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Some aspects of the life history of *Cobitis avicennae* (Actinopterygii: Cypriniformes: Cobitidae) from Western Iran

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ABSTRACT

Objective: To describe the age structure, growth, reproductive characteristics and length-weight relationship of *Cobitis avicennae* (*C. avicennae*) population inhabiting the Gamasiab River, Western Iran.

Methods: *C. avicennae* was collected throughout the spawning season (February to July, 2015) in Gamasiab River and its age, growth, and reproductive traits were investigated. Total length was measured to the nearest 1 mm, and total weight and gonad weight to the nearest 0.001 g. The age was determined using operculum. Sex was determined by examination of the gonad tissue. The number of eggs was estimated by gravimetric method. Average egg diameter was examined by measuring 30 eggs for each female with an ocular micrometer microscope.

Results: The maximum age was 3 years. The specimens size ranged from 32.63 to 100.00 mm in total length, weighing from 0.22 to 5.17 g in total weight. Length-weight relationship was estimated as $W = 1E{-}05TL^{2.85}$ for females, $W = 1E{-}05TL^{2.83}$ for males and $W = 7E{-}06TL^{2.94}$ for the population. The growth model was isometric for males and sexes combined and negatively allometric for females. The absolute fecundity ranged between 132 and 900 eggs with a mean of 490.55 eggs.

Conclusions: The life history traits described for *C. avicennae* from the Western Iran basin indicated a moderate life span, a moderate body weight, a short duration of spawning season, relatively high heterogeneity in egg size and low egg number. Some life history traits of *C. avicennae* demonstrated obvious differences compared with its closely related species, indicating that latitude and local environment conditions are important selective forces for this species.

1. Introduction

The *Cobitis* genus fishes are represented in Iran by three valid species. These species are *Cobitis linea*, *Cobitis faridpaki*[1] and *Cobitis keyvani* (*C. keyvani*)[2]. *Cobitis faridpaki* and *C. keyvani* are found in the Southern Caspian Sea basin. However, some researchers reported that the spined loach *Cobitis taenia* Linnaeus, 1758 (*C. taenia*) was also found in the basin[3]. While some others believe that the fish cannot be *C. taenia*; *C. taenia* is rather a Northern European species and its occurrence in the Southern Caspian Sea basin is unlikely[4]. *Cobitis linea* was found in the Kor River basin and the upper Kul River drainage of the Hormozgan basin[5,6]. Species of this family are small benthic freshwater fishes with a wide distribution area covering large parts of Eurasia and Africa[7]. Spined loach during the day remains buried in sand, mud or dense weed growths, being active at night, and is mostly solitary[8]. The loaches achieve sexual maturity in the first (males) or second (females) year of their life[9,10].

Mousavi-Sabet *et al*.[11] recently described *Cobitis avicennae* (*C. avicennae*) as a new Cobitidae species from Western Iran. *C. avicennae* is known from the Tigris River drainages. This river drains from the Zagros Mountains. Detailed description of its life history has not been given in the literature. In this context, examination of the basic biological parameters for each species is fundamental for understanding species life history patterns and important with respect to implementing effective management and

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conservation measures for the species. In light of this hypothesis, the present study aimed to describe detailed life history of *C. avicennae* from Gamasiab River, Western Iran, serving as the first documentation for the species biology, thereby, contributing to its future conservation.

2. Materials and methods

The Tigris drainage is 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.

The present study was carried out in the Gamasiab River, one of tributaries of the Tigris drainage, situated in the Hamedan Province, Western Iran[12]. Sampling on the basis of once per month was carried out from February 2015 to July 2015 [in the last week of each month on different days at two sampling sites (48°09'26" E, 34°16'54" N and 48°11'27" E, 34°16'30" N)]. The specimens were caught using a net, similar to a beach seine, with a mesh size of 2 mm. The net was chosen for its simplicity and higher catch efficiency when sampling small specimens. Following capture, all fish specimens were immediately preserved in 4% formaldehyde solution for transport to the laboratory. We measured total length to the nearest 1 mm and total weight and gonad weight to the nearest 0.001 g. The relationship between the total length and total weight was determined by fitting the data to a potential relationship in the form of: $W = aL^b$, where W is the weight in grams, L is the total length in milimeters, *a* and *b* are the parameters to be estimated, with *b* being the coefficient of allometry based on *t*-test[13].

The age was determined using operculum taken from right side of the body. Operculum was reviewed for banding patterns using a binocular microscope under reflected light at 10–40×. Sex was determined by examination of the gonad tissue. We calculated the gonadosomatic index (GSI) using the formula: (gonad weight/total body weight) × 100 for each fish and all values were averaged for each sampling date.

To estimate fecundity, ovaries were removed from females, weighed, and then placed in Gilson's fluid for 3–4 days to harden eggs and dissolve ovarian membranes. The number of eggs was estimated by gravimetric method[14] using pieces removed approximately 0.02 g from both ovarian lobes of 47 ripe females caught in April and May. Average egg diameter was examined by measuring 30 eggs for each female. Measurements were made to the nearest 0.05 mm with an ocular micrometer microscope.

The Pauly *t*-test[13] was used to find out whether the calculated *b* value was significantly different from $b = 3$ (isometric growth). The comparison of GSI values during the reproductive period and its temporal variation in each sex was carried out by ANOVA. ANCOVA was performed to test the significance of differences in weight-length relationships between sexes. The overall sex ratio was assessed using *Chi*-square test[15]. Statistical analyses were performed using SPSS version 11.5 software package and a significant level of 0.05 was accepted.

3. Results

A total of 131 specimens of *C. avicennae* were caught during the sampling period. The total length and weight of males ranged from 33.5 to 79.9 mm and 0.22 to 3.08 g, while for females it ranged from 32.63 to 100.00 mm and 0.17 to 5.17 g, respectively. Opercula examination revealed that the majority of specimens were in the age group of 2 years, with 3 years being the oldest age recorded for both sexes. Observed length-at-age in the population was different between sexes, females being longer and heavier than males (Table 1). Length frequency distribution of the fish (Figure 1) indicated that the most males and females were in the size range of 39.3–52.9 mm. Males with length over 73.3–80.1 mm were rare.

Table 1
Average total length (mm) and weight (g) of *C. avicennae* in Gamasiab River.

Age (years)		Total length	Min–Max	Total weight	Min–Max
Male	1	36.55 ± 6.25	33.50–39.78	0.26 ± 0.08	0.22–0.33
	2	52.91 ± 12.51	40.34–68.00	0.80 ± 0.19	0.39–1.54
	3	76.89 ± 17.23	67.00–79.90	2.45 ± 0.57	1.41–3.08
Female	1	41.25 ± 9.65	32.63–45.57	0.41 ± 0.15	0.17–0.60
	2	55.08 ± 17.24	45.35–68.00	0.95 ± 0.26	0.62–1.28
	3	81.37 ± 22.14	67.00–100.00	2.79 ± 0.62	1.24–5.17

Values of total length and weight were expressed as mean ± SD. Min: Minimum; Max: Maximum.

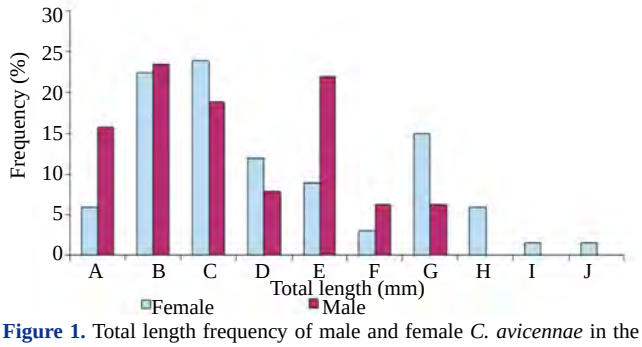

Figure 1. Total length frequency of male and female *C. avicennae* in the Gamasiab River (Western Iran).
A: 32.5–39.3; B: 39.3–46.1; C: 46.1–52.9; D: 52.9–59.7; E: 59.7–66.5; F: 66.5–73.3; G: 73.3–80.1; H: 80.1–86.9; I: 86.9–93.7; J: 93.7–100.5.

The growth model was isometric for males and sexes combined because the *b* value was not significantly different from 3 (Pauly's *t*-test, $t_{male} = 1.59$, $t_{sexes\ combined} = 1.19$, $t_{pooled} = 1.96$, $P > 0.05$) while growth model was negatively allometric for females (Pauly's *t*-test, $t_{female} = 2.51$, $t_{pooled} = 1.96$, $P < 0.05$). The overall ratio of males to females was 1:1.05 and *Chi*-square analysis indicated a significant difference from an expected ratio of 1:1 ($\chi^2 = 18.70$, $P < 0.05$). An unequal sex ratio was observed among length classes (Figure 1). The total length-weight relationships were evaluated for males, females and sexes combined. A significant relationship with the high regression coefficient ($r > 0.96$) was found between the length and weight of the loach. Length-weight relationships were found as $W = 1E-05TL^{2.83}$ for males, $W = 1E-05TL^{2.85}$ for females, and $W = 7E-06TL^{2.94}$ for sexes combined (Figure 2).

The GSI values of males were significantly lower than those of

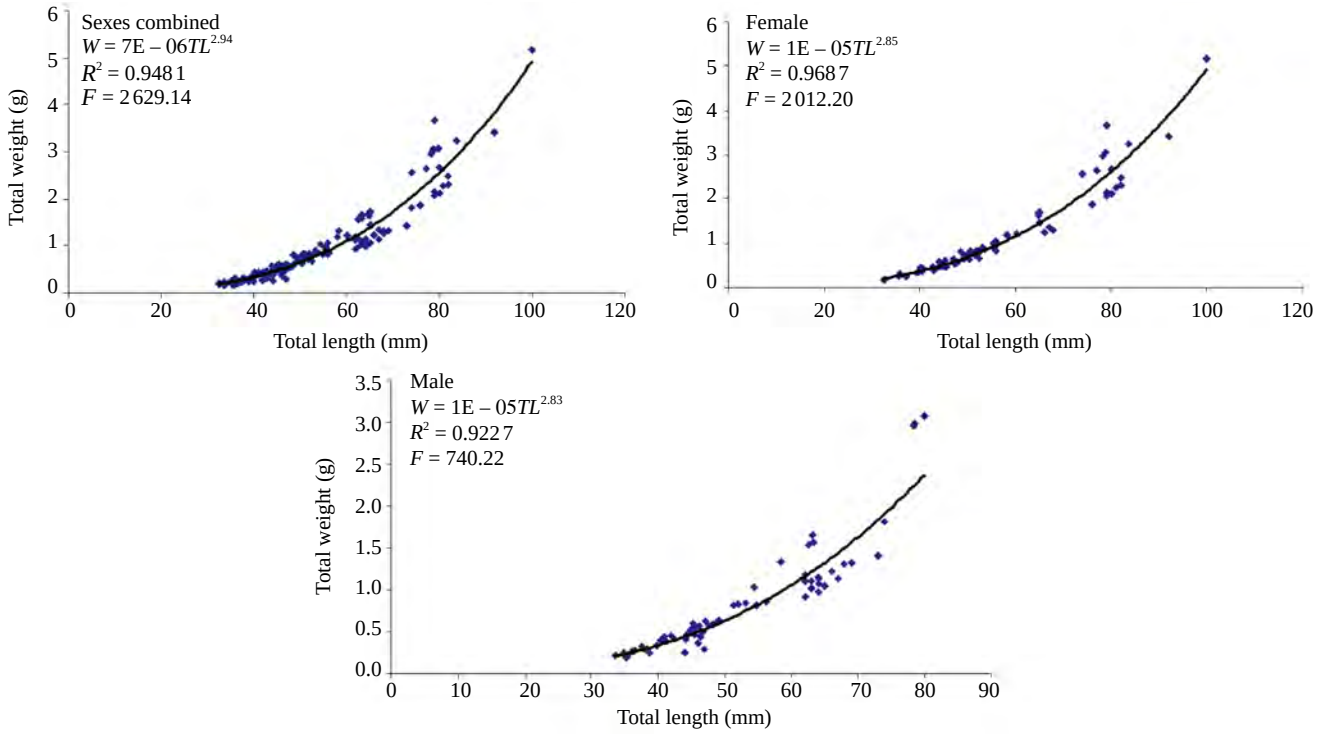

Figure 2. Relative growth curves (total length *vs.* total weight) for males, females, and sexes combined of *C. avicennae* in the Gamasiab River (Western Iran).

females. The maximum recorded values of GSI were 3.89 ± 0.96 and 14.33 ± 2.30 in April for males and females, respectively. The GSI of both sexes followed almost the same pattern (Figure 3). The reproductive period for this species in the river was thus March and April when GSI was considerably higher. It thereafter decreased in May showing start of the resting period.

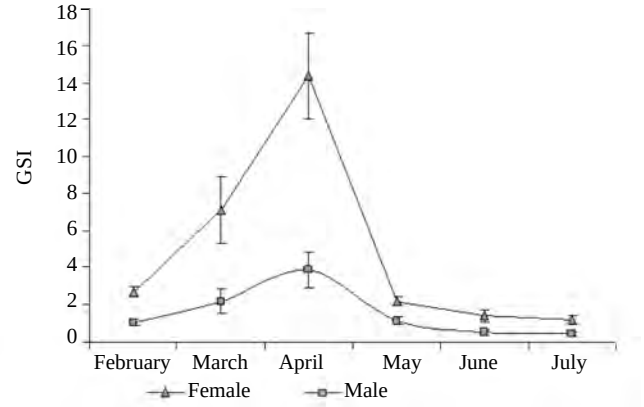

Figure 3. Monthly distribution of GSI in *C. avicennae* in the Gamasiab River.

The minimum and maximum of absolute fecundity was 132 and 900 eggs from a 2-year old and 3-year old female, respectively. The mean value of absolute fecundity was (490.55 ± 209.71) eggs/female. The linear function was adequate for expressing fecundity-total weight and fecundity-total length relationships (Figure 4). All correlation coefficients calculated between fecundity and each of the independent variables, while moderate, were statistically significant ($P < 0.05$). Fecundity relative to total weight fluctuated from 40 to 209 eggs/g, with a mean value of (146.70 ± 43.62) eggs/g. The relationship of relative fecundity (fecundity per gram) with total weight was not found to be statistically significant ($P > 0.05$), while the relative fecundity-total length relationship was significant though with a low correlation coefficient (Figure 5). The ovaries of mature females contained large yolk-filled eggs that ranged in size from 0.3 to 2.0 mm [mean: (1.10 ± 0.21) mm]. The majority of oocytes ranged from 1.18 to 1.40 mm in diameter (Figure 6).

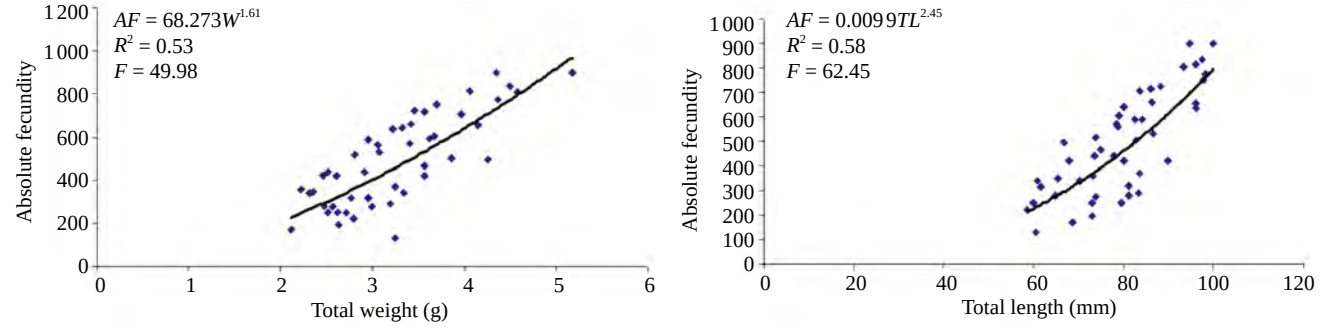

Figure 4. Relationship between absolute fecundity and total length (mm) or total weight (g) of female *C. avicennae* in the Gamasiab River.
AF: Absolute fecundity; W: Total weight; TL: Total length.

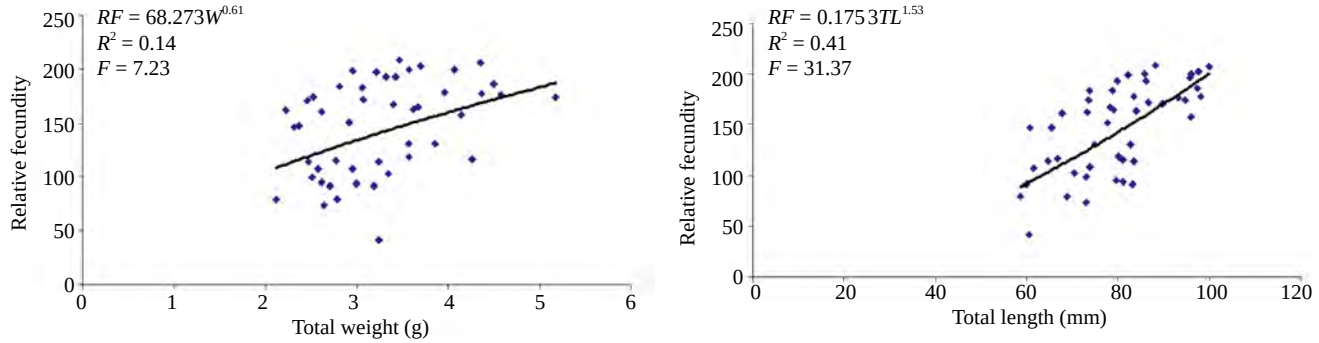

Figure 5. Relationship between relative fecundity and total length (mm) or total weight (g) of female *C. avicennae* in the Gamasiab River.
RF: Relative fecundity; W: Total weight; TL: Total length.

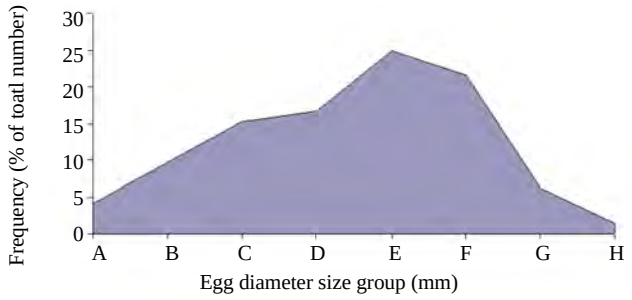

Figure 6. Size frequency distribution of oocyte diameter in female *C. avicennae* in the Gamasiab River.
A: 0.30–0.52; B: 0.52–0.74; C: 0.74–0.96; D: 0.96–1.18; E: 1.18–1.40; F: 1.40–1.62; G: 1.62–1.84; H: 1.84–2.04.

4. Discussion

To our knowledge, there is no other published information on the maximum age of this species for comparison. In comparison with other *Cobitis* species from Iran (*C. keyvani*[16] and *Cobitis* sp. [17]), *C. avicennae* has a minimum life span, not exceeding three years, and females exhibit a much wider range in length and a higher maximum length than males, a trend common to the loaches.

Weight-length relationships in the present study are statistically and biologically comparable to those of other teleosts. The relationships show that growth is negatively allometric for female and isometric for male and both sexes combined. Different *b* values for male or female *C. avicennae* and also for other loaches[18-20] reflect slight changes in body form with sex and species and could be attributable to different environmental habitat conditions and species characteristics.

A trade-off between growth rate and maximum theoretical size is often found and this is usually explained by local environmental factors. The higher coefficient in males suggests that they undergo rapid early growth and approach their asymptotic length earlier in life. This 'front loading' may explain in part the slight dominance of females at the study site, with higher survival rates amongst older females. Fish species would usually be expected to have a sex ratio that does not differ significantly from unity (*i.e.* 1:1). For *C. avicennae*, the highly female dominated sex ratio could be due to a higher survival rate or a longer life span in females. Our data showed that longevity was the same for both sexes, however, the most likely hypothesis is that survival rate is different between the sexes. In most *Cobitis* populations, the sex ratio is slightly biased toward females, and Bohlen and Ritterbusch[21] have proposed that males are more vulnerable to predation due to their smaller size.

The spawning period for *C. avicennae* in the Western Iran basin (from February to April) is similar to that described for *Cobitis elongatoides* and *Cobitis trichonica* from Europe. Other European *Cobitis* species have different spawning periods, *e.g. Cobitis bilineata* and *Cobitis narentana* in April–August, *Cobitis paludica* (*C. paludica*) and *C. taenia* in April–July, and *Cobitis tanaitica* in May. The single peak in GSI during the spawning season indicated that *C. avicennae* is not a multiple-spawner in the Western Iran basin. The production of multiple batches of eggs provides certain advantages[22], especially for those species living in fluctuating environments[23], and has been suggested for *C. taenia*, *Cobitis bilineata* and *C. paludica*[10,24-26], but could not be confirmed for *C. avicennae* in the study area.

In the present study, absolute fecundity was positively correlated with fish size (length and weight). Biologically, it might be deduced that total energetic investment in reproduction tends to increase with fish size, while the relationship between relative fecundity and fish weight is not significant. This implies that proportional energetic investment in reproduction, as energy allocation per unit of fish size, is variable and not significant for this species. It was revealed from the study that absolute fecundity and egg size in *C. avicennae* increase linearly with an increase in fish size. The positive relationships observed in the present study correspond well with earlier reports on *C. paludica*[26].

The maximum absolute fecundity of 900 eggs from a 3 years old *C. avicennae* female was lower than the 1 400 eggs[27], 1 235 eggs[17] and 1 986 eggs[26] observed for *C. paludica*, and the 4 282 eggs for *C. taenia*[28]. The variation in *Cobitis* fecundity is believed to be not only due to species characteristics but also due to nutrition, food availability and supply, and ecological conditions in the water bodies[29].

To summarise, the life history traits described for *C. avicennae* from the Western Iran basin indicated a moderate life span (3 years for both sexes), a moderate body weight (weight-length relationship: $b > 3$), a short duration of spawning season,

relatively high heterogeneity in egg size (0.30 to 2.00 mm), and low egg number (ranging from 132 to 900). These findings provided important new data with respect to the life history of this endemic species. In following the future status of *C. avicennae*, scientists should endeavor to expand the database on growth and reproduction and to assess the potential impacts of habitat degradation on populations of this species.

Conflict of interest statement

We declare that we have no conflict of interest.

References

[1] Mousavi-Sabet H, Vasil'eva ED, Vatandoust S, Vasil'ev VP. *Cobitis faridpaki* sp. nova-a new spined loach species (Cobitidae) from the Southern Caspian Sea basin (Iran). *J Ichthyol* 2011; **51**: 925-31.

[2] Mousavi-Sabet H, Yerli SV, Vatandoust S, Ozeren SC, Moradkhani Z. *Cobitis keyvani* sp. nova-a new species of spined-loach from south of the Caspian Sea basin (Teleostei: Cobitidae). *Turk J Fish Aquat Sci* 2012; **12**: 7-13.

[3] Abdoli A, Naderi M. [*The biodiversity of fishes of the southern basin of the Caspian Sea*]. Tehran: Abzian Scientific Publication; 2009. Persian.

[4] Kottelat M, Freyhof J. *Handbook of European freshwater fishes*. Cornol: Publications Kottelat; 2007.

[5] Bânârescu P, Nalbant TT. The 3rd Danish expedition to Central Asia. Zoological results 34. Cobitidae (Pisces) from Afghanistan and Iran. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i København* 1966; **129**: 149-86.

[6] Bianco PG, Nalbant TT. Redescription of *Cobitis linea*, with some remarks on the subgenus *Bicanestrinia* (Cypriniformes: Cobitidae). *Copeia* 1980; **4**: 903-6.

[7] Perdices A, Doadrio I. Phylogenetic relationships and classification of the genera *Cobitis* and *Sabanejewia* (Cobitidae) based on allozyme data. In: Ninth International Congress of European Ichthyologists (CEI9) "Fish Biodiversity"; 1997; Napoli-Trieste, Italy.

[8] Coad BW. Freshwater fishes of Iran. Ottawa: Brian W. Coad's Personal Website; 2012. [Online] Available from: http://www.briancoad.com/Species%20Accounts/Cobitidae%20to%20Cyprinodontidae.htm#Cobitis [Accessed on 10th April, 2012]

[9] Boron A, Pimpicka E. Fecundity of spined loach, *Cobitis taenia* from the Zegrzyński Reservoir, Poland (Osteichthyes, Cobitidae). *Folia Zool* 2000; **49**: 135-40.

[10] Marconato A, Rasotto MB. The biology of a population of spined loach *Cobitis taenia* L. *Boll Zool* 1989; **56**: 73-80.

[11] Mousavi-Sabet H, Vatandoust S, Esmaeili HR, Geiger MF, Freyhof J. *Cobitis avicennae*, a new species of spined loach from the Tigris River drainage (Teleostei: Cobitidae). *Zootaxa* 2015; **3914**: 558-68.

[12] Afshin I. [*Rivers of Iran*]. Tehran: Ministry of Energy of Iran Publications; 1994. Persian.

[13] Pauly D. *Fish population dynamics in tropical waters: a manual for use with programmable calculators*. Manila: International Center for Living Aquatic Resources Management; 1984.

[14] Ricker WE, editor. *Methods for assessment of fish production in fresh waters*. Oxford: Blackwell Scientific Publ.; 1978.

[15] Zar JH. *Biostatistical analysis*. Englewoods Cliffs: Prentice Hall; 1984.

[16] Mousavi-Sabet H, Kamali A, Soltani M, Bani A, Esmaeili HR, Rostami H, et al. Age, reproduction, and fecundity of a population of *Cobitis* sp. (Actinopterygii: Cypriniformes: Cobitidae) from the Babolrud River in the Southern Caspian Sea basin. *Acta Ichthyol Piscat* 2011; **41**: 117-22.

[17] Mousavi-Sabet H, Kamali A, Soltani M, Bani A, Esmaeili HR, Khoshbavar Rostami H, et al. Reproductive biology of *Cobitis keyvani* (Cobitidae) from the Talar River in the Southern Caspian Sea basin. *Iran J Fish Sci* 2012; **11**: 383-93.

[18] Slavik O, Rab P. Life history of spined loach, *Cobitis taenia*, in an isolated site (Psovka Creek, Bohemia). *Folia Zool* 1996; **45**: 247-52.

[19] Soriguer MC, Vallespin C, Gomez-Cama C, Hernando JA. Age, diet, growth and reproduction of a population of *Cobitis paludica* (de Buem, 1930) in the Palarncar Stream (southwest of Europe, Spain) (Pisces: Cobitidae). *Hydrobiologia* 2000; **436**: 51-8.

[20] Przybylski M, Valladolid M. Age and growth of the Iberian loach, *Cobitis paludica* in the Lozoya River (Madrid, Central Spain), an intermittent stream. *Folia Zool* 2000; **49**: 163-9.

[21] Bohlen J, Ritterbusch D. Which factors affect sex ratio of spined loach (genus *Cobitis*) in Lake Muggelsee? *Environ Biol Fish* 2000; **59**: 374-52.

[22] Burt A, Kramer DL, Nakatsuru K, Spry C. The tempo of reproduction in *Hyphessobrycon pulchripinnis* (Characidae) with a discussion on the biology of 'multiple spawning' in fishes. *Environ Biol Fish* 1988; **22**: 15.

[23] Nikolsky GV. *The ecology of fishes*. London: Academic Press; 1963.

[24] Bohlen J. Similarities and differences in the reproductive biology of loaches (*Cobitis* and *Sabanejewia*) under laboratory conditions. *Folia Zool* 2000; **49**(Suppl 1): 179-86.

[25] Bohlen J. Behaviour and microhabitat of early life stages of *Cobitis taenia*. *Folia Zool* 2000; **49**(Suppl 1): 173-8.

[26] Oliva-Paterna FJ, Torralva MM, Fernández-Delgado C. Age, growth and reproduction of *Cobitis paludica* in a seasonal stream. *J Fish Biol* 2002; **60**: 389-404.

[27] Lobon-Cervia J, Zabala A. Observation on the reproduction of *Cobitis paludicola* De Buen, 1930 in the Jarma River. *Cybium* 1984; **8**: 63-8.

[28] Bohlen J. Reproduction of spined loach, *Cobitis taenia*, (Cypriniformes; Cobitidae) under laboratory conditions. *J Appl Ichthyol* 1999; **15**: 49-53.

[29] Patimar R, Amouei M, Mir-Ashrafi Langroudi SM. New data on the biology of *Cobitis* cf. *satunini* from the southern Caspian basin (Northern Iran). *Folia Zool* 2011; **60**: 308-14.