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Biometrics of the rare fish *Rhinomugil corsula* (Hamilton, 1822) (Mugiliformes: Mugilidae) in the Ganges, Northwestern Bangladesh

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PEER REVIEW

ABSTRACT

Objective: To investigate biometrics of the *Rhinomugil corsula* (Hamilton, 1822) (*R. corsula*), including length–weight relationships (LWRs), condition factors (Allometric, K_A; Fulton's, K_F; Relative, K_R; Relative weight, W_R), and sex ratio and length–frequency distributions in the Ganges (Padma River), Northwestern Bangladesh.

Methods: Monthly sampling was conducted using traditional fishing gears during June to August 2012. Total length was measured to the nearest 0.01 cm using digital slide calipers, and total body weight was measured using an electronic balance with 0.01 g accuracy. The LWR was calculated using the expression: $W = a \times L^b$, where the W is the body weight, L is the total length, a and b are the parameters of the regression.

Results: A total of 350 specimens ranging from 8.59–15.71 cm in total length and 9.57–32.59 g in body weight were analyzed during this study. The overall sex ratio was not significantly different from the expected value of 1:1 ($\chi^2 = 2.57$, $P > 0.05$), but there was significant difference in the length–frequency distributions between the sexes ($P = 0.03$). The allometric coefficient b for the LWR indicated negative allometric growth ($b \approx 3.00$) in males, female and combined sexes. Results further indicated that K_F was not significantly different between the sexes ($P = 0.57$). However, the mean W_R of *R. corsula* showed significant differences from 100 for males ($P = 0.03$) and females ($P < 0.001$) in this study, indicating the imbalance habitat with food availability relative to the presence of predators.

Conclusions: This study reported the first description of biometric relationships for *R. corsula*, which would be useful for the sustainable conservation of this rear fishery in Bangladesh and also neighboring countries.

1. Introduction

Rhinomugil corsula (*R. corsula*) (Hamilton, 1822) (Mugiliformes: Mugilidae) is a freshwater and brackish species commonly known as *Khorsula* in Bangladesh and Corsula mullet in India[1,2]. This fish is widely distributed in the rivers and estuaries throughout the Indian sub–continent including Bangladesh, India, Nepal and Myanmar[2]. It

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attains a maximum total length of 45 cm[3]. *R. corsula* is an important species in the Padma River[4] and is widely preferred by the consumers in Bangladesh. However, the conservational status of this fish has been referred as least concern in the world, and the species has been categorized as rare (found in small quantity during monsoon) in Bangladesh[4,5].

The length–weight relationship (LWR) is a handy tool in fishery assessment which helps in predicting weight from length required in yield assessment[6] and in the calculation of the standing crop biomass[7]. In sampling programs, it is generally easier to measure length only (*e.g.*, owing to the bobbing motion of the boat), or weight cannot be measured simply (*e.g.*, underwater visual censuses). The LWR of a particular species allows the inter–conversion of these parameters. In addition, LWR of fishes are necessary for various purposes such as stock/ecological assessment, monitoring and management[8]. Furthermore, estimates of mean weight by length class are essential to assess biomass through analytic models such as cohort or virtual population analyses. The parameters are also used to estimate the weight of a length frequency sample[9,10].

Detailed knowledge on the life history of *R. corsula* is needed for initiating conservation measures for the proper management of this important fish species in the Padma River[11,12]. However, though a few works on these aspects of some threatened fishes are available from Bangladesh[11–15], no such studies prevail in case of the least concerned fish *R. corsula*. This study therefore presents the first reference on biometrics including sex ratio, length frequency distribution (LFD), LWR, and condition factors for this fish species in the Ganges (Padma River), Northwestern Bangladesh.

2. Materials and methods

2.1. Study site

This study was conducted in the Ganges (Padma River) (Latitude 24° 22′ N; Longitude 88° 35′ E) of Bangladesh. The Padma River is the main distributary of the Ganges in Bangladesh and is believed to be an important spawning and feeding ground for many riverine fish species[4].

2.2. Sampling and laboratory analyses

Samples were collected from commercial catches landed at the Shaheb bazar fish market, Rajshahi during June to August 2012. The commercial fishers mainly used traditional fishing gears including gill net and cast net for catching fish. Samples were immediately chilled in ice on site and fixed with 10% buffered formalin upon arrival in the laboratory, Department of Fisheries, University of Rajshahi, Bangladesh. Samples were identified[2]. For each individual, total length was measured to the nearest 0.01 cm using digital slide calipers (Mitutoyo, CD–15PS), and wet body weight was taken on a digital balance (Shimadzu, EB–430DW) with 0.01 g accuracy.

2.3. LWR

The LWR was estimated using the equations: $W=a{\times}L^b$ and $ln(W)=ln(a)+b\ ln(L)$, Where W is the whole body weight (g) and L the total length (cm). The 95% confidence limits of parameters a and b and the coefficient of determination r^2 were also calculated. During this study, prior to the regression analysis of *ln* body weight on *ln* total length, *ln–ln* plots of length and weight values were performed for visual inspection of outliers, with extremes being excluded from the regression analyses.

2.4. Condition factors

Fulton's condition factor (K_F)[16] was calculated using the equation: $K_F=100{\times}(W/L^3)$, where W is the total body weight (g) and L is the total length (cm). The relative condition factor (K_R) for each individual was calculated as[17]: $K_R=W/a{\times}L^b$, where W is the body weight, L is the total length, and a and b are the LWR parameters. In addition, the allometric condition factor (K_A) was calculated as[18]: $K_A=W/L^b$, where W is the body weight, L is the total length, and b is the LWR parameter. Furthermore, relative weight was calculated as[8]: $W_R=(W/W_S){\times}100$, where W is the weight of a particular individual and W_S is the predicted standard weight for the same individual as calculated by $W_S=a{\times}L^b$ where the a and b values are obtained from the relationships between total length and body weight.

2.5. Statistical analyses

Statistical analyses were performed using Microsoft® Excel–add–in–DDXL, and GraphPad Prism 5. Tests for normality of each group were conducted by visual assessment of histograms and box plots, and confirmed using the Kolmogorov–Smirnov test. The Mann–Whitney U–test was used to compare the length–frequency distributions between the sexes. A *Chi*–square test was used to identify the sex–ratio divergence from the expected value of 1:1 (male: female). Moreover, the parameters a and b of the LWR between sexes were compared by ANCOVA. Where the normality assumption was met, the one sample test was used to compare the mean relative weight (W_R) with 100[19]. The unpaired *t*–test was used to compare the condition factors between sexes. All statistical analyses were considered significant at 5% ($P<0.05$).

3. Results

Out of the 350 specimens of *R. corsula* collected from the Padma River during present study, 54% were males and 46% were females (Table 1). The overall sex ratio did not differ from 1:1 ratio statistically ($\chi^2=2.57$, df=1, $P>0.05$). The variation in sex ratio with length class showed that males dominated all the length classes except 14.00–14.99 cm total length size group which was predominated by females. Nonetheless, there were no significant differences among these groups ($P>0.05$).
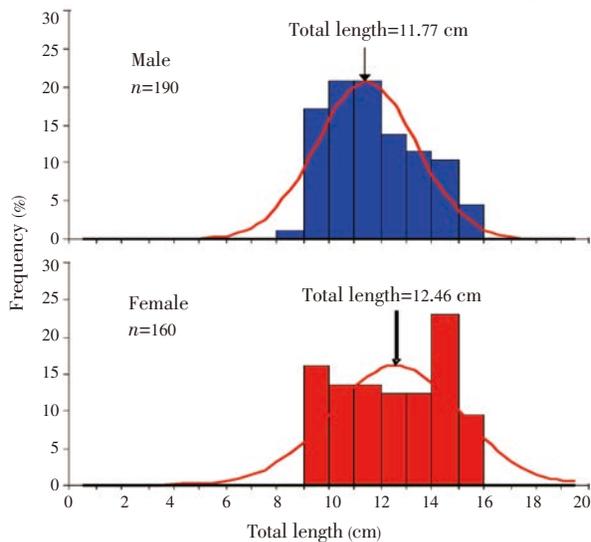
Table 1
Number of male, female and sex ratio (male: female=1:0.84) of the *R. corsula* in the Padma River, Northwestern Bangladesh.

Class size	M	F	Total	Ratio	Chi–square value (χ^2)	Significance
8.00 − 8.99	1	0	1	1:0.00	1.00	NS
9.00 − 9.99	30	27	57	1:0.90	0.16	NS
10.00 − 10.99	33	25	58	1:0.76	1.10	NS
11.00 − 11.99	33	25	58	1:0.76	1.10	NS
12.00 − 12.99	27	24	51	1:0.89	0.18	NS
13.00 − 13.99	25	24	49	1:0.96	0.02	NS
14.00 − 14.99	24	28	52	1:1.17	0.31	NS
15.00 − 15.99	17	7	24	1:0.41	4.16	*
Total	190	160	350	1:0.84	2.57	NS

M: male; F: female; NS: not significant; *: significant at 5% level ($\chi^2_{t\,1,\,0.05}$ =3.84)

The LFD of *R. corsula* illustrated the smallest and the largest specimens as 8.59 and 15.71 cm total length for males and 9.15 and 15.66 cm tota length for females, respectively (Figure 1, Table 2). However, the LFD for males and females did not pass the normality test (Kolmogorov−Smirnov test; $P<0.05$). Therefore, the Mann−Whitney U−test showed significant differences in the LFDs between sexes (Mann−Whitney U−test, $P=0.03$). Furthermore, the results showed that body weight of males (18.11±4.67 g, range 11.05−31.58 g) was not significantly varied (Mann−Whitney U−test, $P=0.26$) from that of females (19.26±5.58 g, range 9.57−32.59 g).
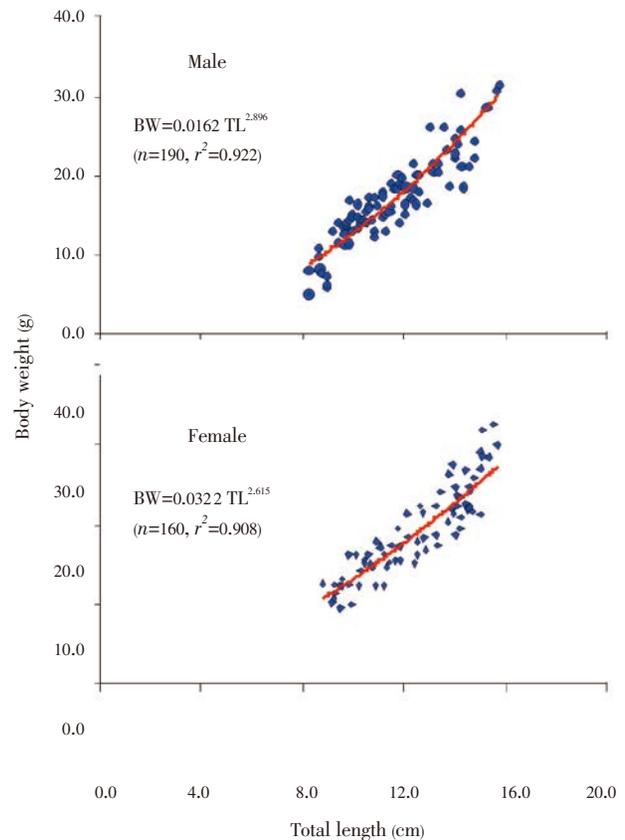

Figure 1. LFD of *R. corsula* in the Padma River, Northwestern Bangladesh.

Table 2
Descriptive statistics and 95% confidence limit of the length (cm) and weight (g) measurements for *R. corsula* in the Padma River, Northwestern Bangladesh.

Sex	Measurements	Min	Max	Mean±SD	CL$_{95\%}$
Male	TL	8.59	15.71	11.77±1.74	11.40−12.14
	BW	11.05	31.58	18.11±4.67	17.11−19.10
Female	TL	9.15	15.66	12.46±1.98	11.99−12.92
	BW	9.57	32.59	19.26±5.58	17.96−20.55
Combined	TL	8.59	15.71	12.09±1.88	11.79−12.38
	BW	9.57	32.59	18.64±5.13	17.84−19.43

Min: minimum; Max: maximum; SD: standard deviation; CL: confidence limit for mean values; TL: total length; BW: body weight.

Sample sizes (n), regression parameters and 95% CI for a and b of the LWR, coefficients of determination (r^2), and growth type of *R. corsula* are presented in Figure 2 and in Table 3.

Figure 2. LWR ($W=a\times L^b$) of male and female *R. corsula* in the Ganges (Padma River), northwestern Bangladesh.
BW: body weight; TL: total length.

Table 3
Descriptive statistics and estimated parameters of the LWR ($BW= a\times TL^b$) for *R. corsula* in the Padma River, Northwestern Bangladesh.

Sex	n	a	CL$_{95\%}$ of a	b	CL$_{95\%}$ of b	r^2	t_s	GT
M	190	0.0160	0.0112−0.0218	2.896	2.781−2.987	0.922	−0.60	I
F	160	0.0321	0.0289−0.0431	2.615	2.612−2.881	0.908	−1.84	−A
C	350	0.0221	0.0117−0.0412	2.761	2.660−2.821	0.918	−1.73	−A

M: male; F: female; C: common sex; n: sample size; BW: body weight; TL: total length; a and b: intercept and slope parameters; r^2: coefficient of determination; t_s: t−test value; GT: growth type; I: isometric; −A: negative allometric.

The calculated allometric coefficient (b) indicated isometric growth in males ($b=2.896$). But negative allometric growths were recorded in females ($b=2.615$) and combined sexes ($b=2.761$), as t−test for b showed significant difference from 3 ($b<3.00$, $P<0.01$) in both cases. However, the LWRs were significantly different between males and females in this study ($P<0.05$). The analysis of covariance (ANCOVA) revealed significant differences between sexes for the intercepts (a) and slopes (b) of the regression lines (F=1.533, df=346, $P=0.218$).

The minimum and maximum values, mean±SD, 95% confidence levels of each of the condition factors (K_F, K_R, K_A, W_R) of *R. corsula* are shown in Table 4.

Table 4

Condition factor of the *R. corsula* in the Padma River, Northwestern Bangladesh.

Sex	Condition factor	Min	Max	Mean±SD	CL$_{95\%}$
M	K_F	0.63	1.79	1.14±0.28	1.09–1.20
	K_R	0.51	1.40	0.91±0.21	0.86–0.95
	K_A	0.0083	0.0227	0.0147±0.0034	0.0140–0.0154
	W_R	51.10	140.20	90.93±20.93	86.47–95.39
F	K_F	0.63	1.76	1.03±0.27	0.96–1.09
	K_R	0.56	1.32	0.83±0.17	0.79–0.87
	K_A	0.0179	0.0424	0.0266±0.0056	0.0253–0.0279
	W_R	55.78	131.68	82.68±17.42	78.64–86.71
C	K_F	0.63	1.79	1.09±0.28	1.05–1.13
	K_R	0.53	1.39	0.88±0.19	0.85–0.91
	K_A	0.0119	0.0119	0.0196±0.0044	0.0188–0.0202
	W_R	53.19	138.66	87.74±19.82	84.65–90.82

M: male; F: female; C: common sex; Min: minimum; Max: maximum; SD: standard deviation; CL: confidence limit for mean values; K_F: Fulton's condition factor; K_R: relative condition factor; K_A: allometric condition factor; W_R: relative weight.

All the condition factors of this fish in the Padma River passed normality test (Kolmogorov–Smirnov test; $P>0.10$). The K_F ranged from 0.63 to 1.79 (1.14±0.28) and 1.09 to 1.20 (1.03±0.27) for males and females, respectively. The unpaired t–test showed no significant difference in K_F between males and females ($P=0.57$) during the study, likely indicating the absence of mature females. In addition, K_R varied from 0.51 to 1.40 (0.91±0.21) for males and 0.56 to 1.32 (0.83±0.17) for females. On the other hand, minimum and maximum K_A values for males were 0.0083 and 0.0227 (0.0147±0.0034) while in case of females K_A values ranged from 0.0179 to 0.0424 (0.0266±0.0056). Furthermore, the mean W_R of *R. corsula* showed significant differences from 100 for males ($P=0.03$) and females ($P<0.001$) in the Padma River (Figure 3). *R. corsula*≤9.00 total length were in also bad condition.
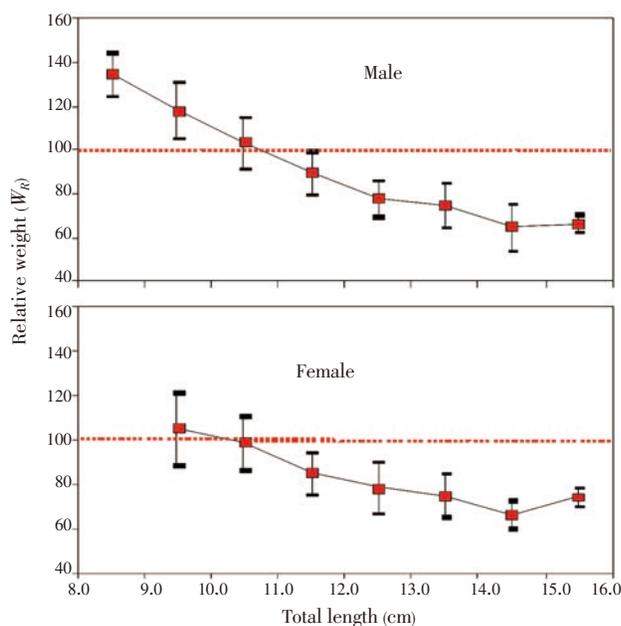

Figure 3. The relative weight (W_R) in relations to body sizes for male and female *R. corsula* in the Padma River, Northwestern Bangladesh.

4. Discussion

During this study, the overall sex ratio did not differ from 1:1 ratio statistically which is expected for most of the aquatic animals[20]. However, lack of references dealing with the sex ratio of this species restrains the comparison with previous results. In addition, in spite of considering a number of specimens with different body sizes, *R. corsula* smaller than 8.59 cm total length were found to be absent. This can be attributed to biological reasons but are more likely owing to technical reasons such as different sample sizes, different gear selectivity and/or shrinkage in body size of the formalin preserved specimens[20–24]. In contrast, the maximum size of *R. corsula* observed in this study within the Padma River is far less than the half of the maximum recorded value of 45.00 cm total length in India[3]. Nonetheless, lack of reference restrains the comparison of this finding with previous ones.

In this study, the regression parameter *b* of LWR for males was higher than that of females, which indicated that male individuals increase the body weight at a more rapid rate than female individuals do. Earlier study[25] reported isometric growth of males, females and combined sexes of the same species using merged data from different fish–markets without indication of water bodies, therefore their study was not presented in a sound and/or scientific study. However, the values of *a* and *b* for *R. corsula* in this study were within the limits[8]. The LWR with *b* values significantly different from 3.0 is often associated with narrow size ranges of the specimens examined and such LWR should be used only within the respective size ranges (with caution for sample–size inadequacy). To the best of the authors' knowledge, this study provides the first information on the LWRs of *R. corsula*.

Four types of condition factors were used to assess the overall health and productivity of *R. corsula* in this study. The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes. It shows the welfare of the population during various life cycle stages[26]. No references dealing with the condition factors of *R. corsula* are available in the literature, preventing the comparison with previous results. However, condition factor based on the LWR is an indicator of the changes in food reserves, and therefore an indicator of the general fish condition[27]. In general, the seasonal cycle in fish's condition suggested a relationship to gonadal development. According to Ahmed *et al*[28], the condition factor of the silver hatchet chela, *Chela cachius* (Hamilton, 1822) (Cyprinidae) was constant during the pre–spawning period, decreased in the period of spawning and became the lowest immediately after spawning. However, only several seasonal data were used during this study, thus it is difficult to compare among the condition of fishes

throughout the year.

Furthermore, the W_R showed significant differences from 100 for males (P=0.03) and females, indicating an imbalance habitat with food availability relative to the presence of predators for *R. corsula* in the Padma River[19]. However, no references dealing with the relative weight on the *Khorsula* fish are available in the world, preventing the comparison with previous results.

This study provides invaluable information on the biometrics including sex ratio, LFDs, LWRs and condition factors of the *R. corsula* from Bangladesh. The results of this study would be an effective tool for fishery biologists, managers and conservationists to initiate management strategies and regulations for the sustainable conservation of the remaining stocks of this species in the Ganges ecosystem. In addition, these information for *R. corsula* are clearly lacking in literature and data bases including FishBase. Therefore, results of this study provide invaluable information for the online FishBase database, as well as an important baseline for further studies.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

Comments

Background

R. corsula is a freshwater and brackish specie, widely distributed in the rivers and estuaries throughout the Indian sub–continent. However, the conservational status of this fish has been referred as least concern in the world and the species was categorized as rare in Bangladesh. This study presents the first reference of sex ratio, LWR, and condition factors in the Padma River, Northwestern Bangladesh.

Research frontiers

This study presents the first reference on life history traits including sex ratio, LFD, LWR, and condition factors for this fish species in the Padma River, Northwestern Bangladesh.

Related reports

Though a few works on these aspects of some threatened fishes are available from Bangladesh, no such studies prevail in case of the least concerned fish *R. corsula*.

Innovations and breakthroughs

Four types of condition factors were used to assess the overall health and productivity of *R. corsula* in this study. No references dealing with the relative weight on the *Khorsula* fish are available in the world, this study reported it for the first time.

Applications

This study would be an effective tool for fishery biologists, managers and conservationists to initiate management strategies and regulations for the sustainable conservation of the remaining stocks of this species in the Ganges (Padma River) ecosystem. In addition, results of this study provide invaluable information for the online FishBase database, as well as an important baseline for further studies.

Peer review

This paper has been written well and presented biometrics in a very clearly and scientific way. In fact, this paper deals with the first description of biometric relationships including sex ratio, LFD, LWR, condition factors (Allometric, Fulton′s, Relative, Relative weight) of *R. corsula* in the Ganges, which would be useful for the sustainable conservation of this rear fishery in Bangladesh and also neighboring countries.

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