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Biometric Relationships of the Pool Barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) from Three Major Rivers of Bangladesh

(Hubungan Biometrik Pool Barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) daripada Tiga Sungai Utama di Bangladesh)

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ABSTRACT

The present study describes population structure (length-frequency distribution-LFD) and biometric relationships including length-weight relationship (LWR), length-length relationship (LLR), Fulton's condition factor (K), relative weight (W_r) and form factor ($a_{3.0}$) of Puntius sophore *wild populations from three major rivers of different geographical locations of Bangladesh. A total of 784 specimens were caught by traditional fishing gear from March 2010 to February 2011. For each individual, the total length (TL), fork length (FL) and standard length (SL) were measured by digital slide calipers. Individual body weight (BW) was also taken by a digital balance. The results showed significant differences in TL-frequency distributions among populations ($p<0.05$), with larger mean TL size (6.92 ± 1.21 cm) was recorded from the Rupsha River. The coefficient* b *of the LWR was close to the isometric value (*$b\approx3.000$*) in these rivers of Bangladesh, although it suggested negative allometric growth in the Padma River (*$b\approx2.900$*). The results also indicated that the LWRs were highly correlated (*$r^2>0.921$*). Fulton's condition factor (K) showed significant variations (*$p<0.001$*) among the populations, with best performance by the Padma River, followed by the Jamuna and Rupsha River; whereas, relative weight (W_r) was close to 100 for all the populations, indicating the balance habitat with food availability relative to the presence of predators. The estimated values of $a_{3.0}$ were as 0.0158, 0.0142 and 0.0152 for* P. sophore *in the Jamuna, Padma and Rupsha River. These results will be useful for fishery biologists and conservationists to suggest adequate regulations for sustainable fishery management and conservation its numerous stocks in the region.*

Keywords: Biometric; condition factor; length-weight relationships; Puntius sophore

ABSTRAK

Kajian ini menghuraikan struktur populasi (pengagihan kekerapan-panjang-LFD) dan hubungan biometrik termasuk hubungan panjang berat (LWR), hubungan panjang-panjang (LLR), faktor keadaan Fulton (K), berat relatif (W_r) dan faktor pembentukan ($a_{3.0}$) populasi liar Puntius sophore *daripada tiga sungai utama dengan keadaan geografi berbeza di Bangladesh. Sebanyak 784 spesimen telah ditangkap menggunakan penangkap ikan tradisi dari bulan Mac 2010 hingga Februari 2011. Untuk setiap individu, panjang total ikan (TL), panjang cabang (FL) dan panjang piawai (SL) telah diukur menggunakan angkup slaid digital. Berat badan (BW) individu telah diukur dengan menggunakan penimbang digital. Hasil kajian menunjukkan perbezaan yang bererti (*$p<0.05$*) dalam kepelbagaian TL-kekerapan antara populasi, dengan purata saiz TL (6.92 ± 1.21 cm) direkodkan dari Sungai Rupsha. Pekali* b *daripada LWR adalah hampir kepada nilai isometrik (*$b\approx3.000$*) di sungai-sungai Bangladesh, walaupun ianya mencadangkan pertumbuhan negatif 'allometric' di Sungai Padma (*$b\approx2.900$*). Hasil kajian juga menunjukkan bahawa LWR berbeza mempunyai korelasi yang amat tinggi (*$r^2>0.921$*). Faktor keadaan Fulton's (K) menunjukkan variasi yang bererti (*$p<0.001$*) antara populasi, dengan prestasi terbaik ditunjukkan oleh Sungai Padma, diikuti oleh Sungai Jamuna dan Sungai Rupsha; manakala, berat relatif (W_r) didapati menghampiri 100 untuk semua populasi, menunjukkan kesetaraan habitat dengan kebolehdapatan makanan berbanding dengan kehadiran pemangsa. Nilai jangkaan $a_{3.0}$ didapati adalah 0.0158, 0.0142 dan 0.0152 untuk* P. sophore *di Sungai Jamuna, Padma dan Rupsha. Hasil kajian ini amat berguna bagi ahli biologi ikan dan ahli pemuliharaan untuk mencadangkan peraturan-peraturan yang sesuai bagi tujuan pengurusan perikanan mapan dan pemuliharaan stok yang pelbagai di rantau ini.*

Kata kunci: Biometrik; faktor keadaan; hubungan panjang berat; Puntius sophore

INTRODUCTION

Pool barb *Puntius sophore* (Hamilton 1822) is a small indigenous fish of Bangladesh member of the family Cyprinidae. This species is widely distributed throughout the Indian sub-continent including Bangladesh, Bhutan, India, Nepal and Pakistan (Menon 1999; Petr 1999; Rahman 1989; Talwar & Jhingran 1991). This fish is also reported from Afghanistan (Petr 1999), China (Talwar & Jhingran 1991) and Myanmar (Oo 2002). As *P. sophore* inhabits rivers, streams, ponds, beels, floodplains, *baors*,

haors in plains and sub-montane regions dominantly (Craig et al. 2004; Menon 1999), it is an important target species for small scale fishers (Rahman 2005; Shafi & Quddus 1982), who use a variety of traditional fishing gears (Kibria & Ahmed 2005). However, *P. sophore* is declining rapidly due to heavy fishing pressure and in recent studies from the Indian waters, it is categorized as lower risk near threatened in the Western Ghat (Balasundaram et al. 2000) and in Harike wetland, a Ramsar site (Dua & Parkash 2009). This fish is a major source of animal protein and micronutrients in the diet of rural small-scale farmers (Roos et al. 2007). In addition, it is an important small indigenous fish species of Bangladesh and very much famous food fish item (Rahman 2005) and can also be used as aquarium fish (Froese & Pauly 2011).

The relationship between length and weight as well as the condition factors are useful parameters for assessing the well-being of the individuals and for determining possible differences among different stocks of the same species (King 2007). In addition, condition factor is a quantitative parameter of the state of well-being of the fish that will determine the present and future population success by its influence on growth, reproduction and survival (Richter 2007). Moreover, relative weight (W_r) is one of the most popular indexes for assessing condition of fishes in the USA for the last two decades (Rypel & Richter 2008).

Several studies on *P. sophore* population including the biology, length-weight relationship (LWR), relative condition factor in Indian waters (Menon 1999; Reddy & Rao 1992; Talwar & Jhingran 1991), growth in Jamuna river, Bangladesh (De Graff 2003), length-weight and length-length relationships in the Mathabhanga river, northwestern Bangladesh (Hossain et al. 2006a), biodiversity in Pravana Sangam district Ahmednagar, India (Shinde et al. 2009) and breeding ground profile in Damodar River System, India (Sarkar & Banerjee 2010) have been conducted. However, detailed studies on the length-weight relationships (except Hossain et al. 2006a) and condition factors of this species are evidently lacking in Bangladesh (Hossain 2010a; Hossain et al. 2006b). Therefore, this study describes the LFD, LWRs, LLRs, condition factor, relative weight and form factor of *P. sophore* wild populations from different geographical regions using various body dimensions over a one year study period.

Materials and Methods

Study area and sampling

The sampling was conducted in different three geographical regions of Bangladesh including the north (Jamuna River), northwest (Padma River, also known as lower part of the Ganges) and south (Rupsha River). The samples of *P. sophore* were collected during daytime on a seasonal basis from different fisherman catch landed such as Sariakandi, Bogra (Jamuna River: Latitude 24°88'N; Longitude 89°57'E), Godagari, Rajshahi (Padma River: 24°46'N; 88°32'E) and Khulna city, Khulna (Rupsha River: 22°44'N; 89°36'E) during March 2010 to February 2011 (Figure 1). *Puntius sophore* were caught by the traditional fishing gears including *jhaki jal* (cast net), *tar jal* (square lift net) and *dughair* (conical trap) (Kibria & Ahmed 2005). Samples were immediately preserved with ice in the fish landed area and fixed with 5% formalin on arrival at the laboratory. For each individual, total length (TL), fork length (FL) and standard length (SL) were measured to the nearest 0.01 cm using digital slide calipers and whole body weight (BW) was taken on a digital balance with 0.01 g accuracy.

Length-weight and length-length relationships

The weight-length relationship was calculated using the expression: $W = aL^b$, where the W is the body weight (g) and L the total length (cm), fork length (cm) or standard length (cm). Parameters a and b were estimated by linear regression analysis based on natural logarithms: $\ln(W) = \ln(a) + b \ln(L)$. Additionally, 95% confidence limits of b and the coefficient of determination r^2 were estimated. In order to confirm whether b values obtained in the linear regressions were significantly different from the isometric value (b=3), a t-test was applied, expressed by the equation according to Sokal and Rohlf (1987): $t_s = (b\text{-}3) / s_b$, where t_s is the t-test value, b the slope and s_b the standard error of the slope (b). The comparison between obtained values of t-test and the respective tabled critical values allowed for the determination of the b values statistically significant and their inclusion in the isometric range (b=3) or allometric range (negative allometric; b<3 or positive allometric; b>3). Furthermore, TL vs. SL; TL vs. FL and FL vs. SL relationships were estimated by linear regression (Hossain et al. 2009a, 2011).

Condition factors

The Fulton's condition factor K was calculated using the equation given by Fulton (1904) as $K = 100 \times (W/L^3)$, where W is the body weight (BW) and L the total length (TL). In addition, relative weight (W_r) was calculated by the equation given by Froese (2006) as $W_r = (W / W_s) \times 100$, where W is the weight of a particular individual and W_s is the predicted standard weight for the same individual as calculated by $W_s = aL^b$ (a and b values obtained from the composite of length-weight relationships throughout the range of the species).

Form factor

The form factor ($a_{3.0}$) for each species was calculated using the equation given by Froese (2006) as: $a_{3.0} = 10^{\log a - s(b-3)}$, where a and b are regression parameters of LWRs (TL vs. BW) and S is the regression slope of log a vs b. During this study, a mean slope S = -1.358 (Froese 2006) was used for estimating the form factor because information on LWRs is not available for these species for estimation of the regression (S) of $ln\ a$ vs b.

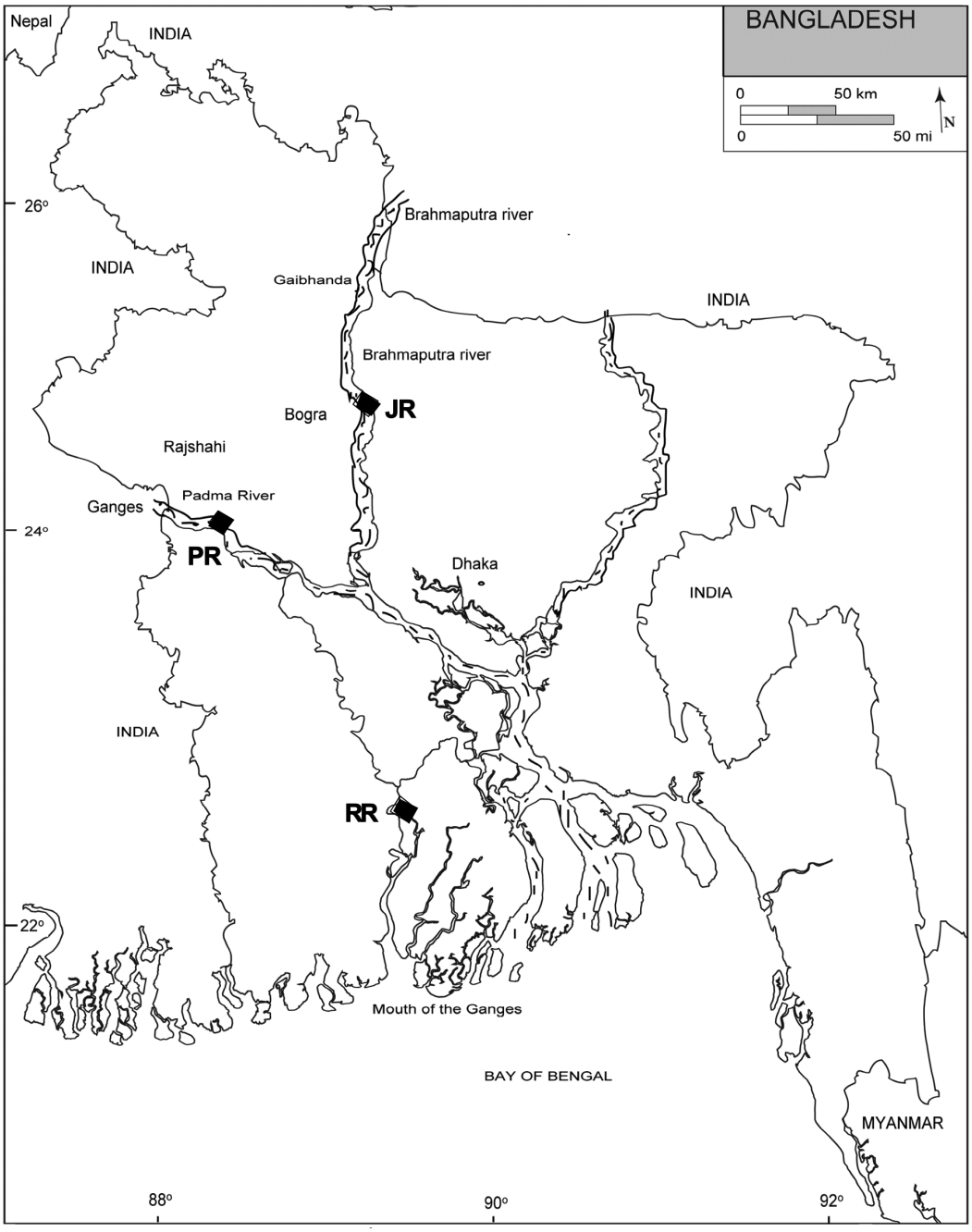

FIGURE 1. Map showing the sampling site for *Puntius sophore* (Hamilton 1822) of three major rivers of Bangladesh. The solid rectangles indicate the study site including the Jamuna River (JR), Padma River (PD) and Rupsha River (RR)

STATISTICAL ANALYSES

Statistical analyses were performed using Microsoft® Excel-add-in-DDXL, GraphPad Prism 5 and VassarStats softwares. All data were checked for homogeneity of variance. Tests for normality of each group were confirmed with a Kolmogorov-Smirnov test. Kruskal-Wallis test was used to compare the sizes (total length) among populations. A one sample t-test was used to compare between the mean relative weight (W_R) and 100 (Anderson & Neumann 1996). The parameters *a* and *b* of the LWR was compared by the analysis of covariance (ANCOVA). All statistical analyses were considered significant at 5% (p<0.05).

RESULTS

A total of 969 specimens of *P. sophore* were collected from four different geographical locations of Bangladesh during the study. Descriptive statistics on the length and weight measurements are given in Table 1. The minimum observed total length of all individuals captured was 3.51 cm from the Padma River, while the maximum size (10.20 cm) of *P. sophore* was found in the Rupsha River. The Kruskal-Wallis test revealed significant differences in TL-frequency distributions among populations (p<0.05), with larger mean size (6.92 ± 1.21 cm) was recorded from the Rupsha River (Figure 2).

TABLE 1. Descriptive statistics on the length (cm) and weight (g) measurements of the pool barb *Puntius sophore* (Hamilton 1822) from three major rivers of Bangladesh

River / Beel (Region)	*n*	Measurements	Minimum	Maximum	Mean ± SD	95% CL
Jamuna River:	208	TL	3.78	7.31	5.55 ± 0.82	4.37 – 6.37
24° 88' N - 89° 57' E		FL	3.47	6.59	5.00 ± 0.72	4.28 – 5.72
(Sariakandi, Bogra)		SL	3.04	5.77	4.35 ± 0.65	3.70 – 5.00
		BW	0.70	6.40	2.78 ± 1.23	1.55 – 4.01
Padma River:	204	TL	3.51	8.22	5.66 ± 1.04	5.51 – 5.81
24° 46' N - 88° 32' E		FL	3.17	7.36	5.09 ± 0.93	4.96 – 5.22
(Godagari, Rajshahi)		SL	2.74	6.47	4.44 ± 0.85	4.32 – 4.56
		BW	0.50	10.00	3.12 ± 1.65	2.89 – 3.35
Rupsha River:	372	TL	4.00	10.20	6.92 ± 1.21	6.68 – 7.16
22° 44' N - 89° 36' E		FL	3.60	9.20	6.27 ± 1.10	6.16 – 6.38
(Khulna city, Khulna)		SL	3.40	8.20	5.48 ± 0.97	5.38 – 5.58
		BW	1.01	18.80	5.42 ± 3.12	5.10 -5.74

n, sample size; TL, total length; FL, fork length; SL, standard length; BW, body weight; SD, standard deviation; CL, confidence limit

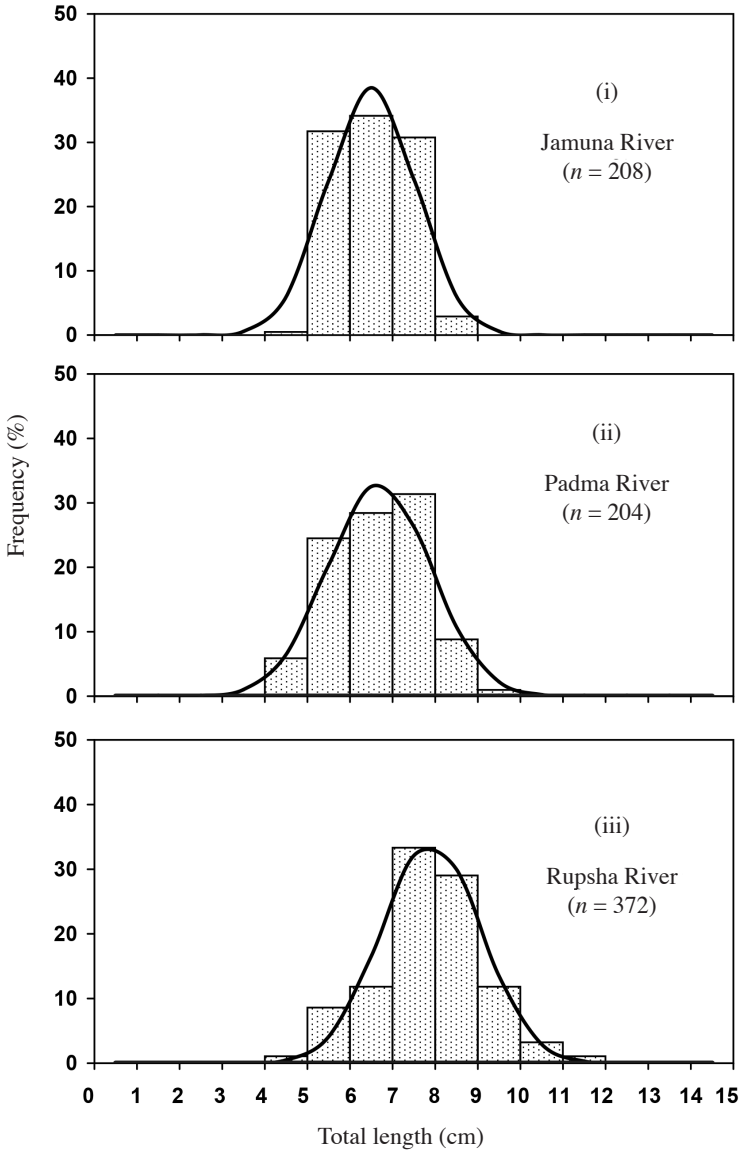

FIGURE 2. The length-frequency distribution of the pool barb *Puntius sophore* (Hamilton 1822) from three major rivers of Bangladesh

The sample size (*n*), regression parameters *a* and *b* of the LWR, 95% confidence intervals of *a* and *b*, the coefficient of determination (r^2) and growth type of *P. sophore* are given in Figure 3 and Table 2. All relationships were highly significant ($p<0.01$), with r^2 values being greater than 0.921. The calculated allometric coefficient *b* ranged from a minimum of 2.796 (for SL) in the Padma River, to a maximum of 3.175 (for FL) in the Jamuna River, with an average value of 3.088. The coefficient (*b*) of the LWR indicated isometric growth with pool barb in these

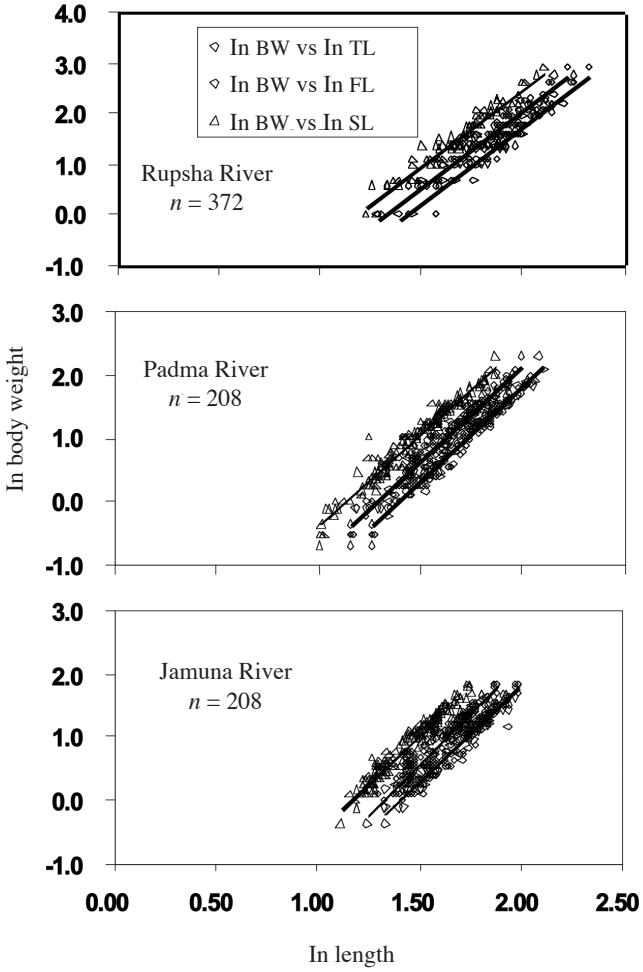

FIGURE 3. Relationship between total length (cm) and body weight (g) (ln BW = ln a + b× ln TL) for *Puntius sophore* (Hamilton 1822) based on various body dimensions from three major rivers of Bangladesh

TABLE 2. Descriptive statistics and estimated parameters of the length-weight relationships of the pool barb *Puntius sophore* (Hamilton 1822) from three major rivers of Bangladesh

Site	Equation	*n*	Regression parameters		95% CL of a	95% CL of b	r^2	*Growth type
			a	*b*				
Jamuna River	$BW = a \times TL^b$		0.014	3.038	0.012 – 0.017	2.943 – 3.133	0.950	I
	$BW = a \times FL^b$	208	0.016	3.175	0.013 – 0.018	3.067 – 3.282	0.942	I
	$BW = a \times SL^b$		0.029	3.054	0.025 – 0.034	2.954 – 3.154	0.946	I
Padma River	$BW = a \times TL^b$		0.017	2.943	0.015 – 0.020	2.853 – 3.030	0.953	I
	$BW = a \times FL^b$	204	0.022	2.990	0.018 – 0.025	2.898 – 3.083	0.952	I
	$BW = a \times SL^b$		0.039	2.882	0.034 – 0.044	2.796 – 2.968	0.955	I
Rupsha River	$BW = a \times TL^b$		0.014	3.027	0.012 – 0.016	2.940 – 3.113	0.927	I
	$BW = a \times FL^b$	372	0.019	3.025	0.016 – 0.022	2.935 – 3.116	0.921	I
	$BW = a \times SL^b$		0.027	3.058	0.023 – 0.038	2.977 – 3.139	0.937	I

n, sample size; BW, body weight; TL, total length; FL, fork length; SL, standard length; *a*, intercept; *b*, slope ; CL, confidence limit; r^2, coefficient of determination; I, isometric growth; (* based on Sokal & Rohlf (1987): $t_s = (b\text{-}3) / s_b$, where t_s is the t-test value, *b* the slope and s_b the standard error of the slope (*b*))

three rivers (b=3.00, p>0.05), as the t-test revealed the b value was not significantly different from 3 (Table 2). This study observed significant differences in intercepts (a) of the LWR (F=1575.06, p<0.001), but not with slopes (b) (F=0.176, p=0.838) in same population with different length dimensions (TL, FL / and SL). Moreover, ANCOVA revealed significant differences with intercept (a) of the LWRs (p<0.001) (Figure 3), but the slopes were not significantly different between rivers (p>0.05) (Table 3). In addition, the relationships between TL, FL and SL of the three populations 784 specimens along with the estimated parameters of the LLR and the coefficient of determination (r^2) are presented in Table 4. All LLRs were highly significant (p<0.001) and most of the coefficients of determination values being > 0.968. ANCOVA analyses further indicated significant differences in intercepts (p) and slopes (q) of the LLRs among the populations (F=80.60, p<0.001).

The Fulton's condition (K) and relative weight (W_r) values calculated for the four populations are shown in Table 5. Fulton's condition factor K showed significant variation (F=07.029, p<0.001) among the populations, with best condition in the Padma River (1.57 ± 0.22) followed by the Jamuna River (1.52±0.16) and Rupsha River (1.48±0.23). The calculated minimum and maximum relative weight (W_r) was 62.98 in the Rupsha River and 206.42 in the Padma River, respectively, with a mean value of 101.24±14.54, which was very closed to 100 (p=0.081). The estimated values of $a_{3.0}$ were as 0.0158, 0.0142 and 0.0152 for *P. sophore* in the Jamuna, Padma and Rupsha River based on TL vs. BW relationships.

Discussion

Information on biometric aspects of *P. sophore* from Bangladesh is quite insufficient (Hossain et al. 2006a). The present study recorded the maximum size of *P. sophore* in the Rupsha River as 10.20 cm TL, which was lower than the maximum record value of 18.00 cm TL in India (Froese & Pauly 2011). However, Hossain et al. (2006a) reported the maximum TL for *P. sophore* from the Mathabhanga River as 10.20 cm, northwestern Bangladesh and Rahman et al. (2012) found maximum length as 9.02 cm TL in the Chalan *beel*, north-central Bangladesh, while Shrestha (1994) recorded the maximum length of this fish as 10.00 cm TL from Nepal, which is in accordance with the present study. Nevertheless, Shan et al. (2000) recorded the maximum size of this fish as 6.00 cm SL (standard length), which is lower than any population of Bangladesh, India and Nepal. Maximum length is necessary to estimate the population

TABLE 3. The analyses of the length-weight relationships for the pool barb *Puntius sophore* (Hamilton 1822) among three major rivers of Bangladesh though analysis of covariance (ANCOVA)

	Jamuna River	Chalan Beel	Padma River	Rupsha River
Jamuna River				
Chalan Beel	a, (p < 0.01) b, (p < 0.01)			
Padma River	a, (p < 0.01) b, (p = 0.16)	a, (p < 0.01) b, (p < 0.01)		
Rupsha River	a, (p < 0.01) b, (p = 0.88)	a, (p < 0.01) b, (p < 0.01)	a, (p < 0.01) b, (p = 0.22)	

a, intercept; b, slope, P value indicates significance level

TABLE 4. Descriptive statistics and estimated parameters of the length-length relationships of the pool barb *Puntius sophore* (Hamilton 1822) from three major rivers of Bangladesh

Family	n	Equation	Regression parameters		95% CL of p	95% CL of q	r^2
			p	q			
Jamuna River		TL = p + q × SL	0.0095	1.27	-0.0493 to 0.0684	1.26 to 1.29	0.994
	208	TL = p + q × FL	-0.1895	1.15	-0.2699 to -0.1091	1.13 to 1.16	0.990
		FL = p + q × SL	0.2026	1.10	0.1441 to 0.2611	1.09 to 1.12	0.992
Padma River		TL = p + q × SL	0.0030	1.28	-0.0590 to 0.0650	1.27 to 1.29	0.992
	204	TL = p + q × FL	-0.2483	1.17	-0.3118 to -0.1847	1.16 to 1.18	0.993
		FL = p + q × SL	0.2434	1.09	0.1823 to 0.3044	1.08 to 1.10	0.989
Rupsha River		TL = p + q × SL	0.1561	1.23	0.0321 to 0.2801	1.21 to 1.26	0.970
	372	TL = p + q × FL	0.1144	1.09	-0.0103 to 0.2390	1.07 to 1.11	0.970
		FL = p + q × SL	0.1396	1.12	0.0238 to 0.2553	1.10 to 1.14	0.968

n, sample size; TL, total length; FL, fork length; SL, standard length; p, intercept; q, slope ; CL, confidence limit; r^2, coefficient of determination

TABLE 5. Fulton's condition factor, $K = 100\times (BW/TL^3)$ and Relative weight, (W_r) of the pool barb *Puntius sophore* (Hamilton 1822) from three major rivers of Bangladesh

Site	*n*	Fulton's condition factor (*K*)				Relative weight (W_r)			
		Min	Max	Mean ± SD	95% CL	Min	Max	Mean ± SD	95% CL
Jamuna River	208	0.96	2.19	1.52 ± 0.16	1.50 – 1.54	63.08	145.39	145.39 ± 10.45	98.89 – 101.75
Padma River	204	1.55	3.62	1.57 ± 0.22	1.54 – 1.60	72.15	206.42	100.80 ± 14.02	98.86 – 102.73
Rupsha River	372	0.91	2.43	1.48 ± 0.23	1.46 – 1.50	62.98	168.14	0.989 ± 0.118[c]	99.84 – 103.06

n, sample size; TL, total length; BW, body length; Min, Minimum; Max, maximum; SD, standard deviation; CL, confidence limit

parameters important for fisheries resource planning and management (Hossain 2010b). Size differences might be attributed to the variation of environmental factors, particularly water temperature and food availability (Hossain & Ohtomi 2010). Indeed, the decrease in the maximum sizes of individuals of *P. sophore* landed in major three rivers signaling the need for urgent measures to conduct extensive studies on these species to provide more information for their management and conservation. In addition, the maximum weight of *P. sophore* observed in this study (18.80 g) was also lower than the maximum recorded value of 70.0 g in Maharashtra, India (Archarya & Iftekhar 2000).

The values of *b* were within the limits 2.5-3.5 reported by Froese (2006) for most fishes. In general and despite the many variations in fish forms between species, *b* is close to 3, indicating that fish grow isometrically; values significantly different from 3.0 indicate allometric growth (Tesch 1971). LWR with *b* values significantly different from 3.0 were often associated with narrow size ranges of the specimens examined; such LWR should be used only within the respective size range. In the present study, such variations may be attributed to differences in ecological conditions of the habits or variation in the physiology of animals, or both (Le Cren 1951). In addition, the length-weight relationship in fishes can vary significantly due to sex and season (Hossain et al. 2006b; 2008), feeding rate, gonadal development and growth phase (Hossain et al. 2009b; Tarkan et al. 2006), behavior (active or passive swimmer) and water flow (Muchlisin et al. 2010), all of which were not accounted for the present study. Since samples of each species included individuals collected over several seasons, the parameters *a* and *b* would be treated as mean annual values (Hossain 2010c). According to Rypel and Richter (2008), the predicted standard weight for respective observed length was calculated using the estimated *a* and *b* parameters of the length-weight regression. However, ANCOVA showed that there was no significant difference between observation and prediction growth patterns in all populations. In a recent study, Hossain et al. (2006a) recorded the length-weight regression parameters are $a = 0.0134$ and $b = 3.050$ for *P. sophore* from the Mathabhanga River, southwestern Bangladesh, which is in accordance with the present study. Nevertheless, the slope (*b*) of the LWR was quite a bit lower (b=2.440) than 3.00, as reported by De (1985) from the Bankura, West Bengal, India.

Furthermore, body weights of *P. sophore* across sizes can be estimated from our LWRs, including asymptotic weights (W_∞) of 33.91 g in the Jamuna River, 32.27 g in the Padma River and 32.96 g in the Rupsha River, as based on the asymptotic total length (L_∞) of 13.00 cm (without regard for sex) from the Brahmaputra (Jamuna) River, Tangail, Bangladesh (De Graaf 2003).

The *K* values among the three populations showed significantly differences in the present study. No references dealing with the condition factors of *P. sophore* are available in the literature (Hossain 2010b), preventing the comparison with previous results. However, condition factor based on the LWR is an indicator of the changes in food reserves and therefore an indicator of the general fish condition (Hossain et al. 2012). In general, the seasonal cycle in fish's condition suggested a relationship to gonadal development. According to Hossain et al. (2006b), the condition factor of *Mystus vittatus* (Bloch 1794) (Siluriformes: Bagridae) was constant during the pre-spawning period, decreased in the period of spawning and was lowest immediately after spawning. However, only the seasonal data were used during this study, thus it is difficult to compare among the condition of fishes throughout the year.

In addition, the values of W_r falling below 100 for an individual, size group or population suggest problems such as low prey availability or high predatory density; whereas values above 100 indicate a prey surplus or low predatory density (cf. Rypel & Richter 2008). Recently, a number of studies have espoused the use of W_r for assisting in the management and conservation of nongame fishes, particularly those that are threatened or endangered (Bister et al. 2000; Didenko et al. 2004; Richter 2007). However, to the best of our knowledge, the present paper was to carry out the first comprehensive description of W_r for the sub-tropical freshwater fishes from differential geographical locations. This study showed that the condition factor values (W_r) of *P. sophore* was close to 100 for all studied populations, indicating the balance habitat with food availability relative to the presence of predators (Anderson & Neumann 1996). In addition, it might be indicated that the water quality of these water-bodies are still adequate to support fish communities including *P. sophore*. Nevertheless, this fish is categorized as lower risk near threatened in the Western Ghat (Balasundaram et al. 2000) and in Harike wetland - a Ramsar site (Dua & Parkash 2009) in India. This might be attributed to other reasons rather than water quality. Moreover, this information would allow for urgent detection of any long-term declines in condition that may have occurred, possibly as a result of environmental change as the relative condition integrates key physiological components of fish life history (lipid storage and growth), it suggests a strong, handy metric that managers can use to evaluate the overall health and fitness as well as population-level responses to ecosystem disturbance (cf. Rypel & Richter 2008). However, according to (Offem et al. 2007), the seasonal variation in food supply may change this condition factor. According to Froese (2006), the application of the form factor $a_{3.0}$ can be used to verify whether the body shape of individuals in a given population or species is significantly different from others. In this study, the estimated values of $a_{3.0}$ were as 0.0158, 0.0142 and 0.0152 in the Jamuna, Padma and Rupsha River suggesting that *P. sophore* can be classified as relatively elongate which is characteristic of many riverine fishes. No references (except Rahman et al. 2012) dealing with the $a_{3.0}$ are available in the literature for tropical or sub-tropical freshwater species (Froese 2006) and the present results provide an important basis for future

comparisons. However, Rahman et al. (2012) calculated the $a_{3.0}$ of this fish from the Chalan *beel* was 0.0138, which is in accordance with the present study.

Conclusions

In conclusion, this study also provide the basic information on the length-weight, length-length relationships based on various body dimensions, condition factor, relative weight and form factor for *P. sophore* from three major rivers of Bangladesh, which would be effective for fishery biologists and conservationists to impose adequate regulations for sustainable fishery management and conservation its numerous stocks in the region. Moreover, no condition factors currently exist in the FishBase for this species and therefore, our results may contribute to this invaluable electric database.

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