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Exploring the biological aspects of *Harpodon nehereus* in the Bay of Bengal, Bangladesh: Suggestions for catchable Size

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ABSTRACT

The biological features of the *Harpodon nehereus* from Bay of Bengal, Bangladesh are thoroughly analyzed in this study. The study covers characteristics including length frequency distribution (LFD), growth pattern (length-weight and length-length relationship), form factor ($a_{3.0}$), multiple condition factor (allometric K_A, Fulton K_F, relative K_R, and relative weight W_R), size at sexual maturity (L_m), growth parameter, natural mortality (M_w), and optimum catchable length (L_{opt}). Between September 2021 and August 2022, 400 samples were randomly gathered through a variety of distinctive fishing techniques. Measurements of total length (TL), standard length (SL), and total body weight (BW) for each specimen were obtained with a precision of 0.1 cm and 0.01 g, respectively. Most of the fish population was concentrated within the total length (TL) size classes ranging from 18.00 cm to 20.00 cm TL. LWRs had exponentially *b* values with 2.96 and r^2 value > 0.931. With the values of r^2 is >0.909, The LLR demonstrated statistical significance with a p-value less than 0.001. An $a_{3.0}$ of 0.0042 suggests this fish has a somewhat extended profile body shape. For assessing the health of *H. nehereus* in the Bay of Bengal, K_F is the most pertinent of the four condition factors. Furthermore, W_R revealed extremely significant dispersion from 100 ($p < .0001$), indicating an unstable environment for *H. nehereus*. The estimated L_m, L, W_∞, K, t_0, M_w, and L_{opt} variables for *H. nehereus*, comprised 15.24 in TL, 27.79 cm, 89.64 g, 1.06, 0.013, 1.63/year, and 18.37 cm TL, accordingly. The current study found the optimum catchable size 18.37 cm. Therefore, the most recent findings from study may be useful for efforts in the future to maximize strategic planning in the Bay of Bengal.

Introduction

The Bombay duck, *Harpodon nehereus* (Hamilton, 1822), is a species of coastal and estuarine fish inhabiting the Bay of Bengal, Indian Ocean, and Arabian Sea. In the regions of Chittagong and Cox's Bazar, it is commonly known among locals as 'Laity Mach' or 'Loittya. Belonging to the synodontidae family, this fish shows aggressive predatory behavior and has been known to engage in cannibalism while feeding. The Bombay duck is a native of Bangladesh and found in the Bay of Bengal, estuaries and tidal rivers that reach higher ground (Rahman, 1989 and 2005). They dwell in marine, brackish, benthopelagic and semi-saline Sundarbans waters (Hasin, 2016).

The studied species (Table 1) has traditionally been harvested in the seas of the Bay of Bengal. Fishermen consistently catch Bombay ducks with 'Behundi nets'

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(set bag nets) which mesh size ranges from 70 mm at one end to 10 mm at the other. Fishing is best from July to September. 10 mm at the other. Fishing is best from July to September. According to Rahman, 2005; it is held in very high regard as a food source, notably in Chittagong (Bangladesh), where one may find an abundance of them. Rahman (1989, 2005) claimed that it is greatly regarded as foodstuff, especially in Chittagong, Bangladesh, where it is abundant. In Bangladesh, the Bombay duck was responsible for 1.56 percent of the total fish capture (71922 metric tons) (DoF, 2021). This is the second biggest commercial fishery for a single species and it provides Bangladesh with around 10.32% of its entire sea landings (68,101 metric tons) while also contributing above 35% of the world's output of *H. nehereus* (DoF 2019). In the region under consideration for this study, *H. nehereus* is a species that is considered to be endangered (IUCN 2021). Because of its delicate body structure, Bombay duck is a fish that spoils very quickly and is known for its short shelf life.

The recent years have seen a significant rise in the amount of time spent fishing off the coast of Chittagong due to the modernization of fishing vessels. Along the shore, the number of Bombay ducks is slowly but surely growing in abundance. As a direct consequence of this, the fishing industry developed into a significant part of the economy and society, providing employment for thousands of people as well as their food and nutrition needs. *H. nehereus* contains a high level of protein (12.3g/100g), calcium (58.7g/100g), vitamin-A (8.22g/100g) and Omega-3 fatty acid (0.0747 g/100g) (Hicks et al. 2019). Due to inadequate culture practices, the studied species captures a large number of specimens from wild environments. Furthermore, fishing exploitation is the greatest threat to the native population of *H. nehereus*.

The present investigation offers a comprehensive as well as elucidating account of the life-history characteristics of *H. nehereus* inhabiting the Bay of Bengal. The length-frequency distribution (LFD), the growth pattern indicated by parameters consisting of the length-weight relationship (LWR) and length-length relationship (LLR), different condition factors, form factor expressed in $a_{3.0}$, size at sexual maturity (L_m), growth parameter, and the estimation of natural mortality are all included in these characteristics. Over the course of a single year, the optimum catchable size (L_{opt}) was discovered by using a sizable collection of individuals with varying body sizes.

Materials and methods

Sampling and Measurement

For study purposes, a number of 400 individuals of *H. nehereus* were captured in the Bay of Bengal (Fig. 1) using conventional fishing gear, such as trawls (mesh size: 2–3 cm) in addition to coast seine bag nets (mesh size: 1.5–3 cm), from September 2021 to August 2022. After being gathered, the specimens were quickly refrigerated and then stored in 10% buffered formalin inside the study laboratory. The next day in the laboratory, we used digital slide calipers to measure each *H. nehereus* vital length to the nearest 0.1 cm, and we also recorded every individual's weight to the nearest 0.01 gram.

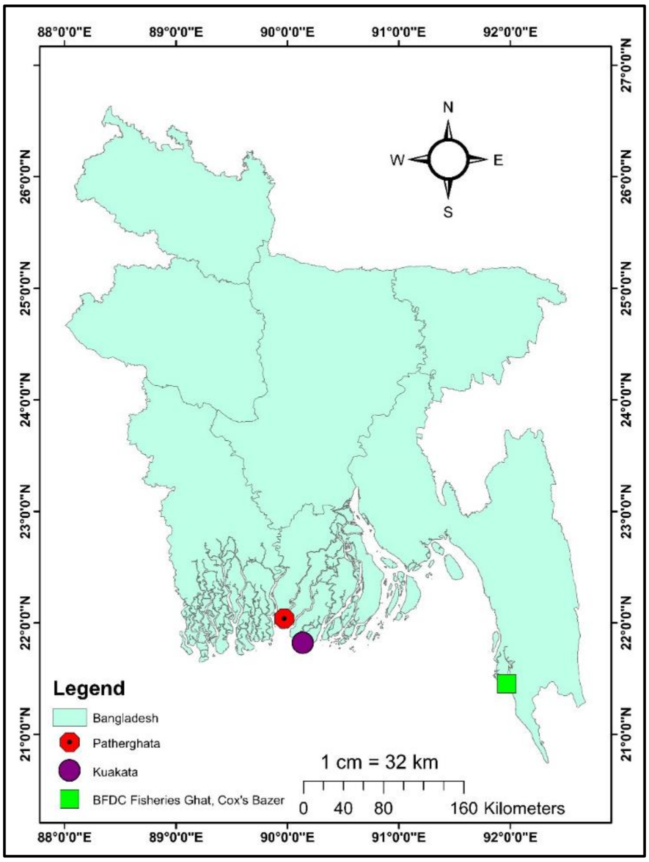

Fig. 1. Map of the study site in the Bay of Bengal, Bangladesh

Length Frequency Distributions

The analysis of length frequency distribution assumes a crucial role in the comprehensive evaluation of both the age structure and growth

Table 1. Available study of *H. nehereus* from worldwide water bodies

Aspects	Habitat/Country	References
Population dynamic	Kutubdia channel, Bangladesh	Mustafa et al. (1998)
Studies on age and growth, VPA analysis and relative condition factor	Neritic water of Bangladesh	Nurul Amin (2001)
Length-weight relationship and condition factor	Chattogram, Bay of Bengal	Hasin (2016)
Comparison relationship of length weight	Juata and Amal, Indonesia	Taqwa et al. (2018)
Length-weight relationship and population dynamics	Min river estuary, East China sea	He et al. (2019)
Growth, mortality and length-weight relationship	North-eastern tip of the Bay of Bengal	Sultana et al. (2020)

rate of fish populations. Length Frequency Distributions (LFDs) were shown in the study for the *H. nehereus* species, encompassing a length range of 2.0 cm.

Growth Pattern

The equation that was applied to determine the connection between length and weight was as follows: $BW = a(TL)^b$; (Total Length (TL), calculated in cm, and Body Weight (BW), stated in g). The growth parameters, denoted as 'a' and 'b', established by the utilization of a linear regression analysis incorporating natural logarithms. A method was used to make this decision is as follows: $\ln BW = \ln a + b \, ln \, TL$. According to Froese (2006), extreme outliers were excluded from the regression analysis by adjustments. On the contrary, by comparing the TL, FL, and SL lengths employing linear regression, the length-length relationship was estimated. The following equation was used to determine the relationship between length and length: $y = a + bx$ in which x is the total length, y is the various body sizes, "a" is constant, and b is the regression coefficient.

Condition factor

The equation employed to calculate the allometric condition factor (K_A) was developed by Tesch denote as parameters of the Length-Weight (1968) and resembles this: $K_A = \frac{W}{L^b}$; where '*W*' denotes the weight of the body in grams, '*L*' stands for the total length in centimeters, and '*b*' is the parameter in the Length-Weight Relationship (LWR) framework. The formula developed by Fulton (1904) was utilized to determine the Fulton condition factor. The equation $K_F = 100 * \frac{W}{L^3}$ represents the relationship between K_F, L, and W. In this equation, L represents the total length measured in cm, while W represents the body weight measured in g. To approximate a K_F value close to unit, a scaling factor of 100 was employed (Froese, 2006). Furthermore, Le Cren's (1951) method, $K_R = \frac{W}{aL^b}$ where W was used to calculate the relative condition factor. In this equation, W stands for body weight in grams, L for total length in centimeters, and '*a*' and '*b*' are characteristics unique to the length-weight connection. Froese (2006) proposed a formula to compute the relative weight (W_R), that is expressed like this: $W_R = \frac{W}{W_S} * 100$ whereby W_S represents the expected standard weight for a specimen of the same kind. The value of W_S is derived using the formula $W_S = aL^b$ whereby the variables '*a*' and '*b*' represent the regression parameters intricately associated with the Length-Weight Relationship (LWR).

Form factor

The Froese (2006) equation, which reads: $a_{3.0} = 10^{\log a - s(b-3)}$; where, the variables '*a*' and '*b*' denote as parameters of the Length-Weight Relationship *(LWR)*, while '*S*' represents the regression slope derived from the natural logarithm transformation of '*a*' against '*b*'., was employed to compute the form factor for *H.*

nehereus. In this work, a mean slope S=-1.358 was utilized as a stand-in for estimating the form factor because there is insufficient information on LWRs for this species to estimate the regression (S) of ln 'a' vs. 'b'

Size at first sexual maturity (L_m)

For the estimation size at sexual maturity (L_m) of *H. nehereus* was determined using a computation method and data obtained from the research conducted by Binohlan and Froese in 2009. The formula used for this estimation is as follows: $\log Lm = -0.1181 + 0.9157 * L_{max}$ whereby L_{max} represents the maximum length measured.

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

The asymptotic length is a variable of the von Bertalanffy Growth Function (VBGF) that expresses average length of the fish would attain if allowed to continue growing at the current rate (in centimeters). The length of the greatest specimen in a population is closely associated with the asymptotic length (L_∞). An empirical formula describing this connection is presented (Froese, 2000). The following formula describes the connection between asymptotic length and maximum length: $\log L = 0.0440 + 0.9841 * \log L_{max}$ and asymptotic weight (W_∞) can be determined by using the formula: $W_\infty = aL_\infty{}^b$.

Growth coefficient (K)

K represents the growth parameter within the context of the von Bertalanffy growth function (VBGF), expressed in units of year^{-1}, signifying the rate at which the asymptotic length (or weight) is progressively attained. K was calculated from the rearranged VBGF: $K = -\ln(1 + L_m/L_\infty)/t_m$ (Beverton, 1992). K represents a growth parameter in the context of the von Bertalanffy growth function (VBGF), measured in units of year^{-1}, which signifies the pace at which the asymptotic length (or weight) is reached. The calculation of K is derived from the rearranged VBGF formula as follows: K = -ln (1 + L_m / (L_∞ * t_m)) (Beverton, 1992).

Age at Zero Length (t_0)

The Parameter of the VBGF venting the notional 'age' in years the fish might have at length zero if they had perpetually expanded in the VBGF-predicted manner as log(-t_0) = -0.3922-0.2752logl_∞-1.038 log$K$ Pauly (1980).

Natural mortality (M_w)

The model of Peterson and Wroblewski (1984) was applied to calculate the M_w value. The model's equations are as follows: M_w = 1.92 year^{-1}* (W) $^{-0.25}$; M_w = Natural mortality at mass W; and $W = aL^b$; where, 'a' and 'b' is the LWR parameters.

Optimum catchable size (L_{opt})

Optimum catchable size (L_{opt}) is the length wherein the biomass of an untapped group might be maximum (Froese et al., 2016). The L_{opt} value was determined by the Beverton (1992) model, as bellow: $L_{opt} = L_\infty[3/(3 + M/K)]$ Where, L_∞ = asymptotic length as proposed to $\log(L_\infty) = 0.044 + 0.9841 * \log(L_{max})$, (Froese & Binohlan, 2000); M = natural mortality; and K = growth coefficient $K = 3/t_{max}$ (Pauly & Munro, 1984).

Statistical analysis

The data was processed and statistical analyses were performed using the software tools Microsoft Excel (version 2010) and Graph Pad Prism 8.0. The Spearman rank correlation test was used to determine whether or not there was a link between the condition variables and TL and BW. A Wilcoxon sign-ranked test was applied to segregate the average relative weight (W_R) from 100 (Anderson & Neumann, 1996). Every statistical test was implemented at the industry standard significance level of 5% ($p < .05$).

RESULTS

Length Frequency Distributions

Researchers received 400 specimens from fishers in the Bay of Bengal. The mean and 95% confidence limit (CL) for length and weight for 400 *H. nehereus* are shown in Table 2. According to the LFD, the smallest and largest individuals

Table 2. Explanatory statistics on the length (cm) and weight (g) measurements of *H. nehereus* in the Bay of Bengal, Bangladesh

Measurement	*n*	Minimum	Maximum	Mean ± SD	95% CL
Total length (cm)		13.50	26.40	19.87 ± 1.906	19.686 -20.061
Fork length (cm)	400	13.68	25.00	18.65 ± 1.744	18.482 - 18.825
Standard length (cm)		12.37	23.50	16.89 ± 1.717	16.732 - 17.061
Body weight (g)		8.80	83.10	35.09 ± 10.966	34.016 - 36.1722

n, sample size; SD, standard deviation; CL, confidence limit for mean values

had total lengths of 13.5 and 26.4 cm, respectively, and had body weights ranging from 8.80 to 83.10 g. The most typical TL length, as indicated by the frequency distribution of length, was between 19 and 20 cm Fig. 2.

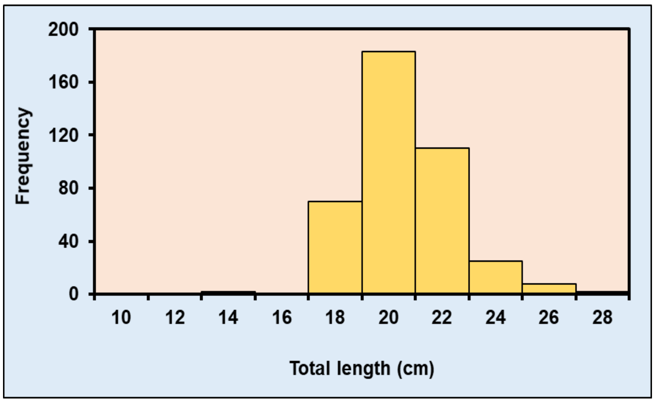

Fig. 2. Length-frequency distribution of *Harpodon nehereus* in the Bay of Bengal, Bangladesh

Growth Pattern

The sample size (n = 400), regression parameters of LWR with 95% CL, coefficient of estimation (r^2), and growth pattern of *H. nehereus* are shown in Table 3 and Fig. 3, respectively. The species *b* value (TL vs BW) indicated an isometric growth pattern. Additionally, the similar development tendency is indicated by the *b* values of LLR (TL against SL and TL vs FL) in Fig. 4 and 5.

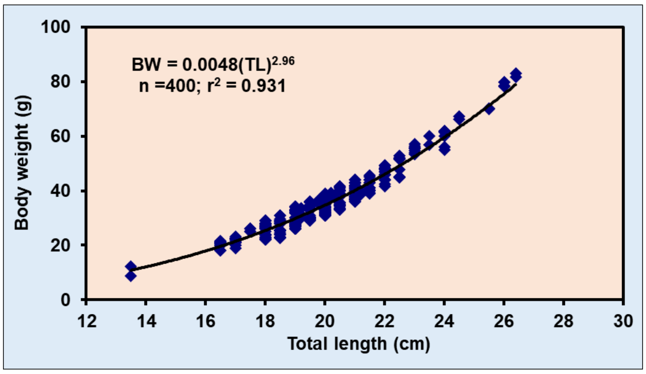

Fig. 3. Length-weight relationships of *Harpodon nehereus* in the Bay of Bengal, Bangladesh.

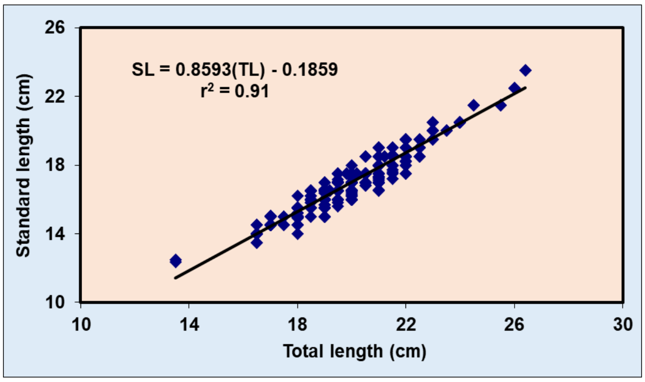

Fig. 4. Relationships between total length and standard length of *Harpodon nehereus* in the Bay of Bengal, Bangladesh.

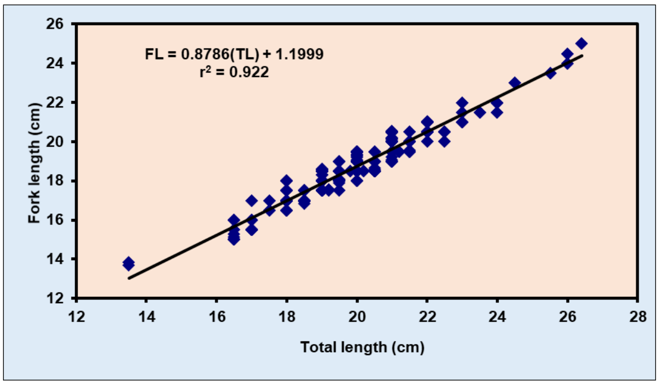

Fig. 5. Relationships between total length and fork length of *Harpodon nehereus* in the Bay of Bengal, Bangladesh.

Condition factor

The values of four condition factors, K_A, K_F, K_R, and W_R, are shown in Table 4. The condition factors have a strong relation with TL and BW, as said by the findings of the Spearman rank correlation test (Table 5). Nevertheless, the W_R of *H. nehereus* in the Bay of Bengal did not considerably diverge from the value of 100 ($p < 0.0001$).

Table 3. Descriptive statistics of length-weight and length-length relationships (LWR & LLR) of *H. nehereus* in the Bay of Bengal (Bangladesh).

Equation	n	Regression parameters		95% CL of *a*	95% CL of *b*	r^2	GT
		a	*b*				
BW=a*TL^b	400	0.0048	2.96	0.0038 - 0.0061	2.884 - 3.043	0.931	A-
SL = a+b×TL		-0.1859	0.859	-0.7177 – 0.3458	0.833 – 0.886	0.910	A-

a, intercept; *b*, slope; CL, confidence limit for mean values; r^2, coefficient of determination; GT, growth type

Table 4. Condition factors measurements and with their 95% CL of *H. nehereus* in the Bay of Bengal, Bangladesh

Condition factors	*n*	Minimum	Maximum	Mean ± SD	95% CL
Allometric condition factor (K_A)		0.0040	0.0056	0.0049 ± 0.0004	0.0048 - 0.0049
Fulton's condition factor (K_F)	400	0.3577	0.4973	0.4352 ± 0.0330	0.4320 - 0.4385
Relative condition factor (K_R)		0.8269	1.1652	1.022 ± 0.077	1.014 - 1.029
Relative weight (W_R)		82.69	116.52	102.166 ± 7.736	101.41 - 102.93

Table 5. Relationships of condition factor with total length (TL) and body weight (BW) of *H. nehereus* in the Bay of Bengal, Bangladesh

Relationships	r_s values	95% CL of r_s	*p* values	Significance
TL *vs.* K_A	-0.03958	-0.1400 to 0.06160	0.4299	ns
TL *vs.* K_F	-0.09943	-0.1984 to 0.001516	0.0469	*
TL *vs.* K_R	-0.04784	-0.1481 to 0.05335	0.3399	ns
TL *vs.* W_R	-0.04802	-0.1482 to 0.05317	0.3381	ns
BW *vs.* K_A	0.2531	-0.1561 to 0.3452	< 0.0001	***
BW *vs.* K_F	0.1961	0.09706 to 0.2912	< 0.0001	***
BW *vs.* K_R	0.2463	0.1491 to 0.3388	< 0.0001	***
BW *vs.* W_R	0.2462	0.1489 to 0.3387	< 0.0001	***

K_A, allometric; K_F, fulton's; K_R, relative condition factors; W_R, relative weight; CL, confidence limit for mean values; r_s, Spearman rank-correlation values; CL, confidence limit; *p*, shows the level of significance; ns, not significant; ***very highly significant.

Form factor

Form factor ($a_{3.0}$) value was determined to be 0.0042 in studied area Table 6.

Size at sexual maturity (L_m)

The L_m of *H. nehereus* in the Bay of Bengal was determined to be 15.24 cm in TL, with a 95% confidence level ranging from 11.90-19.44 cm Table 6.

Growth parameter

The calculated growth parameter asymptotic length (L_∞) was found 27.79 cm, also the asymptotic weight (W_∞) was 89.64 (g) for *H. nehereus* in the Bay of Bengal. Furthermore, the growth co efficient (K) was determined 1.06 year^{-1} and the age at zero length (t_0) was calculated 0.013 years of *H. nehereus* in the studied area.

Natural Mortality (M_W)

During the current investigation, the M_w of *H. nehereus* in study area was determined to 1.63/year. Additionally, it was observed that specimens with a total length (TL) of less than 5.0 cm exhibited a significantly elevated natural mortality (M_w), whereas larger individuals displayed a comparatively reduced M_w value, as depicted Fig. 6.

Optimum catchable size (L_{opt})

The determined optimum catchable size (L_{opt}) for *H. nehereus* was 18.37 cm TL in the studied area Figure 6.

Discussion

There is very little information about the biological characteristics of *H. nehereus* in Bangladesh or even in the global literature. As a

Table 6. The calculated form factor ($a_{3.0}$), size at first sexual maturity (L_m) and natural mortality (M) for the *Harpodon nehereus* of different habitats using available length-weight relationships (LWRs) parameters in the worldwide.

Water body	Sex	Regression parameter		L_{max}	References	$a_{3.0}$	L_m	95% CL of L_m
		a	*b*					
Kutubdia channel,Bangladesh	**Unsexed**	0.0024	3.05		Nurul Amin (2001)	**0.0028**	18.17	
Versora near Bombay,India	Female	0.0006	3.44	32.00	Bapat et al. (1970)	0.0024		14.1-23.33
Versora near Bombay,India	Male	0.0051	3.72	28.00	Bapat et al. (1970)	0.0480		
Daya Bay, Guangdong,China	Unsexed	0.0048	3.52	23.00	Xu et al. (1994)	0.0242	13.43	10.55-17.07
Maharasthra,India	Unsexed	0.0058	2.92	38.00	Biradar (1989)	0.0044	21.27	16.37-27.45
Min River, Estuary,China	Unsexed	0.0005	3.91	27.60	Wang et al. (2016)	0.0086	15.87	12.37-20.28
Cox's Bazar to Satkhira, Bangladesh	Mixed	0.0032	3.00		Sarkar et al. (2017)	0.0032		
Bay of Bengal	**Unsexed**	**0.0048**	**2.96**	**26.40**	**Present Study**	**0.0042**	**15.24**	**11.90-19.44**

result, the current study concentrated on an appropriate description of the biological aspects of *H. nehereus*, including LFD, LWR, LLR, form factor ($a_{3.0}$), multi-approach condition factors (K_A, K_F, K_R, and W_R), size at sexual maturity (L_m), growth parameter, natural mortality *Mw*, and optimum catchable size (L_{opt}) based on analysis of many specimens of various sizes from the Bay of Bengal, over a calendar year.

For a number of reasons, it was not possible to get the individuals of *H. nehereus* with a total length (TL) of 13.50 cm throughout the sampling period. These may have included a bias in the choice of fishing gear (Khatun et al., 2019), insufficient of small individuals in the fishing area (Hossain et al., 2015), a lack of small individuals (Azad et al. 2018).

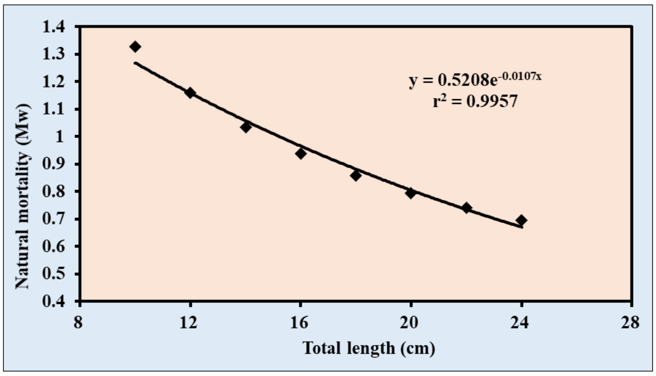

Fig. 6. Natural mortality of *Harpodon nehereus* in the Bay of Bengal, Bangladesh

Moreover, the highest length of *H. nehereus* in the study area was 26.40 cm that is shorter than the highest recorded length estimates of 61 cm (Fernandez et al., 1996) and the average length of male/unsexed individuals, which was 25.0 cm (Sommer et al. 1996). The present study revealed a range of total length between 13.50 cm and 26.40 cm, standard length between 12.37 cm and 23.50 cm, and weight between 8.80 g and 83.10 g. In contrast, Hasin (2016) reported total lengths between 11.8 cm and 25.4 cm, standard lengths between 9.9 cm and 21.4 cm, and weights between 4.36 g and 52.71 g.

According to the current study's findings, *H. nehereus* has an allometric coefficient *b* value of LWR (TL *vs.* BW) of 2.96, which falls within the predicted range of (2.0-4.0) suggested by Tesch (1971) and (2.50-3.50) informed by Froese (2006). According to the *b* value of LWR, *H. nehereus* displayed an isometric growth pattern ($b \leq 3$) in the Bay of Bengal. This growth pattern indicates that the rate of development in body weight was increased in all dimensions at the same rate. Hasin reported in 2016 that the *b* values for *H. nehereus* were 2.404 and 2.169. This was also found by Krishnayya (1968), Bapat (1970) and Kurian et al. (1992), who studied the allometric growth parameter of *H. nehereus* in the Bay of Bengal (*b*=3.27), the Arabian Sea (3.4444 in females and 3.7169 in males), and the north west coast (2.03) accordingly. In contrast to these outcomes, studies of *H. nehereus* in the Bay of Bengal and the Arabian Sea have recorded an isometric growth parameter, with '*b*' values of 3.05 and 2.89, respectively, by Amin (2001) and Bapat et al. (1951), respectively.

The $a_{3.0}$ is a useful tool for determining whether or not the body shape of individuals belonging to a specific population or species is noticeably distinct from that of other individuals Froese 2006. The value for $a_{3.0}$ was 0.0042, which indicates that *H. nehereus* in the Bay of Bengal has an elongated body shape. There has no mention of the form factor of individuals in any of the published research therefore this study represents the initial investigation to concentrate on that particular aspect. The results of this study will arrange for the groundwork for studies to come in the future.

This research examined the physical and ecological state of *H. nehereus* in the Bay of Bengal using four condition parameters (K_A, K_F, K_R, and W_R). However, previous studies have exclusively concentrated on a single facet of the ailment. When compared to the other condition variables, the Spearman rank correlation test shows that only K_F is significantly correlated with both TL and BW. Accordingly, it is reasonable to assume that K_F is the best parameter for evaluating the well-being of *H. nehereus* in the Bay of Bengal, as well as adjoining ecosystems. In addition, the Wilcoxon signed rank test showed that the mean W_R was significantly separate from 100 ($p<.0001$), suggesting the presence of predators in the Bay of Bengal creates an uneven playing field in terms of access to food for *H. nehereus* (Anderson and Neumann, 1996; Rahman et al., 2020). As per the findings of Rypel and Richter (2008), the assessment of the overall physical condition can be carried out using and welfare of the population as well as environmental problems. Therefore, it is unable to compare the findings of the current investigation with any existing literature on the W_R of *H. nehereus*. In order to ascertain the factors contributing to size discrepancies at the point of sexual maturation, it is imperative to take into consideration the size of the fish (Templeman, 1987).

The estimated L_m for *H. nehereus* was found to be 15.24 cm TL. This value is significant in fish population management as it serves as the least-allowable capture size. This information has been previously documented by Lucifora et al. (1999) and Nurdin et al. (2016). The calculated value of L_∞ was 27.79. On the other hand, Mustafa et al. (1994 and 1998), Ghosh et al. (2009), Sarkar et al. (2017) and Sultana et al. (2020) reported the value of L_∞ was 29.00, 24.48, 35.39, 45.05 and 38.50 cm, respectively. In addition, there has been no prior to investigate of the growth parameter asymptotic weight (W_∞); making direct comparisons impossible can't be made. In present study the calculated value of growth coefficient (K) was 1.06, whereas Mustafa et al. (1994 and 1998), Ghosh et al. (2009), Sarkar et al. (2017) and Sultana et al. (2020) reported the value of K was 0.90, 1.50, 0.86, 1.30 and 0.88 year^{-1} respectively. Furthermore, the study conducted for the estimation of age at zero length (t_0) was 0.013 year^{-1} whereas Sultana et al. (2020) recorded the value of t_0 was 0.0181 year^{-1}. The calculated value of natural mortality (M_w) for *H. nehereus* was 1.63/years in the Bay of Bengal and Mustafa et al. (1994), Balli et al. (2011) and Sultana et al. (2020) reported the M_w was 2.46 year^{-1}, 1.30 year^{-1} and 1.51 year^{-1} respectively.

According to Froese et al. (2018), the optimal catchable size (L_{opt}) is defined as the length at which the maximum number of fish can be captured. According to Mawa et al. (2021), L_{opt} facilitates the process of selecting appropriate mesh sizes for fishing equipment and helps prevent the capture of fish that shouldn't meet the catchable size requirements for the targeted fish species. Because this is the first study on this biological feature, no comparisons can be made. On the other hand, the current study estimated L_{opt} for this species applied by L_{max} values provided from the literature. It is recommended to refrain from capturing fish that have a total length of 15.24 cm, and instead capture fish that have a total length of 18.37 cm. The Bay of Bengal's ichthyofaunal resources face significant challenges due to a range of factors, including fishing pressure, habitat degradation, pollution, and destructive fishing practices involving non-selective fishing gear (Islam et al. 2015; Saha et al. 2021). Furthermore, it is recommended to assess the mesh size of fishing nets on a year-round basis, taking into consideration the size of fish upon reaching sexual maturity, in order to ensure sustainable conservation and management practices. It is imperative to enhance public awareness regarding these concerns to ensure effective management of this particular fish species in the Bay of Bengal and nearby aquatic ecosystems.

Conclusion

According to the facts presented here, the growth of the fish is isometric, and the condition of the fish is satisfactory in relation to the habitat in which it was found. Based on our findings, the population structure might also imply that the fish should be harvested when they are over 20 centimeters in length to provide the highest possible sustainable output. In a nutshell, the current research offers vitally significant data to conservationists, aquatic managers, and government officials, which may be used for the purpose of establishing sustainable conservation efforts and management strategies for *H. nehereus* fisheries in the Bay of Bengal.

Conflict Of Interest

There are no conflicting interests that may impact the study.

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