

## Original Article

# Assessment of population dynamics and stock status of the mola carplet (*Amblypharyngodon mola*) in Bangladesh: Implications for conservation and resource management

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## ABSTRACT

The mola carplet (*Amblypharyngodon mola*) is a small native cyprinid fish and has been considered to be a nutritionally good source of food in Bangladesh. To investigate the stock status and population characteristics of this high-valued fish species, a total of 1200 *A. mola* samples were collected with 100 individuals at monthly intervals from the Jhapa baor in Jashore, Bangladesh, during January–December 2022. The computer-based FAO-ICLARM stock assessment tool was applied to study the population dynamics of *A. mola*. We used a linear regression graph and digital slide calipers to find each specimen's total length as  $TW = 7.79013 \times 0.9995$  ( $R^2 = 0.9077$ ) and a digital scale to find each one's body weight. The asymptotic length ( $L_{\infty}$ ) value was 7.88 cm, and the growth coefficient ( $K$ ) was  $1.2 \text{ year}^{-1}$ , respectively. Natural mortality ( $M$ ), fishing mortality ( $F$ ), and total mortality ( $Z$ ) were determined to have yearly values of 2.92,  $-0.28$ , and 2.64, respectively. The exploitation rate ( $E$ ) was  $-0.11$ , and the maximum yield per recruit ( $E_{\max}$ ) was found to be 0.421. The yield per recruit and biomass per recruit were assessed to be 0.05 and 1.00, respectively, as a function of  $L/L$  and  $M/K$ . The growth performance index ( $\phi = 2.70$ ) was determined and found within the acceptable range of good growth. The fishing mortality was significantly higher over mid-lengths, ranging from 3.5 cm to 5.5 cm; the values were reduced between 5.5 cm and 6.5 cm mid-length and stayed constant between 6.5 cm and 7.5 cm. The maximum recruitment peak was observed between June and July 2022. The recruitment peak was found to be almost 19% in June, while the lowest percentage of recruitment (2%) was initiated in December 2022. The results of this study are the first to investigate the complex population dynamics of the ecologically and commercially important mola fish that lives in the area. The results will be very helpful in using resources wisely and protecting biodiversity for this highly valued species, both nationally and regionally.

**Keywords:** *Amblypharyngodon mola*, conservation, exploitation, population characteristics, recruitment, resource management, stock status

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## INTRODUCTION

Jhapa baor is a wonderful arc-shaped lake (oxbow lake) that is located in the Jashore district of Bangladesh, the area of which increases up to 605 acres in the rainy season. Considering the other baors in the Jashore district, Jhapa baor has water more or less every season, and it is managed by the Ministry of Land of the Government of Bangladesh, which grants leases

to fisher organizations for community-based aquaculture. This community-based management for fish cultivation is carried out by an organization of 180 local fishermen called Jhapa Matsajibi Somobay Samiti Limited. Around 600 families, either part-time or full-time, depend on this baor.<sup>[1]</sup> It is the most significant freshwater body in this area, as well as the defunct section of the river Kapotakkho. *Amblypharyngodon mola* is a very important and native fish species in this waterbody

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as well as the country. It is a small freshwater cyprinid fish belonging to the order Cypriniformes and family Cyprinidae, which is also recognized as “Indian carplet” or “Pale carplet,” and locally referred to as mourala, mowa, or mowka in various regions of Bangladesh. Mola is an in-demand food fish because of its excellent taste and high nutritional value, as it contains significant amounts of protein, Vitamin A, and mineral contents.<sup>[2]</sup> It has recently been introduced onto the market as an ornamental fish. The culture of self-recruiting *A. mola* is being promoted.<sup>[3]</sup> The fish is found in a variety of freshwater environments, including rivers, streams, ponds, floodplains, marshes, canals, and paddy fields. It is widely dispersed over Pakistan, Bangladesh, India, and Myanmar.<sup>[4]</sup> Mola is widely distributed across Bangladesh’s ponds, canals, rivers, beels (natural depressions), and floodplains. It is also documented in Chalan beel and Bookbhara baor (oxbow lake) of Bangladesh.<sup>[5-7]</sup>

The growth of an organism is defined when its length or weight or both change over time. Fisheries data are often analyzed using the length-weight relationship (LWR).<sup>[8]</sup> As direct weight measurements in the field are time-consuming, length-weight regressions are employed to estimate weight from length.<sup>[9]</sup> Knowledge of LWR is a crucial tool for efficiently managing any fish species, and it has been used to analyze fish stocks and populations.<sup>[10]</sup> The mathematical weight and length relationship is significant in predicting fish growth, maturity, and overall health condition, which include gonadal development, fatness, and life history. LWR is an essential element that has found extensive application in the field of fisheries for a multitude of reasons. These include estimating weight based on length to evaluate yield, estimating weight by age, calculating standing crop biomass, assessing fish stock, evaluating the well-being index of a fish population, analyzing function and age structure of fish populations, studying fish growth, conducting morphometric comparisons between species and populations, and comparing life histories. For the study of fish biology, LWR of fishes is an important basic idea. Regarding their morphology, biology, nutrition, condition, and pace of growth, the statistical link between two parameters is quite important. In addition, because differences may occur within populations from various locales, this relationship is helpful in differentiating minor taxonomic entities.<sup>[11]</sup>

Studies on the length-weight connections of prominent fish species are very relevant for population management and conservation in natural water bodies. This way, we can look into the natural, fishing, and total mortality rates, as well as the growth rates, recruitment patterns, virtual population analysis (VPA), gear selectivity, length frequency diagrams, catch curve analyses, and a lot of other population parameters that are also important for figuring out the stock assessment of Jhapa baor, Jashore, Bangladesh. However, a paucity of research exists in

the literature regarding the biological traits of *A. mola*, such as population status, LWRs, and condition factors, in diverse aquatic environments, including this important baor. Therefore, the present study has been carried out to investigate stock status, population characteristics, and specific biometric traits, particularly the association between the length and weight of high-valued mola fish in Jhapa baor, Jashore, Bangladesh.

## MATERIALS AND METHODS

### Study Area and Location

The experiment was undertaken at Jhapa baor (89°9'36.39"E, 22°59'1.34"N), located in the south-west region of Monirampur upazila (sub-district) of Jashore district [Figure 1]. It is situated 10 km away from Monirampur upazila and surrounded by 5 villages (viz., Mobarakpur, Komolpur, Jhapa, Rajbari and Rampur) under 3 unions, namely, Chaluahati, Jhapa and Maswimnagar. Jhapa is one of the villages that is surrounded by the Jhapa baor.

### Collection of Samples

In total, 1200 individuals of *A. mola* were collected with 100 individuals at monthly intervals from Jhapa baor, during January–December 2025. Soon after collection, the samples were transported to the laboratory in a large polyethylene bag with 5% formalin, and then thoroughly washed, sorted, and placed on filter paper to remove excess water from their body surfaces.

### Measurement of Length-weight

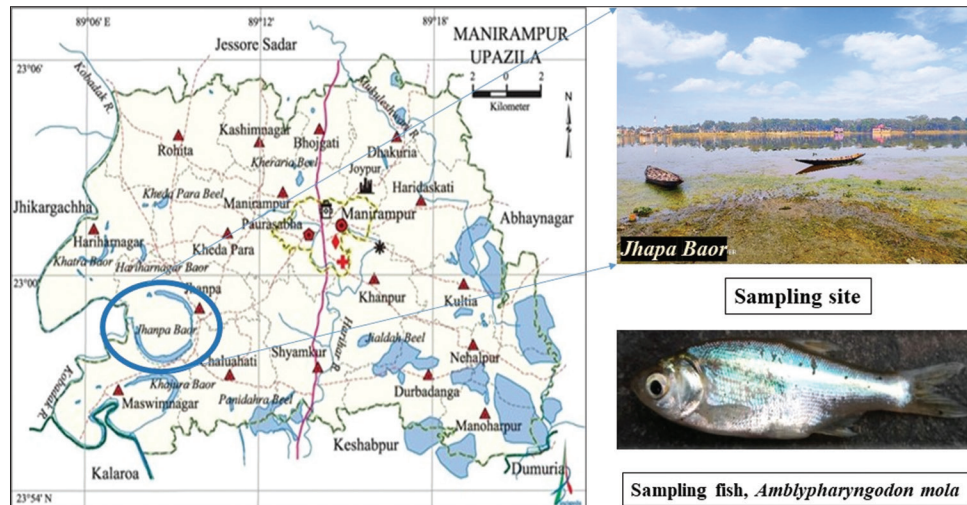
Length measurements of mola fishes were recorded as total length (TL) in cm from the mouth to the end of the caudal fin at the nearest 0.05 cm by using a regular ruler validated against a Vernier caliper, and weight was measured using a digital balance with an accuracy of 0.01 g.

### LWR

The statistical relationship between length and weight was established by the parabolic equation as follows:  $W = aL^b$ , Where,  $W$  = weight of fish (g),  $L$  = length of fish (cm),  $a$  = constant, and  $b$  = a regression coefficient expressing the relationship between length and weight.<sup>[12]</sup> The relationship ( $W = aL^b$ ) was converted into a logarithmic form of the equation, giving a straight-line relationship graphically:  $\text{Log } W = \text{Log } a + b \text{ Log } L$ . The equation is the same to  $Y = a + bx$ , where  $\text{Log } W$  = Dependent variable ( $Y$ ),  $\text{Log } L$  = Independent variable ( $X$ ),  $b$  = Regression coefficient or slope, and  $a$  = Intercept.

### Data Analysis

The data were analyzed using FAO-ICLARM stock assessment tools (FISAT) software. The best growth curve in arriving fitted curve through the maximum number of patterns of the length-frequency distribution was based on the ELEFAN I procedure. With the aid of the best growth curve, the Von



**Figure 1:** Location of Jhapa baor at Monirampur upazila in Jashore district, Bangladesh

Bertalanffy growth function (VBGF) parameters ( $L_{\infty}$  and  $K$ ) were calculated according to Elganainy *et al.*<sup>[13]</sup> and the resulting values were used to estimate the growth performance index ( $\phi$ ) in terms of length growth of *A. mola* using the following formula:

$$\phi' = \text{Log}_{10} K + 2\text{Log}_{10} L$$

The linear relationship  $W = aL^b$  was applied to achieve the LWR.  $W$ ,  $L$ ,  $a$  and  $b$  represent the weight, the TL, the intercept and the relative growth rate or the slope, respectively. The least squares linear graph regression on log–log–transformed data was used to estimate the values of  $a$  and  $b$  parameters as  $\text{Log}_{10} W = \text{Log}_{10} a + b\text{Log}_{10} L$ . The coefficient of determinant ( $r^2$ ) was used as an indicator of the quality of linear regression.<sup>[14]</sup> In addition, the statistical significance level of  $r^2$  and 95% confidence intervals of the parameters  $a$  and  $b$  were estimated. To find the length of the *A. mola* at any age, the inverse Von Bertalanffy growth equation was used.<sup>[15]</sup> Then, the non-linear squares estimation method fitted with VBGF was used to estimate the length-at-age curve, following the formula as given below:

$$L_t = L_{\infty} [1 - e^{-k(t-t_0)}]$$

where  $L_t$ ,  $L_{\infty}$ ,  $K$ ,  $t$ , and  $t_0$  are respectively represent the mean length at age  $t$ , the asymptotic length, the growth coefficient, the age of the specimens and the hypothetical age at which the length is zero.<sup>[16]</sup> A length-converted catch curve was used to compute the total mortality ( $Z$ ), whereas the empirical relationship was used to calculate the natural mortality ( $M$ ):

$$\text{Log}_{10} M = -0.0066 - 0.279\text{Log}_{10} L_{\infty} + 0.6543\text{Log}_{10} K + 0.4634\text{Log}_{10} T$$

Definitions of the above parameters remain the same, with  $T$ , representing the mean annual habitat water temperature. After

computing the  $Z$  and  $M$  values, which are the total mortality and natural mortality, respectively, the fishing mortality ( $F$ ) value was easily estimated using the linear relationship as follows:

$$F = Z - M$$

However, the estimated values of the above expression make it possible to reckon the exploitation level ( $E$ ) of *A. mola* using the following equation:

$$E = \frac{F}{Z} = \frac{F}{F + M}$$

The retrograde projection of the set of available length frequency data on the length axis, as clarified in FISAT II, was used in discovering the recruitment pattern of the stock (Lassen and Medley, n.d.). The relative strength of the pulse and number of pulses per year was determined by a series of length-frequency data using the parameter  $L_{\infty}$ ,  $K$ , and  $t_0$  ( $t_0 = 0$ ) as described above. The NORMSEP procedure in FISAT II was also used to determine the normal distribution of the recruitment patterns.<sup>[17]</sup> Furthermore, SPSS version 16.10 was used to calculate the population structure and length frequency data of *A. mola*.

## RESULTS

### Sample Collection and Measurement

A total number of 1200 live *A. mola* specimens were collected during the entire experimental period, and each individual was measured to the nearest 0.05 mm for TL using Vernier calipers and weighed to the nearest 0.01 g for the total weight (TW) using a digital electronic balance [Table 1]. However, the asymptotic length ( $L_{\infty}$ ) value of *A. mola* was 7.88 cm, where the growth coefficient was 1.20/year [Table 1].

**Table 1: Population parameters of *Amblypharyngodon mola* in Jhapa baor, Jashore, Bangladesh**

| Parameters                                     | <i>Amblypharyngodon mola</i> |
|------------------------------------------------|------------------------------|
| Asymptotic length value ( $L_{\infty}$ ) (cm)  | 7.88                         |
| Growth coefficient or constant (K) per year    | 1.20                         |
| Natural mortality (M)                          | 2.92                         |
| Fishing mortality (F) per year                 | -0.28                        |
| Total mortality (Z) per year                   | 2.64                         |
| Exploitation (E)                               | -0.11                        |
| Length range (cm)                              | 3.2–7.9                      |
| Sample number                                  | 1200                         |
| Average temperature ( $^{\circ}\text{C}$ )     | 28                           |
| Growth performance ( $\phi'$ )                 | 2.70                         |
| Potential longevity ( $t_{\max} = 5/K$ ) years | 2.40                         |

### Population Structure of *A. mola*

#### Size structure and LWR

The scatter plot showed the LWRs of *A. mola* in Jhapa baor, Jashore, Bangladesh, where length was placed on the X-axis and weight on the Y-axis. However, the parameters, such as growth constant ( $a$ ) and relative growth rate were estimated to be 0.9995 and 7.79013, respectively. The equation  $TW = 7.79013TL^{0.9995}$  was obtained at the end of the result. The biometric relationship displayed a positive correlation between length and weight ( $R^2 = 0.9077$ ) [Figure 2].

### Population Parameters and Stock Status of *A. mola*

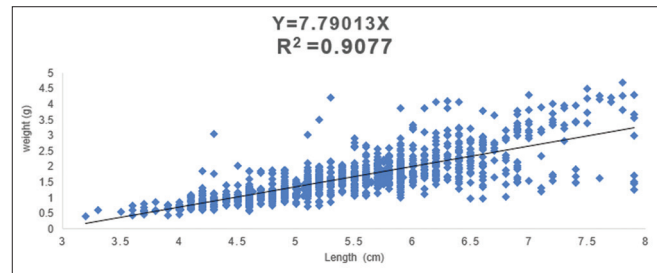
#### Growth parameters

The growth curve of a pooled length-size distribution of *A. mola* is shown in Table 1. The growth parameters of Von Bertalanffy's growth formula were estimated as asymptotic length ( $L_{\infty}$ ) = 7.88 cm and growth coefficient ( $K$ ) = 1.20 year<sup>-1</sup> [Table 1]. The values of  $L_{\infty}$  and  $K$  were used for the calculation of growth performance index ( $\phi' = \text{Log}_{10} K + 2\text{Log}_{10} L$ ), which was found to be 2.70 [Figure 3].

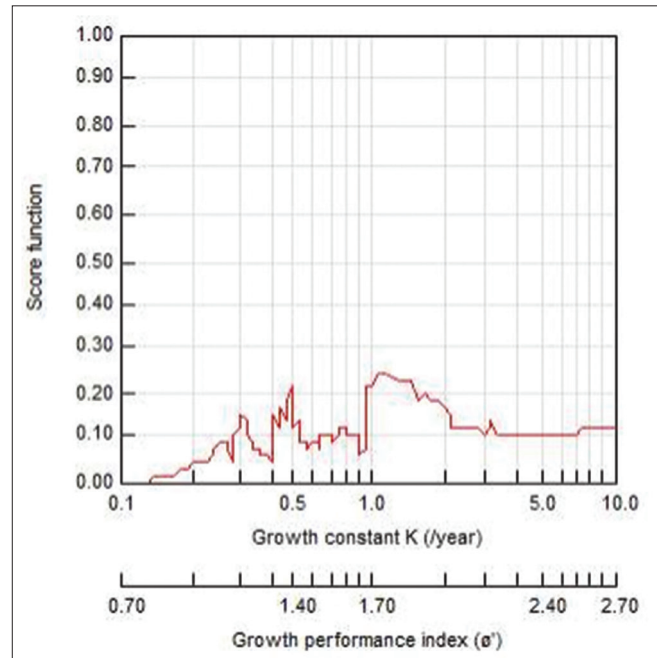
The estimation of the growth coefficient ( $K$ ) per year has been utilized after the direct fit of length frequency data (ELEFAN 1). This value also showed the presence of a range of length classes of *A. mola* that were captured, belonging to two cohort's seasons. The black and white bars in the restructured length-frequency distribution are positive and negative deviations from the weighted moving average. The potential longevity ( $t_{\max} = 5/K$ ) was estimated as 2.40 years, indicating that *A. mola* can live for not more than 3.0 years in the habitat where the study was carried out [Figure 4].

### Mortality and Exploitation Rate

The percentage of a fish stock's population or biomass that is taken out annually is known as its exploitation rate, and it is often quantified by fishing mortality. The distribution of



**Figure 2:** Length weight relationship of *Amblypharyngodon mola* in Jhapa baor, Jashore, Bangladesh



**Figure 3:** The growth performance index ( $\phi'$ - phi prime) of *Amblypharyngodon mola*

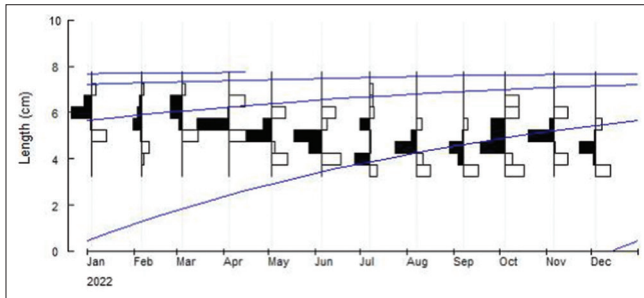
fishing mortality throughout the population's age or length composition is referred to as the "exploitation pattern." The length-converted catch curve analysis revealed an estimated overall mortality value of  $Z = 2.64$  for *A. mola* [Figure 5]. On the other hand, the estimated natural and fishing mortality rates were 2.92 year<sup>-1</sup> and -0.28 year<sup>-1</sup>, respectively, at an average temperature of 28°C. The exploitation level of *A. mola* in the Jhapa baor was not found to be high [Figure 6].

### Recruitment Pattern of *A. mola*

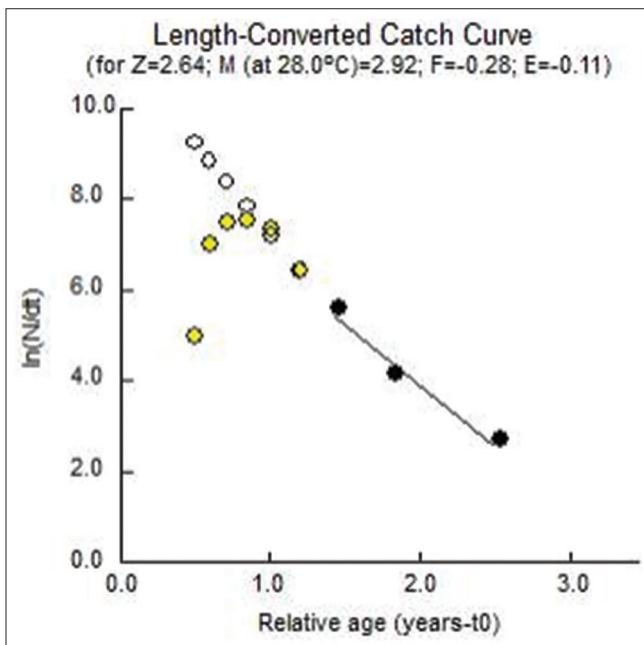
Recruitment pattern of *A. mola* has been recorded throughout the research, where recruitment was found to be high between June and July 2022. In June, recruitment was peaked at about 19%, but in December 2022, just <2% of recruitment was initiated [Figure 7].

### VPA of *A. mola*

The effects of length-structured VPA of *A. mola* with LWR are shown in Figure 6. In the 3.5 cm mid-length group, fishing



**Figure 4:** Growth curve of *Amblypharyngodon mola* by ELEFAN 1 superimposed on the restructured length-frequency diagram ( $L_{\infty} = 7.88$  cm and  $K = 1.2$  year<sup>-1</sup>)

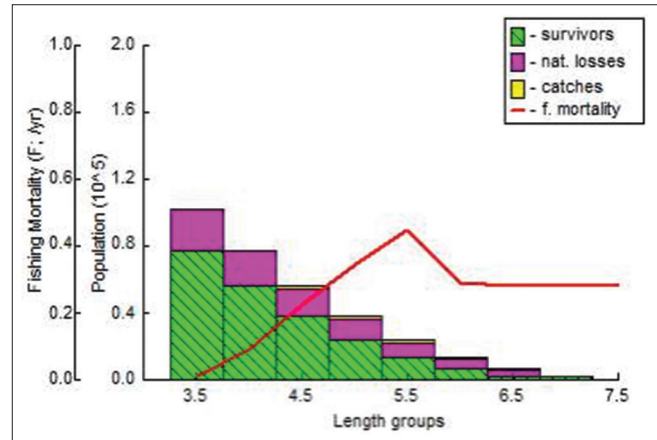


**Figure 5:** Length-converted catch curve of *Amblypharyngodon mola* in Jhapa baor, Jashore, Bangladesh

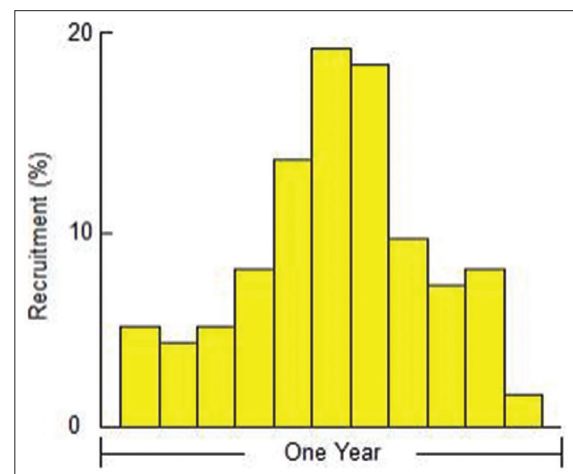
mortality was found to be relatively low, whereas in the 5.5 cm mid-length group, the mortality rate of 0.4 was the highest. The survival rate was found to be high at minimal length and decreased rapidly with increasing length. In contrast, fishing mortality was quite high across mid-lengths ranging from 3.5 cm to 5.5 cm but declined from 5.5 cm to 6.5 cm and remained constant between 6.5 and 7.5 cm [Figure 6].

### The Exploitation Rate of *A. mola*

The calculated exploitation rate of *A. mola* was  $E = 0.42$  year<sup>-1</sup>. The data showed that the stock is under-fished according to the concept that a stock is optimally exploited when  $E = 0.50$  or when mortality due to fishing equals the species' overall mortality. The empirically calculated outcome ( $E = 0.42$  year<sup>-1</sup>) might be related to both internal and external variables. Figure 8 depicts the species relative biomass per recruit and yield per recruit at the given option of  $E_{50} = 0.27$  year<sup>-1</sup>.



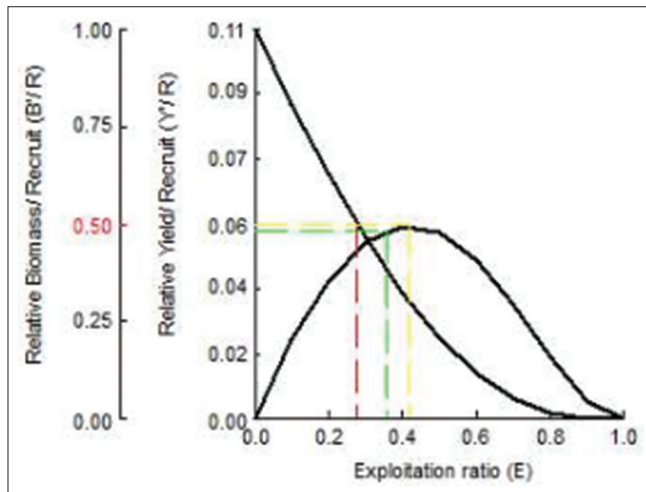
**Figure 6:** Structured length-based virtual population analysis of *Amblypharyngodon mola*



**Figure 7:** Recruitment pattern of *Amblypharyngodon mola* from January to December 2022 in Jhapa baor, Jashore, Bangladesh

## DISCUSSION

The values of all parameters related to the stock assessment have been calculated for the mola carplet from Jhapa baor for the 1<sup>st</sup> time. The range of TL was 3.5 to 7.9 cm. The study focused on the LWR's regression parameters,  $b$ , and the 90% confidence intervals surrounding them. The estimated LWR's  $b$  values demonstrated a positive allometric increase. The values of LWRs were significantly ( $P < 0.001$ ) high, with  $R^2$  values above 0.9077. During their study, Nawer *et al.*<sup>[18]</sup> had collected a total of 308 *A. mola* specimens from the Ganges River in the Northwest region of Bangladesh. They found that the TL of *A. mola* ranged from 3.9 cm to 8.1 cm, with the highest number of individuals falling between 6.0 cm and 7.0 cm TL size category. The allometric results for estimated  $b$  values of LWRs were positive, and each LWR exhibited a highly significant ( $P < 0.001$ ) result, with  $R^2$  values above 0.953. These findings are similar to those obtained in our present study.



**Figure 8:** Biomass per recruit and relative yield per recruit for *Amblypharyngodon mola* in Jhapa baor, Jashore district, Bangladesh

LWR has focused on the population features of mola fish. We used the FISAT software to keep track of the length frequency diagram, growth rates, recruitment patterns, natural, fishing, and total mortality rates, as well as the exploitation rate, gear selectivity, choice of gill nets, and catch curve analysis.<sup>[19]</sup> When using the VBGF, asymptotic length ( $L_{\infty}$ ) is a key factor in determining whether an aquatic stock will grow or shrink over time. In our study, the asymptotic length ( $L_{\infty}$ ) of *A. mola* was found to be 7.88 cm, with a growth coefficient ( $K$ ) of 1.20 year<sup>-1</sup>. Similarly, the computer software FiSAT was used to investigate the length-frequency-based population dynamics of *A. mola*, a small native cyprinid fish inhabiting Kaptai Lake, a man-made reservoir in Bangladesh.<sup>[20]</sup> The growth parameters  $L_{\infty}$  and  $K$  were subsequently ascertained to be 104.65 mm and 0.95 year<sup>-1</sup>, respectively. The annual natural, fishing and total mortality rates were calculated to be 1.22, 2.04 and 3.26, respectively. The exploitation rate ( $E$ ) was calculated as 0.63, with a maximum yield per recruit ( $E_{\max}$ ) of 0.678. The appropriate selection pattern ( $L_{50}$ ) was found to be 51.09 mm. The yield per recruit and biomass per recruit calculated as a function of  $L_c/L_a$  and  $M/K$  were 0.49 and 1.28, respectively.<sup>[20]</sup> The Wetherell plot produced estimates of  $L_a$  and  $Z/K$  of 103.38 mm and 3.31, respectively. The growth performance index ( $\phi'$ ) was 2.70, aligning with the results reported by Azadi and Mamun<sup>[20]</sup> and Rahman *et al.*<sup>[21]</sup> This value further indicates that the Jhapa baor environment is suitable for the growth of *A. mola*. Similar findings were also reported by Memon *et al.*<sup>[22]</sup> for the siluroid catfish *Eutropiichthys vacha* in the Indus River, Pakistan. VPA revealed that the majority of *A. mola* caught were between 75 and 93 mm long, with fishing mortality ( $F$ ) values exceeding 2.04 year<sup>-1</sup>.<sup>[20]</sup> Distinct values for asymptotic length ( $L_{\infty}$  = 11.30 cm) and growth coefficient

( $K$  = 1.30 year<sup>-1</sup>) were also reported for different species of *T. gratilla* in Southern Guimaras, Philippines.<sup>[23]</sup>

Moreover, the natural and fishing mortality in our study revealed the present state of fish stocks in the fisheries. During this research, mortality estimates indicated total mortality ( $Z$ ) of 2.64 year<sup>-1</sup> and natural mortality ( $M$ ) of 2.92 year<sup>-1</sup>. This yielded a negative fishing mortality ( $F$  = -0.28 year<sup>-1</sup>), suggesting little to no fishing pressure on the stock. In line with our findings, previous studies have noted that when fish populations experience extremely low fishing effort – such that fishing pressure is effectively negligible – some stock assessment models may produce estimates of negative fishing mortality. This outcome, however, should generally be interpreted as evidence that fishing has little to no effect, rather than as a literal biological indication of negative mortality.<sup>[21,24-26]</sup> In this study, recruitment patterns of *A. mola* were found to be consistent throughout the year. The lowest and highest recruiting rates were reported in December (<1–2%) and June (19%), respectively. This contrasts with the recruitment analysis, which showed bimodal peaks in July and October, indicating year-round spawning of *A. mola* with distinct recruitment pulses in Jhapa baor, Jashore.<sup>[21]</sup> The result of a VPA indicated that the fishing mortality rate was very low in the 3.5 cm mid-length group, while the greatest rate of 0.4 was found in the 5.5 cm mid-length group. The survival rate was high at the minimal length and rapidly decreased as it increased. However, fishing mortality was quite high at mid-lengths ranging from 3.5 cm to 5.5 cm and lower from 5.5 cm to 6.5 cm, with a constant range of 6.5–7.5 cm. It was calculated that the exploitation rate of *A. mola* was  $E$  = 0.42/year, which means that the stock is still at a level of underfishing based on the idea that a stock should have an optimum exploitation rate of  $E$  = 0.5. Comparable findings were reported during a recent year-round stock assessment study on *A. mola* in Jhapa baor, Jashore, Bangladesh.<sup>[21]</sup> These results are consistent with our observations and further support the reliability of the patterns identified across seasons and recruitment periods in the study area.

Until now, no study has been published on the recruitment, VPA and exploitation rate of *A. mola* in Jhapa baor, Jashore, Bangladesh. Our study is the first of its kind to investigate the growth parameters and population characteristics of *A. mola* in this important natural aquatic ecosystem.

## CONCLUSION

The high-value mola (*A. mola*) fish population in Jhapa baor has been documented as being subjected to less natural and fishing mortality, and the wild population stock remains above the minimum and is not exploited. As a result, if fishing is increased further without any stock enhancement and conservation strategies, the biodiversity of *A. mola* will be

jeopardized. In addition, examining catch data and monitoring stock levels can enhance fisheries management, thereby improving resource protection, profitability, and long-term viability. In any case, this study gives us basic data on the *A. mola* stock status and population characteristics using LWR. This will enable researchers and policymakers to proactively manage and protect this commercially important fish species for the long term.

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