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Population structure of Indian river shad, *Gudusia chapra* (Hamilton, 1822) from the Rupsha River, south-west Bangladesh

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Abstract. The Indian river shad, *Gudusia chapra*, is a well-known species of potamodromous fish belonging to the Clupeidae family. The main focus of this study is to state the sex ratio, growth pattern, length-length relationship, form factor, Fulton's condition factor and relative weight of *G. chapra* harvested from the Rupsha River (south-west Bangladesh). Altogether 300 specimens (male=166 and female=134) were harvested with the help of commercial fisher folks on seasonal basis (summer, rainy and winter) during 2022. Body weight and length of individual specimen were recorded with digital balance and measuring board. Total length varied between 12.7 to 16.5 cm for males and 13.0 to 17.3 cm for females. Further, body weight ranged between 15.82 to 42.48 g for male and 18.36 to 46.65 g for female. As a whole, both sexes revealed positive allometric growth pattern (b>3.00). Moreover, the length-length relationships were found highly correlated for both sexes. The estimated form factor was 0.0087 indicated fusiform body shape for *G. chapra* population. The mean Fulton's condition factor was recorded close to 1 indicated a pleasant health condition for this species. Further, mean relative weight revealed a sound ecological atmosphere regarding prey-predator status. The research outcomes would be helpful to execute a sound management policy in the Rupsha River and connected ecosystem in the south-west Bangladesh.

Keywords: *Gudusia chapra*, Rupsha River, Fulton's condition factor, Sex ratio

Introduction

Data regarding on sex ratio provides vital evidence to estimate reproductive potential of a fish population (Khatun *et al*. 2018). Additionally, knowledge about length-frequency distribution (LFD) is essential to specify the recruitment pattern and mortality of a fish species in a particular aquatic ecosystem (Neuman and Allen 2001). Likewise, information on length-weight relationship (LWR) is indispensable for assessing the life history traits of a single species dwelling in varied geographic arena (Hossain *et al*. 2013, Rahman *et al*. 2019, Rahman *et al*. 2020, Asadujjaman *et al.* 2022, Samad *et al.* 2021). In order to estimate the biomass of a certain fish species, LWR data are frequently used (Khatun *et al*. 2018). Length-length relationship (LLR) is a crucial population parameter. Various eco-physiological characteristics of fish are length dependent (Hossain *et al.* 2006, Sabbir *et al.* 2021, Islam *et al.* 2021). Furthermore, information regarding on LLR is a frequently used technique for stock assessment program (Ahmed *et al*. 2020). Typically form factor ($a_{3.0}$) is a numerical index assumes the probable body shape of a teleost fish (Froese 2006). However, condition factor is used to estimate the health condition and maturity status of a fish in a specific aquatic ecosystem (Le Cren 1951; Sabbir *et al*. 2020). The higher condition index indicates the superior health status of a fish. Conversely, relative weight (W_R) is a frequently used technique to denote the

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environmental condition of a specific fish population considering prey-predator status (Froese 2006).

The Indian River shad, *Gudusia chapra* is a prominent potamodromous species under Clupeidae family (Riede 2004). This clupeid fish is found abundantly in Bangladesh (Rahman 1989), Nepal (Shrestha 1994), India (Menon 1999) and Pakistan (Mirza 2002). This species is locally called *Chapila* in Bangladesh and serve as an important source of protein for the rural fisher folks. This fish commonly inhabits in the surface water and use a wide variety of feed item like phytoplankton, debris and zooplankton (Sheikh *et al*. 2017). Besides, this species attains sexual maturity at around 9.13 cm in total length (Hossain *et al*. 2021) and typically spawns twice (May and October) in a year (Mondal and Kaviraj 2010). The total catch of *G. cahapra* is fulfilled from natural sources and consequently, the wild stock is gradually declining due to over fishing (Sabbir *et al*. 2022). Already numerous research works have been conducted on *G. chapra* including biometric indices and population biology (Hossain *et al*. 2021, Sheikh *et al*. 2017), food and feeding habit (Mondal and Kaviraj 2010, Phukan *et al*. 2012) and reproductive biology (Ahmed *et al*. 2007, Ahamed *et al*. 2014, Basumatary *et al*. 2016, Narejo *et al*. 2006, Mondal and Kaviraj 2010). Nevertheless, biometric information about *G. chapra* is limited from the Rupsha River, Southwest (SW) Bangladesh. Therefore, the current research has been conducted to discover the biometric indices of *G. chapra* harvested from the Rupsha River ecosystem, SW Bangladesh, including sex ratio, length frequency distribution (LFD), length-weight relationships (LWR), length-length relationship (LLR), form factor ($a_{3.0}$), Fulton's condition factor (K_F) and relative weight (W_R).

Materials and methods

Sampling: A total of 300 specimens (Male, n=166 and female, n=134) of *G. chapra* were collected from commercial fishermen on seasonal bases (i.e., summer, April; rainy, August; and winter, December) during 2022 from the Rupsha River (latitude, 22°35'58.11"N and longitude, 89°31'4.65"E), SW Bangladesh. Specimens were sampled using mainly gill net. Males and females were separated by microscopic observation of gonad.

Population structure: Lengths (total length, TL; fork length, FL; and standard length, SL) and body weight (BW) of the experimental specimens were recorded with measuring board and digital scale. TL data set were arranged considering 1 cm intervals to observe the LFDs of *G. chapra* population. Besides, growth pattern (*b*) was studied as LWRs; $W = a \times L^b$, where W represents BW (g) and L is the TL (cm) (Le Cren 1951). Furthermore, linear regression analysis was conducted to assess the LLRs.

Form factor: Calculation of form factor ($a_{3.0}$) was accomplished as $a_{3.0}=10^{\log\ a-s(b-3)}$, where *S* is the regression slope of *ln a vs. b*.

Estimation of K_F and W_R: The value of K_F was derived following the equation of Fulton (1904) as developed, $K_F=100\times(W/L^3)$, where *W* postulates the BW and L indicates the

TL. Additionally, W_R was assessed with the equation of Froese (2006) as described, $W_R=(W/Ws)\times 100$, at this point W_S denotes the standard weight ($W_S=a\times L^b$) for the experimental specimen.

Data analysis: Microsoft® Excel-add-in-DDXL software was used to evaluate the experimental data. In order to evaluate the sex ratio, Chi-square test was applied. Wilcoxon signed rank test was done with GraphPad Prism 6.5 software to assume the relationship between W_R and 100 (Anderson and Neumann 1996). Data analysis was done with 5% significance level.

Results

Sex ratio: All together 300 (Male, n=166 and female, n=134) specimens were sampled during the study period. As a whole sex ratio did not deviate statistically (male: female=1:0.81) from the predicted 1:1 ratio. Further, the seasonal sex ratio indicated that males were dominated during the three seasons (Table I).

Table I. Seasonal deviation of sex ratio of the *Gudusia chapra* from the Rupsha River

Seasons	Number of specimens			Sex ratio (Male:Female)	χ^2 (*df*=1)	Significance
	Male	Female	Total			
Summer	58	42	100	1:0.72	2.56	NS
Rainy	53	47	100	1:0.89	0.36	NS
Winter	55	45	100	1:0.82	1.00	NS
Total	166	134	300	1:0.81	3.41	NS

Note: *df*, degree of freedom; NS, not significant at 5% significance level ($\chi^2>\chi^2_{t\ 1,\ 0.05}=3.84$).

Population structure: The LFDs of *G. chapra* exposed that TL varied from 12.7 to 17.3 cm for the pooled data set. Additionally, LFDs denoted that 15.00-15.99 cm TL group was found numerically exceeding for both male and female population (Fig. 1). Further, the BW varied from 15.82 to 42.48 g for male and 18.36 to 46.65 g for female individuals (Table II).

Table II. Statistics on TL and BW measurements of *Gudusia chapra* from the Rupsha River

Seasons	Sex	*n*	TL (cm)				BW (g)			
			Min	Max	Mean ± SD	95% CL	Min	Max	Mean ± SD	95% CI
Summer	M	58	13.4	16.5	14.47±0.79	14.26-14.68	18.57	42.48	26.86±5.90	25.31-28.41
	F	42	13.7	16.9	15.31±0.74	15.08-15.54	25.10	44.52	33.80±4.82	32.30-35.30
Rainy	M	53	13.5	16.5	15.26±0.83	15.03-15.49	23.45	41.73	33.10±4.92	31.74-34.45
	F	47	13.4	16.5	15.47±0.61	15.29-15.65	22.38	41.62	35.40±3.79	34.29-36.51
Winter	M	55	12.7	16.0	14.23±0.95	13.97-14.48	15.82	38.12	25.08±6.33	23.37-26.79
	F	45	13.0	17.3	15.15±1.12	14.81-15.49	18.36	46.65	32.46±7.90	30.09-34.84

Notes: *n*, sample size; M, male; F, female; TL, total length (cm); BW, body weight (g); min, minimum; max, maximum; SD, standard deviation; CL, confidence limit.

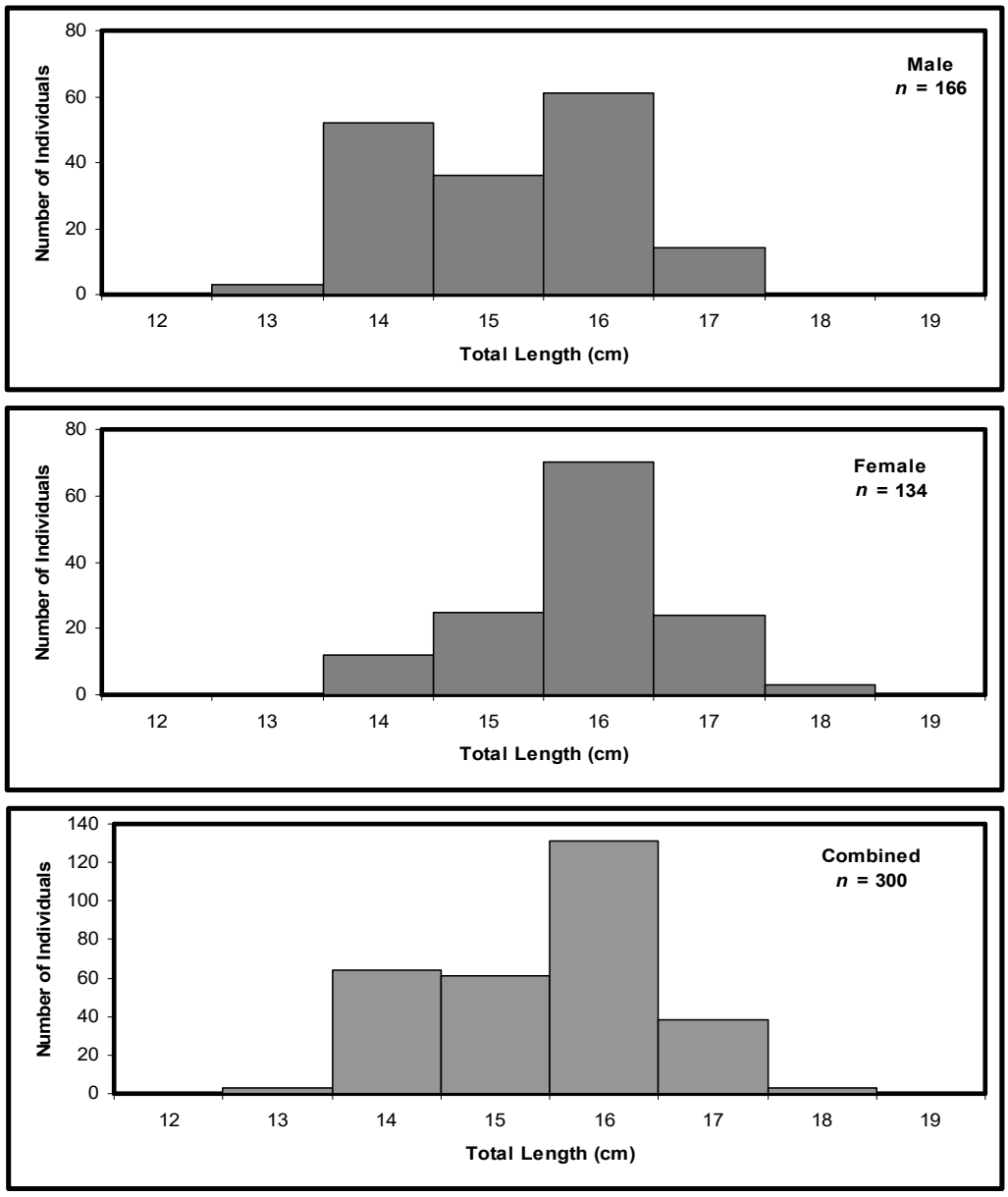

Fig. 1. LFDs of *Gudusia chapra* harvested from the Rupsha River, SW Bangladesh.

The present study further specified that both male and female exposed positive allometric growth pattern (b>3.00) (Fig. 2). However, female exposed isometric growth pattern (b=3.00) during summer and rainy season (Table III). All LWRs were found highly correlated for both sexes (Table III). Moreover, the LLRs (TL *vs.* FL and TL *vs.* SL) displayed strong correlations for both sexes (Figs. 3 and 4).

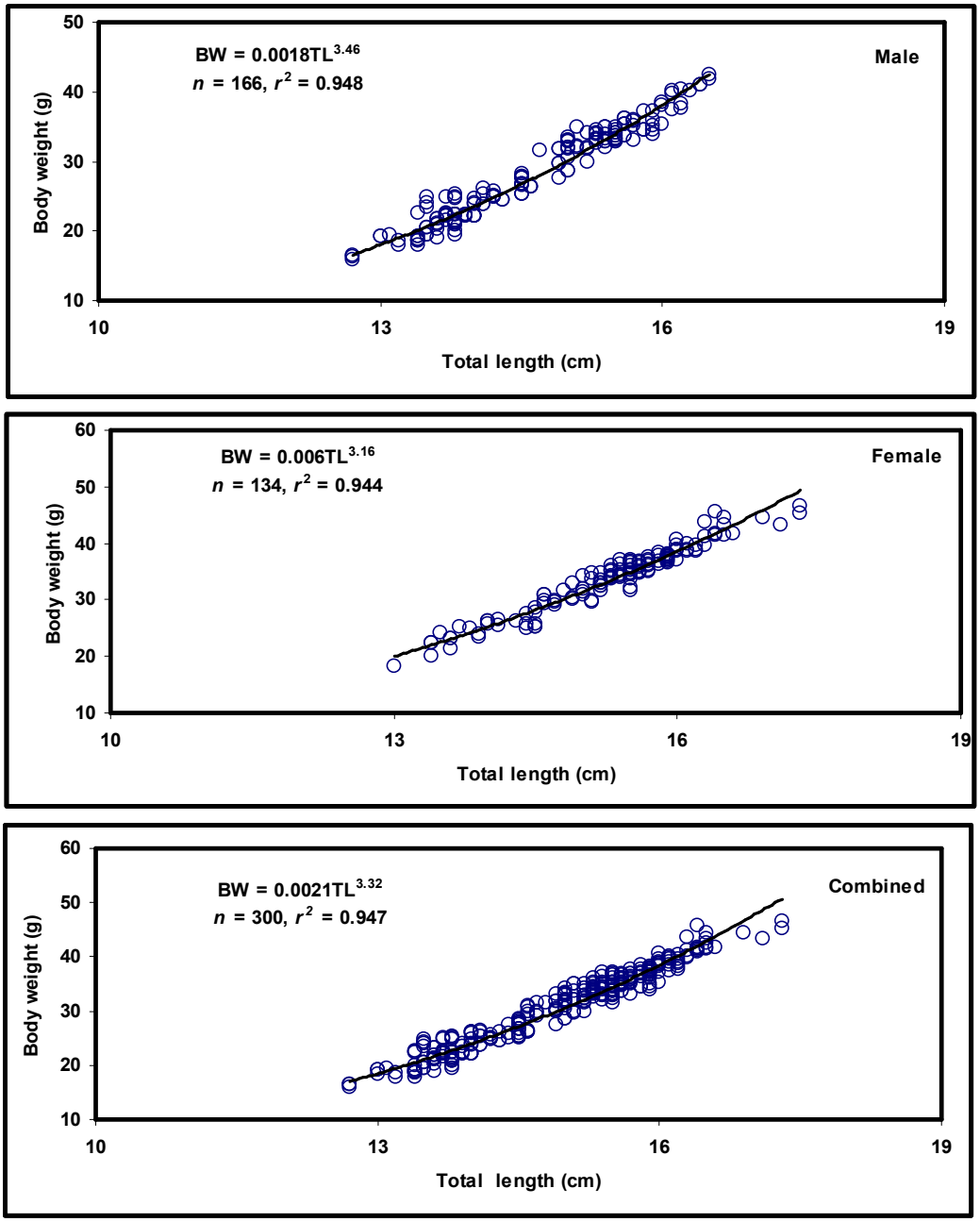

Fig. 2. Relationships between TL and BW between sexes of *Gudusia chapra* collected from the Rupsha River, SW Bangladesh.

Table III. Descriptive statistics of the length-weight relationships ($BW=a\times TL^b$) of the *Gudusia chapra* collected from the Rupsha River

Seasons	Sex	*n*	Regression parameters		95% CL of a	95% CL of b	r^2	GT
			a	*b*				
Summer	M	58	0.0008	3.36	0.0005-0.0015	3.20-3.52	0.957	+A
	F	42	0.0110	2.94	0.0073-0.0166	2.79-3.09	0.975	I
	C	100	0.0014	3.27	0.0009-0.0021	3.18-3.35	0.955	+A
Rainy	M	53	0.0194	2.73	0.0121-0.0311	2.55-2.90	0.951	-A
	F	47	0.0165	2.80	0.0089-0.0304	2.58-3.02	0.934	I
	C	100	0.0162	2.80	0.0108-0.0243	2.65-2.95	0.935	-A
Winter	M	55	0.0015	3.37	0.0008-0.0027	3.24-3.41	0.954	+A
	F	45	0.0042	3.28	0.0023-0.0079	3.05-3.51	0.951	+A
	C	100	0.0019	3.41	0.0012-0.0028	3.36-3.57	0.956	+A

Note: a, intercept; b, slope; GT, growth type; +A, positive allometric growth; -A, negative allometric growth.

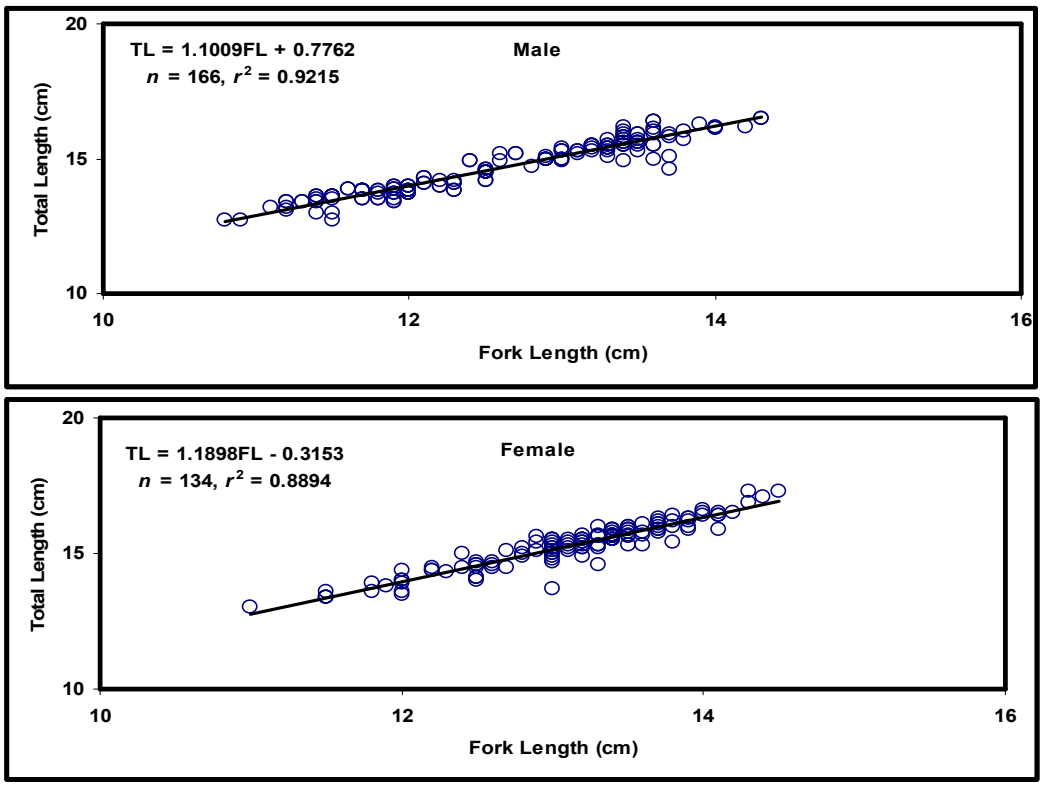

Fig. 3. Relationship between TL *vs.* FL of *Gudusia chapra* collected from the Rupsha River.

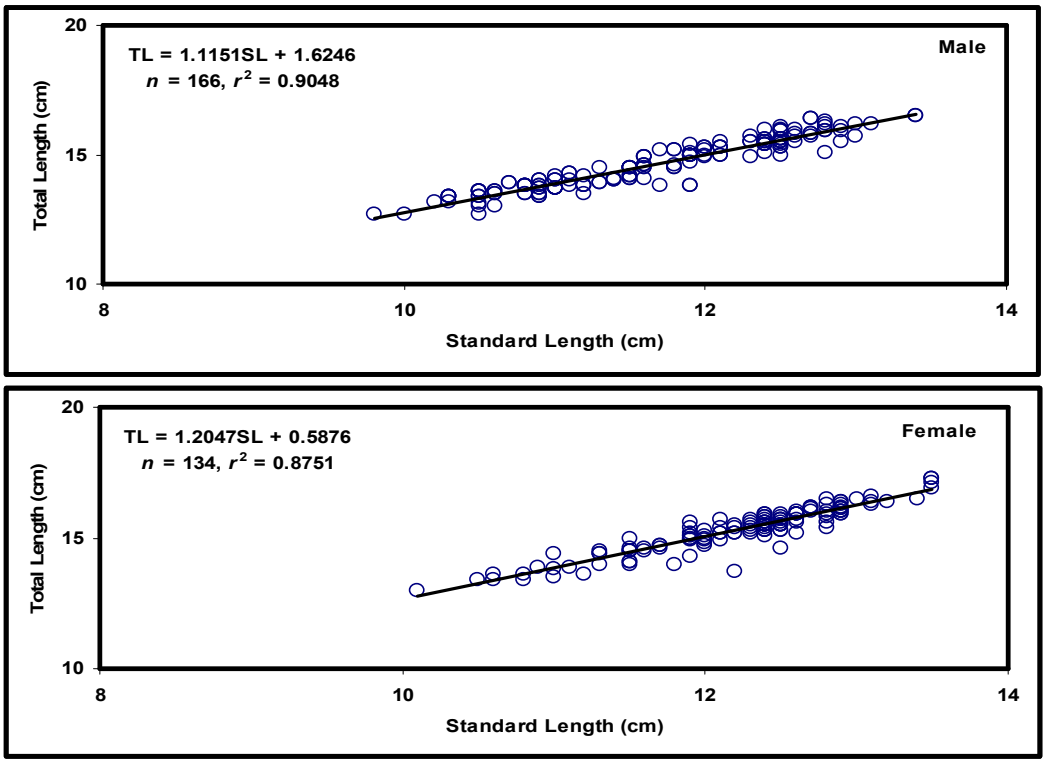

Fig. 4. Relationship between TL *vs.* SL of *Gudusia chapra* collected from the Rupsha River.

Form Factor: The form factor ($a_{3.0}$) was recorded 0.0087 for *G. chapra* indicated fusiform body shape.

Estimation of K_F and W_R: The peak K_F value was recorded for male in summer and winter season (1.01). Further, minimum K_F value for male was found in winter (0.74). For female population, both higher (1.04) and lower (0.82) K_F value was recorded during winter season (Table IV; Fig. 5). However, the higher W_R value was documented in summer (116.4) and the lower value was recorded in winter (87.2) for male population. On contrary, lower (92.7) and higher (113.2) W_R values were known in winter season for female community. Additionally, Wilcoxon sign rank test revealed no significant difference (P=0.25) between W_R and 100 for both sexes (Table V; Fig. 6).

Table IV. Statistics of K_F measurements for *Gudusia chapra* in the Rupsha River

Seasons	Sex	n	Fulton′s condition factor (K_F)			
			Min	Max	Mean±SD	95% CL
Summer	M	58	0.77	1.01	0.87±0.06	0.86-0.89
	F	42	0.89	0.99	0.94±0.02	0.93-0.95

Rainy	M	53	0.84	1.01	0.93±0.03	0.92-0.94
	F	47	0.90	1.02	0.95±0.03	0.94-0.96
Winter	M	55	0.74	0.98	0.85±0.06	0.84-0.87
	F	45	0.82	1.04	0.91±0.05	0.90-0.93

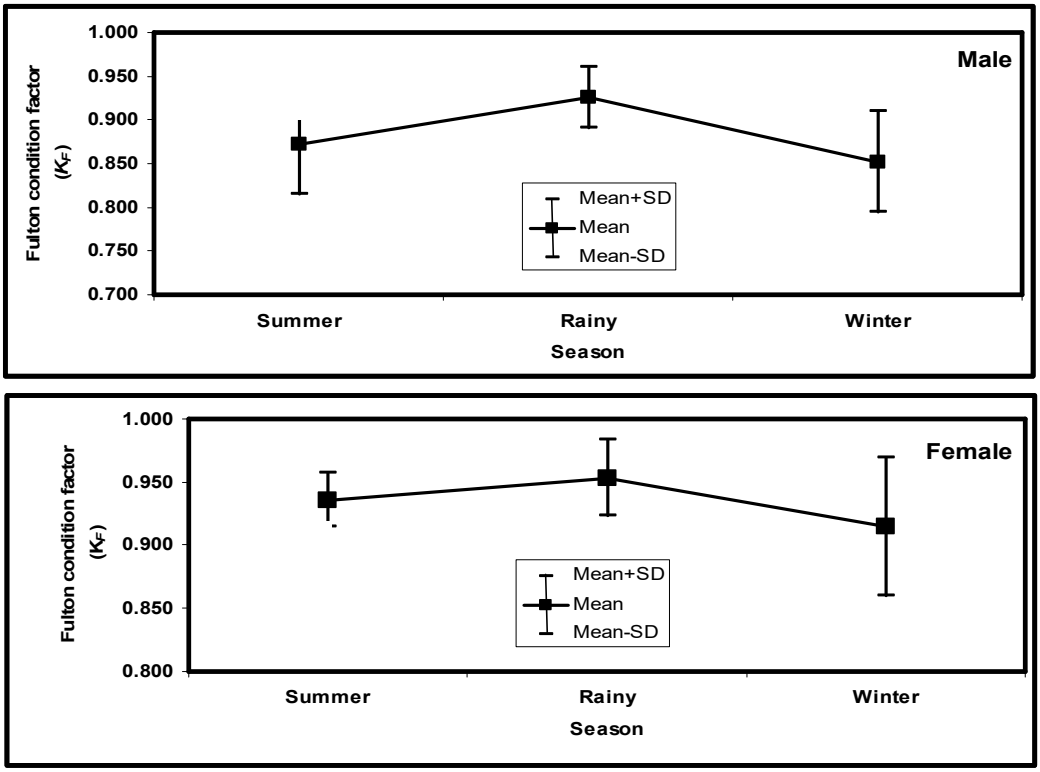

Fig. 5. Seasonal variations of mean K_F of *Gudusia chapra* collected from the Rupsha River.

Table V. Statistics on W_R measurements of the *Gudusia chapra* in the Rupsha River

Seasons	Sex	n	Relative Weight (W_R)			
			Min	Max	Mean±SD	95% CL
Summer	M	58	96.5	116.4	103.89±4.70	102.65-105.12
	F	42	95.4	105.6	100.21±2.29	99.50-100.92
Rainy	M	53	91.6	105.5	99.48±3.41	98.54-100.42
	F	47	94.7	106.5	99.88±3.04	98.99-100.77
Winter	M	55	87.2	112.8	98.54±5.21	97.13-99.95
	F	45	92.7	113.2	101.79±5.70	100.08-103.50

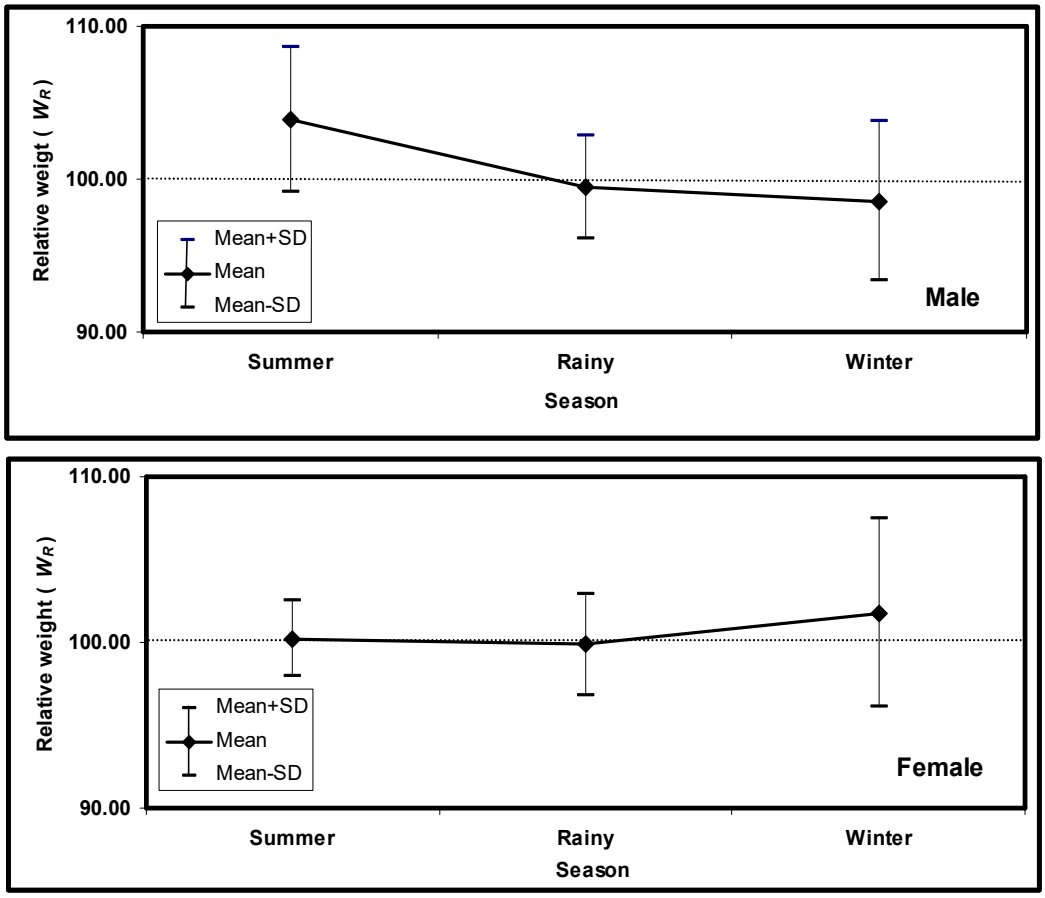

Fig. 6. Seasonal variations of mean W_R of *Gudusia chapra* collected from the Rupsha River.

Discussion

Data regarding on population parameters are prerequisites to ensure sound conservation program for wild fisheries resources in their natural ecosystem (Chowdhury *et al*. 2021). Although *G. chapra* is documented as least concern species but overfishing is the notable threat for which this species may turn to critically endangered species. However, a thorough biometric analysis is crucial for executing appropriate management policy and to ensure sustainability of this species, especially in the open water habitat. Consequently, our research aimed to explain the demographic information of *G. chapra* sampled from the Rupsha River ecosystem, SW Bangladesh. In the current research, we collected 300 specimens from the commercial fishers on seasonal bases.

As a whole sex ratio did not differ significantly (male: female=1:0.81) from the anticipated ratio of 1:1 (df=1, $\chi 2$=3.41, p>0.05). Nevertheless, male individuals were found dominant numerically than female individuals in every season. Ahamed *et al*. (2014) reported parallel results for *G. chapra* population from the Old Brahmaputra

River, Bangladesh. On the other hand, Mondal and Kaviraj (2010) found significant difference between male and female sex ratio (1:1.56) from the anticipated value of 1:1, while the specimens were collected from two floodplain lakes in India. However, sex ratio may fluctuate because of various physiological and ecological factors, including seasonality, salinity, temperature and interactions with other species (Khatun *et al*. 2018). During the experimental period, we did not find specimen less than 12.7 cm TL which is owing to selection of fishing gears (i.e., especially mesh size) (Hossen *et al*. 2019; Sabbir *et al*. 2022). Likewise, highest TL was documented 17.3 cm from female population. Besides, body weight varied between 15.82 to 42.48 g for male and 18.36 to 46.65 g for female individuals. However, Hossain *et al*. (2021) reported that TL ranged between 6.20 to 15.10 cm and BW deviated from 2.44 to 26.10 g for pooled samples of *G. chapra* in the Mahananda River, northwestern Bangladesh. Similarly, Sheikh *et al*. (2017) specified that TL and BW for adult *G. chapra* ranged between 7.1 to 12.95 cm and 3.56 to 19.66 g for pooled samples, respectively, from Dalani wetland ecosystem of Assam, India. Therefore, our study recorded the highest TL and BW compared to other investigations might be attributed that specimens were sampled from the Rupsha river with food availability and optimum water temperature (Hossain and Ohtomi 2010). Moreover, LFDs denoted that 15.00-15.99 cm TL group was more vulnerable to fishing mortality.

According to Carlander (1969), the value of allometric co-efficient (b) should differ from 2.0 to 4.0. In contrast, Froese (2006) recommended that the value of b for teleost fish species might deviate between 2.5 to 3.5. The current study showed that the value of slop b for both male (b=2.73 to 3.37) and female (b=2.80 to 3.28) population remained within the suggested range of Froese (2006). As a whole, both sexes exposed positive allometric growth pattern. However, Ahamed *et al*. (2014) found negative allometric growth pattern for *G. chapra* population from the Old Brahmaputra River, Bangladesh. Similarly, Hossain *et al*. (2021) and Sheikh *et al*. (2017) reported negative allometric growth for this species from the Mahananda River, Bangladesh and the Dalani Beel of Assam, India. Nevertheless, the growth pattern of a particular species may vary due to geographic differences (Jisr *et al*. 2018). In addition, variation possibly resultant because of seasonality, sex, availability of feed and physiological condition (Gosavi *et al*. 2019; Le Cren 1951). Moreover, the LLRs were found highly correlated for both sexes of *G. chapra*.

In case of teleost fish species, body shape can be assumed with form factor ($a_{3.0}$). The calculated form factor ($a_{3.0}$) was 0.0087 for pooled data set of *G. chapra* indicated fusiform body shape (Froese 2006). Hossain *et al*. (2021) also reported similar findings for *G. chapra* collected from the Mahananda River, Bangladesh. Fish is an important source of global protein production. Therefore, it is essential to determine their health status to ensure sustainability, particularly in the open water ecosystem. Condition factor is a numerical index that helps to assume the health condition of a particular fish stock in terms of survival, magnitude of sexual maturity and fitness of aquatic environment (Richter 2007). Therefore, adequate information regarding condition factor is prerequisite to manage a fish stock and maintain the stability of the environment (Hossen *et al*. 2019). The most frequently used condition index is Fulton's condition factor (K_F) for evaluating the population success of fish dwelling in a wild habitat (Hossain *et al*. 2016, Rahman *et*

al. 2023). The current research revealed that the K_F value was higher (1.01) in summer and rainy season for male. For the female, maximum value (1.04) was obtained in winter season. The lowest K_F value was recorded as 0.74 for males and 0.82 for females, respectively in winter season. However, the mean K_F value was recorded close to 1 which specified a moderate health condition for *G. chapra* population in the Rupsha River, SW Bangladesh (Rahman *et al*. 2023). Ahamed *et al*. (2014) reported that K_F value varied monthly for both sexes of *G. chapra* sampled from the Old Brahmaputra River, Bangladesh. The maximum and minimum K_F values were 1.84 to 2.28 for males and 1.88 to 2.28 for females. Additionally, lowest value of K_F was recorded in February and April for male and female population. Conversely, maximum value was recorded in December for both sexes. Furthermore, Hossain *et al*. (2021) reported that the K_F value fluctuated from 0.74 to 1.22 for the pooled sample of *G. chapra* in the Mahananda River, Bangladesh. The condition factor could be prejudiced as a consequence of feed availability, sex, seasonality and temperature (Sabbir *et al*. 2020).

Relative weight (W_R) is a frequently used index that assumes the prey-predator status of a fish population in a specific wild ecosystem (Rypel and Richter 2008). If the value of W_R exists lower than 100, it reveals number of predators is higher compared to prey. Instead, W_R value more than 100 specifies prey surplus compared to predator (Froese 2006). In the current research, the mean W_R revealed no significant difference from 100 for *G. chapra* population in the Rupsha River, SW Bangladesh denoting that the ecosystem was in stable condition. Correspondingly, Hossain *et al*. (2021) found no significant difference between W_R and 100 for *G. chapra* in the Mahananda River, Bangladesh. However, we found no other literatures to compare the result regarding W_R.

Overall sex ratio (male: female) of *G. chapra* did not significantly deviate from the predicted value of 1:1. As a whole, b value for both sexes specified positive allometric growth pattern. Besides, form factor ($a_{3.0}$) assumed fusiform body shape for *G. chapra* species. The mean K_F indicated a moderate health condition for this species. Moreover, the W_R assumed an ecologically balanced environment for *G. chapra* population in the Rupsha River, SW Bangladesh. The results of this research would be helpful to implement a sound management policy for ensuring the sustainability of *G. chapra* stock in the Rupsha River and connected ecosystem, SW Bangladesh.

Literature Cited

Ahmed, Z.F., C. Smith, F. Ahamed. and M.Y. Hossain. 2007. Growth and reproduction of the Indian river shad, *Gudusia chapra* (Clupeidae). *Folia Zool*., 56(4): 429-439.

Ahamed, F., Z.F. Ahmed, M.Y. Hossain and J. Ohtomi. 2014. Population biology of the Indian river shad, *Gudusia chapra* (Clupeidae) in the Old Brahmaputra River, north-eastern Bangladesh. *Sains Malays*., 43: 1645-1655.

Ahmed, Z.F., M.K. Fatema, U.H. Az-Zohora, M.A. Joba. and F. Ahamed. 2020. Interrelationship of linear dimensions as growth corollary of pama croaker *Otolithoides pama* in the Bay of Bengal. *Bangladesh J. Fish*., 32(2): 287-292.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight and associated structure indices, in Fisheries Techniques (2nd ed) Murphy, B.R., and Willis, W.D. (EDs), *American Fisheries Society*, Bethesda, MD.

Asadujjaman, M., M.N. Khan, S. Mahfuj, W. Akram, S.I. Islam, and W. Sabbir. 2022. Life-history traits of grey mullet, *Liza parsia* in the Passur River of Southern Bangladesh: Implications for effective management. *Bangla. J. Fish.*, 34(1): 53-63.

Basumatary, S., B. Talukdar, H. Choudhury, H.K. Kalita, D.J. Saikia, A. Mazumder. and D. Sarma. 2016. Female gonadal histology of Indian river shad, *Gudusia chapra* (Hamilton, 1822) – a tactic of reproductive biology. *Poult. Fish. Wildl. Sci*. 4: 173.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, Vol. 1. The Iowa State University Press, Ames, IA.

Chowdhury, A.A., M.Y. Hossain, Z. Mawa, D. Khatun, M.A. Islam, M.A. Rahman, M.R. Hasan, O. Rahman, R.H. Konok, M.A. Rahman, M.F. Parvin. and U.K. Sarkar. 2021. Some biological aspects of the spotted snakehead *Channa punctata* (Bloch, 1793) in the wetland ecosystem, Gajner Beel, North-western Bangladesh. *Indian J. Fish*., 68: 17–26.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *J. Appl. Ichthyol*., 22: 241-253.

Fulton, T.W. 1904. The rate of Growth of Fishes. Twenty second Annual Report, part III. Edinburg: Fisheries Board of Scotland.

Gosavi, S.M., S.S. Kharat, P. Kumkar. and S.D. Tapkir. 2019. Assessing the sustainability of lepidophagous catfish, *Pachypterus khavalchor* (Kulkarni, 1952), from a tropical river Panchaganga, Maharashtra. India. *J. Basic Appl. Zool*., 80:9 https://doi.org/10.1186/s41936-019-0080-8

Hossain, M.Y., M.M. Rahman, E.M. Abdallah. and J. Ohtomi. 2013. Biometric relationships of the Pool barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) from three major Rivers of Bangladesh. *Sains Malays*., 22: 1571-1580.

Hossain, M.Y., Z.F. Ahmed, P.M. Leunda, S. Jasmine, J. Oscoz, R. Miranda. and J. Ohtomi. 2006. Condition, length-weight and length-length relationships of the Asian striped catfish *Mystus vitatus* (Bolch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, southwester Bangladesh. *J. Appl. Ichthyol*., 22: 304-307.

Hossain, M.Y. and J. Ohtomi. 2010. Growth of the Southern Rough Shrimp *Trachysalambria curvirostris* (Penaeidae) in Kagoshima Bay, Southern Japan. *J. Crustac. Biol*., 30(1): 75-82.

Hossain, M.Y., A.A. Chowdhury, Z. Mawa, M.R. Hasan, M.A. Islam, M.A. Rahman, O. Rahman, D. Khatun, M.S. Sarmin, S. Nasrin, M. A. Rahman, A. Nima. and F. Parvin. 2021. Life-history traits of Indian river shad *Gudusia chapra* (Hamilton, 1822) in the Mahananda River (tributary of the Ganges River) of northwestern Bangladesh. *Songklanakarin J. Sci. Technol*., 43(5): 1466-1472.

Hossain, M.Y., M.M. Rahman, A.H. Bahkali, K. Yahya, M.S. Arefin, M.I. Hossain, M. Elgorban, M.A. Hossen, M.M. Islam. and Z. Masood. 2016. Temporal variations of sex ratio, length-weight relationships and condition factor of *Cabdio morar* (Cyprinidae) in the Jamuna (Brahmaputra River distributary) River, Northern Bangladesh. *Pak. J. Zool*., 48(4): 1099-1107.

Hossen, M.A., A.K. Paul, M.Y. Hossain, J. Ohtomi, W. Sabbir, O. Rahman, J. Jasmin, M.N. Khan, M.A. Islam, M.A. Rahman, D. Khatun. and Sk. Kamruzzaman. 2019. Estimation of biometric indices for Snakehead *Channa punctata* (Bloch, 1973) through Multi-model inferences. *Jordan J. Biol. Sci*., 12: 197-202.

Islam, S.I., M.S. Mahfuj, M.I. Hoshan, M. Asadujjaman, M.A. Samad. and M.Y. Hossain. 2021. Biometric indices of near threatened reba carp, *Cirrhinus reba* from an oxbow lake in southwestern Bangladesh. *Bangladesh J. Fish*., 33(2): 195-204.

Jisr, N., G. Younes, C. Sukhn. and M.H. El-Dakdouki. 2018. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. *Egypt. J. Aquat. Res*., 44: 299–305.

Khatun D, M.Y. Hossain, M.F. Parvin. and J. Ohtomi. 2018. Temporal variation of sex ratio, growth pattern and physiological status of *Eutropiichthys vacha* (Schilbeidae) in the Ganges River, NW Bangladesh. *Zool Ecol*., 28: 343-354.

Le Cren, E.D. 1951. The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol*., 20(2): 201-219.

Menon, A.G.K. 1999. Check list-fresh water fishes of India. Rec. Zool. Surv. India, Misc. Publ., Occas. Pap. No. 175, p 366.

Mirza, M.R. 2002. Checklist of freshwater fishes of Pakistan. Department of Zoology, Government College University, Lahore, Pakistan.

Mondal, D.K. and A. Kaviraj. 2010. Feeding and reproductive biology of Indian shad *Gudusia chapara* in two floodplain lakes of India. *Electron. J. Biol*., 6(4): 98-102.

Narejo, N.T., P.K. Lashari, M.Y. Laghari, A.M. Mastol. and H.B. Khoso. 2006. Fecundity of palri, *Gudusia chapra* (Hamilton) from fishponds of Chilya hatchery (Distt. Thatta), Sindh, Pakistan. *Pak. J. Zool*., 38: 269-272.

Neuman, R.M. and M.S. Allen. 2001. Analysis and Interpretation of Freshwater Fisheries Data. Stors, USA: Department of Natural Resources Management and Engineering, University of Connecticut.

Phukan, B., S. Baishya, P. Sharma, A. Rajbongshi. and A. Rahman. 2012. Food and feeding habits of *Gudusia chapra* (Hamilton, 1822) from Silinga beel of lower reaches of Subansiri River in Assam, N-E India. *Environ. Ecol*., 30(3): 578-580.

Rahman M.A., M.S. Islam, M.Y. Hossain, M.R. Hasan, M.A. Islam, D. Khatun, O. Rahman, M.F. Parvi, Z. Mawa. and A.A. Chowdhury. 2019. Morphometric and meristic characteristics of the Banded Gourami, *Trichogaster fasciata* (Bloch & Schneider, 1801) in a wetland ecosystem from Northwestern Bangladesh. *Jordan J. Biol. Sci*., 14(5): 561-565.

Rahman, M.A., M.A. Bashar, Z. Mawa, O. Rahman, M.A. Samad, M.A., M.S.E. Mahfuj, M.A. Islam, M.S. Sarmin, M.R. Islam. and M.Y. Hossain. 2020. Life history traits of the barred spiny eel *Macrognathus pancalus* (Hamilton, 1822) in a wetland ecosystem. *Egyp. J. Aqua. Biol. Fish*., 24(6): 425-438.

Rahman, A.K.A. 1989. Freshwater fishes of Bangladesh. Zoological Society of Bangladesh. Department of Zoology, University of Dhaka. p 364.

Rahman, M.A., M.R.K. Manon, M.R. Ullah, A. Alam, M.J. Islam, M.A.B. Siddik and M.M. Iqbal. 2023. Biometric indices, growth pattern, and physiological status of captive-reared indigenous Yellowtail brood catfish, *Pangasius pangasius* (Hamilton,

1822). *Environ. Sci. Pollut. Res.*, 30: 83388-83400. https://doi.org/10.1007/s11356-023-28328-9

Richter, T.J. 2007. Development and evaluation of standard weight equations for bridge-lip suckers and large-scale suckers. *N. Am. J. Fish. Manag.*, 27: 936-939.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany. p 329.

Rypel, A.L. and T.J. Richter. 2008. Empirical percentile standard weight equation for the black tail red horse. *N. Am. J. Fish. Manag*., 28: 1843-1846.

Sabbir, W., M.A. Rahman, M.Y. Hossain, M.R. Hasan, Z. Mawa, O. Rahman, S. Tanjin. and M.S. Sarmin. 2021. Stock assessment of Hooghly Croaker *Panna heterolepis* in the Bay of Bengal (Southern Bangladesh): implication for sustainable management. *Heliyon*. e07711. https://doi.org/10.1016/j.heliyon.2021.e07711.

Sabbir, W., M.Y. Hossain, M.A. Rahman, M.R. Hasan, Z. Mawa, S. Tanjin, H.U. Hasan. and J. Ohtomi. 2020. First report on condition factor of *Panna heterolepis* (Trewavas, 1977) in the Bay of Bengal (Southwestern Bangladesh) in relation to eco-climatic factors. *Egypt. J. Aquat. Biol. Fish*., 24(2): 591-608.

Sabbir, W., M.Y. Hossain, M.N. Khan, F.A. Rima, M.S. Sarmin. and M.A. Rahman. 2022. Biometric indices of Flathead Sillago, *Sillaginopsis panijus* (Hamilton, 1822) from the Bay of Bengal (Southern Bangladesh). *Thalassas*, 38, 811–820. https://doi.org/10.1007/s41208-022-00421-9

Samad, M.A., M.A. Rahman, M.S.E. Mahfuj, S.M. Yeasmin, M.F. Sultana, M.H. Rahman, F.F. Ahmed. and M.Y. Hossain. 2021. Life-history traits of ten commercially important small indigenous fish species (SIFS) in the Oxbow lake (Southwestern Bangladesh): key for sound management. *Env. Sci. Poll. Res.*, 1-15.

Sheikh, J., N. Singha, R. Nag. and P. Deka. 2017. Length-weight relationship and relative condition factor of *Gudusia chapra* (Hamilton, 1822) of Dalani Beel (wetland) of Assam, India. *Int. J. Fish. Aquat. Stud.,* 5(3): 485-489.

Shrestha, J. 1994. Fishes, fishing implements and methods of Nepal. Smt. M.D. Gupta, Lalitpur Colony, Lashkar (Gwalior), India. p150.

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