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Evaluating Biometric Indices and Life History Traits of Indian Glassy Perch, *Parambasis ranga*: Implications for Sound Management

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ABSTRACT

The current study described the biometric indices and life-history traits, including population structure, growth pattern, condition factors, form factor (a3.0), size at first sexual maturity (L_m), natural mortality (M_W) and optimum catchable length (L_{opt}) of *Parambassis ranga* from three culture management systems (S1, S2 and S3) in the Oxbow Lakes, southwest Bangladesh. Fish samples (n = 2415) were harvested (January-December, 2021) using cast, push and gill nets. S1 comprises the Baors of Boluhor and Joidia; S2 comprises the Baors of Nasti and Porapara and S3 comprises the Baors of Kushna and Jagodishpur. Specimen's total lengths (TL) spanned from 2.40–4.60cm for S1, 2.30–4.51cm for S2 and 1.90–3.90cm for S3, respectively. The length-frequency distributions (LFDs) revealed that the size groups with 3.6–3.7cm TL for S1, 3.0–3.10cm TL for S2 and 2.80–2.90cm TL were numerically dominant. The growth pattern for S1 was found to be positive allometric based on the length-weight relationships (LWRs), while S2 and S3 showed negative allometric growth. Allometric, relative, Fulton condition parameters and relative weight (K_A, K_R, K_F and W_R) showed positive associations (P< 00.05) using correlation assessment suggesting that the species are performing well. Among all the three condition indices, the Fulton condition factor is highly used and is the prominent condition factor among all three condition indices. The L_m values for S1, S2 and S3 were 3.0753, 3.0143 and 2.6442cm TL, respectively, based on the maximum length (L_{max}). Furthermore, for S1, S2 and S3 the M_W values were 1.72, 1.91 and 20.05/year correspondingly. The outcomes of this investigation would be extremely helpful for managing *P. ranga* in the three management systems and in the southwestern Bangladeshi Oxbow Lakes in an efficient and sustainable manner.

INTRODUCTION

Oxbow Lake, a segment of a dead river in the moribund delta is more popularly called as Baor in Bangladesh. The general shape of a Baor seems to be a saucer-shaped depression. There are more than 600 Baors located in southwestern region of Bangladesh with a total volume of 5,488 hectares. The majority of these Baors are located in several greater districts such as Jashore, Kustia and Faridpur, with the Jashore district having the largest numbers **(DoF, 2020)**. Many people in the local population only rely on the Baor fishery for their living, and the region boasts a wide variety of fishing resources. The Baors of Bangladesh serves as major breeding ground of small indigenous fish species (SIFS). Three systems are primarily in charge of managing Baors in Bangladesh: system-1 **(OLP, 1997)**, system-2 **(OLP, 1997)**, and system-3 **(GJMP, 2009)**. The three management systems differ in a few significant ways, which are listed in Table (1). Department of Fisheries stocks fingerlings in system-1, although fishermen's groups that are primarily involved in the management system stock fingerlings in systems-2 and 3. The main characteristics of system-1 are the creation of sanctuaries and the absence of feeds, fertilizers, and pesticides. Furthermore, local populations collect small indigenous fish from Baors all year-round using nets with a minimum mesh size of 2.0cm in system-1; however, there are no limits in system-2 and system-3. Nevertheless, the majority of Baor fisheries have lost their trendy potentials because of overfishing, use of destructive fishing methods, loss and degradation of fish habitats, natural siltation of water bodies and water contamination from industrial and agricultural operations **(Gain *et al.*, 2017; Mahfuj *et al.*, 2019, 2022; Samad *et al.*, 2022a, b; Samad *et al.*, 2023)**.

The fish, *Parambassis ranga* is a significant species of the Ambassidae family. They can be observed in South Asian and South East Asian countries **(Froese & Pauly, 2018)**. This fish species has a high market value and is generally kept in aquariums **(Arunachalam *et al.*, 2000; Dawes, 2001)**. These fish live in wetlands, beels, ponds, ditches, clean streams and flooded waters **(Rahman, 1989; Kapoor *et al*., 2002)**. Worms, crustaceans, and other invertebrates are their primary food sources **(Mills & Vevers, 1989; Rainboth, 1996)**. *P. ranga* is the most well-known tiny native species with rich levels of protein, minerals and vitamin A **(Hossain *et al.*, 2015; Hossen *et al.*, 2020)**. The utilization of illicit fishing gear, indiscriminate fishing, habitat destruction and modification, water pollution and further environmental instabilities change their environment, causing the decline in the wild populations **(Hossain *et al.*, 2015a)**. According to **IUCN (2018)**, *P. ranga* are universally considered as least concern (LC) species.

For the purpose of managing and conserving these fish sustainably, knowledge on their life history characteristics is crucial. In addition, these data make it easier to compare the health of the fish's habitat and condition **(Hossain *et al.*, 2015a)**. The size at sexual maturity **(Hossain *et al.*, 2015b; Hossain *et al.*, 2020)**, condition factors **(Islam *et al.*, 2021)**, the length-frequency distribution (LFDs), length–weight relationships, LWRs **(Asadujjaman *et al.*, 2022)**, and form factor **(Khan *et al.*, 2023; Sabbir *et al.*, 2023)** of various fish species from diverse ecosystems are well documented; nevertheless, there is infrequent information on the life history of *P. ranga* in the Oxbow Lakes. Few studies concerning the biometric and life history traits have been performed on this species from other ecosystems (Table 2). For effective management of these species and initiate conservation efforts for the Oxbow Lakes in southwest Bangladesh, comprehensive data on their life history traits (LHT) are vital. Hence, this study emphasized on describing the LFDs, LWRs, condition factors, form factor ($a_{3.0}$), size at first sexual maturity (L_m) and natural mortality (M_W) of *P. ranga* from the Oxbow Lakes in the southwestern Bangladesh.

Table 1. Major characteristics of three different systems practiced for Baor management in southwest Bangladesh

	System-1 (S1)	**System-2 (S2)**	**System-3 (S3)**
Characteristics	1. Baor directly supervised by Department of Fisheries DoF.	1. Baor partially supervised by DoF.	1. Baor supervised by local administration.
	2. Baor operated by Baor communities and DoF.	2. Baor operated by Baor communities and DoF.	2. Baor operated by a group of influenced people through leasing system.
	3. Production costs borne by DoF.	3. Production cost borne by Baor communities.	3. Production costs borne by lessee people.
	4. Feed, fertilizers and chemicals not used.	4. Feed, fertilizers and chemicals partially used.	4. Feed, fertilizers and chemicals highly used.
	5. Fish sanctuary established.	5. Sanctuary not established.	5. Sanctuary not established.
	6. DoF highly benefitted.	6. DoF moderately benefitted.	6. DoF not benefitted, lessee people highly benefitted.
	7. Baor communities moderately benefitted.	7. Baor communities highly benefitted.	7. Baor communities not benefitted.
	8. Fishing gear restricted for small indigenous fish species (SIFS).	8. Fishing gear partially restricted for SIFS.	8. Fishing gear not restricted for SIFS.
	9. Traditional culture practice used.	9. Improved traditional culture practice used.	9. Semi-intensive culture practice used.
References	**(OLP, 1997a)**	**(OLP, 1997b)**	**(GJMP, 2009)**

Table 2. Morphometrics, meristics, growth, condition and reproduction aspects for ambassid fish species

Aspects	Water body and locations	References
Growth and condition	Ganges river, Bangladesh	Hossain *et al*., (2016)
	Brahmaputra river, Bangladesh	Islam *et al*., (2017)
	Deepor Beel, Assam, India	Borah *et al*., (2017)
	Hirakud Reservoir, India	Karna *et al*., (2018)
Meristics, growth and condition	Mathabhanga River, Bangladesh	Hossen *et al*., (2020)
	Chalan Beel, Bangladesh	Rana *et al*., (2022)
Reproduction	Haebaru reservoir, Southern Japan	Ishikawa and Tachihara (2012)
Truss-based morphometrics	Madhumati, Tulshiganga rivers and Jhapa oxbow lake, Bangladesh	Azad *et al*., (2020)
Stock status	Ganges river, Bangladesh	Asaduzzaman *et al*., (2024)
Life-history traits	Bukvora oxbow lake, Bangladesh	Samad *et al*., 2022

MATERIALS AND METHODS

Sampling locations

A total of 2415 *Parambassis ranga* specimens were collected from six *Baors* under three different management systems through the fishers' catch from January to December 2021. System-1 **(OLP, 1997a)** comprises the Baors of Boluhor and Joidia; System-2 **(OLP, 1997b)** comprises the Baors of Nasti and Porapara; and System-3 **(GJMP, 2009)** comprises the Baors of Kushna and Jagodishpur (Fig. 1). Three classic fishing nets namely, push net (mesh sizes: 0.8 to 1.4cm), cast net (mesh sizes: 0.8 to 1.4cm), and gill nets (mesh sizes: 0.8 to 1.4cm) were used to sample fish from fishermen's catch in each month. To ensure that all of the specimens from the same research locations were included in the catch. These three fishing nets were set up once a month at the same spot within 0.5km of each Baor. The specimens were gathered and maintained using 8% alcohol and brought in the Fisheries Biology Laboratory, Jashore University of Science and Technology (JUST) in Bangladesh for further experimentation.

Fish measurement

The total length (TL) and body weight (BW) were measured with an accuracy of 0.01cm and 0.01g correspondingly using modern slide calipers and weight scale. Furthermore, TL and BW were taken into account for the data analyses using MS Excel.

Length-frequency distribution (LFD)

Class intervals (0.10cm) of total length were used to reveal LFD for the population of *P. ranga* using PAST software and a normal distribution curve was generated for the TL frequency distribution of *P. ranga* **(Hammer *et al*., 2001)**.

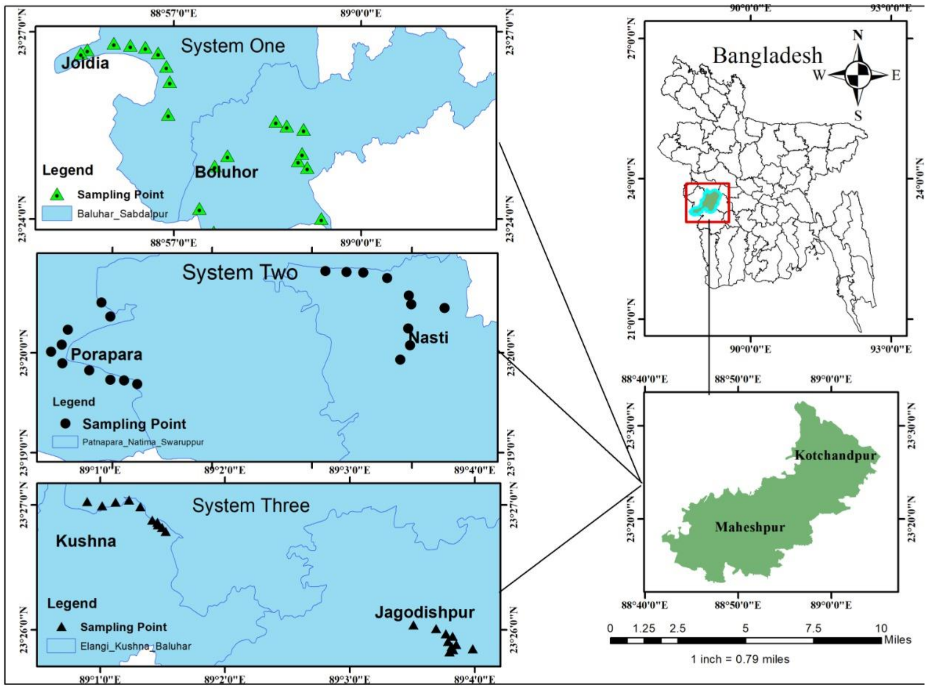

Fig. 1. Map indicating the study locations (Baor*s*) in southwestern region of Bangladesh where samples of *Parambassis ranga* were gathered (S1 = System 1, S2 = System 2, S3 = System 3)

Growth pattern

Following the formula BW = a×(TL)^b allowed for the identification of growth analysis. Using TL and BW of fish, the linear regression equation, ln (BW) = ln (a)+b×ln (TL), was used to estimate natural logarithms as well as determine the value of the regression parameters, 'a' and slope 'b'. Additionally, the coefficient of determination (r^2) and the 95% confidence limits for 'a' and 'b' were calculated. To find outliers, ln-ln plots of the TL and BW values were performed before the regression analysis of ln-BW on ln-TL (**Froese, 2006)**. Regression analysis was conducted without including extreme outliers.

Condition factors and form factor

The allometric condition factor (K_A) was evaluated using the model of **Tesch (1968)** as follows: $K_A = W/L^b$. Where, W = BW; L = TL and b = LWRs parameter. The Fulton condition factor (K_F) was determined using the equation, K_F = 100×(W/L3) **(Fulton, 1904)**, where W is the BW and L is the TL. To get the K_F near to the unit, a scaling factor of 100 was applied. The relative condition factor (K_R) was calculated, **Le Cren (1951)** ($K_R = W/(a×L^b)$; where, W is the BW, L is the TL and 'a' and 'b' are LWR parameters. The $a_{3.0}$ was calculated using the method developed by **Froese (2006)**, $a_{3.0} = 10^{\log a - S(b-3)}$. Where 'a' and 'b' represented regression parameter of LWRs and S = regression slope of ln 'a' versus 'b'. A mean slope, S = −1.358 **(Froese, 2006)** was utilized in this study to evaluate the form factor ($a_{3.0}$).

Assessment of relative weight (W_R)

The prey-predator status **(Froese, 2006)** was evaluated using the relative weight formula, $W_R = (W/W_S)\times100$. Where, W is BW and WS represents the expected standard weight for the same specimen, determined by WS = a×L. WS represents the expected standard weight for the same person, determined by $W_S = a\times L^b$.

Size at sexual maturity and natural mortality

The L_m **(Binohlan & Froese, 2009)** was evaluated using the following equation: $\log(L_m) = -0.1189+0.9157\times\log(L_{max})$. Additionally, the M_W was considered using the model developed by **Peterson and Wroblewski (1984)**: $M_W = 1.92\text{year}-1*(W)^{-0.25}$. Where, M_W = natural mortality at body mass $W = a*L^b$, where 'a' and 'b' represented LWR regression parameters.

Optimum catchable length (L_{opt})

The optimal catchable length (L_{opt}) can be defined as maximum number of fish can be caught **(Froese *et al.*, 2018)**. The optimal catchable length, L_{opt} was calculated using the **Binohlan and Froese (2009)** model: $\text{Log}L_{opt} = 1.0421*\log(L_\alpha)-0.2742$, where L_α is the asymptotic length.

Statistical analyses

Statistical analyses were conducted using PAST and SPSS 25 software tools and considered at 5% significance level.

RESULTS

Population structure

Table (3) exhibits the descriptive statistics for TL and BW of *P. ranga* collected from three management systems. The lengths of the specimen ranged from 2.40–4.60 for S1, 2.30–4.51 for S2 and 1.90–3.90cm TL for S3. Similarly, the body weights of the specimens ranged from 0.17–1.62g for S1, 0.24–1.01g for S2 and 0.11–0.74g for S3. The LFDs indicated that the 3.5–3.7cm TL size groups (77.5% of total specimens) for S1, 3.0–3.1cm TL size group (62.9% of total specimens) for S2 and 2.7–2.8cm TL size group (37.3% of total specimens) for S3, were numerically dominant in the three culture systems (Fig. 2).

Table 3. Descriptive statistics of the total length (cm) and body weight (g) measurements or *P. ranga* collected from three culture systems (Oxbow Lakes), southwest Bangladesh

		Total length (cm)				Body weight (g)			
Locations	**n**	**Min**	**Max**	**Mean ± SD**	**95% CL**	**Min**	**Max**	**Mean ± SD**	**95% CL**
S1	644	2.40	4.60	3.60 ± 0.45	3.57 – 3.64	0.17	1.62	0.99 ± 0.35	0.96 – 1.02
S2	1075	2.30	4.51	3.27 ± 0.39	3.26 – 3.31	0.24	1.01	0.54 ± 0.18	0.53 – 0.55
S3	696	1.90	3.90	2.78 ± 0.39	2.74 – 2.80	0.11	0.74	0.30 ± 0.11	0.29 – 0.31

Abbreviations: n, sample sizes, SD, Standard deviation; CL, Confidence limits

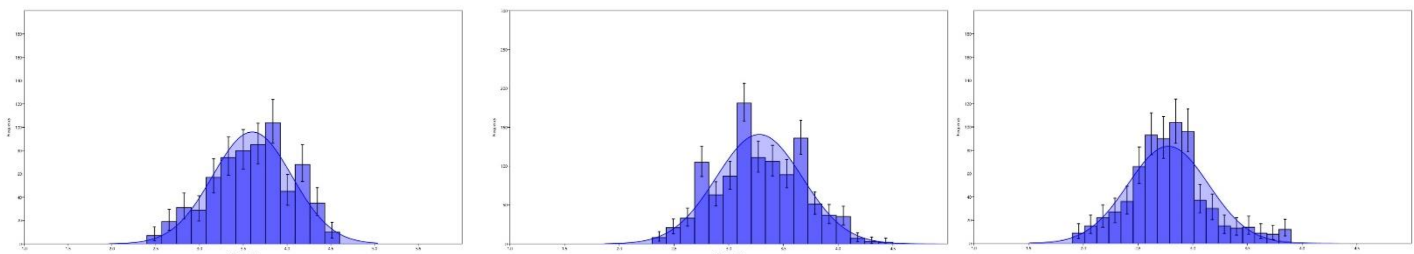

Fig. 2. Length-frequency distribution of *Parambassis ranga* collected from three culture systems (Oxbow Lakes), southwestern Bangladesh

Growth pattern

The sample sizes (n), regression parameters (‘a’ and ‘b') and 95% confidence intervals for a and b of the LWRs, coefficients of determinations (r^2) and growth types of *P. ranga* collected from three management systems are presented in Table (4). The allometric coefficient (b) of the LWRs (TL versus BW) indicated positive allometric growth (b > 3) for S1, negative allometric growth (b < 3) for S2 and S3 (Fig. 3). All LWRs were highly significant (*P*< 00.05) with all r^2 values exceeding 0.800.

Table 4. Length-weight relationships (LWRs) parameter of the *P. ranga* collected from three culture systems (Oxbow Lakes) southwest, Bangladesh

Locations	**Equations**	**Regression parameters**		**95% of CI ‘a’**	**95% of CI ‘b’**	$\mathbf{r^2}$	$\mathbf{t_s}$	**GP**
		Intercept (a)	**Slope (b)**					
S1	BW = a * TL^b	0.0176	3.0988	0.0149 – 0.0206	2.9735 – 3.2239	0.8320*	48.6037	A+
S2	BW = a * TL^b	0.0206	2.7213	0.0195 –0.02173	2.6756 – 2.7668	0.9273*	117.0164	A–
S3	BW = a * TL^b	0.0245	2.4210	0.0228 – 0.0262	2.3529 – 2.4890	0.8755*	69.8595	A–

Abbreviations: CI, Confidence interval for mean values; TL, total length; BW, body weight; r^2, co-efficient of determination, t_s, sample t-test value; GP, growth pattern; A–, Negative allometry; *, Significant correlations.

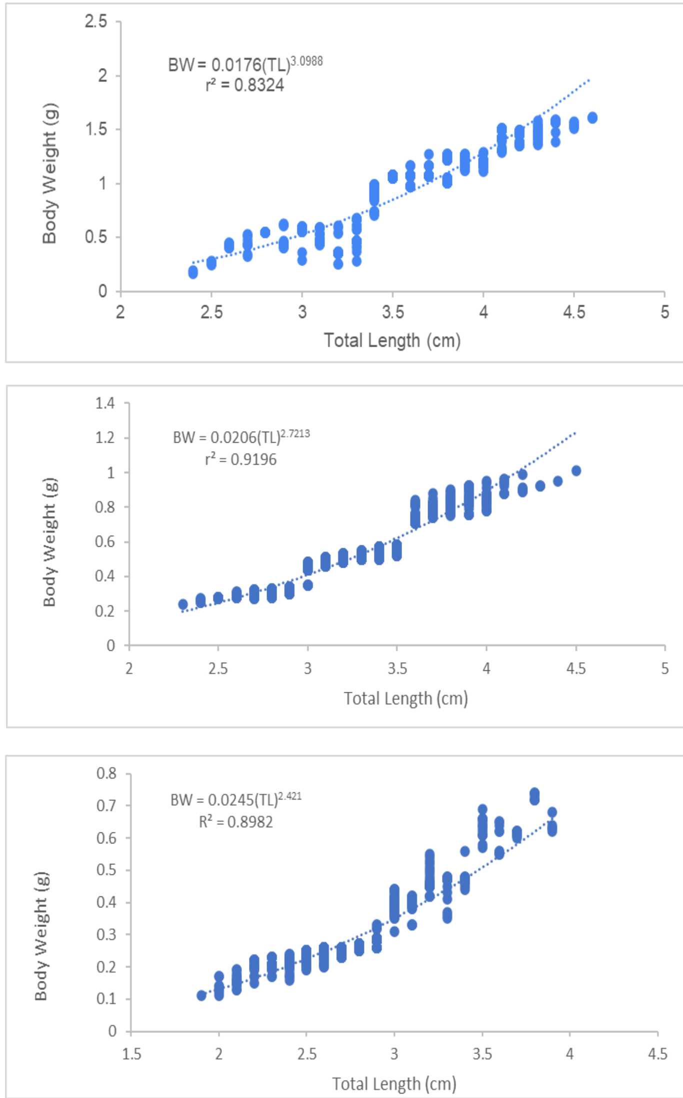

Fig. 3. Length-weight relationships (LWRs) of *Parambassis ranga* collected from three management systems (Oxbow Lakes), southwest Bangladesh

Condition factor and form factor

The K_A ranges in the present study were 0.0077–0.0268 for S1, 0.0165–0.0257 for S2 and 0.0192–0.0332 for S3 of *P. ranga* (Table 5). The K_F ranges were 0.7791–2.6926 for S1, 1.1083–1.9725 for S2 and 1.3751–2.1252 for S3 (Table 5). The K_R ranges were 0.4478–1.5492 for S1, 0.8033–1.2489 for S2 and 0.7842–1.3567 for S3 (Table 5). The W_R was ranges 44.7850–154.9212 for S1, 80.3397–124.8952 for S2 and 78.4264–135.6733for S3 (Table 5). The associations of condition factors (i.e. K_A, K_F, K_R and W_R) with TL and BW are shown in Table (6). The evaluated $a_{3.0}$ values were 0.01703, 0.01762 and 0.01882 for S1, S2 and S3 separately (Table 7).

Table 5. Condition factors (K_A, K_F, K_R *and* W_R) of *P. ranga* collected from three culture systems (Oxbow Lakes), southwest Bangladesh

Condition factors	**Min**	**Max**	**Mean ± SD**	**95% CL**
S1				
Allometric condition factor (K_A)	0.0077	0.0268	0.02018 ± 0.0036	0.0199 – 0.0204
Fulton´s condition factor (K_F)	0.7791	2.6926	2.0308 ± 0.3710	2.0021 – 20.0595
Relative condition factor (K_R)	0.4478	1.5492	1.1668 ± 0.2132	1.1503 – 1.1834
Relative Weight (W_R)	44.7850	154.9212	116.6898 ± 21.3294	115.0393 – 118.3402
S2				
Allometric condition factor (K_A)	0.0165	0.0257	0.0196 ± 0.0018	0.0205 – 0.0207
Fulton´s condition factor (K_F)	1.1083	1.9725	1.4889 ± 0.1468	1.4801 – 1.4977
Relative condition factor (K_R)	0.8033	1.2489	1.0036 ± 0.0920	0.9981 – 1.0091
Relative Weight (W_R)	80.3397	124.8952	100.3670 ± 9.2098	99.8158 – 100.9181
S3				
Allometric condition factor (K_A)	0.0192	0.0332	0.0146 ± 0.0030	0.0244 – 0.0248
Fulton´s condition factor (K_F)	1.3751	2.1252	1.7690 ± 0.2013	1.7206 – 1.8173
Relative condition factor (K_R)	0.7842	1.3567	1.0069 ± 0.1228	0.9977 – 1.0160
Relative Weight (W_R)	78.4264	135.6733	100.7069 ± 12.2713	99.7936 – 101.6202

Table 6. Condition factors (K_A, K_F, K_R *and* W_R) of *P. ranga* collected from three culture systems (Oxbow Lakes), southwest Bangladesh

Parameters	**TL**	**BW**	**KA**	**KF**	**KR**	**WR**
S1						
TL	1.000					
BW	0.948**	1.000				
KA	0.041	0.225**	1.000			
KF	0.049	0.233**	1.000**	1.000		
KR	0.041	0.225**	1.000**	1.000**	1.000	
WR	0.041	0.225**	1.000**	1.000**	1.000**	1.000
S2						
TL	1.000					
BW	0.977**	1.000				
KA	-0.006	0.142**	1.000			
KF	-0.421**	0.276**	0.896**	1.000		
KR	-0.006	0.142**	1.000**	0.896**	1.000	
WR	-0.006	0.142**	1.000**	0.896**	1.000**	1.000
S3						
TL	1.000					
BW	0.948**	1.000				
KA	0.067	0.317**	1.000			
KF	-0.524**	0.285**	0.766**	1.000		
KR	0.065	0.314**	1.000**	0.767**	1.000	
WR	0.065	0.314**	1.000**	0.767**	1.000**	1.000

** Correlation is significant at the 00.05 level (2-tailed).

Table 7. Calculated asymptotic length (L_∞), form factor ($a_{3.0}$), size at first sexual maturity (L_m), natural mortality (M_W) and optimum catchable length (L_{opt}) for *P. ranga* collected from three management systems (Oxbow Lakes), southwest Bangladesh

Locations	L_∞ (cm)	L_{opt} (cm)	L_m (cm)	M_w (year)	$a_{3.0}$
S1	4.9670	2.8261	3.0753	1.72	0.01703
S2	4.8607	2.7631	3.0143	1.91	0.01762
S3	4.2227	2.3883	2.6442	20.05	0.01882

L_∞ = Calculated asymptotic length, L_{opt} = optimum catchable length, L_m = size at first sexual maturity, M_w = natural mortality and $a_{3.0}$ = form factor.

Size at sexual maturity and natural mortality

Size at sexual maturity based on the maximum lengths of *P. ranga* were assessed from three management systems (S1, S2 and S3). The sizes at sexual maturity, L_m were estimated as 3.0753cm TL for S1, 3.0143cm TL for S2 and 2.6442cm TL for S3 (Table 7). Considering the maximum lengths, the calculated asymptotic lengths were 4.9670cm TL for S1, 4.8607cm TL for S2 and 4.2227cm TL for S3 (Table 7). Further, the natural mortalities (M_W) were 1.72/year, 1.91/year and 20.05/year for S1, S2 and S3 culture systems, respectively (Table 7).

Optimum catchable length (L_{opt})

The optimum catchable lengths were (Lopt) 2.8261cm TL for S1, 2.7631cm TL for S2 and 2.3883cm TL for S3 (Table 7).

DISCUSSION

No studies based on the biometric and life history traits of *P. ranga* have been carried out in the ecosystems of Oxbow Lakes in Bangladesh despite the abundance of literature addressing, in particular, ecosystems across the globe **(Hossain *et al.*, 2016; Islam *et al.*, 2017)**. Therefore, the current study presents the first details on the biometric and life history characteristics of *P. ranga* species from three management systems in the Oxbow Lakes in southwest Bangladesh. The current study examined 2415 *P. ranga* individuals of different body sizes taken from three different management systems. It should be mentioned that fish total length (<1.90cm) could not be harvested in the current study. This happened since smaller fish are not present in the study regions or the fishing gear's selectivity **(Hossain *et al.*, 2015a)**. The maximum total lengths (TL) for S1, S2, and S3 in the current study were 4.60cm, 4.51cm and 3.90cm, respectively, although the maximum total length in a different study reported 8.0cm **(Rahman, 1989)**. Similarly, **Hossain *et al.* (2016)** recorded a maximum length (6.4cm) for *P. ranga* collected from the Padma River, Bangladesh. This result is consistent with the current study's observations. Fish growth coefficient and asymptotic length are vital metrics for managing fisheries resources. These two parameters (i.e. growth coefficient and asymptotic length) can only be estimated using the maximum length information **(Hossain *et al.*, 2015a)**. Growth coefficient (b = 3) usually specifies isometric fish growth, regardless of fluctuations in fish morphologies; values higher than 3.0 designate a positive allometric growth and lower than 3 refer to a negative allometric growth. Considering the ‘b’ values of LWRs in the study, we found that S1 displayed positive allometry ($b > 3.0$), whereas S2 and S3 exhibited negative allometry ($b < 3.0$). Plethora of reasons behind the issues of getting allometric variations such as health condition (fatty and lean fish), sex, food sources, feeding patterns, gonadal maturity and preservation methods of the collected specimens can all affect the growth pattern of *P. ranga* in the three management systems **(Hossain *et al.*, 2014)**. According to **Hossain *et al.* (2019)**, *P. ranga* in the Padma River showed ‘b’ values of 3.23 and 3.20, respectively, which are reliable with the results of this investigation.

Three condition factors (i.e. K_A, K_F, K_R) and relative weight (W_R) were analyzed in the present study. In case of condition factors, many studies merely observed only one factor, but we conducted three condition factors and relative weight (W_R). The obtained K_A ranges in the present study were 0.0077–0.0268 (average, 0.0201) for S1, 0.0165–0.0257 (average, 0.0196) for S2 and 0.0192–0.0332 (average, 0.0146) for S3. The obtained K_F ranges were 0.7791–2.6926 (average, 2.0308) for S1, 1.1083–1.9725 (average, 1.4889) for S2 and 1.3751–2.1252 (average, 1.7690) for S3. The obtained K_R ranges were 0.4478–1.5492 (average, 1.1668) for S1, 0.8033–1.2489 (average, 1.0036) for S2 and 0.7842–1.3567 (average, 1.0069) for S3. While the W_R ranges were 44.7850–154.9212 (average, 116.6898) for S1, 80.3397–124.8952 (average, 100.3670) for S2 and 78.4264–135.6733 (average, 100.7069) for S3. Throughout this study, the value of K_A, K_F, K_R and W_R were higher for S1 than S2 and S3, indicating the fish gets heavier as it grows larger than the other two systems of S2 and S3. Based on the above average values, it can be noted that the best condition factor will be K_F for the studied species as well as for the three systems (S1, S2 and S3). In the system of S1, natural aquatic environment is maintained by establishing the sanctuary, inhibiting the use of artificial feed, fertilizers, and chemicals, and restricting the mesh sizes of fishing gears in the water bodies. As a result, fish can get chances to grow properly. **Ricker (1975)** stated that variables including sex, gonad development, age, growth, seasonal variations, and feeding circumstances affect the condition factor values of the fish population.

The condition indices (i.e. K_A, K_F, K_R and W_R) showed significant differences with BW in the correlation tests for the three management systems (i.e. S1, S2 and S3) and thereby the condition factors considering the best markers for well-being in the three management systems (i.e. S1, S2 and S3). **Islam *et al.* (2017)** reported that *P. ranga* from the Brahmaputra River in Bangladesh exhibited a K_F range of 1.16–1.84 and W_R range of 75.68–130.60. Conversely, in our present study the K_F ranges from 1.4889 to 2.0308 and the W_R ranges from 75.68 to 1.3060, indicating the better performance of K_F and W_R in the present study. In the present study, three types of conditions and relative weight were higher in S1 system which could have been caused by establishment of natural aquatic environments for inhabiting and growth of this species, such as presence of sanctuary, accelerating mass vegetation, and restricting the mesh sizes of fishing gears in the water bodies. Similar results were also observed by **Hossain *et al.* (2019)**, where they found similar age and growth of individuals.

The management system could all have an impact on the conditions, which varied somewhat across the three systems **(Khatun *et al.*, 2019)**. To determine whether a fish's body shape is substantially different from that of other members of the same population or species, the $a_{3.0}$ value is highly crucial **(Froese, 2006)**. The form factor ($a_{3.0}$) values for S1, S2 and S3 in the current study were 0.01703, 0.01762 and 0.018882 separately, whereas **Islam *et al.* (2017)** reported $a3.0$ value of 0.007 for *P. ranga* collected from the Brahmaputra River, northern part of Bangladesh. The three conditions can be varied, which could have been caused by the method of preservation, the health of the stock, the fullness of the stomach, the gonadal maturity, the gender, the season, or the location **(Hossain *et al.*, 2019; Khatun *et al.*, 2019)**.

To ascertain the cause(s) of the variances in fish sizes at maturity, one must consider the size of the fish during sexual maturity (L_m) **(Templeman, 1987)**. Based on L_{max}, the computed L_m values were 3.0753 for S1, 3.0143 for S2, and 2.6442cm for S3, respectively. In contrast, L_m value of 2.58cm TL for *P. ranga* reported by **Ishikawa and Tachihara (2012)** from the Haebaru basin, Japan, is in parallel with the results of this investigation. On contrary, results of the current investigation don't align with the study of **Hossain *et al.* (2019)**, who found L_m value of 4.28cm TL for *P. ranga* from the Mathabhanga River, Bangladesh. The natural mortalities (M_W) were 1.72, 1.91 and 20.05/year, respectively, in the three culture systems (i.e. S1, S2, and S3). Conversely, **Hossain *et al.* (2019)** found that *P. ranga* from the Mathabhanga River, Bangladesh exhibited a (M_W) of 2.70cm TL, which is higher than the results of this investigation. The optimum catchable lengths (L_{opt}) for S1, S2 and S3 were 2.8261, 2.7631 and 2.3883cm TL individually. On the contrary, **Hossain *et al.* (2019**) found that *P. ranga* from the Mathabhanga River displayed a L_{opt} value of 4.65cm TL, which is greater than the results of the current investigation. It is reported that Oxbow Lake in southwest Bangladesh maintains ideal water levels all year round since government rules and regulations are scrupulously followed, there is no option to kill fish without any causes. Fishing enthusiasts and people in the area will be benefited if sexually mature *P. ranga* species will be preserved in the Oxbow Lakes and allow back to their natural breeding grounds.

CONCLUSION

Based on the current investigation, it can be concluded that the growth pattern of *P. ranga* in the Baors of S1 management system is isometric. By establishing the sanctuary, banning the use of chemicals, artificial feed, and fertilizers, and limiting the mesh sizes of fishing gear in the S1, this approach preserves the natural aquatic ecosystem and natural environment for wellbeing of this species. On the other hand, negative allometric growth of *P. ranga* in the Baors of S2 and S3 management may be caused by the application of supplemental feed, fertilizer, and chemicals, the lack of a sanctuary, and the lack of restrictions on fishing gear. This species mainly depends on natural feeds such as zooplanktons and other aquatic live feeds. These factors may also affect the condition indices as well in S2 and S3 systems. The results of this study will be an indispensable asset for the sustainable management of Baors, providing biologists, conservationists, and fisheries managers the knowledge they need to establish the groundwork for management plans and implement guidelines for the sustainable conservation of *P. ranga* in the three culture systems. Nonetheless, additional research is required to examine the inherent food supply and aquatic environmental factors that could impact the general growth circumstances of *P. ranga* fish within the current Baor management frameworks.

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