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Research Article

Age, growth, sex ratio, spawning season and fecundity of *Capoeta razii* from Sefid River in the southern Caspian Sea basin

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Abstract: Some aspects of reproductive biology of *Capoeta razii*, an endemic cyprinid species from the Sefid River in the southern Caspian Sea basin, were studied by monthly sampling throughout a year. Age, growth, sex ratio, spawning season, fecundity, gonado-somatic, modified gonado-somatic and Dobriyal indices were estimated. The sex ratio (F: M) was obtained as 1.00:2.63, and the percentage of males was greater than females. The mature males and females were longer than 88 and 148 mm in total length, and 1^+ and 2^+ in age, respectively. The spawning of *C. razii* took place from late May to late August when the water temperature was between 19.7 and 22.8°C. At the beginning of the reproduction period, the average gonado-somatic index values were 10.0% ranging from 4.03% to 15.90% in ripe females. The estimated gonadal indices showed that the ripe males were ready to spawn earlier than females. The average egg diameter was 0.99±0.65, ranging from 0.2 to 2.3 mm. The averages absolute and relative fecundity were 4386±2174 and 66.3±37.8, respectively. The absolute fecundity was significantly related to body weight and gonad weight.

Keywords: Reproductive biology; Oocyte diameter; Gonado-somatic index; Spawning season.

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Introduction

The genus *Capoeta* Valenciennes, 1842 has a wide distribution in Iran containing about 18 species (Esmaeili et al. 2018). *Capoeta razii* is commonly found in the southern Caspian Sea basin, north of Iran (Jouladeh-Roudbar et al. 2017). The southern Caspian Sea basin encompasses 156000 km, about 15.5% of the whole country (Coad 2017). This basin is located in the European area of the Eurasia (Banarescu & Coad 1991) and is one of the most various freshwater ecosystems in Iran (Coad 1995). Sefid River is the most important river in the southern Caspian Sea basin, with about 765 km length in this region (Aghili et al. 1999). One of the predominant fishes in its River is *C. razii* (Heidari et al. 2013, 2014a, b).

There are available some morphological studies on this species from the Caspian Sea basin (Heidari et al. 2013), and some biological studies on the genus from the Caspian Sea basin and the Tigris River drainage (Unlu 1991). Also, few researches have been carried out on the reproductive biology of this genus in Iran and Turkey (Duman 2004; Kalkan 2008; Sen et al. 2008; Rezai et al. 2009; Patimar & Farzi 2011; Poria et al. 2014; Javaheri & Taghavi Niya 2014).

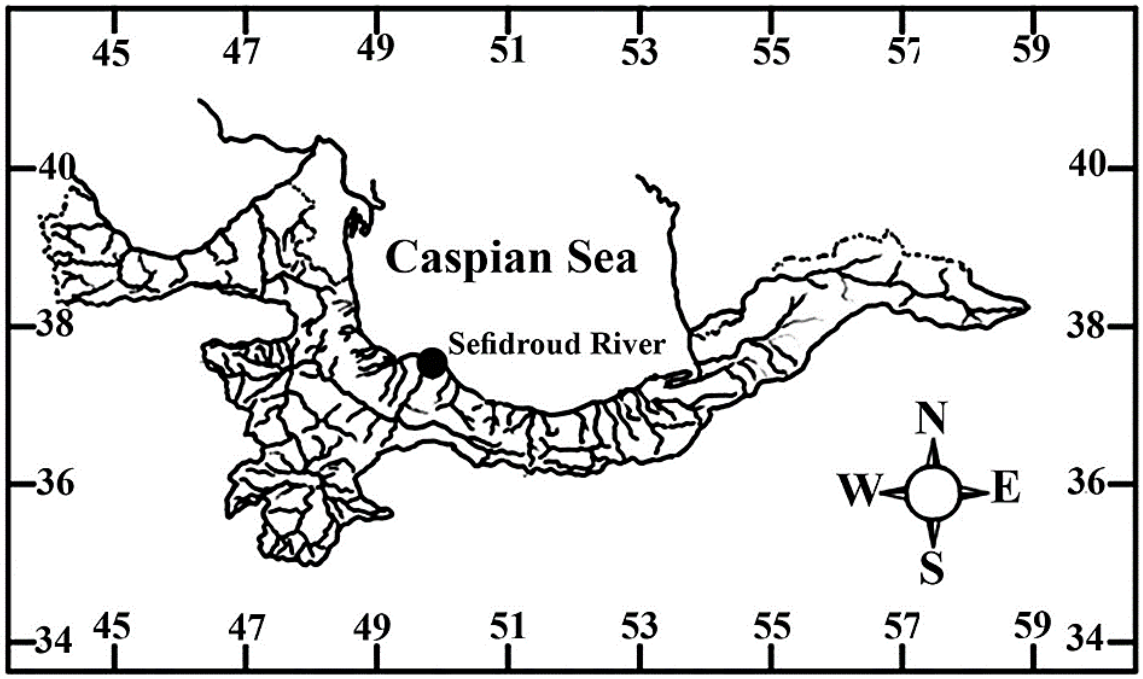

Fig.1. Location of the sampling site in the southern Caspian Sea basin, Sefid River, in north of Iran.

As studies on the reproductive biology of endemic fish species are necessary for stock management and conservation programs, and as there is no available detail about reproductive aspects of *C. razii*, therefore this study aimed to investigate various aspects of reproductive biology of this species in the southern Caspian Sea basin.

Materials and Methods

A total of 320 individuals of *C. razii* were collected from lower parts of Sefid River (37°01'16.82"-36° 50'44.71"N; 49°37'56.86"-49°35'01.23"E), in the southern Caspian Sea basin (Fig. 1). Fish were collected monthly from November 2013 to October 2014 by electrofishing device (200-300 V), with mesh size of 0.2cm. After anesthesia, the collected specimens were fixed in 10% formaldehyde, measured (TL: total length, SL: standard length to the nearest 0.1mm) and weighed (*Wb*: body weight to the nearest 0.01 g). Two samplings per month were done at the peak of spawning time. The analysis of water throughout the year showed that the temperature was 9.4-26.7°C, pH 7.29-8.04, dissolved oxygen 5-10mg.L^{-1}, and the water hardness 175-199.5 mg.L^{-1}.

To examine the monthly changes in gonads as a mean for estimating the spawning season of *C. razii,* three indices were used: GSI (gonado-somatic index), MGSI (modified gonado-somatic index) and D.I. (Dobriyal index). In order to determine the GSI (GSI= [$Wg \times Wb^{-1}$] ×100) (Nikolski 1963), MGSI (MGSI= [$Wg \times Wb^{-1}$] - $Wg \times 100$ (Nikolski 1963), and D.I. (D.I.= $\sqrt[3]{Wg}$) (Dobriyal et al. 1999), ovaries also were weighed (Wg) with 0.001g accuracy. The absolute fecundity (*Fa*) was estimated in 24 ovaries by calculating the number of oocytes with a diameter greater than 0.2mm. The relative fecundity (*Fr*) was expressed by dividing the *Fa* by the fish body weight. The result was presented as the number of eggs per gram of body weight (Bagenal 1967). To determine the ovum diameter, the ovaries were preserved in Bouin's fixative for 24 hours. The diameters of 30-60 ova of each female were measured using a Zeiss stereomicroscope model SV 6 fitted with an ocular micrometer.

The Chi-square test was used to assess deviation from a 50:50 sex ratio (Robards et al. 1999). In order to compare significant differences in the GSI

Table 1. Standard length (SL), total length (TL) and body weight (*Wb*) (mean ±SD) in different age classes of males and females *Capoeta razii* from Sefid River.

Age	N		SL (mm)		TL (mm)		*Wb* (g)	
	M	F	M	F	M	F	M	F
1+	22	15	665.0±0.47	58.4±0.70	8.09±0.58	7.09±0.77	6.71±2.04	4.22±1.30
2+	125	41	127.0±1.40	75.0±1.47	14.7±1.63	9.02±1.78	13.54±6.51	8.94±5.81
3+	67	15	116.0±1.28	124.0±12.97	13.73±1.42	14.68±3.01	29.96±9.38	41.97±23.99
4+	13	13	136.1±1.54	158.1±15.81	16.11±1.63	18.65±2.21	52.88±18.75	73.38±30.75
5+	1	-	166.0	-	175.0	-	53.07	-

Table 2. Absolute (*Fa*) and relative (*Fr*) fecundity in particular ranges of body length (SL), body weight (*Wb*) and age classes of females of *Capoeta razii* from Sefid River (*n* = number of specimens).

Parameters		*n*	*Fa*		*Fr*	
			Range	Mean ±SD	Range	Mean ±SD
SL (mm)	122.1-142	7	2293-8242	4255±2118	53-186	95±46
	142.1-162	11	1987-8315	4800±2456	32-124	65±28
	162.1<	6	1777-6480	3778±1558	20-52	35±12
Wb (g)	32.1-60	9	2045-8242	3728±1979	39-186	84±45
	60.1-90	10	1777-8315	4702±2515	20-62	62±33
	90.1<	5	2390-6667	4937±1876	16-65	44±16
Age	2+	1	3197-00	3197±00	20-00	99±00
	3+	10	1777-8242	3970±2360	20-186	74±48
	4+	13	1987-8315	4796±2106	24-117	57±29

between samples taken on various months, the analysis of variance was applied (P<0.05). The strength and significance of the relationship between the absolute fecundity and selected individual features of the females included in this study (body length and weight, the gonad weight and the fish's age) were analyzed by calculating Pearson's correlation coefficient r (P<0.05) and regression equations. The data were analyzed using SPSS Version 16.0 software package and Microsoft Excel 2010.

Results

Of 320 collected specimens, 229 males, 87 females and 4 immatures were examined. Sex ratio of the total samples (over all the seasons) was F1.00:M2.63 accounting for 27.54% females and 72.46% males. The difference between the number of males and females was significant (Chi square, X^2=31.905, P<0.05). Total length of the mature *C. razii* ranged from 56 to 235mm, standard length 45 to 100mm, fork length 51 to 110mm and total weight 13.0 to 124.16g (Table 1). The female specimens were longer and heavier than the males and achieve maturity later than males. At the age of 1^+, TL was higher than 80.0mm and body weight was about 6g. The results revealed that this population of *C. razii* had a narrow age range of 1^+ to 5^+ years. Most of the sampled fish were 2^+ (49.68%) and 3^+ (15.61%) years old, some were 1^+ (11.87%) and 4^+ (7.18%), and only one specimen was 5^+ (0.31%). The oldest females were 4^+ years old and the oldest male were 5^+ years old (Table 1).

Significant differences in male and female DI, GSI and MGSI in different months were observed (P<0.05). There were no significant differences between GSI and MGSI in the same month. Assessment of the spawning season for *C. razii* in the Sefid River was based on the examined gonadal indices (DI, GSI, MGSI; Figs. 2-3). Ovary development began at late April, peaking at May, and decreased until late August. According to the averages, the highest GSI values were estimated in the first half of May for males and in the second half of May for females. In females, the peak of D.I was 2.617 in May, falling until August (0.2973) which

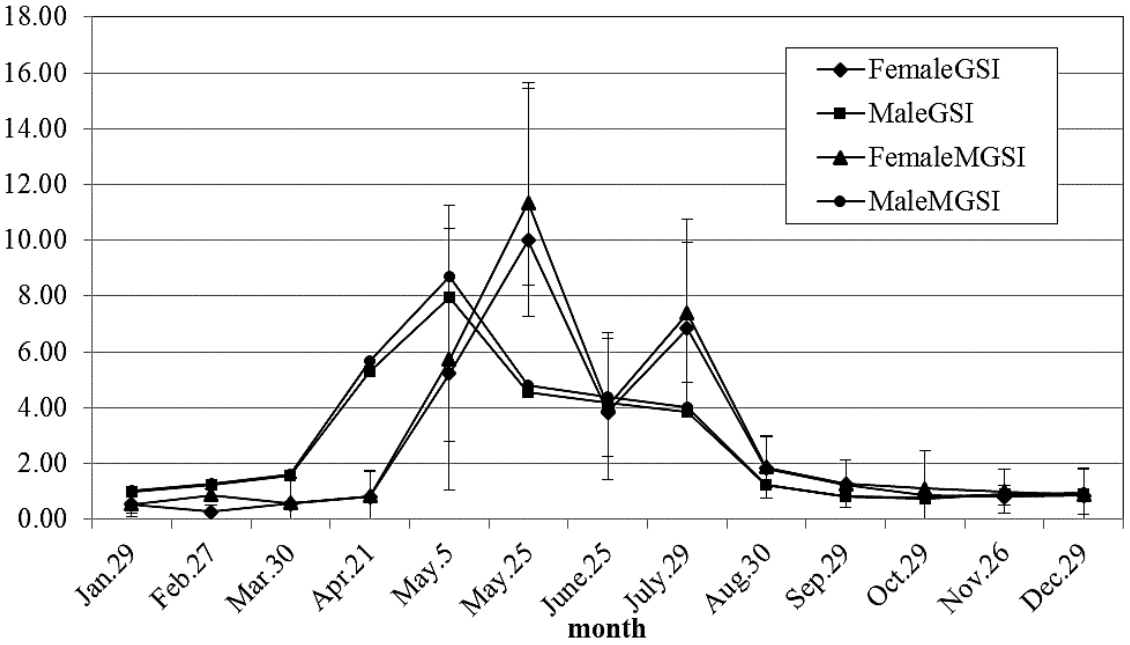

Fig.2. Variation of mean (±SE) gonadosomatic index (GSI) and modified gonadosomatic index (MGSI) of *Capoeta razii* females (F) and males (M) from the southwestern Caspian Sea basin in different months.

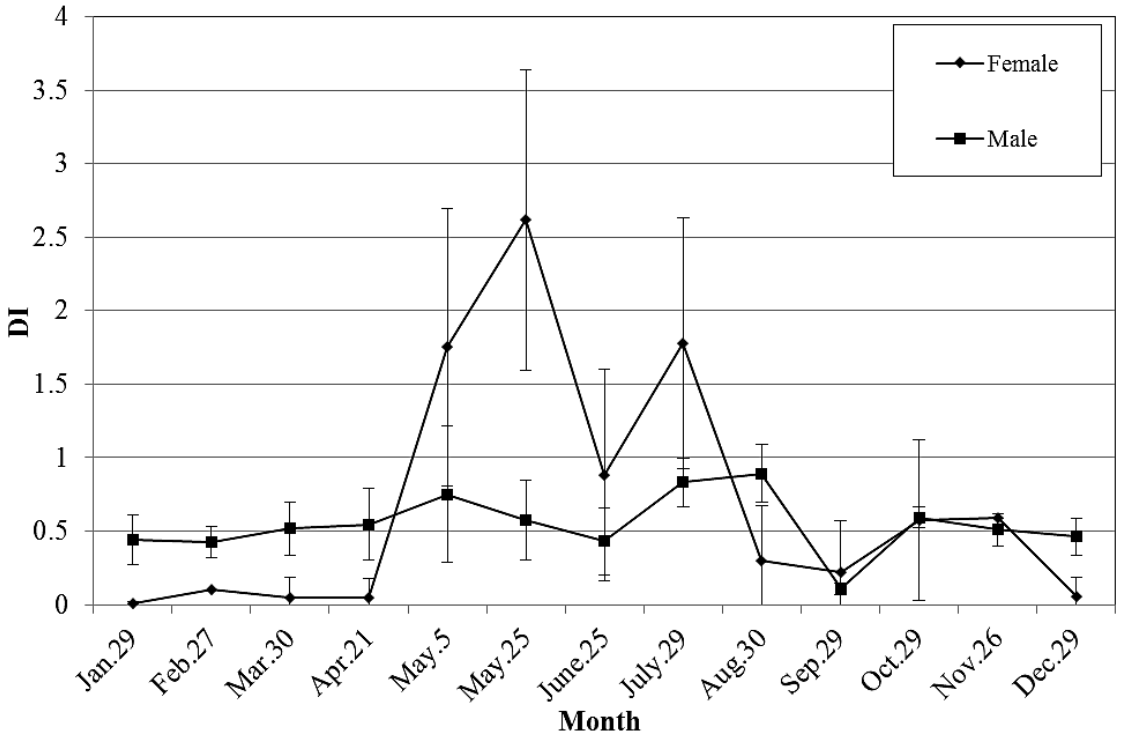

Fig.3. Variation of Dobriyal Index (DI) of *Capoeta razii* females (F) and males (M) from the southwestern Caspian Sea basin in different months.

was an indicator of attempting to spawn in these months. In males, the Dobriyal index ranged from 0.040 to 0.865.

The ovum diameter ranged from 0.2 to 2.3mm with a mean of 0.9907 (SD=±0.6547). It was highest in May and lowest in August (Fig. 4).

The absolute fecundity ranged from 1777 to 8315 eggs with an average of 4386 (SD=±2174). The relative fecundity ranged from 20 to 186 eggs with a mean of 66 (SD=±38) eggs per gram body weight

Table 3. Correlation coefficients *r* and regression equations for relationships between absolute fecundity (Fa) and body length (SL), body weight (*Wb*), gonad weight (*Wg*) and age classes of *Capoeta razii*.

Relationship	N	Liner Regression	*r*	F	P
Fa-SL	24	Y=190.17x+1326.6	0.092	0.187	0.669
Fa-Wb	24	Y=21.054x+2858.1	0.261	1.614	0.217
Fa-Wg	24	Y=249.67x+3318.3	0.424	4.809	0.039
Fa-Age	24	Y=816.25x+1528.8	0.221	1.134	0.298

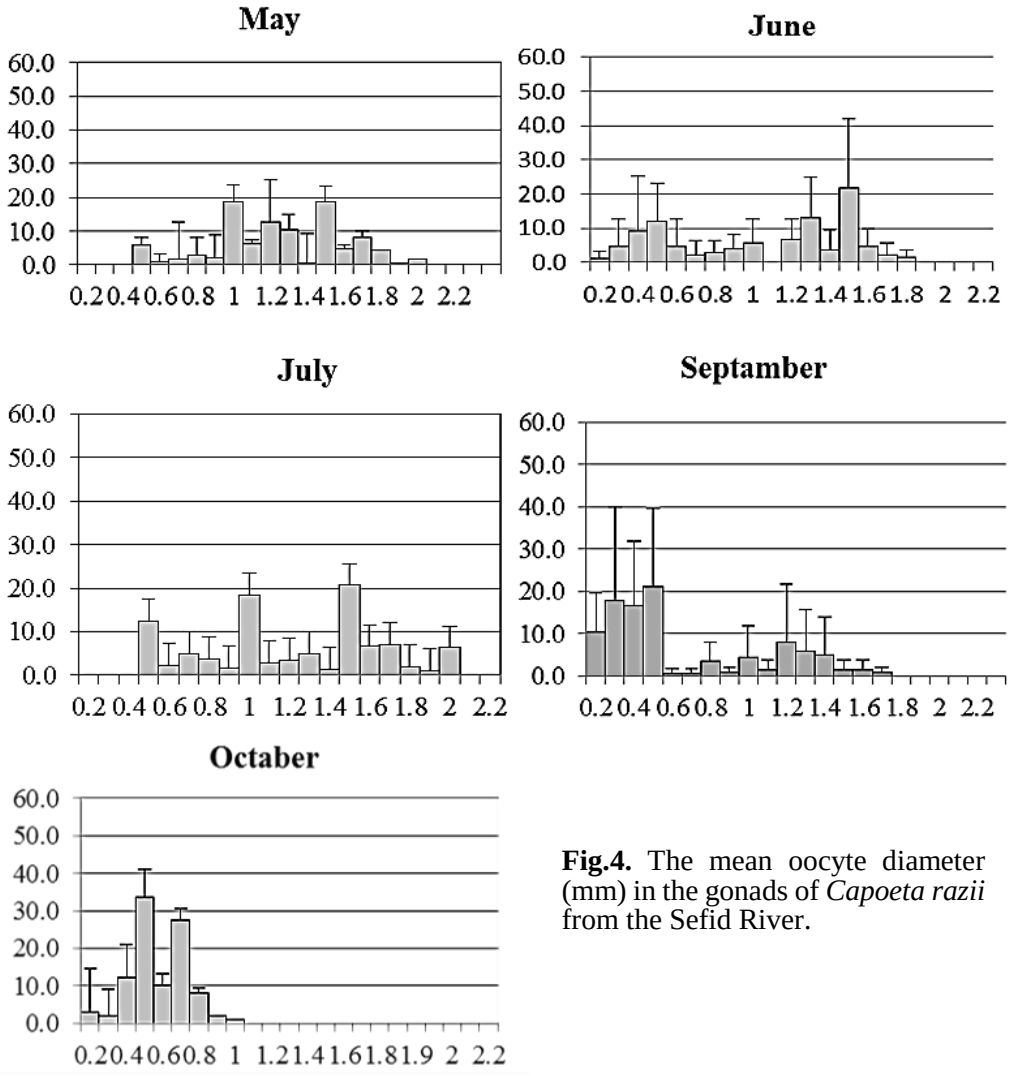

Fig.4. The mean oocyte diameter (mm) in the gonads of *Capoeta razii* from the Sefid River.

(Table 2). The relationships between total length-absolute fecundity, body weight-absolute fecundity, age-absolute fecundity, gonad weight-absolute fecundity is plotted in Table 3. The absolute fecundity was significantly related to only fish female gonad weight (P<0.05).

Discussion

Age composition of *C. razii* in the present study was determined from 1^+ to 5^+. There are some available reports on the age classes for the genus *Capoeta*, e.g., for *C. trutta,* reported age classes included 0^+ to 6^+ (Javaheri Baboli & Taghavi Niya 2014), 1^+ to 6^+ (Poria et al. 2014), 1^+ to 6^+ (Patimar & Farzi 2011), 1^+ to 7^+ (Kalkan 2008), 1^+ to 8^+ (Duman 2004), 1^+ to 8^+ (Polat 1987), and 1^+ to 10^+ (Unlu 1991). Variation in maximum age and size of fishes usually is resulted from the differences in availability of food resources, individual growth rates and natural selection processes and exploitation patterns (Patimar & Farzi

2011; Mousavi-Sabet et al. 2011, 2012, 2017).

In the present study, sex ratio was estimated 1.00:2.63 (F:M) for *C. razii* from the southern Caspian Sea basin. There are some available reports on the sex ratio (F: M) for the genus *Capoeta*, e.g., for *C. trutta* was 1.00:1.27 from Alvand River (Poria et al. 2014), 1.00:1.35 from Meymeh River (Patimar & Farzi 2011), 1.00:1.96 from Shour River (Javaheri & Taghavi Niya 2014), 1.03:1.00 from Ataturk Dam lake (Oymak et al. 2009), 0.98:1.00 from Karakaya Dam lake (Kalkan 2008), and 1.21:1.00 from Keban Dam lake (Duman 2004). The sex ratio was also recorded for *C. capoeta gracilis* (now *C. razii*) 1.00:1.50 and 1.78:1.00 from Madarsoo River (Rezai et al. 2009) and from Gorgan River (Shamekhi et al. 2012); for *C. capoeta capoeta* was 1.72:1.00 from Zerenk Dam lake (Sen et al. 2008) and 1.43:1.00 from Kockopru Dam lake (Elp & Karabatak 2007). The estimated sex ratio in the present study differed high significantly from the 1:1 ratio, also it differed from the available reports. The sex ratio in most species is close to one, but it may vary from one population to another of same species and may vary year to year in the same population (Nikolsky 1963).

The gonadal indices (GSI, MGSI and DI) trends in the present study showed that the fish spawn from mid spring through late summer. According to the average GSI, the highest values for females (10.0%) and males (7.9%) were observed in the caught specimens in late and early May, respectively. These indices showed that the ripe males were ready to spawn earlier than females. These indices decreased until August, exhibiting that almost all individuals were spawned. The mean GSI values were found to be increased gradually from October through the new spawning season. The GSI values determined by Unlu (1991) from the Tigris River were 12.03% and 1.45% in May and August for females and 6.00% and 1.05% in May and August for males. Also, the highest GSI determined by Kalkan (2008) for female *C. trutta* from Karakaya Dam Lake was 7.91% (in May), and the lowest value was 0.29% (in September). Duman (2004) reported that the highest and lowest GSI for *C. trutta* were 10.278% and 0.8230%, respectively. From the viewpoint of Duman (2004), fish characteristics associated with spawning vary with respect to their species and ecological characteristics of their habitat. Also, Nikolsky (1963) stated that the spawning characteristics of fishes are influenced by environmental factors. In species which spawn in late spring and in summer such as *C. razii*, and its sympatric species in the same basin or in adjacent basins in the region (e.g., the genera *Alburnoides*, *Alburnus*, *Cyprinion*, *Ponticola*, *Cobitis* and *Oxynoemacheilus*), gonadal indices remain low in winter and then rises sharply just before the spawn then rapid increase in the weight of ovaries takes place when the temperature rises and increasing amounts of food are consumed (Wootton 1979; Mansouri-Chorehi et al. 2016; Mohammadi-Darestani et al. 2016; Mousavi-Sabet 2012, 2017; Pourshabanan et al. 2017; Faghani-Langroudi & Mousavi-Sabet 2018).

The mean absolute fecundity of 2^+, 3^+ and 4^+ year-old *C. razii* females in Sefid River were 3198, 3970 and 4796, respectively. While the recorded fecundities are in a wide range in the genus *Capoeta* e.g., the absolute fecundity of *C. trutta* in 3^+ and 6^+ year-olds were 11995 and 28285 (Duman 2004); in 1^+ and 6^+ year-olds were 1627 and 18329 (Patimar & Farzi 2011); in 1^+ and 6^+ year-olds were 1980 and 16756 (Poria et al. 2014), and in 2^+, 3^+ and 4^+ year-olds were 3412, 5067 and 6002 (Javaheri Baboli & Taghavi Niya 2014), respectively. The absolute fecundity can be changed in relation to fish age, length and weight and especially temperature which is the most important ecological factor affecting the egg number. Differences in fecundity estimates among studies might partly be artifacts due to differences in methods or might be natural due to differences in geographical locality, time, intraspecific and inter-specific differences among species (Nikolsky 1963, 1980; Barbin & Mccleave 1997; Jonsson and Jonsson 1999).

The relative fecundity ranged from 20 to 66 eggs

per gram of the body weight, 38 on average. The average relative fecundity values were 37 and 70 for *C. trutta* (Patimar & Farzi 2011; Poria et al. 2014).

In the present study, the maximum measured ova diameter in the population of *C. razii* was 2.3mm. The reported maximum ova diameter has a wide range in the genus *Capoeta*; e.g., for *C. trutta* it was 2.02 (Poria 2014), 1.160 (Javaheri Baboli & Taghavi Niya 2014), 1.90 (Patimar & Farzi 2011), 1.85 (Duman 2004), 1.38 (Unlu 1991), 1.20, (Gul et al. 1996), 1.04, (Kalkan 2008), and 1.03 (Polat 1987). The diameter of the ovule depends on the size and species of fishes, and individuals which belong to the same species may have various ovule sizes in different regions (Zulfu et al. 2002).

Studies on the reproductive biology of endemic fish species are necessary for stock management and conservation programs, however the stock management programs on population dynamics depend on the biological and environmental characteristics of the fish (Mousavi-Sabet et al. 2015a, b). Based on reproduction parameters, it was concluded that this fish has a prolonged active reproduction period, which is a type of adaptation of short-lived small fishes to environmental conditions.

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مقاله پژوهشی

سن، رشد، نسبت جنسی، فصل تخمریزی و هماوری *Capoeta razii* از رودخانه سفیدرود، حوضه آبریز جنوبی دریای خزر

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چکیده: برخی از جنبه‌های زیست‌شناسی تولیدمثل *Capoeta razii*، از کپورماهیان بومزاد رودخانه سفیدرود در حوضه آبریز جنوبی دریای خزر، با نمونه‌گیری ماهانه در طول یک سال مورد مطالعه قرار گرفت. سن، رشد، نسبت جنسی، فصل تخمریزی، هماوری، شاخص‌های گنادی-بدنی، اصلاح شده گنادی-بدنی و دابریال محاسبه گردید. نسبت جنسی (ماده: نر) به‌صورت ۱/۰۰ : ۲/۶۳ به‌دست آمد، به‌طوری که درصد نرها بیشتر از ماده ها بود. نرها و ماده‌های بالغ به‌ترتیب بیش از ۸۸ و ۱۴۸ میلی‌متر طول و ۱ و ۲ سال سن داشتند. تخم‌ریزی *C. razii* در اواخر اردیبهشت‌ماه تا اواخر تیرماه، زمانی که دمای آب بین ۱۹/۷ و ۲۲/۸ درجه سانتی‌گراد بود، رخ داد. در ابتدای دوره تولیدمثل، میانگین مقادیر شاخص گنادی-بدنی در ماده‌های دارای گناد رسیده ۱۰ درصد بود که از ۴/۰۳ تا ۱۵/۹۰ درصد متغیر بود. شاخص‌های گنادی محاسبه شده نشان داد که نرهای رسیده زودتر از ماده‌های رسیده آماده تخم‌ریزی می‌شوند. میانگین قطر تخمک ۰/۶۵±۰/۹۹ بود که از ۰/۲ تا ۲/۳ میلی‌متر متغیر بود. میانگین هماوری مطلق و نسبی به‌ترتیب ۲۱۷۴±۴۳۸۶ و ۳۷/۸±۶۶/۶ بود. هماوری مطلق به‌طور معنی‌داری به وزن بدن و وزن گناد وابسته بود.

کلمات‌کلیدی: زیست‌شناسی تولیدمثل، قطر تخمک، شاخص گنادی-بدنی، فصل تخمریزی.