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Morphometric and Meristic Variation of Endangered Pabda Catfish, *Ompok pabda* (Hamilton-Buchanan, 1822) from Southern Coastal Waters of Bangladesh

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A B S T R A C T

The present study was aimed to determine the variation in diversity of *Ompok pabda* based on morphometric and meristic analyses of samples collected from four southern coastal rivers of Bangladesh. A total of 80 individuals ranging from 9.50-13.50 cm in total length (TL) and 4.44-14.83 g in body weight (BW) were compared for morphometric and meristic analysis to explore their taxonomic relationship. Eighteen morphometric characters out of 25 showed significant variation ($p<0.05$) while 3 meristic characters out of 5 differ significantly. In case of morphometric measurements, the 1st, 2nd and 3rd discriminant function (DF) accounted for 64.4%, 19.5% and 16.1%, respectively of among group variability explaining 100% of the total among-group variability. The dendrogram based on morphometric data revealed that the Baleswer and Payra river population showed high degree of overlapping whereas Halda river population was more diversified with all population. The canonical graph also showed all population of Halda river was highly intermediate with the Baleswer and Payra river population compare to Tentulia River in isometric condition. The present findings may provide useful information for the conservation and sustainable management of this important fish.

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Authors' Contributions
MRC and MAB collected samples, performed laboratory analyses and wrote the article. MAH and AN helped in sampling and analysis of data. SM and MP supervised the work.

Key words
Diversity, morphometric, meristic, conservation, *Ompok pabda.*

INTRODUCTION

The rivers and estuaries of southern coastal region of Bangladesh are characterized by high amounts of commercial fish catch having great contribution to the national economy of Bangladesh (Islam, 2003; Alam and Thomson, 2001; Belton *et al.*, 2014; Hanif *et al.*, 2015a,b). In spite of having vast potentiality, the coastal rivers are facing a continuous degradation which is caused by over exploitation, apparent deterioration of the habitat, recreational activities, demographic increase and even global change consequences (Ahamed *et al.*, 2012; Chaklader *et al.*, 2015; Murshed-e-Jahan *et al.*, 2014; Siddik *et al.*, 2013, 2015).

Pabda catfish *Ompok pabda* (Hamilton-Buchanan, 1822), an indigenous freshwater catfish of Bangladesh popularly known as 'butter catfish'. The people of Bangladesh, East India, and Myanmar consider the fish is highly delicious and nutritious food item because of rich lipoprotein content and soft bony structure (Fagede *et al.*, 1984; Pillay, 2000; Jhingran, 2004). This species is widely distributed throughout the India, Bangladesh, Pakistan, Afghanistan and Myanmar (Jayaram, 1999; Chakrabarti *et al.*, 2009). Earlier, the *Ompok pabda* was available in beels, haors, baors, wetlands, lakes, rivers and streams of Bangladesh (Rahman, 2005) but indiscriminate fishing during monsoon, application of pesticide in agriculture, soil erosion and siltation formation in river, contamination of habitat due to sewage and industrial pollution etc. over the decades have sharply declined the population of this fish species (Chakrabarti *et al.*, 2009; Banik and Bhattacharya, 2012; Chaklader *et al.*, 2014). Presently, this species is categorized as threatened species according to the criteria of conservation assessment (IUCN Bangladesh, 2000) and need to impose immediate adequate management plan in order to protect and conserve the species in this area.

The study of morphological characters on fishes

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play a vital role from various perspectives including evolution, ecology, behavior, conservation, water resource management, and stock assessment and may be applicable in order to study short-term and environmentally induced variations (Kalhoro *et al*., 2015; Başusta *et al*., 2014; Özcan and Altun, 2015). These characters has also been widely used as a powerful technique for the determination of morphological relationships between the population of a species and for identifying fish stocks and describing their spatial distributions (Turan, 2004; Mustač and Sinovčić, 2010; Ivanković *et al.,* 2011). Moreover, the stock structure can be used as an effective tool for the development of management strategies that will be helpful in conserving the biodiversity associated with different species, subspecies, stocks and races (Turan *et al*., 2005; Sharker *et al*., 2015; Nahar *et al*., 2015). Currently there is no knowledge of endangered butter catfish, *Ompok pabda* biology and ecology among fishing areas of the southern coastal waters of Bangladesh. Considering the above facts, the aim of the present study was to assess and describe intraspecies variation in morphometric and meristics characters of *Ompok pabda* from four different rivers in the southern coastal waters of Bangladesh.

Table I.- Sources, number of specimens and date of collection of *O. pabda* population.

Sample No.	Population	Collection site (District)	No. of fish	Date of collection
01	Tentulia river	Sonatala (Bogra)	20	20.01.14
02	Baleshwer river	Kaukhali (Pirojpur)	20	01.03.14
03	Payra river	Labukhali (Patuakhali)	20	10.05.14
04	Halda river	Hathazari (Chittagong)	20	20.08.14

MATERIALS AND METHODS

Study area and sampling

A total of 80 individuals of *Ompok pabda* were sampled from four coastal rivers located in the southeastern coastal region of Bangladesh from January, 2014 to August, 2014 (Table I). The traditional fishing gears like *Jhakijal* (cast net), and *Dughair* (conical trap) were used to catch the specimen and preserved in 10% formalin. The collected samples were transferred to the wet laboratory, Faculty of Fisheries, Patuakhali Science and Technology University, where all morphometric and meristic characteristics were detected by Froese and Pauly (2007). Measurement system is presented in Figure 1.

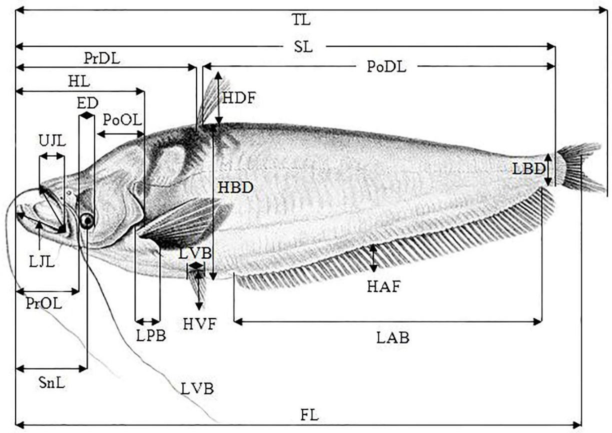

Fig. 1. Morphometric measurements taken on the body of *Ompok pabda* (Hamilton-Buchanan, 1822).

Statistical analysis

Separate statistical analyses were conducted on the meristic and morphometric characters. The discriminate function analysis (DFA) were used to differentiate characters among four different stock based on morphometric characters and Kruskal-Wallis test (non-parametric test) was performed to determine the difference significantly among the meristic characters of the samples. One-way analysis of variance (ANOVA) was accomplished to identify the meristic and morphometric differences among the four groups. For the elimination of any variation resulting from allometric growth (Straus, 1985), all morphometric measurements were standardized according to Elliott *et al.* (1995).

$$M_{adj} = M\,(L_s/L_o)^b$$

Where, M is the original morphometric measurement, M_{adj} is the size-adjusted measurement, L_o is the total length of fish, and L_s is the overall mean of total length for all fish from all samples for each variable. b is the constant value of the equation. The parameter *b* was estimated for each character from the observed data as the slope of the regression of log M against log Lo, using all specimens. SPSS v12 and SYSTAT v10 were used in order to perform all statistical analyses.

RESULTS AND DISCUSSION

Morphometric characters

In the present study, twenty five morphometric characters were measured (Fig. 1, Table II) among which TL, FL, HBD, PsOL, PsDL, HVF and MNBL showed no significant variation ($p>0.05$). The head depth of

Baleswer and Payra river population displayed significant variation compare to Tentulia and Halda river population ($p<0.05$). The lowest body depth of Tentulia and Baleswer population revealed significant variation from Payra and Halda river population, as well as the height of anal fin of Tentulia and Baleswer population ($p<0.05$). The length of dorsal base, length of ventral base and lower jaw length of Baleswer, Payra and Halda river population showed significant variation compared Tentulia river population. Also, the maximum barbell length of Baleswer and Payra river population differ significantly than the Tentulia and Halda river population ($p<0.05$). These phenotypic variability may be related to the geography, ecology, human activities and genetic diversity of the population (Junguera and Perez-Gandaras, 1993). The phenotypic variability is considered to be the greatest in fish among the vertebrates, which have relatively higher within-population coefficients of variation of phenotypes (Carvalho, 1993; Sajina *et al.*, 2011). The changes of environmental factors influence greatly phenotypic plasticity of fishes and these variability are arisen from these alteration (Wimberger, 1992). Moreover, some modification of aquatic environment are continuing all times due to manmade and natural factors and these modifications may responsible for changing their morphology (Stearns, 1983).

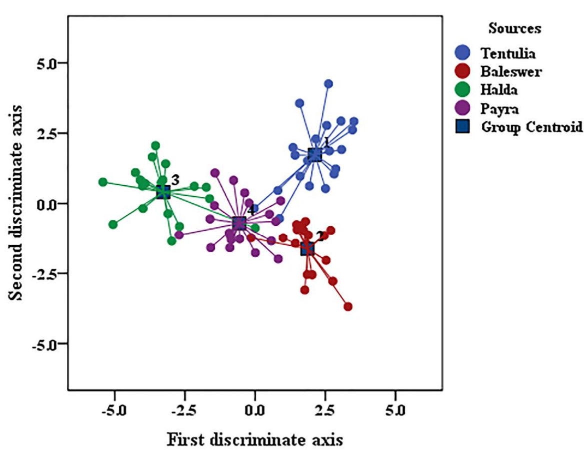

Fig. 2. Samples centroid of the discriminant function scores based on morphometric measurements of *Ompok pabda* (Hamilton-Buchanan, 1822) from four investigated rivers.

The different proportions of morphometric characteristics (TL:SL, HBD:LBD, HL:ED, TL:HBD, TL:LBD, TL:HL, SL:HL) of *O. pabda* are shown in Table III. The ratio of TL:SL of all river population did not show significant variation but the proportions of two morphometric characters of TL**:** LBD, TL:HL and SL**:** HL of all populations were significantly different ($p<0.05$) from each other. The ratio of HBD:LBD of Tentulia and Baleswer population showed significant variation with Payra and Halda population and the proportion of TL:HBD of Tentulia and Halda population differed significantly from rest two river populations. The total length of *O. pabda* populations were 1.2, 4.6-5.2, 20-14.2 and 8.1-5.4 times, respectively higher than SL, HBD, LBD and HL; and the highest body depth (HBD) was 3.8-3.1 times higher than the lowest body depth (LBD). Again, the head length (HL) was 3.5-5.9 times higher than the eye diameter and the standard length (SL) was 7.2-4.7 times higher than the head length (HL). The univariate statistics (ANOVA) revealed that 15 (HL, HD, LBD, PrOL, ED, SnL, HDF, HPF, HAF, LDB, LPB, LVB, UJL, LJL and MXBL) out of 25 morphometric measurements significantly differed to varying degrees ($p < 0.05$, $p < 0.01$ or $P < 0.001$) among samples (Table IV).

The discriminate function analysis (DFA) showed that the 1st DF accounted for 64.4%, the 2nd DF accounted for 19.5% and the 3rd accounted for 16.1% of among group variability, and together they explained 100% of the total among-group variability. According to the 1st and 2nd discriminant function (DF), the relationships among the 4 stocks were different (Fig. 2). Considering 1st DF, the Halda stock exposed intermediate characteristics between the Baleswer and Payra stocks. Since the Tentulia River has more salinity compare to others, the Halda stocks showed some nearness to Baleswer and Payra stocks. Based on the 2nd DF, the Baleswer, Payra and Halda stocks, however, broadly overlapped, while the Tentulia stock clearly different which might be due to the geographic isolation and environmental condition of the river. These results are similar to the findings of Mir *et al.* (2013) who reported variation among the stocks of six populations in Ganga basin due to uncommon hydrological conditions such as differences in alkalinity, current pattern, temperatures, turbidity, and land-use patterns among these drainages, as well as closeness between stocks may be due to their similar habitat attributes and to environmental impacts. The 1st DF accounted for much more (64.4%) of the among group variability than did the 2nd DF (19.5%) and 3rd DF (16.1%). It is noticeable that the 3rd DF explains much less of the variance than does the 1st DF and 2nd DF. The 3rd DF therefore, much less informative in explaining differences among the stocks.

The dendrogram which were employed on the basis of morphometric characters produced 2 clusters: the

Table II.- Morphometric characters observed in three river populations of *O. pabda* (Hamilton-Buchanan, 1822).

Acronyms	Tentulia river	Baleswer river	Payra river	Halda river
TL	10.67±.20[a]	10.70±.19[a]	10.74±.24[a]	11.20±.27[a]
SL	9.31±.21[ab]	9.03±.17[b]	9.44±.22[ab]	9.75±.25[a]
FL	9.85±.19[a]	9.81±.19[a]	10.01±.24[a]	10.26±.24[a]
HL	1.99±.06[a]	1.83±.04[ab]	1.32±.08[c]	1.73±.04[b]
HD	1.27±.05[b]	1.44±.06[a]	0.80±.05[c]	1.13±.05[b]
HBD	2.31±.06[a]	2.14±.07[a]	2.15±.07[a]	2.15±.05[a]
LBD	0.75±.03[a]	0.69±.02[a]	0.58±.03[b]	0.56±.02[b]
PrOL	0.74±.04[a]	0.63±.02[b]	0.67±.02[ab]	0.65±.02[b]
PsOL	1.07±.04[a]	1.03±.03[a]	1.04±.03[a]	1.02±.01[a]
ED	0.34±.01[b]	0.40±.02[a]	0.38±.01[ab]	0.37±.01[ab]
SnL	0.94±.04[a]	0.83±.02[b]	0.87±.02[ab]	0.85±.02[b]
PrDL	3.23±.09[a]	2.91±.10[b]	3.06±.07[ab]	3.09±.07[ab]
PsDL	6.42±.11[a]	6.01±.12[a]	6.40±.18[a]	6.44±.18[a]
HDF	1.45±.03[a]	1.38±.04[ab]	1.26±.05[b]	1.29±.03[b]
HPF	1.71±.06[a]	1.60±.06[b]	1.48±.03[ab]	1.59±.04[ab]
HVF	0.64±03[a]	0.57±.03[a]	0.64±.05[a]	0.56±.03[a]
HAF	0.54±.02[c]	0.59±.02b[c]	0.77±.03[a]	0.62±.03[b]
LDB	0.14±.01[a]	0.10±.00[b]	0.10±.00[b]	0.12±.01[b]
LPB	0.66±.03[a]	0.63±.02[ab]	0.58±.01[bc]	0.54±.03[c]
LVB	0.43±.03[a]	0.31±.01[b]	0.24±.02[c]	0.28±.01[bc]
LAB	6.33±.12[a]	5.95±.12[b]	6.02±.10[ab]	6.12±.15[ab]
UJL	0.82±.03[a]	0.79±.03[ab]	0.73±.02[bc]	0.71±.02[c]
LJL	0.99±.05[a]	0.89±.03[b]	0.87±.02[b]	0.82±.02[b]
MXBL	3.93±.11[a]	3.52±.11[bc]	3.61±.05[bc]	3.85±.08[a]
MNBL	0.85±.07[a]	0.80±.05[a]	0.93±.05[a]	0.79±.04[a]

Values are mean±standard error. Mean values in each row bearing different superscripts are significantly different (P<0.05).
ED (eye diameter), distance from the pre-orbital length to post-orbital length; FL (Fork length), distance from the tip of the snout to the end of the fork of caudal fin; HAF (height of anal fin), horizontal distance of anal fin; HBD (highest body depth), vertical distance from the anterior part of the 1st dorsal fin and ventral part of the body; HD (Head depth), vertical distance of head; HDF (height of dorsal fin), horizontal distance of dorsal fin; HL (Head length), distance from the tip of the snout to the posterior margin of the opercula; HPF (height of pectoral fin), horizontal distance of pectoral fin; HVF (height of ventral fin), horizontal distance of Ventral fin; LAB (length of anal base), vertical distance from the anterior part to the posterior part of anal fin; LBD (lowest body depth), vertical distance from the upper part to lower part of the body near the caudal peduncle region; LDB (length of dorsal base), vertical distance from the anterior part to the posterior part of dorsal fin; LJL (lower jaw length), distance between the snout tip and posterior edge of mandible; LPB (length of pectoral base), vertical distance from the anterior part to the posterior part of Pectoral fin; LVB (length of ventral base), vertical distance from the anterior part to the posterior part of Ventral fin; MBL (maximum barbell length), length of the barbel having highest elongation; MBL (minimum barbell length), length of the barbel having lowest elongation; PrDL (Pre-dorsal length), distance from the snout tip to the anterior base of the dorsal fin; PrOL (Pre orbital length), distance from the tip of the snout to the anterior margin of the eye; PsDL (Post-dorsal length), distance from the posterior base of the dorsal fin to the anterior end of the caudal fin; PsOL (Post orbital length), distance from the posterior margin of the eye to the end of the operculum; SL (snout length), distance from the tip of the snout to the middle position of eye; SL (Standard length), Distance from the tip of the snout to the end of the vertebral column; TL (total length), distance from the tip of the snout to the longest caudal fin rayl; UJL (upper jaw length), distance between the snout tip and posterior edge of maxilla.

Table III. - Different morphometric proportions of *O. pabda* from four coastal rivers of Bangladesh.

Group	TL:SL	HBD:LBD	HL:ED	TL:HBD	TL:LBD	TL:HL	SL:HL
Tentulia river	1.15[a]	3.08[c]	5.85[a]	4.62[c]	14.23[d]	5.36[d]	4.68[d]
Baleswer river	1.18[a]	3.10[c]	4.58[b]	5.00[b]	15.51[c]	5.85[c]	4.93[c]
Payra river	1.14[a]	3.71[b]	3.47[c]	4.99[b]	18.52[b]	8.14[a]	7.15[a]
Halda river	1.15[a]	3.84[a]	4.68[b]	5.21[a]	20.00[a]	6.47[b]	5.64[b]

For Abbreviations see Table II.

Baleswer, Halda and Payra stocks in one and the Tentulia stock in another (Fig. 3). The difference between the Tentulia and other stocks may have been due to environmental changes as well as genetic deviations (Tomljanović *et al.,* 2011).

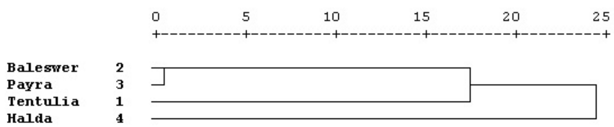

Fig. 3. Distance of squared euclidean dissimilarity based on morphometric characters showing the relationship among the Tentulia, Baleswer, Payra and Halda river populations.

Table IV.- Univariate statistics (ANOVA) of morphometric characters observed in four river populations of *O. pabda.*

Characters	Wilks' Lambda	F	df1	df2	Significance
TL	0.96	1.14	3	73	0.340
SL	0.93	1.72	3	73	0.171
FL	0.97	0.79	3	73	0.506
HL	0.57	18.50	3	73	0.000***
HD	0.47	27.29	3	73	0.000***
HBD	0.95	1.36	3	73	0.261
LBD	0.65	13.29	3	73	0.000***
PrOL	0.88	3.21	3	73	0.028*
PsOL	0.96	0.62	3	73	0.607
ED	0.87	3.53	3	73	0.019*
SnL	0.89	3.21	3	73	0.028*
PrDL	0.93	1.82	3	73	0.151
PsDL	0.95	1.34	3	73	0.267
HDF	0.85	4.15	3	73	0.009**
HPF	0.87	3.70	3	73	0.015*
HVF	0.95	1.35	3	73	0.265
HAF	0.60	16.31	3	73	0.000***
LDB	0.81	5.59	3	73	0.002**
LPB	0.80	5.98	3	73	0.001**
LVB	0.51	23.82	3	73	0.000***
LAB	0.94	1.54	3	73	0.213
UJL	0.83	5.16	3	73	0.003**
LJL	0.82	5.42	3	73	0.002**
MXBL	0.85	4.29	3	73	0.008**
MNBL	0.94	1.50	3	73	0.223

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
For Abbreviations see Table II.

Meristic characters

Five meristic characters were counted of which VFR and NB didn't show significant variation from each other. The DFR and CFR of Payra and Halda river population differ significantly from the Tentulia and Baleswer river population while the BSR of Baleswer, Payra and Halda river population revealed significant variation compare to Tentulia river population (Table V). This differences may be caused due highest degree of inheritance of meristic counts which have better reliability for distinguishing fish populations (Treer, 1993) but if they are affected by environmental factors such as pH and water temperature, heritability may vary (Treer, 1993). Meristic counts for all population were varied from 10-12 for BSR, 3-4 for DFR, 11-14 for PFR, 7-9 for VFR, 54-57 for AFR and 16-18 for CFR which coincide with data presented by Talwar and Jhingran (1991) and Rahman (2005). Sometimes it is difficult to expound the causes of morphological variances between populations (Cadrin, 2000). Genetics and environment, and their interaction determine the morphological characteristics of fish suggested by Poulet *et al.* (2004). Apparently, the different location of river impoundments can lead to an enhancement of pre-existing genetic differences, providing a high interpopulation structuring (Esguicero and Arcifa, 2010). Therefore, the observed morphological variations in the present study are probably due to genetic differences among the populations.

Table V.- Meristic characters observed in four river populations of *O. pabda* (Hamilton-Buchanan, 1822).

Acronyms	Tentulia	Baleswer	Payra	Halda
BSR	10.20±.12c	11.00±.23b	11.20±.20ab	11.70±.15a
DFR	3.60±.11b	3.55±.11b	3.95±.05a	3.90±.07a
PFR	12.75±.12a	12.20±.29ab	11.95±.22b	11.60±.21b
VFR	7.95±.09a	7.55±.40a	7.60±.11a	7.85±.08a
AFR	55.30±.26a	54.20±.12b	54.75±.19ab	54.50±.20b
CFR	17.30±.11b	17.15±.13b	17.95±.05a	18.00±.00a
NB	4.00±.00a	4.00±.00a	4.00±.00a	4.00±.00a

Values are mean±standard error. Mean values in each row bearing different superscripts are significantly different (P<0.05).
AFR (Anal fin rays), number of soft rays present in anal fin; BSR, (Branchiostegal rays), number of rays present in branchiostegal area; CFR (Caudal fin rays), number of soft rays present in caudal fin; DFR (Dorsa fin rays), number of soft rays present in dorsal fin; NB (No. of barbell), number of barbell present in fish; PFR (Pectoral fin rays), number of soft rays present in pectoral fin; VFR (Ventral fin rays), number of soft rays present in ventral fin.

CONCLUSION

The output of the research will provide useful baseline information of *Ompok pabda* populations not only in southern Bangladesh but on its whole geographic region. The morphometric and meristic diversity which were observed in this study will definitely also help monitoring the species status in the southern coastal regions of Bangladesh as a bid to take appropriate management measures for the populations in future.

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