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Morphometric and Meristic Characteristics of *Salmostoma bacaila* (Hamilton, 1822) (Cyprinidae) from the Ganges River in Northwestern Bangladesh

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Abstract

This study is performed for the determination of morphometric characters including length-weight relationships (LWRs) and length-length relationships (LLRs) using 9 linear dimensions and meristic characteristics covering various fin-rays of *Salmostoma bacaila* (Hamilton, 1822) from the Ganges River in northwestern (NW) Bangladesh. A total of 236 individuals of *S. bacaila* were collected occasionally from the Ganges River from July 2015 to June 2016, using traditional fishing gears including a cast net (mesh size ranges: 1.5 - 2.5 cm), a gill net (mesh size ranges: 1.5–2.0 cm), and a square lift net (mesh size: ~2.0 cm). For each individual, a total of nine various lengths were measured nearest to 0.01 cm with digital slide calipers, and the body weight was measured to the nearest 0.01g accuracy by an electronic balance. The LWRs were calculated using the formula: $W = a \times L^b$, where W is the body weight (g), L is the length (cm), and *a* and *b* are LWRs parameters. Fin-ray numbers from all fins as well as scales were computed by a magnifying glass. Total length (TL) varied from 5.9 -11.5 cm and the total body weight (BW) ranged from 1.31-8.8g. All LWRs were highly significant ($p < 0.001$) with r^2 values ≤ 0.959. Based on r^2 value, LWR by BW *vs.* TL ($W= a \times L^b$) was the best fitted model among nine equations. In addition, the LLRs were also significant with r^2 values ≤ 0.985. According to r^2 value, LLR by TL *vs.* FL (TL = $a + b\times$ FL) was the best fitted model among eight equations. The fin formula of *S. bacaila* is: dorsal, D. 8-9 (2–3/6-7); pectoral, Pc. 12 (2-4/8-10); pelvic, Pv. 8-9 (2–4/8-10); anal, An. 13-16 (2-4/10-13); caudal, Ca. 20–24 (6–7/14–17), respectively. This study would be very operative for species identification and stock assessment in the Ganges River of NW Bangladesh and the contiguous ecosystems.

Keywords: *Salmostoma bacaila*, Morphometric, Meristic, Fin rays and scale, Ganges River, Bangladesh

1. Introduction

The Large razorbelly minnow, *Salmostoma bacaila* (Hamilton, 1822), is a small indigenous freshwater cyprinid occurring in rivers, ponds, *beel*s and inundated fields throughout the Indian sub-continent including Bangladesh, India, Pakistan, Nepal, and also in Afghanistan (Froese and Pauly, 2016). It has a high nutritional value, containing excellent amounts of iron, zinc and vitamin-A (Thilsted *et al.*, 1997 Mohanty *et al.*, 2013). This fish species is listed in the IUCN as least concern in Bangladesh (IUCN Bangladesh, 2015) and worldwide (IUCN 2016).

Morphometric and meristic traits are very helpful for the identification and classification of any fish species in a laboratory or in the fields (Bagenal and Tesch, 1978; Jayaram, 1999; Nawer *et al.*, 2017). Additionally, morphometric characters have a significant role in fisheries research as it is used for comparing life history and the morphological traits of the populations of different regions (Hossain, 2010; Hossen *et al.*, 2018). To the best of the authors' knowledge, a few studies were conducted on *S. bacaila* including length-weight and length-length relationships (Masud and Singh, 2015; Islam and Mia, 2016; Muhammad *et al*., 2016; Baitha *et al.*, 2017; Nath *et al.*, 2017). However, none of these studies covered the morphometric and meristic using multi-linear dimensions from the Ganges River. Therefore, the objectives of the present study are to describe the morphometric and meristic characteristics of *S. bacaila* in the lower part of Ganges River in NW Bangladesh using multi-linear dimensions.

2. Material and Methods

This study was performed in different parts of the Ganges River, known also as the Padma River in Bangladesh (Charghat: 24°15' N, 88°44' E; and Shaheb Bazaar: 24°20' N, 88°34'). A total of 236 specimens of *S. bacaila* were caught using different fishing gears including a cast net (mesh size ranges: 1.5 - 2.5 cm), a gill net (mesh

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size ranges: 1.5–2.0 cm), and a square lift net (mesh size: ~2.0 cm) during July 2015 to June 2016. The fresh samples were immediately iced on site, and were preserved after reaching the laboratory in 10 % formalin for further use in this study. Fin-ray numbers from all fins were counted using a magnifying glass. Preserved specimens were individually weighed by an electronic balance (Shimadzu, EB-430DW; Shimadzu Seisakusho, Tokyo, Japan) with 0.1 g accuracy and different linear dimensions i.e., lengths (see Table 1 and Figure 1) were measured to the nearest 0.1cm by digital slide calipers.

The equation: $W= a\times L^b$ was used to calculate the LWR, where W is the body weight (g), and L is the nine different lengths in cm. Linear regression analyses based on natural logarithms: ln (W) = ln (a) + b ln (L) were used to estimate the regression parameters a and b. In addition, 95% confidence intervals (CL) of a and b, and the co-efficient of determination (r^2) were estimated. Outliers that seemed extremes were deleted from the regression analyses according to Froese (2006). To verify whether b values obtained in the linear regressions were significantly different from the isometric value (b = 3), a t-test was done (Sokal and Rohlf, 1987). The LLRs (eight relationships) were estimated by linear regression analysis (Hossain *et al.*, 2006). For statistical analysis, GraphPad Prism 6.5 Software was used. All statistical analyses were considered significant at the level of 5% ($p< 0.05$).

3. Results

Table 1 demonstrates the descriptive statistics for the length and weight measurements of *S. bacaila* in the Ganges River of NW Bangladesh. The total sample (n), regression parameters and 95 % confidence intervals for a and b of the LWRs, coefficients of determination (r^2) and growth type of *S. bacaila* were given in Table 2. The calculated allometric coefficient (b) indicated isometric growth (b = 3.00). The LWRs were highly significant ($p<0.001$), with all r^2 values ≤ 0.959.

Based on r^2 value, LWR by BW *vs.* TL was the best fitted model among nine equations. Moreover, the LLRs (eight relationships) along with the estimated parameters and the coefficient of determination (r^2) were given in Table 3. Also, the calculated LLRs were highly significant ($p<0.001$) with r^2 values ranging from ≤ 0.985. According to r^2 value, LLR by TL *vs.* FL was the best fitted model among eight equations. All the meristic characteristics were given in Table 4.

Table 1. Morphometric measurements of the *Salmostoma bacaila* (n = 236) captured from the Ganges River, northwestern Bangladesh.

Measurements	Min (cm)	Max (cm)	Mean ± SD	95% CL	%TL
TL (Total length)	5.90	11.50	8.16 ± 0.88	8.05 - 8.28	
BW (Body weight)	1.31*	8.80*	3.31 ± 1.22	3.16 - 3.47	
FL (Fork length)	5.50	10.30	7.23 ± 0.79	7.13 - 7.33	88.55
SL (Standard length)	4.80	9.20	6.58 ± 0.72	6.49 - 6.67	80.61
PrDL(Pre-dorsal length)	3.00	6.20	4.46 ± 0.48	4.40 - 4.53	54.71
PoDL(Post-dorsal length)	3.50	6.70	4.93 ± 0.52	4.87 - 4.99	60.42
PvL (Pelvic length)	2.20	4.70	3.37 ± 0.37	3.32 - 3.42	41.31
AnsL(Anus length)	3.00	6.30	4.56 ± 0.49	4.50 - 4.62	55.89
PrAnL(Pre-anal length)	3.10	6.40	4.66 ± 0.50	4.60 - 4.72	57.10
PoAnL(Post-anal length)	3.80	7.60	5.49 ± 0.59	5.41 - 5.56	67.26

Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values; TL, total length; SL, standard length; FL, fork length; BW, body weight; PrDL, pre-dorsal length; PoDL, post-dorsal length; PvL, pelvic length; AnsL, anus length; PrAnL, pre-anal length; PoAnL, post-anal length; *, weight in g.

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships of *Salmostoma bacaila* (n = 236) from the Ganges River, northwestern Bangladesh.

Equation	Regression parameters		95% CL of a	95% CL of b	r^2
	a	b			
BW= $a \times TL^b$	0.0051	3.06	0.0043 - 0.0061	2.98 - 3.14	0.959
BW= $a \times FL^b$	0.0079	3.04	0.0067 - 0.0093	2.95 - 3.12	0.958
BW= $a \times SL^b$	0.0108	3.02	0.0091 - 0.0128	2.93 - 3.11	0.948
BW= $a \times PrDL^b$	0.0379	2.96	0.0328 - 0.0438	2.87 - 3.06	0.941
BW= $a \times PoDL^b$	0.0227	3.10	0.0192 - 0.0286	2.99 - 3.20	0.936
BW= $a \times PvL^b$	0.0938	2.90	0.0812 - 0.1084	2.78 - 3.02	0.908
BW= $a \times AnsL^b$	0.0353	2.97	0.0302 - 0.0411	2.87 - 3.07	0.934
BW= $a \times PrAnL^b$	0.0310	3.01	0.0264 - 0.0364	2.91 - 3.12	0.932
BW= $a \times PoAnL^b$	0.0188	3.01	0.0159 - 0.0222	2.92 - 3.11	0.940

n, sample size; a and b are regression parameters; CL, confidence intervals for mean values; r^2, co-efficient of determination

Table 3. The estimated parameters of the length-length relationships ($y = a + b \times x$) of *Salmostoma bacaila* (n=236) from the Ganges River, northwestern Bangladesh.

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
	a	*b*			
TL = *a* + *b*× FL	0.1590	1.11	0.0183 to 0.2997	1.09 - 1.13	0.982
TL = *a* + *b*× SL	0.1094	1.22	-0.0197 to 0.2384	1.21 - 1.24	0.985
TL = *a* + *b*×PrDL	0.2442	1.77	0.0235 to 0.4649	1.73 - 1.82	0.956
TL = *a* + *b*×PoDL	-0.1311	1.68	-0.3610 to 0.0989	1.64 - 1.73	0.956
TL = *a* + *b*×PvL	0.3724	2.31	0.0889 to 0.6560	2.23 - 2.40	0.927
TL = *a* + *b*×AnsL	0.1971	1.75	-0.0022 to 0.3963	1.70 - 1.79	0.964
TL = *a* + *b*×PrAnL	0.0824	1.73	-0.1204 to 0.2852	1.69 - 1.78	0.964
TL = *a* + *b*×PoAnL	0.1218	1.47	-0.0905 to 0.3340	1.43 - 1.50	0.960

TL, total length; SL, standard length; FL, fork length; PrDL, pre-dorsal length; PoDL, post-dorsal length; PvL, pelvic length; AnsL, anus length; PrAnL, pre-anal length; PoAnL, post-anal length; *a*, intercept; *b*, slope; CL, confidence limit for mean values; r^2, co-efficient of determination

Table 4. Meristic counts of *Salmostoma bacaila* (n=236) from the Ganges River, northwestern Bangladesh.

Meristic data	Numbers	Unbranched	Branched
Dorsal fin rays	8-9	2-3	6-7
Pectoral fin rays	12	2-4	8-10
Pelvic fin rays	8-9	2-3	5-7
Anal fin rays	13-16	2-4	10-13
Caudal fin rays	20-24	6-7	14-17

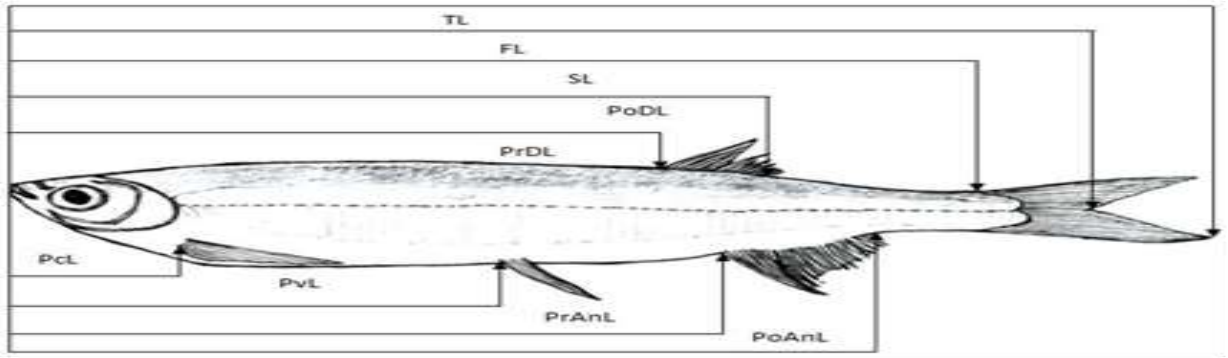

Figure 1. Showing the morphometric measurement of *Salmostoma bacaila* from the Ganges River, northwestern Bangladesh.

4. Discussion

Information on the morphometric and meristic traits are quite scant for *S. bacaila* in the Ganges River, NW Bangladesh. Some works on length-length and length-weight relationship of *S. bacaila* have been done in Bangladesh by Islam and Mia (2016), and in India by Masud and Singh (2015), and Nath *et al*. (2017). In this study, the maximum length was found to be 11.5 cm TL in the Ganges River, which is higher than that in the Atrai River, Dinajpur, Bangladesh (TL= 10.5 cm; Islam and Mia, 2016) and that in the Barak River, Assam, India (TL= 10.4 cm; Nath *et al.*, 2017), but it is lower than the following values: FishBase value 18.0 cm TL (Menon, 1999), 15.2 cm TL from the river Yamuna, India (Masud and Singh, 2015), 15.7 cm TL from Gandak River, Bihar, India (Baitha *et al.*, 2017), and 16.3 cm TL from the Indus River, Pakistan (Muhammad *et al.*, 2016). However, declining in the maximum sizes of *S. bacaila* in the Ganges River might be attributed either to the absence of larger-sized individuals in the populations of fishing grounds (Khatun *et al*., 2018), or simply because fishermen did not go where the larger size might exist. The evidence on maximum length/size is quite helpful to estimate the asymptotic length and growth coefficient of the fishes, which are essential for fisheries stock assessment and management (Hossain *et al*., 2016a, b, 2017).

In the present study, the regression parameter *b* value was found to be 3.06 which exhibits the isometric growth pattern. However, negative allometric growth was reported from several habitats including the Atrai River in Bangladesh (b = 2.76) by Islam and Mia (2016), the river Yamuna in India (b = 2.86) by Masud and Singh (2015), the Barak River in Assam, India (b = 2.47) by Nath *et al.* (2017), the Gandak River in Bihar, India (b = 2.80) by Baitha *et al.* (2017), and the Indus River in Pakistan (b=2.88) by Muhammad *et al.* (2016). The allometric co-efficient (b) values of LWRs ranging from 2.5 to 3.5 are more common (Froese, 2006). In the present study, most of the *b* values were within the limit (2.5–3.5). However, the *b* values may vary in the same species because of the combination of various factors including habitat, stage of stomach fullness, seasonal effect, gonadal maturation, gender, physiology, preservation methods and differences in the observed length ranges of the specimens collected (Hossen *et al.*, 2016), which are not accounted in this

study. In addition, all the LLRs were highly correlated (Table 3) ($p < 0.001$). Furthermore, the fin formula for *S. bacaila* is: dorsal, D. 8-9 (2–3/6-7); pectoral, Pc. 12 (2-4/8-10); pelvic, Pv. 8-9 (2–4/8-10); anal, An. 13-16 (2-4/10-13); caudal, Ca. 20–24 (6–7/14–17). However, in an earlier study, Rahman (2005) reported the fin formula of *S. bacaila* as D. 10(2/8); P_1. 12-13; P_2. 9; A. 14-15(2/12-13), which is quite similar with the current study.

The present study serves as a priceless tool for the fishery manager to recognize *S. bacaila* in the laboratory or fields and commence stock assessment of the existing stock of this species in the Ganges River, NW Bangladesh and other subtropical countries. Also, these results update the information of the FishBase, and provide an important baseline for future studies within the Ganges River and the adjacent ecosystems.

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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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