



## Research Article

# Growth and Conditions Appraisal of *Atropus atropus* (Carangidae) in the Bay of Bengal

Nur-E-Farjana Ilah<sup>1</sup>, Md. Joynal Abedin<sup>2</sup>, Esmout Jahan Alice<sup>1</sup>, Taiba Akter Laboni<sup>1</sup>, Mst. Shahinur Khatun<sup>1</sup>, Most. Shakila Sarmin<sup>1</sup>, Md. Ashekur Rahman<sup>1</sup>, Obaidur Rahman<sup>1</sup>, Md. Akhtarul Islam<sup>1</sup>, Muhammad Ali Fardoush Siddiquy<sup>3</sup> and Md. Yeamin Hossain<sup>1\*</sup>

<sup>1</sup>Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh; <sup>2</sup>Department of Zoology, Carmichael College, National University, Bangladesh; <sup>3</sup>Department of Geography and Environment, Nachol Women's College, Chapainawabganj, Rajshahi 6301, Bangladesh.

**Abstract** | This study aims to provide insights into the growth pattern and conditions of *Atropus atropus* in the Bay of Bengal, Bangladesh. The lack of information on this species in the region has made it crucial to carry out such research for better understanding about its growth and health in this particular habitat. A total 100 individuals were collected from fishers catch during November 2021 to October 2022 by using traditional fishing gears such as trawl and gill nets (mesh size: 2-3 cm). Data showed that TL was found to be between 15 and 21 cm and the BW remained as 46 and 136 g. All LWRs had  $r^2$  values below 0.945 and were significant ( $P < 0.001$ ). The estimated allometric coefficient ( $b$ ) suggested the combined sexes showed isometric growth ( $b \sim 3$ ). The statistical analysis conducted in this study revealed a highly significant LLR ( $p < 0.001$ ) with an  $r^2$  value exceeding 0.944. The form factor ( $a_{3.0}$ ) was found as 0.0155, while the size at first sexual maturity ( $L_m$ ) was determined as 12.36 cm TL. The natural mortality ( $M_w$ ) was calculated as  $1.57 \text{ y}^{-1}$ . A major connection between  $K_R$  and BW for this species, indicating that  $K_R$  was an exceptionally significant in revealing the health of *A. atropus*. Thereafter, a high condition rating ( $K_p$ ,  $K_d$  and  $K_R$ ) indicates that the species is in short and deep shape. This study found that the habitat was in a state of equilibrium and the mean  $W_R$  indicated that there was no significant deviation from the expected value of 100 for *A. atropus*. Consequently, information gathered from the present study would be impactful for managing this fishery in the Bay of Bengal, Bangladesh, along with the surroundings.

**Received** | March 11, 2023; **Accepted** | October 03, 2023; **Published** | October 02, 2023

**\*Correspondence** | Md. Yeamin Hossain, Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh; **Email:** yeamin.fish@ru.ac.bd

**Citation** | Ilah, N-E-F, M.J. Abedin, E.J. Alice, T.A. Laboni, M.S. Khatun, M.S. Sarmin, M.A. Rahman, O. Rahman, M.A. Islam, M.A.F. Siddiquy and M.Y. Hossain. 2023. Growth and conditions appraisal of *Atropus atropus* (Carangidae) in the Bay of Bengal. *Sarhad Journal of Agriculture*, 39(4): 823-831.

**DOI** | <https://dx.doi.org/10.17582/journal.sja/2023/39.4.823.831>

**Keywords** | *Atropus atropus*, Bay of Bengal, Condition factor, Cleftbelly trevally, Growth, Relative weight



**Copyright:** 2023 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## Introduction

The family Carangidae includes the species *Atropus atropus* which is commonly known as

the Cleftbelly trevally. It is native to the tropical as well as subtropical water bodies of the Indo-West Pacific area. It is locally known as “Tak Chanda” in Bangladesh. This is a demandable fish species and is

abundantly found in winter. In Bangladesh, *A. atropos* is classified as LC (Least Concern) (IUCN, 2023). Fowler and Henry (1935) and Carpenter *et al.* (2001) stated that the distribution of this species spans across South Africa to the East African coast and throughout the rest of Africa, the Middle East, Asia, Oceania, and Europe, with recent sightings in the Persian Gulf, India, Southeast Asia, the Philippines, Taiwan, and southern Japan. However, the specimens collected by Henry Fowler from South and Eastern Africa in the 1930s suggested that this claim is not entirely accurate, despite Fowler and Henry (1935) statement that the westernmost point of the species range is the Persian Gulf.

*A. atropos* lives in shallow coastal water and swim near to surface. Certain species may be able to survive in brackish water conditions based on the results of a study of those, found in locations near estuary that experienced a substantial amount of freshwater drift (Ansari *et al.*, 1995). This species is amphidromous and pelagic-neritic marine fish (Riede, 2004). Cleftbelly trevally are predators that dine on a variety of smaller marine organisms, including crustaceans like prawns and zooplankton even some smaller fish also (Masuda *et al.*, 1984). *A. atropos* contains a high level of Omega-3 fatty acid (0.314 g/100g) (Hicks *et al.*, 2019).

The production of marine fisheries accounts for 16.18% of overall fish production in Bangladesh (DoF, 2019). Throughout its range, the species has minor importance to fisheries, being caught primarily with methods like trawls, traps, various hooks and line also. Study species is catching widely from savage environments due to inadequacy of culture practice. Moreover, exploitation of fishing is the most serious alarm to the wild population of *A. atropos*.

Length-frequency distribution (LFDs) is considered as an important biometric statistic that should be used for calculating the growth rate, growth performance index as well as fish morbidity are accepted widely (Sabbir *et al.*, 2022). Furthermore, LFD is employed for estimation the state of a river health by conducting stock assessments of residual biomass and breeding season (Ranjan *et al.*, 2005; Ilah *et al.*, 2022). Moreover, LFD aids in comparing the physical traits of many species and the population of a single species from various aqueous ecosystem (Sabbir *et al.*, 2020a; Hasan *et al.*, 2022). Alternatively, the

length-weight relationships (LWRs) and the length-length relationships (LLRs) are major biometrically indicates that may be used to compare and contrast a range of biological conditions (Sabbir *et al.*, 2020b). In addition, LWRs and LLRs both are criteria to carry out successful assessment of a natural species of lotic water territory (Muchlisin *et al.*, 2010).

Form factor ( $a_{3.0}$ ) is applied all over the world for determining the anatomical structure of fish living in water bodies (Froese, 2006; Mawa *et al.*, 2022). Since, fish are the primary source of protein, producing on a worldwide scale is crucial to comprehend fish biology and health. A condition factor may be thought of as an indicator that is used to learn about fish ability to survive, mature, maintain their health and reproduction (Le Cren, 1951; Sabbir *et al.*, 2020c). It measures how fit the habitat is, as a whole along with how healthy the water is, in a given waterbody (Tsoumani *et al.*, 2006). All of these attributes, fertility, environmental factors, dietary accessibility and the time of year are taken into account when assessing fish condition (Hossain *et al.*, 2006). Having details on the circumstances of *A. atropos*, in order to calculate the lifespan of a specific group for the purpose of precise governance as well as to maintain the balance of an environment is highly required (Hossain *et al.*, 2013).

Furthermore,  $W_R$  approach is most commonly used to analyze fish population in a certain ecosystem, whereby, considering their function as either prey or predator (Froese, 2006). Moreover, the fish resources of the Bay of Bengal are in severe vulnerability due to a multitude of factors, including overfishing, destruction of habitat, degradation, fishing practices that are harmful to marine life and a great number of other problems. A few studies on the length weight relationship and conditions of *A. atropos* were carried out (Table 1). As a consequence, earlier study lacked appropriate demographic data on conditions and form factors throughout the year. During twelve-month period, we were trying to explain LFDs, growth patterns depending on LWRs, LLRs, form factor ( $a_{3.0}$ ) and status of *A. atropos* from the studied region.

## Materials and Methods

### Sampling and sampling site

*A. atropos* (100 specimens) were collected from fishers in the Bay of Bengal, Bangladesh. By means of

**Table 1:** Available literature of *Atropus atropos* from worldwide water bodies.

| Aspects                                                  | Water body                           | References                    |
|----------------------------------------------------------|--------------------------------------|-------------------------------|
| Biology                                                  | Ratnagiri coast of India             | Rakhunde <i>et al.</i> (2023) |
| Length-weight relationship                               | Northern Arabian Sea coast, Pakistan | Qamar and Panhwar (2018)      |
| Length-weight relationship and relative condition factor | Mangalore coast, India               | Rajesh <i>et al.</i> (2020)   |
| Length-weight relationship                               | Bay of Bengal, Bangladesh            | Rahman <i>et al.</i> (2021)   |
| Population characteristics                               | Mangalore coast, India               | Rajesh <i>et al.</i> (2019)   |

traditional fishing techniques and gears such as gill nets and trawls during the months of November 2021 to October 2022 (wire spacing: 2-3 cm), these fish were captured. After the collection of specimens, they were immediately placed on ice and afterwards in the research center, in order to keep them in good condition for subsequent research and 10% buffered formalin was used for preservation. Using digital slide calipers, the essential length of each individual *A. atropos* was measured the next day in the laboratory to the closest 0.01 cm. In addition, using an electric balance, the total body weight of every specimen was determined to an accuracy of within 0.01 g.

#### Population structure

LFD in the species of *A. atropos* was arranged through 1.0 cm class interval of total length (TL).

#### Length- weight and length- length relationship

Body weight (g) and total length (cm) were entered into the equation  $BW = a*(TL)^b$  to get LWRs (cm). Using natural logarithms and linear regression analysis, we were able to get the values of  $a$  and  $b$ :  $\ln(BW) = \ln a + \ln b(BW)(TL)$ . According to Froese (2006), the regression analysis was adjusted such, that extreme outliers were not included. On the other hand, the linear regression of TL, FL and SL was respectively used to estimate the length-length associations among the three variables. The equation used to compute the length-length connection is as follows:  $y = a + bx$ ; as,  $y$  representing the different body length,  $x$  represents overall length,  $a$  represents a constant, and  $b$  represents a regression coefficient.

#### Condition factor

Tesch (1968) provided the equation that was used to determine the allometric condition factor ( $K_A$ ), which is as follows:  $K_A = W/L^b$ ; where,  $W$  represents the body weight in grams,  $L$  represents the total length in centimeters and  $b$  refers to the LWR parameter. While calculating the Fulton condition factor, the following formula from Fulton (1904) was utilized:

$K_F = 100*(W/L^3)$ . In this formula,  $W$  represents the body weight in grams, and  $L$  represents the total length in cm. The scaling factor of 100 was utilized to obtain the  $K_F$  value that is nearer to unit (Froese, 2006). Additionally, the relative condition factor was determined by applying the access this information by Le Cren (1951):  $K_R = W/(a*L^b)$ ; in which  $W$  represents the body weight in grams,  $L$  represents the total length in centimeters and  $a$  and  $b$  refer to the LWR parameters.

The equation of Froese (2006) was used to calculate the relative weight ( $W_R$ ); which reads as follows:  $W_R = (W/W_s)*100$ ; whereby  $W_s$  is for estimated standard weight of the specimen no different calculated as  $W_s = a*L^b$ ; wherein  $a$  as well as  $b$  are regression parameters of LWR.

#### Form factor

In order to determine the form factor for *A. atropos*, the formula given by Froese (2006) was employed:  $a_{3.0} = 10 \log^{a^{-s(b-3)}}$ , where  $a$  and  $b$  denote the LWR parameters and  $S$  represents the slope of the regression line that compares  $\ln a$  to  $b$ . However, due to insufficient data on LWRs for this species, a mean slope of -1.358 was used as a substitute during this study to estimate the form factor.

#### Size at first sexual maturity ( $L_m$ ) and natural mortality ( $M_w$ )

$\log(L_m) = -0.1189 + 0.9157*(L_{max})$ ; where  $L_{max}$  is the longest length recorded, was used to calculate  $L_m$  (Binohlan and Froese, 2009). Peterson and Wroblewski (1984) developed a model to calculate the  $M_w$  as follows:  $M_w = 1.92 \text{ year}^{-1}*(W)^{-0.25}$ ; where,  $M_w$ =Natural morbidity at mass  $W$ ; and  $W = a*L^b$ , where  $a$  and  $b$  are the LWR parameters.

#### Statistical analysis

The statistical analysis was delegated to the use of the software packages Microsoft Excel (version 2010) and Graph Pad 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). Statistical analysis was performed using a significance threshold of 5% ( $p < .05$ ).

## Results and Discussion

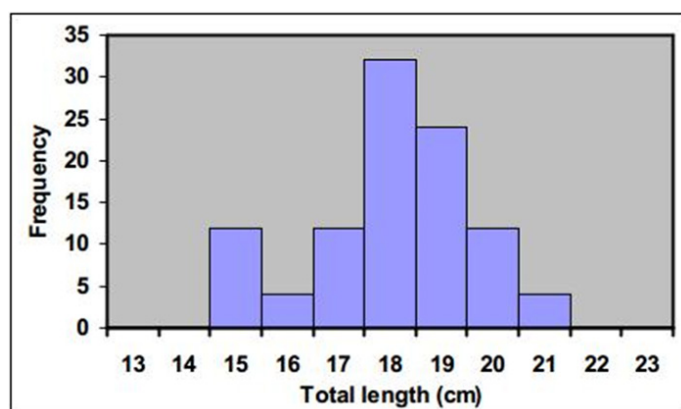
### Population structure

A number of 100 individuals were collected from fishermen of the Bay of Bengal. Table 2 contains the descriptive data for length and weight and their respective 95% confidence limit (CL). LFD revealed that the lowest along with biggest values (15 cm and 21 cm) in total length respectively and that the body mass ranged from 46 to 136 g. According to LFD, the size range of 17.99 to 18.99 cm TL was numerically predominant (Figure 1).

**Table 2:** Explanatory statistics on length (cm) and weight (g) measurements with their 95% confidence interval of *Atropus atropus* in the Bay of Bengal (Bangladesh).

| Measurement          | n    | Min. | Max. | Mean±SD     | CI <sub>95%</sub> |
|----------------------|------|------|------|-------------|-------------------|
| Total length (cm)    | 100  | 15   | 21   | 17.92±1.617 | 17.599-18.241     |
| Fork length (cm)     | 13   | 18.5 |      | 15.66±1.562 | 15.35-15.97       |
| Standard length (cm) | 11.5 | 16.5 |      | 13.82±1.41  | 13.541-14.099     |
| Body depth (cm)      | 6    | 9    |      | 7.76±0.94   | 7.573-7.947       |
| Body weight (g)      | 46   | 136  |      | 90.69±24.15 | 85.896-95.48      |

n, sample size; CI, confidence interval for mean values.



**Figure 1:** Total length-frequency distribution of *Atropus atropus* in the Bay of Bengal (Bangladesh).

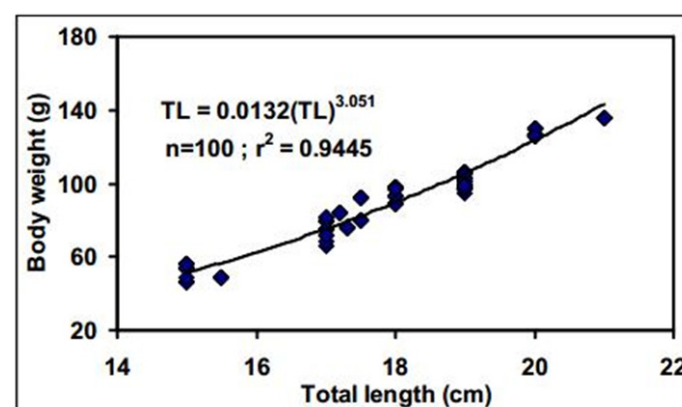
Length-length and length-weight relationships (LWR and LLR)

Table 3 and Figure 2 show the growth pattern of *A. atropus* and provides information on the sample size (n), regression parameters of LWRs with 95% CL and the estimation coefficient ( $r^2$ ). This species exhibited an isometric growth pattern, as shown by the estimated  $b$  value of LWRs. In addition,  $b$  value of LLRs showed the similar growth pattern ( $b < 1$ ) in Figures 3 and 4.

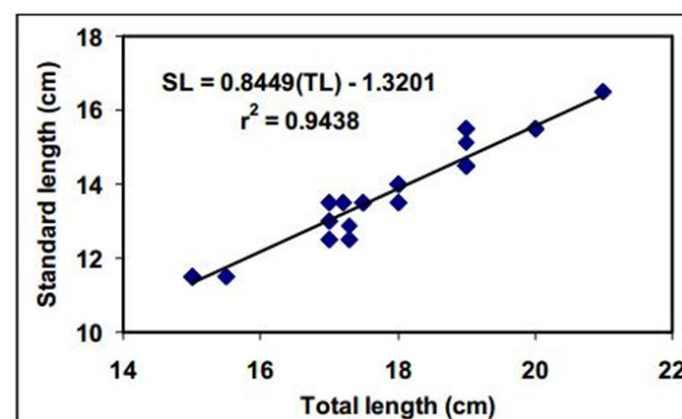
**Table 3:** Descriptive statistics of length-weight and length-length relationships (LWR and LLR) of *Atropus atropus* in the Bay of Bengal (Bangladesh).

| Formula                | n   | Regression variables |       | a (±95% CI)      | b (±95% CI)    | $r^2$ |
|------------------------|-----|----------------------|-------|------------------|----------------|-------|
|                        |     | a                    | b     |                  |                |       |
| BW = $a \times TL^b$   | 100 | 0.013                | 3.051 | 0.009 to 0.02    | 2.903 to 3.199 | 0.945 |
| FL = $a + b \times TL$ |     | -0.996               | 0.930 | -1.810 to -0.181 | 0.885 to 0.975 | 0.944 |

n, sample size; TL, total length; BW, body weight; SL, standard length; a, intercept; b, slope; CI, confidence interval for mean values;  $r^2$ , coefficient of determination



**Figure 2:** Relationship ( $BW = a \times TL^b$ ) between total length (cm) and body weight (g) of *Atropus atropus* in the Bay of Bengal (Bangladesh).



**Figure 3:** Relationship ( $SL = a + b \times TL$ ) between standard length (cm) and total length (cm) of *Atropus atropus* in the Bay of Bengal (Bangladesh).



### Condition factor

Table 4 reveals the frequencies of four condition factors, namely  $K_A$ ,  $K_F$ ,  $K_R$  and  $W_R$ . Spearman rank correlation test showed that condition of this fish had no relationship with TL and BW except BW vs.  $K_R$  (Table 5). Further,  $W_R$  has no significant difference from 100 ( $P < .0001$ ) for *A. atropos* in the Bay of Bengal. The form factor ( $a_{3.0}$ ) was calculated as 0.0155 in the Bay of Bengal, Bangladesh (Table 6).

**Table 4:** Descriptive statistics on condition factors measurements and with their 95% CI of *Atropus atropos* in the Bay of Bengal (Bangladesh).

| Condi-<br>tions | Mini-<br>mum | Maxi-<br>mum | Mean±SD         | CI <sub>95%</sub> |
|-----------------|--------------|--------------|-----------------|-------------------|
| $K_A$           | 0.0114       | 0.0148       | 0.0133 ± 0.0009 | 0.0131-0.0135     |
| $K_F$           | 1.3158       | 1.7166       | 1.5383± 0.1036  | 1.518-1.559       |
| $K_R$           | 0.867        | 1.124        | 1.006 ± 0.068   | 0.993-1.02        |
| $W_R$           | 86.68        | 112.384      | 100.612 ± 6.786 | 99.265-101.958    |

Condition factors ( $K_A$  Allometric;  $K_F$  Fulton's;  $K_R$  Relative;  $W_R$  Relative weight); and CI, confidence interval.

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

| Relation-<br>ships | $r_s$ values | 95% CL of $r_s$    | p values | signifi-<br>cance |
|--------------------|--------------|--------------------|----------|-------------------|
| TL vs. $K_A$       | -0.08567     | -0.2828 to 0.1184  | 0.3967   | NS                |
| TL vs. $K_F$       | -0.02693     | -0.2278 to 0.1764  | 0.7902   | NS                |
| TL vs. $K_R$       | -0.08031     | -0.2779 to 0.1238  | 0.4270   | NS                |
| BW vs. $K_A$       | 0.1099       | -0.09426 to 0.3052 | 0.2764   | NS                |
| BW vs. $K_F$       | 0.1735       | -0.02963 to 0.3628 | 0.0843   | NS                |
| BW vs. $K_R$       | 0.9960       | 0.9939 to 0.9973   | <0.0001  | ****              |

Condition factors ( $K_A$  Allometric;  $K_F$  Fulton's;  $K_R$  Relative);  $r_s$  coefficient of spearman rank correlation test values; CL, confidence limit; NS, not significant; \*\*\*\*extremely significant; and P, exhibitions the intensity of significance.

**Table 6:** The calculated form factor ( $a_{3.0}$ ), size at sexual maturity ( $L_m$ ), and natural mortality of *Atropus atropos* (sample size, n=100).

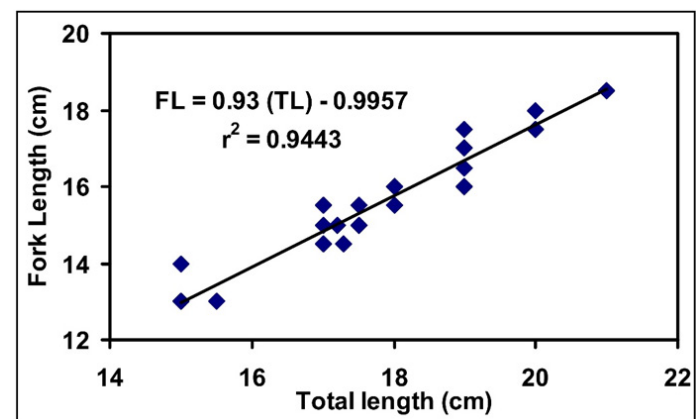
| Sex           | Total length a<br>(cm) |     | b     | a <sub>3.0</sub> | L <sub>m</sub> | M <sub>w</sub> | 95%<br>CL of<br>L <sub>m</sub> |                |
|---------------|------------------------|-----|-------|------------------|----------------|----------------|--------------------------------|----------------|
|               | Min                    | Max |       |                  |                |                |                                |                |
| Com-<br>bined | 15                     | 21  | 0.013 | 3.051            | 0.0155         | 12.36          | 1.57                           | 9.74-<br>15.66 |

Min, minimum; Max, maximum

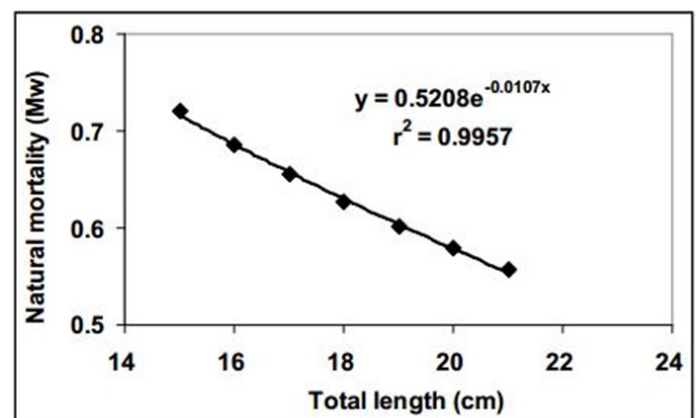
### Size at first sexual maturity ( $L_m$ ) and natural mortality ( $M_w$ )

The  $L_m$  of *A. atropos* in the Bay of Bengal was estimated as 12.36 cm in TL with 95% CL of 9.74-15.66 cm

(Table 6). During this study, the  $M_w$  of *A. atropos* was determined as 1.57 year<sup>-1</sup> in the Bay of Bengal (Table 6 and Figure 5).



**Figure 4:** Relationship ( $FL = a+b \times TL$ ) between Fork length (cm) and total length (cm) of *Atropus atropos* in the Bay of Bengal (Bangladesh).



**Figure 5:** Natural mortality of *Atropus atropos* in the Bay of Bengal (Bangladesh).

There is a scarcity of information on *A. atropos* in published literature. As a result, the current study was concentrated on providing an accurate description of *A. atropos*, including population structure, LWR, LLR, multi-approach condition factors ( $K_A$ ,  $K_F$ ,  $K_R$  and  $W_R$ ), form factor ( $a_{3.0}$ ), size at first sexual maturity ( $L_m$ ), and natural mortality ( $M_w$ ), using numerous specimens of varying sizes collected a year-round from the Bay of Bengal, Bangladesh. During the sampling time, it was difficult to catch any *A. atropos* with a (TL) length of less than 15 centimeters in population or selection of fishing gear (Hossain et al., 2012b). In this research, *A. atropos* was measured 21.0 centimeters in maximum total length, which is shorter than the highest recorded values of 40.3 centimeters in TL (Pradhan et al., 2020) and 44.0 centimeters in TL (for combined data) according to Talwar and Jhingran (1991). This variance could have happened as a result of the geographic location and the availability of food

(Hossain and Ohtomi, 2010). For effective fisheries management and planning, comprehensive data is essential, addition of asymptotic length along with fish growth coefficient (Hossain *et al.*, 2012a; Khatun *et al.*, 2018, 2019; Parvin *et al.*, 2018).

Value of the regression parameter  $b$  for the LWR of *A. atropos* is within the recommended range (2.5–3.5) for aquatic animals Froese (2006). Our findings show that the  $b$  value of *A. atropos* obtained in subsequent investigations from India (2.86) and Pakistan (2.87) is less than what was found in those countries and current investigation is (3.05) similar with China (3.02) (Reuben *et al.*, 1992; Xu *et al.*, 1994; Qamar and Panhwar, 2018) and this number is substantially comparable (3.098) to the findings of Rahman *et al.* (2021). In the present study,  $b$  value was 3.05, i.e., isometric growth. This means that, fish gain weight as their length growing proportionally (Tesch, 1971), which states that, fish should have an isometric growth rate (Hossain *et al.*, 2016; Hasan *et al.*, 2020). The reasons for differences in  $b$  values have been identified as a lack of standardized sampling procedure, particularly with regard to the selection of fishing equipment, conservation efforts, environment, food, sexual orientation, health and seasonal influences and other factors that are not taken into consideration in our study. These reasons are not taken into account (Hasan *et al.*, 2020).

In addition to losing weight, fish that are preserved in formalin may also endure variable degrees of length decreases. On the other hand, the rate of declination might change depending on the species and can be observed over a significant amount of time. In our investigation, the time frame between catching the fish and measuring them was just 36 hours; as a result, any shrinkage that occurred may have been little thus far. Advised that, future research quantify the influence of stabilization on LWR using fresh and stored specimens for a period ranging from a few weeks to several months.

Enough information is not available about the condition factor of *A. atropos*. This research is the attempt to explain the condition component, to attempting to explain the relative weight of *A. atropos*. We incorporated a number of different condition components in order to come up with the most accurate condition index to evaluate *A. atropos* overall health ( $K_F$ ,  $K_A$  and  $K_R$ ). The Spearman rank correlation test manifested a substantial link into

$K_R$  and BW for this species, indicating that,  $K_R$  was an exceptionally significant factor in describing the health of *A. atropos* (Table 5). Furthermore,  $W_R$  values that are lower than 100 indicate an environment with a limited quantity of prey, whereas  $W_R$  values that are higher than 100 indicate an environment with an abundance of prey (Froese, 2006). In the course of our research, we determined that the ecosystem was in a condition of stability when the average  $W_R$  revealed that, neither *A. atropos* had a statistically significant deviation from the value of 100.

In current study, form factor ( $a_{3.0}$ ) value was 0.0155 which indicates the population of *A. atropos* had a body form that was short and deep in the Bay of Bengal, Bangladesh, (Froese, 2006). In spite of the fact, a few research were carried out, that the relevant published material makes no mention of the form factor of this individual. When the length of the *A. atropos* had reached its first sexual maturity was 12.36 cm in TL. There has not been available research carried out on  $L_m$  for this fish from the seas around Bangladesh (Hossain *et al.*, 2012c). When it attained at initial sexual maturity, the TL was 21.0 cm, which is comparable to the length that we determined. A few research has been conducted on  $L_m$  and contrasting it with other fields of study is challenging for obvious reasons.

According to the findings of the current study, the average yearly growth rate ( $M_w$ ) of *A. atropos* in the Bay of Bengal is  $1.57 \text{ year}^{-1}$ . However, the comparison with other species of *A. atropos* is restricted due to the lack of sufficient information on  $M_w$ . Despite of this, the current study was successful in collecting baseline data that will be beneficial for future exploration and managing strategies of Bay of Bengal.

## Conclusions and Recommendations

The current research highlighted that fish grew isometrically in the Bay of Bengal, Bangladesh. Through our findings, it could also be recommended from population structure that the fish might be caught above 18 cm for maximum sustainable yield. In essence, the present study contains fundamental information for further research.

## Acknowledgements

We owe a great deal of gratitude for the financial

assistance to the PIU-BARC-NATP-2 PBRG-156. The researchers would also want to express their gratitude to the fishermen, whose identities have been withheld, for providing encouragement and assistance throughout the sample collecting process.

## Novelty Statement

We provided critical insights into the growth patterns, condition, and habitat equilibrium of *Atropus atropus* in the Bay of Bengal, Bangladesh, addressing a significant knowledge gap and offering valuable data for the sustainable management of this fishery.

## Author's Contribution

**Md. Yeamin Hossain, Nur-E-Farjana Ilah, Md. Joynal Abedin, Esmout Jahan Alice and Taiba Akter Laboni:** Conceive the concept of the review.  
**Mst. Shahinur Khatun, Most. Shakila Sarmin, Md. Ashekur Rahman, Obaidur Rahman, Md. Akhtarul Islam and Muhammad Ali Fardoush Siddiquy:** Analyzed the data.  
**Md. Yeamin Hossain, Nur-E-Farjana Ilah and Md. Joynal Abedin:** Wrote and edit the manuscript.

## Conflict of interest

The authors have declared no conflict of interest.

## References

- Anderson, R.O. and R.M. Neumann. 1996. Length, weight and associated structural indices. In: Fisheries techniques, 2<sup>nd</sup> ed. (Murphy, B.R. and Willis, D.W. Eds.). Bethesda, M.D: American Fisheries Society. pp. 447–482.
- Ansari, Z.A., A. Chatterji, B.S. Ingole, R.A. Sreepada, C.U. Rivonkar and A.H. Parulekar. 1995. Community structure and seasonal variation of an inshore demersal fish community at Goa, west coast of India. *Estuarine Coastal Shelf Sci.*, 41(5): 593–610. [https://doi.org/10.1016/0272-7714\(95\)90029-2](https://doi.org/10.1016/0272-7714(95)90029-2)
- Binohlan, C. and R. Froese. 2009. Empirical equations for estimating maximum length from length at first maturity. *J. Appl. Ichthyol.*, 25(5): 611–613. <https://doi.org/10.1111/j.1439-0426.2009.01317.x>
- Carpenter, Kent, E. Niem and H. Volker. 2001. Species identification guide for fishery purposes. The living marine resources of the western central pacific. 5. Bony Fishes part 3 (Menidae to Pomacentridae) (PDF). Rome: FAO. p. 2684. ISBN 92-5-104587-9.
- DoF, 2019. National Fish Week (2019) Compendium (In Bangla). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. <http://www.fisheries.gov.bd/>.
- Fowler and W. Henry. 1935. South African fishes received from Mr. H.W. Bell-Marley in 1935. *Proc. Acad. Natl. Sci. Philadela.*, 87: 361–408.
- Froese, R., 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *J. Appl. Ichthyol.*, 22: 241–253. <https://doi.org/10.1111/j.1439-0426.2006.00805.x>
- Fulton, T.W., 1904. The rate of growth of fishes, 22<sup>nd</sup> Annual Reports, part III. Fisheries Board of Scotland, Edinburgh. pp. 141–241.
- Hasan, M.R., Z. Mawa, H.U. Hassan, M.A. Rahman, S. Tanjin, N.A. Abro, K. Gabol, M.A. Bashar, S. Jasmine, J. Ohtomi and M.Y. Hossain. 2020. Impact of eco-hydrological factors on growth of the Asian stinging catfish *Heteropneustus fossilis* (Bloch, 1794) in a wetland ecosystem. *Egypt. J. Aquat. Biol. Fisher.*, 24: 77–94. <https://doi.org/10.21608/ejabf.2020.105438>
- Hasan, M.R., Z. Mawa, M.A. Rahman, S. Yeasmin, Y. Mahmud and M.Y. Hossain. 2022. Population structure and length-weight relationships of *Anadara granosa* and *Meretrix lamarckii* from the Bay of Bengal. *Sarhad J. Agric.*, 38(4): 1254–1259. <https://doi.org/10.17582/journal.sja/2022/38.4.1254.1259>
- Hicks, C.C., P.J. Cohen, N.A. Graham, K.L. Nash, E.H. Allison, C. D'Lima, D.J. Mills, M. Roscher, S.H. Thilsted, A.L. Thorne-Lyman and M.A. MacNeil. 2019. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*, 574(7776): 95–98.
- Hossain, M.Y. and J. Ohtomi. 2010. Growth of the southern rough shrimp *Trachysalambria curvirostris* (Penaeidae) in Kagoshima Bay, southern Japan. *J. Crustac. Biol.*, 30(1): 75–82. <https://doi.org/10.1651/08-3133.1>
- Hossain, M.Y., M.A. Hossen, M.N.U. Pramanik, K. Yahya, A.H. Bahkali and A.M. Elgorban. 2016. Length-weight relationships of *Dermogenys pusilla* Kuhl and van Hasselt, 1823 (Zenarchopteridae) and *Labeo bata* (Hamilton, 1822) (Cyprinidae) from the Ganges River (NW Bangladesh). *J. Appl. Ichthyol.*, 32: 744–



746. <https://doi.org/10.1111/jai.13070>
- Hossain, M.Y., M.A.S. Jewel, L. Nahar, M.M. Rahman, A. Naif and J. Ohtomi. 2012a. Gonadosomatic index-based size at first sexual maturity of the catfish *Eutropiichthys vacha* (Hamilton, 1822) in the Ganges River (NW Bangladesh). J. Appl. Ichthyol., 28: 601–605. <https://doi.org/10.1111/j.1439-0426.2012.01954.x>
- Hossain, M.Y., M.M. Rahman, E.M. Abdallah and J. Ohtomi. 2013. Biometric relationships of the Pool barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) from three major Rivers of Bangladesh. Sains Malays., 22: 1571–1580.
- Hossain, M.Y., M.M. Rahman, M.A.S. Jewel, Z.F. Ahmed, F. Ahamed, B. Fulanda, E.M. Abdallah and J. Ohtomi. 2012b. Condition and form factor of the five threatened fishes from the Jamuna (Brahmaputra River Distributary) River, Northern Bangladesh. Sains Malays., 41: 671–678.
- Hossain, M.Y., M.M. Rahman, R. Miranda, P.M. Leunda, J. Oscoz, M.A.S. Jewel, A. Naif and J. Ohtomi. 2012c. Size at first sexual maturity, fecundity, length–weight and length–length relationships of *Puntius sophore* (Cyprinidae) in Bangladeshi waters. J. Appl. Ichthyol., 28: 818–822. <https://doi.org/10.1111/j.1439-0426.2012.02020.x>
- Hossain, M.Y., Z.F. Ahmed, P.M. Leunda, S. Jasmine, J. Oscoz, Miranda and J. Ohtomi. 2006. Condition, length–weight and length–length relationships of the Asian striped catfish *Mystus vittatus* (Bolch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, southwester Bangladesh. J. Appl. Ichthyol., 22: 304–307. <https://doi.org/10.1111/j.1439-0426.2006.00803.x>
- Ilah, N.E.F., M.J. Abedin, M.A. Rahman, M.A.K. Azad, M.T. Khatun, M. Asadujjaman, M.A. Samad, K.A. Habib, M.N. Ali and M.S. Sarmin. 2022. Estimation of population structure, growth and condition of *Lates calcarifer* (Bloch, 1790) in the Bay of Bengal. Pak. J. Mar. Sci., 31(2): 129–139.
- IUCN, 2023. The IUCN Red List of Threatened Species, version 2022-2. <https://www.iucnredlist.org> (accessed 14 January 2023).
- Khatun, D., M.Y. Hossain, M.A. Rahman, M.A. Islam, O. Rahman, M.S. Sharmin, M.F. Parvin, A.T.U. Haque and M.A. Hossain. 2019. Life-history traits of the climbing perch *Anabas testudineus* (Bloch, 1792) in a wetland ecosystem. Jordan J. Biol. Sci., 12(2): 175–182.
- Khatun, D., M.Y. Hossain, M.F. Parvin and J. Ohtomi. 2018. Temporal variation of sex ratio, growth pattern and physiological status of *Eutropiichthys vacha* (Schilbeidae in the Ganges River, NW Bangladesh. Zool. Ecol., 28: 343–354. <https://doi.org/10.1080/21658005.2018.1520680>
- Le Cren, E.D., 1951. The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca Fluviatilis*). J. Anim. Ecol., 20: 201–219. <https://doi.org/10.2307/1540>
- Masuda, H., K. Amaoka, C. Araga, T. Uyeno and T. Yoshino. 1984. The fishes of the Japanese Archipelago. Vol. 1. Tokyo, Japan: Tokyo University Press. pp. 437. ISBN 978-4-486-05054-4.
- Mawa, Z., M.Y. Hossain, M.R. Hasan, M.A. Rahman, S. Tanjin and J. Ohtomi. 2022. Life history traits of *Mystus vittatus* in the Ganges River, Bangladesh: Recommendation for its sustainable management considering climate change. Int. J. Biometeorol., 66(5): 927–943. <https://doi.org/10.1007/s00484-022-02249-7>
- Muchlisin, Z.A., M. Musman and M.N. Siti-Azizah. 2010. Length–weight relationship and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius Tawarensis*, endemic to Lake Laut Tawar, Aceh province, Indonesia. J. Appl. Ichthyol., 26: 949–953. <https://doi.org/10.1111/j.1439-0426.2010.01524.x>
- Parvin, M.F., M.Y. Hossain, M.S. Sarmin, D. Khatun, M.A. Rahman, O. Rahman, M.A. Islam and W. Sabbir. 2018. Morphometric and meristic characteristics of *Salmotoma bacaila* (Hamilton, 1822) (Cyprinidae) from the Ganges River in Northwestern Bangladesh. Jordan J. Biol. Sci., 11: 533–536.
- Peterson, I. and J.S. Wroblewski. 1984. Mortality rates of fishes in the pelagic ecosystem. Can. J. Fish. Aquat. Sci., 41: 1117–1120. <https://doi.org/10.1139/f84-131>
- Pradhan, S.K., S.K. Roul, S. Ghosh, P. Tripathy, A.K. Jaiswar, S. Bhusan and B.B. Nayak. 2020. Biometry, length–weight and length–length relationships of flathead sillago *Sillaginopsis panijus* (Hamilton, 1822) (Perciformes:



- Sillaginidae) from the north-western Bay of Bengal. *Indian J. Fish.*, 67(3): 144–151. <https://doi.org/10.21077/ijf.2020.67.3.95369-16>
- Qamar, N. and S.K. Panhwar. 2018. Length–weight relationships of nine rarely occurring carangids in the Northern Arabian Sea Coast of Pakistan. *J. Appl. Ichthyol.*, 34: 221–223. <https://doi.org/10.1111/jai.13540>
- Rahman, M.A., M.Y. Hossain, S. Tanjin, Z. Mawa, M.R. Hasan, K.A. Habib and J. Ohtomi. 2021. Length weight relationships of five marine fishes from the Bay of Bengal. *J. Appl. Ichthyol.*, 37(2): 364–366. <https://doi.org/10.1111/jai.14176>
- Rajesh, D.P., H.N. Anjanayappa, L.G. Prasad and S. Benakappa. 2019. Population characteristics of *Atropus atropus* (Bloch and Schneider, 1801) from Mangalore coast, India. *Int. J. Curr. Res.*, 11: 6574–6577.
- Rajesh, D.P., H.N. Anjanayappa, S. Benakappa and P. Nayana. 2020. Length-weight relationship and relative condition factor of *Atropus atropus* (Bloch and Schneider, 1801) from Mangalore coast, India. *J. Exp. Zool. India*, 23(1).
- Rakhunde, A.V., V.H. Nirmale, R.A. Pawar, S.Y. Metar and B.P. Bhosale. 2023. Biology of the cleftbelly trevally *Atropus atropus* (Bloch and Schneider, 1801) from Ratnagiri coast of India. *Indian J. Fish.*, 70(2): 33–40.
- Ranjan, J.B., W. Herwig, S. Subodh and S. Michael. 2005. Study of the length frequency distribution of Sucker head, *Garra gotyla* (Gray, 1830) in different rivers and seasons in Nepal and its application. *Kathma Univ. J. Sci. Eng. Tech.*, 1: 1–14.
- Reuben, S., H.M. Kasim, S. Sivakami, P.N. Radhakrishnan, K.N. Kurup, M. Sivadas, A. Noble, K.V.S. Nair and S.G. Raje. 1992. Fishery, biology and stock assessment of carangid resources from the Indian seas. *Indian J. Fish.*, 39: 195–234.
- Riede, K., 2004. Global register of migratory species from global to regional scales. Final report of the R and D-Project 808 05 081. Fed Agen Nat Conserve Bonn, Germany, pp. 329.
- Sabbir, W., M.Y. Hossain, Z. Mawa, M.R. Hasan, M.A. Rahman, M.A. Islam, S. Tanjin, M.A. B.K. Rahman Sarker and M.N. Khan. 2020a. New Maximum size record, length weight relationships and form factor of Hooghly Croaker *Panna heterolepis* Trewavas, 1977 from the Bay of Bengal (Bangladesh). *Lak. Res.*, 25: 346–349. <https://doi.org/10.1111/lre.12333>
- Sabbir, W., M.Y. Hossain, M.A., Rahman, M.R. Hasan, M.N. Khan, Z. Mawa, S. Tanjin, M.S. Sarmin, O. Rahman, A. Nima and K.A. Habib. 2020b. Growth pattern of the Hooghly Croaker *Panna heterolepis* Trewavas, 1977 in the Bay of Bengal (Bangladesh) in relation to eco-climatic factors. *Egypt. J. Aquat. Biol. Fish.*, 24(7): 847–862. <https://doi.org/10.21608/ejabf.2020.132074>
- Sabbir, W., M.Y. Hossain, M.A. Rahman, M.R. Hasan, Z. Mawa, S. Tanjin, H.U.L. Hasan and J. Ohtomi. 2020c. First report on condition factor of *Panna heterolepis* (Trewavas, 1977) in the Bay of Bengal (Southwestern Bangladesh) in relation to eco-climatic factors. *Egypt. J. Aquat. Biol. Fish.*, 24(2): 591–608. <https://doi.org/10.21608/ejabf.2020.87095>
- Sabbir, W., M.Y. Hossain, M.N. Khan, F.A. Rima, M.S. Sarmin and M.A. Rahman. 2022. Biometric Indices of Flathead Sillago, *Sillaginopsis panijus* (Hamilton, 1822) from the Bay of Bengal (Southern Bangladesh). *Thalassas: An In. J. Mar. Sci.*, 38(2): 811–820. <https://doi.org/10.1007/s41208-022-00421-9>
- Talwar, P.K. and A.G. Jhingran. 1991. Inland fishes of India and adjacent countries. Volume 2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay, Calcutta, pp. 1158.
- Tesch, F.W., 1968. Age and growth. In: (Ricker, W.E. ed.), *Methods for assessment of fish production in Freshwaters*. Blackwell Scientific Publications, Oxford, pp. 93–123.
- Tesch, F.W., 1971. Age and growth. In: (ed. Ricker, W.E. ed.), *Methods for assessment of fish production in fresh waters*, Blackwell Scientific Publications. pp. 99–130.
- Tsoumani, M., R. Liasko, P. Moutsaki, I. Kagalou and I. Leonardos. 2006. Length-weight relationships of an invasive cyprinid fish (*Carassius gibelio*) from 12 Greek lakes in relation to their trophic states. *J. Appl. Ichthyol.*, 22: 281–284. <https://doi.org/10.1111/j.1439-0426.2006.00768.x>
- Xu, G., W. Zheng and G. Huang. 1994. Atlas of the fishes and their biology in Daya Bay. Anhui Scientific and Technical Publishers.