

ORIGINAL ARTICLE

Biological traits of the endemic Kiabi Loach (*Oxynoemacheilus kiabii*) from western Iran

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Abstract

Despite describing Kiabi loach (*Oxynoemacheilus kiabii*), lack of information on biological characteristics is evident in the scientific literature. This study reports for the first time some information about life history traits of endemic *O. kiabii*, based on 205 specimens collected from the Gamasiab River, Hamedan Province, in western Iran from March to June 2011. The species was found at a limited number of sites within the drainage system, suggesting restricted population support. The maximum age was 3⁺ years for both sexes. The males ranged from 32 to 63 mm and 0.37 to 3.63 g, and females from 34 to 71 mm and 0.43 to 4.11 g. Length-weight relationship (LWR) was estimated as $TL = 0.0107 \times TW^{3.10}$ for males, $TL = 0.0173 \times TW^{2.80}$ for females, and $TL = 0.0146 \times TW^{2.91}$ for sexes combined, implying positive allometric growth for males and negative for females and population. The sex ratio was 1:1.50 in favor of females. The spawning of *O. kiabii* in the Gamasiab River took place from April to late May. At the beginning of the reproduction period, the average GSI values were 2.05 ± 0.90 for males and 10.40 ± 3.44 for females. The absolute and relative fecundity were 507.23 ± 345.19 (S.D.) eggs/female and 283.89 ± 79.30 (S.D.) eggs/g of body weight, respectively. Ova diameter ranged from 0.45 to 1.15 mm with a mean value of 0.70 ± 0.13 (S.D.). There was a positive significant effect of fish size on both absolute and relative fecundities, and diameter of oocytes as well. Considering the results, the given information on the species is unique and important for conservation of species and the biodiversity as well.

Keywords: *Oxynoemacheilus kiabii*, Age, Growth, Reproduction, Gamasiab River, Iran

INTRODUCTION

Iranian loaches have been placed in several genera and species, which belong to family Nemacheilidae. Members of this family are found from Bulgaria east to Iran (Kottelat & Freyhof 2007). This family comprises 48 species belonging to 6 genera recorded from Iran, widely distributed in inland drainages (Jouladeh-Roudbar et al. 2020). Golzarianpour et al. (2011) introduced *Oxynoemacheilus kiabii*, a new Nemacheilid species from the Karkheh River, western Iran in 2011. The species is thought to be widely distributed across major drainages in western Iran (Jouladeh-Roudbar et al. 2020). The species is new taxa, and detailed description of its life history has not been given in the literature. However, data is deficient for about the species' life history aspects, including population trends over its range distribution. In this context, examination of the basic biological parameters (e.g. growth and reproduction) for each species is fundamental for understanding species' life history patterns and important with respect to implementing effective management and conservation measures for the species.

In light of this hypothesis, the present contribution

serves to describe detailed basic life history, including age, growth and reproduction, of the *O. kiabii* from the Gamasiab River in the Hamedan province, western Iran, a first documentation for the species biology, thereby contributing to its future conservation.

MATERIAL AND METHODS

The Karkheh drainage and Gamasiab River as its main stream are situated in western Iran. In terms of conservation, the drainage is of special concern because it contains a high proportion of endemic fish species. The unique fish fauna of the drainage is threatened due to a variety of factors, including habitat degradation by human activities, water removal and pollution and the introduction of exotic fishes (Jouladeh-Roudbar et al. 2020). The study was conducted in the Gamasiab River, one of tributaries of the Karkheh drainage, situated in the Hamedan Province, western Iran (Afshin 1994). The specimens were caught monthly from March to June 2011 by electro-fishing (D.C. at 150–200 V, 50 Hz frequencies and one anode). This zone is, located along the Zagros Mountains biome with a semi-arid climate. The sampling area is a small stream (mostly

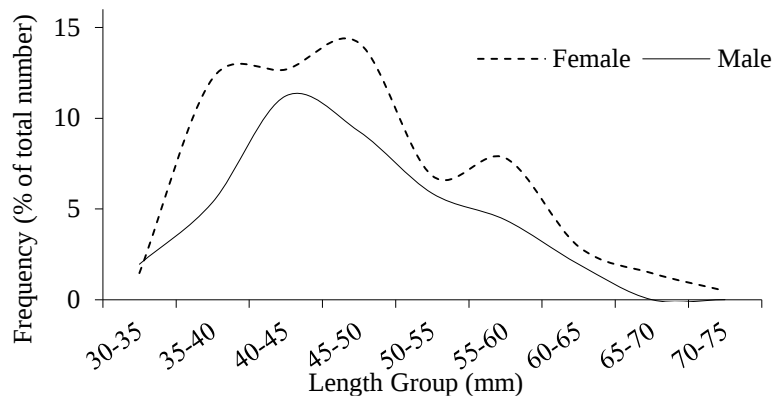


Fig.1. Total length (mm) frequency of males and females of *O. kiabii* in the Gamasiab River- Karkheh drainage, western Iran.

<2m wide) that feeds into the Gamasiab River. The shape of the area river bottom was natural, with riffles, runs and pools, but had steep riparian banks leading up from the water's edge on either side. The stream bottom was composed mainly of gravel, pebbles and sand, with some silt deposits (Afshin 1994). In the field, all fish specimens were immediately preserved in 10% formaldehyde until they could be examined. A total of 205 specimens were analyzed. In the Ichthyology laboratory of Gonbad Kavous University, all specimens were measured for total length (TL), total body weight (TW) and gonad weight (to the nearest 0.01g). Age was determined from both left and right opercula; banding patterns being reviewed three times (each time by a different person) using a 20-40× binocular microscope under reflected light. Length frequency distribution analysed using Sturges' formula. The relationship between TL and TW was determined using the equation: $TW = aTL^b$; where a is the intercept and b is the slope (coefficient of allometry), as per Pauly (1984). Sex was determined by visual examination of the gonad tissue. The gonadosomatic index ($GSI\% = \frac{\text{gonad weight}}{TW} \times 100$) was calculated for each fish and mean values calculated for each sampling date. The ovaries of 58 ripe females at maturity stage IV were used to estimate absolute (AF) and relative (RF) fecundity. The ovaries were removed, weighed and placed in Gilson's fluid for 1-3 days to harden the eggs and dissolve the ovarian membranes. AF was estimated using the gravimetric method, using three pieces removed from the anterior, medial and posterior of the ovary (Bagenal & Tesch 1978). Mean egg diameter was examined by measuring 25-30 eggs taken randomly from the ovaries of the females used for fecundity determination. Measurements were made to the nearest 0.05 mm using a microscope fitted with an

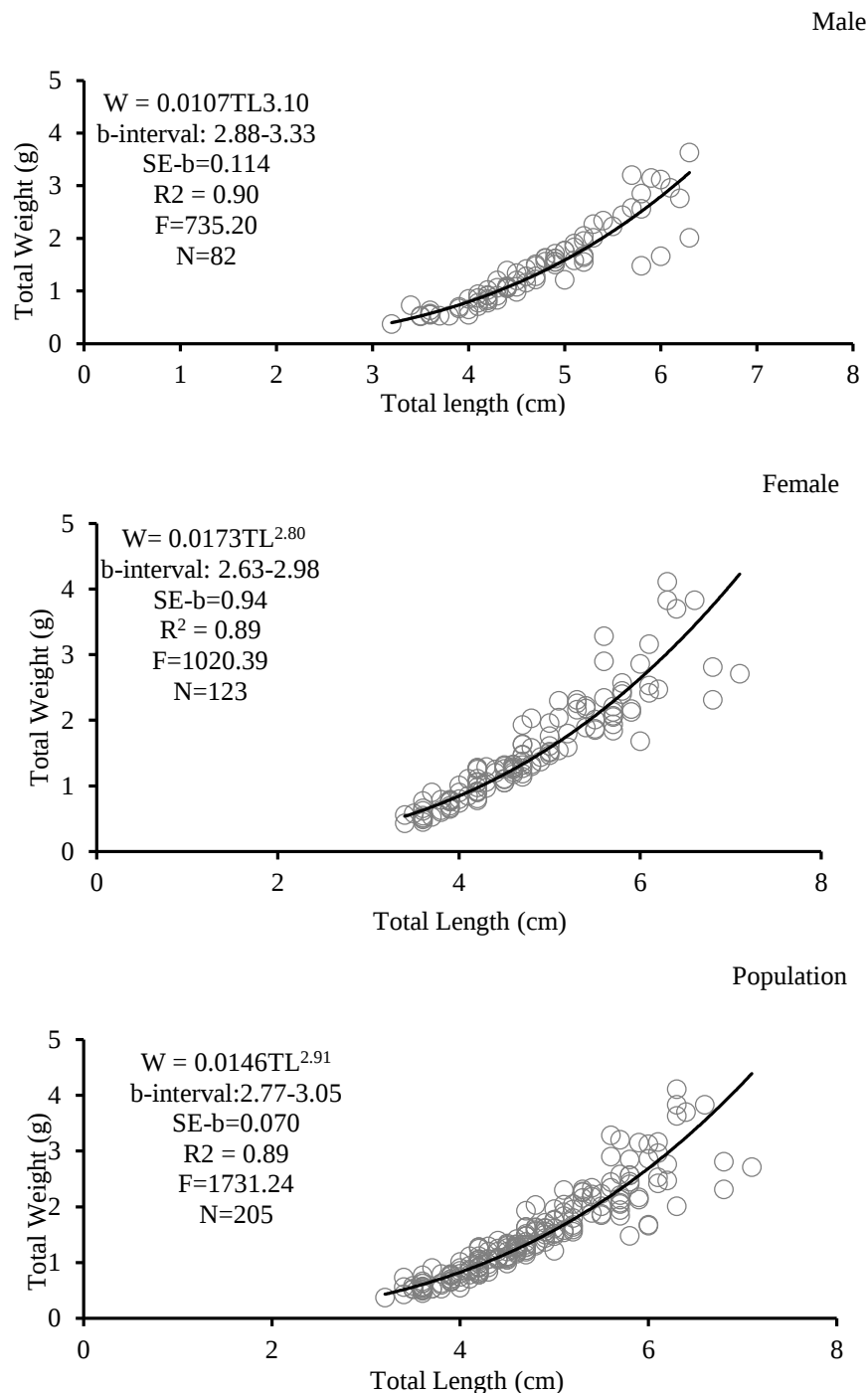
ocular micrometer. Analysis of co-variance (ANCOVA) was performed to test for significant differences in weight-length relationships between sexes. Any significant difference in the overall sex ratio was assessed using the chi-square test (Zar 1984). Comparison of GSI values between sexes was carried out by analysis of variance (ANOVA). All statistical analyses were performed with a significance level of $P < 0.05$ using the SPSS 21 software package.

RESULTS

During this study, 205 specimens of *O. kiabii* were caught, with a total length ranging from 32 to 71mm (47.38 ± 8.05 mm) and total weight from 0.37g to 4.11g (1.49 ± 0.77 g). Male specimens ranged from 32 to 63mm (47.01 ± 7.47) and 0.37 to 3.63 g (1.43 ± 0.74 g). Females ranged from 34 to 71mm (47.62 ± 8.45) and 0.43 to 4.11g (1.52 ± 0.77 g). Length frequency distribution of the fish (Fig. 1) indicated that the most frequent size classes in the samples were 45-50mm for males and 40-45mm for females. Males were absent in the length classes larger than >65mm TL. Opercula readings revealed that the older recorded ages were 3⁺ for both sexes. In the population, observed length-at-age were different between sexes, females were longer and heavier than males (ANCOVA, $P < 0.05$) (Table 1). Length-weight relationships evaluated by using the lengths and weights were found significant with the high regression coefficient ($r > 0.89$). The b-value implies that the body shape of males displays positive allometric form, while that of the females and population showed negative growth model (Pauly's t-test). The length-weight curves of the samples were plotted in Figure 2.

Table 1. Total length (TL mm) and body weight (W g) (mean±SD) in different ages of *O. kiabii* males and females in the Gamasiab River, Karkheh drainage, western Iran.

Ages	Females (N=123)		Males (N=82)	
	TL±SD	W±SD	TL±SD	W±SD
1+	42.37±4.15	1.11±0.43	41.06±2.93	0.82±0.21
2+	52.35±6.68	1.97±0.62	49.35±2.49	1.61±0.25
3+	64.11±3.55	3.03±0.69	58.80±2.65	2.70±0.41

**Fig.2.** Relative growth curves (Total length cm-Total weight g) for *O. kiabii* in the Gamasiab River, Karkheh drainage, Western Iran.

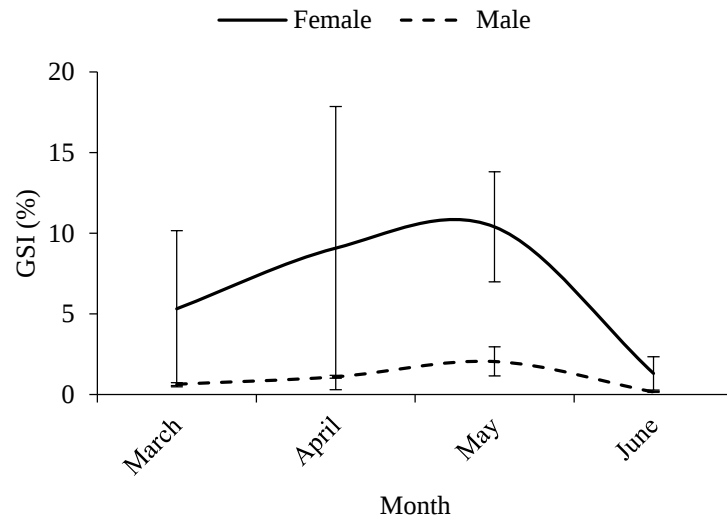


Fig.3. Monthly variation of GSI in *O. kiabii* in the Gamasiab River, Karkheh drainage, western Iran.

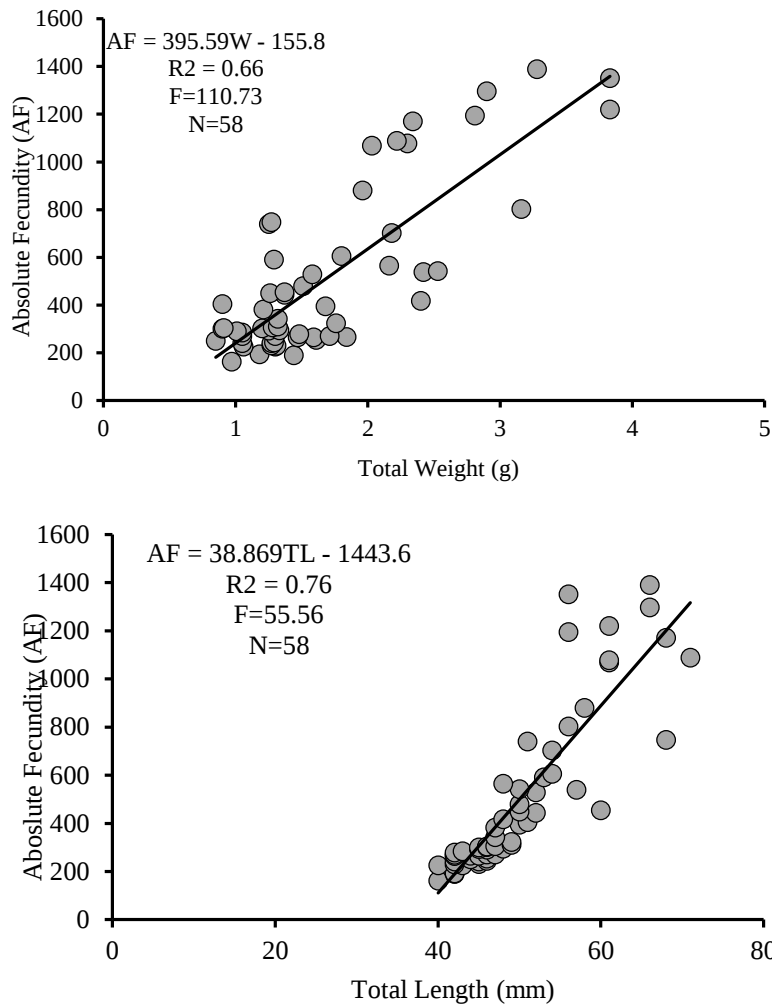


Fig.4. Relationship between absolute fecundity (AF) and total weight (g) and total length (mm) of female *O. kiabii* in the Gamasiab River, Karkheh drainage, western Iran.

The overall ratio of males to females was 1:1.50, and Chi-square analysis indicated a significant difference from

the expected ratio of 1:1 ($\chi^2=8.20$, $P<0.05$). Considering the distribution of sexes in length classes (Fig. 1), an

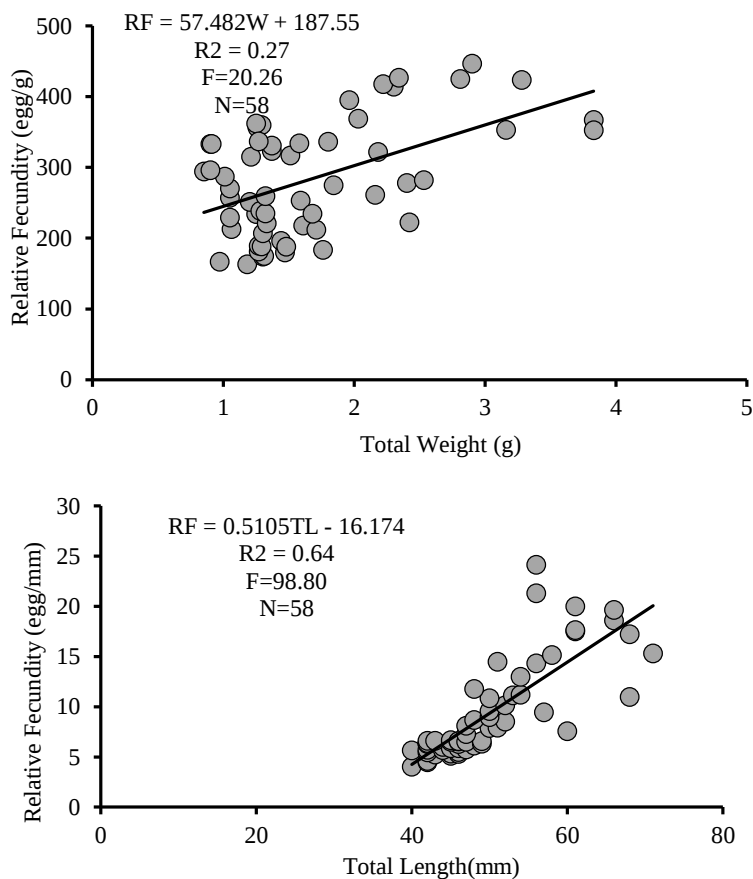


Fig.5. Relationship between relative fecundity (RF) and total weight (g) and total length (mm) of female *O. kiabii* in the Gamasiab River, Karkheh drainage, western Iran.

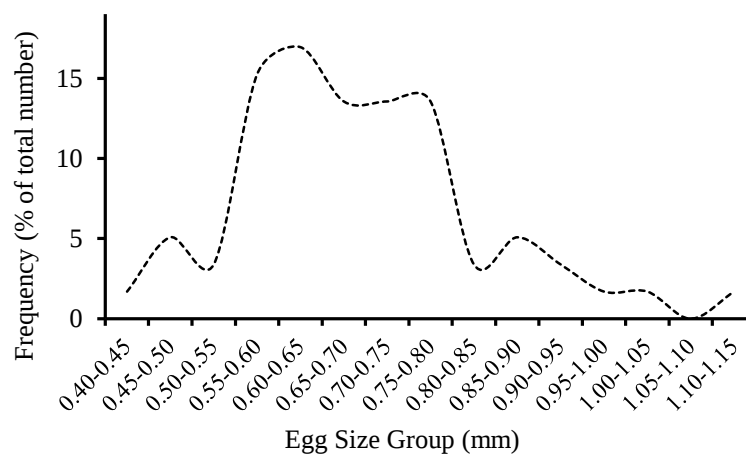


Fig.6. Size frequency distribution of oocytes diameters of *O. kiabii* in the Gamasiab River, Karkheh drainage, western Iran.

unequal sex ratio was observed among the classes, females were dominant in the all size classes, which in turn increases the survival of the species in changing environmental conditions.

Significant differences in female and male GSI in different months were observed (ANOVA, $P < 0.05$) (Fig. 3). The GSI values of males were significantly lower than

those of females (ANOVA, $P < 0.05$). The highest average recorded values of GSI were 2.05 ± 0.90 (SD) and 10.40 ± 3.42 (SD) in May for males and females respectively. Following the seasonal cycle of the gonadosomatic index, the reproductive period for this species in the river is extended from April to May when GSI is considerably higher. It thereafter decreases in June

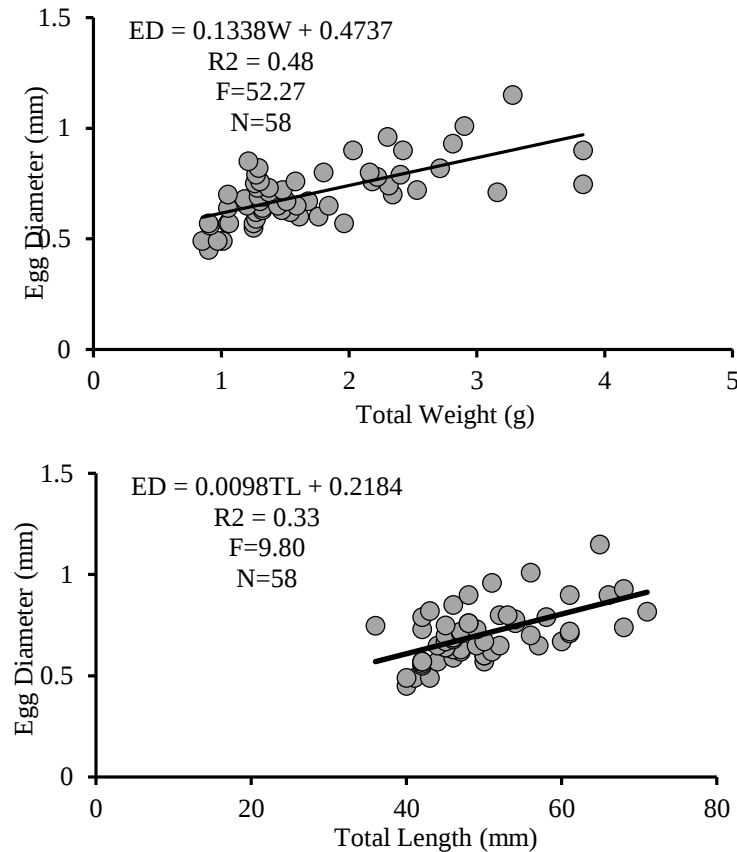


Fig.7. Relationship between ova diameter and total length (mm) and total weight (g) of female *O. kiabii* in the Gamasiab River, Karkheh drainage, western Iran.

showing start of the resting period.

It was observed that the absolute fecundity related to the growth of age, weight and length of the female fishes. Individual values of the absolute fecundity varied in a wide range from 161 to 1389 eggs with an average of 507.23 ± 345.19 (SD). The relative fecundity varied 163 to 447 eggs/g with a mean of 283.89 ± 79.30 (SD) per gram body weight. The absolute fecundity was significantly related to fish female total weight and also gonad weight. The linear function was found significant for expressing the AF/W (g) and AF/TL (mm) relationships (Fig. 4). All the correlation coefficients examined between the fecundity and each of independent variables, are judged to be moderate and statistically significant ($P < 0.05$).

The relationships of relative fecundity (per gram) (RF) with body size (both length and weight) were found to be statistically significant ($P < 0.05$) (Fig. 5).

The ova diameters ranged from 0.45 to 1.15mm with a mean value of 0.70 ± 0.13 (SD). Size frequency distribution of the eggs indicated that the most frequent sizes in the ovaries were between 0.60-0.80mm (Fig 6). Ova diameter was correlated with female total length and weight

significantly (Fig. 7).

DISCUSSION

Because of lack of data on the *O. kiabii*, it is rather difficult to describe the current position of biology and ecology of the species. The sample size clearly indicates that the species has a population distributed in the river with low numbers, indicating that the species may be at risk because of ecological threats.

The population displays an age structure in which the younger age-classes are underrepresented in the overall sample. Longevity proved to be 3 years, which is in line with observations made in other for other loach species, indicating that the species has a relatively short life span, a trend common to the loaches (Kottelat & Freyhof 2007).

Our analyses revealed sexual dimorphism in growth, though females have occasionally been found to grow more rapidly than males. Males *O. kiabii* have a smaller body size compared to females, confirming the general sexual dimorphism for species of the family Nemacheilidae (Kottelat & Freyhof 2007). The narrow size range of age groups indicates a single short spawning season producing

single cohort. This increases the vulnerability of the species in nature.

Weight-length relationships produced good fits and could be used for comparison purposes. The total length-somatic weight relationship showed that growth model was different between the males and females, suggesting an apparent difference in fitness condition between sexes. The b -value > 3 for males of *O. kiabii* indicating that the fish becomes more rotund as length increases with age (Bagenal & Tesch 1978). Analysis of the data available in the literature (Slávik & Ráb 1996; Przybylski & Valladolid 2000; Soriguer et al. 2000; Patimar et al. 2011a,b; Mouludi-Saleh et al. 2023) shows that the value of b in loach species can vary considerably, indicating a change in body form with species, itself probably an effect of different environmental habitat conditions and species characteristics (i.e. morphological characteristics of the species).

Females were significantly more abundant than males, a pattern also common among species of the family Nemacheilidae (Kottelat & Freyhof 2007). The relatively low abundance of males may be related to their more susceptibility to extreme environments than the females, consequence of a higher survival rate of adult females. However, it is not clear which factors might be responsible in the female's domination in the species, so this imbalance can hardly be explained. A similar female biased sex ratio has also been observed in other species of Nemacheilidae (e.g. *Paracobitis malapterura*, Patimar et al. 2009, *Barbatula barbatula*, Vinyoles et al. 2010). Bohlen and Ritterbusch (2000) have proposed that males of genus Cobitis are more vulnerable to predation due to their smaller size.

For the species, reproductive investment is not homogeneous throughout the age-classes; fecundity is low in 1⁺ females, but steadily rises in the subsequent age-classes, indicating positive effect of age on fertility. The absolute fecundity of the species corresponded well with range values reported elsewhere for other loaches (Kottelat & Freyhof 2007). The maximum absolute fecundity value of 1389 eggs from a 3⁺ years old *O. kiabii* female is lower than the 1400 eggs (Lobon-Cervia & Zabala 1984) and 1986 eggs (Oliva-Paterna et al. 2002) observed for *C. paludica*, and the 4282 eggs for *C. taenia* (Bohlen 1999) and 4666 for *C. cf. satunini* (Patimar et al. 2011a), and higher than 1180 for *P. malapterura* (Patimar et al. 2009) and 1246 for *Metaschistura cristata* (Patimar et al. 2011b). Compared with these loach species, therefore, the species

is characterized by moderate fecundity, meaning moderate parental investment in this species.

The spawning of *O. kiabii* in the studied locality occurred once according to our observations and lasted 4 weeks, started from late April, potentially in May. This rather short period of reproduction may be a result of the unstable river environment in the sampling area. The course of spawning is similar to those of other loach species: *C. cf. satunini* (April-May) (Patimar et al. 2011a), *P. malapterura* (April-May) (Patimar et al. 2009) and *M. cristata* (April) (Patimar et al. 2011b). The mean maximum GSI values for females *O. kiabii* are commonly lower than those for *C. cf. satunini* (Patimar et al. 2011a) and *M. cristata* (Patimar et al. 2011b), and higher than that for *P. malapterura* (Patimar et al. 2009), which could be interpreted through a moderate energetic investment in reproduction.

In summation, the present study reports the first documentation on *O. kiabii*, indicating age, growth and reproduction. Although the Karkheh River Basin has priority areas for ichthyodiversity conservation in western Iran, there is no officially protected area for the fishes. In this sense, understanding the geographical distribution and spawning of the species are essential to promote strategies and select priority areas for conservation of the species. Additionally, this species must be considered as vulnerable as regards its future survival.

Even though the information given in the present study is of great importance for the conservation of the species, it is necessary to conduct a more comprehensive study in different range distribution of species. In general, a comprehensive temporal-spatial research on such endemic species of Iran is necessary, which this work has covered only a small part of it.

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مقاله کامل

ویژگی‌های زیستی جویبارماهی کیابی (*Oxynoemacheilus kiabii*) از غرب ایران

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چکیده: علی‌رغم توصیف جویبارماهی کیابی (*Oxynoemacheilus kiabii*)، کمبود اطلاعات در مورد خصوصیات زیستی آن در منابع علمی مشهود است. مطالعه حاضر، برای اولین بار اطلاعاتی را در مورد ویژگی‌های زیستی گونه بومی *O. kiabii* را براساس ۲۰۵ نمونه جمع‌آوری شده از رودخانه گاماسیاب استان همدان در غرب ایران در فاصله زمانی اسفند ۱۳۸۹ تا خرداد ۱۳۹۰ گزارش می‌کند. حداکثر سن ۳+ سال برای هر دو جنس بود. نرها بین ۳۲ تا ۶۳ میلی متر و ۰/۳۷ تا ۰/۶۳ گرم و ماده ها از ۳۴ تا ۷۱ میلی متر و ۰/۴۳ تا ۴/۱۱ گرم بودند. رابطه طول-وزن (LWR) برای نرها $TL = 0.0107 \times W^{3.10}$ ، برای ماده‌ها $TL = 0.0173 \times W^{2.80}$ و برای جمعیت $TL = 0.0146 \times W^{2.91}$ به‌دست آمد که نشان‌دهنده رشد آلومتریک مثبت برای نرها و آلومتریک منفی برای ماده‌ها و جمعیت است. نسبت جنسی ۱:۱/۵ به نفع ماده‌ها بود. تخم‌ریزی *O. kiabii* در رودخانه گاماسیاب از فروردین تا اواخر اردیبهشت ماه انجام می‌شود. در ابتدای دوره تخم‌ریزی، میانگین مقادیر GSI برای نرها 2.05 ± 0.09 و برای ماده‌ها 10.4 ± 3.44 بود. هم‌آوری مطلق و نسبی به‌ترتیب $50.7 \pm 23.45/19$ (S.D.) تخمک در ماده و $23.8/8.9 \pm 7.9/30$ (S.D.) تخمک در گرم وزن ماده‌ها بود. قطر تخمدان از ۰/۴۵ تا ۱/۱۵ میلی‌متر با مقدار متوسط 0.7 ± 0.13 (S.D.) متغیر بود. اثر مثبت و معنی‌داری اندازه ماهی بر روی هم‌آوری مطلق و نسبی و قطر تخمک وجود داشت. با توجه به نتایج، اطلاعات ارائه شده در خصوص این گونه منحصر به‌فرد بوده و برای حفاظت از گونه و تنوع زیستی دارای اهمیت می‌باشد.

کلمات کلیدی: *Oxynoemacheilus kiabii*، سن، رشد، تولیدمثل، رود گاماسیاب، ایران