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Growth, Condition, Maturity and Mortality of the Dwarf Gourami, *Trichogaster lalius* (Hamilton, 1822) in a Wetland Ecosystem (Beel Dakatia), Southwestern Bangladesh

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ABSTRACT

The dwarf gourami, *Trichogaster lalius*, is a low-cost freshwater edible fish for the people of South Asian countries containing a variety of essential nutrients. The first wide-ranging explanation on the population parameters specifically; length-frequency distribution (*LFD*), length-weight relationships (*LWRs*), length-length relationship (*LLR*), form factor ($a_{3.0}$), condition factors (allometric, K_A; Fulton's, K_F; relative, K_R; relative weight, W_R), size at first sexual maturity (L_m) and natural mortality (M_w) of *T. lalius* were estimated. 768 specimens were collected over one calendar year (March 2019 to February 2020) from a wetland ecosystem named *Beel* Dakatia, Khulna, southwestern Bangladesh through various traditional fishing gears. Lengths (in cm) and weight (in g) were assessed through a wooden fitted measuring scale and digital balance with accuracy 0.1 cm and 0.01g, respectively. In the current study, the total length ranged from 2.6-9.9 cm while the bodyweight ranged from 0.63-23.80 g for *T. lalius*. The TL size for classes of 7.00 to 7.99 and 8.00 to 8.99 cm indicated numerically prominent groups. Moreover, the calculated allometric coefficient (b) of *LWRs* represented a negative allometric growth pattern (b<3.00) for *T. lalius* in the *Beel* Dakatia. Noticeably, the $a_{3.0}$ was 0.015 signifying that the fish is fusiform in shape. K_F is the best-suited tool to assess the well-being of *T. lalius* among the four types of condition factors. According to Wilcoxson signed-rank test, the W_R revealed significantly dissimilarities from 100 ($P<0.0001$), signifying the unbalanced territory for *T. lalius*. Moreover, the estimated L_m was 5.91 (~6.0) cm TL and M_w was 1.28 year^{-1} in the *Beel* Dakatia, southwestern Bangladesh. Finally, the knowledge about the biological aspects of *T. lalius* may be used for improved management tools in the future.

INTRODUCTION

Fishes are diverse groups of vertebrates in the world, demonstrating amazing taxonomic volume and distribution over the world **(Collen *et al.*, 2014)**. The order Perciformes is a morphologically diverse group which contains more than 40% of all

bony fishes under 20 sub-orders **(Nelson, 2006; Nelson *et al.*, 2016)**. Gourami is a diversified fish group of freshwater perciform in the Osphronemidae family. At present, more than 130 fish species are available under four sub-families and 15 genera **(Nelson *et al.*, 2016; Jena *et al*., 2019)**.

The dwarf gourami, *Trichogaster lalius*, **(Hamilton, 1822)** is a well-recognized gourami in the southern Asia along with Bangladesh, Nepal, Vietnam, India, Sri-Lanka, Thailand, Malaysia, Pakistan and few of other continents like the United States, Australia and Columbia **(Zuanon *et al*., 2013; Darshan *et al*., 2019)**. Earlier it was classified as *Colisa lalia* and in Bangladesh it is known as Lal Khailsa, Boicha and Ranga Khailsa. It is an air-breathing fish, found in well-oxygenated as well as hypoxic water bodies such as ponds, rivers, swamps, marshes, pools, beels, flood plains, canals, haors, baors and rice fields **(Rahman, 2005; IUCN, 2015)**. It is omnivore in nature and used to feed on zooplankton as well as vegetable particles from aquatic vegetation **(Goodwin, 2003)**. *T. lalius* is considered as small indigenous target fish for artisanal fishers who engage fishing with different traditional gears like drag net, trap, push net, hook and line and lift net so on **(Goodwin, 2003; Roy *et al*., 2020)**. It is of significant demand for people with the lower income as an important source of animal protein. Moreover, it is well recognized and used as a peaceful ornamental fish worldwide **(Talwar & Jhingran, 2001; Froese & Pauly, 2018)**. Thus, aquaculturists have developed programs for its culture in captive condition. On the flip of site, wild *T. lalius* is facing various environmental pressures such as habitat devastation and drying out the shallow water bodies. But for being a robust fish, it is grouped in the 'least concern' category in Bangladesh as well as globally in the aspect of conservational **(IUCN, 2015)**.

Length-weight relationship (*LWR*) variable is used for the estimation of weights from lengths as in the field level study direct weight measurements of larger amount of sample is difficult and time consuming **(Chaklader *et al*., 2018; Azad *et al*., 2020; Hossen *et al*., 2020)**. Moreover, length-weight relationship is important for evaluating the fish stock **(Chaklader *et al*., 2016; Nahar *et al*., 2018; Saha *et al*., 2019)**. On the other hand, length-length relationship (*LLR*) is considered as more accurate than age and some eco-physiological factors are reported to be more length-based than the age-based **(Hossain *et al*., 2017a)**. On the basis of fish biology, ecological relationships and condition of the aquatic habitat can be explained. Thus, in case of aquatic animal the condition factor has become an important parameter for predicting their survival, reproduction, maturity and health status **(Hossen *et al*., 2019; Rahman *et al*., 2020)**. Both condition factor and form factor are fundamental tools that can be utilized to determine the distinction among different population of the identical species **(Chaklader *et al*., 2016)**. Relative weight (W_R) was one of the most well-liked indices in the USA for the previous two decades **(Rypel & Richter, 2008)** to know the condition of fishes, and in recent times it has been broadly used in Bangladesh for assessing the well-being of freshwater fishes **(Hossain *et al*., 2017b; Hasan *et al*., 2020)**. Other population

parameters such as growth pattern, reproduction, fish mortality are essential to the execution of sustainable management practices for improved conservation **(Hossain *et al*., 2016; Hossain *et al*., 2019; Hossen *et al*., 2019; Ahmed *et al*., 2020)**.

A number of research works on the length-weight relationship and condition factors **(Awasthi *et al*., 2015; Sandhya *et al*., 2016; Borah *et al*., 2017; Islam *et al*., 2017; Sangma *et al*., 2019)**, captive breeding **(Jain *et al*., 2016; Saha *et al*., 2017; Jena *et al*., 2019)**, reproduction and spawning behavior **(Saha *et al*., 2018)** and the growth performance of *T. lalius* **(Sahu *et al*., 2018; Biabani *et al*., 2020, Ramee *et al*., 2020)** were carried out. This is believed to be the first report on population parameters of this population in this region. However, there is still very few documentation available on population parameters of this species from Bangladeshi waters or elsewhere which attracted the attention of the authors of the present study. Therefore, the present work would provide a downright summary and very informative delineation on the population parameters of *T. lalius*- including *LFD, LWRs, LLR,* form factor ($a_{3.0}$), condition factors (allomatric, K_A; Fulton's, K_F; relative, K_R), size at first sexual maturity (L_m) as well as natural mortality (M_w) from a wetland ecosystem named as *Beel* Dakatia, Khulna, southwestern Bangladesh using several small and large specimens for a one year duration. The findings could be utilized as a beneficial tool in the sectors of fisheries biology, conservation and management.

MATERIALS AND METHODS

Study Region and Sampling

Collection of fish sample was carried out from the wild capture of *Beel* Dakatia (Lat. 22°54'34.1"N; Long. 89°27'48.6"E) located in the northeastern part of Khulna district, Bangladesh (Fig. 1). It is very large saucer like water bodies and literally meaning robber saucer **(Rahman *et al*., 2010)** which is considered as one of the second largest *beel* (wetlands) in Bangladesh. A total of 768 individuals of *T. lalius* were collected occasionally over the period from March 2019 to February 2020, through different conventional fishing techniques such as cast net (mesh size: 1.0-2.0 cm), drag net (mesh size: 0.5-1.5 cm), lift net (mesh size: <0.5 cm) and gill net (mesh size: 1.5-2.5 cm). After collection, samples of fish were quickly chilled with ice on the spot and then preserved in 10% buffered formalin solution in laboratory until examination. For each specimen, total length (TL) and standard length (SL) were assessed to the closest 0.1 cm by a measuring scale, while body weight (BW) was measured through digital balance to 0.01 g precision.

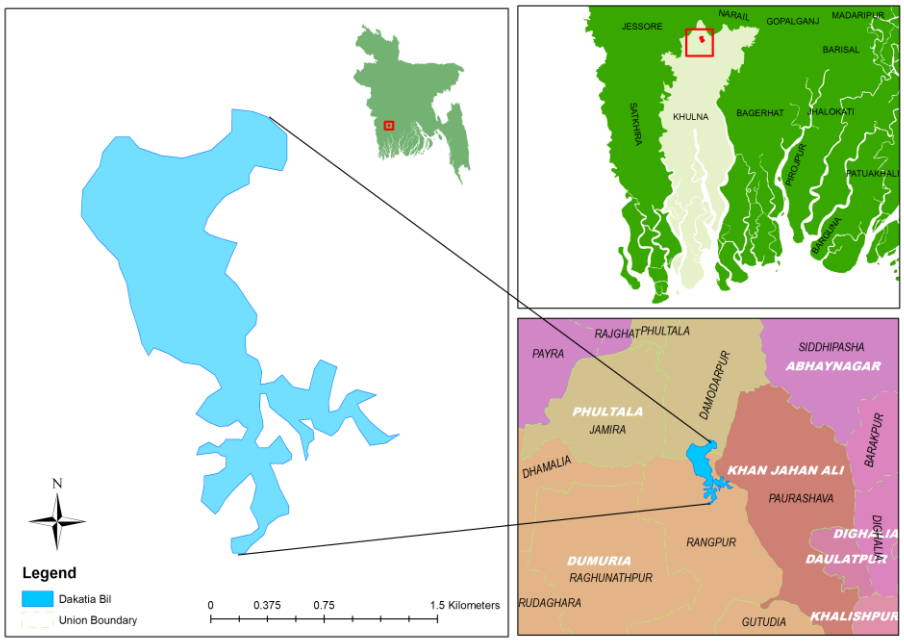

Fig. 1. Map viewing location of the study site for *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

Length Frequency Distribution (*LFD*)

Length frequency distributions (*LFD)* for total population of *T. lalius* were constructed using 1.0 cm class intervals of TL.

Length-weight Relationships and Length-length Relationship (*LWRs* and *LLR)*

Relationship between length and weight was enumerated using the following expression: $W = a*L^b$ **(Le Cren, 1951)** where W is the whole body weight (g), L is the total length (cm), *a* intercept and *b* is the regression coefficient (slope). The parameters *a* and *b* of the length-weight relationship will be estimated by linear regression analysis derived from natural logarithms: ln (W) = ln (*a*) + *b* ln (L) **(Froese, 2006; Hossain *et al.*, 2016)**. According to **Froese (2006)**, extreme outliers were expelled from the analyses. Additionally, t-test was applied to evaluate significant variations from the isometric value (for length weight relationship, b= 3 and for length-length relationship, b= 1) **(Sokal & Rohlf, 1987)**. The divergence of b from the hypothetical isometric value implies that allometric growth is either positive (b> isometric value) or negative (b< isometric value). Analysis of covariance (ANCOVA) **(Zar, 1984)** was used to analyze the significant dissimilarities in slopes and intercepts among the relationships. Additionally, the *LLR* (TL *vs*. SL) was calculated using the linear regression model of **Hossain *et al.* (2006)**.

Form Factor ($a_{3.0}$)

Form factor ($a_{3.0}$) of *T. lalius* was estimated by the formula of **Froese (2006)** as: $a_{3.0} = 10^{\log a - s(b-3)}$, where *a* and *b* are the regression variables of *LWR* (TL vs. BW), and s

is the slope of *loga vs. b*, a mean slope was used; where S = -1.358 **(Froese, 2006)** for assessing the form factor due to scarcity of available information on LWR for this species to calculate the regression (S) of *loga vs. b*.

Condition Factors

The allometric condition factor (K_A) was calculated using following expression proposed by **Tesch (1971)**: W/L^b, where W is the body weight (g), L is the TL (cm), and b is the *LWR* parameter. Based on the expression of **Fulton (1904)**: K_F=100× (W/L^3), (where W is the body weight in g, and L is the TL in cm), Fulton's condition factor (K_F) was estimated. To obtain the K_F close to the unit, a scaling factor of 100 was used **(Froese, 2006)**. Additionally, the relative condition factor (K_R) was evaluated through following the formula of **Le Cren (1951)**: $K_R = W/(a \times L^b)$, where W is the body weight (g), L is the total length (cm), and a and b are the *LWR* parameters. For assessing the relative weight (W_R), the formula of **Froese (2006)** was used: $W_R = (W / W_s) \times 100$, where W is the weight of a specific individual and W_s is the anticipated standard weight as intended by $W_s = a*L^b$ where the a and b values are achieved from the correlation between TL vs. BW.

Size at First Sexual Maturity *(L_m)*

The size at first sexual maturity (L_m) of *T. lalius* was measured through the empirical formula proposed by **Binohlan and Froese (2009)** as: $log\ (L_m) = -0.1189 + 0.9157 \times log\ (L_{max})$; where, the L_m= size at first sexual maturity in TL, L_{max} = maximum observed length (TL) of *T. lalius* in the present study.

Natural Mortality (M_w)

The M_w of *T. lalius* was assessed through the model proposed by **Peterson and Wroblewski (1984)**: $M_w = 1.92\ year^{-1} * (W)^{(-0.25)}$; where, M_w = natural mortality at mass W; and $W = a*L^b$, a and b are the regression variables of *LWR* (TL vs. BW).

Statistical Analysis

For data processing, Microsoft® Excel-add-in DDXL and GraphPad Prism 8 software were used. To evaluate the association of condition factors with TL and BW, the Spearman rank-correlation test was applied.Wilcoxon sign-ranked test was used to link with the average relative weight (W_R) with 100 **(Anderson & Neumann, 1996)**. At 5% ($p<0.05$) significant level, all statistical analysis were performed.

RESULTS

Length Frequency Distribution (LFD)

During the period of study, a total number of 768 specimens were collected from the local fishermen throughout the various parts of *Beel* Dakatia, Khulna, southwestern

Bangladesh. Explanatory statistics of maximum and minimum total length and body weight measurement, with their 95% confidence interval (CI) of *T. lalius* are illustrated in the Table (1). The *LFD* of *T. lalius* revealed that the range of TL was 2.6-9.9 cm; whereas, BW ranged from 0.63-23.80 g. The TL size for classes of 7.00-7.99 and 8.00-8.99 cm was statistically prominent and together constituted 48.83% of the total population (Fig. 2).

Table 1. Explanatory statistics of length (cm) and weight (g) measurements and their 95% confidence interval (CI) of the *T. lalius* (Hamilton, 1822) (n= 768) in the *Beel* Dakatia, Khulna, southwestern Bangladesh.

Measurement	Total	Minimum	Maximum	Mean±SD	95% CI
Total length (TL)		2.6	9.9	6.69±2.07	6.54-6.83
Standard length (SL)	768	2.1	7.9	5.24±1.59	5.13-5.35
Body weight (BW)		0.63	23.80	8.23±5.61	7.83-8.63

SD, standard deviation; and CI, confidence interval for mean values

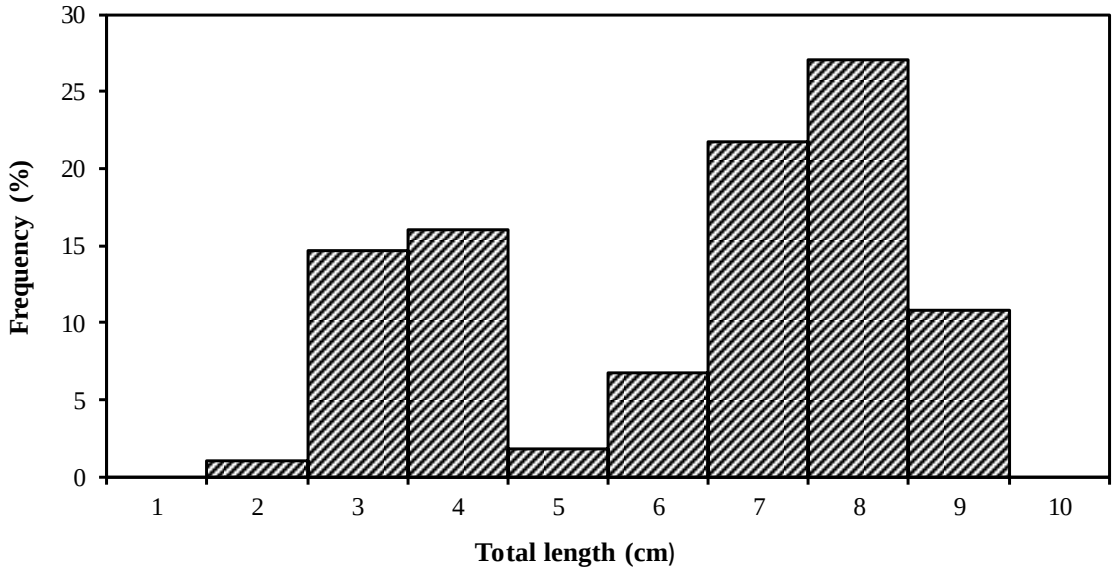

Fig. 2. Total length-frequency distributions of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

Length-weight Relationships (*LWRs*)

In Table (2) and Fig. (3); the regression parameter, 95% CL of *a* and *b*, and the coefficient of determination (r^2) and growth type of *T. lalius* are specified. In this study, the calculated allometric coefficient (b) of TL vs. BW exhibited negative allometric growth pattern (Table 2 & Fig. 2), and displayed the similar growth pattern in the SL vs.

BW relationship (Table 2 & Fig. 4) for this species in the *Beel* Dakatia. Moreover, the *LWRs* were extremely significant (*p<0.0001*) with a coefficient of determination values $r^2 \geq 0.982$.

Table 2. Descriptive statistics and estimated parameters of the length-weight and length-length relationships of *T. lalius* (Hamilton, 1822) in the *Beel* Dakatia, Khulna, southwestern Bangladesh.

Species	Total	Regression parameters		95% CI of *a*	95% CI of *b*	r^2	GT
		A	b				
BW = *aTL^b**	768	0.0390	2.70	0.0378 to 0.0413	2.68 to 2.72	0.984	A-
BW = *aSL^b**		0.0680	2.77	0.0654 to 0.0714	2.74 to 2.79	0.982	A-
TL=*a*+*bSL**		-0.1030	1.30	-0.1560 to -0.0517	1.29 to 1.31	0.989	A+

BW, body weight; TL, total length; SL, standard length; *a*, intercept; *b*, regression slope; CI, confidence interval for mean values; r^2, coefficient of determination, GT, growth type; A-, negative allometric; A+, positive allometric.

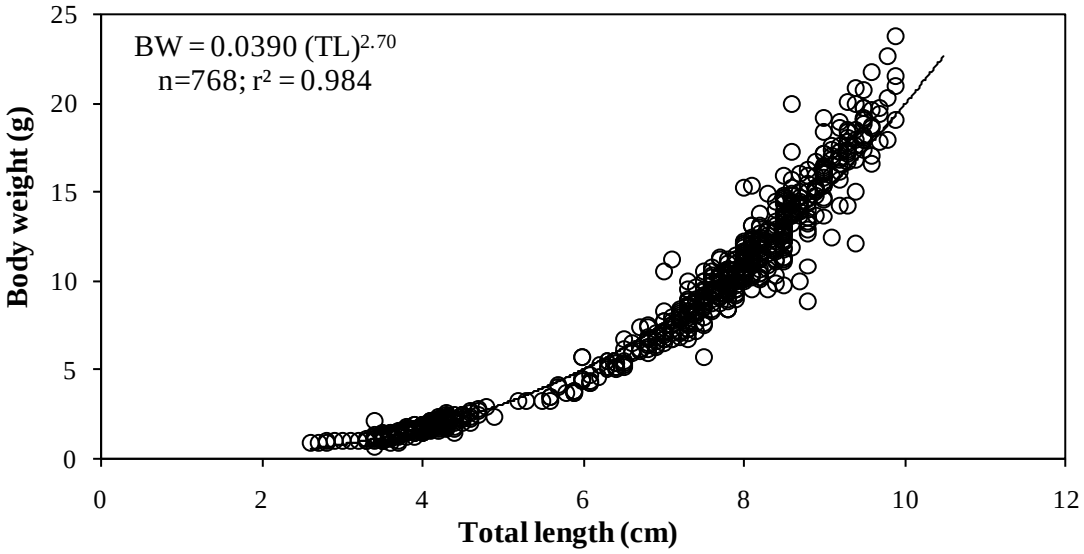

Fig. 3. Relationship between total length and body weight of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

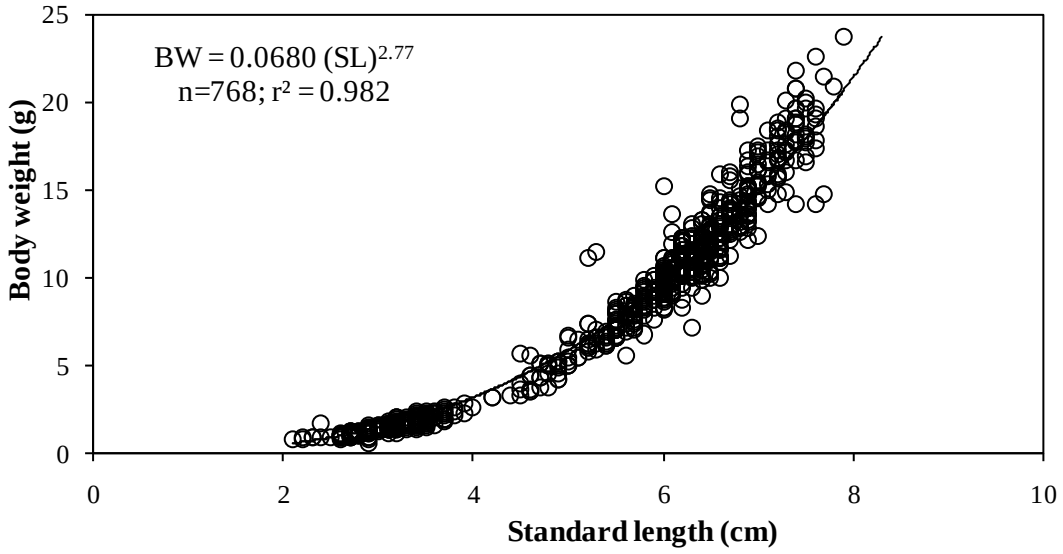

Fig. 4. Relationship between standard length and body weight of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

Length-length Relationship *(LLR)*

Association between SL and TL of *T. lalius* alongside the calculated variables of the *LLR* and the coefficient of determination (r^2) are displayed in Table (2) and Fig. (5). In research work, the estimated allometric coefficient (*b)* value of the *LLR* revealed positive allometric growth pattern. In addition, the *LLR* was very much significant ($p<0.0001$) with a coefficient of determination value of 0.989.

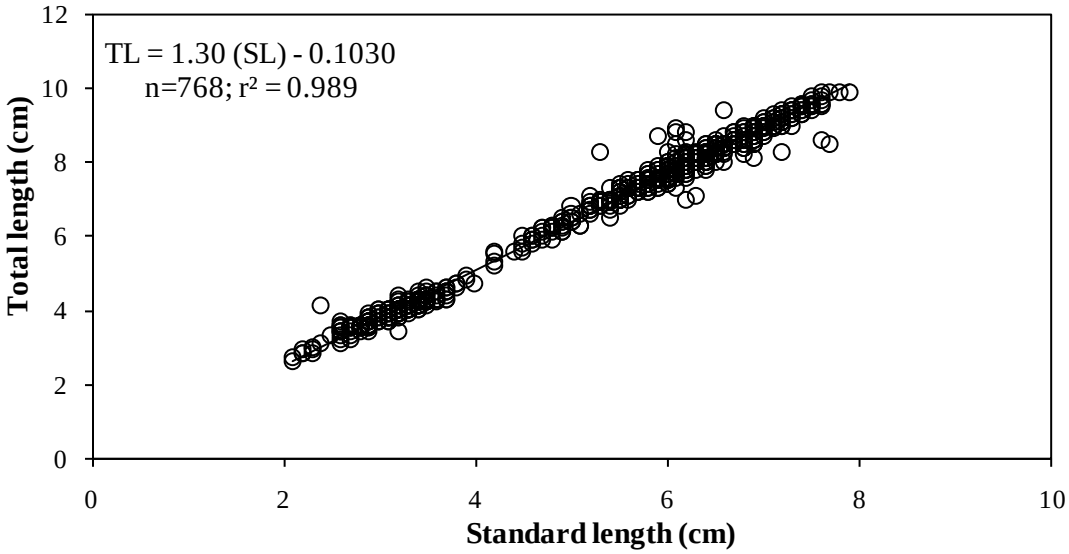

Fig. 5. Standard length- total length relationship of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

Form Factor ($a_{3.0}$)

The form factor ($a_{3.0}$) was determined as 0.015 for combined sex of *T. lalius* in the *Beel* Dakatia, and this estimated value signified that this fish is fusiform like in shape.

Condition Factors

Allometric condition factor (K_A)

During this study, the calculated K_A of *T. lalius* varied from 0.0231-0.0775 (Mean ±SD, 0.0398 ± 0.0049) (Table 3). Additionally, spearman rank-correlation tests revealed that K_A had profoundly huge association with both TL (r_s= 0.1664, p < 0.0001) and BW (r_s= 0.3004, p < 0.0001) (Table 4).

Table 3. Descriptive statistics of condition factors measurements with their 95% CL of *T. lalius* (Hamilton, 1822) in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh).

Condition factors	Minimum	Maximum	Mean±SD	95% CI
Allometric, K_A	0.0231	0.0775	0.0398 ± 0.0049	0.0395-0.0402
Fulton's , K_F	1.2972	5.3684	2.3067 ± 0.4082	2.2778-2.3357
Relative, K_R	0.5933	1.9871	1.0217 ± 0.1258	1.0128-1.0306
Relative weight, W_R	59.33	198.71	102.17 ± 12.58	101.28-103.06

SD, standard deviation; CI, confidence interval for mean values.

Fulton's Condition Factor (K_F)

The determined K_F varied from 1.2972- 5.3684 (Mean ± SD, 2.3067 ± 0.4082) (Table 3). According to spearman rank-correlation test, there were greatly significant relationships between TL vs. K_F (r_s= -0.5079, p < 0.0001), eventhough there were highly significant associations between BW vs. K_F (r_s= -0.3966, p < 0.0001) (Table 4).

Relative Condition Factor (K_R)

In this study, the calculated K_R of *T. lalius* varied from 0.5933- 1.9871 (Mean ± SD, 1.0217 ± 0.1258) (Table 3). According to Spearman rank-correlation test, there were very much significant associations between TL vs. K_R (r_s= 0.1664, p < 0.0001), even that there were highly significant relationships between BW vs. K_R (r_s= 0.3004, p<0.0001) (Table 4).

Table 4. Estimation of correlation for condition factors with total length (TL) and body weight (BW) of *T. lalius* (Hamilton, 1822) in the *Beel* Dakatia, Khulna, southwestern Bangladesh.

Relationship	r_s value	95% CI of r_s	*p* values	Degree of significance
TL *vs.* K_A	0.1664	0.0947 to 0.2364	<0.0001	***
TL *vs.* K_F	-0.5079	-0.5601 to -0.4518	<0.0001	***
TL *vs.* K_R	0.1664	0.0947 to 0.2364	<0.0001	***
TL *vs.* W_R	0.1664	0.0947 to 0.2364	<0.0001	***
BW *vs.* K_A	0.3004	0.2327 to 0.3652	<0.0001	***
BW *vs.* K_F	-0.3966	-0.4563 to -0.3334	<0.0001	***
BW *vs.* K_R	0.3004	0.2327 to 0.3652	<0.0001	***
BW *vs.* W_R	0.3004	0.2327 to 0.3652	<0.0001	***

TL, total length; K_A, allometric condition factor; K_F, Fulton's condition factor; K_R, relative condition factor; W_R, relative weight; BW, body weight; r_S, Spearman rank-correlation values; CI, confidence interval; *p*, exhibitions the intensity of significance; ***very highly significant.

Relative Weight (W_R)

W_R of *T. lalius* varied from 59.33- 198.71 (Mean ± SD, 102.17 ± 12.58) during this research (Table 3). As per Spearman rank-correlation test, there were highly significant associations between TL vs. W_R (r_s= 0.1664, p < 0.0001), even that there were highly significant relationships between BW vs. W_R (r_s= 0.3004, p < 0.0001) (Table 4). As per a Wilcoxon sign-ranked analysis, W_R demonstrated very significant difference from 100 (p<0.0001) for *T. lalius*. Moreover, the correlation between TL and W_R is displayed in Fig. (6).

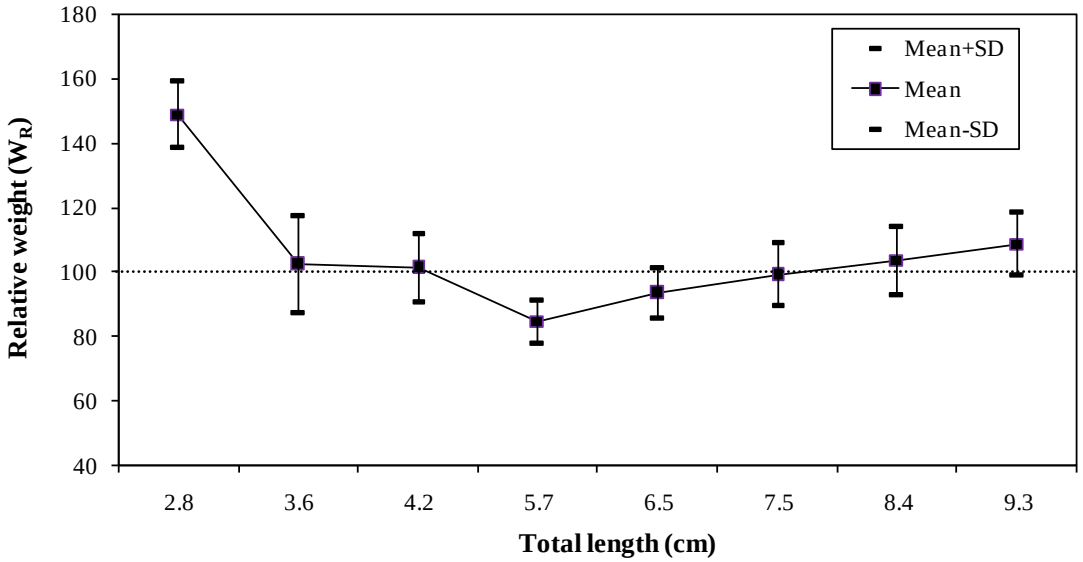

Fig. 6. Relationship between total length (cm) and relative weight (W_R) of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

Size at First Sexual Maturity (L_m)

The L_m for combined sex of *T. lalius* was calculated as 5.91 (~6.0) cm TL in the *Beel* Dakatia, Khulna, southwestern Bangladesh.

Natural Mortality (*Mw*)

During the study work, the mean natural mortality (M_w) for the *T. lalius* population was calculated as 1.28 year^{-1} in the *Beel* Dakatia, Khulna, southwestern Bangladesh and it is shown in Fig. (7).

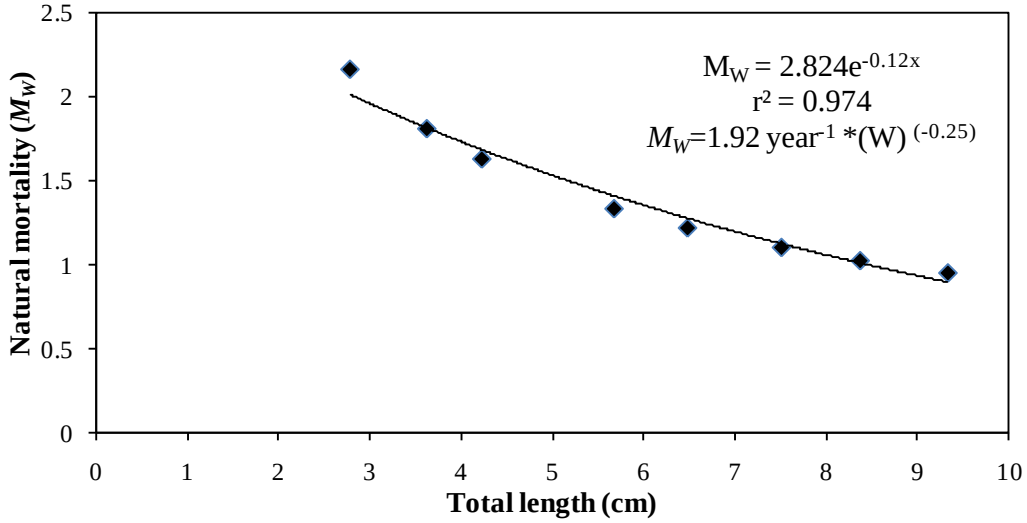

Fig. 7. Natural mortality of *T. lalius* in a wetland (*Beel* Dakatia, Khulna, southwestern Bangladesh) ecosystem.

DISCUSSION

Existing research work on the population parameters of *T. lalius* is still very rare in both Bangladesh and worldwide literature. Hence, the current study intends to focus on the proper description on population parameters including *LFD*, *LWRs*, *LLR*, multi-approach condition factors (K_A, K_F, K_R, W_R), $a_{3.0}$, L_m and M_w of *T. lalius* using many specimens of various sizes from the *Beel* Dakatia, Khulna, southwestern Bangladesh.

During research period, it was not possible to sample individuals of *T. lalius* below 2.6 cm TL, because of one or more following arguments: (i) fishermen might not reach where the smaller size remain **(Hossain *et al*., 2012a; Khatun *et al*., 2018, 2019; Azad *et al*., 2018)** (ii) or probably for the scarcity of small fishes in the fishing areas **(Hossain *et al*., 2012a,b,c; Hossain *et al.*, 2017a,b; Khatun *et al.*, 2019)** and (iii) or due to the fishermen's propensity to discard smaller fishes **(Rahman *et al*., 2018)**. Furthermore, the highest total length of *T. lalius* inside the *Beel* Dakatia was 9.9 cm which is somewhat higher than the highest recorded estimation of 9.5 cm **(Froese & Pauly, 2020)**. This dissimilarity perhaps is due to the selectivity of fishing gear **(Hossen *et al.*, 2019; Sabbir *et al.*, 2020)**. It may also relate to the fact that fishers did not reach the sites of larger fish **(Ahamed *et al*., 2017; Khatun *et al*., 2019; Sabbir *et al*., 2020)**. Generally, for the calculation of the asymptotic length and growth coefficient of fishes, information on the maximum length is very crucial and is often useful for the better planning and management of wild fish population.

The current study stated that the allometric co-efficient b values (varied from 2.70 to 2.77) for *T. lalius* were found to be accordant with the expected range (2.0-4.0) stated by **Tesch (1971)** and (2.50-3.50) by **Froese (2006)**. According to **Froese (2006)**, b < 3 might be inferable from an over-corresponding expansion in length comparative to increment in weight.

Overall, despite many variations in fish form between particular species, b values being near to 3, suggesting that fish grow isometrically and dissimilar from 3.0 signifies allometric growth (where, > 3 positive allometry and < 3 negative allometry) **(Tesch, 1968)**. In this context, estimated *b* values of the *LWRs* (TL *vs.* BW; SL *vs.* BW) were <3 suggesting the population does not flow the cube law strictly. Parallel growth patterns were revealed in the combined population (b=2.88) from five (5) sub-population of *T. lalius* of middle and eastern India **(Awasthi *et al.*, 2015)**; and from Deepor beel (b=2.82), a Ramsar site, Assam, India (**Borah *et al.*, 2017**). On the flip of site, other south Asian investigations have observed positive allometric growth pattern for this species: **Islam *et al*. (2017)** recorded b= 3.17 in Pultakanda fish market, Kishoregonj, Bangladesh. While, **Sandhya *et al*. (2016)** found b= 3.16 from Khalsi wetland, West Bengal, India. Both previous results are entirely unparalleled with the present finding. Moreover, isometric growth pattern was reported from Tripura India (b= 3.08) found by **Sangma *et al*. (2019)** which is also unlike with the current result. Those differences in the value of b may be attributed to distinction in observed length class, sample preservation methods, degree of

stomach completeness, gonad ripeness, sex, diet, physiology, seasonal effect or geographical position **(Hossain *et al*., 2010, 2017a; Hossen *et al*., 2016, 2018; Khatun *et al*., 2019)**; that were not predicted in the current research.

Froese (2006) recommended the form factor ($a_{3.0}$) assists to check whether the body dimension of individuals in a particular population or specific species is considerably varied from others. The calculated $a_{3.0}$ for *T. lalius* was within the range 0.0131-0.0140 narrated by **Froese (2006)**; suggesting fusiform like body shape in *T. lalius* in the *Beel* Dakatia. Owing to lack of related reference regarding form factor of this fish species, it was not possible to make comparisons across the water bodies.

In this research, we have focused on four types of condition factor (K_A, K_F, K_R, W_R) to assess the health and environmental status of *T. lalius* in the *Beel* Dakatia, nevertheless, most of the investigations address only a single condition features. The spearman correlation values (r_s) showed the same value (r_s= 0.1664) between length (TL) and condition factors (K_A, K_R, W_R) as also did so between weight (BW) and condition factors (K_A, K_R, W_R) with same values (r_s= 0.3004) (Table 4). But within those four condition factors, only Fulton's condition factor showed the different correlation values between TL vs. K_F (r_s= -0.5079) and BW vs. K_F (r_s= -0.396). That's why, the Fulton's condition factor (K_F) could be considered to be the best way to assess the well-being of this population in the *Beel* Dakatia, Khulna, southwestern Bangladesh as well as the adjacent ecosystem.

Wilcoxon signed rank test confirms that the mean W_R was notably dissimilar from 100 ($p<0.0001$) signifying an inequality territory with food availability proportionate to the event of hunters **(Anderson & Neumann, 1996; Rahman *et al*., 2020)** for *T. lalius* in the *Beel* Dakatia. Moreover, the W_R can be used to judge the general health and wellness including ecosystem disruptions at population-level **(Rypel & Richter, 2008)**. There is however, no literature attainable dealing with W_R of *T. lalius*, which prevents comparison with the present studies.

The size at first sexual maturity (L_m) is very essential for fish stock assessment which is an important indicator for minimum permissible capture size **(Lucifora *et al*., 1999; Khatun *et al*., 2019; Hossain *et al*., 2019)**. This study revealed that the L_m for *T. lalius* was 5.91 (~6.0) cm in the *Beel* Dakatia. Hence, this research delivers first effort to estimate the size at first sexual maturity for *T. lalius* from the *Beel* Dakatia (a wetland ecosystem) as well as Bangladeshi waters. Consequently, it comprises baseline information for the additional research to the fisheries biologists. Furthermore, the M_w for the total population of *T. lalius* was intended as 1.28 year^{-1} in the *Beel* Dakatia, which is also the first global assessment.

CONCLUSION

The current findings provide first inclusive information on the population patterns of the *T. lalius* including length-frequency distribution, growth pattern based on LWRs,

form factor, best suited condition factor, size at first sexual maturity and natural mortality. Hence , the present work would offer a valuable evidence for fishery biologists, conversationalists and administrators to enforce promptly management approach and recommendations in case of sustainable resource conservation of the lasting stocks of this fish species. To conclude, findings of current research provide basic knowledge for the fishbase online database and provide an imperative framework for prospective research within wetland ecosystems.

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