Pakistan Journal of Marine Sciences, Vol. 29(2), 99-114, 2020.

LIFE-HISTORY TRAITS OF LONG WHISKER CATFISH *MYSTUS GULIO* (SILURIFORMES: BAGRIDAE) IN THE COASTAL WATER (MALONCHO RIVER) OF SOUTHERN BANGLADESH

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ABSTRACT: This analysis illustrates the life history traits of Long whisker, *Mystus gulio* (Hamilton, 1822) including sex ratio, length-weight (LWRs) and length-length relationships (LLRs), condition factors (K_A, K_F, K_R), relative weight (W_R) and form factor ($a_{3.0}$), empirical based size at first sexual maturity length (L_m) and natural mortality (M_W, year-1). Total of 407 individuals were scarcely collected from January-December 2017 using different fishing gears. The sex ratio (M/F) was calculated as 1:1.26 (p<0.05). The overall sex ratio did not differ significantly from the expected 1:1(p>0.05). The minimum-maximum total length and body weight were observed as 5.20-15.50 cm and 2.11-33.60g for male, 5.20-17.50 cm and 1.25-57.12g for female. All LWRs were very significant with all coefficients of determination (r^2)>0.967. The allometric coefficient indicated negative allometric growth in male (b<3.0), positive allometric growth in female and also in combined (b>3.0). All LLRs were significant with r^2 values >0.965. The K_F indicated the best condition of this species for their well-being. The W_R was not significantly diverse from 100 for males (p = 0.552) and females (p = 0.249), which indicate suitable condition for habitat. The $a_{3.0}$ were 0.0103 and 0.0108, and the L_m were 9.13 and 10.46 cm in total length for male and female, respectively. Moreover, M_W was 1.16 year-1 for male and 1.02 year-1 for female. The results will be operative for the sustainable conservation of *M. gulio* in Bangladeshi coastal waters and also nearby countries.

KEYWORDS: *Mystus gulio*, population structure, condition factor, size at first sexual maturity, natural mortality, Maloncho River

INTRODUCTION

The long whiskers catfish, *Mystus gulio* is a small indigenous species under the Siluriformes order and Bagridae family. This genus is innate to the coastal waters of Bangladesh and the countries of the East Indian Ocean, from India to Indonesia and Vietnam, as well as Pakistan (Talwar and Jhingran, 1991). It is also known as nuna tengra

in Bangladesh, Nga-zin in Mayanmar and long whisker cat fish in India and Srilanka (Froese and Pauly, 2018). It is categorized as least concern in Bangladeshi water-bodies (IUCN, 2015). This is mainly coastal water fish that enter fresh water and live there. Adults *M. gulio* are found in freshwater, especially in larger water bodies (Rivers and streams), with soil or clay matrices that are difficult to found in smaller streams. This fish are rarely exported as an ornamental fish (Ng, 2010). This species is playing a great role in commercial and local fisheries in the coastal areas of Bangladesh. Its catch is gradually more decreasing due to the mutual effect of various factors such as destructive fishing pressure, over-exploitation, habitat degradation and different ecological modifications (Alam *et al.*, 2006).

Basic information constitutes sex ratio and size structure in assessing stock size of fish populations (Vazzoler, 1996). Deviation from a 1:1 sex ratio is not regular for most aquatic species, but some fish populations may possibly indicate strong dissimilarities (Hossain *et al.* 2012a). These variations might be due to thermal effects on sex determination, selective gender-specific mortality and sexual behavior, growth rates or longevity (Conover and Kynard, 1981; Schultz, 1996). Furthermore, length-weight relationships (LWRs) are useful for applied and basic needs to convert the length distribution into weight for biomass estimation in fisheries management (Pitcher *et al.*, 1982; Gerritsen and McGrath, 2007). In addition, LWRs is necessary to evaluate the weights from the lengths, because direct weight measurements at the site may take more time and the parameters are essential in fish biology and may provide information on stock or stock status of the organism (Koutrakis and Tsikliras, 2003; Acosta *et al.*, 2004; Ecoutin *et al.*, 2005). Besides, length-length relationships (LLRs) are more applicable than age; a number of ecological and physiological aspects are more length-dependent than age-dependent Hossain *et al.* (2006a). Essentially, conditions of aquatic animal reveal environmental (abiotic and biotic) statuses, fluctuation of feeding conditions in which they interact, physiological factors, and infections of parasites (Le Cren, 1951).

Moreover, the relative weight (WR) allows to detect environmental changes as well as physiological components of fish (lipid storage and growth) and to evaluate the overall health and ecosystem disturbance (Rypel and Richter, 2008). Also, the form factor (a3.0) used to determine a particular body shape of a species (Froese, 2006). Several studies have been accompanied on different aspects of *M. gulio* containing age and growth (Pantulu, 1961), biometry and length-weight relationship (Dasgupta,1997) growth and survival (Islam *et al.*, 2007), length-weight and length-length relationships (Hossain *et al.*, 2016), reproductive biology (Lal *et al.*, 2016), spawning biology (Kaliyamurthy, 1981) fecundity and gonadosomatic index (Sarker *et al.*, 2002), embryonic and larval development (Begum*et al.*, 2009), formulation of quality fish feeds (Begum *et al.*, 2008c), stocking density (Begum *et al.*, 2008a), disease (Guchhait *et al.*, 2017), accumulation of heavy metal (Senarathne and Pathiratne, 2007). Based on authors' awareness, there is no available literature on life-history traits of least concern species *M. gulio*. Description on life-history traits of eurihalaine estuarine cat fishes as*M. gulio* is crucial for the sustainable management techniques in the Maloncho River, Southern (SW) Bangladesh and closest countries.

Therefore, this work reported the comprehensive and instructive information on life-history traits containing sex ratio, population structure, LWRs, LLRs, condition factors,

relative weight, form factor, size at first sexual maturity, and natural mortality of *M. gulio* using individuals with small to large body sizes from the Maloncho River, Southern Bangladesh.

MATERIALS AND METHOD

Sampling and Laboratory Analysis: This work was accompanied in the Maloncho River (Latitude 21° 40' N; Longitude 89° 35' E), Satkhira region Bangladesh. A total of 407 individuals of *M. gulio* were obtained from the Maloncho River of Bangladesh during January-December 2017 from the fisher's catch. Samplings were conducted by the commercial fishermen's gill net (mesh size; 1.5–2.5 cm), cast net (mesh size; 1.0–2.0 cm), and seine net (mesh size; ~1.0 cm).

The collected samples were promptly preserved with ice at the spot and then subsequently fixed with 10% formalin solution upon arrival in work place. Total length (TL), standard length (SL) and fork Length (FL) were measured through digital slide calipers and total wet body weight (BW) by a digital balance.

Sex ratio and Population Structure: Fishes were sexed by observing the gonads under microscope. To defined the sex-ratio deviance from the expected value of 1:1 (male: female), a chi-square test was followed. The population structure separately for males and females constructed with 1 cm intervals of TL. Based on maximum-likelihood method (Hasselblad, 1966) the normal distribution was fitted to TL frequency distributions.

Length-weight and Length-length relationships (LWRs and LLRs): Using $W = a*L^b$ equation, the relationships between length and weight (LWRs) were determined, where W is the total body weight (BW, g); L is the total length (TL, cm) and parameters a and b were estimated by $ln\ (BW) = ln\ (a) + b\ ln\ (TL)$. Extremes outliers were deleted from the regression analyses according to (Forese, 2006). Furthermore, on the basis of the b values of LWRs (TL vs. BW, SL vs. BW, and FL vs. BW) and LLRs (TL vs. SL, TL vs. FL, and SL vs. FL) for both sex of *M. gulio* were determined.

Condition Factors: The equation of $K_A = W/L^b$ (Tesch, 1968) was used to calculate allometric condition factor. Fulton's condition factor was obtained by $K_F=100*(W/L^3)$ where 100 was used as scaling factor. Relative condition factor was calculated with $K_R = W/(a\times L^b)$ equation given by (Le Cren, 1951). The relative weight (W_R) was determined by $W_R = (W/W_S) \times 100$ (Froese, 2006), where W_S is the predicted standard weight for the certain individual as estimated by $W_S = a\times L^b$.

Form Factor ($a_{3.0}$): According to $a_{3.0} = 10^{\log\ a\text{-}s\ (b\text{-}3)}$ equation (Froese, 2006), form factor ($a_{3.0}$) was calculated where s is the regression slope of log *avs.b*. During our analysis, a mean slope S = -1.358 was used for assessing form factor because information on LWRs is not obtainable for this species.

Size at first sexual maturity (L_m): By the empirical formula, $\log (L_m) = -0.1189 + 0.9157 * \log (L_{max})$, where L_{max} is the maximum TL (Binohlan and Froese, 2009), the size at sexual maturity (Lm) of male and female *M. gulio* was assessed. Likewise, the maximum length of different species of *M. gulio* was collected from available literature, and then we used this length to estimate size at first sexual maturity in different water bodies of the world.

Natural Mortality (M_w): The M_W of *M. gulio* was estimated with the model of (Peterson and Wroblewski, 1984) M_W = 1.92 year-1 *(W)-0.25, where, M_W = Natural mortality at mass W, and $W = a*L^b$, a and b are regression parameters of LWR.

Statistical Analysis: For statistical analyses were performed by using Microsoft® Excel-add-in solver and GraphPad Prism 6.5 Software. To compare the mean relative weight (W_R) with 100, one sample t-test was used. The Spearman rank-correlation test was followed to identify the relationship between conditions factor with TL and BW. Also, the LWRs between the sexes were compared by ANCOVA. All statistical analyses were considered significant at 5% ($P < 0.05$).

RESULTS AND DISCUSSION

In our study, 407 individuals of *M. gulio* (males = 227 and females = 180) were hardly collected from the Maloncho River, with 56% males and 44% females and the whole sex ratio was indistinguishable from the possible 1:1 ratio (df = 1, x2 = 5.43, p> 0.05) (Table 1). Table 2 showed descriptive statistics for measuring the length and weight of male and female *M. gulio*. Population structure presented that, 7.00-7.99 cm TL size group was dominant (22.47%) of male population, whereas females were dominated by the 7.00-7.99 cm with 16.11% of its population (Fig. 1).

Table 1. Number of male, female and sex ratio (male: female=1:1) of *Mystus gulio* (Hamilton, 1822) from the Maloncho River, southern Bangladesh during January to December 2017.

Length class (TL, cm)	Number of specimens			Sex ratio (Male/Female)	÷2 (df=1)	Significance
	Male	Female	Total			
5.00-5.99	5	2	7	1:0.40	1.29	ns
6.00-6.99	33	12	45	1:0.36	9.80	*
7.00-7.99	51	29	80	1:0.57	6.05	*
8.00-8.99	29	17	46	1:0.59	3.13	ns
9.00-9.99	37	20	57	1:0.54	5.07	*
10.00-10.99	36	27	63	1:0.75	1.29	ns
11.00-11.99	16	28	44	1:1.75	3.27	ns
12.00-12.99	14	21	35	1:1.50	1.40	ns
13.00-13.99	5	15	20	1:3.00	5.00	*
14.00-14.99	0	6	6	-	6.00	*
15.00-15.99	1	2	3	1:2.00	0.33	ns
17.00-17.99	0	1	1	-	1.00	ns
Overall	227	180	407	1:0.79	5.43	*

TL, total length; *df*, degree of freedom; *ns*, not significant; *, significant.

There were significant differences in the LFDs between sexes (Two tailed test, Mann-Whitney U = 14035, p<0.0001). Furthermore, we found that BW of males

(mean±SD = 8.29± 5.53cm) was significantly smaller than females (mean±SD = 12.93± 9.22cm) (U=13886, p<0.0001). The regression parameters, coefficients of determination (r^2) of *M. gulio* are shown in Table 3 and Fig. 2. The (*b*) values of the LWRs indicated negative allometric growth in male, female and combined sexes (*b*<3.0) (Table 3). All LWRs were significant with all r^2 values more than 0.971. The ANCOVA expressed that there was no significant differences in LWRs between the sexes (p = 0.142). Additionally, the LLRs (TL vs. L, TL vs. FL, and SL vs. FL) of a total of 407 *M. gulio* with parameters and r^2 are given in Table 4. This length-length relationship of male and female are shown below Fig. 3. The LLRs were very significant and most of the r^2 values >0.965.

Table 2. Descriptive statistics on the length (cm) and weight (g) measurements of *Mystus gulio* (Hamilton, 1822) from the Maloncho River in Bangladesh during January to December, 2017.

Measu-rements	Sex	*n*	Min	Max	± SD	95% CL
TL	Male	180	5.60	15.10	8.9318±1.9672	8.6745-9.1891
FL			4.50	12.50	7.Mean 5101±1.5925	7.3018-7.7184
SL			4.30	11.70	6.8625±1.4959	6.6669-7.0582
BW			1.82	33.60	8.2921±5.5300	7.5688-9.0154
TL	Female	227	5.20	17.50	10.1861±2.3796	9.8361-10.5361
FL			4.50	14.60	8.5250±1.8990	8.2456-8.8043
SL			3.90	13.80	7.8727±1.8258	7.6042-8.1413
BW			1.25	57.120	12.9397±9.2222	11.588-14.296
TL	Combined	407	5.20	17.50	9.4865±2.2449	9.2678-9.7053
FL			4.50	14.60	7.9589±1.8045	7.7831-8.1348
SL			3.90	13.80	7.3083±1.7214	7.1406-7.4760
BW			1.25	57.120	10.3476±7.7370	9.5937-11.1015

TL, total length; FL, fork length; SL, standard length; BW, body weight; n, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values.

During the study, minimum-maximum K_A values for males were 0.0062-0.0139(mean±SD: 0.0103±0.0010) and in females it ranges from 0.0064-0.0122 (0.0090±0.0009) (Table 5). According to Unpaired t- test, the mean K_A values showed significant difference between sexes (p<0.001). The K_F ranged from 0.6145-1.3733(1.0165±0.1005) for males and 0.7469-1.3924(1.0384±0.1130) for females, respectively (Table 5). The mean K_F had significant difference between males and females (Mann-Whitney U = 17155, p = 0.005). As well, KR ranged from 0.6056-1.3531 (1.0024±0.0990) for males and 0.7197-1.358 (1.0093±0.1086) for females (Table 5).

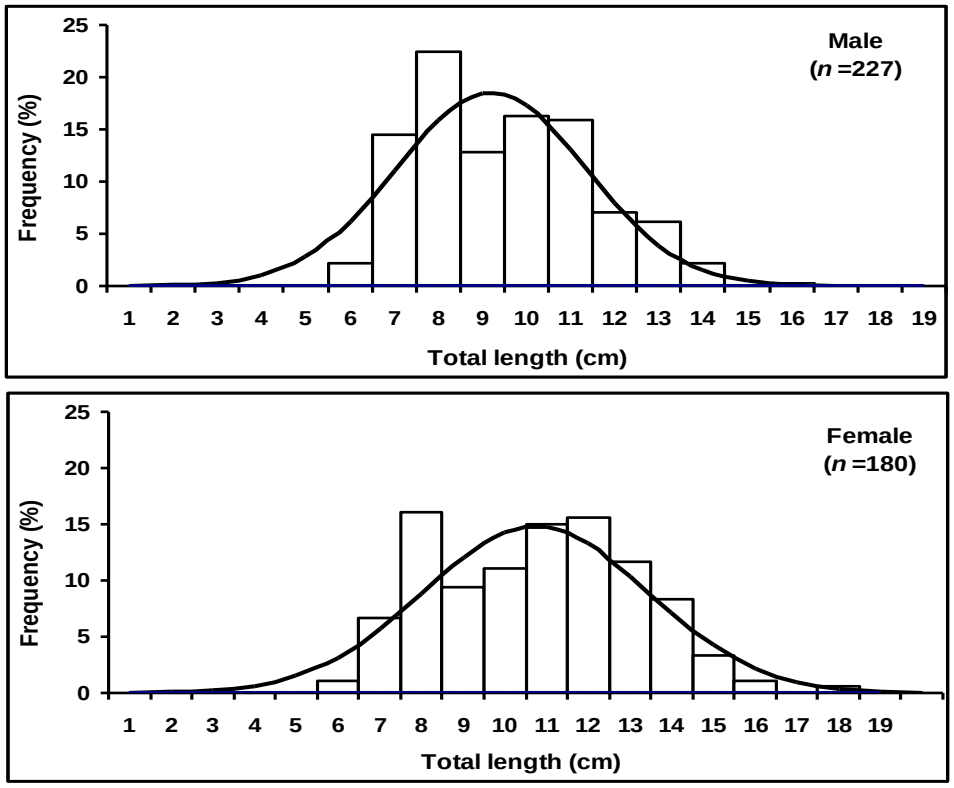

Fig. 1. The length-frequency distribution of male and female *Mystus gulio* in the Maloncho River, southern Bangladesh.

Table 3. Descriptive statistics and estimated parameters of the length-weight relationships (BW = *a*×TL*b*) of *Mystus gulio* (Hamilton, 1822) from the Maloncho River southern in Bangladesh January to December, 6017.

Equation	Sex	*n*	Regression parameters		95% CL of *a*	95% CL of *b*	r^2	GT
			a	*b*				
BW=*a*×TL*b*	Male	227	0.0103	2.99	0.0090-0.0117	2.934-3.052	0.977	A-
BW=*a*×FL*b*			0.0138	3.10	0.0121-0.0158	3.036-3.166	0.974	
BW=*a*×SL*b*			0.0228	2.99	0.0200-0.0260	2.219-3.057	0.970	
BW=*a*×TL*b*	Female	180	0.0090	3.06	0.0057-0.0105	2.991-3.126	0.978	A-
BW=*a*×FL*b*			0.0110	3.22	0.0092-0.0133	3.129-3.304	0.967	
BW=*a*×SL*b*			0.0197	3.06	0.0165-0.0235	2.975-3.149	0.964	
BW=*a*×TL*b*	Combined	407	0.0095	3.03	0.0086-0.0104	2.992-3.077	0.979	A-
BW=*a*×FL*b*			0.0123	3.16	0.0110-0.0137	3.112-3.215	0.972	
BW=*a*×SL*b*			0.0212	3.02	0.0192-0.0235	2.973-3.077	0.970	

a, intercept; *b*, slope; GT, growth type; -A, negative allometric.

Table 4. The estimated parameters of the length-length relationships (Y = *a* +*b* × X) of *Mystus gulio* (Hamilton, 1822) from the Maloncho River, southern Bangladesh January to December, 2017.

Equation	Sex	Regression parameters		95% CL of a	95% CL of *b*	r^2
		a	*b*			
TL = *a* + *b*× SL	Male	0.0659	1.2919	-0.1607 to 0.2915	1.2596-1.3242	0.965
TL = *a* + *b*× FL		-0.2107	1.2173	-0.4223 to 0.0009	1.1897-1.2449	0.971
SL = *a* + *b*× FL		-0.0889	0.9256	-0.2503 to 0.0723	0.9046-0.9466	0.970
TL = *a* + *b*× SL	Female	0.0635	1.2857	-0.1912 to 0.3183	1.2542-1.3172	0.973
TL = *a* + *b*× FL		-0.3603	1.2371	-0.6180 to 0.1026	1.2076-1.2666	0.974
SL = *a* + *b*× FL		-0.2166	0.9489	-0.4167 to-0.0164	0.9259-0.9718	0.974
TL = *a* + *b*× SL	Combined	0.0901	1.2857	-0.0701 to 0.2503	1.2643-1.3070	0.971
TL = *a* + *b*× FL		-0.2907	1.2284	-0.4473 to-0.1340	1.2092-1.2476	0.974
SL = *a* + *b*× FL		-0.1876	0.9418	-0.3084 to-0.0668	0.9270-0.9566	0.974

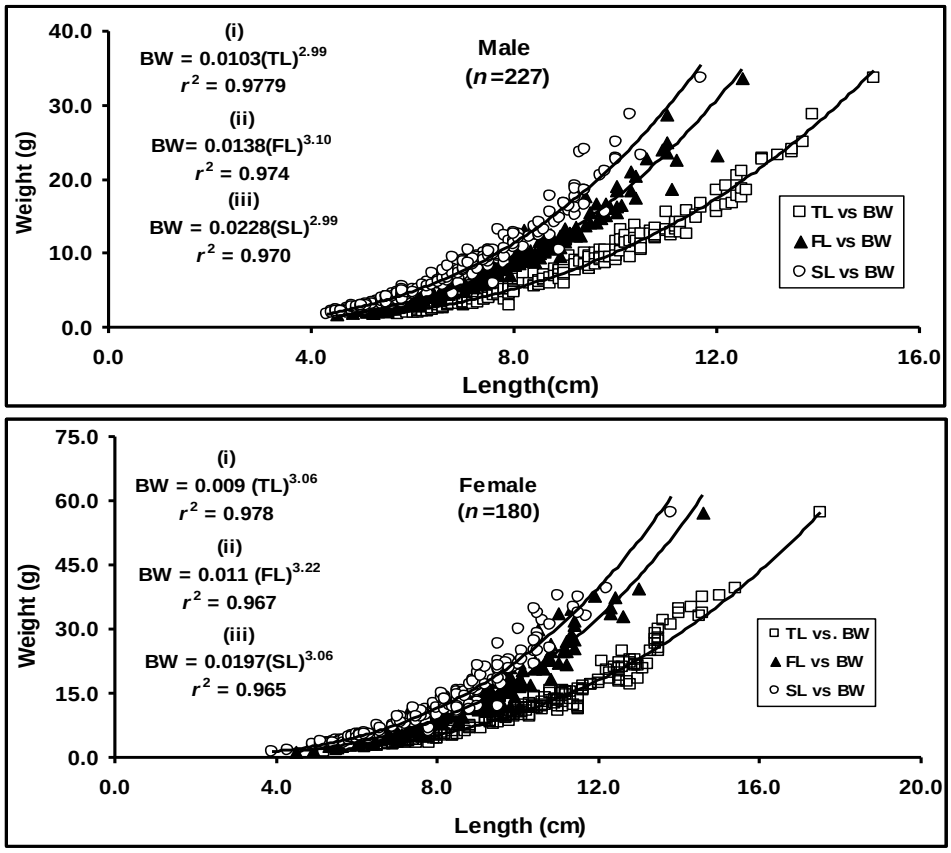

Fig. 2. The length-weight relationships of male and female *Mystus gulio* in the Maloncho River, southern Bangladesh.

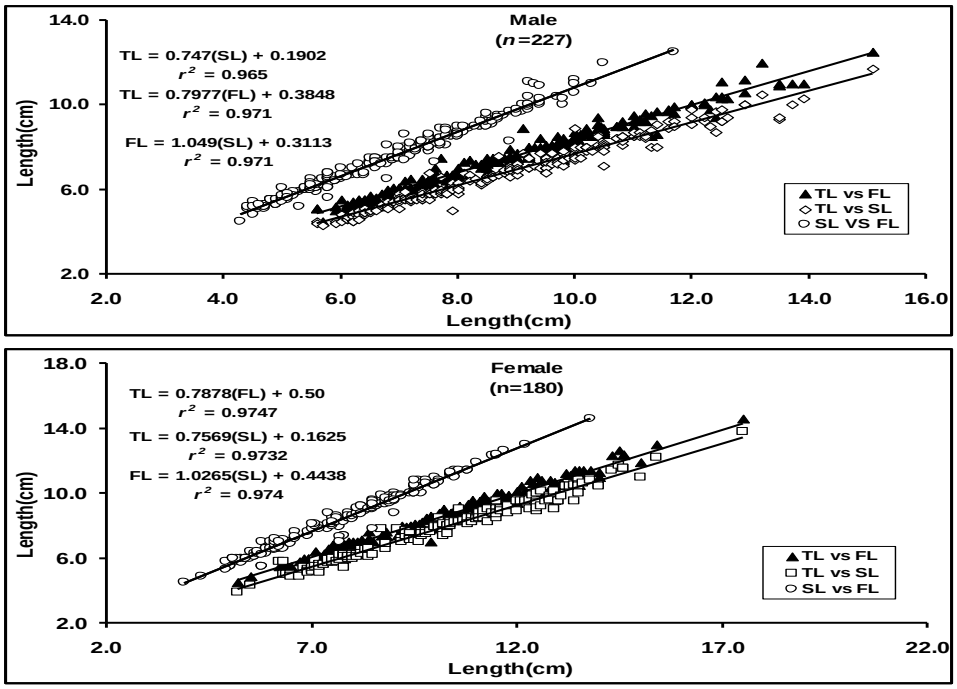

Fig. 3. The length-length relationships of male and female *Mystus gulio* in the Maloncho River, southern Bangladesh.

Table 5. Condition factors; Allometric condition factor (K_A), Fulton′s condition factor (K_F), Relative condition factor (K_R) and Relative weight (W_R) of *Mystus gulio* (Hamilton, 1822) from the Maloncho River, southern Bangladesh January to December, 2017.

Condition factors	Sex	*n*	Min	Max	Mean ± SD	95% CL
K_A		180	0.0062	0.0139	0.0103±0.0010	0.0101-0.0104
K_F	Male		0.6145	1.3733	1.0165±0.1005	1.0033-1.0296
K_R			0.6056	1.3531	1.0024±0.0990	0.9894-1.0153
W_R			60.560	135.313	100.24±9.9091	98.944-101.53
K_A		227	0.0064	0.0122	0.0090±0.0009	0.0089-0.0092
K_F	Female		0.7469	1.3924	1.0384±0.1130	1.0218-1.0550
K_R			0.7197	1.3585	1.0093±0.1086	0.9933-1.0253
W_R			71.978	135.851	100.93±10.861	99.339-102.53
K_A		407	0.0057	0.0128	0.0095±0.0009	0.0094-0.0096
K_F	Combined		0.6145	1.3924	1.0262±0.1066	1.0158-1.0366
K_R			0.6025	1.3574	1.0007±0.1036	0.9906-1.0108
W_R			60.250	135.746	100.07±10.368	99.060-101.08

K_A, allometric condition factor; K_F, Fulton′s condition factor; K_R, relative condition factor; W_R, relative weight.

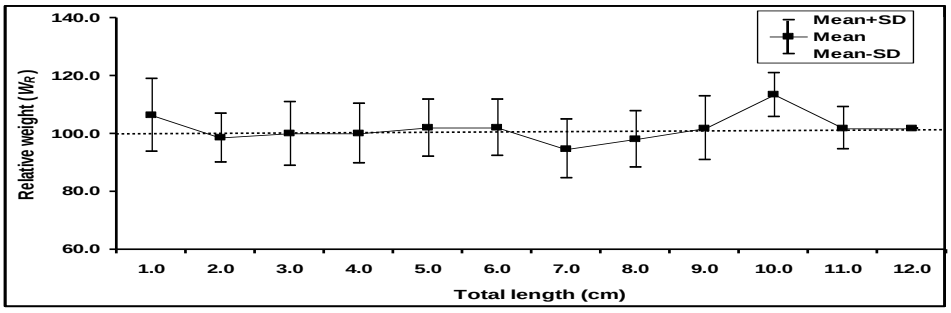

Fig. 4. The Relative weight (WR) of *Mystus gulio* in the Maloncho River, southern Bangladesh.

Table 6. Relationships of condition factor with total length (TL) and body weight (BW) of *Mystus gulio* (Hamilton, 1822) from the Maloncho River, southern Bangladesh January to December, 2017.

Relationships	Sex	*rs* values	95% CL of *rs*	*p* values	Significance
TL vs. K_A	Male	0.0160	-0.1183 to 0.1497	0.8103	*ns*
TL vs. K_F		-0.0013	-0.1353 to 0.1328	0.9843	*ns*
TL vs. K_R		0.0178	-0.1165 to 0.1515	0.7897	*ns*
TL vs. W_R		0.0175	-0.1168 to 0.1513	0.7925	*ns*
BW vs. K_A		0.1462	-0.0048 to 0.2589	0.0517	*ns*
BW vs. K_F		0.1293	0.0124 to 0.2749	0.0276	*ns*
BW vs. K_R		0.1482	0.0144 to 0.2768	0.0256	*ns*
BW vs. W_R		0.1480	0.0142 to 0.2765	0.0258	*ns*
TL vs. K_A	Female	0.0205	-0.1260 to 0.1663	0.7849	*ns*
TL vs. K_F		0.1497	0.0035 to 0.2897	0.0448	*
TL vs. K_R		0.0203	-0.1264 to 0.1661	0.7872	*ns*
TL vs. W_R		0.0203	-0.1264 to 0.1661	0.7870	*ns*
BW vs. K_A		0.2040	0.0594 to 0.3402	0.0060	**
BW vs. K_F		0.3210	0.1833 to 0.4464	< 0.0001	****
BW vs. K_R		0.2039	0.0593 to 0.3401	0.0060	**
BW vs. W_R		0.2040	0.0594 to 0.3401	0.0060	**
TL vs. K_A	Combined	0.0098	-0.0903 to 0.1098	0.8431	*ns*
TL vs. K_F		0.0884	-0.0118 to 0.1868	0.0750	*ns*
TL vs. K_R		0.0110	-0.0892 to 0.1109	0.8257	*ns*
TL vs. W_R		0.0107	-0.0895 to 0.1106	0.8302	*ns*
BW vs. K_A		0.1384	0.0388 to 0.2352	0.0052	**
BW vs. K_F		0.2160	0.1185 to 0.3094	< 0.0001	****
BW vs. K_R		0.1395	0.0399 to 0.2363	0.0048	**
BW vs. W_R		0.1392	0.0396 to 0.2360	0.0049	**

rs, spearman rank correlation values; CL, confidence limit; *p*, shows the level of significance; *ns*, not significant; * significant; ** highly significant; **** Extremely significant

There was significant variations of K values between sexes (p = 0.1306). The calculated W_R were 60.56-135.31 (100.24±9.9091) for males and 71.978-135.851(100.93±10.861) for females (Table 5 and Fig. 4). According to One sample t- test, the W_R revealed no significant variances from 100 for males (p = 0.552) and females (p = 0.249). The relationships of different conditions factor with TL and BW are presented in Table 6.

The determined $a_{3.0}$ values were 0.0103, 0.0108 and 0.0106 for males and females and combined sexes, respectively (Table 7). The calculated Lm for males and females were calculated as9.13cm (95% CL = 7.30-11.46 cm TL) and 10.46 cm TL (95% CL = 8.30-13.18 cm), respectively (Table 7). Size at first sexual maturity of *M. gulio* is shown by dividing early phase and late phase in Fig. 5. The mean M_W for the *M. gulio* population was assessed for males and females as 1.16 and 1.02 year-1 in the Maloncho River. Though, the M_W was very high with the individuals <5.00 cm TL in the Maloncho River, it was decreased with the increasing of body sizes (Fig. 6).

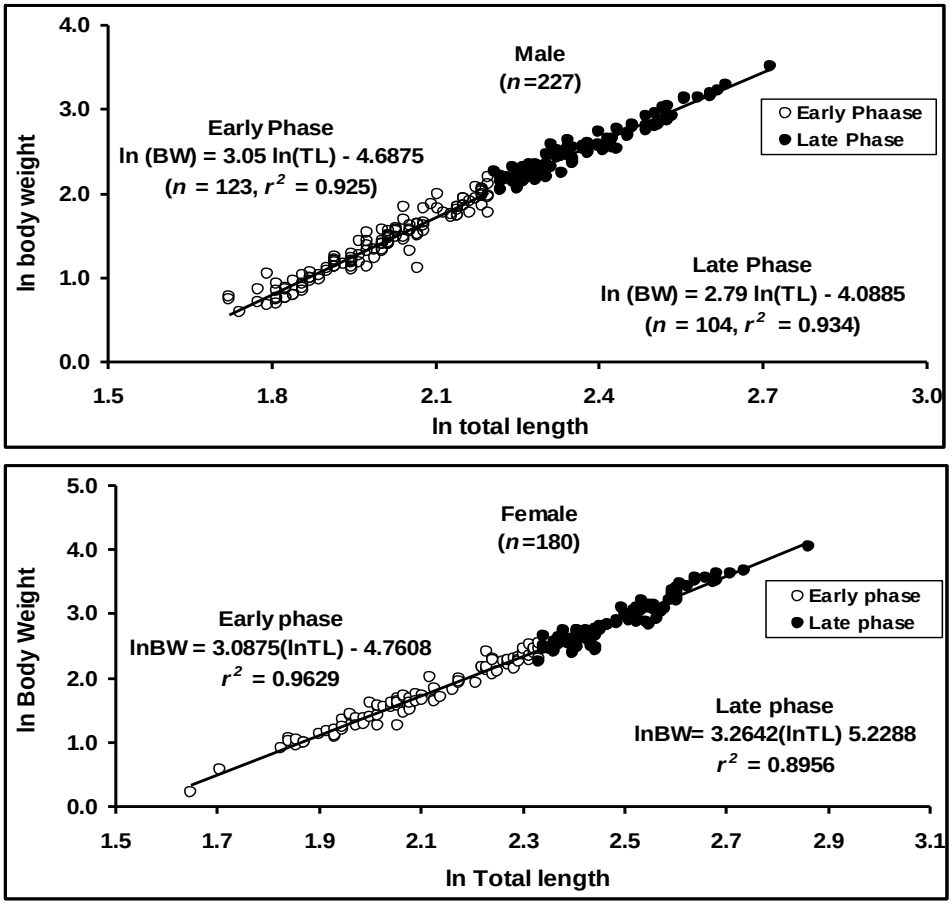

Fig. 5. Size at first sexual maturity (early phase and late phase) of male and female *Mystus gulio* in the Maloncho River, southern Bangladesh.

Table 7. The calculated form factor, $a_{3.0}$= 10 $^{\log a - s\,(b\text{-}3),}$ size at first sexual maturity (L_m) and natural mortality (M_w) for the *Mystus gulio* (Hamilton 1822) of different habitats using available length-weight relationship (LWRs) parameters in the worldwide.

Water body	Sex	Regression parameter		L_{max}	$a_{3.0}$	L_m (95% CL of L_m)	M_w	References
		a	*b*					
Chilika lagoon India	M	0.0059	3.18	17.7	0.0104	10.56 (8.39-13.32)	0.99	Panda et al. (2016)
	F	0.0106	3.00	21.5	0.0106	12.62 (9.94-16.01)	0.79	
Rupsha River Bangladesh	M	0.0180	3.03	17.2	0.0198	10.29 (8.18-12.96)	0.82	Hossain et al. (2016)
	F	0.0219	3.10	17.2	0.0299	10.29 (8.18-12.96)	0.075	
	C	0.0091	3.11	17.2	0.128	10.29 (8.18-12.96)	0.093	
Chilika lagoonIndia	U	0.0077	3.11	21.5	0.0109	12.62 (9.94-16.01)	0.79	Panda et al. (2016)
Narreri Lagoon, Pakistan	C	0.1100	2.20	20.7	0.0091	12.19 (9.62-15.45)	0.78	Haroun et al. (2017)
Maloncho River, Bangladesh	**M**	**0.0103**	**2.99**	**15.10**	**0.0103**	**9.13 (7.30-11.46)**	**1.16**	**Present study**
	F	**0.0090**	**3.05**	**17.50**	**0.0108**	**10.46 (8.30-13.18)**	**1.02**	

n, sample size; TL, total length; Min, minimum; Max, maximum; *a*, intercept; *b*, slope; $a_{3.0}$, form factor; L_m size at first sexual maturity; CL, confidence limit.

Features on life-history traits of *M. gulio* from Bangladesh are not available in the literature; however, this study from the Maloncho River, southern Bangladesh for presenting the life-history that would be effective for sustainable management and it's comparisons with any other populations from different geographical locations will be possible.

In our study, from 407 individuals, the overall male: female sex ratio was 1:0.79. The overall sex ratio did not differ significantly from the expected value (1: 1). Still, for this species, there is no sufficient information on sex ratio that hinders comparison. During the study, 407 individuals of various body sizes were captured using conventional fishing gears. In sampling period, it was quite impossible to caught *M. gulio*, which is smaller than 5.20 cm and larger than 17.5cm TL due to the deficiency of small and large size in the population or for fishing gears selectivity (Hossain *et al.* 2012b). The maximum length of *M. gulio* was 17.50 cm in this study, which is lower than the maximum value recorded as 21.5 cm in TL (Panda *et al.* 2016). It has been stated that information on maximum length is needed to assessment of population parameters (the asymptotic length and growth coefficient fishes) which is important for the management of fisheries resources (Hossain *et al.*, 2012c).

The regression parameter b of LWRs for males (*b*=2.99) and females (*b* = 3.06), where females were larger than males which indicating female fish increase in body weight at a more rapid rate than male. Though, , the b value for male was less than 3.0 and for female and combined were more than 3.0 in our study. Thus the growth of

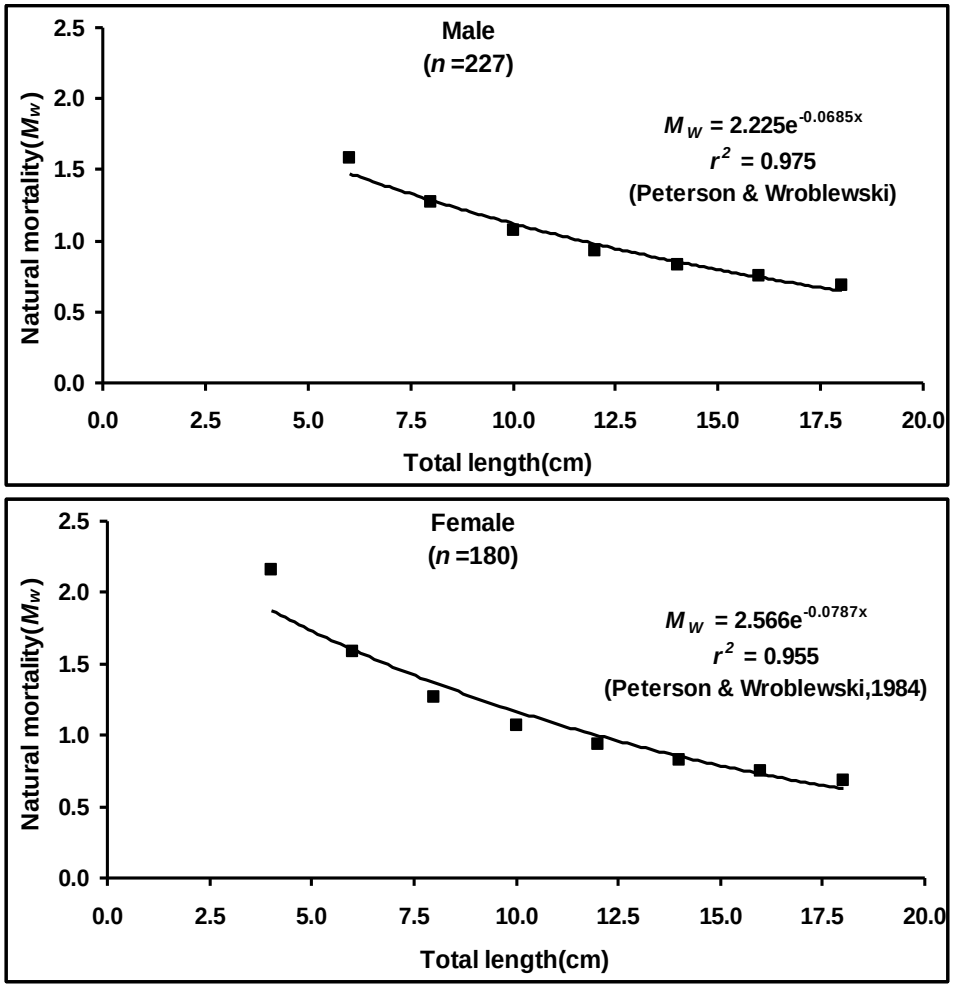

Fig. 6. The relationships between natural mortality and total length of male and female Mystus gulio in the Maloncho River, southern Bangladesh.

M. gulio in male population states negative allometric in the Maloncho River, southern Bangladesh that specifies faster growth for length than weight. However, positive allometric was reported from Rupsa River, Bangladesh (b=3.11) (Hossain *et al.*, 2016), isometric growth pattern was reported from Chilika lagoon, India (b = 3.03) by Panda *et al.* (2016) and negative allometric was reported from Narreri Lagoon, Pakistan (b = 2.20) (Haroun *et al.*, 2017). However, growth pattern may be different due to habitat condition, seasonal effects and level of stomach fullness, gonad maturation, health, preservation method and differences in the observation of length classes of collecting sample (Tesch, 1971; Weatherley *et al.*, 1987; Hossain *et al.*, 2010a).

The data of *M. gulio* were gathered over a long time and were not representing of a particular season. Therefore, they must be considered as mean annual averages only for comparison purposes. All LLRs of male and female and the combined sexes of *M. gulio* were greatly related. In present work, we have deal with condition factors (K_A, K_F, K_R) and W_R. Spearman rank correlation test defined that K_F has significant correlation with TL, and K_A, K_F, K_R and W_R have significant correlation with female populations and can be used for the well-being of *M. gulio*in the Maloncho River and adjoining ecosystem. Also, based on One sample t-test, the relative weight W_R showed no significant differences from 100 for males (p = 0.552) and females (p = 0.249) indicating the habitat was suitable condition with prey-predator relationships and available food for *M. gulio* in the Maloncho River.

The $a_{3.0}$ was 0.0103 and 0.0108 for male and female of *M. gulio* in the Maloncho River. The form factor can be confirmed whether the body shape of individuals in a certain population or species considerably differs from others (Froese, 2006). There is no indication in the literature, regarding the form factor of this species, and this is the first study of *M. gulio* on this issue that will provide the base for future studies. The L_m for male and female populations of *M. gulio* was 9.13 cm and 10.46 cm in TL, respectively. Pantulu (1961) estimated 6.2 L_m for combined sex of *M. gulio*in Hooghly estuary, David (1963), Jhingran and Natarajan (1969) and Kaliyamurthy (1981) also calculated L_m 7.9 cm, 8.2 cm and 5.4 cm respectively for this species in Indian water bodies which are lower than our estimated value. Studies on L_m for the fishes of Bangladeshi waters are very rare (Hossain *et al.*, 2010a; Hossain *et al.*, 2012c; Hossain *et al.*, 2013). Subsequently, this research will provide more detailed information to find out a combination of factors affecting the size at first maturity and spawning period in different populations of *M. gulio*. The natural mortality rates (M_w) for the population of *M. gulio* were estimated as 1.16 and 1.02 years-1 male and female Maloncho River, southern Bangladesh. This is the first natural mortality study of this species that's why it was not possible to compare with other literature.

In conclusion, this study was presented the life history traits *M. gulio* in the Maloncho River, southern Bangladesh which would be very effective for its sustainable management and conservation in the Coastal waters of Bangladesh and neighboring countries.

ACKNOWLEDGEMENT

We express our gratitude to PIU-BARC, NATP-2, PBRG-156 for technical supports.

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