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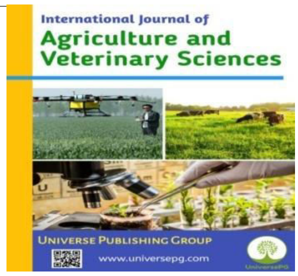

Morphology and Condition Factors of Mola Puti *Pethia conchonius* (Hamilton 1822) from the Atrai River, Bangladesh

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ABSTRACT

The objectives of this study were to describe the length-weight relationships (LWRs), and condition factors of *P. conchonius* collected from the Atari River in Dinajpur, Bangladesh. A total of 1746 male and female individuals were captured where length as 4.2-8.1 cm and weight as 1.0-8.7 g was recorded. In LLRs (among TL, SL, HL and FL), strong relationships were found of TL *vs.* SL ($r^2 > 0.003$), TL *vs.* FL ($r^2 > 0.006$), FL *vs.* SL ($r^2 > 0.001$), HL *vs.* TL ($r^2 > 0.016$), HL *vs.* SL ($r^2 > 0.005$) and HL *vs.* FL ($r^2 > 0.009$) between sexes of this species. Condition factors were recorded such as Fulton's condition factor (CF_f) as 1.08-2.10 and 1.17-2.11, relative body weight (BW_r) as 73.99-126.88 and 68.60-126.18, and foam factor ranged from 0.0001 to 0.089 and 0.0004 to 0.046 for female and male, respectively. Lastly, it may be concluded that the findings of this research on *P. conchonius* would be baseline information for future research and management of this species.

Keywords: Length-weight relationship, Length-length relationship, Health status, Mola Puti, and River.

INTRODUCTION:

Bangladesh rich with approximately 260-265 fresh-water indigenous fishes out of them 160 species considered as small indigenous species (SIS) (Hanif *et al.,* 2015a; Rahman, 2005). These small fishes are have high nutritional value as they contain protein, vitamin A, iron, calcium, phosphorus etc. The Atrai River having total length is about 380 km (Ahmed *et al.,* 2013) in which 61-74 species out of 265 fresh-water fishes (Chaki *et al.,* 2014; Mia *et al.,* 2019) are available. Out of them *Pethia conchonius* is self-recruiting and naturally available small indigenous species but the abundance of this species is const-antly and easily facing in upheaval due to artificial and natural factors (Stoddard *et al.,* 2006). It is also an important ornamental fish in aquarium (Rahman, 2005). Although SIS have high economic and nutri-tional importance, they are regularly facing to the indiscriminate exploitation of brood and young using destructive fishing gears (Hanif *et al.,* 2015b; Islam *et al.,* 2019; Mia *et al.,* 2019; Siddik *et al.,* 2014).

The knowledge on the morphology and health status such as condition factors is primarily required for their conservation, management, or domestication (Islam and Mia, 2016; Islam *et al.,* 2017, 2018). For example, length and weight bears a truthful tool for the measurement of growth, health, and community status (Philips, 2014; Sabrah, 2015; Sarkar *et al.,* 2009), the stock assessment (Chaklader *et al.,* 2015; Siddik *et al.,* 2016), and management and conser-vation of the fisheries resources (Ilkyaz *et al.,* 2008; Pathak *et al.,* 2013). It also uses comprise between sexes of population and life history of fishes from different areas (Akel and Philips, 2014; Sabrah, 2015). Length-length relationship (LLR) is also useful for equivalence of length type when data are summarized (Simon and Mazlan, 2008). LLRs are essential to know the relative growth rate (Moutopoulos and Stergiou, 2002), stock assessment and population structure of fishes in each aquatic habitat (Kara and Bayhan, 2008). Condition factors (CFs) are used for assimilating the condition, fatness, or well-being of fishes. It provides indication on physical status of fishes and fish community to manage and protect of natural populations (Muchlisin *et al.,* 2010; Sarkar *et al.,* 2009). It can also influence the reproductive cycle or other physiological factors before high mortality rates are suffered (Nehemia *et al.,* 2012; Victor *et al.,* 2014). Fulton's condition factor (CF_f) is a main parameter used in fishery research and have been closely related since it was first proposed (Froese, 2006). Variations of CF_f between species are greatly influenced by the body shape, which is well described by the form factor (Froese, 2006). Related body weight (BW_r) was used to recognize the prey availability, food abundance and gonad maturation of fishes (Anderson and Neumann, 1996).

Presently studies are available on LWRs, LLRs, and CFs was precisely texted for different freshwater fishes in Bangladesh (Islam *et al.,* 2016; 2017). To the best of our knowledge, very few earlier reports are available on LWRs, LLRs and CFs of *Pethia conchonius*. Therefore, in this study, aims were considered to the know of the length-weight relationship (LWR) and length-length relationship (LLR) including the condition factors (CF_f) of *P. conchonius* captured from the Atrai River of Dinajpur district of Bangladesh.

MATERIALS AND METHODS:

Sample collection

A total of 1746 fish individuals was captured from Khansama (KS, KS, 25.937° N and 88.722° E) and Mohanpur (MP, 25.534° N and 88.762° E) stations of Atrai River at monthly interval during morning (07:00-10:00 AM) using push net (1.50 × 1.00 m^2, mesh size 6 mm) and seine net (15 × 3.5 m^2, 4 mm) with the help of commercial fishermen (**Fig. 1**). The collected fresh samples were conserved in ice box and immediately transferred to the laboratory of Fisheries Biology and Genetics under Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Next, the five morph-metric characteristics such as the total length TL, standard length SL, head length HL, fork length FL and body weight BW were measured by the method of Froese, (2006). However, TL, SL, HL, FL, and BW were the calculated with the help of slide calipers nearest to 0.1 cm for each specimen where BW (g) were taken using a digital electronic balance (HD-602ND, MEGA, Japan) to the nearest 0.1 g accuracy. Lastly, the fish samples preserved with the 10% buffered formalin for future study at the laboratory.

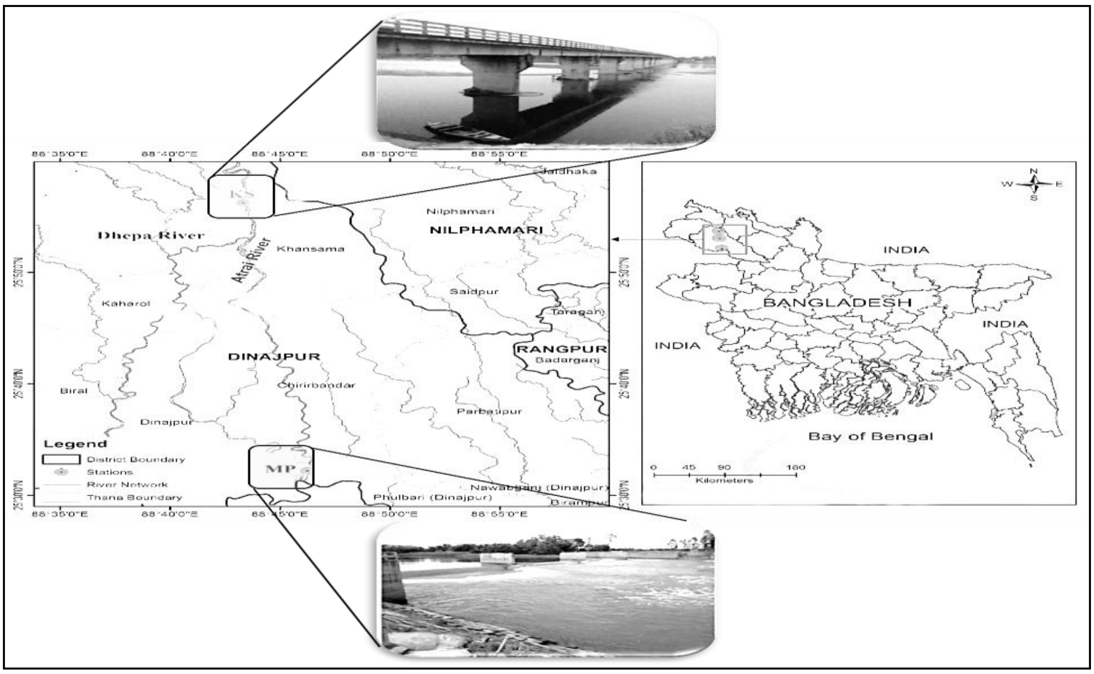

Fig. 1: Fish specimens collected from two sampling stations such as Khansama (KS) and Mohanpur (MP) by using push net (1.50 × 1.00 m^2, mesh size 6 mm) and seine net (15 × 3.5 m^2, 4 mm).

Calculation of length-weight relationship

Length-weight relationship (LWR) of the fishes is known as useful tools for determining biomass and to judge fish individuality from small number of specimens and to contrast health grade, plumpness, or well-being of species (Froese, 2006; Le Cren, 1951; Ndome *et al.,* 2012). It also measures the variation from the expected weight for length of the individual specimen of fishes. However, the estimation for the female and male individuals of *P. conchonius* done separately using the conventional cubic or log-transformed formula described by Le Cren (1951) as $BW = a\ TL^b$ or Log BW = log a + b log TL. Where, BW = Body weight of each sample of *P. conchonius* (g), TL = Total length (cm), a = Coefficient related to body form, and b = An exponent indicating isometric growth (b = 3.0) or allometric growth (3.0 < b > 3.0) followed by the Simon and Mazlan, (2008). The regression parameters "a" and "b" of the linear equation were calculated through the following the equation as a = Y–bX and $b = [n\sum XY - \sum XY] / [n\sum X^2 - (\sum X)^2]$. Where b = Exponent (slope), Y = Dependent variable, X = Independent variable, a = Intercept (constant), n = Number of individuals.

Calculation of length-length relationship

There exists a simple linear relationship between two linear dimensions of aquatic animals since increases of length measurements are proportional to each other over the period of growth progression. TL, SL, HL, FL, and BW were calculated with the help of slide calipers nearest to 0.1 cm. Relationship between two length types of *P. conchonius* is linear that can be measured in the form of straight-line equation as the Y = a + bX followed by Islam *et al.* (2017). Where Y = Dependent variable, X = Independent variable, a = Intercept (constant), b = Exponent (slope).

Determination of condition factors

Fulton condition factor

The physical condition and health status of a specimen is known as Fulton's condition factor (CF_f) was determined to calculate as $CF_{f\,=}$ (BW × 100) / TL^3. Where CF_f = Condition factor of an individual, BW = Body weight (g), TL = Total length (cm).

Relative body weight

Relative body weight (BW_r) is mainly used for the regularly used conserving of a species (Bister *et al.,* 2000). Therefore, it is a good physiological indicator contrasting experiential body weight (BW) with the standard body weight (BW_s) of an individual of same fishes and same length (Giannetto *et al.,* 2012) calculated as $BW_r = (BW/a\ TL^b) \times 100$ (Froese, 2006). Where BW_r = Relative body weight, BW = Body weight (g), TL = Total length (cm) and "a" and "b" = Regression parameters estimated from the LWRs.

Form factor

Form factor ($a_{3.0}$) was also used to differentiate body shape of a fish from. According to Froese, (2006) form factor ($a_{3.0}$) was estimated through an equation as $a_{3\cdot0}$ = 10 log a-S (b-3) (Froese, 2006). Where "a" and "b" = Regression parameters, S = -1.358 reported by Froese, (2006) to estimate $a_{3.0}$ by plotting log10 "a" vs. "b" due to lack of information on LWRs for *P. conchonius*.

Statistical analysis

All sorts of statistical analysis for each species were performed by using SPSS (Statistical Package for Social Science) Version 22.0 software and Microsoft Office Excel (IBM Corporation, 2013) and the PAST (Paleontological statistics, version 3.10). According to Froese, (2006), the 95% confidence interval (CI) was determined for the regression parameters "a" and "b". To find out the significance differences of regression coefficient (b) from isometric value (b = 3) for the LWR. The respective critical values allowed the purpose of the "b" values statistically and their addition in the isometric range (b = 3) or the allometric range (3.0 < b < 3.0). Moreover, one-way analysis of variance (ANOVA) tested to notice dissimilarities ($P < 0.05$ or 0.01) of this species based on CF_f and BW_r values followed by Tukey's pairwise post-hoc test. A Spearman rank correlation coefficient (r_s) test used to know the relationships of the condition factors (CF_f and BWr) with TL, SL and BW of *P. conchonius*, collected from this river.

RESULTS AND DISCUSSION:

Very few earlier reports are the available on *P. conchonius* except for (Mir and Mir 2012; Gupta and Tripathi, 2017). Besides, the result of this study on *P. conchonius* also judged with closely related fishes.

Length-weight relationship

The calculated values of LWRs and regression factors using a total of 1748 fish individuals of *P.*

conchonius from the Atrai River of Dinajpur district in Bangladesh are shown in **Table 1**. Here, TL of the present species were ranged from 4.2 to 8.1 cm and 4.3 to7.8 cm while BW varied from 1.02 to 8.65 & 1.09 to 7.73 g for female and male *P. conchonius*, respectively (**Table 1**). Moreover, LWRs calculated as BW = 0.0108 $TL^{2.764}$ to BW = 0.0222 TL $^{3.213}$ and BW = 0.0057 $TL^{2.671}$ to the BW = 0.0332 $TL^{3.507}$ for female and male, respectively. Thus, the calculated a-values from LWRs were found within the expected limit as 0.0032-0.0162 (Froese *et al.,* 2014). The calculated b-values also lied within the expected limit as 2.5-3.5 or Bayesian limit as 2.88-3.26 (Froese, 2006; Froese *et al.,* 2014). This data suggested that fish growth was mostly isometric or positive allometric rather than negative allometric. Gupta and Tripathi, (2017) found that length, "a" and "b" values of *P. conchonius* that collected from the Ganga Rivers in India ranged from 3.8 to 11.0 cm, -1.816 to -1.711 and 2.548 to 2.665, which were close to the present findings. Although different species but had similar genus and behavior, thus, LWR relationship was previously recorded as BW= 0.0139 $TL^{3.03}$ and BW= 0.0174 $TL^{2.88}$ for male and female *P. ticto* species (Hossain *et al.,* 2014) and as BW= 0.004 $TL^{3.396}$ and 0.011 $TL^{3.966}$ for *Puntius sophore*. Rahman *et al.* (2012) and 0.043 $TL^{2.93}$ for *P. ticto* (Alam *et al.,* 2013).

Table 1: Descriptive statistics and LWRs parameters for fish species in the Atrai River Dinajpur, Bangladesh.

Months	Source	Sex	n	Total length (cm)		Body weight (g)		Regression factors		95% of confidence limits		Growth type	r^2
				Min.	Max.	Min.	Max.	*a**	*b*	*a**	*b*		
January	KS	Male	49	4.3	7.2	1.09	5.39	0.0145	3.004	0.0101-0.0208	2.803-3.205	IG	0.950
		Female	8	5.9	6.8	3.03	4.76	0.0113	3.168	0.0042-0.0303	2.629-3.707	PGA	0.971
	MP	Male	56	5.4	7.4	2.34	6.01	0.0143	3.020	0.0087-0.0234	2.750-3.290	IG	0.903
		Female	36	5.1	8.1	1.85	8.09	0.0122	3.123	0.0079-0.0187	2.893-3.354	PGA	0.956
February	KS	Male	36	5.4	7.8	2.61	7.73	0.0172	2.955	0.0115-0.0258	2.736-3.174	NAG	0.956
		Female	27	5.2	7.6	2.33	6.84	0.0222	2.835	0.0162-0.0305	2.665-3.005	NAG	0.979
	MP	Male	16	5.6	6.7	2.74	4.61	0.0181	2.913	0.00878-0.0375	2.514-3.313	NAG	0.945
		Female	33	5.7	7.5	2.7	6.4	0.0138	3.038	0.0096-0.0197	2.841-3.235	IG	0.969
March	KS	Male	33	4.9	7.2	1.79	5.35	0.0144	3.004	0.0103-0.0202	2.814-3.194	IG	0.971
		Female	53	4.6	8.1	1.61	8.65	0.0161	3.002	0.0138-0.0189	2.913-3.091	IG	0.988
	MP	Male	26	4.7	7.5	1.55	6.62	0.0160	3.006	0.0110-0.0232	2.796-3.216	IG	0.973
		Female	37	4.2	7.0	1.27	6.2	0.0122	3.182	0.0098-0.0153	3.048-3.316	PGA	0.985
April	KS	Male	35	4.3	5.5	1.31	2.83	0.0164	3.008	0.0105-0.0257	2.722-3.295	IG	0.932
		Female	56	4.4	6.6	1.16	4.54	0.0162	2.981	0.0114-0.0230	2.762-3.201	NAG	0.932
	MP	Male	5	5.4	7.8	2.23	6.92	0.0111	3.271	0.0064-0.0194	2.918-3.624	PAG	0.900
		Female	79	4.4	6.6	1.14	4.46	0.0162	2.981	0.0114-0.0230	2.762-3.201	NAG	0.932
May	KS	Male	28	4.4	5.7	1.33	3.01	0.0136	3.095	0.0088-0.0210	2.824-3.365	IG	0.955
		Female	45	4.5	6.9	1.42	5.04	0.0141	3.062	0.0099-0.0200	2.846-3.278	IG	0.949
	MP	Male	10	5.2	6.5	2.26	4.21	0.0136	3.056	0.0040-0.0459	2.379-3.732	IG	0.931
		Female	103	4.5	7.3	1.46	6.69	0.0136	3.068	0.0109-0.0169	2.939-3.196	IG	0.956
June	KS	Male	20	4.8	5.9	1.61	2.97	0.0154	3.000	0.0081-0.0291	2.622-3.378	IG	0.939
		Female	59	4.6	6.6	1.5	4.34	0.0160	2.992	0.0108-0.0236	2.754-3.230	NAG	0.917

	MP	Male	21	4.9	6.6	1.66	4.34	0.0133	3.060	0.0069-0.0257	2.682-3.438	IG	0.938
		Female	88	4.3	6.8	1.16	4.35	0.0141	3.001	0.0106-0.0188	2.826-3.175	IG	0.931
July	KS	Male	33	4.5	6	1.38	3.63	0.0159	3.030	0.0077-0.0300	2.617-3.443	IG	0.878
		Female	74	4.4	7.4	1.56	6.44	0.016	3.009	0.0117-0.0218	2.820-3.197	IG	0.933
	MP	Male	16	5.1	6.3	2.03	3.87	0.0159	2.988	0.0070-0.0359	2.520-3.456	NAG	0.930
		Female	84	4.8	6.6	1.77	4.25	0.0144	3.060	0.0084-0.0246	2.745-3.374	IG	0.820
August	KS	Male	20	4.6	5.7	1.71	3.2	0.0144	3.048	0.0050-0.0409	2.481-3.677	IG	0.851
		Female	38	4.5	5.8	1.18	2.36	0.0155	3.005	0.009-0.024	2.738-3.273	IG	0.852
	MP	Male	9	5	6.3	1.98	3.86	0.0164	2.955	0.0031-0.0850	1.997-3.913	NAG	0.883
		Female	88	4.6	6.1	1.52	3.5	0.0155	3.005	0.0099-0.0242	2.738-3.273	IG	0.852
September	KS	Male	15	5.2	5.8	2.03	2.98	0.0135	3.049	0.0030-0.0590	2.185-3.914	IG	0.817
		Female	49	4.8	5.8	1.52	2.81	0.0126	3.067	0.0054-0.0292	2.559-3.574	IG	0.753
	MP	Male	11	4.7	6.6	1.41	3.92	0.0122	3.056	0.0039-0.0375	2.402-3.711	IG	0.925
		Female	45	4.5	6.2	1.02	2.99	0.0116	3.048	0.0073-0.0186	2.765-3.331	IG	0.916
October	KS	Male	12	4.7	6	1.52	3.63	0.0161	3.002	0.0053-0.0492	2.328-3.676	IG	0.907
		Female	20	4.8	7.2	1.7	6.43	0.016	3.006	0.0078-0.0327	2.584-3.427	IG	0.925
	MP	Male	28	4.6	6.7	1.69	4.61	0.0154	3.003	0.0078-0.0304	2.261-3.396	IG	0.904
		Female	28	5.6	7.5	2.1	6.4	0.0132	3.061	0.0048-0.0352	2.521-3.601	IG	0.839
November	KS	Male	19	5.1	7.0	1.8	5.48	0.0141	2.998	0.0081-0.0243	2.688-3.308	IG	0.960
		Female	24	4.7	7.4	1.78	6.48	0.0147	3.044	0.0067-0.0322	2.583-3.505	IG	0.895
	MP	Male	18	5.0	6.2	2.06	3.76	0.0150	3.009	0.0073-0.0310	2.590-3.428	IG	0.935
		Female	34	4.3	7.8	1.27	7.7	0.0159	3.007	0.0098-0.0258	2.718-3.295	IG	0.933
December	KS	Male	7	5.3	6.2	2.94	4.41	0.0332	2.671	0.0069-0.1603	1.782-3.560	NAG	0.922
		Female	11	5.1	6.7	2.2	4.76	0.0108	3.213	0.0026-0.0444	2.433-3.993	PGA	0.906
	MP	Male	49	5.1	7.2	1.78	5.94	0.0057	3.507	0.0032-0.010	3.177-3.837	PGA	0.906
		Female	57	5.2	6.9	1.94	4.57	0.0205	2.764	0.0118-0.0355	2.450-3.077	NGA	0.843

KS, Khansama; MP, Mohanpur; n, number of specimens; TL, total length; BW, body weight; a*, anti-log a; a, intercept; b, slope; r^2, coefficient of determination; Min, Minimum; Max, Maximum; NAG, negative allometric growth; IG, isometric growth; PAG, positive allometric growth.

Lastly, coefficient of determination (r^2) also varied from 0.753 to 0.988 and 0.817 to 0.973 for female and male, respectively (**Table 1**); may be varied due to the differences in sample size, range of length, age, sex, season, ecology, habitats (Jobling, 2008; Khan and Sabah, 2013), and the gonadal maturity (Tarkan *et al.,* 2006) that were not examined in the present study.

Length-length relationship

For LLRs, a relationship of TL, SL, HL and FL was considered (**Table 2**). Here, "a"-values ranged from 1.204-2.561 to 1.074-4.752; "b" from 0.527-1.034 to 0.473-1.098; "r^2" from 0.302–0.976 to 0.003–0.992 for female and male *P. conchonius*, respectively (**Table 2**). Hossain *et al.* (2014) reported that relationship between TL and SL of *P. ticto*, the values of "a" found as 0.315, "b" as 1.21 and "r^2" as 0.978, respectively. A relationship between TL and FL, values of "a" found between 1.161 to 2.302 and 1.088 to 4.509; "b" varied from 0.197 to 0.966 and 0.549 to 1.015 "r^2" between 0.310 to 0.975 and 0.006 to 0.984 for female and male, respectively. Hossain *et al*. (2014) investigated on LLRs of *P. ticto* were 3.24-6.37, 3.71-8.00 and 3.24-8.00 cm, respectively with BW were 0.43-4.16, 0.59-8.94 and 0.43-8.94 for these sexes. Besides, the regression parameter "a" was 0.0139, 0.0174, and 0.0157; "b" was 3.03, 2.88, and 2.95; and "r^2" were 0.952, 0.960, and 0.954 for male, female, and combined sexes, respectively. Hossain, (2010) estimated on LLRs (TL vs. FL) for three small freshwater fishes where the values of "a", "b" and "r^2" were as 0.309, 1.129 and 0.995 for *A. mola*; and -0.075, 1.036 and 0.960 for *P. ticto*, respectively. The values of "a", ranged from 1.123 to 1.746 and 0.961 to 4.526; "b" 0.697 to 1.007 and 0.034 to 1.113; "r^2" 0.567 to 0.986 and 0.001 to 0.992 for female and male from FL vs. SL, respectively. From FL vs. SL relationship, the values of regression parameters (a, b, and r^2) calculated as 0.196, 1.076 and 0.995 for *A. mola* and 0.053, 1.133 and 0.932 for *P. ticto*, respectively (Hossain, 2010). For HL vs. TL, "a" values ranged from 0.186 to 0.751 and 0.227 to 0.640; "b" values from 0.193 to 0.940 and 0.153 to 1.024; "r^2" values from 0.016 to 0.928 and 0.036 to 0.830 for female and male, respectively. A linear relationship between HL and TL of *A. mola* and *P. ticto* was estimated where the values of "a", "b" and "r^2" recorded as -0.457, 0.235 and 0.955 for *A. mola* and 3323, 1519 and 0.879 for *P. ticto*, respectively (Alam *et al.,* 2013). In HL vs. SL relationship, values of "a" ranged from 0.263 to 0.835 and 0.294 to 0.874, "b" from 0.111 to 0.969 and 0.158 to 0.900, r^2 from 0.011 to 0.923 and 0.005 to 0.860 for female and male respectfully. While "a", "b" and "r^2" were fluctuated from 0.238 to 0.832, 0.126 to 0.950 and 0.009 to 0.919 from HL vs. FL among the sexes of *P. conchonius* in this river that were not possible to compare due to lack of earlier findings.

Table 2: Length-length relationships of TL, SL, HL, and FL of *Pethia conchonious.*

Months	Source	Sex	n	TL = a + b SL			*TL = a + b FL*			*FL = a + b SL*			*HL = a + b TL*			*HL = a + b SL*			*HL = a + b FL*		
				a*	b	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2
January	KS	Male	49	1.074	1.098	0.92	1.045	1.031	0.947	1.065	1.041	0.928	0.549	0.436	0.397	0.591	0.451	0.324	0.515	0.498	0.463
		Female	8	1.44	0.887	0.963	1.24	0.919	0.953	1.203	0.951	0.982	0.354	0.66	0.448	0.509	0.513	0.331	0.453	0.548	0.349
	MP	Male	56	1.495	0.888	0.867	1.481	0.833	0.903	1.173	0.973	0.799	0.496	0.488	0.388	0.623	0.414	0.306	0.597	0.411	0.358
		Female	36	1.248	1.002	0.966	1.161	0.97	0.892	1.249	0.941	0.899	0.57	0.405	0.402	0.609	0.422	0.418	0.584	0.415	0.398
February	KS	Male	36	1.491	0.868	0.952	1.497	0.818	0.845	1.24	0.929	0.863	0.438	0.535	0.49	0.559	0.447	0.431	0.547	0.434	0.407
		Female	27	1.634	0.804	0.678	1.297	0.889	0.691	1.307	0.899	0.97	0.45	0.53	0.359	0.551	0.46	0.285	0.486	0.506	0.287
	MP	Male	16	1.512	0.856	0.992	1.56	0.786	0.955	1.05	1.034	0.937	0.367	0.657	0.157	0.461	0.59	0.172	0.461	0.555	0.173
		Female	33	1.826	0.738	0.856	1.55	0.789	0.828	1.284	0.909	0.977	0.731	0.297	0.055	0.835	0.247	0.06	0.736	0.304	0.078
March	KS	Male	33	1.441	0.934	0.975	1.314	0.914	0.969	1.13	1.006	0.976	0.227	0.894	0.75	0.3	0.867	0.786	0.277	0.845	0.776
		Female	53	1.415	0.937	0.975	1.293	0.919	0.971	1.123	1.007	0.979	0.186	1.024	0.928	0.263	0.969	0.923	0.239	0.95	0.919
	MP	Male	26	1.347	0.954	0.969	1.088	1.004	0.963	1.272	0.93	0.966	0.235	0.912	0.83	0.294	0.9	0.86	0.238	0.954	0.867
		Female	37	1.487	0.882	0.976	1.291	0.9	0.975	1.182	0.973	0.986	0.232	0.91	0.872	0.328	0.815	0.879	0.286	0.835	0.885
April	KS	Male	35	1.594	0.82	0.857	2.066	0.574	0.63	1.364	0.857	0.49	0.284	0.765	0.724	0.373	0.693	0.758	0.545	0.375	0.331
		Female	56	1.51	0.851	0.845	1.171	0.964	0.865	1.42	0.819	0.841	0.257	0.811	0.168	0.409	0.597	0.106	0.35	0.662	0.104
	MP	Male	5	1.709	0.824	0.812	1.108	1.015	0.953	1.438	0.851	0.937	0.488	0.538	0.674	0.744	0.359	0.36	0.54	0.519	0.579
		Female	79	2.561	0.527	0.377	2.377	0.531	0.331	1.338	0.889	0.913	0.751	0.233	0.064	0.57	0.462	0.346	0.429	0.607	0.468
May	KS	Male	28	2.568	0.473	0.351	2.534	0.446	0.3	1.189	0.956	0.951	0.494	0.503	0.166	0.464	0.622	0.398	0.423	0.637	0.401
		Female	45	2.128	0.618	0.564	2.302	0.521	0.361	1.506	0.783	0.679	0.514	0.36	0.065	0.407	0.586	0.254	0.246	0.804	0.432
	MP	Male	10	2.766	0.488	0.644	2.357	0.549	0.685	1.305	0.905	0.937	0.232	0.94	0.334	0.804	0.28	0.08	0.675	0.364	0.113
		Female	103	1.622	0.813	0.947	1.228	0.922	0.924	1.39	0.863	0.98	0.743	0.209	0.07	0.82	0.171	0.067	0.767	0.199	0.069
June	KS	Male	20	4.752	0.082	0.003	4.509	0.111	0.006	4.526	0.034	0.001	0.615	0.359	0.048	0.874	0.172	0.005	0.791	0.225	0.009
		Female	59	2.321	0.564	0.548	2.037	0.605	0.469	1.53	0.782	0.822	0.305	0.736	0.115	0.525	0.47	0.081	0.383	0.638	0.111
	MP	Male	21	1.521	0.855	0.976	1.37	0.86	0.874	1.33	0.887	0.889	0.64	0.193	0.036	0.699	0.16	0.033	0.594	0.248	0.071
		Female	88	2.422	0.528	0.366	2.245	0.53	0.31	1.447	0.835	0.829	0.672	0.153	0.016	0.738	0.111	0.011	0.71	0.126	0.012
July	KS	Male	33	1.6	0.82	0.901	1.188	0.946	0.821	1.546	0.781	0.892	0.309	0.747	0.164	0.489	0.537	0.113	0.582	0.382	0.039
		Female	74	1.605	0.822	0.928	1.333	0.876	0.908	1.281	0.912	0.966	0.341	0.652	0.323	0.454	0.556	0.319	0.415	0.569	0.288
	MP	Male	16	1.661	0.801	0.955	1.478	0.817	0.882	1.259	0.922	0.959	0.361	0.704	0.366	0.538	0.538	0.318	0.499	0.546	0.291
		Female	84	1.726	0.772	0.884	1.353	0.863	0.844	1.41	0.854	0.953	0.58	0.389	0.084	0.773	0.251	0.051	0.708	0.286	0.051
August	KS	Male	20	1.593	0.825	0.989	1.209	0.93	0.945	1.424	0.846	0.953	0.307	0.771	0.217	0.438	0.64	0.216	0.363	0.705	0.198
		Female	38	1.756	0.755	0.942	1.904	0.635	0.721	1.256	0.934	0.808	0.391	0.593	0.078	0.593	0.39	0.056	0.544	0.411	0.067
	MP	Male	9	1.642	0.805	0.992	1.21	0.929	0.982	1.405	0.859	0.992	0.349	0.712	0.541	0.505	0.564	0.52	0.392	0.675	0.553
		Female	88	1.685	0.787	0.924	1.399	0.84	0.848	1.374	0.869	0.939	0.33	0.729	0.179	0.475	0.587	0.174	0.397	0.652	0.172
September	KS	Male	15	1.755	0.76	0.937	1.021	1.035	0.859	1.98	0.627	0.796	0.402	0.58	0.048	0.853	0.158	0.005	0.331	0.727	0.061

Months	Source	Sex	n	TL = a + b SL			*TL = a + b FL*			*FL = a + b SL*			*HL = a + b TL*			*HL = a + b SL*			*HL = a + b FL*		
				a*	b	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2	*a**	*b*	r^2
		Female	49	2.194	0.607	0.571	2.294	0.527	0.37	1.746	0.697	0.567	0.664	0.326	0.059	0.794	0.253	0.055	0.832	0.202	0.03
	MP	Male	11	1.7	0.784	0.992	1.284	0.897	0.984	1.385	0.864	0.988	0.46	0.521	0.272	0.613	0.402	0.261	0.548	0.44	0.326
		Female	45	1.971	0.682	0.711	1.657	0.734	0.71	1.318	0.899	0.941	0.206	0.997	0.415	0.417	0.659	0.277	0.344	0.726	0.289
October	KS	Male	12	1.416	0.924	0.979	1.919	0.644	0.604	1.464	0.827	0.54	0.264	0.838	0.699	0.342	0.799	0.727	0.422	0.592	0.507
		Female	20	1.647	0.84	0.302	1.332	0.906	0.357	1.184	0.973	0.932	0.281	0.783	0.741	0.336	0.81	0.339	0.285	0.848	0.377
	MP	Male	28	1.531	0.878	0.944	1.167	0.971	0.945	1.359	0.884	0.957	0.264	0.837	0.713	0.375	0.739	0.681	0.283	0.851	0.737
		Female	28	1.204	1.034	0.923	1.495	0.824	0.72	1.329	0.906	0.669	0.423	0.541	0.155	0.52	0.491	0.11	0.463	0.52	0.152
November	KS	Male	19	1.534	0.898	0.966	1.25	0.954	0.984	1.252	0.934	0.967	0.356	0.627	0.598	0.452	0.585	0.623	0.397	0.618	0.627
		Female	24	1.689	0.827	0.871	1.53	0.818	0.845	1.228	0.951	0.912	0.218	0.917	0.825	0.325	0.814	0.829	0.294	0.807	0.809
	MP	Male	18	1.358	0.959	0.923	1.366	0.882	0.913	1.105	1.014	0.88	0.315	0.74	0.579	0.424	0.663	0.466	0.366	0.704	0.615
		Female	34	1.317	0.969	0.975	1.209	0.936	0.937	1.18	0.984	0.939	0.287	0.775	0.825	0.335	0.756	0.814	0.337	0.717	0.755
December	KS	Male	7	1.932	0.686	0.74	1.975	0.618	0.789	0.961	1.113	0.942	0.552	0.464	0.202	0.813	0.268	0.106	0.643	0.379	0.279
		Female	11	1.684	0.799	0.679	1.433	0.83	0.706	1.249	0.945	0.926	0.308	0.775	0.376	0.398	0.713	0.339	0.258	0.906	0.528
	MP	Male	49	2.409	0.586	0.731	1.653	0.764	0.755	2.371	0.527	0.458	0.271	0.827	0.368	0.54	0.51	0.298	0.375	0.689	0.33
		Female	57	1.475	0.908	0.846	1.337	0.887	0.9	1.235	0.957	0.819	0.51	0.461	0.173	0.567	0.468	0.183	0.645	0.348	0.113

KS, Khansama; MP, Mohanpur; n, number of specimens; TL, total length; SL, standard length; HL, head length; FL, fork length; a*, anti-log a; a, intercept; b, slope; r^2, coefficient of determination.

Condition factors

In the Atrai River, values of the Fulton's condition factor (CF_f) were 1.0796–2.104 and 1.172–2.105 for female and male *P. conchonius*, respectively (**Table 3**). Mir and Mir, (2012) recorded that CF_f ranged from 0.57–0.98 in *P. conchonius* which is lower than the present values might be due to the geographical differences. Relative body weight (BW_r) ranged from 73.989 to the 126.880 and 68.602 to 126.184 for both sexes (**Table 3**). According to Rahman *et al.* (2012), BW_r ranged from 48.62 to 179.96 (102.28±16.38) in *Puntius sophore* from the Chalan Beel, Bangladesh. Hossain *et al.* (2012) also recorded the values of the CF_f were1.55 to 2.17 (1.78±0.14) whereas BW_r were 87.54 to 121.82 (100.10±7.71) of *P. ticto*, more or less similar tendency to the present findings. Moreover, a fish was scanty and elongated with lean (CF_f = 1.0), sound (CF_f = 1.20) and healthy body (CF_f = 1.40) reflected by Barnham and Baxter, (1998). So, the female (1.268±0.014 < CF_f < 1.667±0.016) and the male (1.353±0.033 < CF_f < 1.862±0.036) sexes of the *P. conchonius* were in lean, sound health and healthy body of the fishes collected from the Atrai River. Thin and elongated body form where the differences may be due to food loads and the sexual maturity (Gupta *et al.,* 2011). Besides, the values of BW_r decreasing fewer than 100 for a specimen, stock or fish community represent as little prey availability or high predation whereas values above 100 designate vice-versa (Rypel and Richter, 2008). So, the average values very close to 100 expressing an equilibrium relation with prey and predator (Anderson and Neumann, 1996). The foam factor of the *P. conchonius* ranged from 0.0001–0.089 and 0.0004–0.046 for female and male, respectively (**Table 3**). Hossain *et al.* (2012) found that the foam factors of *Ailiichthys punctata* were 0.0062. The values of this factor were 0.0138, 0.0345 and 0.0435 for *P. sophore* based on TL, FL, and the SL, respectively (Abedin *et al*., 2020; Rahman *et al.,* 2012).

Table 3: Descriptive statistics and one way ANOVA for condition factors (CFs) of *Pethia conchonious*.

Months	Source	Sex	n	Fulton's condition factor CF_f = (BW × 100)/TL^3			Relative body weight $BW_r = BW/aTL^b$			Foam factor ($a_{3.0}$)
				Min.	Max.	Mean±SE	Min.	Max.	Mean±SE	
January	KS	Male	49	1.256	1.734	1.471±0.017	85.992	118.860	100.735±1.202	0.015
		Female	8	1.475	1.602	1.543±0.017	96.896	104.570	100.428±1.052	0.006
	MP	Male	56	1.275	1.734	1.496±0.015	86.067	117.219	100.824±0.985	0.013
		Female	36	1.315	1.800	1.545±0.019	86.455	120.188	100.922±1.281	0.006
February	KS	Male	36	1.427	1.731	1.595±0.015	90.040	109.198	100.740±0.930	0.025
		Female	27	1.502	1.812	1.645±0.015	91.433	110.872	100.582±0.870	0.089
	MP	Male	16	1.472	1.653	1.554±0.012	95.059	107.049	100.611±0.762	0.046
		Female	33	1.348	1.604	1.483±0.009	91.203	108.490	100.237±0.639	0.009
March	KS	Male	33	1.324	1.630	1.461±0.013	91.292	112.460	100.751±0.936	0.014
		Female	53	1.447	1.810	1.627±0.012	89.609	112.040	100.729±0.695	0.015
	MP	Male	26	1.492	1.820	1.628±0.016	92.445	112.551	100.660±1.000	0.015
		Female	37	1.480	1.829	1.667±0.016	90.394	113.545	100.832±0.920	0.0004

Months	Source	Sex	n	Fulton's condition factor CF_f = $(BW \times 100)/TL^3$			Relative body weight $BW_r = BW/aTL^b$			Foam factor ($a_{3.0}$)
				Min.	Max.	Mean±SE	Min.	Max.	Mean±SE	
April	KS	Male	35	1.479	1.849	1.673±0.016	88.137	112.180	98.743±0.987	0.014
		Female	56	1.293	1.831	1.580±0.0133	82.232	116.272	100.550±0.848	0.025
	MP	Male	5	1.232	1.481	1.381±0.047	68.602	82.871	75.580±2.796	0.0034
		Female	79	1.253	1.773	1.504±0.012	79.931	112.985	95.918±0.757	0.0030
May	KS	Male	28	1.422	1.703	1.593±0.014	88.868	106.904	100.483±0.876	0.0010
		Female	45	1.365	1.743	1.564±0.0140	87.223	112.33	100.327±0.894	0.0026
	MP	Male	10	1.354	1.607	1.489±0.022	91.892	106.375	101.256±1.505	0.0027
		Female	103	1.134	2.104	1.536±0.011	74.073	137.751	100.614±0.720	0.0016
June	KS	Male	20	1.446	1.666	1.545±0.014	90.552	106.963	99.881±0.996	0.0155
		Female	59	1.808	1.429	1.588±0.011	90.420	114.464	100.540±0.7093	0.0210
	MP	Male	21	1.371	1.620	1.472±0.015	94.287	110.845	101.026±0.964	0.0015
		Female	88	1.200	1.647	1.420±0.009	84.970	116.601	100.508±0.682	0.0136
July	KS	Male	33	1.451	1.785	1.619±0.020	89.878	111.559	100.478±1.185	0.0013
		Female	74	1.364	1.904	1.629±0.013	83.170	115.232	99.177±0.819	0.0111
	MP	Male	16	1.423	1.779	1.565 ±0.020	91.298	114.206	100.476±1.251	0.0259
		Female	84	1.310	2.007	1.602±0.016	82.298	126.880	100.420±1.018	0.0010
August	KS	Male	20	1.417	1.759	1.568±0.024	90.766	113.383	100.597±1.530	0.0016
		Female	38	1.210	1.470	1.321±0.009	88.355	110.600	98.670±0.848	0.0353
	MP	Male	9	1.330	1.650	1.526±0.038	85.575	105.884	99.076±2.460	0.0210
		Female	88	1.289	1.820	1.574±0.014	82.463	116.463	100.721±0.742	0.0119
September	KS	Male	15	1.334	1.554	1.456±0.018	92.665	106.899	100.609±1.199	0.0005
		Female	49	1.146	1.759	1.420±0.018	81.434	123.451	100.544±1.330	0.0002
	MP	Male	11	1.172	1.527	1.353±0.033	87.322	113.454	100.803±2.484	0.0004
		Female	45	1.079	1.483	1.268±0.014	86.415	120.923	102.128±1.097	0.0006
October	KS	Male	12	1.464	2.105	1.683±0.048	86.680	126.184	100.902±2.917	0.0142
		Female	20	1.36	2.020	1.647±0.0340	84.817	125.330	100.520±1.994	0.0089
	MP	Male	28	1.380	1.944	1.558±0.025	87.351	124.643	102.644±1.851	0.0004
		Female	28	1.133	1.759	1.487±0.025	73.989	117.657	100.452±1.727	0.0001
November	KS	Male	19	1.279	1.598	1.408±0.018	91.320	120.580	99.397±1.589	0.0163
		Female	24	1.225	1.880	1.595±0.032	78.559	120.483	102.454±2.112	0.0005
	MP	Male	18	1.383	1.688	1.532±0.018	90.071	110.138	101.122±1.251	0.0073
		Female	34	1.250	2.027	1.638 ±0.030	76.412	126.670	103.108±1.929	0.0089
December	KS	Male	7	1.767	2.015	1.862±0.036	93.261	105.190	100.329±1.726	0.012
		Female	11	1.420	1.784	1.603±0.039	90.399	111.591	101.105±2.425	0.021
	MP	Male	49	1.184	1.678	1.444±0.019	85.287	120.404	102.056±1.276	0.009
		Female	57	1.184	1.657	1.365±0.015	84.206	119.280	100.536±1.106	0.017

KS, Khansama; MP, Mohanpur; n, number of specimens; Min, Minimum; Max, Maximum.

Spearman rank correlation (r_s) for the condition factor

In this study, the Spearman rank correlation (r_s) test of condition factors such as CF_f and BW_r with some morphometric characteristics of *P. conchonius* is shown in the **Table 4**. Here, CF_f were significantly correlated with TL ($-0.220 < r_s > 0.122$) in May–August and October–November, SL ($0.073 < r_s > 0.130$) in May–July and BW ($0.230 < r_s > 0.469$) in all months except October and November (**Table 4**). Moreover, BW_r showed significant correlations with TL ($0.057 < r_s > 0.247$), SL ($0.074 < r_s > 0.301$) and BW ($0.234 < r_s > 0.462$) almost all study periods in the Atrai River (**Table 4**).

Table 4: Spearman rank correlation coefficient (*rs*) for the condition factors (Fulton's condition factor and relative body weight) with lengths (cm) and body weights (g) of *Pethia conchonious* fishes in the Atrai River, Dinajpur, Bangladesh.

Months	Source	Sex	n	Fulton's condition factor (CF_f)			Relative body weight (BW_r)		
				TL-CF_f	SL-CF_f	BW- CF_f	TL-BW_r	SL-BW_r	BW-BW_r
January	KS	Male	49	-0.003	0.026	0.247**	0.059*	0.090**	0.234**
		Female	8	0.008	0.036	0.263**	0.057*	0.088**	0.234**
	MP	Male	56	0.008	0.035	0.264**	0.057*	0.088**	0.234**
		Female	36	0.022	0.048	0.279**	0.063*	0.092**	0.239**

Months	Source	Sex	n	Fulton's condition factor (CF_f)			Relative body weight (BW_r)		
				TL-CF_f	SL-CF_f	BW- CF_f	TL-BW_r	SL-BW_r	BW-BW_r
February	KS	Male	36	0.018	0.043	0.276**	0.058*	0.087**	0.235**
		Female	27	0.005	0.030	0.280**	0.050	0.081**	0.238**
	MP	Male	16	-0.014	0.008	0.268**	0.049	0.080**	0.241**
		Female	33	-0.018	0.005	0.269**	0.047	0.079**	0.242**
March	KS	Male	33	-0.004	0.022	0.289**	0.045	0.079**	0.245**
		Female	53	0.009	0.027	0.304**	0.046	0.078**	0.247**
	MP	Male	26	-0.021	0.023	0.239**	0.062*	0.090**	0.239**
		Female	37	-0.019	0.006	0.289**	0.044	0.074**	0.252**
April	KS	Male	35	-0.026	0.000	0.289**	0.044	0.075**	0.258**
		Female	56	0.008	0.034	0.324**	0.044	0.074*	0.263**
	MP	Male	5	0.033	0.053	0.355**	0.054	0.080**	0.276**
		Female	79	0.039	0.058	0.361**	0.064*	0.088**	0.268**
May	KS	Male	28	0.043	0.053	0.370**	0.083*	0.090**	0.304**
		Female	45	0.056	0.061	0.383**	0.091*	0.092**	0.312**
	MP	Male	10	0.068*	0.073*	0.379**	0.093**	0.095**	0.314**
		Female	103	0.073*	0.078*	0.406**	0.092**	0.095**	0.315**
June	KS	Male	20	0.065	0.073*	0.419**	0.102*	0.109**	0.333**
		Female	59	0.065	0.073*	0.421**	0.098*	0.111**	0.330**
	MP	Male	21	0.091*	0.102**	0.443**	0.104**	0.121**	0.333**
		Female	88	0.094*	0.107**	0.451**	0.105**	0.122**	0.335**
July	KS	Male	33	0.039	0.057	0.407**	0.120*	0.128**	0.357**
		Female	74	0.057	0.070	0.421**	0.127**	0.133**	0.359**
	MP	Male	16	0.122**	0.130**	0.468**	0.118**	0.134**	0.349**
		Female	84	0.117**	0.124**	0.469**	0.120**	0.137**	0.359**
August	KS	Male	20	0.094*	0.075	0.448**	0.138**	0.158**	0.363**
		Female	38	0.104*	0.080	0.457**	0.138*	0.160**	0.361**
	MP	Male	9	0.031	0.028	0.384**	0.101*	0.128*	0.336**
		Female	88	-0.021	0.023	0.239**	0.062**	0.090**	0.239**
September	KS	Male	15	0.104	0.046	0.430**	0.118*	0.152**	0.327**
		Female	49	0.100	0.045	0.433**	0.120*	0.156**	0.332**
	MP	Male	11	0.060	0.028	0.382**	0.117	0.179**	0.314**
		Female	45	0.058	0.041	0.378**	0.124	0.191**	0.319**
Octobers	KS	Male	12	-0.169*	-0.102	0.102	0.201**	0.280**	0.436**
		Female	20	-0.141	-0.077	0.134	0.213**	0.294**	0.457**
	MP	Male	28	-0.159	-0.071	0.107	0.247**	0.301**	0.488**
		Female	28	-0.220*	-0.124	0.049	0.165	0.229**	0.416**
November	KS	Male	19	-0.215*	-0.081	0.073	0.158	0.262*	0.430**
		Female	24	-0.149	-0.049	0.137	0.186	0.275*	0.458**
	MP	Male	18	-0.175	-0.140	0.069	0.206	0.232	0.433**
		Female	34	-0.172	-0.153	0.103	0.215	0.227	0.462**
December	KS	Male	7	-0.021	0.023	0.239**	0.062**	0.090**	0.239**
		Female	11	-0.027	0.016	0.233**	0.062*	0.091**	0.239**
	MP	Male	49	-0.031	0.012	0.230**	0.062*	0.091**	0.240**
		Female	57	-0.025	0.014	0.235**	0.058*	0.091**	0.237**

KS, Khansama; MP, Mohanpur; n, number of specimens; TL, total length; SL, standard length; BW, body weight; Min, Minimum; Max, Maximum.

This data indicated that fish body weight showed more impacts on the health condition rather than its body length. Hossain *et al.* (2012) studied that CF_f were significantly correlated with TL and BW, but no correlation recorded with SL in *A. punctata*.

CONCLUSION:

Pethia conchonius can play a significant role to the national fish production of Bangladesh. The body size of this species ranged from 4.2 to 8.1 cm and 1.02 to 8.65 g, respectively. A strong relationship was found in LWRs and LLRs. Here, the calculated a- or -b-values from LWRs were found within the expected limit as the 0.0032–0.0162 or 2.5–3.5 and Bayesian limit as 2.88–3.26. In case of health status, CF_f ranged from 1.0796 to 2.104 and 1.172 to 2.105 for female and male respectively while relative body weight (BW_r) ranged from 73.989 to 126.880 and 68.602 to 126.184 for those sexes. During the study foam factor ranged from 0.0001 to 0.089 and 0.0004 to 0.046 for female and male. This small fish species is essential for pregnant and the lactating women, infants, and rural communities. Analyzing its length-weight, length-length, and conditioning factors will help assess its biology, growth, population structure, health, productivity, stocking density, ratio, spawning time, and season, as well as the fisheries management. This research will provide valuable information to conserve this species from extinction.

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CONFLICTS OF INTEREST:

The authors declare that there is no potential conflict of interest.

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