Age, sex ratio, spawning season and fecundity of *Alburnoides samiii* (Pisces: Cyprinidae), from Sefidroud River (the southwestern Caspian Sea basin)

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**Abstract.** The objective of this study was to determine reproductive biology of *Alburnoides samiii* including age structure, maturity, sex ratio, spawning season and fecundity, which are barely known. A total of 312 specimens were caught monthly from the Sefidroud River in the southwestern Caspian Sea basin, including 152 males, 128 females and 32 immature. Age, sex ratio, fecundity, oocytes diameter, gonadosomatic, modified gonadosomatic and Dobriyal indices were estimated. Regression analyses were used to find relations between fecundity and fish size (length and weight), gonad weight and age. Sex ratio differed significantly from unity, and the percentage of males was greater than that of females. This fish reached sexual maturity at a total length of 45 and 49 mm (+ in age) for females and males, respectively. The mean of oocytes diameter was calculated as 0.732 mm. Spawning was started from mid spring and latest to late summer. The gonad indices (GSI, MGSI and DI) increase from late April, peaking at early May, and decrease until late September. The averages of absolute and relative fecundities were calculated 1571 per individual and 202 per body weight in gram, respectively. The absolute fecundity was significantly related to body length and gonad weight. Based on the pattern of gonad indices, it was concluded that this fish has a prolonged active reproductive period.

**Key words:** Gonadosomatic index, Dobriyal index, Oocyte diameter, Spirlin, Iran.

**Introduction**


Since the reproduction parameters are particularly important in the management of resources, conserve and restore fish populations and asthere is no comprehensive data on biological aspects of *A. samiii*. Therefore, the main aim of the present study was to provide data on the reproductive biology of this species, including age structure, maturity, sex ratio, gonadosomatic index, fecundity, oocyte diameter, and spawning season, time and duration which are necessary for conservation programs of this fish.

**Materials and methods**

**Study area, sampling, and habitat.**

The study was carried out in downstream of the River Sefidroud in the southwestern Caspian Sea basin (Fig. 1), which is situated in Guilan prov., at the north of Iran (latitude: from 37°01'16.82" N to 36°50'44.71" N; longitude: from 49°37'56.66" E to 49°35'01.23" E). The bottom of the sampling site was commonly sandy with incidental silt and pebbles with 5-30 cm in diameter and the water was generally clear with slow running. The depths of river at the sampling sites ranged from 20 to 70 cm. Fish samples were obtained from the river monthly intervals from November 2013 to October 2014 by electrofishing (200-300 V), with mesh size of 0.5 cm. Each sampling covered about 100 meters of river. Two times sampling were done in May 2014, because of the higher reproductive activity. After anesthesia, the caught specimens were preserved in 10% formaldehyde. The water temperature, dissolved oxygen, pH and water hardness of the sample site were measured simultaneously. The parameters given above ranged 94.4-26.7 °C, 7.29-8.04, 5-10 mg L^-1 ^ and 175-199.5 mg L^-1 ^, respectively.

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**Figure 1.** Map of the southern Caspian Sea basin in north of Iran showing some of the most important rivers system and the study area, Sefidroud River.
Biometry and data analysis

Total length (TL), standard length (SL) and fork length (FL) to the nearest 0.1 mm, body weight (Wb) to the nearest 0.01 g and gonad weight (Wg) to the nearest 0.001 g were measured. The fish size at first maturity was estimated by observation of ripe gonads. To examine the monthly changes in gonads as a mean for estimating the spawning season, gonad indices including: gonadosomatic (GSI), modified gonadosomatic (MGSI) and Dobriyal (DI) were calculated following the formulas: 

\[ GSI = \left( \frac{Wg}{Wb} \times 100 \right) \]

\[ MGSI = \left( \frac{Wg}{Wb} \times 100 \right) - Wg \times 100 \]

\[ DI = 3\sqrt{Wg} \]

(Nikolsky 1963) and (Dobriyal et al. 1999). The absolute fecundity (Fa) was estimated in 26 ovaries by calculating the number of oocytes with a diameter greater than 0.2 mm. The sex of each specimen was determined using a Zeiss SV 6 dissecting microscope. Six to eight scales were removed from the left side of the body between the lateral line and dorsal fin and mounted under binocular stereoscope for age determination (Ambrose, 1989). The relationships between fecundity and body length, body weight, ovary weight, and age were determined by regression analysis. The Chi square test was used to assess sex ratio deviation from a 50:50 (Wotton, 1998). Comparison of significant differences in the GSI index between samples taken on different months was done using analysis of variance (ANOVA I). The data were analyzed by SPSS (version 16.0) software and Microsoft Excel 2010 spreadsheet.

Results

Size, sex ratio, and age.

A total of 312 specimens of Alburnoides samiii were caught, including 152 males, 128 females and 32 immature. The range of total length was 45-112 mm, standard length was 35-95 mm, fork length was 40-102 mm, and body weight was 0.8-17.3 g. The longest captured fish for male and female were 98 and 112 mm, respectively. The age of the fish ranges from 1+ to 3+ years (Table 1). The majority of the caught fish were 2+ years old (56.09%), some were 1+ (30.77%) and small percentage was 3+ (13.14%). Alburnoides samiii reached sexual maturity at total length of 45 and 49 mm (1+ in age) for female and male, respectively. The overall ratio of females to males was 1: 1.19 and \( \chi^2 \) analysis showed this to be significant (\( \chi^2 = 1.029; P < 0.05 \)).

Gonadosomatic, modified gonadosomatic and Dobriyal indices

In order to determine the reproduction period, GSI, MGSI and DI were evaluated by monthly intervals. Significant differences were observed in both female and male GSI, MGSI and DI in different months (\( P < 0.05 \)). There was no significant difference between GSI and MGSI trend for each sex (\( P > 0.05 \)). The gonad indices increased from late April, peaked in early May, and decreased in late September (Figs 2-3). In females, DI was estimated as 0.37 in early May and fall down in late September (0.02) for females. According to GSI, MGSI and DI the spawning period was started in May and continue to until late September in this region.

![Figure 2](image1.png)

**Figure 2.** Variation of mean (±SE) gonadosomatic index (GSI) and modified gonadosomatic index (MGSI) of female (F) and male (M) for A. samiii from the southwestern Caspian Sea basin in different months, from November 2013 to October 2014.

![Figure 3](image2.png)

**Figure 3.** Variation of Dobriyal Index (D.I.) and of female (F) and male (M) A. samiii from the southwestern Caspian Sea basin in different months, from November 2013 to October 2014.

Oocyte diameter and fecundity

The size of oocytes ranged from 0.1 to 1.7 mm with a mean of 0.732 (SD ±0.384). They were highest in April (1.1 mm) and May (1.14 mm) and lowest in November (0.51 mm). There was a peak in the number of yellowish-yolk oocytes (1-1.7 mm diameter) in May (Fig. 4).

The absolute fecundity varied in a wide range from 763 to 2901 eggs per specimen with an average of 1571.1 (SD ± 586.7). The relative fecundity was 88 to 412 with a mean of 202.7 (SD ± 79.8) per gram body weight (Table 2).

Significant correlations were observed between absolute fecundity and fish body length and also gonad weight (Table 3). The regression coefficient values were calculated as 0.3976 for gonad weight and 0.3318 for total body weight, respectively.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>SL (mm)</th>
<th>TL (mm)</th>
<th>Wb (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>1+</td>
<td>46</td>
<td>50.4±7.08</td>
<td>51.0±6.24</td>
<td>66.1±7.99</td>
</tr>
<tr>
<td>2+</td>
<td>97</td>
<td>62.3±8.18</td>
<td>66.2±9.46</td>
<td>74.9±13.64</td>
</tr>
<tr>
<td>3+</td>
<td>9</td>
<td>71.5±5.19</td>
<td>76.0±7.27</td>
<td>88.0±6.52</td>
</tr>
</tbody>
</table>

Table 1. Length and weight (mean ± SD) in different age groups of males and females of A. samiii from the southwestern Caspian Sea basin (SL = standard length; TL = total length; Wb = body weight; n = number of specimens; SD = standard deviation; M = male; F = female).
Table 2. Absolute ($F_a$) and relative ($F_r$) fecundity in particular ranges of body length (SL), body weight ($W_b$), and age of $A.\ samiii$ females from the southwestern Caspian Sea basin.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>n</th>
<th>$F_a$</th>
<th>$F_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL [mm]</td>
<td></td>
<td>Range</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>45.1-60</td>
<td>3</td>
<td>823-1081</td>
<td>914±145</td>
</tr>
<tr>
<td>60.1-75</td>
<td>15</td>
<td>863-2901</td>
<td>1616±185</td>
</tr>
<tr>
<td>75.1-80</td>
<td>8</td>
<td>1619-2161</td>
<td>1734±306</td>
</tr>
<tr>
<td>$W_b$[g]</td>
<td></td>
<td>Range</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>2.1-6</td>
<td>4</td>
<td>823-912</td>
<td>859±59</td>
</tr>
<tr>
<td>6.1-10</td>
<td>16</td>
<td>763-2901</td>
<td>1696±421</td>
</tr>
<tr>
<td>10.1-15</td>
<td>6</td>
<td>1140-2161</td>
<td>1714±468</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>Range</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>1+</td>
<td>2</td>
<td>837-912</td>
<td>875±53</td>
</tr>
<tr>
<td>2+</td>
<td>10</td>
<td>823-2901</td>
<td>1594±704</td>
</tr>
<tr>
<td>3+</td>
<td>14</td>
<td>762-2236</td>
<td>1654±486</td>
</tr>
</tbody>
</table>

Table 3. Correlation coefficients $r$ and regression equations for the relation between absolute fecundity ($F_a$) and: body length (TL), body weight ($W_b$), weight of ovary ($W_g$), and age of $A.\ samiii$ females from the southwestern Caspian Sea basin.

<table>
<thead>
<tr>
<th>Relation</th>
<th>n</th>
<th>Linear regression</th>
<th>$r^2$</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_a$ - SL</td>
<td>26</td>
<td>$y = 29.874x - 559.69$</td>
<td>0.2343</td>
<td>7.345</td>
<td>0.012</td>
</tr>
<tr>
<td>$F_a$ - $W_b$</td>
<td>26</td>
<td>$y = 81.862x + 903.97$</td>
<td>0.1101</td>
<td>2.968</td>
<td>0.098</td>
</tr>
<tr>
<td>$F_a$ - $W_g$</td>
<td>26</td>
<td>$y = 460.31x + 1164.80$</td>
<td>0.1381</td>
<td>4.507</td>
<td>0.044</td>
</tr>
<tr>
<td>$F_a$ - Age</td>
<td>26</td>
<td>$y = 234.77x + 1011.30$</td>
<td>0.0650</td>
<td>1.669</td>
<td>0.209</td>
</tr>
</tbody>
</table>

Discussion

Age and size of fish
Most of the examined fish were 2+ years old, some were 1+ and small percentage was 3+ (13.14%). Matthews (1998) stated that a proportion of oldest specimens is low indicates that very few individuals survive to maximum age, as is typical of most fishes. The examined $A.\ samiii$, were mature at 1+ in age for both sexes. In Azerbaijan, maturity in $A.\ bipunctatus$ is attained at 1-2 years and life span is 3 years.
(Abdurakhmanov, 1962). In the studied specimens, body length and weight of females were larger than males also males were darker than females in body colour (especially in the reproductive period). In this regard and by comparison between female and male spirlin, Bura et al. (2008) stated that average body length and weight, and maximum body height in females is bigger than males.

Reproduction
The gonad indices (GSI, MGSI and DI) were low in winter and then increased at the beginning of spring, peaked at the mid of spring and then decreased until late summer. The process of accumulating reserve substances in the ovaries of the females can be obtained partly by tracing the changes in the gonad indices. In species which spawn in late spring and in summer such as spirlin, these indices remain low in winter and then increase sharply just before the spawn (Wootton 1979, Marconato & Rassoto 1989, Rinchard & Kestemont 1996). A rapid increase in the weight of ovaries takes place when the temperature rises and increasing amounts of food are consumed (Wootton 1979).

Spawning of A. samii started from beginning of May and latest to late summer, which at the late September the ovaries of most of the spirlin under study indicated the end of the reproductive period. While a shorter spawning period is reported for Alburnoides sp. from Rudava stream, in western Slovakia (Poláčik & Kovač 2006), and from the Keselian stream in the southeastern Caspian Sea basin (Seifali et al. 2012). It has been found that the reproductive indices for females were always higher than for males. Papadopol and Cristofori (1980) reported a large reproductive potential of spirlin in Romania, where it reproduces four to five times in a season. It can be concluded that the potential spawning period in these fishes (Alburnoides sp.) is very prolonged (Bless, 1994).

Our obtained results showed that the spawning season of A. samii started from the mid spring to late summer (19.7-22.8 °C), while Abdurakhmanov (1962) reported that spawning of A. bipunctatus takes place in spring (April-June) at 13-15.6°C and Yildirim (1999) concluded that A. bipunctatus fasciatis (Nordman, 1840) began to spawn at the end of May when water temperature was 16 °C and the spawning continued to the end of the July when water temperature was 25°C.

Fecundity and oocyte diameter
In this study, the average absolute fecundity of female A. samii from the southwestern Caspian Sea basin was 1571 (±586.70) eggs per individual, ranging from 763 to 2901. In a related study, Seifali et al. (2012) stated that the mean absolute fecundity of female A. bipunctatus was 1723 (±653.88) eggs per individual. Alburnoides bipunctatus fasciatis, from the Olthu Stream (Turkey) has been reported to attain mean absolute fecundity 13135 eggs (Yildirim et al., 1999). The wide and significant difference between mean absolute fecundity of spirlin from Turkey (Yildirim et al. 1999; 13135 eggs) and Iran (the present study and Seifali et al. 2012, 1571-1723 eggs) may be due to the bigger mean size of the Turkish females (mean fork length 103 mm vs. 72 mm, mean weight 18.9 g vs. 6.18 g). It is well known that fecundity is affected by species, age, size, feeding, season and environmental conditions (Thorpe 1984, Fleming & Gross 1990).

Oocyte diameter distribution analysis shows that the reproductive season was absolutely protracted (from late May to late September), a common feature for batch spawner fishes. Spirlin is reported to belong to batch spawners (fractional, partial, heterochronal; Papadopol and Cristofori 1980, Bless 1996, 2001, Breitenstein and Kirchhofer 2000). Statistically significant relationships were found between the absolute fecundity and body length and gonad weight in A. samii. A large fish lays more eggs than a small one, and the correlation of fecundity with weight in most fish is higher than that with length, which in turn is higher than that with age (Nikolsky 1969).

The results of this study provide the first data on reproductive biology of A. samii, including age structure, maturity, sex ratio, gonadosomatic index, fecundity, oocyte diameter, and spawning time and duration. From the point of view of management, the obtained information is useful for conservation programs of this fish. Upstream of Sefidroud River is more preferred for living by A. samii, since there are more individuals. Spawning in this species takes place between early May and late September, although in some cases a later starting and shorter period is reported, the reproductive cycle starting earlier and its duration being longer in lower latitudes. This population of spirlin had a narrow age range (1+ to 3+ years), which most of the examined fish were 2+ years old. Based on our observation during the sampling and the obtained results, it can be concluded the population of A. samii (and probably other fish species in the river) is under pressure by habitat degradation and illegal sport fishing. So, an urgent habitat protection and a limited fishing activity are suggested.

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References


