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Original Article

Growth, reproduction and feeding biology of an endemic Sucker Catfish, *Glyptothorax silviae* (Coad, 1981) (Actinopterygii: Sisoridae), in the Maroon River, Iran

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Abstract: This study was carried out to provide some information on the biological features of the endemic Sucker Catfish, *Glyptothorax silviae*, from the Maroon River in the Tigris basin, Iran. Samples were collected at monthly intervals throughout the year and 277 individuals of *G. silviae* were caught. The mean total length and weight were 8.1 ± 1.7 (±SD) cm and 5.8 ± 3.5 (±SD) g and maximum length and weight were 11.9 cm and 17.4 g, respectively. Length-Weight relationship of the total specimens was calculated as W = 0.006 TL3.205, (r^2 = 0.956) indicating allometric growth pattern and was not significantly different between males and females. The overall condition factor was 0.62. The sex-ratio (1.23M:1F) was not significantly different from the expected 1:1 ratio. *Glyptothorax silviae* reproduces during June-September. Absolute and relative fecundity was 1129 eggs/fish and 105 eggs/g body weight, respectively. The egg size ranged from 0.994 to 1.76 mm with a mean value of 1.29 ± 0.171 (±SD) mm. The highest values of gonadosomatic index were observed in June-July. The gut content analysis revealed that *G. silviae* feeds only on aquatic insects.

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Introduction

Two species of the genus *Glyptothorax* are reported from Iran (Coad, 2013): *Glyptothorax silviae* Coad, 1981 and *G. kurdistanicus* (Berg, 1931). They are rheophilic fish in fast flowing streams, being able to attach themselves on hard substrates to resist strong currents (Ng and Rachmatika, 2005). *Glyptothorax silviae* is only found in rivers draining to the Persian Gulf in south western Iran (Coad, 2013). Abdoli (2000) has also reported this species in the Karun and middle to lower Khersan, and middle to lower Dez Rivers in the Tigris basin and in the Mond and Shur Rivers of the Bushehr basin.

Glyptothorax silviae is an endemic species in south western Iran and, therefore, conservation of gene pool of this fish is very important. For this purpose, basic biological information on the fish is necessary. Some information on the biology of *G. silviae* is already available (Coad, 1981; Esmaeili and Ebrahimi, 2006; Esmaeili et al., 2009; Coad, 2013), but comprehensive data for this species are still missing. The principal aim of this paper was to provide an update of data on some biological features of this endemic catfish, including growth (length frequency distribution, length-weight relationship, Fulton condition factor), reproduction (sex ratio, fecundity, oocytes diameter, gonadosomatic index), and feeding (relative length of gut, gastrosomatic and hepatosomatic indices).

Materials and Methods

Study area and sampling: The present study was carried out in the Maroon River, which is situated mainly in Khuzestan Province, and passes through

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north of Behbahan City (Fig. 1). The length of the Maroon River is about 421 km, with an average slope of 2% in mountain area and less than 1% in plain area. The mean discharge of the river is about 48 m^3/s. Because of damming, its discharge is almost constant, but it slightly increases in early autumn.

Sampling were performed in two locations adjacent to Behbahan City, Emamreza village (30º40'11.12"N, 50º18'13.27"E) and Kharestan (30º39'21.32"N, 50º11'39.56"E). Sampling were carried out once per month in the late mornings using a small seine (4-6 m long and 1.5 m depth) with a mesh size of about 2 mm, between October 2010 and September 2011. This species is a weak swimmer and swept away when detached from gravels. The seine was placed across the flood-ways and narrow parts of river, to close entire width of water and fish were driven away into the net by disturbing the substrate. Sometimes, in shallow and clear waters, larger fish were caught by small scoop net or by hand, when attached to coarse gravels.

Biometry and data analysis: A total of 277 specimens were collected, transported to laboratory freshly, and all measurements were performed at the same day. The recorded biometric characteristics and measurements were total length (TL), fork length (FL), standard length (SL), gut length (GL), body weight (W), gonad weight (GW), hepatic weight (HW), and gut weight (GuW) with its contents. All lengths were measured to the nearest 0.05 mm using digital calipers and were rounded to the nearest 0.1 cm, whereas weights were recorded with an electronic balance to the nearest 0.01 g. In addition, gut contents were identified. Geographical locations of sampling areas were registered to the nearest 5 m using a GPS (model Garmin).

The relationships between TL-FL and TL-SL were calculated. The total length-weight relationship (LWR) was established by the exponential regression equation, $W = aL^b$, where W is the weight in g, L is the total length (TL) in cm, a and b are the parameters to be established (Esmaeili and Ebrahimi, 2006); a is a coefficient related to body form and b is an exponent indicating isometric growth when

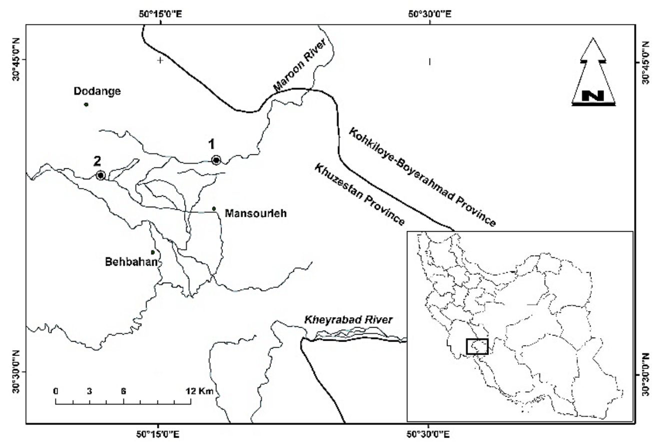

Figure 1. Sampling location of *Glyptothorax silviae* in Iran (1 = Emamreza and 2 = Kharestan).

equal to 3 and indicating allometric growth when significantly different from 3. Fulton condition factor (CF) was calculated using $CF = (W / TL^x) \times 100$ (Johari et al., 2009), where x = 3.2, because exponent b in LWR equation was significantly different from 3.

Sex was determined by visual observation of the gonads (n = 241). To estimate absolute fecundity (AF), ovaries of 16 ripe females caught in June and July were removed and after weighing, placed in Gilson's fluid for 3-4 days to harden eggs and facilitate the separation and counting the eggs. The number of eggs was estimated using the gravimetric method. Pieces of approximately 0.01 g were removed from the anterior, middle and posterior parts of each ovarian lobe. The eggs in each piece were counted under a binocular microscope. The AF was calculated as the proportion of eggs in the sample to the weight of whole ovary. Relative fecundity (RF) was calculated as RF = AF / W, where W is the body weight. Three samples of each ovary (about 20 ova from each sample) from 16 ripe females caught in June and July were chosen randomly to measure the egg diameter. The gonadosomatic index, GSI = Gonad Weight × 100 / Body Weight, was calculated for each fish and all values averaged for each month.

Guts were stored in 4% formaldehyde and gut contents were examined monthly. The primary food items were determined using a binocular

Table 1. Length, weight, and CF of the 277 *Glyptothorax silviae* specimens captured in the Maroon River

Parameter	Sex	Min	Max	Average ± SD
Total Length (cm)	Total	3.4	11.9	8.1 ± 1.73
	Male	4.1	10.9	8.3 ± 1.52
	Female	3.8	11.9	8.3 ± 1.65
Fork Length (cm)	Total	3.1	10.6	7.3 ± 1.55
	Male	3.7	9.9	7.4 ± 1.36
	Female	3.6	10.6	7.5 ± 1.48
Standard Length (cm)	Total	2.7	9.6	6.6 ± 1.45
	Male	3.2	9.3	6.7 ± 1.28
	Female	3.3	9.6	6.8 ± 1.38
Weight (g)	Total	0.31	17.39	5.83 ± 3.505
	Male	0.65	16.06	5.99 ± 3.191
	Female	0.53	17.39	6.35 ± 3.782
Condition Factor	Total	0.43	0.95	0.62 ± 0.104
	Male	0.44	0.93	0.62 ± 0.101
	Female	0.43	0.95	0.62 ± 0.107

microscope. The formula for Relative length of gut, RLG = GL / TL, where GL is the gut length and TL the total fish length, was used to indicate the feeding habits. The gastrosomatic index was calculated using GI = GuW × 100 / W, where GuW is the gut weight and W the body weight for each specimen and averaged for each month to determine the degree of feeding intensity (Biswas, 1993). The hepatosomatic index was calculated as HSI = HW × 100 / W, where HW is the hepatic weight.

The significance of LWR regression was assessed using ANOVA (Esmaeili and Ebrahimi, 2006). To examine significant differences in b values of LWR between males and females, ANCOVA was performed (Abdoli et al., 2008; Patimar et al., 2010). T-test (ts = b – 3 / SE), where SE = standard error, was used to examine significant differences between b exponent and 3 (Morey et al., 2003; Sangun et al., 2007). Comparison of CF and GSI of males and females was carried out using a paired t-test. The overall ratio of males and females was evaluated using Chi-square test (Patimar et al., 2010). Statistical analysis of data was carried out using Microsoft Excel 2003 and SPSS 16.0 software package at a significance level of 0.05.

Results

Size, growth and sex ratio: Biometric results of the 277 *G. silviae* specimens (133 male, 108 female) are summarized in Table 1. Length frequency distributions of males and females are shown in Figure 2. The specimens in the 8.5-9 cm length class had the highest frequency.

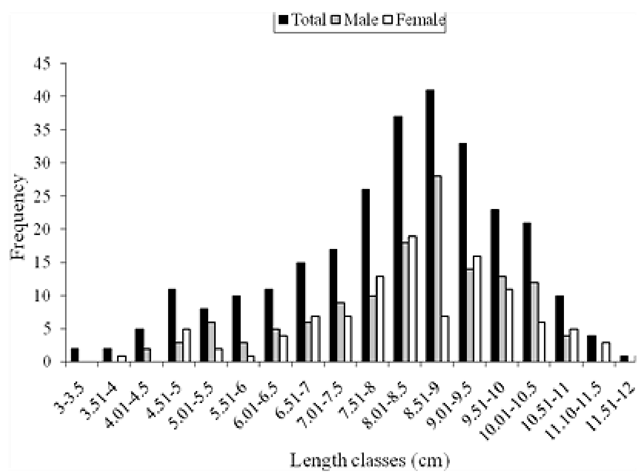

Figure 2. Length frequency distribution of *Glyptothorax silviae* from the Maroon River, Iran.

The relationship between TL-FL and TL-SL were calculated as FL = 0.888 TL + 0.094 (r^2 = 0.98) and SL = 0.823 TL – 0.06 (r^2 = 0.97), respectively. The LWR was W = 0.006 $TL^{3.205}$ (r^2 = 0.956) (Fig. 3) and W = 0.008 $FL^{3.206}$ (r^2 = 0.948). Based on the ANOVA, weight and length were significantly correlated ($P \leq 0.05$). The LWR of males and females were Wm = 0.005 $TL^{3.240}$ (r^2 = 0.947) and Wf = 0.005 $TL^{3.265}$ (r^2 = 0.947), respectively. There was no significant difference between LWR of males and females (ANCOVA, $P>0.05$). However, based on the t-test analyses, exponent b was significantly different from 3 ($P \leq 0.05$). The condition factor

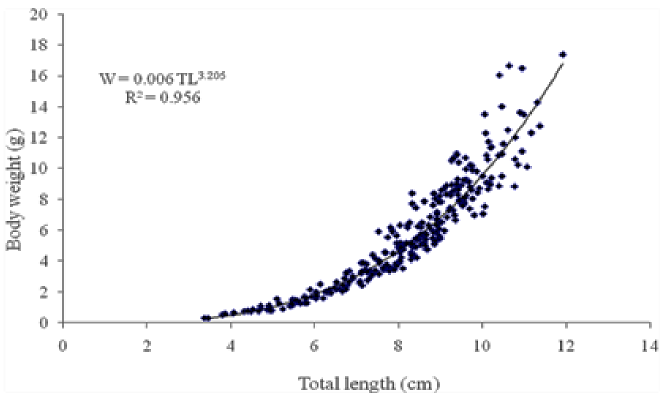

Figure 3. Length–weight relation of *Glyptothorax silviae* from the Maroon River, Iran.

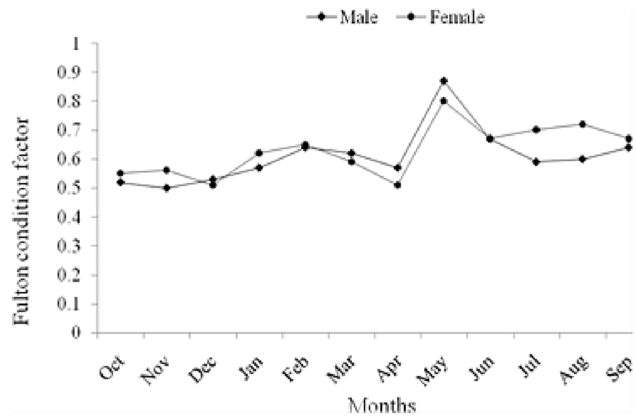

Figure 4. Fulton condition factor of males and females of *Glyptothorax silviae* from the Maroon River, Iran.

Table 2. Sex ratio in *Glyptothorax silviae* during different seasons

Month	No. Male	No. Female	Season	Male:Female ratio	χ^2 Value
Apr	7	3	Spring	1.4:1	0.862
May	7	5			
Jun	3	4			
Jul	7	3	Summer	1.7:1	3.449
Aug	10	8			
Sep	14	7			
Oct	3	5	Autumn	1.3:1	0.714
Nov	5	3			
Dec	12	7			
Jan	31	25	Winter	1.0:1	0.031
Feb	30	27			
Mar	4	11			
Total	133	108		1.2:1	2.593

(Table 1, Fig. 4), was not significantly different in males and females (P>0.05).

Sex determination was carried out for 241 specimens (including 133 males, 108 females and 36 immature). The overall ratio of males to females was 1.2M:1F, but was not significantly different (P>0.05) from the expected 1:1 ratio (Table 2).

Reproduction: The maximum value of 1165 eggs was observed in the largest fish weighing 17.39 g and the minimum value of 1053 eggs was recorded in the fish weighing 7.45 g (1129 ± 35.6 eggs/fish). Relative fecundity fluctuated from 67 to 141 eggs/g (105 ± 32.25 eggs/g). The egg size ranged from 0.99 to 1.76 mm with a mean value of 1.29 ± 0.171 (±SD) mm. GSI varied from 0.54 to 3.15 (with a mean value of 1.64 ± 0.858) and from 0.75 to 13.17 (6.14 ± 4.772) for males and females, respectively (Fig. 5). The highest values of GSI were observed in June-July. GSI values of males were lower than for females (P>0.05). All ova of each female were at the same developmental stage and had uniform size.

Feeding: The primary food items in all months were aquatic insects such as Plecoptera (Perlodidae) and Ephemeroptera (Baetidae and Potamanthidae). In addition, other orders were also identified in the river substrate such as: Plecoptera (Luctridae), Ephemeroptera (Caenidae and Ephemerellidae), Diptera (Chironomidae, Simuliidae, Tabanidae and Tipulidae), Hemiptera (Veliidae and Notonectidae), Odonata (Cordulegastridae) and Trichoptera (Hydropsychidae). The remains of crustaceans and molluscs (snail) observed in river, were not identified in guts. Contents of the alimentary canal of small, medium and large specimens were compared, and there were not significant differences between them. Furthermore, different developmental

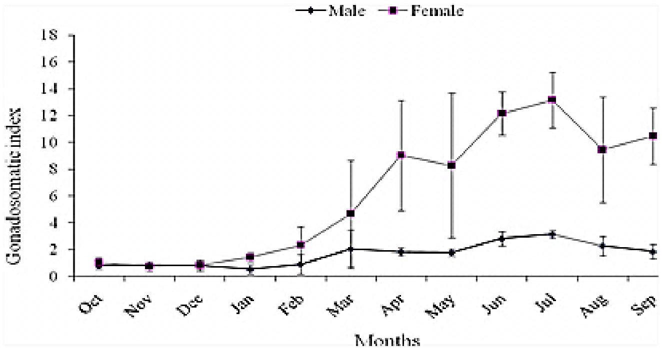

Figure 5. Monthly gonadosomatic index of males and females of *Glyptothorax silviae* from the Maroon River, Iran.

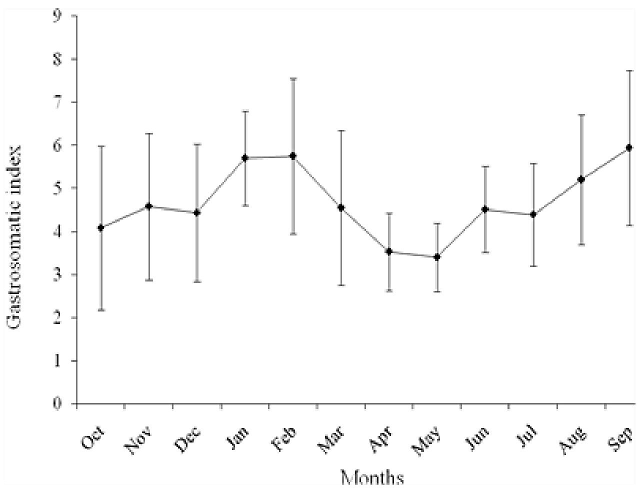

Figure 6. Monthly changes of gastrosomatic index of *Glyptothorax silviae* from the Maroon River, Iran.

stages (pupa and nymph) of aquatic insects were found in different seasons. Relative length of gut (RLG) was 0.66 ± 0.123 in average.

The severity of feeding based on the GI in different months is shown in Figure 6. Based on the GI, the greatest intensity of feeding was in January-February and August-September, while the least intensity was in April-May and October.

The HSI for *G. silviae* was calculated over a period of 12 months and is shown in Figure 7. The lowest values of HSI were observed in November-December, and the highest in May-June.

Discussion

Size, growth and sex ratio: The highest TL observed in *G. silviae* from the Maroon River was 11.9 cm. Coad (2013) reported the maximum of SL as 13.5 cm (16.47 cm TL, employing SL-TL relationships). Esmaeili and Ebrahimi (2006) indicated the

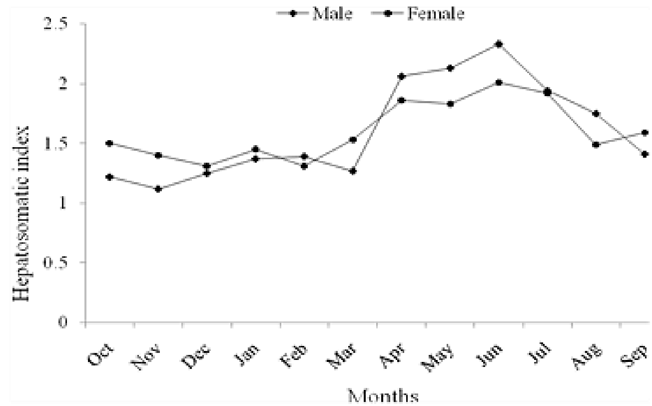

Figure 7. Monthly changes of hepatosomatic index of *Glyptothorax silviae* from the Maroon River. Iran.

maximum TL of *G. silviae* as 11.85cm (n = 10). Their size distribution pattern is very close to the results obtained in this study. However, they did not present any information about the location and physicochemical properties of the sampling area. The variations in maximum size (i.e., lengths or weights) among different populations of the same species could be due to different exploitation patterns and/or ecological condition. In this respect, as far as the fish is not either a commercially important species or a sport fish, the ecological conditions seem to be the most important factor affecting the size and growth of this species. The most frequent range of lengths for all specimens was 8-9.5 cm and specimens were more frequent in 8.51-9 length class. Determining the sex of the fish smaller than about 4.5 cm was impossible using visual method. As a result, distribution of length classes of total specimens was different from distribution of length classes of males and females.

In terms of growth type, the results showed that *G. silviae* had an allometric growth. Therefore, this species become more rotund as their length increase. Esmaeili and Ebrahimi (2006) demonstrated a positive *b* value for total length and negative *b* value for fork length (*b* = 3.102 and 2.975, respectively, n = 10). But in the present study, *b* value was positive for both TL and FL. According to strong relationship between TL-FL ($r^2 = 0.98$), positive *b* value for both TL and FL is more expectable. Variation in *b* exponent could be attributable to fish response to different ecological condition (Sangun et al., 2007;

Patimar, 2008). As mentioned previously, Esmaeili and Ebrahimi (2006) did not present any information about the location and physicochemical properties of sampling area, and furthermore they have calculated LWR using limited number of samples (n = 10). In the present study, there was no significant difference between males and females in LWR. In addition, CF was similar for both sexes. Therefore they had similar growth type and fish condition. However, CF of females was higher than those of males in reproduction season. It suggests that females are more rotund in this period because of accumulating yolk in ovaries. In the present study, overall sex ratio and sex ratio in various seasons showed different values, but they were not significantly different from 1:1 ($P>0.05$). However, male:female ratio was at the maximum value in reproduction season (summer) and minimum value in winter. The overall sex ratio was different compared to *G. madraspatanum* in India (1M:1.24F) (Dobriyal and Singh, 1993). In *G. silviae*, ratio of males was higher than females in all seasons, but in *G. madraspatanum* ratio of females was higher than males.

Reproduction: This is the first study concerning reproductive biology of *G. silviae*. The study of reproductive biology is useful in various applied aspects of fisheries. The process of accumulating yolk in the ovaries of the females can be determined partly by tracing the changes in the gonadosomatic index. In species which spawn in late spring and in summer such as sisorid catfish, the index remains low in winter and then rises sharply just before the spawn (Wootton, 1979; Rinchard and Kestemont, 1996; Mousavi-Sabet, 2011). A rapid increase in the weight of ovaries takes place when the temperature rises and increasing amounts of food are consumed (Wootton, 1979). Males had a lower GSI, because egg is much larger than sperm and it includes energy for further development of embryo. In addition, HSI and CF of males were higher than females before reproduction season. But as stated earlier, growth parameters of both sexes were not significantly different. Based on GSI, reproduction of the endemic sucker catfish starts in June and lasts to September. A similar time of spawning was observed for *G. madraspatanum* (Dobriyal and Singh, 1993) and *G. poonaensis* (Dahanukar et al., 2011) from India. *Glyptothorax silviae* has a relatively protracted spawning period. In this study, histological examination was not performed. In addition, measuring the diameter of ova was carried out only in the middle of reproductive season, and in that period the ova have approximately the same size. According to Rinchard and Kestemont (1996), this fish probably is a batch spawner. However, Dobriyal and Singh (1993) indicated that *G. madraspatanum* spawns for a limited period (July-August) with a single batch of developing eggs showing a single spawning frequency. Considering the climate of this region, it is expected that *G. silviae* to have a spawning pattern such as *G. madraspatanum*. However, damming as well as irregular release of dam water could influence mean temperature and sexual maturation of this species in the Maroon River. It seems necessary to compare biological characteristics of *G. silviae* in different rivers of the region, for example Kheyrabad River, in the vicinity of Behbahan City or other hillstreams of Karun basin.

Fecundity was relatively low (AF = 1129 eggs/fish, RF = 105 eggs/g), maybe due to relatively large egg size of this species (1.29 ± 0.171 (±SD) mm). There is no any information about fecundity of *G. silviae*. However, Dobriyal and Singh (1993) reported a total length ranging from 12.1 to 15.2 cm and fecundity ranging from 1640 to 6830 eggs/fish for *G. madraspatanum*. These results are significantly different from those obtained in the present study. According to their study, *G. madraspatanum* with similar size to *G. silviae* has higher AF. But they indicated that average relative fecundity was 122.5 eggs/g. In this particular case their results are close to ours. Dobriyal and Singh (1993) found that fecundity correlates closely with size. But further investigation is required with more sample size, which makes it possible to analyze the correlations between the fecundity and length and weight.

Feeding: Investigating gut contents revealed that this species is carnivorous. Results of RLG confirmed this hypothesis. RLG was 0.66, indicating that *G. silviae* feeds only on animal materials. There were no significant differences between gut contents of different fish sizes. Guts of the smallest and biggest specimens were examined, and the only food items were aquatic insects in different sizes and developmental stages such as pupa and nymph. It is probable that in addition to Plecoptera and Ephemeroptera, some other insects have been consumed. Dahanukar et al. (2011) reported that *G. poonaensis* feeds on benthic microinvertebrates such as freshwater prawns, maxillopod crustaceans (Branchiura) and Odonata nymph. Changes in GI showed that feeding was the highest in winter and summer and the lowest in spring, late summer and autumn. It seems that increasing and decreasing of this index is related to water temperature and reproduction cycle. It was increased immediately after reproduction season to recover energy lost during this season (Johari et al., 2009) and in the winter due to low temperature, foods remains longer in the gut. Changes in HSI approved results of GI. HSI decreased in cold season due to decrease of metabolism and increase in spring and summer, coincided with increasing water temperature. Likewise, HSI variations followed GSI variations. In fact, an increase in HSI is highly correlated with energy mobilization for reproduction.

In conclusion, the present study shows that *G. silviae* has an allometric growth, and is a carnivorous species that feeds only on aquatic insects. This species reproduces between June-September. Changes in GI and HSI show that feeding is correlated with water temperature and reproduction cycle. More research is needed to determine age structure of populations of this species and further examinations to investigate correlation between fecundity and size. This information will be useful for conservation of this endemic sucker catfish.

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