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Population Parameters of the Minor carp *Labeo bata* (Hamilton, 1822) in the Ganges River of Northwestern Bangladesh

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Abstract

The Minor carp, *Labeo bata* (Cyprinidae), is one of the important fish species in northwestern (NW) Bangladesh. This study illustrates the population parameters of *L. bata* i.e., population structure (length-frequency distributions; LFDs), growth (length-weight relationships, LWRs; length-length relationships, LLRs), condition factors (allometric, K_A; Fulton's, K_F; relative, K_R; relative weight, W_R), form factor ($a_{3.0}$), reproduction (length at first maturity, L_m) and natural mortality (M_w) in the Ganges River, NW Bangladesh. Samples were collected occasionally between July, 2013 to June, 2014 using different fishing gears i.e., gill net (mesh sizes: 2.5–3.5 cm) and cast net (mesh sizes: 1.5–3.0 cm). A total 157 individuals of *L. bata* were collected, where sixty-nine were male, and eighty-eight were female. The sex ratio did not fluctuate significantly from the anticipated 1:1 ratio (df =1, χ^2=2.30, p>0.05). Total length varied from 7.9 to 25.2 cm and body weight ranged from 4.68 to 181.35g. All LWRs were highly significant (p<0.01), with all r^2 values ≥0.984. The analysis of covariance (ANCOVA) revealed no extensive differences in LWRs between genders (p>0.05). The allometric coefficient (b) indicated positive allometric growth in both sexes (b>3.00, p<0.01). All LLRs were highly correlated (p<0.001), and most of the r^2 values were ≥0.992. Among four condition factors, K_F was the best fitted, and can be used as indicator of safe life for *L. bata* in the Ganges River. Wilkoxon Sign Ranked Test for W_R showed no considerable dissimilarity from 100 for male (p=0.295) and female (p=0.057). The a_{30} for both sexes was 0.0108. The L_m for male and female population was 14.12 cm and 14.60 cm in TL, respectively. The M_w for the population of *L. bata* was 0.86 year^{-1} in the Ganges River. This result would be effective for a sustainable management of this Minor carp in Bangladesh and its adjoining ecosystems.

Keywords: *Labeo bata*, growth, condition, maturity, mortality, Ganges River.

1. Introduction

The Minor carp, *Labeo bata* (Hamilton, 1822), is an important native target species for fishers, much sought-after in Bangladesh because of its high commercial value. It is a freshwater benthopelagic, potamodromous cyprinid, commonly known as Bata in Bangladesh, Bhagan in India, and Bata labeo in Nepal (Froese and Pauly, 2016). It can be found throughout the Indian sub-continent, including Bangladesh, India, Myanmar, Nepal and Pakistan (Robins *et al*., 1991), inhabiting rivers, canals, *haors*, ponds and ditches. In spite of some local threats impacting this species, there is no present information on its population decline. Nowadays, this fish is being cultured commercially, and no risk is expected in the near future. Hence, at the present this species is assessed as a least concern, although it had been assessed as endangered earlier in Bangladesh (IUCN Bangladesh, 2015).

Information regarding the length, weight, sex, first maturity and mortality is of elemental significance to the effective management of an exploitable fish population in that they can be employed to determine a maximum sustainable yield (Chen and Paloheimo, 1994; King, 1997). Nevertheless, several authors reported on the biology, ecology (Talwar and Jhingran, 1991), breeding performance, growth, survival rate, morphometric relationships and the condition factor (Siddique *et al*., 1976; Naeem *et al*., 2012; Hossen *et al*., 2015, Hossain *et al*., 2016a) for this species, but in spite of the economic importance of this species, no prior research was performed on the population parameters of *L. bata*.

Hence, the aim of this research is to elucidate the population parameters including growth pattern (length-

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weight relationships, LWRs; length-length relationships, LLRs), condition factors (allometric, K_A; Fulton's, K_F; relative, K_R; and relative weight, W_R), reproduction (size at first maturity, L_m), and natural mortality (M_W) of *L. bata* from the Ganges River in northwestern (NW) Bangladesh using a number of specimens with various sizes over a study period of one year.

2. Material and Methods

2.1. Study Area and Sampling

A sum of 157 individuals of *L. bata* was collected occasionally from the Ganges River (known as Padma River in Bangladesh) (Lat. 24.35′ N; Long. 88.64′ E) NW Bangladesh) between July, 2013 to June, 2014 from artisanal fishers. The samples were caught using gill net (mesh sizes 2.5–3.5 cm), and cast net (mesh sizes 1.5–3.0 cm). Fresh samples were instantly chilled in ice on site and were transported to the laboratory and were fixed with 10% buffered formalin for laboratory analysis.

2.2. Fish Measurement

Morphological traits (Total length, TL; fork length, FL; and standard length, SL) were assessed via digital slide calipers (±0.01 cm). The whole body weight (BW) was taken using an electronic balance with a 0.01 g accuracy.

2.3. Sex Ratio and Length-Frequency Distributions (*LFDs*)

Sex determination of samples was done by a microscopic observation of the gonads. The chi-square test was conducted to verify the sex-ratio variance from the anticipated value of 1:1 (male: female). The LFDs were constructed separately for male and female using 1 cm intervals of TL.

2.4. Growth Pattern

The growth pattern was estimated through LWR with the equation: $BW= a*L^b$, where BW is the total body weight (g), and L is the length (TL, FL and SL in cm). Through linear regression analysis, the parameters *a* and *b* were estimated based on natural logarithms: ln (*W*) = ln (*a*) + *b* ln(*L*). Outliers were excluded from the regression analysis by Froese (2006). The *t*-test was employed to confirm whether the *b* values obtained in the linear regressions were significantly departed from the isometric value (*b*=3) (Sokal and Rohlf, 1987). Furthermore, linear regression was applied to estimate LLRs i.e., TL *vs*. SL; TL *vs.* FL and SL *vs.* FL relationships (Hossain *et al*., 2006a).

2.5. Condition Factors and Form Factor ($a_{3.0}$)

The allometric condition (K_A) was estimated by the equation of Tesch (1968): W/L^b, where *W* is the BW (g), *L* is the TL (cm), and *b* is the LWR parameter. The Fulton's Condition Factor (K_F) was determined by the equation, $K_F =100\times (W/L^3)$, where *W* is the BW (g), and *L* is the TL in cm (Fulton, 1904). The scaling factor of 100 was used to bring the K_F close to unit. Moreover, the relative condition (K_R) was calculated by the equation of Le Cren (1951): $K_R = W/(a\times L^b)$, where *W* is the BW (g), *L* is the TL (cm), and *a* and *b* are LWRs parameters. For assessing W_R, the equation of Froese (2006): $W_R = (W/W_s)\times 100$ was used, where *W* is the weight of a particular individual and W_s is the expected standard weight for the same individual. Additionally, the $a_{3.0}$ of *L. bata* was estimated through the equation of Froese (2006) as: $a_{3.0} = 10^{log\ a\text{-}s(b\text{-}3)}$, where *a* and *b* are regression parameters of LWRs and *s* is the regression slope of *ln a vs. b*. In this study, a mean slope *S* = -1.358, was used for calculating the form factor to estimate of the regression (S) of *ln a vs. b*, since information on the LWRs for this species is unavailable

2.6. Size at Sexual Maturity (L_m) *and Natural Mortality* (M_W)

The L_m of *L. bata* was estimated via the equation, log (L_m) = -0.1189 + 0.9157* log (L_{max}) by Binohlan and Froese (2009) for males and females, separately. Also the M_W was determined using the model, M_W = 1.92 year^{-1} *$(W)^{-0.25}$ (Peterson and Wroblewski, 1984), where, M_W = natural mortality at mass *W*, and $W = a*L^b$, *a* and *b* are regression parameters of LWRs.

2.7. Statistical Analyses

The Microsoft® Excel-add-in-DDXL and GraphPad Prism 6.5 software were used in statistical analysis of this study. The homogeneity and normality of data were checked. The non-parametric Spearman Rank Test was employed to assess the relationship between the morphometric indices (*e.g*., TL, FL, SL, and BW) with condition factors. The Mann-Whitney U-test was employed to compare the mean values between sexes. Furthermore, ANCOVA was utilized for the comparison of LWRs between male and female. The Wilkoxon Sign Ranked Test was applied to evaluate the mean W_R with 100 (Anderson and Neumann, 1996). All statistical analyses were considered significant at 5% (p<0.05).

3. Results

3.1. Sex ratio

This study revealed that, out of the 157 individuals of *L. bata*, sixty-nine (43.95%) were males, and eighty-eight (56.05%) were females. The male and female ratio was 1:1.28; the whole sex ratio did not differ statistically from the expected 1:1 ratio (df=1, χ^2=2.30, p>0.05) (Table 1). However, the deviation in the sex ratio with length class illustrated that both males and females were dominated for 8.00-8.99 cm to 8.99-9.99 cm TL size groups, respectively, though statistically, there was no considerable variations among these groups (p>0.05).

Table 1. Number of male, female and sex ratio (male: female=1:1) of *Labeo bata* (Hamilton, 1822) from the Ganges River, northwestern Bangladesh.

Length class (TL, cm)	Number of specimens			Sex ratio (Male/Female)	χ^2 (*df*=1)	Significance
	Male	Female	Total			
7.00 – 7.99	0	1	1	-	1.00	*ns*
8.00 – 8.99	11	13	24	1:1.18	0.17	*ns*
9.00 – 9.99	12	13	25	1:1.08	0.04	*ns*
10.00 – 10.99	5	6	11	1:1.2	0.09	*ns*
11.00 – 11.99	3	4	7	1:1.33	0.14	*ns*
12.00 – 12.99	3	4	7	1:1.33	0.14	*ns*
13.00 – 13.99	4	3	7	1:0.75	0.14	*ns*
14.00 – 14.99	2	5	7	1:2.5	1.29	*ns*
15.00 – 15.99	2	3	5	1:1.5	0.20	*ns*
16.00 – 16.99	3	5	8	1:1.67	0.50	*ns*
17.00 – 17.99	3	4	7	1:1.33	0.14	*ns*
18.00 – 18.99	3	4	7	1:1.33	0.14	*ns*
19.00 – 19.99	4	4	8	1:1	0.00	*ns*
20.00 – 20.99	3	4	7	1:1.33	0.14	*ns*
21.00 – 21.99	5	4	9	1:0.80	0.11	*ns*
22.00 – 22.99	2	4	6	1:2	0.67	*ns*
23.00 – 23.99	2	4	6	1:2	0.67	*ns*
24.00 – 24.99	2	1	3	1:0.50	0.33	*ns*
25.00 – 25.99	-	2	2	-	2.00	*ns*
Overall	69	88	157	1:1.28	2.30	*ns*

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

3.2. Length-Frequency Distributions (LFDs)

Table 2 illustrates the descriptive statistics for length and weight measurements of the *L. bata.* The LFDs point out that the smallest and largest specimens were 8.00 to 24.3 cm TL for males and 7.9 to 25.2 cm TL for females (Figure 1). The LFDs for both males and females did not pass the normality (Shapiro- Wilk Normality Test, $p<0.001$). In addition, the Mann-Whitney U-test indicates that there was no noteworthy variations in the LFDs between sexes (U= 2872, $p=0.056$). Furthermore, the results showed that, BW of males and females did not pass the normality test (Shapiro- Wilk Normality Test, $p<0.001$), also the Mann-Whitney U-test indicated no significant differences in the BW between sexes (U= 2818, $p>0.05$).

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships ($BW= a \times TL^b$) of *Labeo bata* (Hamilton, 1822) from the Ganges River, northwestern Bangladesh.

Equation	Sex	*n*	Length (cm)		Body weight (g)		Regression parameters		95% CL of *a*	95% CL of *b*	r^2	GT
			Min	Max	Min	Max	*a*	*b*				
$BW=a \times TL^b$	M	69	8.0	24.3	4.68	175.57	0.0070	3.14	0.0062 – 0.0080	3.09 – 3.19	0.996	+A
$BW=a \times FL^b$			7.0	22.1			0.0120	3.08	0.0100 – 0.0144	3.01 – 3.16	0.990	I
$BW=a \times SL^b$			6.2	20.3			0.0215	2.99	0.0178 – 0.0260	2.91 – 3.07	0.988	I
$BW=a \times TL^b$	F	88	7.9	25.2	4.94	181.35	0.0085	3.08	0.0076 – 0.0094	3.04 – 3.12	0.996	+A
$BW=a \times FL^b$			6.9	22.2			0.0153	3.00	0.0128 – 0.0182	2.93 – 3.07	0.988	I
$BW=a \times SL^b$			6.0	19.8			0.0243	2.95	0.0200 – 0.0295	2.87 – 3.03	0.984	-A
$BW=a \times TL^b$	C	157	7.9	25.2	4.68	181.35	0.0078	3.11	0.0072 – 0.0084	3.07 – 3.14	0.996	+A
$BW=a \times FL^b$			6.9	22.2			0.0137	3.04	0.0120 – 0.0155	2.99 –3.09	0.989	I
$BW=a \times SL^b$			6.0	20.3			0.0229	2.97	0.0200 – 0.0362	2.91 – 3.03	0.986	-A

TL, total length; FL, fork length; SL, standard length; BW, body weight; M, male; F, female; C, combined; *n*, sample size; Min, minimum; Max, maximum; *a* and *b* are regression parameter; CL, confidence limit for mean values; r^2, coefficient of determination; GT, growth type; +A, positive allometric; -A, negative allometric; I, isometric

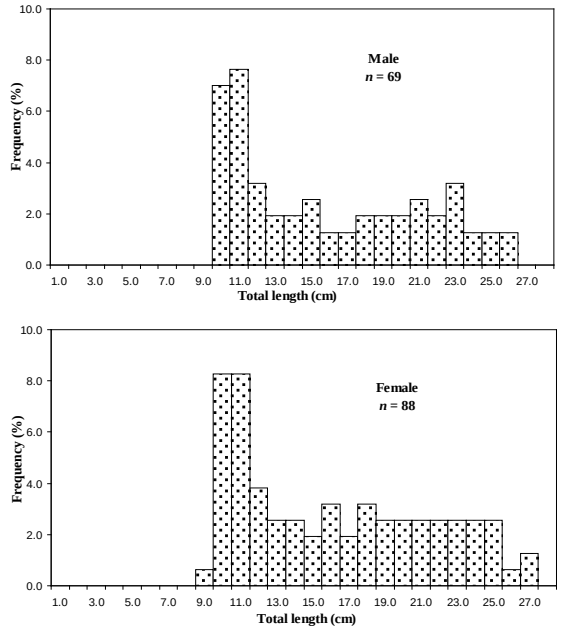

Figure 1. Length-frequency distribution of male and female *Labeo bata* from the Ganges River, northwestern Bangladesh

3.3. Growth Pattern

The sample sizes (*n*), regression parameters and 95% confidence limits for *a* and *b* of the LWRs, coefficients of determination (r^2), and growth type of *L. bata* are shown in Figure 2 and in Table 2. All LWRs were highly significant (p<0.01), with all r^2 values ≥ 0.984. The ANCOVA expressed no considerable differences in LWRs between sexes (p>0.05). Moreover, the LLRs i.e., TL *vs*. SL, TL *vs*. FL and SL *vs*. FL of the *L. bata* along with the estimated parameters, and the coefficient of determination (r^2) are presented in Table 3. All LLRs were highly significant (p<0.001) and most of the r^2 values exceeded 0.992.

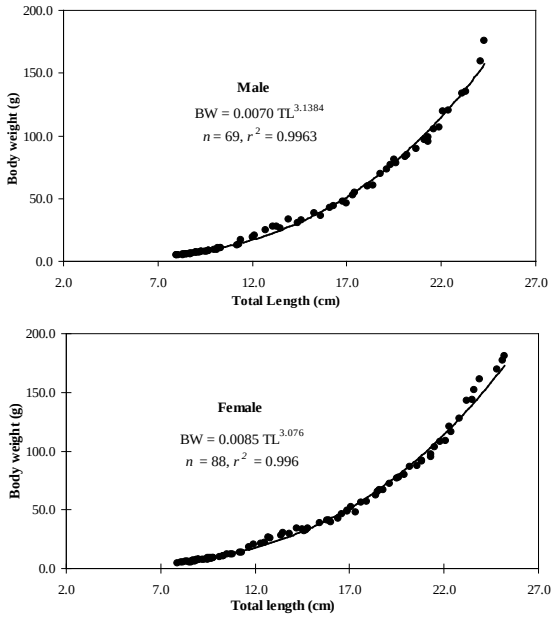

Figure 2. The length-weight relationships (BW= a * TL^b) of male and female *Labeo bata* from the Ganges River, northwestern Bangladesh

Table 3. The estimated parameters of the length-length relationships ($Y = a + b \times X$) of *Labeo bata* (Hamilton, 1822) from the Ganges River, northwestern Bangladesh.

Equation	Sex	Regression parameters		95% CL	95% CL	r^2
		a	*b*	of *a*	of *b*	
TL = *a* + *b* × SL	M	0.8775	1.18	0.5898-1.1651	1.16-1.21	0.993
TL = *a* + *b* × FL		0.4018	1.10	0.1703-0.6334	1.08-1.12	0.996
SL = *a* + *b* × FL		-0.3750	0.93	-0.5053 to -0.2447	0.91-0.94	0.998
TL = *a* + *b* × SL	F	0.6887	1.213	0.3949-0.9825	1.18-1.24	0.991
TL = *a* + *b* × FL		0.5121	1.10	0.2857-0.7386	1.08-1.11	0.995
SL = *a* + *b* × FL		-0.1052	0.90	-0.2610 to 0.0506	0.89-0.91	0.997
TL = *a* + *b* × SL	C	0.7591	1.20	0.5717-0.9466	1.19-1.22	0.994
TL = *a* + *b* × FL		0.4881	1.10	0.3310-0.6452	1.08-1.11	0.995
SL = *a* + *b* × FL		-0.1957	0.91	-0.3038 to -0.0875	0.90-0.92	0.997

TL, total length; FL, fork length; SL, standard length; M, male; F, female; C, combined; *a*, intercept; *b*, slope; CL, confidence limit of mean values; r^2, coefficient of determination

3.4. Condition Factors and Form Factor ($a_{3.0}$)

The different condition factors (K_A, K_F, K_R and W_R) for both sexes of the *L. bata* are given in Table 4. The relationship between TL *vs.* W_R is shown in Figure 3, and the relationships of different condition factors (K_A, K_F, K_R and W_R) with TL and BW are shown in Table 5. Additionally, the calculated $a_{3.0}$ of both sexes of the *L. bata* was 0.0108 (Table 6)·

Table 4. Allometric (K_A), Fulton's (K_F), relative condition factors (K_R) and relative weight (W_R) of *Labeo bata* (Hamilton, 1822) from the Ganges River, northwestern Bangladesh.

Condition factors	Sex	*n*	Min	Max	Mean ± SD	95% CL
K_A	M	69	0.0064	0.0087	0.0071 ± 0.0005	0.0069 – 0.0072
K_F			0.8797	1.2440	1.0114 ± 0.0904	0.9897 – 1.0331
K_R			0.9165	1.2359	1.0097 ± 0.0752	0.9916 – 1.0277
W_R			91.651	123.594	100.968 ± 7.517	99.162 – 102.774
K_A	F	88	0.0070	0.0110	0.0085 ± 0.0006	0.0083 – 0.0086
K_F			0.8930	1.2859	1.0350 ± 0.0787	1.0184 – 1.0517
K_R			0.8797	1.2471	0.9973 ± 0.0709	0.9823 – 1.0123
W_R			87.966	124.707	99.732 ± 7.090	98.230 – 101.234
K_A	C	157	0.0070	0.0100	0.0080 ± 0.0010	0.0077 – 0.0079
K_F			0.8800	1.2900	1.0200 ± 0.0800	1.0100 – 1.0400
K_R			0.9800	1.4100	1.1100 ± 0.0800	1.1000 – 1.1300
W_R			98.340	140.670	111.250 ± 8.220	109.950 –12.540

n, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values; K_A, allometric condition factor; K_F, Fulton's condition factor; K_R, relative condition factor; W_R, relative weight

Table 5. Relationships of condition factors with total length (TL) and body weight (BW) of *Labeo bata* from the Ganges River, northwestern Bangladesh.

Condition factor	Sex	r_s value	95% CL of r_s	p value	Degree of significance
TL *vs.* K_A	M	0.0559	-0.1902 to 0.2953	$p = 0.648$	*ns*
TL *vs.* K_F		0.6826	0.5266 to 0.7941	$p < 0.001$	***
TL *vs.* K_R		0.0555	-0.1905 to 0.2950	$p = 0.650$	*ns*
TL *vs.* W_R		0.0579	-0.1883 to 0.2971	$p = 0.637$	*ns*
BW *vs.* K_A		0.0746	-0.1720 to 0.3124	$p = 0.542$	*ns*
BW *vs.* K_F		0.6964	0.5454 to 0.8036	$p < 0.001$	***
BW *vs.* K_R		0.0750	-0.1716 to 0.3126	$p = 0.540$	*ns*
BW *vs.* W_R		0.0767	-0.1699 to 0.3143	$p = 0.531$	*ns*
TL *vs.* K_A	F	0.0069	-0.2221 to 0.2089	$p = 0.949$	*ns*
TL *vs.* K_F		0.4843	0.3002 to 0.6337	$p < 0.001$	***
TL *vs.* K_R		-0.0055	-0.2207 to 0.2202	$p = 0.960$	*ns*
TL *vs.* W_R		-0.0041	-0.2194 to 0.2116	$p = 0.970$	*ns*
BW *vs.* K_A		0.0134	-0.2027 to 0.2282	$p = 0.901$	*ns*
BW *vs.* K_F		0.5019	0.3211 to 0.6473	$p < 0.001$	***
BW *vs.* K_R		0.0150	-0.2011 to 0.2298	$p = 0.889$	*ns*
BW *vs.* W_R		0.0166	-0.1996 to 0.2313	$p = 0.878$	*ns*
TL *vs.* K_A	C	0.0586	-0.1036 to 0.2178	$p = 0.466$	*ns*
TL *vs.* K_F		0.5877	0.4711 to 0.6841	$p < 0.001$	***
TL *vs.* K_R		0.0419	-0.1201 to 0.2018	$p = 0.602$	*ns*
TL *vs.* W_R		0.0452	-0.1169 to 0.2050	$p = 0.574$	*ns*
BW *vs.* K_A		0.0871	-0.0751 to 0.2449	$p = 0.279$	*ns*
BW *vs.* K_F		0.6084	0.4958 to 0.7009	$p < 0.001$	***
BW *vs.* K_R		0.0705	-0.0917 to 0.2292	$p = 0.380$	*ns*
BW *vs.* W_R		0.0740	-0.0883 to 0.2325	$p = 0.357$	*ns*

r_S, coefficient of spearman rank correlation test; *ns*, not significant; ***, highly significant

Table 6. The calculated form factor ($a_{3.0}$), size at first sexual maturity (L_m) of *Labeo bata* from the Ganges River, northwestern Bangladesh.

Sex	n	Length (cm)			a	b	$a_{3.0}$	L_m	95% CL of L_m
		Type	Min	Max					
Male	69	TL	8.0	24.3	0.0070	3.14	0.0108	14.12	11.07 - 17.98
Female	88	TL	7.9	25.2	0.0085	3.08	0.0108	14.60	11.43 - 18.61

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

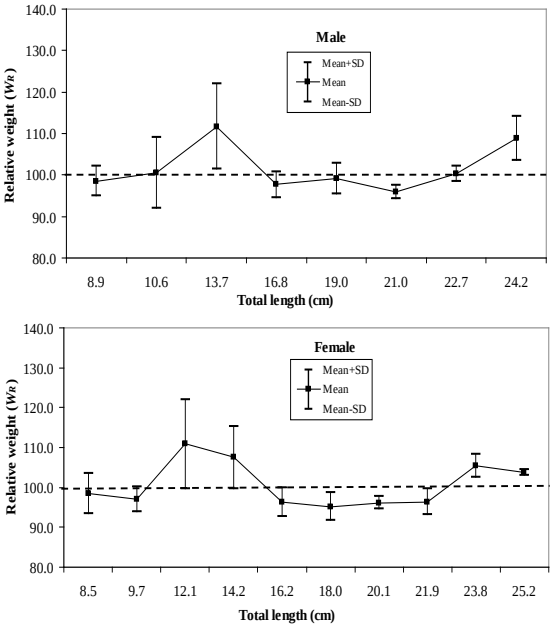

Figure 3. The relationship between total length and relative weight of *Labeo bata* from the Ganges River, northwestern Bangladesh

3.5. Size at First Sexual Maturity (L_m) and Natural Mortality (M_W)

The calculated L_m for male and female populations of *L. bata* was 14.12 cm and 14.60 cm in TL, respectively (Table 6). The M_w for the population of *L. bata* was estimated 0.86 year^{-1} in the Ganges River in northwestern Bangladesh (Figure 4).

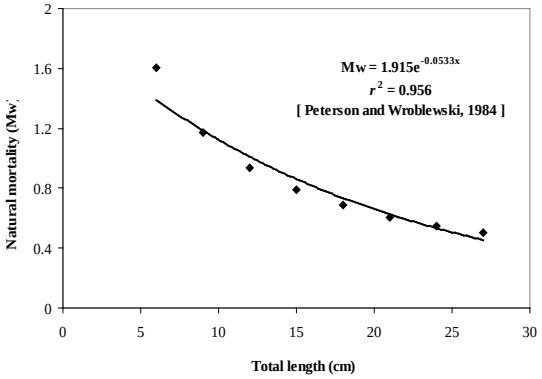

Figure 4. The relationships between total length and natural mortality of *Labeo bata* from the Ganges River, northwestern Bangladesh

4. Discussion

The population parameters are valuable approaches for the evaluation of the status of fish stocks and are vital means for the management of exploited fish populations (Sparre and Venema, 1997). Information on the population parameters of the *L. bata* is very deficient, therefore, the present study provides a complete description on the above-mentioned issue including- growth patterns, condition factors, form factor, reproduction and mortality using a number of individual *L. bata* collected from the Ganges River in NW Bangladesh.

In the current study, the females were more dominant than the males with the sex ratio of male and female of the *L. bata* being 1:1.28, which is statistically not different from the anticipated value of 1:1 (χ^2=2.30, *df*=1, *p*>0.05). Fumio (1960) stated that an increase in the sex ratio in relation to body size for some fish species may be attributed to the high mortality rate in males, and the greater longevity of females.

During the study, *L. bata* with < 7.90 cm TL could not be collected as a result of possible conditions, including the outcomes of the selectivity of the fishing gears, the inability of the fishermen to reach where the smaller size were (Hossain *et al*., 2012a; 2016b), the indiscriminate killing of fry and fingerlings (Rema Devi and Ali, 2013), or because of the spawning season (Rahman, 2005). In the present study, the maximum length found of the *L. bata* was 25.2 cm TL, which is lower than the maximum documented value of 61.0 cm TL (Talwar and Jhingran, 1991). Maximum length is important for estimating the asymptotic length and the growth coefficient of fishes (Azad *et al*., 2018; Hossain *et al*., 2012b; Hossen *et al*., 2016; Nawer *et al*., 2017).

The accepted range of the *b* value is 2.5-3.5 (Froese, 2006). In the present study, all the *b* values for different LWRs were within this limit (2.95-3.14). According to Tesch (1971), when the *b* value is close to 3, it signifies that the fish grow isometrically. The 3.0 signifies an allometric growth, (>3 means positive allometric, and <3 means negative allometric). In this study, the *b* values for TL *vs*. BW relationships were >3.00 (3.08-3.14) indicating a positive allometric growth for males, females and the combined sexes of *L. bata* in the Ganges River, NW Bangladesh. Hossain *et al*. (2016a) reported positive allometric growth for the *L. bata* of the Ganges River, which is similar with the present findings regarding the TL *vs.* BW relationships. Naeem *et al*. (2012) reported negative allometric growth (*b* = 2.92 for combined sexes) for the same species in the Head Panjnad in Pakistan (see Fig. 5), which were inconsistent with the findings in this study. However, the differences in the *b* values may be attributed to the habitat condition, seasonal effects, degree of stomach fullness, gonad maturity, sex, fish health, preservation techniques, and differences in the observed length (Hossain *et al.*, 2006b, 2013a, b, 2014; Tesch, 1971), which we did take into consideration during the study.

All LLRs were highly significant (p<0.001), and most of the r^2 values were ≥0.992 and were dissimilar with the results of Naeem *et al*. (2012). Such variations arise because of differences in the ecological conditions of the habitats, or as a result of the variation in the physiology of animals (Le Cren, 1951), or because the length ranges and the sampling times were not similar.

In the current study, four condition factors (K_A, K_F, K_R and W_R) were used to know the physical and environmental conditions of the *L. bata* in the Ganges River. The Spearman Rank Correlation Test illustrated that only K_F is strongly correlated with TL and BW for both sexes (Table 5) indicating that the Fulton′s Condition Factor (K_F) is the best biometric index for establishing the welfare of *L. bata* in the Ganges River and the adjacent ecosystems. Because this is the first assessment of the condition factor for the *L. bata,* it was not possible to compare the findings of this study with other findings from the same habitat or elsewhere.

The W_R helps to assess the overall health and fitness, as well as the population-level responses to the ecosystem disturbance (Rypel and Richter, 2008). In the present study, according to the Wilkoxon Sign Ranked Test, the W_R showed no significant differences from 100 for both males and females indicating that the population of the *L. bata* in the Ganges River ecosystem is in an equilibrium state with the availability of food and a lower numbers of predators. However, the lack of available information in the literature dealing with the W_R of the *L. bata* limits the comparison of the findings reported in this study to other research findings.

In this study, the $a_{3.0}$ for both the male and female populations of *L. bata* was 0.0108. The $a_{3.0}$ can be used to verify whether the body profile of individuals in a particular population is considerably different from others (Froese, 2006).

Also, the L_m for male and female *L. bata* populations was 14.12 cm and 14.60 cm in TL, respectively. Studies on L_m for Bangladeshi freshwater fishes are very rare (except Azadi and Naser, 1996; Hossain *et al*., 2010; 2012c; 2016b,c; 2017). The L_m is broadly used as an indicator for minimum allowable capture size (Lucifora *et al*., 1999). This research presents the first attempt to determine the L_m for the *L. bata* of the Ganges River. Hopefully this will be the foundation for more detailed studies to investigate the factors affecting the first sexual maturation and spawning size.

The M_w for the population of the *L. bata* was estimated 0.86 year^{-1} in the Ganges River, NW Bangladesh. Since this is the first assessment of the M_w for this species, it was not possible to compare the findings with other studies. Therefore, further studies are recommended to find out the reasons of mortality of this species in the future.

5. Conclusion

The present work is the first of its kind to provide fundamental information on the wild population of the *L. bata*, including sex ratio and length-frequency distribution, length-weight and length-length relationships, condition factors (allometric, Fulton's, relative and relative weight), form factor, first sexual maturity and natural mortality. The findings of this study would be a baseline for developing and controlling the *L. bata* exploitation, to achieve an effective and sustainable management of this fishery in the Ganges River of NW Bangladesh, as well as in other subtropical countries.

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Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of the present paper.

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