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Original Article

Biological and Reproductive Indices of *Mystus bleekeri* (Day, 1877) in Open Water Body (Dekhar Haor) of Bangladesh

Sabuj Kanti Mazumder[1], Mohammad Abdus Salam[1], Md. Arifur Rahman Khan[2], Sarker Mohammed Ibrahim Khalil[3], Md. Tawheed Hasan[4]

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ABSTRACT

Some biological and reproductive aspects of the *Mystus bleekeri* from Dekhar Haor were investigated. From the commercial catches, a total of 600 sample collections were performed on a monthly basis from July 2017 to June 2018. Total length (TL, cm), body weight (W, g) and individual's sex were identified between 216 male (36%) and 384 female (64%) fish (ratio 1.00: 1.78). Mean TL and W of samples were 14.85±3.38 cm and 27.54±15.76 g, respectively. The TL of male and female ranged from 6.9-21.3 and 7.80-24.60 cm, respectively; and W ranged from 5.3-63.3 and 6.70-76.40 g, respectively. In length–weight relationship of this fish depicted a negative allometric growth (*b*=2.408) with a condition factor (*K*n) of 1.04±0.11. Fish of 16.00-16.90 and 10.00-10.90 cm length groups demonstrated the highest (1.45±0.23) and lowest (0.89±0.18) *K*n values, respectively which was significantly varied among different length groups. Monthly study of gonadosomatic index showed two peaks in the month of May-June and November for both sexes. The results of this study provide baseline data on some biological aspects of *M. bleekeri*, which would be useful in predicting the responses of *M. bleekeri* populations in Dekhar Haor.

Keywords: Condition factor, Gonadosomatic index, Length-weight relationship, *Mystus bleekeri*, Sex ratio

ORCID IDs of the author:
S.K.M. 0000-0002-3604-2363;
M.A.S. 0000-0001-7463-4936;
A.R.K. 0000-0002-6995-166X;
S.M.I.K. 0000-0001-6925-9385;
T.H. 0000-0002-9726-7374

[1]Department of Genetics and Fish Breeding, Faculty of Fisheries, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

[2]Department of Agronomy, Faculty of Agriculture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

[3]Department of Fish Health Management, Faculty of Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

[4]Department of Aquaculture, Faculty of Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

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Correspondence:
Sabuj Kanti Mazumder
E-mail:
sabujgfb@bsmrau.edu.bd

INTRODUCTION

Mystus bleekeri (Day, 1877), a member of the Bagridae (Siluriformes) family locally known as gulsha, is widely available in the tropical countries like Bangladesh, Myanmar, Pakistan, Cambodia, India, Malaysia, Sri Lanka, Vietnam, Cambodia, and Laos (Froese & Pauly, 2006). This species inhabits rivers, canals, khals, beels, lakes, swamps, and other freshwater bodies in Bangladesh (Rahman, 2005). Being a dominant catch in Dekhar Haor (northeastern Bangladesh), it has become an important target species for small-scale fishermen (Alam et al., 2017; Bhattacharjee et al., 2017). Similar to other small indigenous fish species of Bangladesh, this species also possessed high nutritional factors like protein, micronutrients, vitamins, and minerals (Sultana et al., 2019). Due to its nutritive values but also taste and palatability, the demand and price of this fish is increasing day by day. Development of seed production technology of this species is the prime need to protect and conserve natural stock. Investigation and securing of research knowledge on some important biological aspects of fish like length-weight relationships (LWRs), sex ratio, condition factor (*K*n), and gonadosomatic index (GSI) are the prerequisite strategies for successful production and stock management (Mazumder et al., 2020).

Length–weight relationships (LWRs) are needed to estimate weight from length because direct weight measurements can be time-consuming in the field (Hossain et al., 2006a) as well as these parameters are important in fish biology and can provide information on the stock condition (Gonzalez Acosta et al., 2004). In fish, *K*n reflects the physiological status, health condition, and well-being of stock directly interrelated to future sustainability. This parameter also acts as an indicator of life cycle status of a species, including management practices and equilibrium condition of an ecosystem (Lizama & Ambrosio, 2002). An index of gonad size relative to fish size is termed as GSI, and gradual increment of GSI value indicates the gonadal development of fish reaching to the spawning in the monsoon and late monsoon period (Amtyaz et al., 2014). However, there is scarcity of literature on the biological parameters of *M. bleekeri* in the Haor wetland ecosystems of Bangladesh. Only, in the previous study, the author checked the seasonal effect on trophic level, stomach contents, LWRs, and condition factor of *M. bleekeri* (Mazumder et al., 2021). Subsequently, this study aimed to investigate the biology of *M. bleekeri* in terms of LWRs, *K*n, GSI and sex ratio to provide an updated knowledge that can be utilized for captive spawning, wild stock management, successful farming, and environmental management of this species.

MATERIALS AND METHODS

Dekhar Haor was selected for the present study as it is one of the largest and most important haors in Bangladesh. This wetland is positioned between 24°34′N to 25°12′N and 90°56′E to 91°49′E latitude and longitude, respectively (Figure 1). In Sunamganj district, this waterbody covers Sunamganj Sadar, Dakshin Sunamganj, Dowarabazar, and Chhatak upazilas. It is made up of 36 small, medium and large interconnecting beels, canals, rivers, and crop lands. During the monsoon, Haor looks like an inland sea full of water, but in the dry season it becomes almost dry except for some deeper beels. This Haor contributes to fish production for the local and regional demand, livelihood for small scale fishermen, place of aquatic biodiversity, and a source of natural fish seed supply for the local fish culture (Pandit et al., 2015).

Mystus bleekeri specimens were sampled from July 2017 to June 2018 from three geographical locations as Pagla Bazar, Sunamganj Fish market and Dowarabazar. These three sites were major fish landing zones of Dekhar Haor. Each month 50 fish samples were obtained, meaning 600 samples in 12 months. The fish were caught using three layered trammel net, cast net, scoop net, and different sized traps. In stretched condition, mesh sizes of the trammel nets were 4.2, 6.5 and 7.5 cm in three different layers, and cast nets were 2 cm. Specimen identification was carried out in the field according to Talwar and Jhingran (1991). After collection, specimens were confirmed to the species level, preserved by date in plastic jars with 10% (w/v) formalin and transported to the laboratory for further study (Alam et al., 2018).

TL and W of all fish were measured in laboratory condition by using a centimeter scale and weighing balance to the nearest centimeter (cm) and gram (g), respectively. Then, the specimen was dissected, gonads were removed and weighted. For size structure measurement, length measurements were pooled into

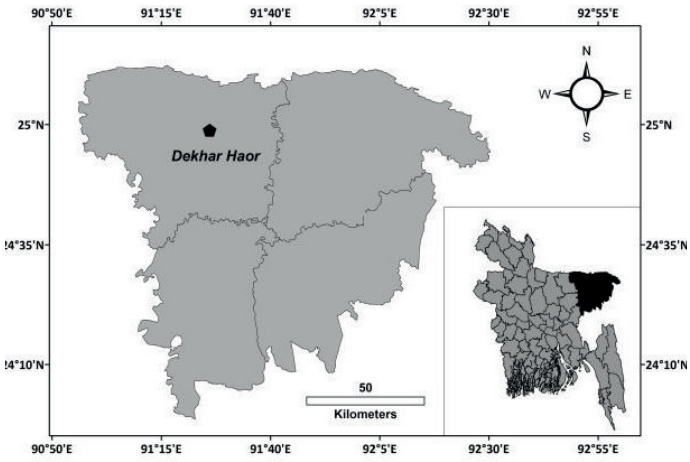

Figure 1. Map depicting the location of Dekhar Haor, Sylhet, Bangladesh (Map modified by Mazumder et al., 2021).

groups of 1 cm length intervals. Throughout the examination of the gonad, sex of the individual fish was determined; sex ratio was calculated as total number of males relative to total number of females depicted as M: F (males: females) (Oliveira et al., 2012). The chi-square (χ^2) was employed to quantify the significant difference between the sex ratio as commonly expected value is 1:1(Sokal & Jamesrohlf, 1987).

The LWR was estimated with a nonlinear regression equation (Froese, 2006):

$$W = a \text{ x } TL^b$$

Here *W*, *a*, TL and *b* indicate body weight (g), total length (cm); intercept in the y-axis, and the regression coefficient (isometric growth value is 3), respectively. Analysis of covariance in both slope and intercept to quantify the level of significance.

*K*n of each individual fish was estimated according to the equation of Le Cren (1951).

$$Kn = \frac{W}{(a\ x\ TL^b)}$$

Where, the meaning of *a* and *b* is the scaling coefficient for the weight at a certain length and body shape parameter, respectively. Obtained values of *a* and *b* from the LWR equation were also employed in this equation.

Digital balance (Model: AND Gulf EK600, country of origin: China) with an accuracy of 0.01 g was used to measure individual fish and its removed gonad weight. Then, individual fish GSI (%) was calculated using an equation developed by Bagenal & Tesch (1978).

GSI (%) = Gonad weight (g) /body weight (g) x 100

All the data sets were analyzed by using Microcalc Origin™ v 8.0 software employing Student's *t*-test. A *p* value less than 0.05 ($P < 0.05$) was considered as the level of significance.

RESULTS AND DISCUSSION

Among the 600 specimens, most of the fish belongs to 11-18 cm size groups. The size pattern demonstrated a normal distribution (Figure 2), and the TL of largest mature male and female were 21.30 and 24.60 cm, respectively.

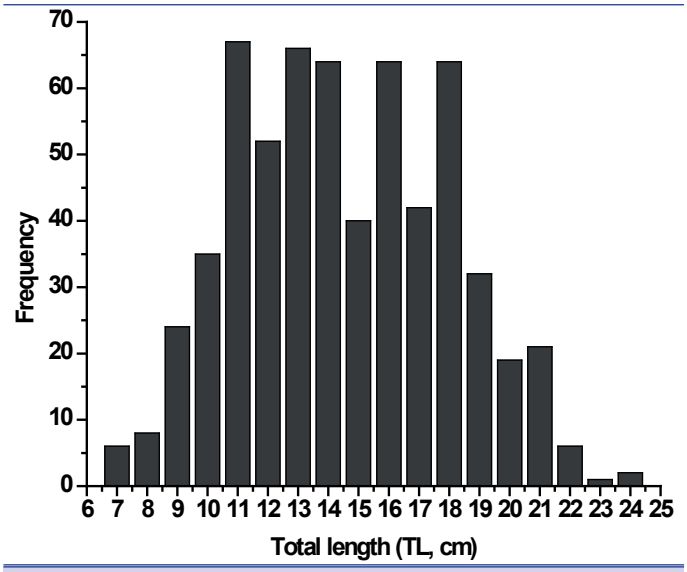

Figure 2. Length frequency distribution of *M. bleekeri* from Dekhar Haor.

Average length and weight (±SD) for all fish were 14.85±3.38 cm TL and 27.54±15.76 g, respectively. The TL of males and females ranged from 6.90–21.30 and 7.80–24.60 cm, respectively and weighed between 5.30–63.30 g and 6.70–76.40 g, respectively. The reported maximum TL of *M. bleekeri* was 17.7 cm for male (Hossain et al., 2017). However, the highest TL found in this study was higher than the reported TL. LWRs regression slope *b* valued at 2.41 (Figure 3) was not different ($P > 0.05$) from the mean exponent 3.

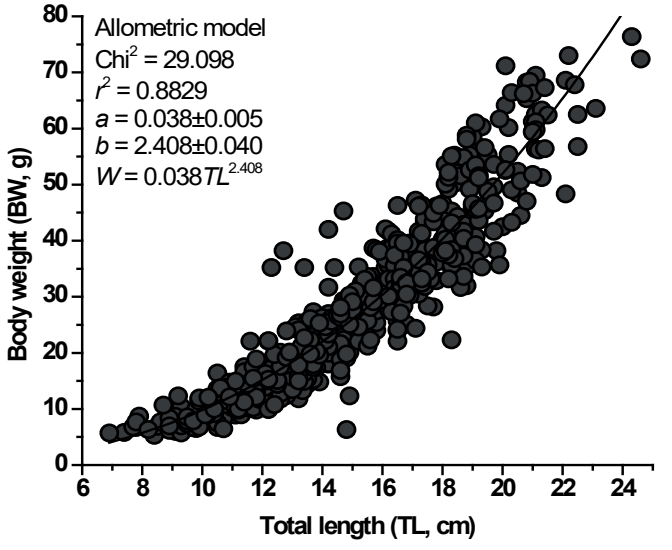

Figure 3. Length–weight relationship of *M. bleekeri* from Dekhar Haor (n=600).

Fish LWRs differences can be governed by different influential factors like physico-chemical parameters of living environment, season of the year, degree of feed availability, sex variations and gonadal maturity, normal growth pattern, length ranges of specimens, and number of fishes investigated (Cherif et al., 2008). Findings of this study demonstrated the allometric coefficient (*b*) is 2.41, which was positioned between the expected range of 2.00 to 4.00 (Bagenal and Tesch, 1978). If the slopes or exponents *b* remain between 2.00 to 4.00, the growth pattern (relationships between length and weight) of fish remain in the acceptable limit. A high value of correlation coefficient r^2 indicated a high degree of relation between length and weight of this species. Table 1 depicted the LWRs of different *Mystus* species from different parts of the world, indicating these parameters can differ due to locations and species variations. Seasonal fluctuations of value (*b*) of LWRs are directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions, and other factors, such as sex, age, fishing time, and area and fishing vessels (Kalaycı et al., 2007; Subba and Adhikaree, 2011). Changes in (*b*) value can also be attributed to factors such as overfishing and competition for food (Alam et al., 2018; Bagenal & Tesch, 1978; Mazumder et al., 2016; Mir et al., 2012). Thus, LWRs of fish are affected by above-mentioned factors although none of them was considered in current research.

Among different size groups, mean *K*n differs significantly ($P < 0.05$), highest (1.45±0.23) and lowest (0.89±0.18) TL values were documented in 16.00-16.90 and 10.00-10.90 cm fish groups, respectively (Table 2). It was also observed that the number of individuals caught was also higher with length groups from 11.00 cm to 18.00 cm. The mean *K*n values that were ≥ 1 in all the size groups except in 10.00-10.90 are the indication of stable physiological condition of studied fish species (Mazumder et al., 2016). The *K*n values of the studied species in the present study varied between 0.89 and 1.45 as shown in Table 2. These values suggested a state of wellbeing for the species evaluated. A number of factors that affect the growth condition including reproductive cycles, availability of food as well as habitat and environmental factors (Morato et al., 2001). The variation of *K*n from 1 divulges information regarding the differences in the availability of food and the consequence of physicochemical features on the life cycle of fish species (Le Cren, 1951). On the other hand, gonad weight and *K*n having proportional relation meaning of *K*n value elevated with the increasing of gonad weight just before the spawning. Moreover, after spawning, *K*n decreased because of releasing gonadal materials (Gupta & Banerjee, 2013). It should be noted that, prevalence of parasites, food availability and physiological status of fish influence the *K*n values (Simon et al., 2013) might be the probable causes of differences with the previous findings.

Fish physiological status depends on their different food and feeding habits, which is also relevant to year-round food supply. Nonetheless, aquatic climatic conditions and their correlation matrix might have played essential roles for the shaping of fish *K*n in Dekhar Haor. The adult *M. bleekeri* in 16.00-16.90 cm TL group demonstrated higher *K*n than the lower size classes, and better foraging tactics may be responsible for these kinds of outcomes (Fagade et al., 1984).

Table 1. Comparison of length-weight relationships of the genus *Mystus*.

Species	Sex	LWR parameters			Growth type	Locality	References
		a	*b*	r^2			
M. baramensis	B	0.004	2.88	0.92	(-) ve	Malaysia	Martin-Smith 1996
M. vittatus	M	0.023	2.96	0.96	(-) ve	Bangladesh	Hossain et al. 2006b
M. vittatus	F	0.018	3.13	0.97	(-) ve	Bangladesh	Hossain et al. 2006b
M. vittatus	B	0.020	3.06	0.96	(-) ve	Bangladesh	Hossain et al. 2006b
M. pelusium	B	0.028	3.00	0.99	I	Iran	Heydarnejad 2009
M. cavasius	B	0.012	2.91	0.96	(-) ve	India	Sani et al. 2009
M. bleekeri	M	0.013	2.64	0.987	(-) ve	Pakistan	Naeem et al. 2012
M. bleekeri	F	0.014	2.70	0.986	(-) ve	Pakistan	Naeem et al. 2012
M. bleekeri	B	0.015	2.62	0.892	(-) ve	Pakistan	Naeem et al. 2012
M. bleekeri	B	4.310	2.816	0.99	(-) ve	India	Maurya et al. 2018
M. bleekeri	B	0.026	2.54	0.98	(-) ve	Bangladesh	Hossain et al. 2016
M. cavasius	B	0.007	3.10	0.969	(+) ve	Bangladesh	Hossain et al. 2016
M. gulio	B	0.009	3.11	0.975	(+) ve	Bangladesh	Hossain et al. 2016
M. tengra	B	0.016	2.80	0.958	(-) ve	Bangladesh	Hossain et al. 2016
M ystus vittatus	B	0.017	2.77	0.960	(-) ve	Bangladesh	Hossain et al. 2016
M. bleekeri	B	0.038	2.41	0.88	(-) ve	Bangladesh	This study

*M=male, F=female, B=both sexes, (-) ve = negative allometric growth, I = isometric growth

From the total of 600 fish studied, 384 (64%) were females and 216 (36%) were males, giving an indication of male and female sex ratio at 1:1.80 (Table 3). Significantly higher numbers of females over males were found from January to April ($P<0.01$) and May to June ($P<0.05$). Fish sex ratio can be varied with season among different size and age groups although overall female number is higher relative to male. Investigation results of this study showed female *M. bleekeri* dominance in that population compared to the male group, indicating deviation from 1:1 as the expected value. These results are very much similar to the previous reports of Bhatt (1971), Rao & Sharma (1984) and Roy & Hossain (2006), in which the number of female *Mystus* species was higher than males. Similar types of deviation in male and female number (sex ratio) were also found in two archer fish: *Toxotes chatareus* and *T. jacularix* (2012). Reason of *M. vittatus* female dominance in the stock is not clear, but Fagade et al., (1984) described it as a natural way of population dynamics and stock regulation for fish species. During the period of spawning, mortality

Table 2. Condition factor (*Kn*) of *M. bleekeri* in relation to size classes.

TL (cm)	n	Mean	SD	95% CI of *b*	P-Value
<8.00	6	0.97	0.09	-0.17, 4.99	0.060
8.00-8.90	10	1.03	0.18	-1.93, 7.19	0.220
9.00-9.90	24	1.03	0.23	-0.71, 5.39	0.126
10.00-10.90	35	0.89	0.18	0.46, 6.39	0.025
11.00-11.90	67	1.00	0.19	-0.09, 4.71	0.058
12.00-12.90	52	1.00	0.31	-2.51, 8.45	0.281
13.00-13.90	66	0.99	0.21	-0.32, 7.32	0.072
14.00-14.90	64	1.07	0.27	-7.25, 4.10	0.581
15.00-15.90	40	1.01	0.14	0.52, 9.88	0.030
16.00-16.90	63	1.45	0.23	-5.65, 4.77	0.868
17.00-17.90	43	0.99	0.14	-0.93, 10.61	0.098
18.00-18.90	54	1.01	0.18	-1.08, 13.49	0.093
19.00-19.90	32	1.17	0.19	-12.54, 7.66	0.625
20.00-20.90	19	1.00	0.16	-9.58, 23.07	0.395
21.00-21.90	16	1.00	0.08	-16.35, 18.80	0.883
22.00-22.90	6	1.00	0.13	-66.3, 65.8	0.991
>23.00	3	0.99	0.04	-43.07, 57.54	0.319
Overall	600	1.04	0.12	-	-

Table 3. Monthly variation of sex ratio in *Mystus bleekeri*.

Month	No. of Fish	Male (Observed Value)		Female (Observed value)		Ratio of male and female	χ^2	d. f.	*P*	Remark
		No.	%	No.	%					
July' 17	50	24	48	26	52	1:1.10	0.08	1	0.77	NS
August' 17	50	22	44	28	46	1:1.30	0.72	1	0.39	NS
September' 17	50	18	36	32	64	1:1.80	3.92	1	0.06	NS
October' 17	50	26	52	26	48	1:1.10	0.00	1	1.00	NS
November' 17	50	20	40	30	60	1:1.50	2.00	1	0.15	NS
December' 17	50	22	44	28	46	1:1.30	0.72	1	0.39	NS
January' 18	50	14	28	36	72	1:2.60	9.68	1	0.00	S**
February' 18	50	12	24	38	76	1:3.20	13.52	1	0.00	S**
March' 18	50	14	28	36	72	1:2.60	9.68	1	0.00	S**
April' 18	50	12	24	38	76	1:3.20	13.52	1	0.00	S**
May' 18	50	18	36	32	64	1:1.80	3.92	1	0.04	S*
June' 18	50	16	32	34	68	1:2.10	6.48	1	0.01	S*

NB: χ^2 = Chi-square test d.f. = degrees of freedom, P = probability, NS = Non-Significant; S** = Significant at 1% level; S* = Significant at 5% level

of males is greater than that of females as male possess higher metabolic strain than the same aged females of a specific population (Banik et al., 2012; Parvin et al., 2011). In different *Mystus* species, early maturation of males relative to females was previously reported by Bhatt (1971) and Rao & Sharma (1984).

Up to the present time, fishery of *M. bleekeri* is capture-based. As in the present study, *M. bleekeri* was found with a sex ratio of 1: 1.80 (male: female) therefore, two females for one male can be stocked for captive breeding to get success. The present study reveals that the right time to collect the brooders from nature was September-October for *M. bleekeri*. However, proper strategies to conserve the fish species in its natural habitat are required.

The monthly changes in GSI of both female and male mature fish were shown in Fig. 4. GSI of female fish showed a steady increase from minimum in August (1.28±0.71) to maximum in November (8.00±1.88). In December, it fell to a low level; indicating that spawning had occurred. However, from December, the GSI again started to increase up to April, and then gradually decreased (Figure 4). Likewise, GSI in male fish decreased abruptly in August to reach the lowest level (0.39±0.21) and from September it gradually increased up to November (2.59±1.67). From November, it again dropped sharply to a low level, and it increased again in January and February. Nevertheless, after that, it fell in March during spawning and gradually increased up to June. The mean monthly GSI values indicate that *M. bleekeri* might spawn twice a year between April-July and October-November. The high GSI values for female fishes were observed in April and November whereas for male it was observed in May to July and November. GSI value is related to the maturation of gonad and becomes maximum just before the spawning. After completing spawning, the GSI value decreases abruptly (Simon et al., 2012). In monthly basis study, in which GSI value(s) reach at the peak indicating the spawning duration and for any particular fish species higher GSI reading depicts the breeding periodicity (Kiran & Puttaiah, 2003). In case of maturation, GSI values of females are much higher than males as a result of greater proportion of body reserve deposition in the gonads of females (Chatzifotis et al., 2004).

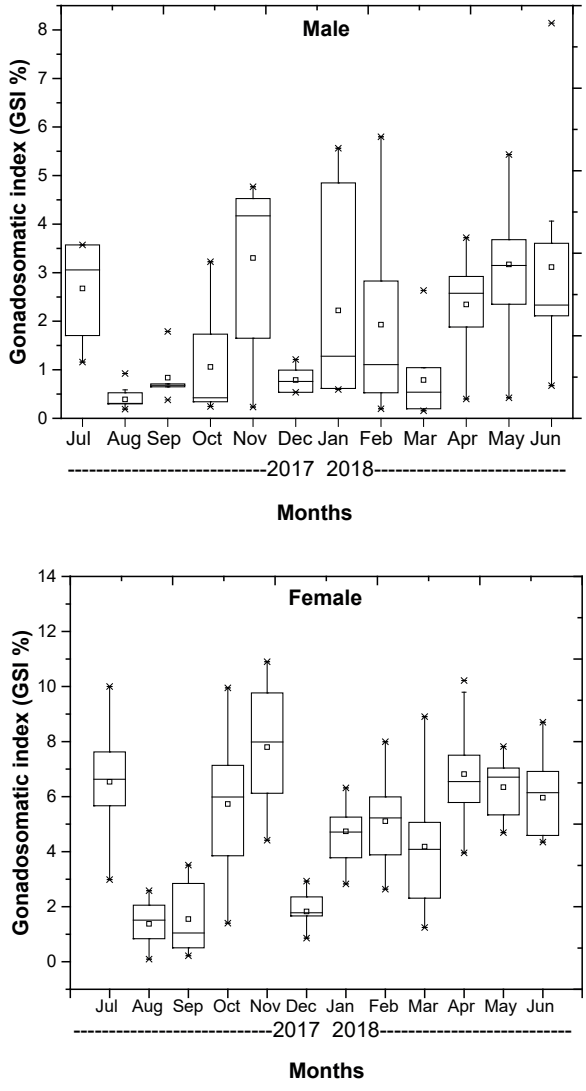

Figure 4. Mean monthly gonadosomatic index for male and female *M. bleekeri*.

CONCLUSION

Production of *M. bleekeri* is completely dependent on natural collection, and it is very important to start artificial breeding to initiate captive culture. Findings of present study reveal that brood fish size at 15-17 cm TL should be collected from wild stock. In breeding seasons, *M. bleekeri* male: female sex ratio becomes 1:1.50; therefore, to achieve artificial breeding success three females for two males should be stocked. However, it is necessary to investigate human interventions (exploitation) and natural environmental alteration for the modulation of fish biological parameters, which will be supporting evidence for the policymakers regarding sustainable exploitation and stock management of *M. bleekeri* in Dekhar Haor.

Conflict of interests: The authors declared no conflict of interest.

Ethics committee approval: Ethics committee approval was not required.

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