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Research Article

Stock status of Greenback mullet, *Planiliza subviridis* (Valenciennes, 1836) from the Shibsa River, coastal water of Southern Bangladesh through length-based models

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Abstract

Our study describes the stock status of *Planiliza subviridis* (Valenciennies, 1836) by emphasizing on growth pattern, growth parameters (asymptotic length, L_∞; asymptotic weight, W_∞; growth co-efficient, K; age at zero length, t_0), sexual maturity size (L_m), age at sexual maturity (t_m), growth performance index ($Ø'$), life-span (t_{max}), relative weight (W_R), form factor ($a_{3.0}$), mortality rates (Z, M and F), exploitation rate (E), maximum sustainable yield (MSY), and relative biomass of *P. subviridis* from the coastal Shibsa River, Southern Bangladesh. A sum of 317 individuals of *P. subviridis* ranging from 6.50-19.70 cm total length (TL) was sampled during July 2017 to December 2019. The overall b value indicated isometric growth (b = 3.0) pattern. The estimated L_∞, W_∞, K, and t_0 were 20.79 cm, 93.20 g, 1.02 per year, and 0.015 year, respectively. The L_m was estimated as 11.65 cm in TL and t_m was 0.82 year. The t_{max} was 2.93 year and $Ø'$ was 2.64. Fulton's condition factor was found most suitable for this species. Further, the average relative weight (W_R) indicated that the habitat was in a stable situation. In addition, the Z, M, and F were obtained as 2.23, 1.57, and 0.66 year^{-1}, respectively. Length at maximum yield per recruit (L_{opt}) was estimated as 13.74 cm. Further, the E (0.30) and MSY, maximum sustainable Yield (0.29) indicated balance harvesting occurred in the coastal Shibsa River. Additionally, the relative numbers of survival, individual growth in weight, and cohort biomass was 24%, 40.0 g, and 100% (9.0 kg) when *P. subviridis* reached 1.2 years. Consequently, the results of our study will be supportive to implement a proper management strategy in the coastal Shibsa River and adjoining ecosystems of Bangladesh.

Keywords: Greenback mullet, *Planiliza subviridis*, Stock status, Coastal water, Shibsa River, Bangladesh

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Introduction

Fish is the leading protein source for many parts of the world's population. The growing demand for fish protein causes immense fishing pressure on wild stock (Panhwar *et al*., 2013). Therefore, it is necessary to conserve the fisheries resources through sustainable management (Sabbir *et al*., 2021). But a majority of the world's fish stocks are data-limited. Management procedures (MPs) have recently been developed to give management advice for data-limited species throughout the world but applications on coastal species are limited.

Length-frequency distribution (LFD) is used to assess river health through stock assessment of standing biomass and spawning period (Ranjan *et al*., 2005). Moreover, LFD helps to compare the morphological characters among different species and populations of a particular species from different aquatic environments (Sabbir *et al*., 2020). On the other hand, growth pattern through length-weight relationships (LWRs) are important biometric tools for implementing proper management of a wild population in an open water ecosystem (Muchlisin *et al*., 2010). Similarly, the condition factor is an index which is used to understand survival, maturity, health status and reproduction of fish (Le Cren, 1951). Information on fish conditions is necessary to evaluate the life cycle of a specific population for the appropriate management and to conserve the stability of an ecosystem (Hossain *et al*., 2013). In addition, relative weight (W_R) is applied most frequently to estimate the condition of fish in a specific environment considering prey-predator status (Froese, 2006).

The mullets (Mugilidae) are ray-finned fish and include 78 species of 26 genera (Froese and Pauly, 2023). The Greenback mullet, *Planiliza subviridis* under the Mugilidae family is a prominent fish species, particularly in the Mediterranean and Asian countries. This fish was earlier known as *Liza subviridis*. Further, the species is locally called *Bata* and is found in brackish water environments, tidal rivers, and mangrove areas of Bangladesh (Rahman, 2005). Moreover, *P. subviridis* is extensively distributed all over the Indo-Pacific region, Africa (Heemstra, 1995), and Oceania (Bathia *et al*., 1974). It is mainly a demersal marine fish which found in the tropical coastal regions (Allen *et al*., 1999).

The wild populations of *P. subviridis* are facing various threats including sweeping harvest from the intrinsic territory spawning ground degradation and other environmental changes to their natural habitat (Hossain *et al*., 2015a,b). Till now, the species has been harvested only from wild sources due to the lack of captive breeding technology. Hence, it is categorized as the least concern worldwide (IUCN, 2018).

A good number of studies were conducted on growth pattern and reproductive biology (Al-Daham *et al*., 1991; Ergene, 2000; Rahman *et al*., 2013), analysis of stomach contents (Fatema *et al*., 2015), reproductive characteristics and spawning (Cherif *et al*., 2007), parasitology (Kritsky *et al*., 2013), stock assessment (Mohamed *et al*., 2013), growth, mortality and stock assessment (Mohamed and Al-Hassani, 2021) of this fish species, but there is no study on any aspects of *P. subviridis* from the coastal rivers of Bangladesh. Therefore, our study aimed to explain the first complete information on the stock status of *P. subviridis* from the Shibsa River, coastal water of Southern Bangladesh.

Material and methods

Fish sampling

Total 317 specimens were harvested occasionally from the Shibsa River (Lat. 23° 55′ N; Long. 89° 33′ E) in the Southern coastal part of Bangladesh from July 2017 to December 2019 using different types of local gear like gill net, cast net, seine net.

Fish measurement

The total length (TL) and body weight (BW) of each individual were measured by measuring board and digital balance. Population structure through LFDs for *P. subviridis* was assessed using 1.0 cm intervals of TL (cm).

Determining growth and reproduction parameters

The growth was determined by using this equation: $BW = a*(TL)^b$, 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:

$ln(BW) = ln(a) + b\ ln(TL)$.

According to Froese (2006), extreme outliers were deleted from the regression analyses. Tesch (1971) found that significant variations from the hypothesized isometric value (b=3) either signify positive (b>3) or negative (b<3) allometric growth, which was confirmed by Student's t-tests (Sokal and Rohlf, 1981). On the basis of the *b* values (LWRs), the growth pattern of *P. subviridis* was determined. The growth parameters were described through the von Bertalanffy (VBG) model (von Bertalanffy, 1938) as $L_t = L_\infty [1-\exp\{-K(t-t_0)\}]$ for length basis and $W_t = W_\infty [1-\exp\{-K(t-t_0)\}]^b$ for weight basis, where L_t=mean length at age t (cm); L_∞=asymptotic length (cm); W_t = weight at age t (g); W_∞ =asymptotic weight (g); K = growth co-efficient (year^{-1}); t = the age year and t_0 = the hypothetical age at which the length is zero. The L_∞ was calculated by Wetherall plot according to King (2007) as a seed value. In this study, L_∞ was also calculated based on maximum observed length (L_{max}) using the empirical model as $\log(L_\infty) = 0.044 + 0.9841* \log(L_{max})$ (Froese and Binohlan, 2000). Additionally, the length at sexual maturity (L_m) was estimated based on the maximum observed length by $\log(L_m) = -0.1189 + 0.9157* \log(L_{max})$ (Binohlan and Froese, 2009). Furthermore, the age at sexual maturity per year (t_m) was calculated by using the equation of $t_{m(50\%)} = (-1/1)*\ln(1-L_m/L_\infty)$ (King, 2007). The growth parameter, K was calculated by $K = \ln(1+L_m/L_\infty)\ t_m$ (Beverton and Holt, 1992). The t_0 of this species was determined by $\log(-t_0)=(-0.3922 - 0.2752 \log L_\infty - 1.038 \log K)$ (Pauly, 1980). The W_∞ was estimated by $W_\infty = a*L_\infty^b$. Moreover, the $Ø'$ was calculated following $\log_{10}K + 2\log_{10}L_\infty$ (Pauly, 1980). The t_{max} was estimated by $t_{max} = 3/K$ (Pauly and Munro, 1984).

Condition factors

Considering a single fish, the value of ‘*a*’ through the equation of $W = aL^b$ can be referred to as the ‘well-being’, index or a relative condition factor for the fish. Another option is to compare the observed weight of fish in a sample with the weight predicted by a generalized length-weight correlation. The equation: $K_F = 100\times(W/L^3)$ (Fulton, 1904) was used to calculate Fulton's condition factor (K_F), where W is the BW in g and L is the TL in cm. To bring the K_F closer to the unit, a scaling factor of 100 was applied. The allometric condition factor (K_A) was estimated by the equation: $K_A = W/L^b$ (Tesch, 1968), where b is the regression parameter of LWRs. According to the equation, the bigger a fish's condition factor is for a particular length, the more it weighs. The relative condition factor, proposed by Le Cren (1951), accounts for changes in form or condition as length increases, and so evaluates an individual's divergence from the average weight for length in the sample. Relative condition factor (K_R) was determined as $K_R = W/(a\times L^b)$ (Le Cren, 1951), where a and b are LWRs parameters. Besides, relative weight (W_R) was estimated as $W_R = (W/Ws)\times 100$ (Froese, 2006), where W_S is the standard weight for an identical specimen calculated as $W_S = a\times L^b$. Form factor ($a_{3.0}$) was calculated as $a_{3.0} = 10^{\log a - s(b-3)}$, where S is the regression slope of *ln a vs. b*.

Mortality and Exploitation

The total mortality rate (Z) was estimated by the length converted catch curve method (Gayanilio *et al*., 2002). The natural mortality (M) was calculated by the empirical formula (Pauly, 1980) using growth parameters: $\log_{10}M = -0.0152 - 0.279 \log_{10}L_\infty + 0.6543 \log_{10}K + 0.4634 \log_{10}T$; where T is the average annual ambient temperature (°C). The fishing mortality (F) was calculated as Z-M. Furthermore, the Exploitation rate (E) was calculated as $E = F/Z = F/(F + M)$ (Gulland, 1983).

Maximum sustainable yield

The Beverton and Holt (1966) model was used for the estimation of yield per recruit expressed as a function of L_{opt}/L_∞, F/K, and M/K. The length at maximum yield per recruit (L_{opt}) was calculated following the equation (Beverton, 1992):

$$L_{opt} = 3\,L_\infty/(3 + M/K)$$

Finally, yield per recruit (Y/R') was estimated by the modified equation of Froese *et al*. (2018) and maximum sustainable yield (MSY) as well as maximum exploitation was assessed consequently (Sarmin *et al*., 2021a):

$$\frac{Y}{R} = \frac{\frac{F}{M}}{1 + \frac{F}{M}}\left(1 - \frac{L_{opt}}{L_\infty}\right)^{M/K}$$

$$\left(1 - \frac{3\left(1 - L_{opt}/L_\infty\right)}{1 + \frac{1}{M/K + F/K}} + \frac{3\left(1 - L_{opt}/L_\infty\right)^2}{1 + \frac{2}{M/K + F/K}} + \frac{3\left(1 - L_{opt}/L_\infty\right)^3}{1 + \frac{3}{M/K + F/K}}\right)$$

Biomass model

According to Ricker (1975), the relative biomass, i.e., the total relative weight of the cohort was estimated by multiplying the individual weight by the numbers surviving. Additionally, the numbers surviving in the cohort were calculated from the exponential decay equation as

$N_{t+1} = N_t*exp[-M]$, where N_t is the number present at the beginning of one year and N_{t+1} is the number at the beginning of the following year.

Statistical analysis

GraphPad Prism software was used with 5% significance level. Spearman's rank test was done to find out the best condition factor. Besides, Wilcoxon signed rank test was applied to observe the relation between W_R and 100 (Anderson and Neumann, 1996).

Results

Population structure

A sum of 317 specimens was harvested from July 2017 to December 2019. The LFDs of *P. subviridis* showed that TL deviated from 6.50 to 19.70 cm (Mean±SD = 11.45±2.98 cm). On the other hand, the study revealed that the BW ranged from 2.90 to 93.20 g (Mean±SD=22.03±17.45 g) (Table 1). Further, population structure denoted that 7.99-8.99 and 11.99-14.99 cm TL size groups were most frequent (Fig. 1).

Table 1: Descriptive statistics and estimated parameters of the length-weight and length-length relationships of *P. subviridis* from the Shibsa River, Southern Bangladesh.

Measurements	Sex	*n*	Min	Max	Mean ± SD	95% CL
TL	Combined	317	6.50	19.70	11.45±2.988	11.12-11.78
FL			5.40	16.80	9.621 ±2.540	9.34-9.90
SL			6.10	18.50	10.79±2.794	10.49-11.10
BW			2.90	93.20	22.03±17.45	20.10-23.96

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2	GT
	a	*b*				
BW = a×TL^b	0.0115	3.019	0.0108-0.0123	2.991-3.048	0.992	I
BW = a×FL^b	0.0208	2.991	0.0196-0.0221	2.964-3.019	0.993	I
BW = a×SL^b	0.0129	3.046	0.0120-0.0138	3.017-3.075	0.992	I

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
	a	*b*			
TL = $a + b$× FL	0.1561	1.1761	0.0718-0.2403	1.1657-1.1826	0.995
TL = $a + b$× SL	-0.0796	1.0679	-0.1545-(-0.0047)	1.0612-1.0746	0.996
FL = $a + b$× SL	-0.1801	0.9076	-0.2436-(-0.1166)	0.9019-0.9133	0.996

TL, total length; FL, fork length; SL, standard length; BW, body weight; *n*, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values; *a*, intercept; *b*, slope; r^2, coefficient of determination; GT, growth type; I, isometric.

Growth pattern

The sample size (*n*) and growth pattern of *P. subviridis* are shown in Figure. 2 and Table 1. Overall *b* value (3.02) specified isometric growth (I) for the data set. Further, the LWRs and LLRs (Table 1; Fig. 3) were found significant (p<0.001).

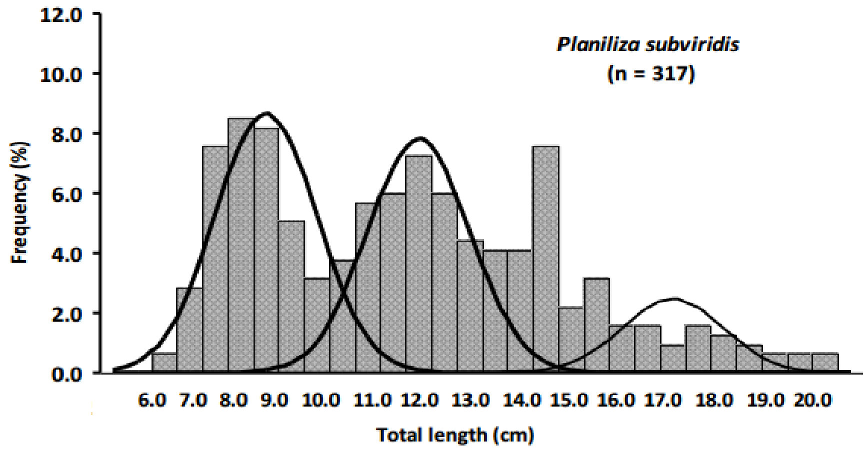

Figure 1: 7.99-8.99 and 11.99-14.99 cm TL size groups were most dominant length-frequency distribution of *P. subviridis* exploited from the Shibsa River, Southern Bangladesh.

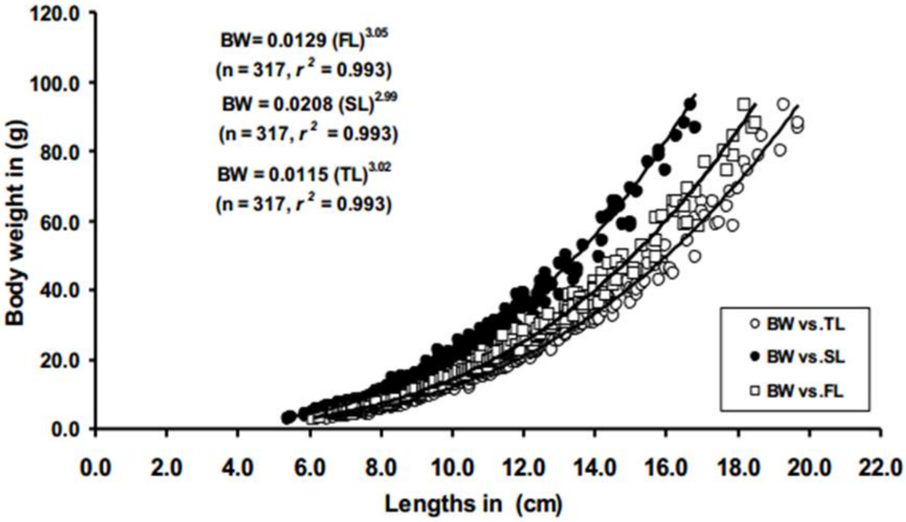

Figure 2: The length-weight relationships (BW = a + TL^b) of *P. subviridis* exploited from the Shibsa River, Southern Bangladesh (2017 -19)

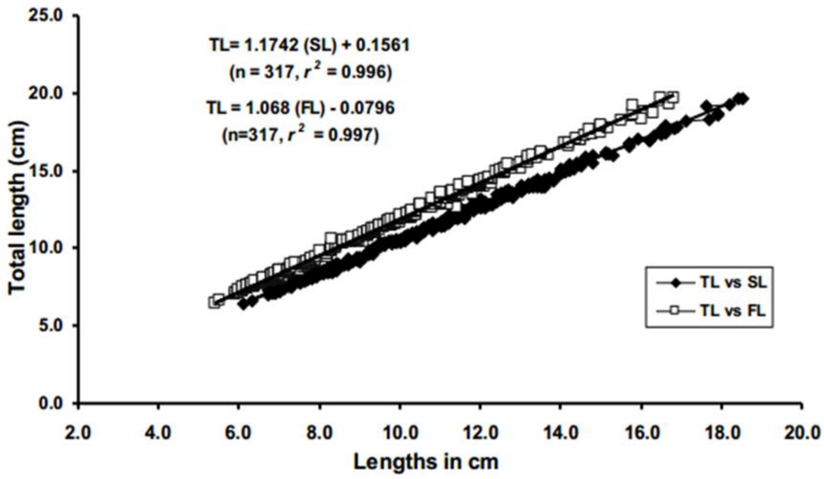

Figure 3: The length-length relationships (TL = a +b* SL) of *P. subviridis* exploited from the Shibsa River, Southern Bangladesh (2017 -19).

Growth and reproduction parameters

The value of growth parameters is shown in Table 2. The equations of von Bertalanffy growth for *P. subviridis* based on maximum length and weight were calculated as:

$$L_t = 20.79\{1-\exp[-1.02(t+0.015)]\} \text{ (Fig. 4a)}$$
$$W_t = 109.8\{1-\exp[-1.02(t+0.015)]\}^{3.02} \text{ (Fig. 4b)}$$

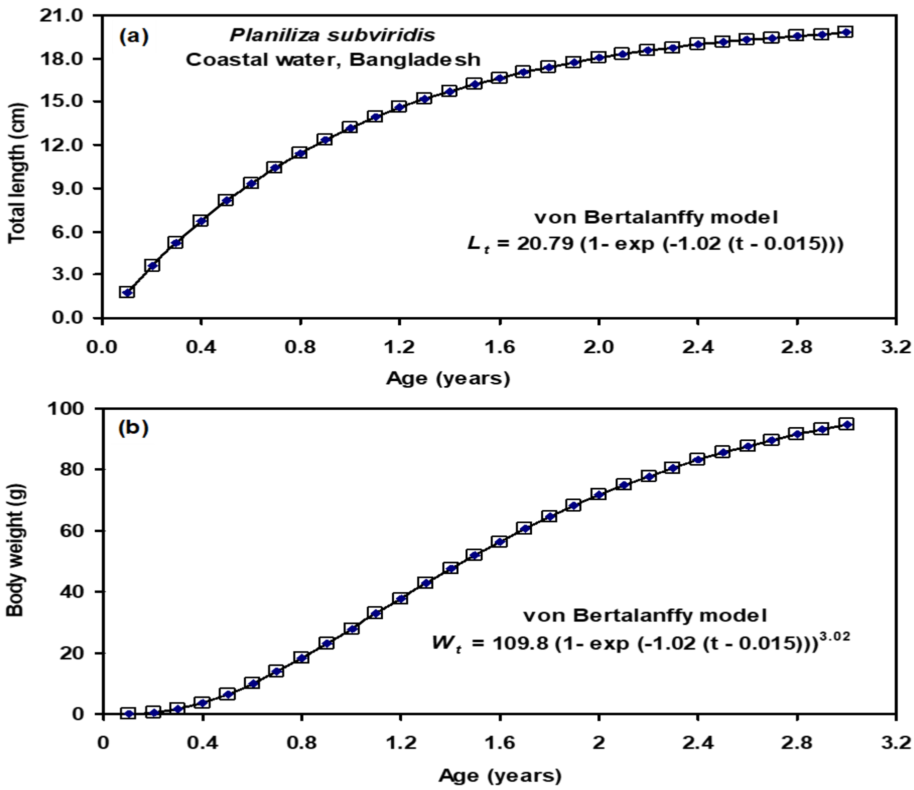

Figure 4: The von Bertalanffy growth curve (L_∞ = 20.79 cm, W_∞ = 109.8 g, K = 1.02 year^{-1}, t_0 = 0.015 year) based on length and weight of *P. subviridis* captured from the Shibsa River, Southern Bangladesh (2017-19).

Additionally, the L_∞ was calculated as 20.70 cm based on the Wetherall plot (Fig. 5). The calculated L_m for *P. subviridis* was 11.65 cm (95% CL = 9.21-14.74 cm TL). Further, age at sexual maturity was recorded as 0.82 years (Table 2).

Condition factors

K_F value ranged from 0.9637 to 1.4925 (1.2099±0.0807) for *P. subviridis* population. K_A value varied from 0.0092 to 0.0142 (0.0115±0.0007). Further, K_R values were found within the range of 0.8045 to 1.2360 (1.0026±0.0667).

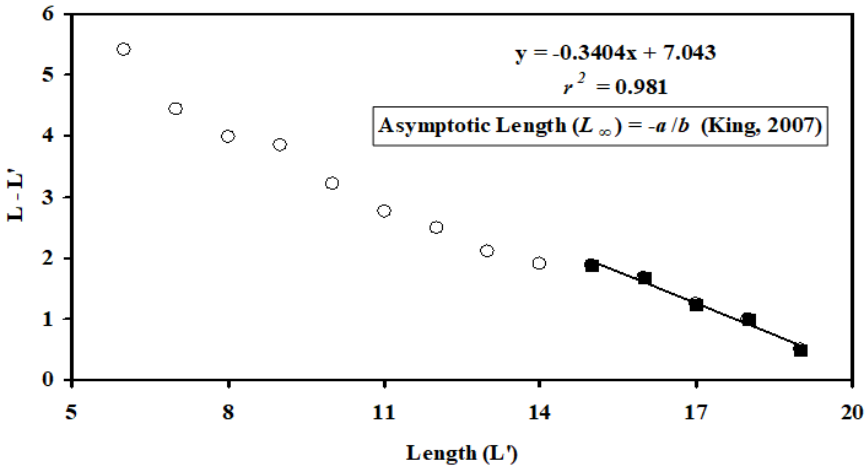

Figure 5: A Wetherall Plot was produced by the MS Excel spread sheet program, where a regression line was fitted through the large squares data point.

Table 2: The estimated parameters of growth, reproduction, mortality and exploitation for *P. subviridis* from the Shibsa River, Southern Bangladesh.

Parameters	Values
Growth parameters	
Asymptotic length (L_∞)	20.79 cm TL
Asymptotic weight (W_∞)	109.80 g
Life-span (t_{max})	2.93 years
Growth coefficient (K)	1.02 year^{-1}
Age at zero length (t_0)	0.015 year
Growth performance index (Ø')	2.64
Reproduction	
Size at sexual maturity (L_m)	11.65 cm
Age size at sexual maturity (t_m)	0.82 years
Mortality	
Total mortality (Z)	2.23 year^{-1}
Natural mortality (M)	1.57 year^{-1}
Fishing mortality (F)	0.66 year^{-1}
Stock status	
Exploitation rate (E)	0.30
Length at maximum yield per recruit (L_{opt})	13.74 cm
Maximum sustainable yield (MSY)	0.29
Biomass	9.0 kg

Besides, Spearman's correlation test revealed statistically significant relationship between BW *vs.* K_F (r_s=0.1391, p=0.0132) (Table 3). Therefore, K_F is the most suitable condition factor to assess the well-being of this species. Additionally, W_R varied from 80.45 to 123.60 (100.26±6.67) for *P. subviridis* (Table 3, Fig. 6). The Wilcoxon sign rank test revealed no statistical difference between W_R and 100 for the wild population indicating the habitat was quite suitable.

Form factor

The form factor ($a_{3.0}$) for *P. subviridis* was 0.0116 in the coastal water of Southern Bangladesh which indicated this fish is fusiform. Our study also calculated the

$a_{3.0}$ of *P. subviridis* from worldwide water bodies using available data (Table 4).

Mortality and Exploitation

The total mortality (Z) was calculated as 2.23 year^{-1} (Fig. 7). Besides, the recorded fishing mortality (F) and natural mortality (M) was 0.66 year^{-1} and 1.57 year^{-1}, respectively. Consequently, the exploitation rate (E) was calculated as 0.30 for *P. subviridis* population in the coastal water of Southern Bangladesh (Table 2).

Table 3: Descriptive statistics and relationships of condition factor with total length (TL) and body weight (BW) of *P. subviridis* from the Shibsa River, Southern Bangladesh.

Condition factors	Sex	*n*	Min	Max	Mean ± SD	95% CL
K_A	Combined	317	0.0092	0.0142	0.0115 ± 0.0007	0.0114-0.0116
K_F			0.9637	1.4925	1.2099± 0.0807	1.2009-1.2188
K_R			0.8045	1.2360	1.0026±0.0667	0.9953-1.0100
W_R			80.45	123.60	100.26± 6.67	99.53- 101.01

Relationship	r_s value	95% CL of r_s	*p* values	Significance
TL *vs.* K_A	-0.0328	-0.1457 to 0.0809	0.5604	*ns*
TL *vs.* K_F	0.0637	-0.0501 to 0.1758	0.2582	*ns*
TL *vs.* K_R	-0.0038	-0.1172 to 0.1096	0.9455	*ns*
TL *vs.* W_R	-0.0041	-0.1175 to 0.1094	0.6317	*ns*
BW *vs.* K_A	0.0403	-0.0734 to 0.1530	0.4745	*ns*
BW *vs.* K_F	0.1391	0.0261 to 0.2486	0.0132	*
BW *vs.* K_R	0.0720	-0.0417 to 0.1840	0.2006	*ns*
BW *vs.* W_R	0.0719	-0.0419 to 0.1838	0.2020	*ns*

n, sample size; TL, total length; BW, body weight; K_A, allometric condition factor; K_F; Fulton′s condition factor; K_R, relative condition factor; W_R, relative weight; r_S, Spearman rank correlation values; CL, confidence limit; *p*, shows the level of significance; *ns*, not significant; * significant.

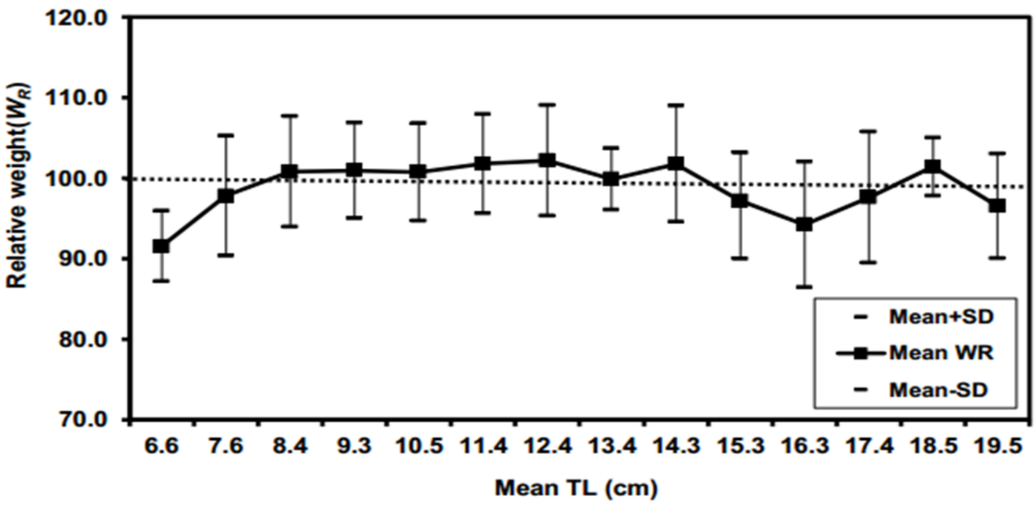

Figure 6: Relative weight against its mean length of *P. subviridis* exploited from the Shibsa River, Southern Bangladesh (2017 -19).

Maximum sustainable yield and biomass

The calculated MSY for *P. subviridis* was 0.29 or 29% (Table 2). The percentage of biomass, survival rate, and individual weight for *P. subviridis* in the Shibsa River, Southern Bangladesh was shown in Figure 8. Additionally, the relative biomass against ages (years) was fitted to estimate the highest biomass (Fig. 8). It was assumed that a number of 1000 individual per cohorts was recruited at the age of 0.1 year. After recruitment, the relative biomass of *P. subviridis* increased with age and became 9.0 kg (highest) at the age of 1.2 years.

Table 4: The calculated form factor, $a_{3.0} = 10^{\log a - s(b-3)}$, size at first sexual maturity (L_m) for the *P. subviridis* of different habitats using available length-weight relationship (LWRs) parameters.

Water body	Sex	Regression parameters		L_{max} (cm)	References	$a_{3.0}$	L_m (cm)	95% CL of L_m (cm)
		a	*b*					
Nuku'alofa, Tonga	M	0.0170	2.89	25.0	Langi *et al*., (1992)	0.0121	14.49	11.35-18.47
	F	0.0130	3.02	31.0		0.0138	17.81	13.81-22.84
Candaba wetland, Philippines	U	0.0410	2.75	13.2	Garcia (2010)	0.0188	8.08	6.49-10.09
Indus delta, Pakistan	M	0.0166	2.89	28.6	Hussain *et al*., (2010)	0.0118	16.39	12.77-20.97
	F	0.0079	3.16	27.8		0.0130	15.97	12.45-20.42
	C	0.0306	2.65	29.6		0.0102	16.92	13.16-21.67
Pagatban River, Philippines	U	0.0140	2.90	35.5	Guino and Robert (2012)	0.0102	19.98	15.43-25.74
East Hammar Marsh, Iraq	C	0.0145	2.93	29.3	Mohamed *et al*., (2013)	0.0116	16.71	13.00-21.39
Southern Taiwan coast, Taiwan	U	0.0080	2.97	44.0	Lin *et al*., (2018)	0.0073	24.37	18.65-31.60
Shibsa River, Bangladesh	C	0.0115	3.02	19.70	Present study	0.0116	11.65	9.21-14.74

M, male; F, female; U, unsex; C, combined sex; *a*, intercept; *b*, slope; L_{max}, maximum length; $a_{3.0}$, form factor; L_m, maturity length; CL, confidence limit.

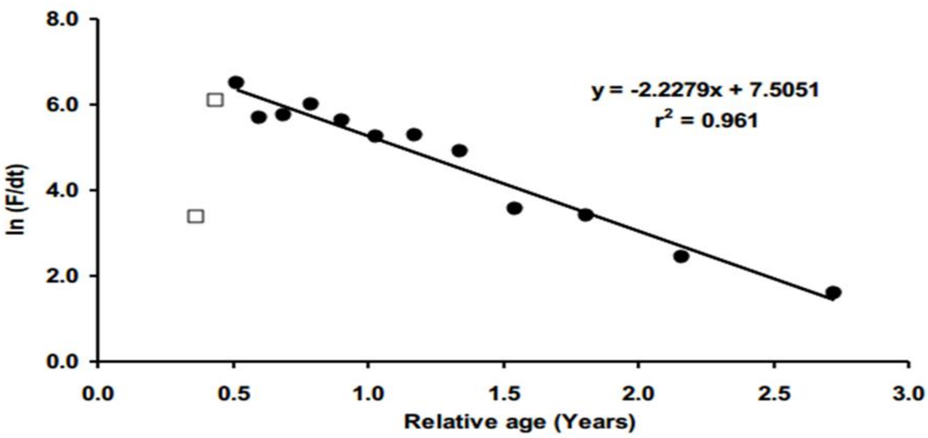

Figure 7: Length-converted catch curve for *P. subviridis* captured from the Shibsa River, Southern Bangladesh, where the slope *b* from the linear regression (*y*= *a* + *b*x*) indicates the total mortality (*Z*).**

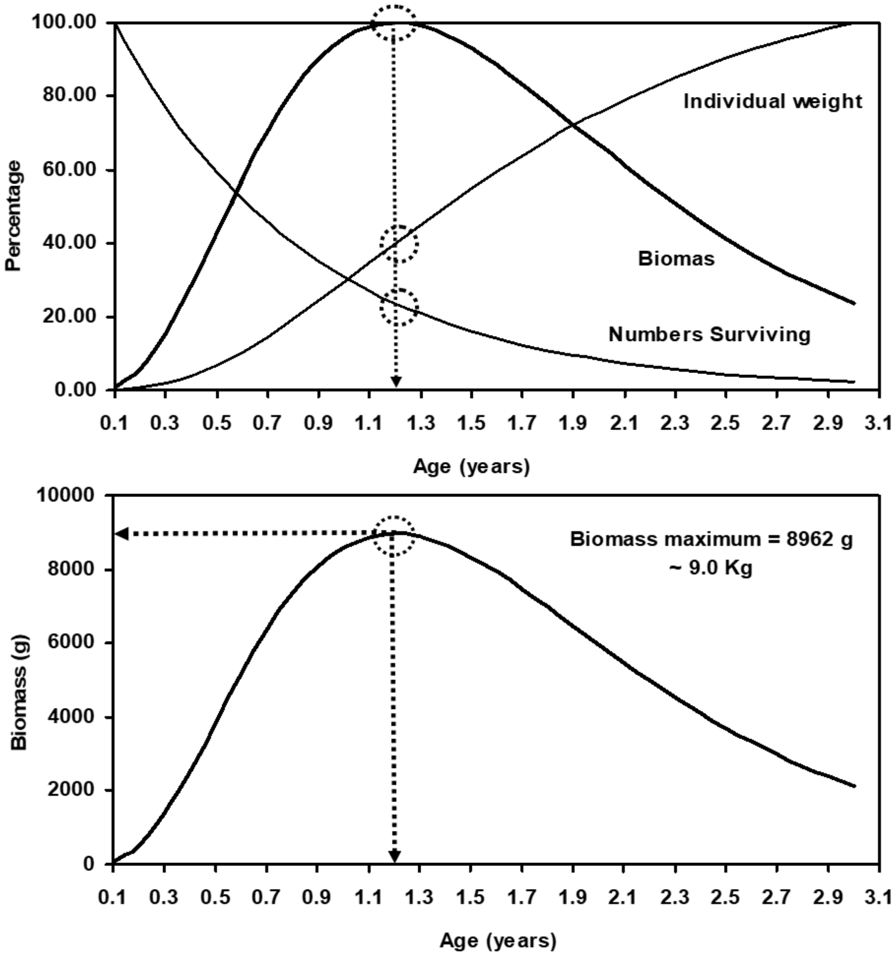

Figure 8: The relative biomass per recruit of *P. subviridis* collected from the Shibsa River, Southern Bangladesh where the biomass was attained about 9.0 kg at the age of 1.2 years if 1000 individuals recruited to the parental stock.

Discussion

Assessment of stock is very crucial to get the maximum benefit from any wild stock (Sabbir *et al*., 2021). Our study recorded the growth parameter as well as sexual maturity size based on the maximum length of *P. subviridis* from the Shibsha River, Southern Bangladesh through empirical models (Binohlan and Froese, 2009). Even though, it was not possible for us to collect the specimens for successive twelve months. However, it is the first challenge to estimate population parameters through the empirical models; therefore, it will contribute to the FishBase and/or other online databases.

Information regarding the stock status of *P. subviridis* from the coastal water of Bangladesh is still absent, although some studies on LFD, LWRs, and LLRs were done throughout the world (Ingles and Pauly, 1984; Langi, 1992; Garcia, 2010; Guino and Roberts, 2012). Besides, Mohamed *et al*. (2013) have observed the stock status of *Liza subviridis* from a wetland ecosystem in Iraq Mohamed and Al-Hassani (2021). However, this study highlighted the sock status of *P. subviridis* including population structure, growth pattern, growth parameters, first sexual maturity size, age at sexual maturity, growth performance index, life-span, condition factors, form factor, mortality, exploitation, maximum sustainable yield and relative biomass of a data limited *P. subviridis* stock in the coastal water of Southern Bangladesh.

During the study, a total of 317 individuals of *P. subviridis* with various body sizes were sampled occasionally. The lowest TL was recorded as 6.50 cm for pooled data. In contrast, the highest TL was found as 19.70 cm. Nevertheless, the lack of individuals <6.50 cm TL in our sampling might be ascribed due to the mesh size of fishing gears (Sabbir *et al*., 2020). We observed the population size structure dominated by the major peak at lengths of 7.99 and 14.99 cm. Mohamed and Al-Hassani (2021) recorded maximum length of 30 cm, and their weights ranged from 36 to 352 g. The peak size and the mid-size group was 10.0 cm and (16.0-22.0 cm), respectively. Harrison and Senou (1997) reported the highest TL for *P. subviridis* 25.0 cm for unsexed data which was higher than our findings. Data about the highest TL is important to calculate the asymptotic length of fish for implementing a suitable management policy (Khatun *et al*., 2018, 2019). Further, we found the L_∞ as 20.79 cm and K as 1.02 year^{-1}, which is lower than the reported value (33.7 cm) by Mohamed *et al*., (2013) in the East Hammar marsh, Iraq, and the L_∞ value 33.8 cm by Mohamed and Al-Hassani (2021 from northwest Persian Gulf, Iraq. This deviation might be occurred because of geographical location and food availability (Hossain and Ohtomi, 2010).

Commonly *b* value of LWRs varies between 2.5 to 3.5 (Froese, 2006). Our study documented the overall *b* value as 3.02 for unsexed data which indicated the isometric growth pattern (Tesch, 1971). Langi *et al*. (1992) also reported a similar growth pattern for *P. subviridis* population. On the other hand, Garcia (2010) and Hussain *et al*. (2010) reported negative allometric growth in the Candaba wetland, Philippines and Indus Delta, northern Arabian Sea, Pakistan, respectively. Mohamed and Al-Hassani (2021) also reported negative allometric growth (b=2.67) from northwest Persian Gulf, Iraq. Nevertheless, the *b* value may fluctuate in a particular species due to sex, food availability, preservation method, gonadal maturation, and physiological condition (Le Cren, 1951; Hossain *et al*., 2016).

If we consider that fishery is the most significant branch of worldwide protein production, it is necessary to know the biology and health condition of fish. Condition factor indicates the quality of a water body and the overall fitness of a population dwelling in a specific ecosystem (Tsoumani *et al*., 2006). Information about the condition factor of *P. subviridis* is inadequate in the literature. Our study is the first effort to explain the condition factor along with the relative weight of *P. subviridis*. We used multiple condition factors (K_F, K_A, and K_R) to find out the most suitable condition index to determine the overall health status of *P. subviridis*. The higher condition value specifies that the fish are in healthier condition (Maurya *et al*., 2018). According to the Spearman rank test, BW and K_F were significantly correlated indicating that K_F was the best for describing the well-being of *P. subviridis*. Further, the W_R below 100 indicates low prey availability and the W_R above 100 indicates a prey surplus environment (Froese, 2006). In our study, the average W_R exposed no statistical deviation from 100 for *P. subviridis* representing that the ecosystem was in a stable situation.

Form factor ($a_{3.0}$) is used extensively to ascertain the body shape of fish in an aquatic environment (Froese, 2006; Sarmin *et al*., 2021b). The form factor ($a_{3.0}$) for *P. subviridis* was 0.0116 indicating fusiform body shape for *P. subviridis* (Froese, 2006) in the coastal water of Bangladesh. The size at sexual maturity (L_m) of *P. subviridis* for pooled data was 11.65 cm in TL. Information on L_m for the fishes from the coastal water of Bangladesh is very rare (Hossain *et al*., 2012). This study is the primary effort to find out the L_m of *P. subviridis* from the Indian sub-continent.

It is important to determine the mortality rate of wild fish stock to set the appropriate harvest limit (Sabbir *et al*., 2021). The recorded mortality parameters were Z = 2.23 year^{-1}, M = 1.57 year^{-1} and F = 0.66 year^{-1}. Fishing mortality is much lower than natural mortality. Therefore, the wild stock of *P. subviridis* is almost stable with the current fishing strategy. However, exploitation rate (E) intensity is also an indicator of the level of fisheries. We recorded E as 0.30 for *P. subviridis* from the coastal water of Southern Bangladesh. Mohamed and Al-Hassani (2021) assessed the total mortality rate (Z), the natural mortality rate (M), and the rate of fishing mortality (F) as 1.12, 0.74, and 0.38 year^{-1}, respectively which were lower than our findings. The exploitation rate (E) of *P. subviridis* estimated as 0.34 from the Persian Gulf which was 4 % higher than present study. Gulland (1971) suggested the assumption that any stock is optimally exploited when the fishing mortality (F) is equal to the natural mortality (M), or $E = (F/Z) = 0.5$. But our study did not show similarity with this finding and we compared MSY as maximum exploitation with the current exploitation rate that showed sustainability of harvest fish (Sarmin *et al.*, 2021a).

The yield per recruit (Y/R') for *P. subviridis* population based on stock parameters was 0.29 or 29% (MSY). Further, the estimates of the present exploitation rate (E)=0.30 (30%), indicating that the *P. subviridis* is at a balanced exploited condition from the coastal water of Southern Bangladesh. Mohamed and Al-Hassani (2021) observed under-exploited stock for *P. subviridis* from the Persian Gulf. As our data were occasionally collected, it is assumed from the present study, if 1000 individuals are recruited in a single cohort then the individual's relative weight will be 40.0 g at the age of 1.2 years when the survival rate will be around 24%. The relative biomass at the same ages for *P. subviridis* was obtained as 9.0 kg. After recruitment, the relative biomass of *P. subviridis* increased with age and became 9.0 kg (highest) at the age of 1.2 years. There was no previous study on the above aspects. Therefore, it was very difficult to compare our results with others due to the lack of literature.

Our study explains first complete information on the stock status of *P. subviridis* from the coastal water of Southern Bangladesh. It is clear that balanced harvesting occurs in the coastal Shibsa River. The findings of our study might be very significant for fishery biologists to ensure proper management strategy in the coastal water of Bangladesh.

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