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Life History Traits of the Gangetic scissortail rasbora, *Rasbora rasbora* (Hamilton, 1822) in the Payra River, Southern Bangladesh

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Abstract

The near threatened gangetic scissortail rasbora, *Rasbora rasbora* (Hamilton, 1822), is an economically important, and nutritionally valuable freshwater food fish in south Asian countries. The present study provides the first inclusive explanation on life-history traits of *R. rasbora* in the Payra River, southern Bangladesh. This species invites research interest due to its nutritional demand and IUCN red list status. Sampling was carried out using different traditional fishing gears during July to December 2019. For each individual, total length (TL) and standard length (SL) were measured to the nearest 0.01 cm using digital slide caliper, while body weight (BW) was taken by an electronic balance with 0.01 g accuracy. A total of 215 specimens were measured ranging from 2.6-12.5 cm TL and 0.22- 10.65 g BW during this study. The 4.00 to 4.99 cm TL was numerically leading group of the total population. The allometric coefficient (*b*) of the length-weight relationships (*LWRs*) indicates negative allometric growth pattern (b<3.00) for *R. rasbora* in the Payra River. The results also indicate that the *LWRs* were highly significant (p<0.001) with r^2 values >0.963. In addition, The *LLR* (SL *vs.* TL) was highly significant (*p<0.0001*) with a coefficient of determination values of 0.988. The estimated form factor ($a_{3.0}$) was 0.007 indicating this fish is elongated in body shape and the size at first sexual maturity (L_m) for combined sexes of *R. rasbora* was calculated as 7.96 (~8.00) cm TL in the Payra River. The allometric condition factor (K_A) varied from 0.0063 to 0.0570 and Fulton′s condition factor (K_F) varied from 0.3933 to 4.1844. However, K_F tended to be lower after 9.0 cm for combined sexes, which may indicate the start of sexual maturation and therefore L_m could be around 8.0 cm TL for *R. rasbora*. The knowledge about the biological aspects of gangetic scissortail rasbora may be used for improved management tools in the future.

Keywords: *Rasbora rasbora*, Growth pattern, Conditions, Size at first sexual maturity, Payra River**.**

1. Introduction

Cyprinidae is the largest and most diverse fish family and the largest vertebrate animal family in general, with about 3,000 species of which only 1,270 remain extant, divided into about 370 genera (Froese and Pauly, 2015). The family belongs to the ostariophysian order Cypriniformes, of whose genera and species the cyprinids make up more than two-thirds. *Rasbora rasbora* (Hamilton, 1822) is a member of family Cyprinidae commonly known as Gangetic scissortail rasbora. Apparently, it is native to Bangladesh, India (Gangetic provinces and Assam), Myanmar, Pakistan and Thailand (Talwar and Jhingran, 1991). It is a surface feeder fish (IUCN Bangladesh, 2015). In Bangladesh, *R. rasbora* is commonly known as darkina/leuzzadarkina of the important small indigenous fish (SIS) species. Being a small indigenous fish species, *R. rasbora* is well-regarded as a quality food containing high amount protein, fat, carbohydrate, calcium and vitamins that helps to eliminate malnutrition, particularly for poor women and children in Bangladesh (Thilsted *et al*., 1997; Ross *et al.,* 2003). In addition, it can also be used as an aquarium fish (Froese and Pauly, 2015). The large numbers of small fish species are still available in southern water bodies amongst them, *R. rasbora* locally known as darkina/ kan chela is one of important ones. The Payra River (southern Bangladesh) is considered as an important natural spawning and nursery grounds for many commercially important fish species and a significant portion of the country's fisheries production is dependent on this coastal river (Islam *et al*., 2015). Nonetheless, the untamed population of this species is waning due to overfishing, reckless fishing of larvae and juveniles, habitat destruction (siltation), pollution and other ecological changes to their surroundings (Islam *et al.*, 2015; Hossen *et al*., 2015; Hossain *et al.*, 2016, 2015) and afterward categorized as near threatened in Bangladesh (IUCN Bangladesh, 2015) although globally categorized as least concern (IUCN, 2019). Hence, there is an urgent need to manage and regulate its numerous

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discrete stocks, which will require basic population dynamics information for the species (Santos *et al.*, 1995).

Usually, studies of length-frequency distribution (*LFD*) express the life-history traits and ecology of fishes (Ranjan *et al.*, 2005). In addition, length-weight relationships (*LWRs*) are considered as a useful tool in fisheries studies for the estimation of weight, biomass, and condition indices (Anderson and Gutreuter, 1983; Froese, 2006; Froese *et al.*, 2019). Moreover, condition factors assist evaluate the status of fish from which the present and future population success can be predetermined (Richter, 2007; Rypel and Richter, 2008).

This is believed to be the first report on biological aspects of this population in this region. However, sufficient information on this species is still now absent in the literature from Bangladeshi waters or elsewhere which attracted our attention. Therefore, the current study provides a complete and informative depiction of the life history traits of *R. rasbora* – including *LFD*, *LWRs*, *LLR*, form factor ($a_{3.0}$), size at first sexual maturity (L_m) and condition factors (allomatric, K_A; Fulton's, K_F; relative, K_R) from the Payra River, southern Bangladesh using many specimens of small to large sizes over a period of six months.

2. Materials and Methods

2.1. Study Area and Sampling:

The present study was carried out in the Payra River (Fig. 1), a southern coastal river of Bangladesh situated in the Patuakhali district (straddling 22º 35´ N and 90º 26´ E). A total of 215 specimens of *R. rasbora* were collected occasionally from that region over the period from July to December-2019, using different types of fishing gears; gill net (mesh size: 1.5–2.5 cm), square lift net (mesh size ~1.0 cm) and cast net (mesh size: 1.0–2.0 cm). Fish samples were quickly chilled in ice on site and then preserved in 10% buffered formalin in laboratory until examination. For each specimen, lengths (total length, TL and standard length, SL) were measured by digital slide caliper (Mitutoyo, CD-6"CSX), and the body weight (BW) was measured using an electronic balance (AND, FSH, Korea), to the nearest 0.01cm and 0.01 g precision, respectively.

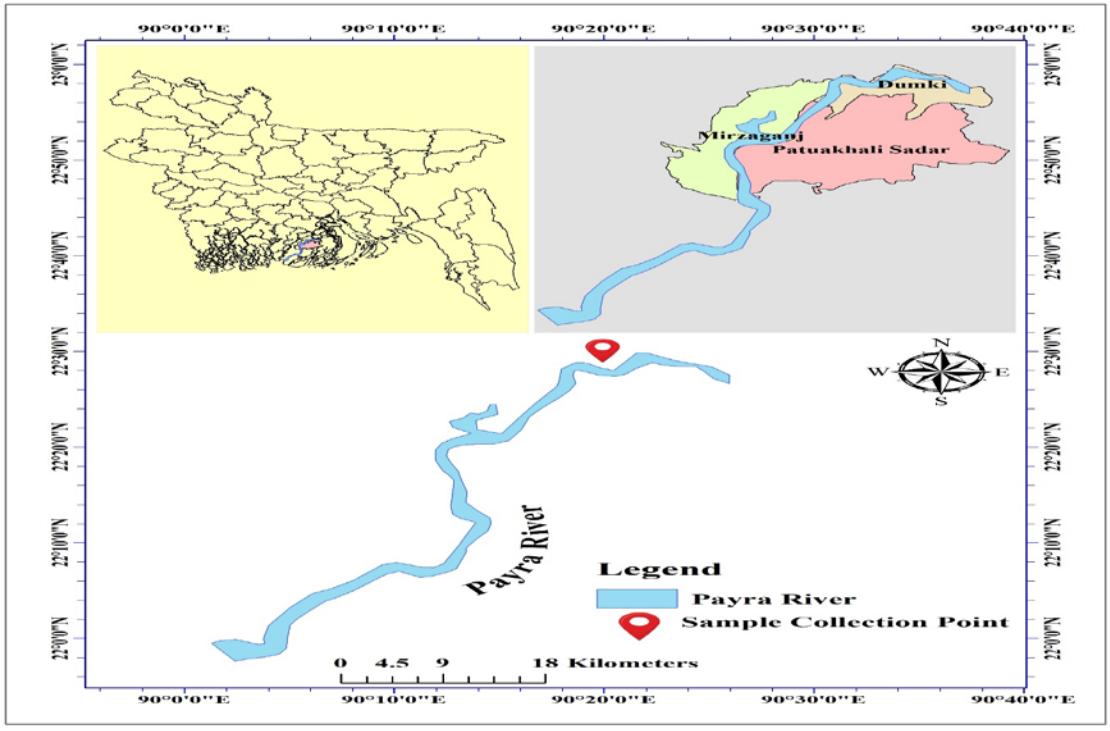

Figure 1. Map showing location of the study area for *R. rasbora* in the Payra River, southern Bangladesh.

2.2. Length Frequency Distribution (LFD):

LFD for total population of *R. rasbora* was constructed using 1.0 cm intervals of TL.

2.3. Length-weight Relationships and Length-length Relationship (LWRs and LLR):

The relationship between length and weight was calculated using expression: $W = aL^b$ (Le Cren, 1951) where the W is the whole body weight (g), L the total length (cm), *a* intercept of the regression and *b* is the regression coefficient (slope). The parameters *a* and *b* of the weight-length relationship will be estimated by linear regression analysis based on natural logarithms: ln (W) = ln (*a*) + *b* ln (L) (Frose, 2006; Hossain *et al.*, 2016a). According to Froese (2006), all extreme outliers were excluded from the analyses. A t-test was applied to determine significant differences from the isometric value (*b*= 3.0 for length-weight relationship and *b* = 1.0 for length-length relationship) (Sokal and Rohlf, 1987). Deviation of the *b* value from the theoretical isometric value indicates either positive (*b* > isometric value) or negative (*b* < isometric value) allometric growth. Analysis of covariance (ANCOVA) (Zar, 1984) was used to test for significant differences in slopes and intercepts among the relationships. Additionally, the *LLR* for SL *vs.* TL was estimated by linear regression analysis (Hossain *et al.*, 2006).

2.4. Form Factor ($a_{3.0}$):

The form factor ($a_{3.0}$) of *R. rasbora* was estimated using the equation of Froese (2006) as: $a_{3.0} = 10^{\log a - s(b-3)}$, where *a* and *b* are the regression parameters of *LWR*, and is the regression slope of *ln a vs. b*. The researchers used a mean slope S = -1.358 (Froese, 2006) for calculating the form factor because there was no available information on LWR for this species to estimate the regression (S) of *ln a vs. b*.

2.5. Size at First Sexual Maturity (L_m):

The size at first sexual maturity (L_m) of *R. rasbora* was calculated using the equation proposed by Binohlan and Froese (2009) as: $\log(L_m) = -0.1189 + 0.9157 \times \log(L_{max})$; where, L_m = size at first sexual maturity in TL, L_{max} = maximum length (TL) of *R. rasbora* in the present study. Furthermore, the maximum length of *R. rasbora* was obtained from available literature in the FishBase used to estimate L_m for water bodies throughout the world.

2.6. Condition Factor:

The allometric condition factor (K_A) was calculated by the equation of Tesch (1971): W/L^b, where *W* is the body weight (g), *L* is the TL (cm), and *b* is the LWR parameter. Fulton′s condition factor (K_F) was estimated using the equation of Fulton (1904): $K_F = 100 \times (W/L^3)$, where *W* is the body weight (g), and *L* is the TL in cm. The scaling factor of 100 was used to bring the K_F close to unit (Froese, 2006). In addition, the relative condition factor (K_R) was analyzed following the equation of Cren (1951): $K_R = W/(a \times L^b)$, where *W* is the body weight (g), *L* is the total length (cm), and *a* and *b* are *LWR* parameters.

2.7. Statistical Analysis:

For statistical analysis, Microsoft® Excel-add-in DDXL and GraphPad Prism 8 software were used. The Spearman rank-correlation test was applied to analyze the relationship of condition factors with TL and BW. All statistical analyses were considered significant at 5% ($p<0.05$).

3. Results

3.1. Length Frequency Distribution (LFD)

During the study period a total of 215 specimens of *R. rasbora* were collected from the Payra River, southern Bangladesh. The length frequency distribution of *R. rasbora* is shown in (Figure 2). Table 1 shows the descriptive statistics of maximum and minimum length and weight measurement of *R. rasbora*. *LFD* showed that the range of TLs was 2.6 to 12.5 cm (Fig. 2), and that body weight ranged from 0.22 to 10.65 g there. The 4.00 to 4.99 cm TL size group was numerically dominant and constituted 41.86% of the total population (Figure 2).

Table 1. Length (cm) and weight (g) measurements of combined sexes of *Rasbora rasbora* (Hamilton, 1822) from the Payra River, southern Bangladesh, July 2019 to December 2019.

Measurement	Total	Min	Max	Mean±SD
Total length (TL)		2.6	12.5	5.58±2.34
Standard length (SL)	215	2.4	10.5	4.40±1.99
Body weight (BW)		0.22	10.65	2.30±3.12

n, sample size; Min, minimum; Max; maximum and SD, standard deviation

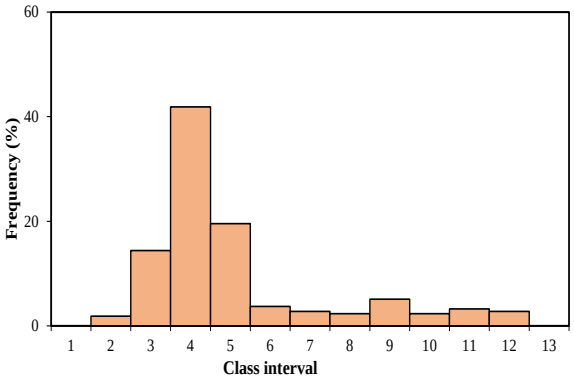

Figure 2. Total length frequency distribution of *R. rasbora* in the Payra River, southern Bangladesh.

3.2. Length -Weight Relationships (LWRs)

The sample size (*n*), regression parameter, 95% confidence interval of *a* and *b*, coefficient determination (r^2), and growth type (*GT*), of *R. rasbora* are shown in Table 2. In the present study, the calculated allometric coefficient (b=2.79) and t-test value (t_s=-7) of TL *vs.* BW indicates a negative allometric growth pattern (Figure 3), as did the SL-BW relationship (Table 2 and Figure 4) in the Payra River. The *LWRs* were highly significant ($p<0.0001$) with r^2 values >0.963.

Table 2. Descriptive statistics and estimated parameters of the length–weight and length-length relationships of *R. rasbora* (Hamilton, 1822) from the Payra River, southern Bangladesh.

Species	n	Regression parameters		95% CI of *a*	95% CI of *b*	r^2	GT
		a	b				
BW = $a*TL^b$	215	0.0120	2.79	0.011 to 0.014	2.726 to 2.862	0.969	A-
BW = $a*SL^b$		0.0290	2.66	0.026 to 0.032	2.604 to 2.747	0.963	A-
TL=$a+b*$SL		0.441	1.169	0.355 to 0.525	1.151 to 1.186	0.988	A+

n, sample size; TL, total length; SL, standard length; BW, body weight; *a*, intercept; *b*, slope; *CI*, confidence interval; r^2, coefficient of determination; GT, growth type; A-, negative allometric; A+, positive allometric.

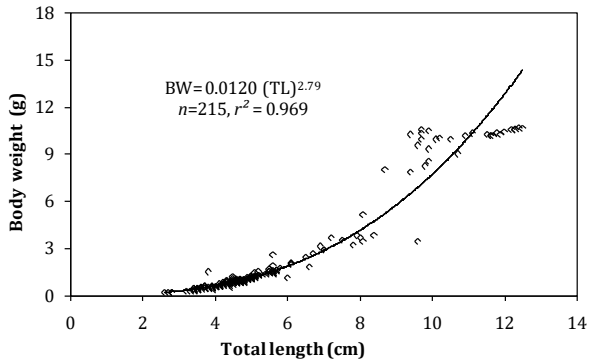

Figure 3. Total length-body weight relationship of *R. rasbora* in the Payra River, southern Bangladesh.

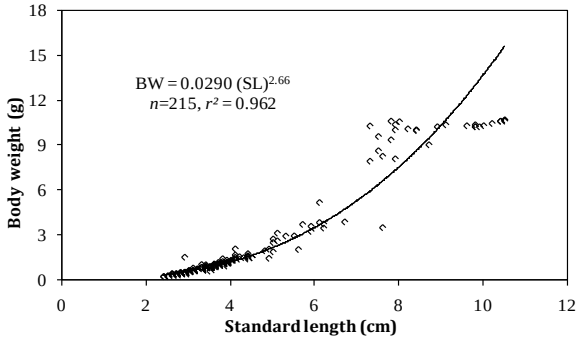

Figure 4. Standard length-body weight relationship of *R. rasbora* in the Payra River, southern Bangladesh.

3.3. Length-length Relationship (LLR)

The length-length relationship between TL and SL of *R. rasbora* along with the estimated parameters of the *LLR* and the coefficient of determination (r^2), are shown in Table 2 and Figure 5. During this study, the calculated allometric coefficent (b=1.16) and t-test value (t_s=20) of the *LLR* indicates positive allometric growth pattern. The *LLR* was highly significant ($p<0.0001$) with a coefficient of determination values of 0.988.

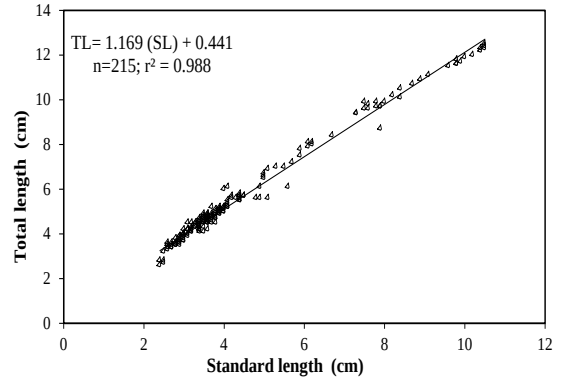

Figure 5. Total length-standard length relationship of *R. rasbora* in the Payra River, southern Bangladesh.

3.4. Form Factor ($a_{3.0}$)

The $a_{3.0}$ was calculated as 0.007 for combined sex of *R. rasbora* in the Payra River, southern Bangladesh, and this value indicates that this fish is elongated in shape.

3.5. Size at First Sexual Maturity (L_m)

Size at first sexual maturity for combined sex of *R. rasbora* was estimated as 7.96 (~8.00) cm TL in the Payra River.

3.6. Condition Factors

3.6.1. Allometric Condition Factor (K_A)

The estimated K_A of *R. rasbora* ranged from 0.0063-0.0570 (Mean ±SD, 0.0128±0.0040) (Table 3). According to Spearman rank-correlation tests, there was a significant relationship between BW *vs.* K_A (r_s= 0.2219, p = 0.0011), but not between TL *vs.* K_A (r_s= 0.0532, p = 0.4375) (Table 4).

Table 3. Condition factors of *R. rasbora* (Hamilton, 1822) in the Payra River (southern Bangladesh).

Condition factors	Min	Max	Mean±SD
Allometric condition factor (K_A)	0.0063	0.0570	0.0128±0.0040
Fulton's condition factor (K_F)	0.3933	4.1844	0.9110±0.2968
Relative condition factor (K_R)	0.5223	4.7535	1.0638±0.3329

Min, minimum; Max, maximum; SD, standard deviation

Table 4. Ralationships of condition factor with total length (TL) and body weight (BW) of *R. rasbora* (Hamilton, 1822) in the Payra River, southern Bangladesh.

Relationship	r_s value	95% CL of r_s	p values	Significance
TL *vs.* K_A	0.05322	-0.08511 to 0.1895	0.4375	*ns*
TL *vs.* K_F	-0.2354	-0.3614 to -0.1009	0.0005	***
TL *vs.* K_R	0.05312	-0.08522 to 0.1894	0.4384	*ns*
BW *vs.* K_A	0.2219	0.08682 to 0.3489	0.0011	**
BW *vs.* K_F	-0.0611	-0.1971 to 0.07726	0.3727	*ns*
BW *vs.* K_R	0.2218	0.08673 to 0.3488	0.0011	**

TL, total length; BW, body weight; K_A, allometric condition factor; K_F; Fulton′s condition factor; K_R, relative condition factor; r_S, Spearman rank-correlation values; CL, confidence limit; p, shows the level of significance; *ns*, not significant; * significant; ** highly significant; ***very highly significant.

3.6.2. Fulton's Condition Factor (K_F)

The calculated K_F ranged from 0.3933-4.1844 (Mean ± SD, 0.9110±0.2968) (Table 3). According to Spearman rank-correlation tests, there was a significant relationship between TL *vs.* K_F (r_s= -0.2354, p = 0.4375), but not between BW *vs.* K_F (r_s= -0.0611, p = 0.3727) (Table 4). The lowest K_F value was found in the size of 12 cm, whilst the highest in 2 cm for both sexes. Furthermore, the K_F value started decreasing after 9.0 cm TL (Figure 6).

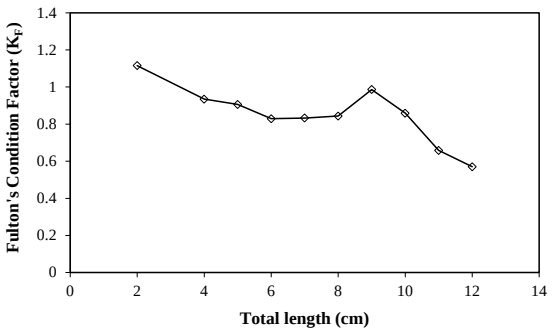

Figure 6. Fulton's condition factor (K_F) with regard to total length (cm) for *R. rasbora* in the Payra River, southern Bangladesh.

3.6.3. Relative Condition Factor (K_R)

The K_R of *R. rasbora* ranged from 0.5223-4.7535 (Mean ± SD, 1.0638±0.3329) during this study (Table 3). From Spearman rank-correlation tests, K_R showed a significant relationship with BW (r_s=0.2218, p =0.0011), but not with TL (r_s= 0.0531, p =0.4384) (Table 4).

4. Discussion:

According to the statement of the local fishers, this fish is mostly abundant during the summer (June-August) and autumn (September-October); other times they rarely found this species in the river which had made a great hindrance to collect fish sample from January to May. In our study, it was not possible to sample individuals of *R. rasbora* from January to May, for one or more of the following reasons: the biased selection of fishing gear or fishermen did not go where the fish were or possibly because of the fish's absence on the fishing grounds, and/or because fishermen discarded smaller fish (Rahman *et al.*, 2018) or the degradation of ecology of the Payra River, which signals the need for urgent measures to conduct extensive studies on these species to provide more information for their management and conservation.

In present study, it was not possible to collect the *R. rasbora* smaller than 2.6 cm, which was attributed to either the absence of small sized fishes (<2.6 cm TL) in the populations or the fishermen did not go where the smaller size exist (Azad *et al.*, 2018, Khatun *et al.*, 2018) or selectivity of fishing gears (Hossain *et al.*, 2012 a, b). Furthermore, the maximum length of *R. rasbora* within the Payra River was 12.5 cm TL which is slightly lower than the maximum recorded value of 13.0 cm TL (Froese and Pauly, 2019). Most likely, this growth differences can be attributed to differences in environmental factors, particularly water temperature and food availability (Ahamed and Othomi; 2012). Generally, maximum length is considered as a functional tool for fisheries resource planning and management, and is utmost for the determination of asymptotic length and growth coefficient of fishes (Hossain *et al.*, 2019; Khatun *et al.*,2019; Ahmed *et al.*, 2012; Hossain *et al.*, 2016b, 2017; Nawer *et al.*, 2017; Hossen *et al.*, 2016, 2018).

In the current study of *R. rasbora*, the estimated *b* values ranged from 2.67 to 2.79 for *LWRs* from the Payra River which were within the usual range (2.50 to 3.50) of *b* values for fishes (Carlander, 1969; Froese, 2006). To the best of our knowledge, no references dealing with *LWRs* for the studied species are available; thus it was not possible to compare the present results with previous references. Hence, the present study was compared with results from studies dealing with other species of the Cyprinid family. In this study, estimated *b* values of the *LWRs* (TL *vs.* BW; SL *vs.* BW) were <3 suggesting fish becomes more slender as the length increase for *R. rasbora* in the Payra River which was generally in agreement with results for fishes of same family and same genus (*R. daniconius*) obtained from the Sharavathi Reservoir, Karnataka (Kumar *et al.*, 2005). The length-weight relationship parameters (*a* and *b*) are influenced by a series of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health of the individuals in their natural habitats as well as the treatment of specimens and preservation techniques after sampling (Bagenal and Tesch, 1978; Tesch, 1971). However, *LLR* for the *R. rasbora* was highly correlated (r^2=0.988; $p<0.0001$). Since the current study is also the first assessment on LLR of *R. rasbora*, so lack of references dealing with *LLR* constrains the comparison of the present results with previous literature on the same population/ species.

Form factor ($a_{3.0}$) can help to determine whether the body profile of individuals in a particular population or species differs from others (Froese, 2006). The estimated $a_{3.0}$ for *R. rasbora* was within the limits 0.00775–0.00906 reported by Frose (2006); suggesting that this fish is elongated in shape in the Payra River. No references dealing with $a_{3.0}$ for this species are in the literature to make comparison across the water bodies.

Though most of the studies deal with single condition factor, we have, however, worked on three condition factors (K_A; K_F and K_R) to evaluate the physical and habitat status of *R. rasbora*. Furthermore, study on relative condition factor (K_R) in preference to the ponderal index (K) is recommended as the latter is generally influenced by many environmental and biological factors (Le Cren, 1951). The studied fish species has K_R >1, which indicates good general conditions of the fish (Le Cren, 1951). Generally, condition factor is influenced by many factors like sex, season, environmental factors, stress, gonadal development and availability of forage items (Lambert and Dutil, 1997; Zargar *et al.*, 2012; Ali *et al.*, 2014). Furthermore, the lowest K_F value was found in the size of 12 cm, whilst the highest in 2 cm for both sexes. The K_F with regard to length class showed a noticeable decrease after 9.0 cm for combined sexes, which might be attributed to the start of sexual maturation, as indicated in the present study, which recorded the size at first sexual maturity of *R. rasbora* as ~8.00 cm. Therefore, the size at first sexual maturity of *R. rasbora* could be around 8.0 cm TL in the Payra River, southern Bangladesh. Studies on L_m are very atypical (except Hossain et al., 2019, 2010, 2016a, 2017). This is the first study on size at first sexual maturity (L_m) for *R. rasbora* worldwide. Thus, our study will be the base for more thorough studies.

5. Conclusion:

The 4.00 to 4.99 cm TL size group (41.86%) was numerically dominant and fish becomes more slender as the length increases in the Payra River. The fish is elongated in body shape and ensures good general

conditions of the fish in the Payra River. The size at first sexual maturity of *R. rasbora* could be around 8.0 cm TL in the Payra River, southern Bangladesh. This study provides valuable information for the online Fish Base database, as well as providing an important baseline for future studies within the Payra River and surrounding ecosystems, as no information on the biological aspects of this species are currently available in the literature. Moreover, further detailed studies (with considering sampling period throughout the year) on spawning frequency and some other biological aspects, i.e. growth and abundance, are still necessary for the future management of this species.

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Conflicts of Interest

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

References

Ahamed F and Ohtomi J. 2012. Growth patterns and longevity of the pandalid shrimp *Plesionika izumiae* (Decapoda: Caridea). *J Crustacean Biol*. **32**:733 -740.

Ahmed ZF, Hossain MY and Ohtomi J. 2012. Modeling the growth of silver hatchet chela *Chela cachius* (Cyprinidae) from the Old Brahmaputra River in Bangladesh using multiple functions. *Zool Stud*, **51:** 336-344.

Ali S, Barat A, Kumar P, Sati J, Kumar R and Halder RS. 2014: Study of length weight relationship and condition factor for the Golden Mahseer, *Tor Putitora* from Himalayan rivers of India. *J. Environ. Biol.* **35(1):** 225-228.

Anderson RO and Gutreuter SJ. 1983. Length, weight, and associated structural indices. In: Nielsen L and Johnson D (Eds), **Fisheries Techniques**, Bethesda: American Fisheries Society. pp 284-300.

Azad MAK, Hossain MY, Khatun D, Parvin MF, Nawer F, Rahman O and Hossen MA. 2018. Morphometric relationships of the tank goby *Glossogobius giuris* (Hamilton, 1822) in the Gorai River using multi-linear dimensions. *Jordan J Biol Sci*, **11:** 81-85.

Bagenal TB and Tesch FW. 1978. **Age and growth. In methods for assessment of fish production in fresh waters,** 3rd ed. IBP Handbook No. 3, edited by Begenal, T. Oxford (UK): Blackwell Science Publications. pp. 101-136.

Binohlan C and Froese R. 2009. Empirical equations for estimating maximum length from length at first maturity. *J. Appl. Ichthyol.*, **25:**611-613.

Carlander KD. 1969. **Handbook of Freshwater Fishery Biology**. Vol:1. The Iowa State University Press. Ames, IA, 752 p.

Froese R and Pauly D, editors. 2019: Rasbora trilineata Steindachner, 1870. FishBase. Available: https://www.fishbase.de/summary/Rasbora-trilineata.html. (February 2019).

Froese R, Pauly D, eds. 2015: "Cyprinidae" in FishBase. July 2015 version.

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

Fulton TW. 1904. The Rate of Growth of Fishes. Twenty-second Annual Reports, Part III. Fisheries Board of Scotland, Edinburgh, 141-241 pp.

Hossain MY, Rahman MM, Miranda R, Leunda PM, Oscoz J, Jewel MAS, Naif A and Ohtomi J. 2012a. Size at first sexual maturity, fecundity, length– weight and length–length relationships of *Puntius sophore* (Cyprinidae) in Bangladeshi waters. *J. appl. Ichthyol.*, **28:** 818-822.

Hossain MY, Ahmed ZF, Islam ABMS, Jasmine S and Ohtomi J. 2010. Gonadosomatic index-based size at first sexual maturity and fecundity indices of the Indian River shad *Gudusia chapra* (Clupeidae) in the Ganges River (NW Bangladesh). *J Appl Ichthyol*, **26**: 550-553.

Hossain MY, Ahmed ZF, Leunda PM, Islam AKMR, Jasmine S, Scoz J, Miranda R and Ohtomi J. 2006. Length-weight and length-length relationships of some small indigenous fish species from the Mathabhanga River, southwestern Bangladesh. *J Appl Ichthyol*, **22**: 301-303.

Hossain MY, Hossen MA, Khatun D, Nawer F, Parvin MF, Rahman O and Hossain MA. 2017. Growth, condition, maturity and mortality of the Gangetic leaffish *Nandus nandus* (Hamilton, 1822) in the Ganges River (northwestern Bangladesh). *Jordan J Biol Sci*, **10:** 57-62.

Hossain MY, Islam R, Hossen MA, Rahman O, Hossain MA, Islam MA and Alam MJ. 2015. Threatened fishes of the world: *Mystus gulio* (Hamilton, 1822) (Siluriformes: Bagridae). *Croatian J. Fish.*, **73:** 43-45.

Hossain MY, Naser SMA, Bahkali AH, Yahya K, Hossen MA, Elgorban AM, Islam MM and Rahman MM. 2016a. Life History Traits of the Flying Barb *Esomus danricus* (Hamilton, 1822) (Cyprinidae) in the Ganges River, Northwestern Bangladesh. *Pakistan J. Zool.*, **48(2):** 399-408.

Hossain MY, Rahman MM and Abdallah EM. 2012b. Relationships between body size, weight, condition and fecundity of the threatened fish *Puntius ticto* (Hamilton, 1822) in the Ganges River, Northwestern Bangladesh. *Sains Malay.*, **41**: 803-814.

Hossain MY, Rahman MM, Bahkali AH, Yahya K, Arefin MS and Hossain MI. 2016b.Temporal variations of sex ratio, length-weight relationships and condition factor of *Cabdio morar* (Cyprinidae) in the Jamuna (Brahmaputra River distributary) River, northern Bangladesh. *Pakistan J Zool*, **48**: 1099-1107.

Hossen MA, Hossain MY, Pramanik MNU, Khatun D, Nawer F, Parvin MF, Arabi A and Bashar MA. 2018. Population Parameters of the Minor carp *Labeo bata* (Hamilton, 1822) in the Ganges River of northwestern Bangladesh. *Jordan J Biol Sci*, **11:** 179-186.

Hossen MA, Hossain MY, Pramanik MNU, Nawer F, Khatun D, Parvin MF and Rahman MM. 2016. Morphological characters of *Botia lohachata*. *J Coast Life Med*, **4:** 689-692.

Hossen MA, Hossain MY, Yahya K and Pramanik MNU. 2015. Threatened fishes of the world: *Labeo bata* (Hamilton, 1822) (Cypriniformes: Cyprinidae). Croatian J. Fish., **73:** 89-91.

Islam MA, Hossain MM, Ahsan ME and Nahar A. 2015. Status and current worries of fish diversity in the Payra River, Patuakhali, Bangladesh. *Int. J. Fish. Aquat. Stud*. **2(3):** 160-165.

IUCN 2019. **IUCN Red List of Threatened Species**. Version 2019-2. IUCN Red List of Threatened Species. Downloaded on 23 July 2019.

IUCN Bangladesh. 2015. **Red List of Bangladesh Volume 5: Freshwater Fishes.** IUCN, International Union for Conservation

of Nature, Bangladesh Country Office, Dhaka, Bangladesh, xvi+360 p.

Khatun D, Hossain MY, Parvin MF and Ohtomi J. 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.

Khatun D, Hossain MY, Rahman MA, Islam MA, Rahman O, Azad MAK, Sarmin MS, Parvin MF, Haque ATU, Mawa Z and Hossain MA. 2019. Life-history traits of the climbing perch *Anabas testudineus* (Bloch, 1792) in a wetland ecosystem. *Jordan J Biol Sci*, **12**: 175-182.

Kumar KH, Kiran BR, Purushtham R, Puttaiah ET and Manjappa S. 2005. Length-weight relationship of cyprinid fish, *Rasbora daniconius* (Hamilton-Buchanan) from Sharavathi Reservoir, Karnataka. *Zoos Print J.*, **21(1):** 2140-2141.

Lambert Y and Dutil JD. 1997. Can simple condition indices be used to monitor and quantify seasonal changes in the energy reserves of Atlantic cod (*Gadus morhua*).*Can J Fish Aquat Sci*, **54 (1):** 104-112.

Le Cren ED. 1951. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in the Perch (*Perca fluviatilis*). *J Anim Ecol*, **20(2)**, 201-219.

Nawer F, Hossain MY, Hossen MA, Khatun D, Parvin MF, Ohtomi J and Islam MA. 2017. Morphometric relationships of the endangered ticto barb *Pethia ticto* (Hamilton, 1822) in the Ganges River (NW Bangladesh) through multi-linear dimensions. *Jordan J Biol Sci*, **10**: 199-203.

Rahman MM, Hossain MY, Jewel MAS, Billah MM and Ohtomi J. 2018. Population biology of the pool barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) in the Padma River, Bangladesh. *Zool Ecol*, **28:** 100-108.

Ranjan JB, Herwig W, Subodh S and Michael S. 2005. Study of the length frequency distribution of sucker head, *Garragotyla gotyla* (Gray, 1830) in different rivers and seasons in Nepal and its applications. *Kathmandu Univ J Sci Eng and Technol*, **1:** 1-14.

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

Ross N, Islam M and Thilsted SH. 2003. Small indigenous fish species in Bangladesh: contribution to vitamin A, calcium and iron intakes. *J. Nutr.* **133**:4021–4026.

Rypel AL and Richter TJ. 2008. Empirical percentile standard weight equation for the blacktail redhorse. *N Am J Fish Manag*, **28**: 1843-184.

Santos RS, Hawkins S, Monteiro LR, Alves M and Isidro EJ. 1995. Case studies and reviews. Marine research, resources and conservation in the Azores. Aquatic Conservation: Marine and Freshwater Ecosystem. **5**:311–354.

Sokal RR and Rohlf FJ. 1987. **Introduction to Biostatistics**, 2nd edn. Freeman Publication, New York, 225-227 pp.

Talwar PK and Jhingran AG. 1991. **Inland fishes of India and adjacent countries**, vol. 1. Oxford & IBH Publishing Co Pvt Ltd, New Delhi-Calcutta.pp. 542.

Tesch FW. 1971: **Age and growth. In Methods for Assessment of Fish Production in Fresh Waters,** edited by Rcker, W.E. Oxford: Balckwell Scientific Publications. pp. 99-130.

Thilsted SH, Roos N, Hasan N. 1997. The role of small indigenous fish species in food and nutrition security in Bangladesh. NAGA Newsletter, July–Dec. p. 13.

Zar JH. 1984. **Biostatistical Analysis,** 2nd Edn., Prentice-Hall Inc., Englewood Cliffs, New Jersey, USA.

Zargar UR, Yousuf AR, Mustaq B and Jain D. 2012. Length–weight relationship of the crucian carp, *Carassius carassius* in relation to water quality, sex and season in some lentic water bodies of Kashmir Himalayas. *Turk J Fish Aquat Sci.* **12:** 683–689.