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# Population Dynamics of Male and Female Hilsa, *Tenualosa ilisha* of Bangladesh

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**Abstract:** Population dynamics of male and female *T. ilisha* in Bangladesh water were studied using the length frequency based analysis of FiSAT software to evaluate the growth parameters, mortality rates, exploitation levels, Maximum Sustainable Yield (MSY) and the corresponding fishing mortality. The study reveals that the fishes are harvested at a level than the optimum fishing mortality. The fishing pressure should be reduced to about 1.08/year, i.e. 9% reduction from the present level of mortality per year for obtaining MSY, 235,130 tones.

**Key words:** Population dynamics, *Tenualosa ilisha*, Bangladesh

## INTRODUCTION

Hilsa *(Tenualosa ilisha),* an important diadromous fish species of South and South-East Asia, is regarded as the national fish of Bangladesh, Its catch, inland and marine sector combined, contributed 13.82% to the Bangladesh's total fish production (1,552,417 m ton) in 1998-99[1]. The fishery provides employment, direct and indirect, to about 2.5 million people. In the recent past its fishery in inland waters is on decline, but the total catch has remained stable (above 200,000 metric tons annually) due to its corresponding increase in marine sector. The inland sector contributed 32.7% to the total Hilsa catch of 229,714 m tons during 2000-2001. In the inland sector, maximum catch of this species is obtained from river Meghna (66.2% during 1998-99), both from its fresh water and estuarine stretches. The declining trend in its fishery in the inland sector, particularly in the Padma river, has been a cause of concern which has become an important area of fisheries research in Bangladesh[2-16].

Hilsa shad (*T. ilisha*) is capable of withstanding a wide range of salinity and travel great distances upstream as far as 1287 km. It feeds and grows mainly in the sea, but migrates to fresh water for spawning[17]. Juveniles develop and grow in fresh water, but soon migrate to the ocean, where they spent most of their lives. Although, *T. ilisha* is the largest single species fisheries in the sea, coastal and riverine waters of Bangladesh, detail study on population dynamics of male and female of this species has not been attempted so far except the studies carried out by *Rahman et al.*[5-7] and *Amin et al.*[12-16].

In the present study, the population parameters of male and female *T. ilisha* were estimated to assess the stocks in the Bangladesh waters and make appropriate management recommendations.

## MATERIALS AND METHODS

Length-based stock assessment method was used for the present study. For this purpose, length-frequency data of male and female *T. ilisha* were collected monthly from the commercial catches at different landing sites (Chandpur, Barisal, Bhola and Kuakata) between January to December 2002. To avoid gill net selectivity different landing sides were selected as different mesh of gill nets are used to catch different size group of fishes on their availability. Total length and weight of the specimens were measured in cm and g by a meter scale and a spring balance, respectively. The data from different landing sites were then pooled month-wise and subsequently grouped into length classes by 2 cm interval. Then the data were analysed using the FiSAT (FAO-ICLARM Stock Assessment Tools) software as explained in detail by Gayanilo Jr. *et al.*[18]. Asymptotic length ($L_\infty$) and growth coefficient (K) of the von Bertalanffy's growth equation were estimated by means of ELEFAN-1[19,20].

The growth performance index ($\phi'$) of *T. ilisha* in terms of growth in length was estimated using the formula of Pauly and Munro[21].

$$\phi' = \text{Log}_{10}K + 2\ \text{Log}_{10}.L_\infty$$

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The total mortality rate (Z) was estimated using the length-converted catch curve method. Natural mortality rate (M) was estimated using empirical relationship of Pauly[22].

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

Where, $L_{\infty}$ is expressed in cm and T is the mean annual environmental temperature in °C, which is 27.5°C.

Fishing mortality rate (F) was obtained by subtracting M from Z. The length at first capture ($L_c$) was estimated by the Beverton and Holt's Z-equation[23].

$$Z = \frac{K(L\alpha - \bar{L}_c)}{\bar{L}_c - L_c}$$

Where, $\bar{L}_c$ = average length of fish in the total catch. Recruitment pattern was determined by backward projection on the length axis of a set of length frequency data as described in the FiSAT routine.

The length-weight relationships of *T. ilisha* were established by the formula: $W= aL^b$ given by Le Cren[24] where 'a' is a constant and 'b' is an exponent.

Relative yield-per-recruit (Y/R) and relative biomass-per-recruit (B/R) values were obtained for different levels of $L_c$ and M/K, incorporating probabilities of capture at different size classes[25]. The Y/R and B/R calculations were carried out using the FiSAT software.

The values of $L_{\infty}$, K, M, F, a (constant) and b (exponent) for the species were used as inputs to the VPA analysis. The $t_o$ value in the von Bertalanffy's equation was taken as zero.

The total annual stock, average standing stock and MSY of *T. ilisha* were also estimated. For these purposes, at first, exploitation rate (E) was estimated by the equation given by Beverton and Holt[26] and Ricker[27] as $E = F/Z (1 - e^{-z})$. Then by using the values of E, F and annual catch (Y), the annual stock (Y/E) and average standing stock (Y/F) were determined. The approximate MSY was then calculated by the equation proposed by Cadima[28] for exploited fish.

$$MSY= Z_t * 0.5 * B_t$$

Where, $Z_t$ is the rate of total mortality in year t and $B_t$ is the standing stock size in year t.

## RESULTS AND DISCUSSION

**Growth parameters:** The $L_{\infty}$ values for the male, female and combined sex were 51.50, 65.55 and 54.60 cm , K values were 0.53, 0.51 and 0.52/year, respectively. The growth curves produced with these parameters have been shown over the restructured length distribution of the species in Fig. 1a-c. The values of various population parameters obtained during the present study (for juvenile and adults separately as well as both combined) are given in Table 1.

**Mortality:** The values Z were 3.08, 2.87 and 2.16 for the male, female and both sex of the species, respectively. The M and F were 1.01, 0.92, 0.98 and 2.07, 1.95, 1.18, respectively (Table 1). Fishing mortality was higher than the natural mortality in all the cases, which indicates that the species has been over fished.

**Exploitation rate:** The E values of the male, female and both sex were 0.67, 0.68 and 0.55 that of the maximum allowable limit of exploitation ($E_{max}$) and the values were 0.62, 0.53 and 0.37 (Table 1) for highest Y/R. The higher value of E indicates over fishing during this period. According to Gulland[29], the yield is optimized when F = M; therefore, when E is more than 0.5, the stock is over fished. Beverton and Holt's[26] Emax ($E_{MSY}$) is to decide the state of under or over exploitation and suggest management measures, if necessary, because the hypothetical ideal E value of 0.5 is only possible if natural and fishing moralities are equal, which is generally never the case in any exploited fish population. It can be observed from the Table 1 that exploitation rate (E) of juveniles alone in comparison to its $E_{max}$ is 60% higher than that of adult (5.17%) alone. The exploitation rate of the total combined catches (juveniles and adults) was higher to its $E_{max}$ by 48.65% during 2002. It clearly shows that there is definite over exploitation of the total Hilsa stock and the same is more pronounced because of heavy exploitation of juveniles.

**Recruitment pattern:** The Fig. 2a-c, shows the recruitment patterns of *T. ilisha*, in Bangladesh. The recruitment occurs more or less continuously with one major peak from May to September. The major recruitment of *T. ilisha* occurred in summer. Rahman *et al.*[4,6] also observed the peak recruitment of this species in the summer.

**Yield-per-recruit and biomass-per-recruit:** The relative yield-per-recruit (Y/R) and biomass-per-recruit (B/R) values were 0.39, 0.31 and 0.04 and M/K values were 1.91, 1.80 and 1.88 for male, female and combined sexes. The exploitation rate of *T. ilisha* obtained in 2002 exceeded the maximum allowable limit ($E_{max}$) (Table 1). This suggests that exploitation of this stock has exceeded the maximum fishing level and there by the fishing mortality seems to be a great concern for this stock. Thus, there is no scope to increase fishing pressure for optimizing the yield.

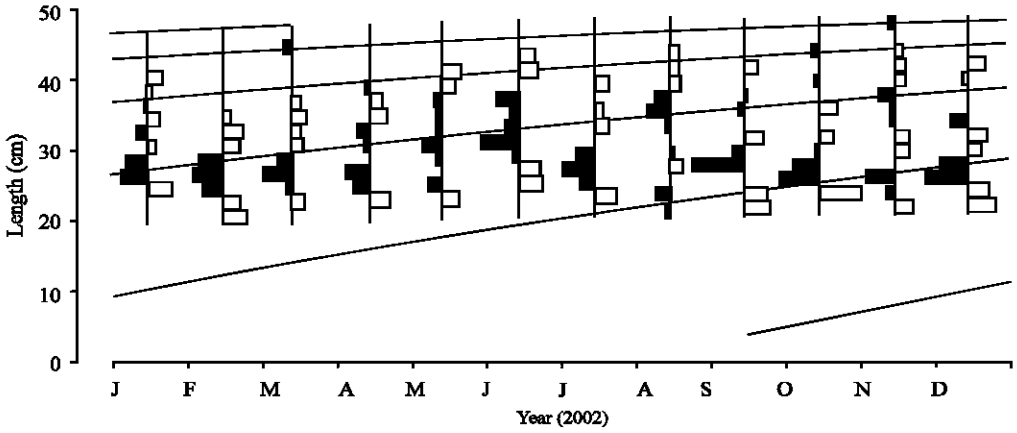


Fig. 1a: Growth curves of male *T. ilisha* in Bangladesh

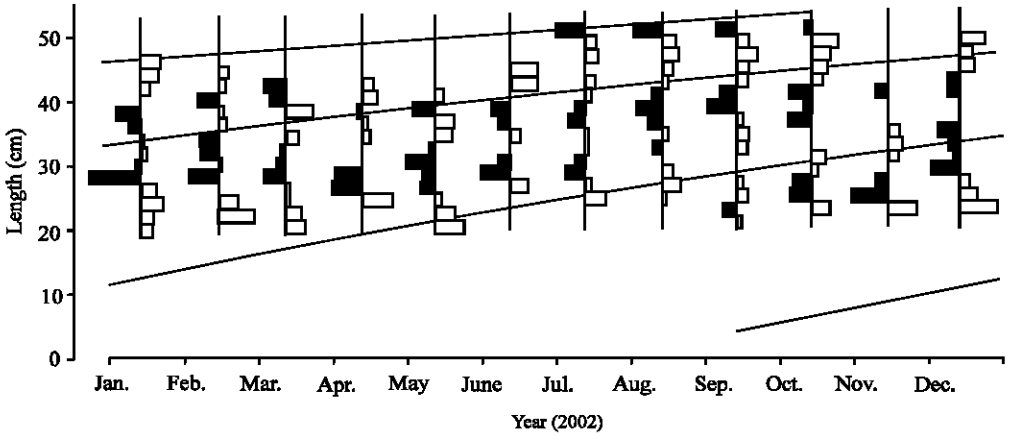


Fig. 1b: Growth curves of female *T. ilisha* in Bangladesh

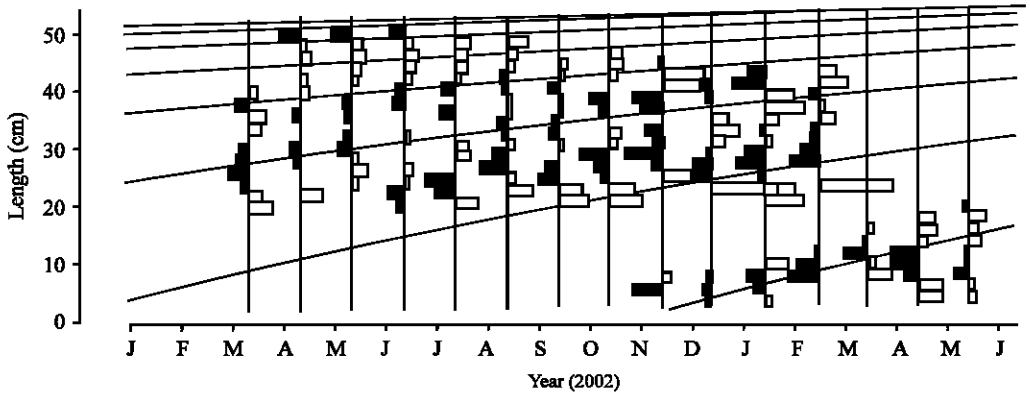


Fig. 1c: Growth curves of combined sexes of *T. ilisha* in Bangladesh

**Virtual Population Analysis (VPA):** The results of length based VPA analysis are depicted in Fig. 3a-c. These figures show the fishing mortality in relation to mean length. Relatively higher fishing mortality of male, female and combined sexes of *T. ilisha* occurred in the length ranges 26-38, 34-44 and 26-44 cm during the study period.

**Length-weight relationship:** The length-weight relationships of male, female and combined sexes of *T. ilisha* have been presented in Table 2. The

Table 1: Various Population Parameters of *T. ilisha* of Bangladesh water for the year 2002

| Parameters | Male | Female | Adult | Juvenile | Combined |
|---|---|---|---|---|---|
| Asymptotic Length ( $L_\infty$ ) in cm | 51.50 | 65.55 | 53.70 | 19.10 | 54.60 |
| Growth Co-efficient (K)/year | 0.53 | 0.51 | 0.86 | 1.50 | 0.52 |
| Length at first capture (Lc) in cm | 20.11 | 20.60 | 19.87 | 1.34 | 2.11 |
| Growth performance index ($\phi'$) | 3.14 | 3.34 | 3.40 | 2.75 | 3.19 |
| Total mortality (Z) | 3.08 | 2.87 | 3.51 | 6.78 | 2.16 |
| Natural mortality (M) | 1.01 | 0.92 | 1.36 | 2.62 | 0.98 |
| Fishing mortality (F) | 2.07 | 1.95 | 2.15 | 4.16 | 1.18 |
| Exploitation rate | 0.67 | 0.68 | 0.61 | 0.61 | 0.55 |
| Exploitation rate (E) for maximum Y/R ($E_{max}$) | 0.62 | 0.53 | 0.58 | 0.38 | 0.37 |
| Sample size (N) | 5,445 | 7,895 | 13,340 | 2448 | 15,788 |
| Length range in cm | 20 - 46 | 20 - 52 | 20 - 52 | 2 - 18 | 2 - 52 |

Table 2: Length–weight relationship of *T. ilisha* in Bangladesh

| | Sample size (N) | Length range (cm) | Constant (a) | Exponent (b) | Co-efficient ( r) |
|---|---|---|---|---|---|
| Male | 292 | 19-40 | 0.02388 | 2.9834 | 0.99 |
| Female | 294 | 20-44 | 0.01779 | 3.0724 | 0.99 |
| Adult | 586 | 20-52 | 0.01713 | 2.8877 | 0.95 |
| Juvenile | 2448 | 02-18 | 0.00361 | 3.4107 | 0.97 |
| Combined+ | 982 | 03-57 | 0.00870 | 3.0770 | 0.99 |

+ After Amin *et al.*[15]

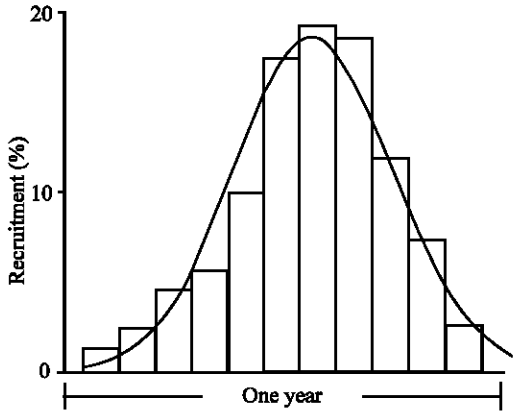


Fig. 2a: Recruitment pattern of male *T. ilisha* in Bangladesh

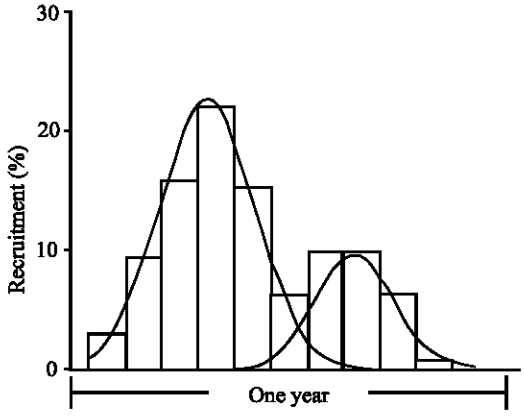


Fig. 2b: Recruitment pattern of female *T. ilisha* in Bangladesh

length-weight relationship was established in the logarithmic form LogW = Loga + bLogL. The exponent 'b' estimated and values were close to 3, which indicates that

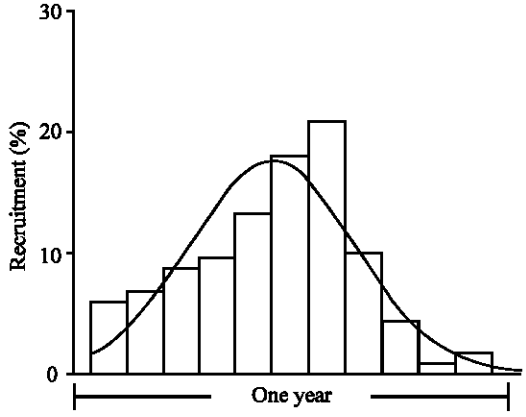


Fig. 2c: Recruitment pattern of combined sexes of *T. ilisha* in Bangladesh

the growth was more or less isometric. The correlation co-efficient values were very close to 0.99, which indicates that the relationships between total length and weight of this species was highly significant. This finding agrees with the findings of Ahmed and Saha[30] and ARG[31].

**Stock size and MSY estimation:** The estimates of standing stock size and MSY for combined sexes of *T. ilisha* were 217, 713 and 235, 130 tones, respectively. From these results it is evident that the value of MSY is very close to the average annual catch, 229.714 in the year 2002 which also indicate the over fishing condition of the hilsa stock. So, immediate steps must be taken to reduce fishing pressure of the stock from the present level of fishing pressure 1.181 to 1.08/year, i.e. 9% reduction, for obtaining MSY.

The results clearly indicate that the problem of over exploitation of this species, resulting in gradual decline of

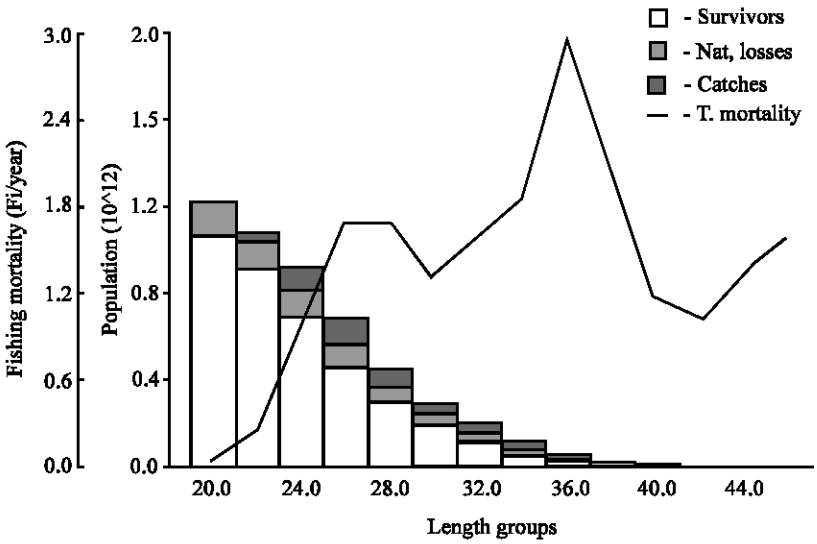


Fig. 3a: Virtual population analysis of male *T. ilisha* in Bangladesh

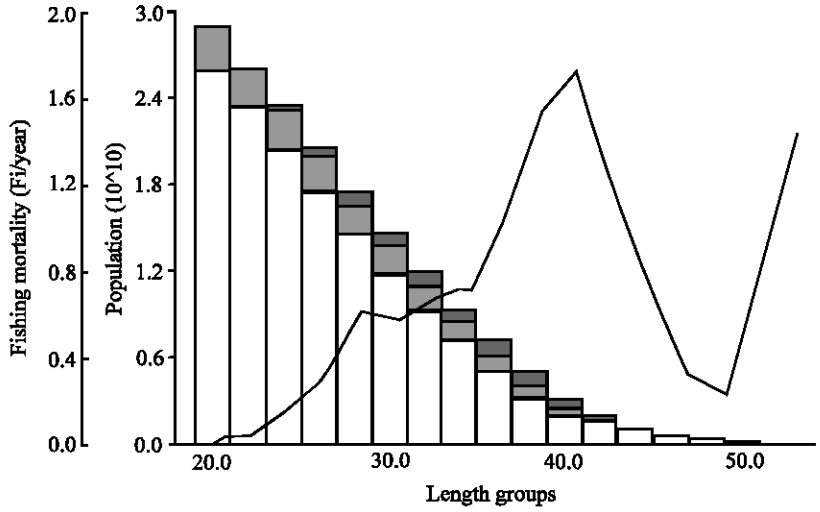


Fig. 3b: Virtual population analysis of female *T. ilisha* in Bangladesh

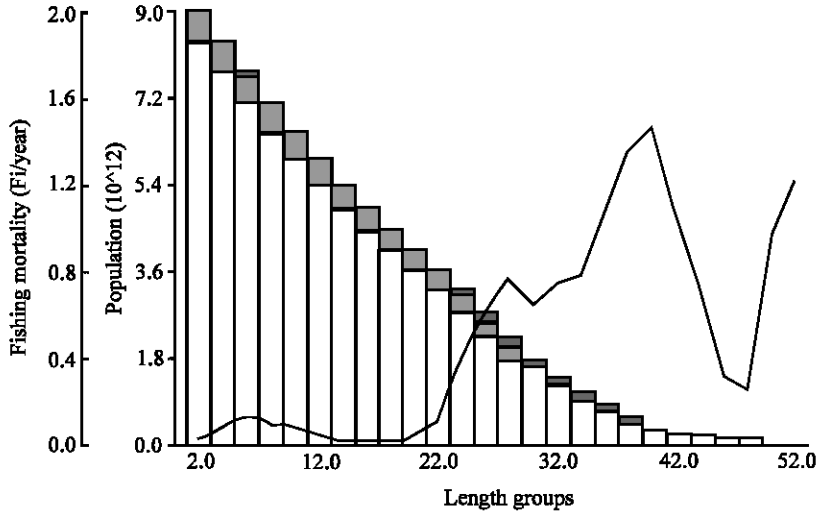


Fig. 3c: Virtual population analysis of combined sexes of *T. ilisha* in Bangladesh

catches in the inland sector, is mainly because of heavy exploitation of its juveniles. Measures need to be taken to minimize juvenile Hilsa catching as far as possible. Banning of nets, specially operated for catching juveniles and through creating mass awareness amongst the fishers and providing alternative source of employment to them during the period of juvenile fishing (December to April) would greatly help to minimize juvenile Hilsa catching. This would substantially decrease the present level of over exploitation and also help to increase the fishable number of adults during subsequent years. Further increase of existing fishing level/exploitation will most likely results in a reduction in the yield-per-recruit and thereby hampering the MSY.

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