitment (Qasim and Qayyum, 1963). Despite the importance of this species in Iranian waters, only limited information exists on the reproductive biology of *C. trutta* in Iran (Patimar and Farzi, 2011). In light of climatic differences between the tributaries of the Tigris-Euphrates basin, we hypothesized that the populations of this species inhabiting Iranian tributaries differ from those of Turkey and Iraq in life history traits (Patimar and Farzi, 2011). Populations of this

species were found in some lakes and rivers of Turkey (Polat, 1987; Unlu, 1991; Gut et al., 1996; Oymak et al., 2009; Kalkan, 2008).

The aim of this study was to report on the reproductive biology of *C. trutta*, such as the spawning season, age at sexual maturity, fecundity and egg size in the Shour River.

MATERIALS AND METHODS

A total of 815 *C. trutta* were captured between July 2010 and June 2011 in the Shour River. Sampling was performed by gill nets with various mesh sizes (12×12, 18×18, 24×24 and 32×32 mm). The stations were located at latitudes 320017/6 N and longitude 490512/3 E and 320555/1N and 485904/6 E and 320543/9 N and 485911/6 E for station 1, 2 and 3, respectively.

In the laboratory, total length (TL) and total fresh weight (TW) were determined to the nearest 1.0 mm and 0.1 g, respectively. After preparing the scales, age reading was carried out by microscopic examination using circular pattern and annulus number on the scales (Bagenal and Tesch, 1978; Barber and Walker, 1988; Biswas, 1993). For age determination, scales were taken from above the lateral line, below the anterior part of the dorsal fin, and age determination was carried out under a binocular microscope (Bagenal and Tesch, 1978). Sexes were determined by macroscopic observation of the gonads (Biswas, 1993). To assess the

state of maturation, the gonado-somatic index (GSI) was calculated for each individual (GSI = gonad weight / body weight) × 100. Gonad weights were determined to the nearest 0.01 g and egg diameter measured to the nearest 0.01 mm (ocular micrometer) (Biswas, 1993). For egg counts, ovaries were preserved in modified Gilson's solution (100 ml 60% alcohol, 800 ml water, 15 ml 80% nitric acid, 18 ml glacial acetic acid and 20 g mercuric chloride) for at least 48 h. The eggs were then completely liberated from ovarian tissues by vigorous shaking. Eggs were spherical, hence diameter measurements approximate to true diameters. There are numerous ways in which to express reproductive effort in terms of egg number and egg size, and young survival (Smith and Fretwell, 1974; Abdoli et al., 2005). The total number of eggs was then weighted and random samples of about 0.1 g eggs were fully counted. The total number of eggs per ovary was calculated ($F = n G / g$, where F = fecundity, n = number of eggs in subsample, G = total weight of ovaries, g = weight of subsample in the same units) (Simpson, 1951; Biswas, 1993). The age at which 50% of fish were mature was considered to be the age at first maturity for both sexes (Biswas, 1993). The relationships between fecundity and fish body size and total length were tested using simple linear regressions (Biswas, 1993; Elliott, 1995). To test the null hypothesis of significant differences in the three biological variables among age classes, ANOVA and Bonferroni tests for unplanned comparison were used (Sokal and Rohlf, 1995).

RESULTS

Age Distribution

During the sampling period (July 2010 to June 2011), a total of 815 *C. trutta* were examined: 513 females and 261 males, while 41 specimens were immature. Two and three-year-old fish were dominant, accounting for over 70% of the total number aged, while older samples were poorly represented (Figure 1). Sex ratio of the total sample (over all seasons) was 1:1.96 accounting for 33.73% of males and 66.27% of females.

Age at first maturity

Captured *C. trutta* were checked for ovary maturity. Of the one-year-old females, 28.37% were mature, while 54.79% of one-year-old males were mature. Of the two-year-old females, 76.06% were mature, while 77.27% of two-year-old males were mature. First spawning occurred at age I for males and II for females (Table 1).

Gonadal development and egg size

Assessment of the spawning season for *C. trutta* in the Sour River was based on the GSI (Figures 2, 3). Ovary developments began in February and finished in April. According to the averages, the highest GSI values were determined in the samples in February (6.603) and March (8.47) in males and females. The highest and lowest mean egg diameters were 1.160 mm in April and 0.60 mm in October, respectively (Figure 4). Frequency histograms of ripe oocyte sizes showed a single spawning mode from February to April. Egg-diameter frequency distribution of ripening female *Capoeta trutta* in the Shour River showed a single mode (Figure 5) indicating that females laid all their eggs during the same period.

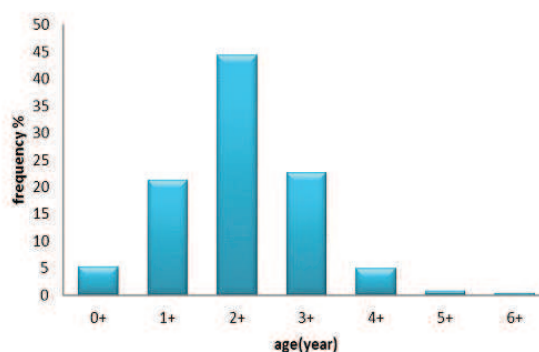


Fig 1. Age distribution of *Capoeta trutta* in the Shour River between July 2010 and June 2011

Table 1. Stage of maturity of female and male *Capoeta trutta* in relation to age, captured in the Shour River (Imm. Immature; Mat. Mature)

Age	Male				Female			
	Imm	Imm%	Mat	Mat%	Imm	Imm%	Mat	Mat%
0	12	80	3	20	3	100	0	0.00
I	33	46.21	40	54.79	63	21.63	21	28.37
II	25	22.73	85	77.27	56	23.94	178	76.06
III	0	0	52	100	6	4.45	129	95.55
IV	0	0	8	100	0	0	29	100
V	0	0	0	0	0	0	5	100
VI	0	0	1	100	0	0	2	100

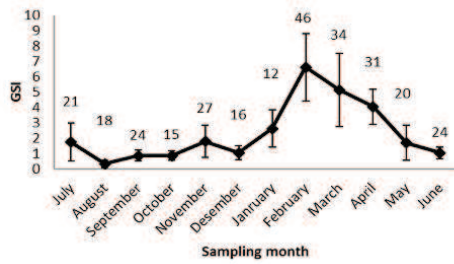


Fig 2. Seasonal fluctuations in the mean gonado-somatic indices (GSI±SD) in male *Capoeta trutta* in the Shour River between July 2010 and June 2011

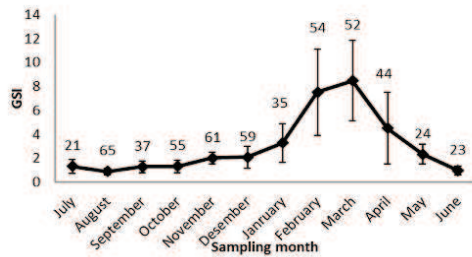


Fig 3. Seasonal fluctuations in the mean gonado-somatic indices (GSI±SD) in female *Capoeta trutta* in the Shour River between July 2010 and June 2011

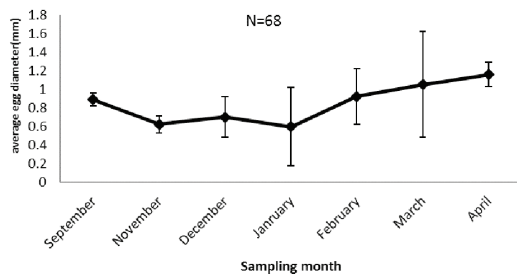


Fig 4. The (Mean ±SD) egg diameter (mm) of *Capoeta trutta* in the Shour River between July 2010 and June 2011. N=Sample size

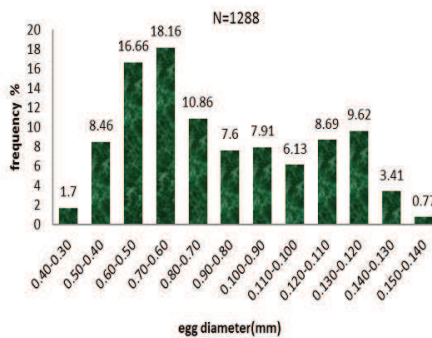


Fig 5. Egg-diameter frequency distribution of ripening female *Capoeta trutta* in the Shour River between July 2010 and June 2011. N=Sample size

General relationships between fecundity and total length and fecundity and body weight (Figures 6a, 6b).

Fecundity ranged from 2591 to 11552 eggs per female (Table 2) and was significantly correlated with body weight (R=0.85) (Figure 6a) and total length (R=0.59) (Figure 6b).

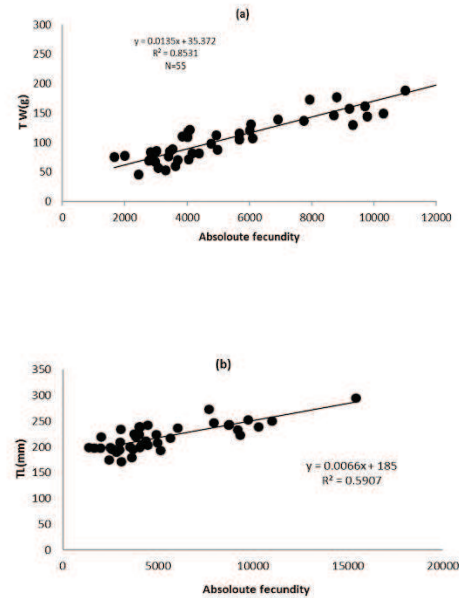


Fig 6. Relation between absolute fecundity and total length b and absolute fecundity and total weight a of *Capoeta trutta* in the Shour River between July 2010 and June 2011 (N=Sample size)

Bonferroni tests showed that mean fecundity mainly increased from age classes 1 to 3 years (from 2591 to 5067), and slightly increased among older females. Mean egg diameter mainly increases from age classes 1 to 2 and 4 to 6 years, and slightly increases from 2 to 4 years (Table 2).

DISCUSSION

The present study is the first report on reproduction biology of *C. trutta* in the Shour River from southwest Iran. Previous work sampled older fish than the one available in this study and reported that *C. trutta* can grow up to 10+ in natural habitats in Turkey (Unlu, 1991; Gul et al., 1996; Polat, 1987). Nikolsky (1980) suggested that the situation in wide range of age distribution in population is accepted as an indication of sufficient level in the food of water system. The decrease in the number of individuals in old age groups in the population would cause an increase of individuals in young age groups, decreasing the food competition.

Table 2. Bonferroni results for the test of significant differences in mean fecundity and egg diameter among age classes of *Capoeta trutta* from the Shour River. Mean values with the same superscript (a-d) do not differ significantly ($p < 0.05$)

N	Age groups	fecundity S.D±Mean	egg diameter (mm) S.D±Mean
7	+1	^a 570±2591	^a 0.125±0.66
15	+2	^b 1226±3412	^b 0.159±0.72
13	+3	^c 2728±5067	^b 0.262±0.75
12	+4	^d 2657±6002	^b 0.411±0.78
5	+5	^e 1909±7850	^c 0.011±0.89
3	+6	^f 5477±11552	^d 0.4±0.97

2009). Comparisons between our results on age-at-maturity of male and female *C. trutta* and males and females of the same species from other geographical locations and other closely-related species are also presented in Table 3. The reason for these differences is that age at first spawning is usually affected by species and such environmental factors as temperature, quantity and quality of food and water systems in which fish live (lake vs. river) (Turkman et al., 2002). The GSI of females and males peaked in March and February, respectively (Figures 3, 4). This is different from the findings for the same species in other areas (Unlu, 1991; Kalkan, 2008; Oymak et al., 2009; Patimar and Farzi, 2011). Most of them in Turkish waters reported the highest GSI values index in May. In contrast, Patimar and Farzi (2011) found the high-

Table 3. Comparison of data on age at first maturity, fork length and spawning season for various species of *Capoeta* species in different geographical areas

Species	Spawning age year	Sex ratio M:F	n	Spawning period	Sex	Study area	References
<i>C. tinca</i>	2	1:0.79	420	May-July	M	Oltu Stream	(Yildirim and Arsalan, 2000)
	3		234		F		
<i>C. umbla</i>	2	1.25:1	509	May-July	M	Karasu River	(Turkman et al., 2002)
	4		404		F		
<i>C. trutta</i>	2	1:1.21	228	June-July	M	Keban Dam Lake	(Duman, 2004)
	3		276		F		
<i>C. trutta</i>	2	1 : 0.98	106	May-June	M	Karakaya Dam lake	(Kalkan, 2008)
	3		104		F		
<i>C. trutta</i>	3	1:1.03	214	May-June	M	Ataturk Dam Lake	(Oymak et al., 2009)
	3		208		F		
<i>C. c. capoeta</i>	1	1:1.43	230	-	M	Kockopru Dam lake	(Elp and Karabatak, 2007)
	4		415		F		
<i>C. damascina</i>		1:1.58	73	May	M	Jordan River	(Stoumboudi et al., 1993)
			126		F		
<i>C. c. capoeta</i>	1	1:1.72	158	June-July	M	Zerenk Dam Lake	(Sen et al., 2008)
	2		272		F		
<i>C. c. gracillis</i>	1	1.5:1	-	May-June	M	Madarsoo River	(Rezai et al., 2009)
	2		-		F		
<i>C. damascina</i>	2	2.2:1	78	May-June	M	Hanna Wetland	(Soofiani and Asadollah., 2010)
	4		171		F		
<i>C. damascina</i>	2	1:1.57	111	May-June	M	Zayandeh-Ruod River	(Asadollah et al., 2011)
	4		241		F		
<i>C. trutta</i>	1	1:1.96	261	Feb-April	M	Shour River	Present study
	2		513		F		

Results obtained from our study showed that the female/male ratio was 1:1.96 but sex ratios in studies of Kalkan (2008) and Duman (2004) were 1: 0.98 and 1: 1.21. The sex ratio in most species is close to one but it may vary from one population of a species to another and may vary from year to year in the same population (Nikolosky, 1980). Females generally attained maturity at an older age than males, being 2+ years, at the Shour River, as opposed to *C. trutta* in Turkish waters (Duman, 2004; Kalkan, 2008; Oymak et al.,

est GSI in the Meymeh River about 1 month later than in the present study. Possible reasons for such differences might be differences in temperature regimes (Bye, 1984). As expected, the fecundity indicated significant correlations with fish length and body weight (Figure 6a and Figure 6b). Our estimates on fecundity are lower than reported for the same species from other areas. Patimar and Farzi (2011) reported oocyte numbers in the range of 1627-18329 from the Meymeh River, and Oymak et al. (2009) showed the

highest fecundity was 33252 eggs. It has been reported that fecundity can change in relation to fish age, length and weight, and especially temperature which is the most important ecological factor effecting the egg number. As we know, older individuals are more productive than the younger. Differences in fecundity estimates among studies might partly be an artifact due to differences in methods, or natural due to differences in fecundity with geographic location or time, or intra-specific and inter-specific differences among species (Nikolsky, 1980; Barbin and McCleave, 1997; Jonsson and Jonsson, 1999; Hossain et al., 2010).

The highest mean egg diameter was found in April (1.16 mm) and lowest value was found in October (0.60 mm) (Fig. 4). The highest and lowest diameters of eggs were determined by Unlu (1991) to be 0.55-1.38 mm, while Polat (1987) found them to be 0.43-1.03 mm. Gul et al. (1996) reported that the highest and lowest diameter of oocyte was 0.46-1.04 mm and Kalkan (2008) found it to be 0.37-1.04 mm. Also Oymak et al. (2009) reported that the highest and lowest egg diameter was in May (1.69 mm) and in August (0.42 mm), respectively.

Bonferroni tests showed that mean fecundity mainly increased from age classes 1 to 3 years (from 2591 to 5067), and slightly increased among older females. Mean egg diameter mainly increases from age classes 1 to 2 and 4 to 6 years, and slightly increases from 2 to 4 years. This relation suggests that older fish tended to have larger eggs (Dupuis and Sutton, 2011) (Table 2). This study showed that female fish spawning for the first time produce the smallest eggs. Egg diameter increases clearly between the first and second spawning.

In conclusion, this study has provided some basic information on the age at sexual maturity and fecundity of *C. trutta* that should be helpful in similar studies. Moreover, it would be useful for fisheries biologists/managers to impose adequate regulations for sustainable fishery management in the Shour River and nearby areas of the Tigris-Euphrates basin.

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Sažetak

BIOLOGIJA RAZMNOŽAVANJA VRSTE *Capoeta trutta* (Heckel, 1843) U RIJECI SHOUR, JUGOZAPADNI IRAN

Istraživanje reproduktivnih osobina vrste *Capoeta trutta* (Heckel, 1843), izvornog ciprinida iz rijeke Shour u Iranu, vršeno je mjesečnim uzorkovanjem od srpnja 2010. do lipnja

2011.

Između 815 ulovljenih primjeraka, ukupni omjer spolova bio je 1: 1,96 (mužjaci: ženke). Mjesečne promjene gonadosomatskog indeksa (GSI) i distribucije frekvencija promjera jaja ukazuju da je mrijest trajao od siječnja do travnja.

Rezultat ukazuje da je dob prve spolne zrelosti za mužjake jedna godina, a kod ženki dvije godine. Plodnost se povećava s dobi i u prosjeku iznosi 2591 jaja za 1+ stare ženke te 11.552 jaja u zrelim ženkama kod dobi od 6+. Korelacija apsolutne plodnosti i tjelesne težine bila je visoka ($R = 0,85$). Apsolutna plodnost između svih dobnih skupina bila je statistički značajna ($p < 0,05$).

Ključne riječi: *Capoeta trutta*, rijeka Shour, biologija razmnožavanja

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