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# Estimation of population structure, growth and condition of *Parastromateus niger* in the Bay of Bengal: suggestions for catchable sizes

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**ABSTRACT** Black pomfret (*Parastromateus niger*) is one of the major commercial species of pomfret fishery in Bangladesh. This study illustrates the population structure (Length Frequency Distribution, LFD), relationship between length and weight (LWR), relationships between length and length (LLRs), Fulton's condition factor ( $K_f$ ) and relative weight ( $W_r$ ) of *P. niger* in the Bay of Bengal (BoB). A total of 225 *P. niger* were collected from the four locations during January to December 2020. LFD analysis indicates three length classes 21-27cm, 30-32 cm and 35-37 cm, respectively. This species showed isometric growth pattern ( $b=2.981$ ) that indicates that the size and weight increases proportionally and the surrounding habitat provides favourable environment for the growth. LWR between TL and BW were highly correlated ( $r^2 = 0.951$ ). LLRs also showed significant correlation between TL and SL ( $r^2 = 0.845$ ) and TL and FL ( $r^2 = 0.861$ ). The mean value of  $K_f$  was found as 1.60 which indicates that the BoB provides healthy environment for this species. The mean value of  $W_r$  (101.09) indicates that the relationship between prey and predator was in balanced condition. This study suggests optimum catchable length for *P. niger* at 27 cm. Therefore, these findings could provide important information to design effective conservation and management planning for this species.

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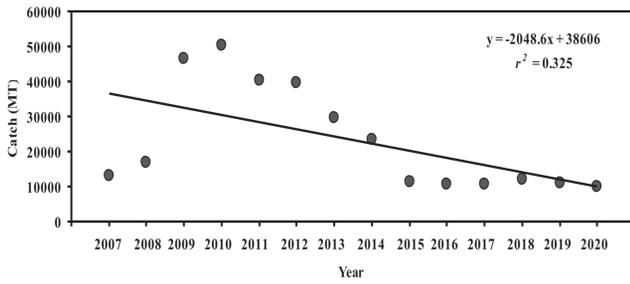
## Introduction

Pomfrets are economically important fish that inhabit in Indian coast, as well as in Singapore, Japan and Kuwait due to their high market price (Yukio et al. 1992; Dadzie et al. 2007; Tan 2009; Mazumdar et al. 2012). Chinese pomfret (*Pampus chinensis*), black pomfret (*Parastromateus niger*) and silver pomfret (*Pampus argenteus*) are important contributor of multispecies commercial fishery that comprises about 95% of the total pomfret catches in Bangladesh (DoF 2016). In the Bay of Bengal, the carangid species, *P. niger* is a commercially important marine fish because of its favored source of high nutritional value for human consumption (Oopkaew et al. 2020). Black pomfret are found mainly in coastal, estuarine and marine habitats and distributed in depth of 5-105 meters of the Bay of Bengal along the Bangladesh coast (Shahidhullah 1986). They are amphidromous and benthic-pelagic fish (Riede 2004) and feeds mainly on zooplankton, ctenophores, scalps, jellyfish, medusa and small benthic organisms (Last 1997). About 13,061 MT pomfret was caught from Bangladesh coast of the Bay of Bengal in 2006-2007 and the production continued increasing until 2009-2010.

There was a significant drop in pomfret production in 2011-2012 and it was 39,537 MT. In last decade pomfret production has gradually decreased and in 2019-2020 it was only 10,023 MT (Fig. 1) (DoF 2021).

Length-weight relationships (LWRs), length-length relationships (LLRs), and condition factor ( $K$ ) are key parameters for designing sustainable management plan of any fish population or species (King 2007). Both LWR and LLRs are also important in fisheries management to compare growth of fish in different habitats and to measure fish stock size for its judicious exploitation (Le Cren 1951; Garcia et al. 1998; Moutopoulos and Stergiou 2002; Froese 2006; Hossain et al. 2006). Another important parameter, condition factor provides important knowledge on the condition and well-being state of the fish species and its community to manage and conserve the natural population (Le Cren 1951; Tesch 1968; Fulton 1904; Sarkar et al. 2009; Muchlisin et al. 2010). In addition, relative weight ( $W_r$ ) is also a biometric tool that is used for assessing condition of the fish (Rypel and Richter 2008).

Several studies on biological aspects were carried out of black pomfret from different part of the world but no report on Length Frequency Distribution (LFD), length-length relationship and relative weight is available in the



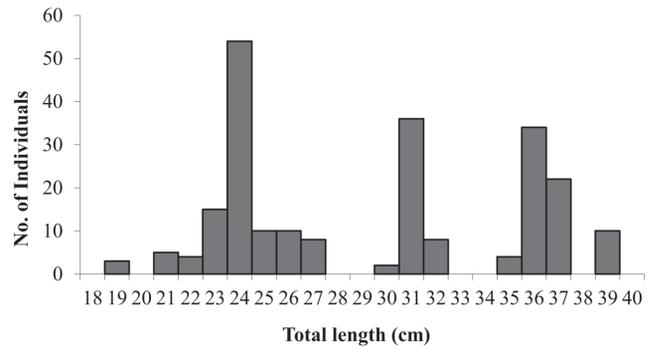
**Figure 1.** Total catch (MT) of pomfrets from 2006-07 to 2019-20 from the Bay of Bengal, Bangladesh.

literature from the Bay of Bengal (Table 1). However, the objective of the current study is to delineate the different biological parameters (LFD, LWR, LLRs, condition factor and relative weight) of *P. niger* which are important to conserve and manage for the sustainability of the fish in their natural habitat.

**Materials and methods**

**Data collection**

For this study 225 black pomfret individuals were sampled from four locations of the Bay of Bengal along the Bangladesh coast (Cox’s Bazar; Chittagong; Kuakata, Potuakhali; Patharghata, Borguna) from January to December 2020 through contract fishermen. These pomfret individuals were caught by using gill net (mesh size: 3 cm). The collected fish individuals were then kept in ice immediately and then 5% formalin solution was used to fix as soon as possible to avoid fish decomposition. Finally, the specimens were transferred to the laboratory where all morphometric data were recorded according to Froese and Pauly (2019). For each specimen length data (total length, TL; standard length, SL; fork length, FL) were recorded by using measuring scale and body weight (BW) was taken on electronic balance with 0.01g accuracy. To study the



**Figure 2.** Population structure of *P. niger* in the Bay of Bengal, Bangladesh.

population structure, length-frequency distributions (LFDs) of black pomfret were measured individually following 1.0 cm intervals of total length (TL).

**Length-Weight Relationship (LWRs)**

To calculate length-weight relationship (LWR) the following equation was used:

$$BW = a \times TL^b$$

Where, BW = body weight, *a* = constant, *b* = regression co-efficient and TL = total length. In addition, *a* and *b* parameters with 95% confidence limits and the statistical significance level of *r*<sup>2</sup> were estimated.

**Length-Length Relationship (LLRs)**

The length-length relationships (LLRs) between total length and different body lengths were measured by an equation:

$$Y = a + bX$$

Where *Y* = various body length, *X* = total length, *a* = proportionally constant and *b* = regression co-efficient.

**Table 1.** Comparative study of estimated biological parameters of *P. niger* from previous studies.

References	Aspects	Habitat
Akhter et al. (2020)	Length-weight relationship, condition factor, hepatosomatic and gonadosomatic index	Bay of Bengal (Cox’s Bazar)
Dadzie et al. (2008)	Length-length relationship, length-weight relationship, gonadosomatic index, condition factor, size at maturity and fecundity	Arabian Gulf (Kuwaiti waters)
Dadzie (2007)	Food and feeding habits	Arabian Gulf (Kuwaiti waters)
Damora et al. (2018)	Growth and mortality rate	Paloh Waters (Indonesia)
Karim et al. (2020)	Length-weight relationship	Bay of Bengal (Cox’s Bazar, Chittagong, Kuakata, Patharghata)
Sahraei et al. (2018)	Length-weight relationship	Persian Gulf
Tao et al. (2012)	Age and growth change and population dynamics	Taiwan Strait

**Table 2.** Descriptive statistics on length (cm) and weight (g) measurements and their 95% CL of *P. niger* from the Bay of Bengal, Bangladesh.

Measurements	n	Min	Max	Mode	Median	Mean ± SD	95% CL
TL		18	38	23	30	28.45 ± 5.71	27.70-29.20
SL	225	11	29	21	20	21.02 ± 4.60	20.41-21.62
FL		16	35	20	23	23.67 ± 5.13	22.99-24.34
BW		99	903	186	399	414.70 ± 249.20	381.9-447.4

**Table 3.** The estimated parameters of length-weight relationship and growth pattern of *P. niger* from the Bay of Bengal, Bangladesh.

Equation	a	b	95% CL of a	95% CL of b	r <sup>2</sup>	GT
BW = a*TL <sup>b</sup>	0.0169	2.981	0.0126-0.0228	2.89-3.07	0.951	I

### Fulton's Condition Factor (K<sub>F</sub>) and Relative Weight (W<sub>R</sub>)

The Fulton's condition factor (K<sub>F</sub>) was assessed by

$$K_F = W/L^3 \times 100$$

Where *W* stands for total body weight and *L* denotes total length.

The relative weight (W<sub>R</sub>) of *P. niger* was determined by the following equation.

$$W_R = (W/W_s) \times 100, \text{ (Froese 2006)}$$

Where *W* denotes total body weight and *W<sub>s</sub>* denotes anticipated standard weight which was measured by  $W_s = a \times L^b$  where *a* and *b* parameters were acquired from the LWRs.

### Statistical analysis

Statistical analyses were performed using Microsoft Excel-add-in-DDXL and Graph Pad Prism (version 6.5)

software. To compare the mean relative weight (W<sub>R</sub>) with 100 Wilcoxon Signed Rank Test was used.

## Results

### Population structure

In this study, the total length of the fish ranged from 18 cm to 38 cm (Table 2) and three distinct size group were identified (21-27cm, 30-32cm and 35-37 cm, respectively) (Fig. 2). About 47% fish was present in the length class of 21-27 cm. However, 20.5% was present in the length class of 30-32 cm and 26.7% in the length class of 35-37 cm.

### Length-Weight relationship (LWR)

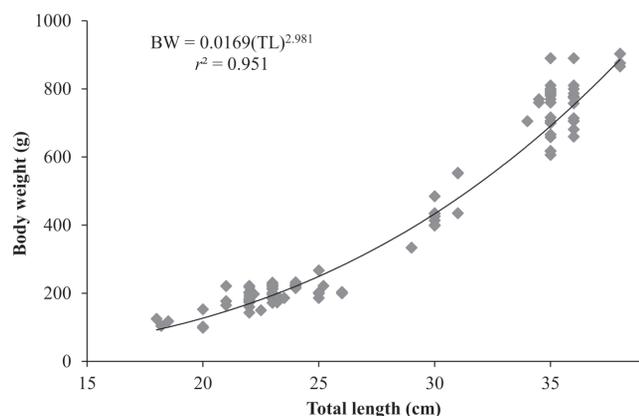
The r<sup>2</sup> (0.951) value of the LWR (TL vs. BW) showed that the relationship between total length (TL) and body weight (BW) was highly correlated (Table 3). The estimated *b* (2.981) value showed isometric growth pattern for *P. niger* indicating the size and weight for the species increases proportionally (Fig. 3).

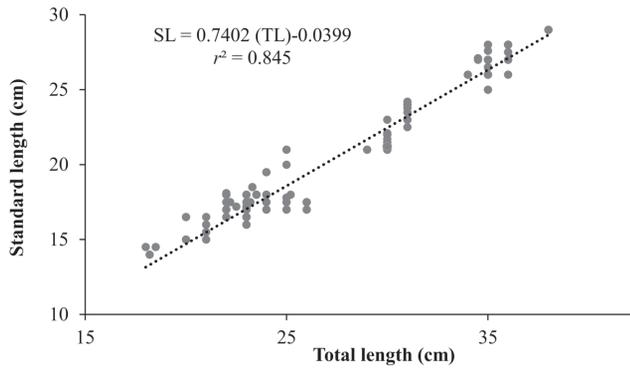
### Length-Length relationships (LLRs)

Both TL vs. SL and TL vs. FL were estimated and plotted as TL = 0.740 (SL) - 0.0399 and TL = 0.833 (FL) - 0.0335. LLRs were highly significant with r<sup>2</sup> (≤0.845) value (Table 4) indicates that TL vs. SL (Fig. 4) and TL vs. FL (Fig. 5) were highly correlated.

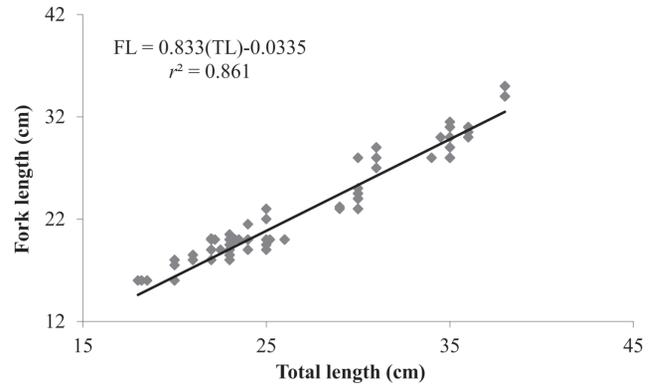
### Fulton's Condition Factor (K<sub>F</sub>) and Relative Weight (W<sub>R</sub>)

This study recorded the value of K<sub>F</sub> for *P. niger* as 1.14 to 2.9 with the mean 1.60±0.015 as well as the 95% confidence of the mean value ranges from 1.57 to 1.63 (Table 5). The calculated standard weight (W<sub>s</sub>) for *P. niger* ranged from 93.29 to 865.41 g and the mean value was 408.94 g where the mean relative weight (W<sub>R</sub>) for *P. niger* was found as 101.09 g with a range of 71.63 to 149.61 g (confidence limit ranged from 99.27 to 102.92 g) (Table 5).

**Figure 3.** Relationship between total length (TL) and body weight (BW) of the *P. niger* in the Bay of Bengal, Bangladesh.



**Figure 4.** Relationship between total length (TL) and standard length (SL) of the *P. niger* in the Bay of Bengal, Bangladesh.



**Figure 5.** Relationship between total length (TL) and fork length (FL) of the *P. niger* in the Bay of Bengal, Bangladesh.

### Discussion

The present study has provided important information on the LFD, growth pattern, LLRs, Fulton condition factor and relative weight of *P. niger* in the Bay of Bengal along the Bangladesh coast.

For the management of the fish populations and resource evaluation length frequency distribution (LFD) analysis plays a vital role (Gayaniilo and Pauly 1997). After examining the total 225 specimens of *P. niger*, the half of the individual of this fish was found for the length class of 21 to 27 cm. Therefore, it could be suggested that the fish might not be caught below 27 cm and allow them to grow for maximum yield for sustainable fisheries.

In our study, the maximum size of *P. niger* was recorded as 38 cm TL (Table 2) from the Bay of Bengal. But the previous study recorded the maximum value of TL as 54 cm from the Bay of Bengal that was much higher than our recorded value (Karim et al. 2020). Another study found the value of TL as 30.9 cm from the Bay of Bengal (Cox's Bazar) which was lower than our finding (Akhter et al. 2020). This maximum length (38 cm) was also smaller than the fish of 56.2 cm caught from the Persian Gulf (Sahraei et al. 2018) and 45 cm from the Indonesian coast (Damora et al. 2018). The information on maximum length can be used to estimate the population parameters of fish species (Hossain 2010).

This study showed the isometric growth pattern of *P. niger* where the *b* value was close to 3 ( $b = 2.981$ ), which indicates that the length increases proportionally with

the body weight and this trend of proportional growth continues throughout the life. Both Akhter et al. (2020) and Karim et al. (2020) found negative allometric growth for this pomfret fish in the Bay of Bengal, where the values of *b* were less than 3. The fish also showed negative allometric growth ( $b < 3$ ) in the Kuwait coast of the Arabian Gulf (Dadzie et al. 2008). Larger or smaller *b* value than 3 indicates positive (fish become weighty as length increases) or negative (fish grow more in length than weight) allometric growth as it will grow differently in three dimensions (Ricker 1973; Wootton 1998; Gayaniilo et al. 2003). Several studies were also performed on condition factors of other pomfret species and two pomfret species Chinese pomfret (*P. chinensis*) and silver pomfret (*P. argenteus*) had negative allometric growth (Dadzie et al. 2008; Akhter et al. 2020; Karim et al. 2020). Additionally, the length-weight relationship (LWR) between TL and BW was found highly correlated as the value of  $r^2$  was 0.951 for *P. niger* which matched with the previous studies (Dadzie et al. 2008; Akhter et al. 2020; Karim et al. 2020).

The current study estimated the relationship between the total length and other body length (Table 2) where the correlation of co-efficient ( $r^2 = 0.845$ ) indicates that the TL and SL increases proportionally for the species in its natural habitat. The similar result was found for TL and FL ( $r^2 = 0.861$ ) as well. The LLR was highly correlated with all  $r^2$  values  $\geq 0.845$ . No information was found on the length-length relationship for black pomfret in the Bay of Bengal along the Bangladesh coast.

The value of  $K_F$  is presented in Table 5 which indi-

**Table 4.** The estimated parameters of length-length relationships of *P. niger* from the Bay of Bengal, Bangladesh.

Equation	<i>a</i>	<i>b</i>	95% CL of <i>a</i>	95% CL of <i>b</i>	$r^2$
TL = $a + b^x$ SL	0.0399	0.740	3.07-5.85	1.08-1.21	0.845
TL = $a + b^x$ FL	0.0335	0.833	2.67-5.32	0.98-1.09	0.861

**Table 5.** Data on Fulton's condition factor ( $K_f$ ), Relative weight ( $W_R$ ) and Standard weight ( $W_s$ ) of *P. niger* from the Bay of Bengal, Bangladesh.

Condition	Min	Max	Mode	Median	Mean $\pm$ SD	95% CL
Fulton's condition factor ( $K_f$ )	1.14	2.9	1.81	1.61	1.60 $\pm$ 0.015	1.57-1.63
Relative weight ( $W_R$ )	71.63	149.61	113.56	101.17	101.09 $\pm$ 0.926	99.27-102.92
Standard weight ( $W_s$ )	93.29	865.41	193.73	427.75	408.94 $\pm$ 15.51	378.37-439.51

cates that the fish (*P. niger*) was still in good condition in its natural habitat which is like the previous study where  $K_f$  values were ranged from 2.89 to 3.51 (Akhter et al. 2020). This result also indicates the Bay of Bengal provides favorable environment for the growth of the fish species. In our study, we found relative weight ( $W_R$ ) ranged from 71.63 to 149.61. The mean value of  $W_R$  was 101.09  $\pm$  0.926 and this value was not significantly different ( $P = 0.563$ ) from the median value of 100 derived from the Wilcoxon Signed Rank Test which indicates that the relationship between prey and predator was in balanced condition for the species in its natural habitat and the surrounding environment provides good condition for the growth of the fish.

## Conclusion

The present findings describe that the fish shows isometric growth and the condition of the fish is good with the surrounding environment. From our findings it could also be suggested from population structure that the fish might be caught above 27 cm for maximum sustainable yield. In a nutshell, the present study provides important information for conservationist, aquatic managers and government for the sustainable conservation and management planning for pomfret fisheries in the Bay of Bengal.

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