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Life-History Traits, Growth Dynamics, and Population Parameters of *Lepidocephalichthys guntea* in a Ramsar Wetland of Bangladesh: Implications for Ecosystem-Based Fisheries Management

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ABSTRACT

Knowledge of species-specific life-history characteristics is vital to sound fisheries management especially in wetlands that are ecologically sensitive. This paper assesses the population, growth trends and important biological parameters of the guntea loach (*Lepidocephalichthys guntea*) in Tanguar Haor, a Ramsar wetland in northeastern Bangladesh. In total, 258 specimens were collected in July 2024-June 2025 and analyzed with length-frequency distribution, length-weight and length-length relationships, and various condition indices. The total length measured between 6.4 and 10.5 cm and the body weight were 2.01 to 9.6 g. The species showed favorable allometric growth (b = 3.12-3.17; r^2 = 0.994) which suggests positive environmental conditions. The condition factors (K_F = 0.748; K_R =0.998; W_R =99.84) were indicative of a healthy and well-balanced population. The body morphology was an elongated body as indicated by the form factor ($a_{3.0}$ = 0.0088). First sexual maturity size was estimated to be 6.5 cm TL, asymptotic length (L_∞) and lifespan were 11.19 cm and 3.1 years, respectively. Natural mortality was estimated as 1.49 year $^{-1}$ and optimum catchable length was estimated to be 7.4 cm TL. These results reveal the ecological soundness of the population but also point towards susceptibility to overfishing and habitat destruction. The research will give a starting biological information that will be used to devise science-based management approaches, such as size-selective harvesting and habitat protection, to achieve long-term sustainability of this economically and ecologically significant small native species.

Introduction

Freshwater ecosystems of Bangladesh are one of the most productive and biodiverse inland fisheries systems in South Asia, with hundreds of finfish species, and supporting millions of livelihoods. Such ecosystems consist of rivers, floodplains, *beels*, *haors* and wetlands which together play a major role in food security and the economies of the rural areas. One of these, Tanguar *Haor*, a wetland listed under Ramsar, is internationally known due to its ecological significance

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with a wide array of aquatic flora and fauna and serving as a vital breeding and nursery area to numerous fish species. Nevertheless, growing anthropogenic stressors, such as overfishing, habitat destruction, and climatic variability are posing a threat to the viability of these ecosystems and fisheries resources. Small indigenous fish species (SIFS), including *Lepidocephalichthys guntea* (Guntea loach) (Hamilton 1822), are important to the ecological and socioeconomic activities in Bangladesh (Rahman 1989 and 2005). These species are significant to the local food supply, supplying vital micro-nutrients, and can be a major source of income to small-scale fishers (Saha et al. 2021). The *L. guntea* is highly dispersed in South and Southeast Asia and lives in all types of freshwater habitats, such as wetlands, floodplains, and rivers (Talwar and Jhingran 1991; Kottelat 1989). Although it is a species of "Least Concern" at present (IUCN Bangladesh 2015), recent research indicates that local populations are susceptible to environmental stresses and fishing pressure, and thus biological evaluations of the region should be conducted to effectively manage the species.

Life-history characteristics, such as growth patterns, condition factors, reproductive parameters, and mortality rates are key to comprehending fish population dynamics and creating sustainable fisheries management strategies (Mawa et al. 2022). Condition indices and length-weight relationship (LWRs) are the most common indices used to assess growth performance, physiological status and habitat suitability of fish populations (Hossain et al. 2006). In the same light, other parameters like size at first maturity (L_m), asymptotic growth, and natural mortality are critical in the evaluation of stocks and to optimize yields (Hossain et al. 2015). The recent research on *L. guntea* in Bangladesh and adjacent areas has mainly been on the reproductive biology, fecundity and morphometric relationships, particularly on the spawning seasons, variability of growth and the effects of the environment on the population dynamics. As an example, studies around the *Payra* River identified maturity sizes of between 6.4-7.0 cm and the significance of seasonal fishing limitations around the peak spawning seasons (Saha et al. 2024).

These developments notwithstanding, there are still gaps in knowledge. The majority of past research is geographically confined to riverine systems and relatively few studies have been conducted on wetland ecosystems especially Ramsar sites like Tanguar *Haor*. Furthermore, the current literature tends to concentrate on single biological parameters (e.g. reproduction or growth) as opposed to a multi-parameter evaluation of life-history characteristics. There is little evidence of integrated analyses of population structure, growth relationships, multiple condition indices, form factor, mortality, and optimum catchable length. This incompleteness of data limits the formulation of habitat-specific ecosystem-based management approaches.

The current paper fills these gaps by offering an in-depth appraisal of the life-history characteristics of *L. guntea* in Tanguar *Haor* on a multi-model and multi-parameter basis. Including length-frequency distribution, length-weight (LWR) and length-length relationship (LLR), condition factor (K_F, K_R, K_A, W_R), form factor, size at first maturity, asymptotic growth, lifespan, natural mortality and optimum catchable length, this study provides a comprehensive insight into the dynamics of the population of a wetland ecosystem. It is an integrative framework, which is a new contribution to the past research where isolated biological parameters were mainly studied.

This study has significant implications to fisheries management and conservation. The scientific basis of the use of size-selective fishing regulations and gear adjustments is found in the identification of crucial biological parameters within the size-maturity relationship and optimum harvest length, as depicted in the study. There is also condition factor and growth pattern testing which provides information about the quality of habitat and health of ecosystems, which is essential in the design of conservation interventions. In the end, the study helps to develop the ecosystem-based fisheries management methods to support biodiversity and increase the resiliency of wetland fisheries.

The particular objectives of the study were to: (i) analyze the population structure and growth trends of *L. guntea;* (ii) estimate several condition indices and relative weight to determine the health and condition of the habitat of fish; (iii) estimate several key life-history parameters such as size at sexual maturity, asymptotic growth, lifespan, and natural mortality; and (iv) determine optimum catchable length to facilitate the management of fisheries.

Materials and Method

The research was prosecuted on length-weight relationships, length-length relationship (LLR) and condition factor of *L. guntea*, fish which was collected

from the fishermen from the Tanguar *Haor*, northeastern Bangladesh. Principally the study was based on sampling of fishes where primary data were collected from the sample and by analyzing it. From different published documents and websites secondary information was collected. Detailed methodology is mentioned under the following-

Study site

This study was conducted in Tanguar *Haor*, Sunamganj, Bangladesh. This is one of the biggest wetland ecosystems in Bangladesh. 90° 58' 46.36" E to 91° 11' 05.53" E (Fig. 1). Samples of *L. guntea* were collected from the fisherman catch landed at different points of the Tanguar *Haor* at Sunamganj district in Bangladesh. Showing the study area in general map view shows the sampling site of the Tanguar *Haor*.

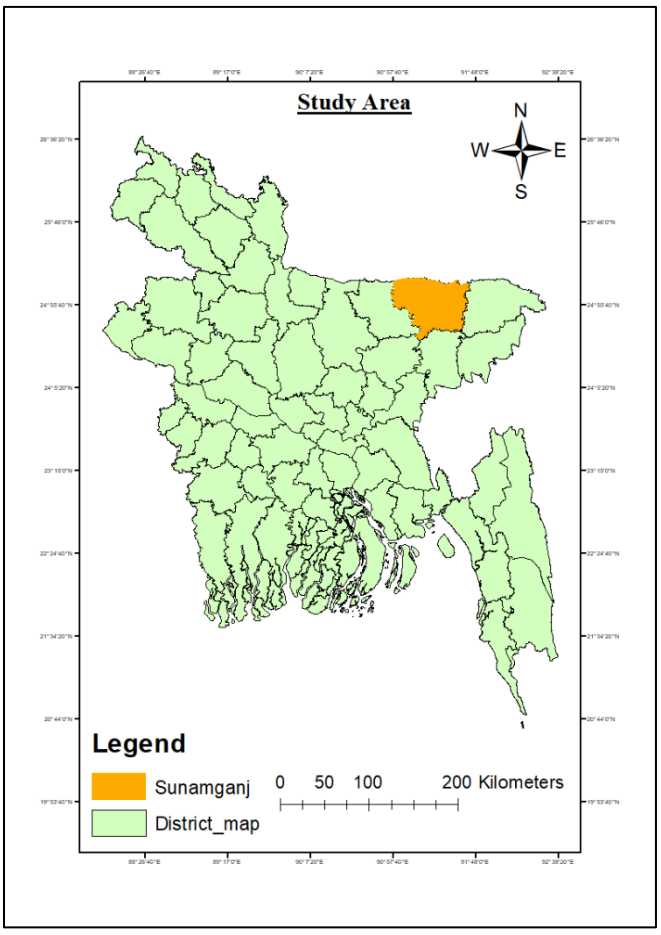

Fig. 1. Location of sampling site in the *Tanguar Haor*, Sunamganj district, Bangladesh.

Sampling period

Sample of *L. guntea* were collected from the *Tanguar Haor* during July 2024 to June 2025.

Sampling method

For the sample collection various types of locally made traditional gears and traps are used in wetland ecosystems in Bangladesh since centuries for *L. guntea* along with other small species. These are described as to preference and available for the fishermen to catch the species along with other fishes in the Tanguar *haor*. This fish is usually caught by means of the traditional fishing gears including *fash jal* (Gill net), *thela jal* (Kibria and Ahmed, 2005). The samples will be immediately preserved with ice and then fixed with 5% formalin solution in a small plastic container as soon as possible to prevent decomposition of fish.

Fish measurement

The specimens were transferred to the Department of Fisheries, University of Rajshahi (Bangladesh), where all morphometric characteristics were examined according to Froese and Pauly (2018) Before measuring, the fishes preserved with formalin were washed with running tap water to remove formalin. For each individual, total length (TL) were measured from the tip of the snout to the most posterior point with the caudal fin of fish, while standard length (SL) were measured from the tip of the snout to the posterior end of the caudal peduncle Length measurements are often taken with the help of a slide calipers and whole body weight (BW) was taken on a digital balance with 0.01 g accuracy (plate-2.2 and plate-2.3.)

Preparation of data

The study was based on sampling of fishes where primary data were collected from the sample and by analyzing it. Secondary information was collected from different published documents and websites.

Population Structure

Population structure was arranged through length-frequency distribution for assessing the age and growth of fish (Nadia *et al.*, 2023). The length frequency distribution is an incredibly important feature to consider when attempting to determine the age of a fish. The species of *L. guntea* have their length frequency distributions, commonly known as LFD, exhibited throughout a class interval of total length of 1.0 cm (TL).

L-W and L-L relationships

In order to make the length-weight relationship, this equation: $BW= a*(TL)^b$ was used, where BW is the total body weight (g) and TL is the total length (cm). The parameters *a* and *b* were calculated by linear regression analyses based on natural logarithms: ln

(BW) = ln (*a*) + *b* ln (TL). Extremes outliers were deleted from the regression analyses according to Froese (2006). Additionally, on the basis of the b values of LWR (TL vs. BW), growth patte rn of *L. guntea* was determined. A t-test was applied to determine significant differences from the isometric value of *b* = 3 for LWR. Furthermore, length-length (L-L) relationship between TL *vs.* SL was calculated according to Hossain et al. (2017).

Condition factors

The allometric condition factor (K_A) was calculated using the equation of Tesch (1968): $K_A = W/L^b$, where W is the body weight in (g), *L* is the total length in (cm) and *b* is the LWRs parameter. The Fulton's condition factor (K_F) was calculated using the equation of Fulton (1904): $K_F = 100*(W/L^3)$, where W is the body weight in (g), and *L* is the total length in (cm). The scaling factor of 100 was used to bring the K_F close to unit and the relative condition factor (K_R) for each individual was calculated using the equation of Le Cren (1951): $K_R = W/(a \times L^b)$, where W is the body weight in (g), L is the total length in (cm), *a* and *b* are the LWRs parameter.

Prey-predator Status

The W_R was calculated by the equation given by Froese (2006), as: $W_R = (W/W_S) \times 100$, where *W* is the weight of a particular individual and W_S the predicted standard weight for the same individual as calculated by $W_S = a \times L^b$, where *a* and *b* values were obtained from the relationships between TL *vs.* BW.

Form factor ($a_{3.0}$)

The form factor ($a_{3.0}$) for *L. guntea* was calculated using the expression of Froese (2006) as: $a_{3.0} = 10^{\log a - s\,(b-3)}$, where *a* and *b* is the regression parameters of LWRs and s is the regression slope of *ln a vs. b*. During this study, a mean slope *s* = -1.358, was used as proxy for estimating the form factor because information on LWRs is not available for this species for estimation the regression (*s*) of *ln a vs. b.*

Size at first sexual maturity (L_m)

The L_m of *L. guntea* in the Tanguar *Haor* was calculated by using the equation, $\log(L_m) = -0.1189 + 0.9157 * \log(L_{max})$, where L_{max} is the maximum observed length (Binohlan and Froese 2009). Moreover, the maximum lengths of different populations were obtained from available literature to estimate the size at first sexual maturity in different world-wide water-bodies.

Asymptotic length (L_∞) and weight (W_∞)

The estimation of the asymptotic length (L_∞) was carried out using the logarithmic expression: $\log L_\infty = 0.044 + 0.9841 \times \log L_{max}$ (Froese and Binohlan 2000). Concurrently, the determination of the asymptotic weight (W_∞) was achieved by employing the formula $W_\infty = aL_\infty^b$ (Ricker 1975).

Life span (t_{max})

Applying the model developed by Froese and Binohlan (2000), the relationship $\log t_{max} = 0.5496 + 0.957 \times \log(t_m)$ was utilized. In this context, t_{max} represents the maximum age or lifespan attained - within a population in years, while tm denotes the average age at first sexual maturity in years. The formula for tm is given by $t_m = (-1/1) \times \ln(1 - Lm/L_\infty)$ (King 2007).

Natural mortality (M)

The calculation of the *M* for *L. guntea* was executed employing the formula $M = -\ln [0.01] / t_{max}$ (King 2007). In this equation, *M* signifies the annual natural mortality rate, ln represents the natural logarithm.

Optimum catchable length (L_{opt})

The L_{opt} is defined as the length at which the highest yield of fish would be obtained (Froese et al. 2006). By applying the Froese and Binohlan (2000) model, the estimation of L_{opt} was carried out using the equation: $\log L_{opt} = 1.0421 \times \log(L_\infty) - 0.2742$, where in L_∞ represents the asymptotic length.

Statistical analyses

The statistical analysis was delegated to the use of the software Microsoft Excel (version 2013) and GraphPad Prism 6.0. The Spearman rank correlation test was carried out with the purpose that determined whether or not there was a link between the condition factors and either TL or BW. For the purpose of distinguishing the mean relative weight (W_R) from 100, a Wilcoxon sign-ranked test was carried out (Anderson and Neumann 1996). In the statistical analysis that was carried out, a significance level of 5% ($p < 0.05$) was used.

Result

Population Structure

A total of 258 fish specimens were randomly collected occasionally from the fishers of the Tanguar *haor*, Northeastern Bangladesh. Table 1 summarizes the explanatory length and weight measurement statistics (with their 95% CI) of *L. guntea*. The TL during the study period varied from 6.4 to 10.5 cm, whereas the BW ranged from 2.01 to 9.6 g. The LFD indicated the

8.00– 8.99 cm and 9.00– 9.99 cm TL size range groups were numerically prominent in the Tanguar *haor*, northeastern Bangladesh (Fig. 2). Based on a Shapiro–Wilk normality test, the LFDs were not normally distributed ($p < .001$ for TL and $p < .001$ for BW) for the population of *L. guntea* in the Tanguar *Haor*.

Table 1. Explanatory statistics on the length (cm) and weight (g) measurements of *Lepidocephalichthys guntea*

Measurement	*n*	Minimum	Maximum	Mean±SD	95%CL
TL (cm)	258	6.4	10.5	8.85±1.02	8.46 to 8.71
SL (cm)		5.4	8.8	7.35±0.88	7.24 to 7.46
BW (g)		2.01	9.6	4.97±1.89	4.74 to 5.21

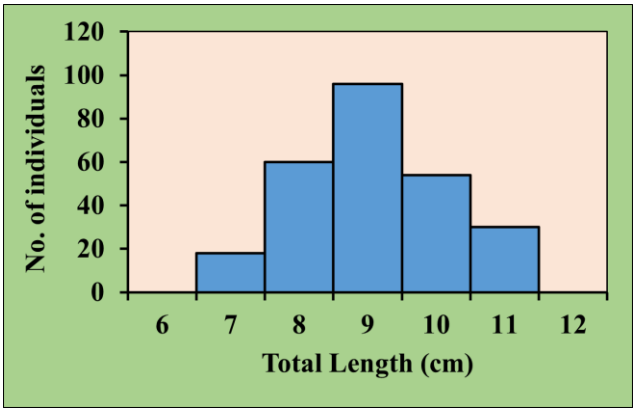

Fig. 2. Location of *Tanguar Haor*, Sunamganj district, Bangladesh.

L-W and L-L relationships

The relationship between TL, SL and BW of *L. guntea* long with the estimated parameters of the LWRs and the coefficient of determination (r^2), are shown in Table 2 and Fig. 3-4. During this study, the calculated *b* value of the LWR indicates a positive allometric growth pattern. The LWRs was highly significant ($p<0.001$) with a coefficient of determination values of 0.994.

Condition Factor

The Fulton's condition factor (K_F) ranged from the minimum value 0.694 to maximum value 0.829 in the Tanguar *Haor* with a mean value of 0.748±0.0265 respectively as well as the 95% confidence limit of mean value also found ranges from 0.7442 to 0.7507 (Table 4).

According to Pearson's correlation test, there were no significant relationships between TL *vs.* K_F (Pearson's, r=-0.01336 and p = 0.7704), however there were highly

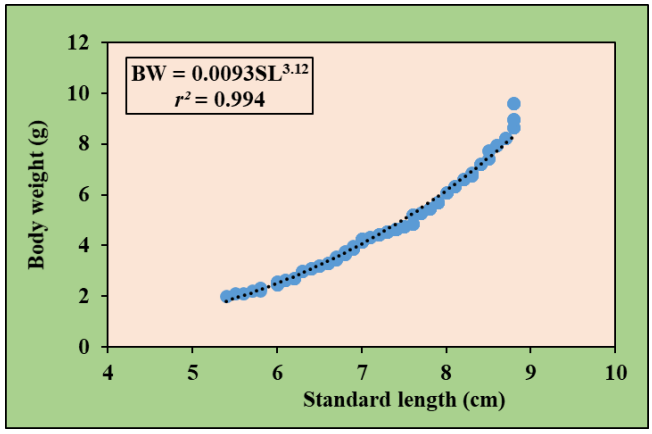

Fig. 4. Relationship between Standard Length-Body weight of *Lepidocephalichthys guntea*

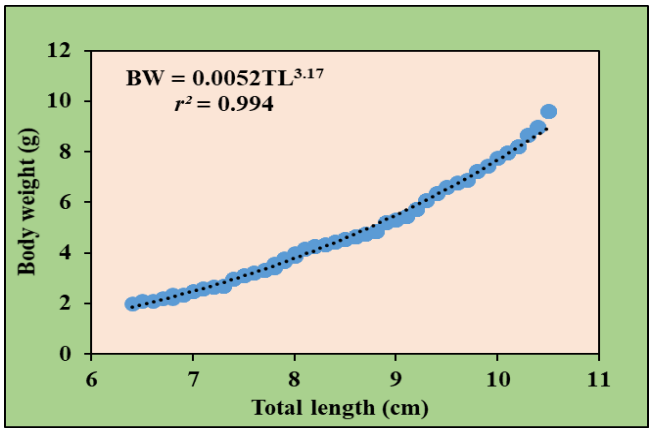

Fig. 3. Relationship between Total Length-Body weight *of Lepidocephalichthys guntea*

Table 3: Descriptive statistics and estimated parameters of the total length (TL), standard length (SL), and body weight (BW) relationship of *Lepidocephalichthys guntea*

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
	a	*b*			
$BW=a*TL^b$	0.0052	3.17	0.0050-0.0056	3.14-3.20	0.994
$BW=a*SL^b$	0.0093	3.12	0.0086-0.0101	3.08-3.17	0.994
TL=a+b*SL	-0.0022	0.994	-0.0561-0.0518	0.85-0.86	0.994

significant relationships between BW *vs.* K_F (Pearson's, r = 0.2740 and p<0.0001).

The Relative Condition Factor (K_R) ranged from the minimum value 0.949 to maximum value 1.075 in the Tanguar *Haor* with a mean value of 0.998±0.0290 respectively as well as the 95% confidence limit of mean value also found ranges from 0.9948 to 1.0019.

Table 4: Condition factors measurements and with their 95% CL of *Lepidocephalichthys guntea*

Condition factors	*n*	Min	Max	Mean±SD	95% CL
K_A	258	0.005	0.006	0.005±0.0002	0.0051 - 0.0051
K_F		0.69	0.83	0.748±0.0265	0.7442 - 0.7507
K_R		0.95	1.0754	0.998±0.0290	0.9948 - 1.0019
W_R		94.95	107.54	99.838±2.9042	9.4820 - 100.1941

K_A, allometric; K_F, fulton's; K_R, relative condition factors; W_R, relative weight; n, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values

According to Pearson's correlation test, there were no significant relationships between TL *vs.* K_R (Pearson's, r_s=-0.0151 and p = 0.7414), however there were highly significant relationships between BW *vs.* K_R (Pearson's, r_s = 0.2694 and p<0.0001) (Table 5).

Table 5: Relationships of condition factor with total length (TL) and body weight (BW) of *Lepidocephalichthys guntea.*

Relationships	r_s values	95% CL of r_s	p values	Significance
TL vs K_A	-0.0462	-0.1709 to 0.07996	0.46	ns
TL vs K_F	0.4941	0.3928 to 0.5835	<0.0001	****
TL vs K_R	-0.0462	-0.1709 to 0.07996	0.46	ns
TL vs W_R	-0.04623	-0.1709 to 0.07994	0.4597	ns
BW vs K_A	-0.04502	-0.1698 to 0.08114	0.4716	ns
BW vs K_F	0.4953	0.3941 to 0.5846	<0.0001	****
BW vs K_R	-0.04502	-0.1698 to 0.08114	0.4716	ns
BW vs W_R	-0.04503	-0.1698 to 0.08112	0.4714	ns

The present study revealed that the Allometric condition factor ranged from the minimum value 0.005 to maximum value 0.006 in the Tanguar *Haor* with a mean value of 0.0052±0.0002 respectively as well as the 95% confidence limit of mean value also found ranges from 0.0052 to 0.0052.

According to Pearson's correlation test, there were no significant relationships between TL *vs.* K_A (Pearson's, r=-0.3476 and p = 0.0001), but there were highly significant relationships between BW *vs.* K_A (Pearson's, r = 0.6087 and p<0.0001).

Prey-predator Status

The current study demonstrates that the Relative weight (W_R) of *L. guntea* ranged minimum weight 94.95g to maximum 107.54g with mean value 99.838±2.9042g as well the 95% CL= 99.482 to 100.194 respectively (Fig. 5).

Form Factor

The calculated form factor ($a_{3.0}$) was found 0.0088 where the minimum and maximum length (6.4 cm and 10.5 cm) in the Tanguar *Haor*.

Size at First Sexual Maturity (Lm)

The initial sexual maturity size (L_m) was estimated to be 6.5 cm TL. This value is the threshold length at which individuals become reproductively active and this is a valuable measure of fisheries management.

Asymptotic length (L_∞) and weight (W_∞)

The calculated asymptotic length was found to be 11.19 cm, and W∞ was recorded as 10.9 g for *L. guntea* in the Tanguar *Haor*.

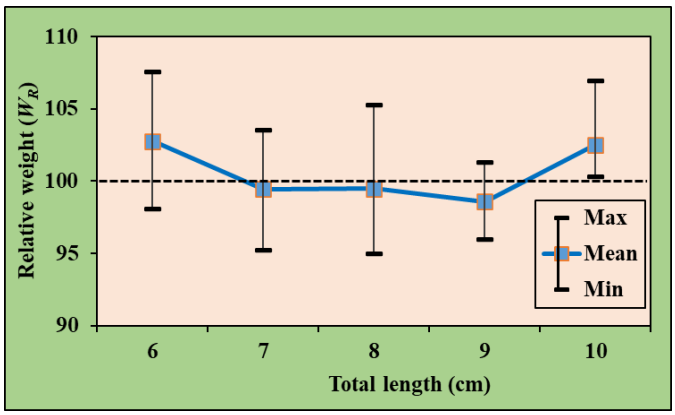

Fig. 5. Prey-predator status of *Lepidocephalichthys guntea*

Life span (t_{max})

From the study area, t_{max} determined for *L. guntea* was 3.1 years.

Natural mortality (M)

The estimation of natural mortality resulted in a value of 1.49 year^{-1} (Fig. 6) for *L. guntea* in the Tanguar *Haor*, Northeastern Bangladesh.

Optimum catchable length (L_{opt})

Optimum catchable length the ascertained optimal catchable length (L_{opt}) for *L. guntea* from the Tanguar *haor* was observed to be 7.4 cm TL.

Table 4: Condition factors measurements and with their 95% CL of *Lepidocephalichthys guntea.*

Species name	Sex	*n*	Total length (cm)		*a*	*b*	$a_{3.0}$
			Min	Max			
Lepidocephalichthys guntea	Combined	258	6.4	10.5	-0.0022	0.994	0.088

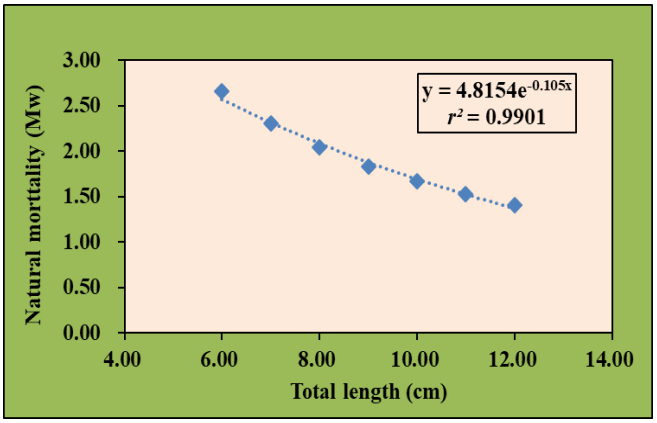

Fig. 6. Relationship between Total length and Natural mortality (*Mw*) of *Lepidocephalichthys guntea.*

Discussion

Very little information on the life- history traits of *L. guntea* is available in literature from Bangladesh or even world- wide. Accordingly, the present study focused on a proper description on the life- history traits of *L. guntea*, including LFD, LWR, LLR, multi-approach condition factors (K_A, K_F, K_R and W_R), $a_{3.0}$, L_m, *Mw*, t_{max}, L_m and L_{opt}, based on analysis of many specimens of various sizes over a calendar year from the Tanguar *Haor* in Northeastern Bangladesh.

Information of length frequency distribution of the *L. guntea* in Bangladesh is quite insufficient. No earlier records of length frequency distribution traced from the related literature, inhibiting the comparison with previous result. The differentiation of morphometric and meristic characteristics between populations, especially found in freshwater fishes, is caused by the non- homogeneous distribution of genetic variation (Salgueiro *et al*, 2003) and the intervention of several factors such as the physical insulation (habitat fragmentation), behavioral insulation, historical factors, human impact, ecological dynamism (inter and intra-species relations (Imre *et al*., 2002).

The present study maximum size of *L. guntea* 10.5 cm TL which is similar than maximum TL 10.5 cm from the Pyra River, Bangladesh recorded by (Saha *et al*., 2021) and higher than fish base value 15.0 cm TL (Menon, 1984). In this study, a number of specimens with small to large body sizes were sampled using traditional fishing gears, however it was not possible to catch *L. guntea* smaller than 6.40 cm TL during the sampling period, which can be attributed to either the absence of small sized fishes (<6.39 cm 11.) in the populations or selectivity of the fishing gears (Hossain *et al*., 2015). These regional differences in total length probably depend on the ecological conditions in the areas of investigation. Water temperatures directly affect fish growth by influencing their physiology (Weatherley and Gill, 1987). Moreover, effects of water temperature can be directly related to rates of biological production and food availability, as well as to nekton and plankton species composition, both of which influence fish growth (Colerbook, 1982: Weatherley and Gill, 1987), However, Hossain *et al*. (2010) reported that the information on maximum length is necessary to estimate the population parameters including asymptotic length and growth coefficient of fishes, which is important for fisheries resource planning and management. Additionally, the maximum weights of *L. guntea* observed in this study were 9.60 g. which was quite Higher than the maximum recorded value ranged from 9.27 at Pyra river, Bangladesh (Saha *et al*., 2024). However, in the present study, maximum population was found for the length class of 8.0 to 9.0 cm group (37.17%).

The length-weight relationships are useful in differentiating populations as variations occur in populations of different localities (Le Cren, 1951; Chonder, 1972). The parameter '*b*' values vary between 2 and 4, however, values ranging from 2.5 to 3.5 are more common (Carlander, 1951). In general, and

despite the many variations in fish forms between species, *b* is close to 3, indicating that fish grow isometrically, values significantly different from 3.0 indicate allometric growth (Tesch, 1968).

In the present study, the values of "*b*" for combined sex of *L. guntea* were 3.12 where co-efficient of determination (0.994) in the Tanguar *Haor*, indicating the growth of this fish in the Tanguar *Haor* was positive allometric growth. The present result was comparable with the earlier study by Saha *et al.* (2021) who revealed and value as 3.20 (r^2=0.954) in Pyra River, southern Bangladesh which is similar with the present study. These differences may be due to environmental or seasonal factors, growth and developmental stages, which were not accounted in this study.

In the present study, the length-length relationship (LLR) of *L.guntea* in the Tangua *Haor* was found TL = 0.8561(SL)- 0.0022 where co-efficient of determination was (r^2= 0.994). (Saha *et al.,* 2021) reported as where co-efficient of determination (r^2) was 0.991 in the Pyra River, Bangladesh which is similar with the finding of this study, However, differences the LLRs may be attributed to differences in ecological conditions of the habits or variation in the physiology of animals, or both (Le Cren, 1951).

Several condition factors including Fulton's condition factor (Fulton, 1904); Relative condition factor (Le Cren, 1951); Allometric condition factor (Tesch, 1968) and Relative weight (Froese, 2006) were used to assess the overall health and productivity of *M. tengara*. The condition factor based on the LWRs is an indicator of the changes in food reserves and general fish condition (Offem *et al.,* 2007). In addition, the condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of the fishes. It shows the well-being of the population during various life cycle stages (Angelescu *et al.,* 1958).

In the present study, the Fulton's condition factor (K_F) was ranged from 0.392 to 0.583 for *L.guntea* in the Tanguar *Haor* with a mean value of 0.7480±0.0265 The result of Spearman random test showed there was highly significant relationship between TL *vs.* K_F (Spearman, r=0.4941 and p = < 0.0001) but there is highly significant relationship BW *vs.* K_F (Spearman, r= 0.4953 and P < 0.0001 for combined sexes. Significant by similar findings also reported by Saha *et al.,* (2021) from pyra River Northern Bangladesh.

During this study, the relative condition factor (K_R)calculated as the ratio of a fish's observed weight (W) to its theoretical weight for a given total length (TL) (Le Cren, 1951) for *L. guntea* in Tanguar *Haor* ranged from 0.1709 to 0.0799, with a mean of 0.998 ± 0.0290. Spearman's rank correlation analysis (which assesses the monotonic relationship between ranked variables) revealed no significant association between TL *vs.* K_R (r = –0.0462, p = *0.46*)

Likewise, there was no significant correlation between body weight BW *vs.* K_R for combined sexes (r = –0.0450, p = 0.4714).

These findings contrast with Saha *et al.* (2021), Pyra River, Bangladesh who similarly reported a non-significant *TL vs.* K_R relationship but did find a significant BW *vs.* K_R correlation.

In the present study, the allometric condition factor (K_A) for *L. guntea* in Tanguar *Haor* ranged from 0.04 to 0.07, with a mean value of 0.005 ± 0.0002. Spearman's rank correlation analysis revealed no significant relationship between total length TL *vs.* K_A (Spearman's r = –0.0462, p = 0.46). Similarly, no significant relationship was found between body weight BW *vs.* K_A (Spearman's r = –0.04502, p = 0.4716) for combined sexes. These findings are in contrast to those of Saha *et al.* (2021), Pyra River, Bangladesh who also reported a non-significant relationship between TL *vs.* K_A, but observed a significant relationship between BW *vs.* K_A.

In the present study, relative weight W_R of *L. guntea* ranged from 99.482 to 100.194 g, with a mean of 99.838 ± 2.904 g. Spearman's rank correlation analysis showed no significant relationship between total length TL *vs.* W_R (r = –0.04623, p = 0.4597), but did reveal a significant association between body weight BW *vs.* W_R (r = –0.04503, p = 0.4714) for combined sexes. These findings contrast with those of Saha *et al.* (2021), Pyra River, Bangladesh who similarly found no TL *vs.* W_R relationship but did report a significant BW *vs.* W_R correlation.

In fish biology, the form factor ($a_{3.0}$) standardizes body-shape comparisons by normalizing the weight–length intercept a to an isometric exponent (b = 3.0) (Froese, 2006).

In the present study, *L. guntea* from Tanguar Haor exhibited an $a_{3.0}$ of 0.0088, indicating a notably elongated body form. This value is slightly higher than the 0.007 reported for *L. guntea* in the Payra River, Bangladesh (Saha *et al.*, 2021), suggesting modest

geographic variation in body-shape metrics within the species.

In fishery biology, knowledge of the size at sexual maturity is essential for understanding the drivers of size variation at maturation (Templeman, 1987). In the present study, the length at first maturity (L_m) for combined sexes of *L. guntea* was estimated at 6.5 cm total length (TL), a value that can be adopted as the minimum legal capture size to promote sustainable stock management (Lucifora *et al.*, 1999; Nurdin *et al.*, 2016).

In the current study, the L_∞ was determined to be 11.19 cm Tanguar *Haor* surpassing the value reported in the 10.04 cm in Payra River, Bangladesh (Saha *et al.*, 2021). Additionally, the parameters W_∞ were quantified as 10.99 g. which is also the first global estimate of this parameter

In the current study, the t_{max} was determined to be 3.1 years Tanguar *Haor*. Notably, no prior research has explored the dimensions of W_∞ making it difficult draw comparisons with existing data.

In the present study, the von Bertalanffy growth coefficient (Mw) of *L. guntea* in Tanguar *Haor* was estimated at 1.49 year^{-1}, identical to the 1.49 year^{-1} reported by Saha *et al.*, (2021) for the Payra River, Bangladesh.

L_{opt} holds a crucial significance in the strategic selection of fishing gear for effective fisheries management. Fishing gear should be created to ensure that individuals below the L_{opt} indicated size are allowed to escape (Mawa *et al.* 2022). In our current study, suggested L_{opt} value was at 7.40 cm which is the first evident in the literature for *L. guntea*. This information serves as a baseline for future research studies in this field.

Conclusion

In conclusion, this study provides essential baseline data on the life-history traits of *L. guntea* in Bangladesh's Tanguar *Haor*, highlighting its positive allometric growth, healthy condition, and moderate natural mortality within a balanced ecosystem. With a sexual maturity size of 6.5 cm TL and an optimum catchable length of 7.4 cm TL, the findings emphasize the need for selective fishing practices that align with the species' reproductive capacity. The observed regional variation in growth parameters further reflects the importance of localized ecological conditions in shaping fish populations. To ensure the long-term sustainability of *L. guntea* and the livelihoods it supports, it is recommended to enforce minimum catch size regulations, promote the use of species-appropriate fishing gear, restore and protect critical habitats, and engage local communities through participatory management. Additionally, adopting an ecosystem-based management approach and establishing regular monitoring programs will be crucial in mitigating overexploitation and environmental threats, ultimately conserving biodiversity and securing the ecological integrity of this Ramsar-designated wetland.

Recommendation

Based on the biological characteristics and population parameters identified in this study, several management actions are recommended to ensure sustainable exploitation and long-term conservation of the species. Establishing a minimum legal catch size above the size at first maturity (≥ 6.5 cm TL), ideally aligned with the optimum catch length (≥ 7.4 cm TL), would allow individuals to reproduce before harvest and support stable recruitment. In addition, improving gear selectivity by promoting the use of appropriate mesh sizes and restricting fine-mesh nets can help reduce the capture of juveniles, while seasonal fishing bans during peak breeding periods would protect spawning stocks. Habitat conservation is equally important; key areas such as breeding and nursery grounds in Tanguar *Haor* should be protected from degradation caused by sedimentation, pollution, and overexploitation, alongside initiatives to restore degraded wetlands through vegetation and hydrological management. Engaging local fishing communities in co-management frameworks can enhance compliance and stewardship, supported by awareness programs on sustainable fishing practices and the ecological significance of small indigenous species. Furthermore, implementing long-term monitoring systems to track population dynamics, growth patterns, and environmental changes is essential, with the integration of biological indicators such as condition factors and relative weight into assessment models. Finally, adopting an ecosystem-based fisheries management approach that considers trophic relationships, habitat conditions, and climate variability will contribute to a more comprehensive and sustainable management strategy.

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Ethical Considerations

The aim of this is to assure that the research study has been conducted in adherence to animal research and welfare guidelines. The entire experiment was performed on the approval of the Ethical Committee of the Faculty of Agriculture, University of Rajshahi (Approval No.: FoA-RU: 003-2016). The research was carried out according to all the applicable institutional, national and international legislations that cover ethical use of animals in scientific research. Informed consent was not necessary.

Final Statement

Life-history characteristics, the dynamics of growth and population parameters utilized in this study offer a strong scientific basis to sustainable management of *L. guntea*. The application of the suggested measures will not only boost the resilience of this species but also lead to the preservation of the ecological integrity of Tanguar *Haor* and livelihoods based on it.

Declarations

Consent to Publication

The research article authors assure that it is a novel study that has never been published in a journal or other publication, and that it is not under submission by another publication. The final manuscript is reviewed and approved by all authors to be submitted.

Conflict Interests

The authors ensure that there are no conflicting interests in the work presented in this paper which are financial or any other interest.

Author Contributions: Author Contributions

M.A.H. contributed to the conceptualization and data analysis of the study. M.A.H. and M.G.S. were responsible for writing the original draft of the manuscript. Data collection was carried out by M.A.A.K., M.T.W.T, and M.S.K. H.A., A.R., and F.J.R. critically reviewed and edited the manuscript. All authors, including M.T.N. and, M.Y.H. read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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