Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Age, sex ratio, spawning season, reproduction, and fecundity of *Channa gachua* (Actinopterygii, Channidae) from Makran basin, Southeastern Iran

Aliakbar Alitabar[1], Saber Vatandoust[1]*, Shayan Ghobadi[1], Hamed Mousavi-Sabet[2]*, Reza Changizi[1]

1. Department of Fisheries, Babol Branch, Islamic Azad University, Babol, Iran
2. Fisheries Department, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran

** Corresponding author's E-mail: s.vatandoust@gmail.com, mosavii.h@gmail.com*

ABSTRACT
Channa gachua is native to the majority of streams in southeastern Iran, but reproductive parameters of the fish are barely known. Reproductive conditions are key parameters of fish populations and their assessment is very important for several reasons. To investigate reproductive biology of the native dwarf snakehead, sampling was done at monthly intervals throughout the year and 404 individuals were caught from Kajou River in Makran basin. Age, sex ratio, fecundity, oocytes diameter, gonado-somatic, modified gonado-somatic 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 from unity and biased to females. The mature females and males were longer than 75 and 61 mm in total length (+2 and +1 in age, respectively). The average egg diameter was 0.50 mm, maximum 0.73 mm in April. The spawning took place from beginning of April to late June. Average GSI value at the beginning of the reproduction period was 2.89% and ranged between 0.3% and 4.4% in ripe, mature females. The average of absolute and relative fecundity was calculated 3471 and 248, 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, which is a type of adaptation by short-lived small fishes to environmental conditions.

Keywords: Reproductive biology, GSI, Ova diameter, Snakehead, Iran.
Article type: Research Article.

INTRODUCTION
The freshwater ichthyofauna of Iran comprises a diverse set of families and species. These form important elements of the aquatic ecosystem and a number of species are of commercial or other significance (Coad 2016). One of the rare species in the country is *Channa gachua* (the family Channidae), which is related to the Orientale region. This species is native for Iran and reported from the Makran, Mashkid and Jazmourian basins (Jouladeh-Roudbar 2015). The family Channidae, is known as the snakeheads or serpentheads because of the characteristic broad head with large scales and a large oblique mouth. They are found from Africa to eastern Siberia and Southeast Asia (Coad 2016). Reproduction has three key components, including sexual maturity, reproductive period and fecundity, which are vital demographic characteristics, essential for understanding a species' life history (Cortes 2000). Gonado-somatic index has been used as an indicator of reproductive activity of fish (Bagenal & Braum 1978; Coates 1988), and in the absence of information on eggs and larvae, this could be used to give an indication of peak spawning periods. Knowledge of gonadal development and the spawning season of a species allow the subsequent studies on spawning frequency of its population, which is important for its management (Chakraborty *et al.* 2007; Pourshabanan *et al.* 2017; Hajiradkouchak *et al.* 2019; Jorfipour *et al.*

Caspian Journal of Environmental Sciences, Vol. 22 No. 4 pp. 813-821 Received: March 05, 2024 Revised: June 26, 2024 Accepted: Aug. 14, 2024
DOI: 10.22124/CJES.2024.7557

Publisher: University of Guilan

2022; Jaafer Abdullah *et al.* 2022). Within a given species, fecundity may vary as a result of different adaptations to environmental habitats (Witthames *et al.* 1995). Fecundity assessments have been useful in racial distinction, progeny survival studies, stock evaluation and aquaculture-based induced spawning and egg incubation (Bagenal & Braum 1978; Coates 1988). Sizes of eggs are also important parameters used in reproduction studies to characterize fish species and can also be used to predict the spawning frequency of fish (Wootton 1979). Ecological conditions such as the water temperature and photoperiod influence the sexual maturity of fish greatly (Pawson *et al.* 2000; Rodríguez *et al.* 2001). The principal aim of this paper was to provide data on the reproductive biology of *Channa gachua* for the first time from Kajou River in Iran, including sex ratio, gonad indices, fecundity, oocyte diameter, and spawning season time and duration which are necessary for conservation programs of the fish in the region. We believe that information on the reproductive biology of this interesting dwarf snakehead may be important in view of its potential aquarium trade.

MATERIALS AND METHODS

The study was conducted in the Kajou River (26°2593′ N, 60°7568′ E) in Makran basin, southeast of Iran. To avoid fishing pressure to the *Channa gachua* population, we used previously caught specimens by M. Amouei who has collected them in order to feeding biology examination during June 2013 to May 2014 by hand net. The fish were measured (Tl: Total length, Sl: Standard length to the nearest 1mm) and weighed (W: body weight, to the nearest 0.1 g). To examine the monthly changes in gonads as a mean for estimating the spawning season: gonadosomatic index (GSI) and Dobryal index (DI) were calculated following the formulas: GSI = (Wg × Wb–1) ×100 (Nikolski, 1963) and DI=3√Wg) (Dobriyal *et al*. 1999). The absolute fecundity (Fa) was estimated in 30 ovaries by calculating the number of oocytes (Mousavi-Sabet *et al.* 2011; Mousavi-Sabet 2012). To achieve accurate results, fishes that were caught in the beginning of April (before spawning), were used. The relative fecundity (Fr) was expressed by dividing the absolute fecundity (Fa) by the fish body weight. The result was the number of eggs per 1 g of body weight (Bagenal, 1967). To determine the oocytes diameter, the ovaries were preserved in 4% formalin solution. The diameters of 60 ova of each female fish were measured using a Zeiss stereomicroscope model SV 6 which was fitted with an ocular micrometer. The sex recognition was determined according to the examinations of gonad morphology after dissection. The Chi square test was used to assess sex ratio deviation from a 50:50 (Wootton 1998). Age determination was done by using scales taken from the left side of the body, between end of the pectoral fin and the beginning of the dorsal fin. In order to compare significant differences in the gonad indices between samples taken on different months, the analysis of variance (ANOVA I) was applied. The relationship between the absolute fecundity (Fa) and body length and weight, the gonad weight and the age of females was determined by regression analysis. The data were analyzed by the SPSS version 16.0 software and Microsoft Excel 2019 software.

RESULTS AND DISCUSSION

During this study, 404 specimens of *Channa gachua* were caught ranging in total length from 32 to 147 mm, standard length 27 to 121 mm and total weight from 0.5 to 40 g (Table 1). The females were longer, heavier and achieves maturity later than males (Fig. 1), at the age of 2+, Tl more than 81 mm and body weight about 9 g. Results revealed that this population of the dwarf snakehead had a narrow age range of 1+ to 5+ years. Most of the caught fish were 3+ and 4+ years old (Table 1). The body length increased proportionally to the age. The older specimens were longer than those which had just reached sexual maturity. The body weight of the older fish was heavier than the young ones. Of the total number of 404 fish specimens caught, 174 were males and 187 were females (and 43 immature), giving an overall sex ratio of 1:1.07. Significant differences were observed in female and male gonad indices in different months (ANOVA, $p < 0.05$). There were no significant differences between GSI and DI. The female gonad indices increased during January to April, peaking at the beginning of spring and then decreased until July, then showed a slow increase until September and finally decreased in November (Figs. 2-3). The oocytes diameter ranged from 0.2 to 1.0 mm with a mean of 0.50 mm (SD ± 0.16). The maximum mean oocyte diameter was observed in April and minimum in February (Fig. 4). The fish used to estimate fecundity were 2+, 3+, 4+ or 5+ years old. Individual values of the absolute fecundity varied in a wide range from 564 to 5940 eggs with an average of 3471 (SD±1408). The relative fecundity was 50 to 688 with a mean of 248 (SD ± 105) per gram body weight (Table 2). The absolute fecundity was significantly related to female body length and also gonad weight ($p < 0.05$; Table 3). The regression coefficient values were 7.67 and 2.77 for gonad weight and total body length, respectively.

Table 1. Total length (TL), standard length (SL), and body weight (W) (mean ± SD) in different ages of *C. gachua* males and females from the Kajou River.

Age	N		TL (mm)		SL (mm)		W (g)	
	M	F	M	F	M	F	M	F
0^+	21	12	41.90 ± 10.60	40.45 ± 4.98	33.88 ± 9.13	32.86 ± 4.14	0.90 ± 0.61	0.72 ± 0.26
1^+	19	5	61.21 ± 4.47	59.20 ± 3.27	50.21 ± 4.17	48.60 ± 3.21	2.40 ± 0.65	2.12 ± 0.50
2^+	17	29	76.84 ± 6.30	77.14 ± 6.99	62.84 ± 5.80	63.28 ± 6.20	5.05 ± 1.56	5.24 ± 1.59
3^+	76	77	100.72 ± 8.81	99.67 ± 4.62	84.22 ± 8.18	83.45 ± 4.18	11.84 ± 3.24	11.39 ± 2.22
4^+	31	59	117.43 ± 3.84	114.70 ± 5.93	98.39 ± 3.29	96.18 ± 5.22	19.09 ± 2.42	18.32 ± 3.65
5^+	10	5	131.54 ± 8.10	135.04 ± 10.17	109.42 ± 4.83	114.59 ± 8.28	26.40 ± 4.49	32.25 ± 10.00

Snakehead maturity and growth patterns in various types of freshwater vary greatly, caused by multiple external and internal factors. External factors that affect snakehead growth patterns include habitat or environmental factors, food availability, seasonal differences, density, and so on. Internal factors that influence include species, fish development stage, sex, gonad maturity level, and other factors (Safran 1992; Mousavi-Sabet et al., 2013). Dwarf snakeheads are short-lived species, the *C. gachua* population examined in Sri Lanka has 90% of the individuals less than 24 months old and 99% less than 38 months, longevity is about 6 years (De Silva 1991). While in present study the oldest females were 5+ years old but most of them were in the fourth year of their lives. Some populations of *C. gachua* in mountain streams are mature at about 13cm while in lower areas maturity is reached at about 10.2cm at 20 months (Coad, 2016). In the studied population, females achieve maturity later than the males, at the age of 2+, when Sl is about 60 mm and body weight about 5 g.

This is the first study concerning reproductive biology of *C. gachua* in Kajou River from southeast of Iran. However, there are some available information on some aspects of reproduction of snakehead species (members of the genus *Channa*); Spawning of *C. gachua* takes place over silt or gravel bottoms or in areas of cleared vegetation forming a "nest". Vegetation is cleared by fin movements and can be 15cm across (Ettrich & Schmidt 1989).

Fig. 1. From above, male and female *C. gachua* from the Kajou River.

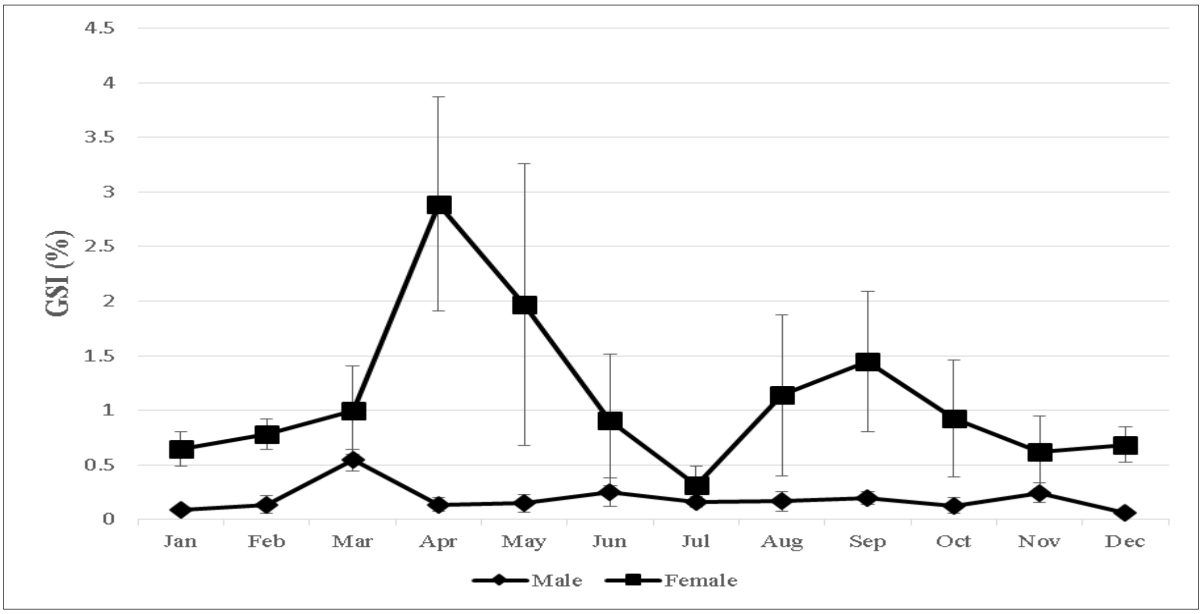

Fig. 2. Variation of mean (± S.E) gonadosomatic index (GSI) of female (F) and male (M) for *C. gachua* from the Kajou River in different months.

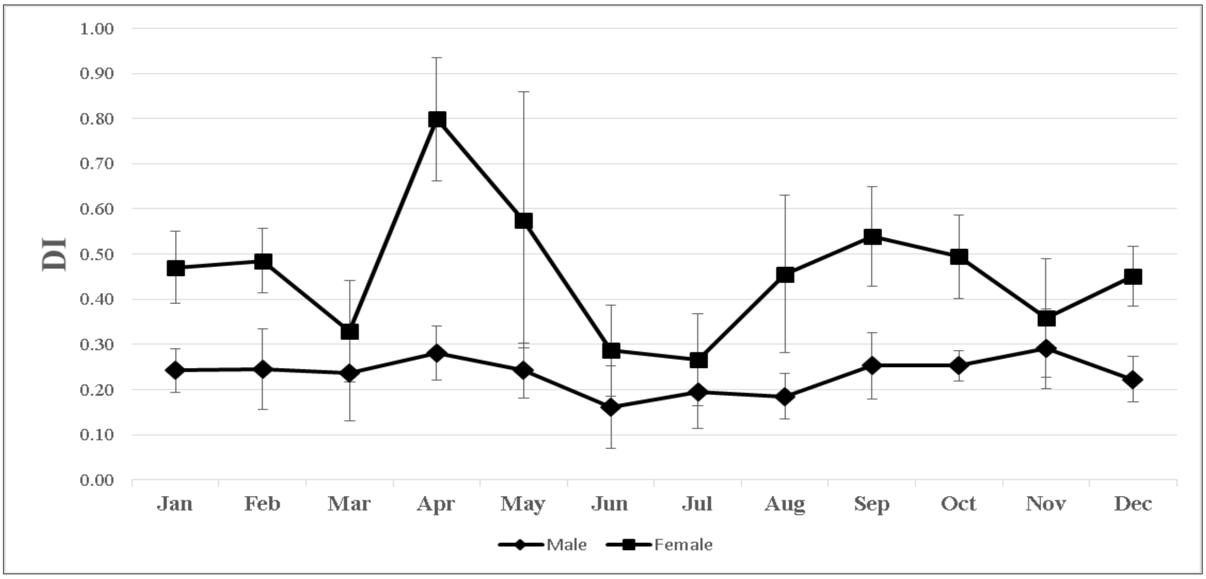

Fig. 3. Variation of mean (± SE) Dobriyal index (DI) of female (F) and male (M) for *C. gachua* from the Kajou River in different months.

Some reports have the female swimming belly up and the male then fertilizes the eggs as they are released by swimming diagonally over the female's vent. Ettrich & Schmidt (1989) state that the male forms a loop around the belly region of the female, an intensive and long-lasting process. This occurs after pair-bonding lasting several weeks which serves to synchronize reproduction, necessary since all the eggs are released at once. The male picks up the eggs in his mouth and keeps them there for 4- 5 days until hatching (Ettrich 1989; Pethiyagoda 1991), as the eggs are oily and slowly float to the surface. The fry may also be protected in the male's mouth for up to three days before releasing them, but the fry are retained behind the gill cover when danger threatens or night descends (Ettrich & Schmidt 1989). Egg numbers vary between 20 and 200 per spawning (Lee & Ng 1994). The process of accumulating reserve substances in the ovaries of the females can be obtained partly by tracing the changes in the gonadosomatic index. In species which spawn in spring and summer such as snakehead, the index remains low in winter and then rises sharply just before the spawn (Wootton 1979; Marconato & Rasotto 1989; Rinchard & Kestemont 1996; Mansouri-Chorehi *et al.* 2016; Mohammadi-Darestani *et al.* 2016; Mousavi-Sabet *et al.* 2017;

Faghani-Langroudi *et al.* 2018). A rapid increase in the weight of ovaries takes place when the temperature rises and increasing amounts of food are consumed (Wootton 1979; Mousavi-Sabet *et al.* 2012a,b), the same pattern was observed in Channa gachua from the Makran basin in the present study.

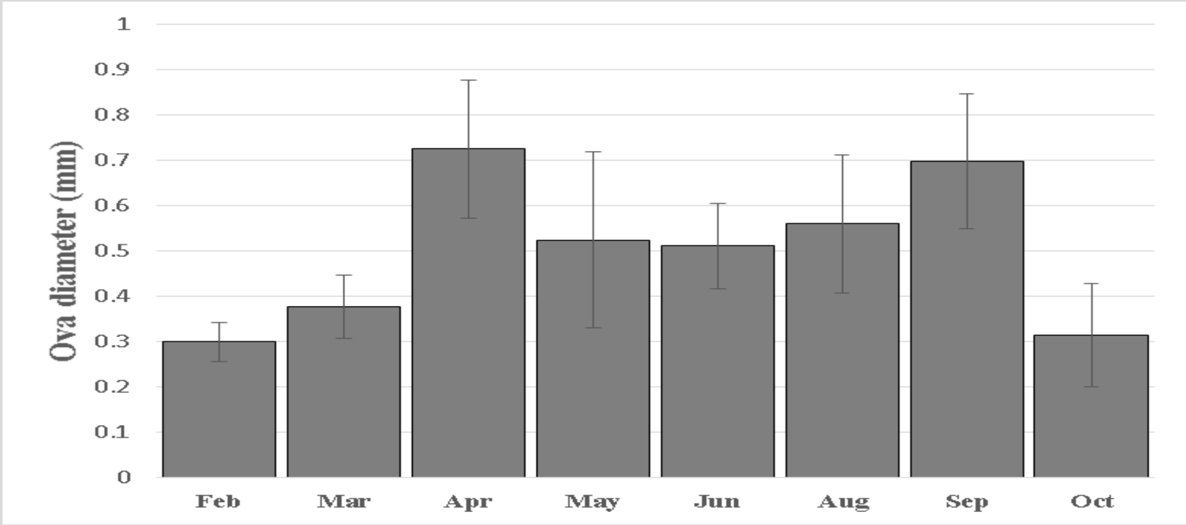

Fig. 4. The mean (± SE) diameter of oocytes (mm) of *C. gachua* from the Kajou River.

Table 2. Absolute (Fa) and relative (Fr) fecundity in particular ranges of body length (SL), body weight (W) and age of female *C. gachua* from the Kajou River.

Parameters		N	Fa		Fr	
			Range	Mean ± SD	Range	Mean ± SD
SL (mm)	<69	9	564 – 4513	2188 ± 1579	246 – 688	444 ± 193
	69.1–80	11	1515 – 4724	2935 ± 1147	221 – 646	366 ± 174
	80.1-92	32	773 - 5039	3050 ± 1138	89 - 383	246 ± 81
	92.1<	31	816 – 5490	4420 ± 1013	50 – 342	220 ± 66
W (g)	<9.6	13	564 – 4513	2065 ± 1241	93 – 688	305 ± 197
	9.6–15.6	41	1106 – 5288	3280 ± 1071	89 – 499	260 ± 85
	15.61-21.6	19	816 - 5490	4376 ± 1140	50 - 342	236 ± 63
	21.61<	10	2927 – 5513	4524 ± 877	102 – 246	175 ± 46
Age	2	9	564 – 4513	2086 ± 1463	117 – 688	370 ± 232
	3	34	773 – 5288	3062 ± 89	93 – 499	260 ± 89
	4	36	816 - 5490	4135 ± 1221	50 - 368	225 ± 72
	5	4	1300 – 5112	4954 ± 223	102 – 179	141 ± 54

Changes in the gonadosomatic index, calculated for the population in which females spawn in batches, must not be used as the only credible indicator of the number of batches laid. Similar to *C. punctatus* from Assam (Saikia *et al.* 2013), our obtained results showed that the gonado-somatic ratio is found to be maximum in April and minimum in November/December. Again, gonads have started developing during July/August to October and being peak during September. The spent stage was recorded from November onwards, indicating that spawning was over. The studied population of *C. gachua* contain single batch of mature ova and are heterochronal breeder having two peak breeding season. From the observed data it may be inferred that the fish spawn twice in a year with double spawning peak. In this regard, the breeding season of *C. striata* was determined by the monthly mean GSI values during April to September (Jannatul *et al.* 2015). The highest GSI values in mid-April to August more exactly mid-April to July with the peak in June suggested that the spawning period of *C. striata* might be extended from mid-April to August, more precisely mid-April to July with the peak in June at natural wetland of Sylhet, Bangladesh. More or less similar findings along with seasonal variation in GSI value were recorded in *Channa* *punctatus* (Hossain *et al.* 2015) and *C. marulius* by (Siddiquee 2015) in from natural wetland of Sylhet and in captive-reared C. striata (Sultana 2009; Ghaedi *et al.* 2013). Ettrich & Schmidt (1989) reported that 6 days after being released from the mouth, the fry of *C. gachua* ascend to the water surface and draw air. A foam nest is produced under which the young fish hide. De Silva (1991) found breeding to take place throughout the year in Sri Lanka, with enhanced breeding in May to July and October to December. In the Karnataka State, India this species breeds from May to August. Individuals appear to spawn once in each rainy season in Sri Lanka.

Table 3. Correlation coefficients r and regression equations for relationships between absolute fecundity (Fa) and: body length (TL), body weight (W), weight of ovary (Wg) and age.

Relationship	N	Linear Regression	*r*	r^2	*F*	*P*
Fa – SL	30	Y = – 2209.595X + 353.480	0.547	0.300	2.775	0.007
Fa – W	30	Y = 554.504X + 50.996	0.547	0.299	1.966	0.056
Fa – Wg	30	Y = 1408.53X + 290.659	0.409	0.167	7.667	0.001
Fa – Age	30	Y = – 654.627X + 987.682	0.629	0.396	1.599	0.115

In this study, the average absolute fecundity of examined females from the Kajou River was about 3561 eggs, ranging from 564 to 5940 eggs. Based on the available report on *C. gachua* from Sri Lanka, fecundity ranges from 389 and 7194 (De Silva 1991; Courtenay & Williams 2004). Brood size (97-343 larvae) is smaller than the number of mature eggs reported for females according to De Silva (1991) and many eggs either fail to develop or are lost to predators despite parental care. The absolute fecundity of other species from the genus *Channa* are different from the studied species, e.g., *Channa striata* ranged from 2843 - 23230 eggs with an average of 9167 eggs (Djumanto *et al.* 2019), 1282-20035 (Puspaningdiah *et al.* 2014), 621-15430 (Makmur & Prasetyo 2006), 7141-16486 (Makmur *et al.* 2003), and 1062-57200 eggs (Harianti 2013), in *C. punctatus* the absolute fecundity is ranged from 2423 to 6466 (Saikia *et al.* 2013), in *C. striatus* varied from 4326 to 9016 (Ali 1999), and it is 9853 to 13624 in *C. barca* (Choudhury 2004). In fact, fecundity of fish is found to vary from species to species, even in members of the same species depending on age, length, weight and environmental conditions (Biswas *et al.* 1984). Statistically significant relationships were found between the absolute fecundity and body length and gonad weight in *C. gachua* from the Kajou River. Fecundity was found to increase with increase in ovary weight in *C. punctatus* (Saikia *et al.* 2013). However, the fecundity per unit ovary weight gradually decreases in spite of the fact that weight of the ovary increased as the fishes grow in size and weight. Hence, the relation between fecundity and weight differs as breeding season approaches (Rath 2000). It is important to note that the relative fecundity generally decreases as the fish grows. This may be due to increase in egg size with the presence of large fatty (Singh 2011). From the regression equations (*b*) it would appear that the fecundity has a linear relationship with body length and ovary weight with highly significant correlation coefficient. It was observed that the fecundity-body length relationship gives a better relationship as compared to fecundity-body weight and fecundity ovary weight relationship in *Channa gachua* similar to *C. punctatus* (Saikia *et al.* 2013). Similar relationships among body parameters and fecundity have also been reported by Joshi & Khanna (1980), Pathani (1981) and Singh (2011). Correlation coefficient (r) indicated a close relation between fecundity and ovary weight than body length. Therefore, fecundity can be better expressed by ovary weight than body length and body weight.

CONCLUSION

Based on reproductive parameters, it was concluded that this fish has a prolonged active reproductive period, which is a type of adaptation by short-lived small fishes to environmental conditions.

ACKNOWLEDGEMENTS

The authors are grateful to M. Amouei for his help in fish collections.

REFERENCES

Ali, AB 1999, Aspects of the reproductive biology of female snakehead (*Channa striata* Bloch) obtained from irrigated rice agroecosystem, Malaysia. *Hydrobiologia*, 411: 71-77.

Bagenal TB 1967, A short review of fish fecundity, pp. 89-111, in: SD Gerking (Ed.), The Biological Basis Freshwater Fish production, Oxford.

Bagenal TB & Braum, E 1978, Eggs and early life history. Pp. 106. In: Bagenal T. (ed.) Methods for assessment of fish production in freshwaters. 3rd edition. Blackwell Scientific, Oxford, UK.

Biswas SP, Nasar SAK & Chatterjee, K 1984, Inter and Intraspecific Comparisons on Some Aspects of the Reproductive Biology of the Two Carps, *Labeo pangusia* (Ham.) and *Labeo dero* (Ham.). *Archives of Biological Sciences (Bruxelles),* 95: 11-27.

Chakraborty BK, Mirza ZA, Miah MI, Habib MAB & Chakraborty A 2007, Reproductive cycle of the endangered sarpunti, *Puntius sarana* (Hamilton, 1822) in Bangladesh. *Asian Fisheries Science,* 20: 145-164.

Choudhury, M 2004, Some Aspects of the Biology and Ecology of *Channa barca* (Ham.), PhD Dissertation, Dibrugarh University, Assam.

Coad, BW 2016, Contribution to the knowledge of the Snakeheads of Iran (Family Channidae). Iranian Journal of Ichthyology, 3(1): 65–72.

Coates, D 1988, Length-dependent changes in egg size, and fecundity in females, and brooded embryo size in males of fork tailed catfishes (Pisces: Ariidae) from the Sepik River, Papua, New Guinea, with some implications for stock assessments. *Journal of Fish Biology,* 33: 455-464.

Cortes, E 2000, Life history patterns and correlations in sharks, Reviews in Fisheries Science, 8(4): 299–344.

Courtenay, WR & Williams, JD 2004, Snakeheads (Pisces, Channidae): A biological synopsis and risk assessment, US Geological Survey Circular 1251: v + 143 pp.

De Silva, KHGM 1991, Population ecology of the paddy field-dwelling fish *Channa gachua* (Günther) (Perciformes, Channidae) in Sri Lanka. *Journal of Fish Biology*, 38: 497-508.

Djumanto Murjiyanti, A, Azlina, N, Nurulitaerka, A & Dwiramdhani, A 2019, Reproductive biology of striped snakehead, *Channa striata* (Bloch, 1793) in Lake Rawa Pening, Central Java. *Journal Iktiologi Indonesia,* 19: 475-490.

Dobriyal, AK, Rautela, KK & Rautela, AS 1999, Invention of a new index for the determination of sexual maturity in fishes. *Uttar Pradesh Journal of Zoology,* 19: 207-209.

Ettrich, G 1989, Breeding the green snakehead - it's a mouthbrooder, Tropical Fish Hobbyist, 37(10): 34-36.

Ettrich, G & Schmidt, J 1989, *Channa gachua* aus Südostasien und *Channa orientalis* von Sri Lanka - zwei gute Arten. *Die Aquarien und Terrarien-Zeitschrift,* 42(8): 465-467.

Faghani-Langroudi, H & Mousavi-Sabet, H 2018, Reproductive biology of lotak, *Cyprinion macrostomum* Heckel, 1843 (Pisces: Cyprinidae), from the Tigris River drainage, *Iranian Journal of Fisheries Sciences,* 17: 288-299.

Ghaedi, A, Kabir, MA & Hashim, R 2014, Effect of lipid levels on the reproductive performance of Snakehead Murrel, *Channa striata*. *Aquaculture Research,* 42: 983-991.

Hajiradkouchak, E, Patimar, R, Harsij, M & Ghorbani, R 2019, Age, growth and reproduction of the Prussian carp, *Carassius gibelio* (Bloch 1782) in 4 waterbodies of Golestan province- Southeast Caspian Sea. *Caspian Journal of Environmental Sciences*, 17: 337_351

Harianti, H 2013, Fekunditas dan diameter telur ikan gabus (*Channa striata* Bloch, 1793) di Danau Tempe, Kabupaten Wajo, *Jurnal Saintek Perikanan*, 8(2): 18-24.

Hossain, MA, Mian, S, Akter, M, Rabby, AF, Marine, SS, Rahman, MA, Iqbal, MM, Islam, MJ, Hassan, MM & Hossain, MM 2015, Ovarian Biology of Spotted Snakehead (*Channa punctatus*) from Natural wetlands of Sylhet, Bangladesh. *Annals of Veterinary and Animal Science,* 2(3): 64-76.

Jaafer Abdullah, AH, Gani Abdullah, SA & Yaseen, AT 2022, Composition of fish assemblages in the southern part of the Main Outfall Drains, Southern Iraq. *Caspian Journal of Environmental Sciences*, 20: 919-928.

Jannatul, H, Chandra, RN, Jannatul, FM, Amzad, HM, Mehed, HM, Das, TB, Sohel, M, Mahbub, IM, Bodrul, MM & Mosarof, HM 2015, Reproductive biology of striped snakehead (*Channa striata*) from natural wetlands of Sylhet, Bangladesh. *Annals of Veterinary and Animal Science*, 2(6): 162-169.

Jorfipour, M, Keivany, Y, Paykan-Heyrati, F & Ghafoori, Z 2022, Feeding indices of Planiliza abu (Heckel, 1843) in Karun River, Southwestern Iran. *Caspian Journal of Environmental Sciences,* 20: 693-700.

Joshi, SN & Khanna, SS 1980, Relative fecundity of *Labeo gonius* (Ham.) from Nanaksagar reservoir. *Proceedings of the Indian Academy of Sciences (Animal Sciences),* 89: 493-503.

Jouladeh-Roudbar, A, Vatandoust, S, Eagderi, S, Jafari-Kenari, S & Mousavi-Sabet, H 2015, Freshwater fishes of Iran; an updated checklist, Aquaculture, Aquarium, Conservation & Legislation. *International Journal of the Bioflux,* 8: 855-909.

Lee, PG & Ng, PKL 1994, The systematics and ecology of snakeheads (Pisces: Channidae) in Peninsular Malaysia and Singapore. *Hydrobiologia*, 285: 59-74.

Makmur, S & Prasetyo, D 2006, Kebiasaan makan, tingkat kematangan gonad dan fekunditas ikan haruan (*Channa striata* Bloch) di suaka perikanan Sungai Sambujur DAS Barito alimantan Selatan. *Jurnal Ilmuilmu Perairan dan Perikanan Indonesia,* 13: 27-31.

Makmur, S, Rahardio, MF & Sukimin, S 2003, Biologi reproduksi ikan gabus (*Channa striata* Bloch) di daerah banjiran Sungai Musi Sumatera Selatan. *Jurnal Iktiologi Indonesia*, 3(2): 57-62.

Mansouri-Chorehi, M, Mousavi-Sabet, H, Sattari, M, Nasrollahzadeh, A & Hedayati, A 2016, Age, sex ratio, spawning season and fecundity of *Alburnoides samiii* (Pisces: Cyprinidae), from Sefidroud River (the southwestern Caspian Sea basin). *Biharean Biologist*, 10(2): 93-97.

Marconato, A & Rasotto, MB 1989, The biology of a population of spined loach *Cobitis taenia* L. *Bolletino del Museo di Zoologia*, 56: 73-80.

Mohammadi-Darestani, M, Mousavi-Sabet, H, Vatandoust, S & Ahmadnejad, M 2016, Age, Growth and Reproduction of the Iranian Goby, *Ponticola iranicus* (Perciformes: Gobiidae) from the Southern Caspian Sea Basin. *Journal of Ichthyology*, 56: 578-587.

Mousavi-Sabet, H 2012, Biology of the southern Caspian Spined Loach and it's keeping in aquarium, *Aquariumwereld*, 65(9): 234-241. (In Dutch).

Mousavi-Sabet, H, Abdollahpour, S, Salehi-Farsani, A, Vatandoust, S, Langroudi, HF, Jamalzade, HR & Nasrollahzadeh, A 2013, Length-weight and length-length relationships and condition factor of *Alburnus mossulensis* from the Persian Gulf basin. *AACL Bioflux*, 6: 297-302.

Mousavi-Sabet, H, Abdollahpour, S, Vatandoust, S, Faghani-Langroudi, H, Salehi-Farsani, A, Salehi, M, Khiabani, A, Habibi, A & Heidari, A, 2017, Reproductive biology of *Alburnus mossulensis* (Teleostei: Cyprinidae) in the Gamasiab River, western Iran, *Iranian Journal of Ichthyology*, 4(2): 171-180.

Mousavi-Sabet, H, Kamali, A, Soltani, M, Bani, A, Esmaeili, HR, Rostami, H, Vatandoust, S & Moradkhani, Z 2011, Age, reproduction, and fecundity of a population of *Cobitis* sp. (Actinopterygii: Cypriniformes: Cobitidae) from the Babolrud River in the southern Caspian Sea basin. *Acta Ichthyologica Et Piscatoria*, 41: 117-122.

Mousavi-Sabet, H, Kamali, A, Soltani, M, Bani, A, Esmaeili, HR, Khoshbavar Rostami, H, Vatandoust, S & Moradkhani, Z 2012b, Reproductive biology of *Cobitis keyvani* (Cobitidae) from the Talar River in South of the Caspian Sea Basin. *Iranian Journal of Fisheries Sciences*, 11: 383-393.

Mousavi-Sabet, H, Kamali, A, Soltani, M, Bani, A & Rostami, H 2012a, Age, sex ratio, spawning season, gonadosomatic index, and fecundity of *Cobitis faridpaki* (Actinopterygii, Cobitidae) from the Siahrud River in the southeastern Caspian Sea basin, *Caspian Journal of Environmental Sciences*, 10: 15-23.

Nikolsky, GV 1963, The Ecology of Fishes, New York, 353 p.

Pathani, SS 1981, Fecundity of mahseer Tor putitora (Ham.), *Proceedings of the Indian Academy of Sciences (Animal Sciences)*, 90: 253-260.

Pawson, MG, Pickett, GD & Witthames, PR 2000, The influence of temperature on the onset of first maturity in sea bass. *Journal of Fish Biology*, 56: 319-327.

Pethiyagoda, R 1991, Freshwater fishes of Sri Lanka, Wildlife Heritage Trust of Sri Lanka, Colombo.

Pourshabanan, A, Sari, A & Mousavi-Sabet, H 2017, Reproductive biology of female *Oxynoemacheilus bergianus* (Actinopterygii: Cypriniformes: Nemacheilidae) from the Jajrud River, the Namak Lake basin, central Iran, *Iranian Journal of Ichthyology*, 4: 281-289.

Puspaningdiah, M, Solichin, A & Ghofar, A 2014, Aspek biologi ikan gabus (*Ophiocephalus striatus*) di perairan Rawa Pening, Kabupaten Semarang. *Diponegoro Journal of Maquares*, 3(4): 75-82.

Rath, RK 2000, Freshwater Aquaculture (2nd Edition), Scientific Publication of India, Jodhpur, 445 p.

Rinchard, J & Kestemont, P 1996, Comparative study of reproductive biology in single and multiple-spawner cyprinid fish. I. Morphological and histological features. *Journal of Fish Biology*, 49: 883-894.

Rodríguez, L, Zanuy, S & Carrillo, M 2001, Influence of day length on the age at first maturity and somatic growth in male sea bass (*Dicentrarchus labrax*, L.). *Aquaculture*, 196: 159-175.

Safran, P 1992, Theoretical analysis of the weight-length relationship in fish juveniles. *Marine Biology*, 112: 545-551.

Saikia, A, Abujam, SS & Biswas SP 2013, Reproductive biology of *Channa punctatus* (bloch) from paddy field of Sivasagar, Assam. *International Journal of Current Research*, 5: 542-546.

Siddiquee, A, Rashid, H, Islam, MA, Ahmed, KKU & Shahjahan, M 2015, Reproductive Biology of Great Snakehead *Channa marulius* from Sylhet Basin in the North East Bangladesh. *Journal of Fisheries and Aquatic Science*, 10: 294-299.

Singh, ASK 2011, Studies on ecology, biology and rearing feasibility of two spiny eel, *Macrognathus aral* (Bloch and Schneider) and *Macrognathus pancalus* (Ham-Buch) from upper Assam, Unpublished Dissertation, Dibrugarh University, 264 p.

Sultana, MA 2009, Breeding biology and cryopreservation of spermatozoa of baim, *Mastacembelus armatus* (Lacepede, 1800) and shol, *Channa striata* (Bloch, 1793), MSc. Dissertation, Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Witthames PR, Greer, M, Walter, M, Dinis, T & Whitting, CL 1995, The Geographical variation in the potential annual fecundity of Dover Sole, *Solea solea*, from European Shelf waters during 1991. *Netherlands Journal of Sea Research,* 34: 45-58.

Wootton, RJ 1979, Energy costs of egg production and environmental determinants of fecundity in teleost fishes, *Journal of the Zoological Society of London*, 44: 133-159.

Wootton, RJ 1998, Ecology of Teleost Fishes, Second edition, Kluwer, Dordrecht.

Bibliographic information of this paper for citing:

Alitabar, A, Vatandoust, S, Ghobadi, S, Mousavi-Sabet, H, Changizi, R 2024, Age, sex ratio, spawning season, reproduction, and fecundity of *Channa gachua* (Actinopterygii, Channidae) from Makran basin, Southeastern Iran, Caspian Journal of Environmental Sciences, 22: 813-821.