Size structure of finescale razorbelly minnow, Salmostoma phulo (Cyprinidae) inhabiting a coastal river of Bangladesh

Chaklader M.R.^{1*}; Siddik M.A.B.¹; Hanif M.A.¹; Nahar A.²

Received: August 2015 Accepted: January 2016

Abstract

The aim of this study was to report the size structure of finescale razorbelly minnow, Salmostoma phulo in the Payra River, Southern Bangladesh, based on length-frequency distribution (LFD), sex ratio (SR), length-weight relationships (LWR), length-length relationships (LLR), condition factors (allometric K_A ; Fulton's, K_F ; relative, K_R and relative weight, W_R) and form factor $(a_{3,0})$. A total of 306 individuals ranging from 6.00–10.70 cm in total length and from 1.26-9.20 g in body weight were collected using traditional fishing gear from January 2014 to November 2014. The overall sex ratio of the species did not reveal significant variation from the expected value of 1:1 (χ^2 =0.32, p<0.05). The allometric coefficient b calculated for the LWR based on various dimensions indicates both sexes grew allometrically (negative for males: b<3 and positive for females: b>3). Moreover, the values of b for LWR, LLR and condition factors did not differ significantly (p>0.05) between the sexes of S. phulo. The estimated value of W_R was very close to 100 indicating the balanced habitat with available food relative to the presence of predators. To the best of our knowledge, this is the first inclusive and comprehensive explanation on the size structure of S. phulo from Bangladesh and it should be crucial for the sustainable management of this SIS fishery not only in southern coastal waters of Bangladesh but also in all of its geographical distributions including India and Myanmar.

Keywords: Length-frequency distribution, Length-weight, Condition factors, Allometric growth, Small indigenous species (SIS)

¹⁻Department of Fisheries Biology and Genetics, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh

²⁻Department of Marine Fisheries and Oceanography, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh

^{*}Corresponding author's email: reazpstu@gmail.com

Introduction

Bangladesh is endowed with 4.5 million hectares of wetland along inland and water bodies which coastal considered aquatic biodiversity hotspots the country (Mustafa Brooks, 2008: Ahmed and Toufique, 2014).There are 260 species freshwater fish in Bangladesh, of which 150 species (58%)have categorised small indigenous species(SIS) (Hanif et al., 2015a). Salmostoma phulo is an important component of SIS which belongs to the order Cypriniformes commonly known finescale razorbelly minnow, as throughout existing the country including the lower reaches of rivers and streams. ponds. rice fields. floodplains, canalsand some mighty river tributaries flowing from India and Myanmar (Talwar and Jhingran, 1991). Among SIS, S. phulois a good source of protein, vitamins and minerals, and plays an important role in providing essential nutrients for the people of Bangladesh. Minnow contains more available vitamin A than any other edible freshwater fish of Bangladesh. Once S. phulo was regarded as trash fish and was used as ingredient for fish feed manufacture. But nowadays, this species have been co-cultured with Indian major carps and exotic carps which led to the development of Carp-SIS culture systems that allow simultaneous production of S. phulo for the farmer's household consumption and carps as a cash crop (Ahmed and Toufique, 2014).

However, in spite of its nutritional and economic importance, SIS are facing high level of risk of extinction due to indiscriminate exploitation of brood and young SIS by destructive fishing gears (Siddik et al., 2014; Hanif et al., 2015b). The S. phuloonce endemic in the wetlands across the country, is now facing tremendous threat due to over exploitation augmented by various ecological changes and degradation of the natural habitats. IUCN (2014) has categorized endangered the species as Bangladesh and indicated the urgent need for adequate measures implement adaptation-centric regulations for sustainable management of small indigenous fishes in the country (Mustafa and Brooks, 2008). Inadequate knowledge with respect to life history traits and conservation status of the species might be one of the significant factors for overexploitation of not only the S. phulo but many others species of southern Bangladesh (Chaklader et al., 2014; Sharker et al., 2015)

As a population parameter, lengthweight relationship is very crucial for the conversion of -growth-in-length equations to growth-in-weight which is useful for the assessment of fish stock, estimation of fish stock from limited sample sizes (Yasemi and Nazari Beigan, 2014; Chaklader et al., 2015; Siddik et al., 2016a,b,c,d) and management of fisheries resources (Ilkyaz et al., 2008; Pathak et al., 2013; Chaklader et al., 2016). These studies are used as a tool with a view to conserving the fish population in several parts of the world providing information on the condition, growth pattern, ontogenic changes and in fish population dynamics (Oscoz et al., 2005: Simon and Mazlan, 2008: Karimzadeh and Gabrielyan 2010). However. comprehensive no information on these aspects of S. phulo Therefore, this study is available. presents the first reference of size structure including length-frequency distribution (LFD), sex ratio (SR), length-weight relationship (LWR) and length-length relationships (LLR), condition factors (allometric, Fulton's, K_F; relative, K_R and relative weight, W_R) and form factor (a_{3.0}) of S. phulo in the Payra River, Southern Bangladesh.

Materials and methods

Sample collection

The sample collection was conducted between January and November 2014 from eight stations of the Payra River by commercial fishers who used traditional fishing gear and seine nets to catch the fish (Fig. 1). The collected fresh samples were preserved with ice on site and fixed with 10% buffered formalin to save the species from spoilage or any damage upon arrival at laboratory. All morphometric characters were measured by following Froese (2006) method. Total length (TL), fork length (FL), and standard length (SL) were measured with the help of using digital slide calipers nearest to 0.01cm and weight was measured with the help of using an electronic balance (Shimadzu, EB-430DW; Shimadzu Seisakusho, Tokyo, Japan) with 0.01 g accuracy.

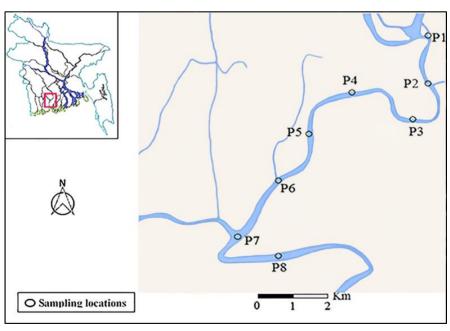


Figure 1: Salmostoma phulo sampling sites in the Payra River of southern Bangladesh.

Length-length relationships

The length-length relationship i.e. (i) TL=p+q×SL, (ii) FL=p+q×TL and (iii) SL=p+q×FL were determined by the method of least squares to fit a simple linear regression model as Y=a+bX, where Y=various body lengths, X=total length, a =proportionality constant and b= regression coefficient.

Length-weight relationships

Length-weight relationship was calculated based on the exponential equation by Le Cren (1951) as $W=aL^b$ where, where W is the body weight (g) and L is the total length (cm) or fork length (cm) or standard length (cm), a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3 and indicating allometric growth when significantly different from 3(Simon and Mazlan, 2008). The parameters a and b were estimated by linear regression analysis log-transformed equation using expressed as $\log W = \log a + b \log L$. The values of the constant a and b of the linear regression was determined by following Rounsefell and Everhart (1953) and Lagler (1966).

Condition factors

A number of condition factors such as Fulton's (Fulton, 1904), relative (Le Cren, 1951), allometric (Tesch, 1971), and relative weight (Froese, 2006) are used to determine the overall health and productivity of freshwater fish populations (Rypel and Richter,2008; Muchlisin *et al.*, 2010). The Fulton's

condition factor K_F was calculated using the equation given by (Fulton, 1904) as $K_F=100\times$ (W/L3), where W is the body weight (BW), and L is the total length (TL). The relative condition factor (K_R) for each individual was calculated using the equation $K_R=W/a\times L^b$ (Le Cren, 1951), where W is the BW, L is the TL and a and b are the LWR parameters. Also, the allometric condition factor (K_A) was calculated by using a formula developed by (Tesch, 1971) $K_A = W/L^b$, where W is the BW, L is the TL and b is the LWR parameter. Furthermore, relative weight (W_R) was determined by using a formula given by Froese (2006) as $W_R = (W/W_S) \times 100$, where W is the body weight of a particular individual and Ws is the predicted standard body weight for the same individual as calculated by $W_S = aL^b(a \text{ and } b \text{ values})$ obtained from the composite of LWRs).

Form factor

Based on Froese (2006), the form factor (a_{3.0}) for *S. phulo* was estimated by using the equation as: $a_{3.0}$ = 10 log ^{a - s (b-3)}, where *a* and *b* are regression parameters of LWRs, and *S*= -1.358 is the regression slope of log *a* vs *b*.

Statistics analyses

A $\chi 2$ goodness-of-fit test was used to assess the sex-ratio divergence from the expected value of 1:1 (male: female). An analysis of covariance (ANCOVA) was used to compare relative condition factor between males and females within the same population. Since the length-weight relationships were

curvilinear, data sets were transformed by natural logarithms to linearise before each analysis. The normality tests for each group were conducted by the Kolmogorov-Smirnov test. The statistical package SPSS Version 15 was used for all statistical procedures at 5% (p<0.05).

Results

Length-frequency distributions

Descriptive statistics for length and weight measurements of male and female *S. phulo* are presented in Table 1. The smallest and largest samples of *S. phulo* were 6.00 cm and 10.70 cm TL, respectively according to the length-frequency distribution (LFD). Numerically the size group was dominant in 7.85-8.30 cm TL and

constituted 28.10% of the total population (Fig. 2 and Table 2). The total length were ranged from 6.10 to 10.70 cm (mean±SD=8.24±0.81) for males and 6.00 to 10.60cm (mean ±SD $= 8.34\pm0.80$) for females S. phulo. The TL-frequency distribution showed that the males and females S. phulo were not normally distributed in the Payra River during this study. Furthermore, the BW of S. phulo varied between 1.44 and $7.21g \text{ (mean} \pm \text{SD} = 3.26 \pm 1.01) in males$ 1.26 9.20g and and $(\text{mean}\pm \text{SD}=3.42\pm1.15)$ females. in Nonetheless, the **BW-frequency** distribution showed that the males and females S. phulo were not normally distributed (Kolmogorov-Smirnov test, p<0.001) in the study area.

Table 1: Descriptive statistics on the length (cm) and weight (g) measurements of the Salmostoma

Sex	Statistics	Measurements						
		TL	FL	SL	BW			
	Min	6.10	5.40	4.90	1.44			
Male (n:158)	Max	10.70	9.90	8.90	7.21			
	Mean \pm SD	$8.24 \pm .81$	$7.29 \pm .72$	$6.62 \pm .67$	3.26 ± 1.01			
	LCL-UCL	8.11-8.37	7.17-7.40	6.52-6.73	3.10-3.42			
	Min	6.00	5.40	4.90	1.26			
Female (n:148)	Max	10.60	9.30	8.50	9.20			
	Mean \pm SD	$8.34 \pm .80$	$7.43 \pm .71$	$6.75 \pm .65$	3.42 ± 1.15			
	LCL-UCL	8.21-8.47	7.31-7.54	6.64-6.86	3.23-3.60			
	Min	6.00	5.40	4.90	1.26			
Combined (n:306)	Max	10.70	9.90	8.90	9.20			
	Mean \pm SD	$8.29 \pm .81$	$7.36 \pm .72$	$6.68 \pm .66$	3.34 ± 1.08			
	LCL-UCL	8.19-8.38	7.28-7.44	6.61-6.76	3.21-3.46			

Note: *n*, sample size; Min, minimum; Max, maximum; SD, standard deviation; LCL; lower confidence limit, UCL; upper confidence limit; TL, total length; FL, fork length; SL, standard length; BW, body weight

Table 2: The sex ratio (male: female = 1:1) by total length category for *Salmostoma phulo* in the Payra River, Southern Bangladesh.

rayra Kiver, Southern Dangiauesh.									
Length class (TL, cm)	No. of Fish	Male No.	Female No.	Ratio		χ^2 (df=1)	Significance		
(1L, CIII)	T ISII	110.	110.	Male	female				
6.00-6.45	6	4	2	1	0.50	0.66	ns		
6.46-6.91	2	0	2	1	-	2.00	ns		
6.92-7.37	21	9	12	1	1.3	0.43	ns		
7.38-7.83	65	40	25	1	0.63	3.46	ns		
7.85-8.30	86	44	42	1	0.95	0.04	ns		
8.31-8.76	60	29	31	1	1.07	0.06	ns		
8.77-9.22	23	8	15	1	1.88	2.14	ns		
9.23-9.68	26	15	11	1	0.73	0.62	ns		
9.69-10.14	11	7	4	1	0.57	0.82	ns		
10.15-10.60	4	1	3	1	3.00	1.00	ns		
10.61-11.06	2	1	1	1	1	0.00	ns		
overall	306	158	148	1	0.94	0.32	ns		

Note: ns, not significant; *, significant at 5% level ($\chi^2_{t \ 1, \ 0.05} = 3.84$), **, 1% level ($\chi^2_{t \ 1, \ 0.01} = 6.63$) and ***, 0.1% level ($\chi^2_{t \ 1, \ 0.001} = 10.83$)

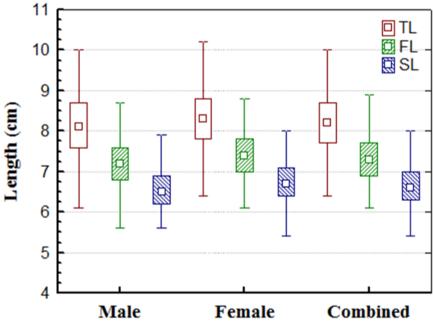


Figure 2: The length-frequency distribution in regard to total length (TL), fork length (FL) and standard length (SL) of *Salmostoma phulo* in the Payra River, southern Bangladesh.

Sex ratio

There were 158 males and 148 females (male: female=1: 1.05) in the 306 specimens of *S. phulo* collected from

Payra River; 51.63% males and 48.37% females. However, the overall sex ratio did not show significant variation from the expected value of 1:1 (df = 1, χ 2 =

0.32, *p*<0.05). Males were dominant in the 7.38 to 8.30 TL groups while females were dominant in the 8.31 to 9.32 TL groups according to the TL dependent sex ratio (Table 2).

Length-weight and length-length relationships

The sample size (n), regression parameters a and b of the LWR, 95% confidence intervals of a and b, the coefficient of determination (r²), and growth type of S. phulo are shown in Figs. 3, 4 and Table 3. The coefficients (r^2) correlation were highly significant (p<0.001) in all cases. The estimated allometric coefficient was 2.82 for males and 3.05 for females based on BW vs TL, 2.84 for male and 3.09 for female based on BW vs FL respectively, whereas the b was 2.79 for male and 3.00 for females based on BW SL in the Payra River. The coefficient b of the LWR indicated negative allometric growth with pool population in the Payra River of Bangladesh, as the t-test revealed that the b value was significantly different from 3 (b < 3.00, p < 0.01) (Table 2). Furthermore, the relationships between TL, FL and SL of males, females and common gender of S. phulo including 306 specimens along with the estimated parameters of the LLR and the coefficient of determination (r²) are presented in Table 4. The coefficients of determination (r²) estimated from length-length relationship for all males, females and combined gender were greater than 0.9 revealing a highly significant difference (p < 0.0001).

Table 3: Descriptive statistics and estimated parameters of the length-weight relationships, and form factor $(a_{3,0}=10^{loga-S} \ ^{(b-3)})$ of Salmostoma phulo in the Payra River, Southern Bangladesh.

Sex	Equation	SE (a)	SE(b)	(LCL _a -	(LCL _b -	r ²	GT	a _{3.0}
				UCL _a)	UCL_b)			
Male	$BW = 0.008 \times TL^{2.82}$	0.14	0.07	0.006-0.011	2.69-2.95	0.920	A-	0.0046
(n:158)	$BW = 0.011 \times FL^{2.84}$	0.12	0.06	0.009-0.014	2.72-2.97	0.930	A-	0.0066
	$BW = 0.016 \times SL^{2.79}$	0.10	0.05	0.013-0.020	2.68-2.89	0.949	A-	0.0081
Female	$BW = 0.005 \times TL^{3.05}$	0.21	0.10	0.003-0.008	2.85-3.25	0.864	A+	0.0059
(n:148)	$BW = 0.007 \times FL^{3.09}$	0.18	0.09	0.005-0.009	2.92-3.37	0.892	A+	0.0093
	$BW = 0.011 \times SL^{3.00}$	0.19	0.10	0.007-0.016	2.81-3.20	0.863	A+	0.0110
Combined	$BW = 0.007 \times TL^{2.93}$	0.13	0.06	0.005-0.008	2.85-3.01	0.890	A-	0.0056
(n:306)	$BW = 0.009 \times FL^{2.95}$	0.11	0.05	0.007-0.011	2.85-3.06	0.908	A-	0.0078
	$BW = 0.014 \times SL^{2.88}$	0.10	0.05	0.011-0.017	2.77-2.99	0.902	A-	0.0095

Note: n, sample size; BW, body weight; TL, total length; FL, fork length; SL, standard length; a, intercept; b, slope; Bold numbers indicate significant differences from b = 3, LCL; lower confidence limit, UCL; upper confidence limit; r^2 , coefficient of determination; GT, growth type (A+, positive allometric growth, A-, Negative allometric growth [based on (Sokal & Rohlf 1981): ts = (b-3)/sb, where ts is the t-test value, b the slope and sb the standard error of the slope b].

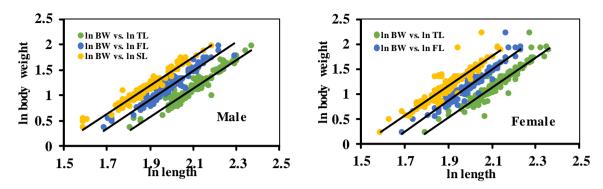


Figure 3: Length-weight relationships ($\ln W = \ln a + b \ln L$) of *Salmostoma phulo* based on various body dimensions from the Payra River, Southern Bangladesh.

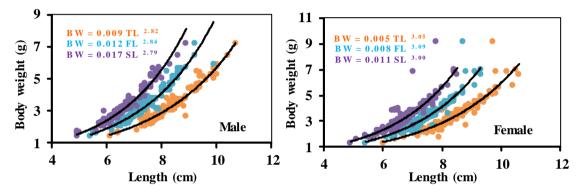


Figure 4: Length-weight relationships ($W = a \times L^b$) of *Salmostoma phulo* based on various body dimensions from the Payra River, Southern Bangladesh.

Condition factors

Descriptive statistics of condition factors (K_F, K_A, K_R and W_R) of S. phulo are presented in. The K_F values ranged from 0.38 to 0.77 (mean \pm SD = 0.57 ± 0.04) in males and from 0.35 to 1.01 (mean \pm SD = 00.57 \pm 0.07) in females. The estimated K_R for male and female S. phulo varied between 0.273 and 1.168 (mean \pm SD = 0.960 \pm 0.23) and 0.818 and 1.124 (mean SD=1.035 \pm .09), respectively. The K_A ranged from 0.0035 to 0.0173 (mean \pm SD = 0.0074 ± 0.004) for males and from 0.0016 0.0189 $(mean \pm SD =$ to

 0.0076 ± 0.006) for females. In addition, the calculated minimum and maximum relative weight (W_R) varied between 116.76 (mean±SD 102.60±5.46) and between 81.81 and $112.35 \text{ (mean} \pm \text{SD} = 102.24 \pm 8.45) in$ males and females, respectively which were not significantly different from 100 (Wilcoxon rank test, p=0.074). Furthermore, Spearman rank test extremely revealed that K was with correlated various body dimensions including TL, FL, SL and BW (*p*<0.001) (Table 5).

Table 4: The estimated parameters of the length-length relationships $(Y = a + b \times X)$ of male and female of *Salmostoma phulo* from the Payra river. Southern Bangladesh.

2
r²
0.940
0.923
0.953
0.943
0.966
0.962
0.940
0.942
0.958

Note: n, sample size; TL, total length; FL, fork length; SL, standard length; a, intercept; b, slope; LCL; lower confidence limit, UCL; upper confidence limit, r², coefficient of determination.

Table 5: Condition factors $(K_F, K_A, K_R \text{ and } W_R)$ of the Salmostoma phulo in the Payra River, Southern Bangladesh.

Statistics	Male (n:158)				Female (n:1	Female (n:148)			Combined (n:306)			
	K _F	K _A	KR	WR	K _F	K _A	KR	WR	K _F	K _A	KR	WR
Min	0.38	0.0035	0.273	95.61	0.35	0.0016	0.818	81.81	0.35	0.0016	0.2730	81.81
Max	0.77	0.0173	1.168	116.76	1.01	0.0189	1.124	112.35	1.01	0.0189	1.1680	116.76
$\mathrm{Mean}\pm\mathrm{SD}$	0.57±0.04	0.007±0.004	0.960±0.23	102.60±5.46	0.57±0.07	0.0076±0.006	1.035±.09	102.24±8.45	0.57±0.06	0.0075±0.005	0.960±0.17	102.43±6.86
LCL-UCL	0.56-0.58	0.0048-0.0099	0.802-1.117	98.93-106.27	0.56-0.58	0.0032-0.0120	0.974-1.098	96.20-108.28	0.56-0.58	0.0053-0.0097	0.914-1.077	99.30-105.55

Note: n, sample size; Min, minimum; Max, maximum; SD, standard deviation; LCL; lower confidence limit, UCL; K_F , Fulton's condition factor; K_R , relative condition factor; K_A , allometric condition factor; W_R , relative weight

Form factor

The calculated form factor (a_{3.0}) was 0.0046, 0.0066, 0.0081 for TL,FL,SL, respectively in males and 0.0059, 0.0093, 0.0110 for TL,FL,SL, respectively in females of *S. phulo* in the Payra River, Southern Bangladesh (Table 2).

Discussion

recorded The present study the maximum size of S. phulo as 10.70 cm TL. which was lower than maximum recorded value of 12.00 cm TL in Fishbase (Froese et al., 2012). recorded The reduction in the maximum sizes of individuals of S. phuloin the Payra River in this study might be attributed either to the absence

of larger-sized individuals in the fishing ground or the selectivity of target species which may greatly influence the size distribution of the individuals (Hossain *et al.*, 2014). Size differentiation between males and females might be influenced by several factors including temperature change, feeding regime and reproductive cycle (Newman *et al.*, 2000).

In a normal distribution, the sex ratio of males and females may vary between 1:1 and 1:1.3 for most aquatic fish and shellfish, although some finfish and prawn populations have shown a strong bias in this ratio (Hossain *et al.*, 2014). In the present study, the male and female sex ratio was 1:1.05 indicating that the overall sex ratio did not differ

significantly from the expected value of 1:1. Sex ratio may be influenced by various causes, including thermal influences sex determination, on selective mortality by sex through differential predation, divergent sexual behavior, variant climate and regional conditions, reproduction, growth and longevity of a species (Stergiou and Moutopoulos, 2001; Oh et al., 2002; Chilari et al., 2005).

In context of length-weight and length-length relationships, b values in this study were within the limits (Froese, 2006) of freshwater fishes from the region reported by Hossain et al. (2014). The allometric coefficient b obtained from length weight relationship (Table 3) indicated negative allometric growth (b<3) for males and positive allometric growth (b>3) for females, as well as negative allometric growth for combined values of both sexes based on various body dimensions. The results of b for both male and female indicate differences in their growth type (FigS. 3 and 4). The calculated b value of S. phulo based on various body dimensions were within the limits of 2.5 to 3.5 indicating that the growth was positively allometric, i.e. weight faster than length (Froese, 2006). Variations in the b values may attributed to differences ecological conditions of the habitats or variations in the physiology of animals, or both (Le Cren, 1951), due to sex and season (Hossain et al., 2014), feeding rate, gonadal development and growth phase, behavior (active or passive swimmer), and water flow (Muchlisin et al., 2010) all of which were not accounted for in the present study. highly There was a significant correlation of coefficient (r²) found in the length-length relationship of fishes indicating intimate relationship lengths to each other in a proportionality which provides strength between the length-length relationship. Due to the lack of literature dealing with LWR and LLR for this species, we are unable to compare these results with previous studies.

Earlier reports on condition factors of Xenentodon cancila in southern Bangladesh were 0.96-1.10 (mean \pm SD $= 1.02 \pm 0.20$), 0.99-1.07 (mean \pm SD = 1.03 ± 0.18) and 0.96-1.05 (mean \pm SD = 1.01 ± 0.20) for males, females and combined gender, respectively (Hossain et al., 2015), which are in accordance that in the present study. Furthermore, the Fulton's condition factor (K_F) was found significantly different between sexes. likely indicating the presence of mature females. Additionally, relative weight (W_R) showed no significant differences from 100 for males and females in this study, indicating the habitat was still in good condition for S. phulo. However, there is no available data in literature comparing the relative weight of this species to the previous results.

The form factor $(a_{3.0})$ of the species was within the limits reported by Froese (2006) and (Hossain *et al.*, 2014). There are no references dealing with the $a_{3.0}$

for this species in the Fish Base and therefore, the present results may contribute to this invaluable electric database.

In conclusion, the present study provided the basic information on some biological aspects including lengthfrequency distributions, sex ratio. length-weight and length-length relationships based on various body dimensions. condition factor. and relative weight for S. phulo from Payra southern Bangladesh, River. which would be effective for fishery biologists, managers and conservationists to implement adequate regulations for sustainable fishery management and conservation of the species. Furthermore, no length-weight and length-length data and condition factors currently exist in the Fish Base for this species, so our results may contribute to this invaluable electric database.

References

Ahmed, N. and Toufique, K.A., 2014.

Greening the blue revolution of small-scale freshwater aquaculture

in Mymensingh, Bangladesh. *Aquatic Research*, 45, 1-18.

Chaklader, M.R., Nahar, A., Siddik, M. A.B. and Sharker, R., 2014. Feeding habits and diet composition of Asian Catfish *Mystus vittatus* (Bloch, 1794) in shallow water of an impacted coastal habitat. *World Journal of Fish and Marine Sciences*, 6(6), 551-556.

- Chaklader, M.R., Siddik, M.A.B. and Nahar, A., 2015. Taxonomic diversity of paradise threadfin *Polynemus paradiseus* (Linnaeus, 1758) inhabiting southern coastal rivers in Bangladesh. *Sains Malaysiana*, 44(9), 1241–1248.
- Chaklader, M.R., Siddik, M.A.B., Hanif, M.A., Nahar, A., Sultan Mahmud, S. and Piria, M., 2016. Morphometric and meristic variation of endangered pabda catfish, *Ompok pabda* (Hamilton-Buchanan, 1822) from southern coastal waters of Bangladesh. *Pakistan Journal of Zoology*, 48(2), 233-240.
- Chilari, A., Thessalou-Legaki, M. and Petrakis, G., 2005. Population structure and reproduction of the deep-water shrimp Plesionika martia (Decapoda: Pandalidae) from the eastern Ionian Sea. *Journal of Crustacean Biology*, 25, 233-241.
- Froese, R., 2006. Cube law, condition factor and weight-length relationships: history, meta analysis and recommendations.

 Journal of Applied Ichthyology, 22, 241-253.
- Froese, R., Zeller, D., Kleisner, K. and Pauly, D., 2012. What catch data can tell us about the status of global fisheries. *Marine Biology*, 159, 1283-1292.
- **Fulton, T.W., 1904.** The rate of growth of fishes. Twenty-second Annual Report. Part III. Fisheries Board of Scotland, Edinburgh.

- Hanif, M.A., Siddik, M.A.B. and Chaklader, M.R., 2015a. Fish diversity in the southern coastal waters of Bangladesh: present status, threats and conservation perspectives. *Croatian Journal of Fisheries*, 73, 251-274.
- Hanif, M.A., Siddik. **M.A.B.**, Chaklader, M.R., Mahmud, S., Nahar, A., Haque, M.S. and Munilkumar, S., 2015b. Biodiversity and conservation of threatened freshwater fishes in Sandha River, South West World Bangladesh. **Applied** Sciences Journal, 33(9), 1497-1510.
- Hossain, M., Rahman, M.M., Ahamed, F., Ahmed, Z. and Ohtomi, J., 2014. Length-weight and length-length relationships and form factor of three threatened fishes from the Ganges River (NW Bangladesh). Journal of Applied Ichthyology, 30, 221-224.
- Ilkyaz, A., Metin, G., Soykan, O. and Kinacigil, H., 2008. Length—weight relationship of 62 fish species from the Central Aegean Sea, Turkey. *Journal of Applied Ichthyology*, 24, 699-702.
- **IUCN, 2014.** Red book of threatened fishes of Bangladesh, Dhaka, Bangladesh, IUCN- The World Conservation Union.
- **Karimzadeh, G. and Gabrielyan B.F., 2010.** Population dynamics and biological characteristics of kilka species (Pisces: Clupeidae) in the southeastern coast of the Caspian

- Sea. Iranian Journal of Fisheries Sciences, 9(3), 422-433.
- **Lagler, K.F., 1966.** Freshwater fishery biology (2nd edn.). Brown W. M. C. (ed), Co. Dubuque, Iowa.
- Le Cren, E., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecology, 20, 201-219.
- Muchlisin, Z., Musman, M. and Azizah, S., 2010. Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. Journal of Applied Ichthyology, 26, 949-953.
- Mustafa, M. and Brooks, A., 2008.

 Status of fisheries resource and management approach in the open Beels of Bangladesh: a comparative case study. *Asian Fisheries Science*, 21, 189-203.
- Newman, S.J., Cappo, M. and Williams, D.M., 2000. Age, growth, mortality rates and corresponding yield using otoliths of the tropical red snappers, Lutjanus erythropterus, L. malabaricus and L. sebae, from the central Great Barrier Reef. Fisheries Research, 48, 1-14.
- Oh, C.W., Suh, H.L., Park, K.Y., Ma, C.W. and Lim, H.S., 2002.

 Growth and reproductive biology of the freshwater shrimp Exopalaemon modestus (Decapoda:

- Palaemonidae) in a lake of Korea. *Journal of Crustacean Biology*, 22, 357-366.
- Oscoz, J., Campos, F. and Escala, M., 2005. Weight–length relationships of some fish species of the Iberian Peninsula. *Journal of Applied Ichthyology*, 21, 73-74.
- Pathak, B.C., Zahid M. and Serajuddin M., 2013. Lengthweight, Length-length relationship of the spiny eel, *Macrognathus pancalus* (Hamilton 1822) sampled from Ganges and Brahmaputra river basins, India. *Iranian Journal of Fisheries Sciences*, 12(1), 170-182.
- Rodríguez-Romero, J.,
 Palacios-Salgado, D.,
 López-Martínez, J., Hernández
 Vázquez, S. and Velázquez Abunader, J., 2009. The length—
 weight relationship parameters of
 demersal fish species off the
 western coast of Baja California
 Sur, Mexico. Journal of Applied
 Ichthyology, 25, 114-116.
- **Rounsefell, G.A. and Everhart, W.H., 1953.** Fisheries science: its methods and application. John Willey and Sons, New York. 440P.
- Rypel, A.L. and Richter, T.J., 2008. Empirical percentile standard weight equation for the blacktail redhorse. *North American Journal of Fisheries Management*, 28, 1843-1846.
- Sharker, M.R., Mahmud, S., Siddik, M. A.B., Alam, M.J. and Alam, M.R., 2015. Livelihood status of hilsha fishers around Mohipur Fish

- Landing site, Bangladesh. World Journal of Fish and Marine Sciences, 7(2), 77-81.
- Siddik. M.A.B., Hanif, M.A., Chaklader, M.R., Nahar, A. and Mahmud, S., 2016a. **Fishery** biology of gangetic whiting Sillaginopsis panijus (Hamilton, 1822) endemic to Ganges delta, Bangladesh. Egyptian Journal of Aquatic Research, 41(4), 307-313. http://dx.doi.org/10.1016/j.ejar.201 5.11.001
- Siddik, **M.A.B.**, Hanif, M.A., Chaklader, M.R., Nahar, A. and Foteder, R., 2016b. A multivariate morphometric investigation delineate stock structure of gangetic whiting, Sillaginopsis panijus (Teleostei: Sillaginidae), Springer Plus, 5, 520.
- Siddik, M.A.B., Chaklader, M.R., Hanif, M.A., Islam, A. and Foteder, R., 2016c. Length—weight relationships of four fish species from a coastal artisanal fishery, southern Bangladesh, *Journal of Applied Ichthyology*, 24, 91-92. DOI: 10.1111/jai.13181
- Siddik, M.A.B., Chaklader, M.R., Hanif, M.A., Nahar, A., Ilham, I., Cole, A. and Foteder, R., 2016d. Variation in the life-history traits of a Schilbid catfish, *Clupisoma garua* (Hamilton, 1822) in the coastal waters of southern Bangladesh. *Chinese Journal of Oceanology and Limnology*, pp. 1-8.

http://dx.doi.org/10.1007/s00343-017-6008-6

- F., Masood, Z. and Hossain, M.Y., 2014. Conservation of critically endangered olive barb *Puntius sarana* (Hamilton, 1822) through artificial propagation. *Our Nature*, 11, 96-104.
- Simon, K. and Mazlan, A., 2008. Length-weight and length-length relationships of archer and puffer fish species. *The Open Fish Science Journal*, 1, 19-22.
- Sokal, R.R. and Rohlf, F.J., 1981.

 Biometry: The principles and practice of statistics in biological research (2nd Edn.), W. H. Freeman and Co., San Francisco.
- Stergiou, K. and Moutopoulos, D., 2001. A review of length-weight

- relationships of fishes from Greek marine waters. *Naga, the ICLARM Quarterly*, 24, 23-39.
- Talwar, P.K. and Jhingran, A.G., 1991. Inland fishes of India and adjacent countries, New Delhi-Calcutta, Oxford & IBH Publishing Co. Pvt. Ltd. Tesch, F.W., 1971. Age and growth. In: methods for assessment of fish production. In fresh waters, edited by Ricker, W.E. Oxford. Blackwell Scientific Publications. 348P.
- Yasemi, M. and Nazari Bejgan, A.R., 2014. The first record of southern ocean sunfish, *Mola ramsayi* from Northern Oman Sea, Iran. *Iranian Journal of Fisheries Sciences*, 13(1), 242-246.