

Some aspects of population dynamics of juvenile hilsa shad (*Tenualosa ilisha* Ham.) from the Meghna river, Bangladesh

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Abstract

Population dynamics of the juvenile hilsa shad (*Tenualosa ilisha*) in the nursery ground of the Meghna river have been studied on the basis of the length cohort analysis of 8023 specimens. The growth parameters *viz*; asymptotic length (L_{∞}), curvature character (K) and initial time (t_0) were found to be 30.69 cm, 1.2 yr^{-1} and 0.45 yr^{-1} respectively. Curvature parameter indicate that jatka is a fast growth performer. The natural, fishing and total mortality were found to be 1.37 yr^{-1} , 1.41 yr^{-1} and 2.78 yr^{-1} respectively. Survival rate (S) was found to be 6.2%. A small difference was found between the age at first capture (T_c) and the recruitment age (T_r). Stocks of jatka seems to be overexploited and need to be conserved.

Key words: Juvenile hilsa, Population dynamics, Meghna river

Introduction

Jatka is the juvenile stage of the hilsa shad. It is the most exploited fishery in Bangladesh water of rivers, estuaries and the coast. As an open water fishery, its exploitation is a crucial phase for sustainable yield. Recruitment is a continuous biologically renewable process in the open water system. If by any means, the recruitment process impaired the adult population will decline in the long run. Biomass is regenerated both from recruitment and tissue growth. Nonetheless, it is necessary to have established clear and strong relationship between the adult stock and the recruiting young to obtain a sustainable yield from any fishery (Cushing 1968). Therefore, jatka fishery has a significant effect on hilsa production year after year. The growth parameters differ from species to species and also vary from stock to stock within the same species and age (Pauly 1980a). The aim of this investigation is to provide practical guidelines to understand the impacts of juvenile hilsa population as a capture fishery.

Materials and methods

Length-frequency data collection

Length-frequency data of 8023 individuals of jatka were collected from the nursery ground of the Meghna river in and around Chandpur during December 1993 through

April 1996. Length-frequency data were collected both by experimental fishing as well as from commercial catches. In each month adequate number of length-frequency data were randomly collected. Total length (cm) was measured from the tip of the snout to the posterior most margin of the caudal fin. Experimental fishing was done by a beach seine net (150m x 18m, 0.75cm mesh) manually hauled by 12 people. Commercial catches were done by a large seine net (400m x 30m, 0.75cm mesh) employing about 60 fishermen for hauling.

Data analysis

Length-frequency data were analyzed by using the Microstat and Excel-statistica computer software packages program. Growth parameters of jatka fishery viz; asymptotic length (L_{∞}), curvature parameter (K) and initial time (t_0) when jatka begins to grow just after hatching, were estimated on the basis of the Von-Bertalanffy growth analysis by using the following growth equation model;

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

A linear regression analysis was done between the two variables X and Y using the formula;

$$Y = a + bX; \dots \dots \dots (ii)$$

Considering $\Delta L / \Delta t$ as X and mean length [$L'(t)$] as Y. Asymptotic length of jatka was calculated by the formula;

$$L_{\infty} = -a/b \dots \dots \dots (iii)$$

Mean length [$L'(t)$] was converted by the formula of $-\ln[1 - L'(t) / L_{\infty}]$ and was denoted as Y_1 variable. In this case the independent variable (X_1) was denoted as assumed cohort age (t). By the regression analysis between X_1 and Y_1 variables, Curvature parameters (K) was calculated as $K = \text{slope}$, b_1 and the initial age as $t_0 = -a_1/b_1$. After determining the values of L_{∞} , K and t_0 length data converted into age data by using the Inverse Von-Bertalanffy growth equation (1938);

$$t(L) = t_0 - 1/k * \ln [1 - L'(t) / L_{\infty}] \dots \dots \dots (iv)$$

The growth pattern of jatka was determined by plotting length against age.

Total mortality

Total mortality was calculated by the "linearized length- converted catch curve" method. The linearized length converted catch curve formula was;

$$\ln C(L_1, L_2) / t(L_1, L_2) = a - Z * t[(L_1 + L_2) / 2] \dots \dots \dots (v)$$

Where $t=1/K \cdot \ln[(L_\infty-L_1)/(L_\infty-L_2)]$, $X = t[(L_1+L_2)/2] = t_0-1/K \cdot \ln[1-(L_1+L_2)/L_\infty]$ and $Y=\ln C(L_1,L_2)/t(L_1,L_2)$, $C(L_1,L_2)$ is the number of fish caught, L_1 and L_2 were the lower and upper limit of each length class, 'a' was the intercept and the slope b ($-Z$) was the total mortality.

Natural and fishing mortality

Natural mortality (M) for jatka fishery was calculated by Pauly's empirical formula (Pauly 1980 b) through various combinations of L , K and average annual temperature ($T^\circ\text{C}$). Here annual temperature was considered only for the period of November to April when Jatka is available in the riverine nursery ground. Natural mortality was calculated by the following formula;

$$M = 0.8 \cdot \exp[-0.0152 - 0.279 \cdot \ln L_\infty + 0.6543 \cdot \ln K + 0.463 \cdot \ln T] \dots\dots (vi)$$

Fishing mortality rate (F) was derived by subtracting the natural mortality from the total mortality, since $Z=M+F$, where Z , M and F were the instantaneous rate of total, natural and fishing mortality.

Exploitation rate

The rate of exploitation of jatka in the Meghna river was calculated by the formula;

$$\text{Exploitation rate, } E = F/Z \dots\dots\dots (vii)$$

Results

Length-frequencies of 8023 specimens of jatka from the riverine nursery grounds of the Meghna river were analyzed and shown in Fig.1.

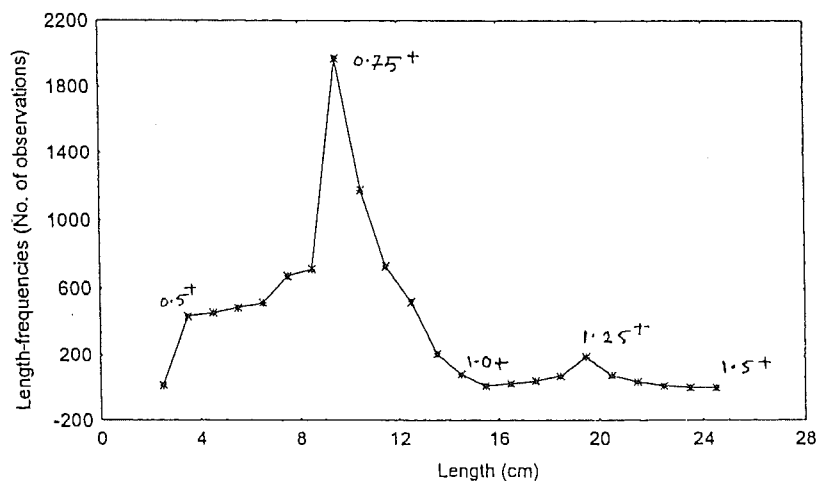


Fig. 1. Length cohort analysis of jatka population for riverine nursery ground of the Meghna river.

Length-frequency analysis revealed that the length cohorts of jatka population were <2, <9, <15, <19 and <22 cm respectively (Fig.1). Cohort assumed age (t), cohort mean

length [$\Delta L/\Delta t$], growth rate $\Delta L/\Delta t$ and individual mean length $L(t)$ were shown in Table 1. Through a regression analysis between Y ($\Delta L/\Delta t$) and X ($L(t)$), the intercept a and slope b were found to be 36.22 and -1.18 respectively. According to the Von-Bertalanffy growth equation asymptotic length (L_∞) of jatka was 30.69 cm, cohort mean length $L(t)$ converted into $-\ln [1-L(t)/L_\infty]$ denoted as Y_1 and assumed cohort age (t) denoted as X_1 were put into a simple regression. The values of curvature parameter K and initial time t_0 were found as 1.2 yr^{-1} and 0.45 yr (Table 2).

Table 1. Growth rate of *Tenualosa ilisha* as a function of cohort age

Age t years	Δt	Cohort mean length cm	$\Delta L(t)$	Growth rate $L(t+\Delta t)-L(t)/t= \Delta L/\Delta t$	$L(t+\Delta t)+L(t)/2= L'(t)$
0.5 ⁺	0.25	<2	7.0	28	5.5
0.75 ⁺	0.25	<9	6.0	24	12
1.0 ⁺	0.25	<15	4.0	16	17
1.25 ⁺	0.25	<19	3.0	12	20.5
1.5 ⁺		<22			

$N=4, x= 13.75$ a (intercept)= 36.22, b= (slope)= -1.18

Table 2. Calculation of Curvature parameter (K) and Initial time (t_0), (using $L_\infty = 30.69$ cm)

Cohort age t (year) (X) X_1	Cohort mean length L(t) cm	$-\ln[1-L(t)/L_\infty]$ (Y) Y_1
0.5 ⁺	2	0.06
0.75 ⁺	9	0.35
1.0 ⁺	15	0.67
1.25 ⁺	19	0.97
1.5 ⁺	22	1.26

a_1 (intercept) = -0.54, b_1 = (slope) = 1.2 yr^{-1} , (Curvature parameters) and initial time $t_0 = -a_1/b_1 = 0.54/1.2 = 0.45 \text{ yr}$.

The values of curvature parameters are indicating that jatka is a fast growth performer. The growth rate of jatka was calculated by using Inverse Von-Bertalanffy growth equation. The length of jatka was converted into age (t). Growth is the change of absolute increase in length and weight with respect of age. The instantaneous rate of increase in length with respect of age $\Delta L(t)$ has been estimated by the Von-Bertalanffy growth equation. The growth curve of jatka was shown in Fig.2.

The growth pattern indicating that the instantaneous rate of growth in the younger phase of life was found much higher. Jatka attain up to 28 cm within 2 years. But 7-15 cm attain within one year. It was also found that maximum peak catch attain with 8-12 cm size groups (Fig. 1).

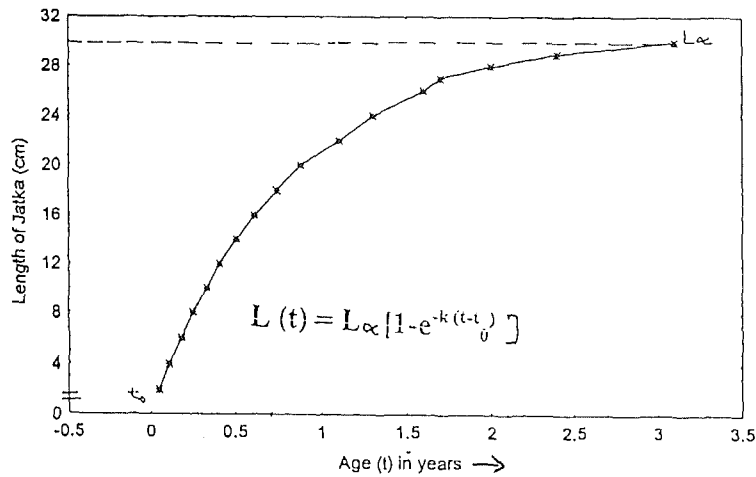


Fig. 2. Growth curve of jatka from the riverine nursery ground.

Total mortality rate (Z)

The instantaneous rate of total mortality was estimated by means of the length converted catch curve method. The total mortality rate (Z) was found to be 2.78 yr⁻¹, which indicating a high value. The length converted age based catch curve was shown in Fig.3.

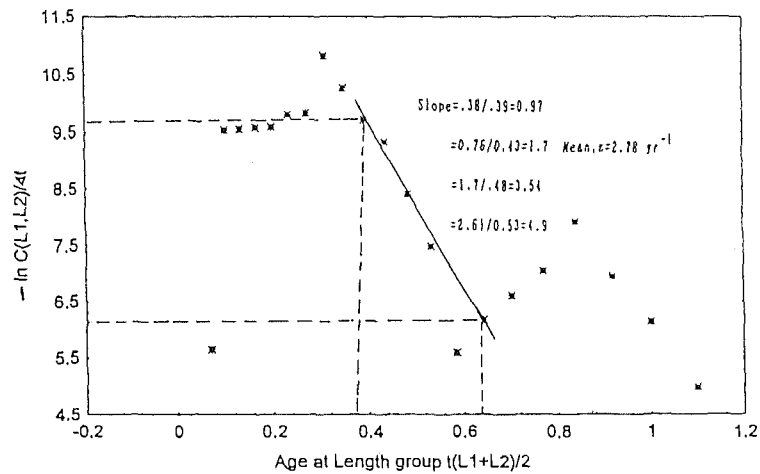


Fig. 3. Length Converted Catch Curve used for estimation of total mortality of jatka fishery.

The descending part of the catch curve was not calculated due to too close to L_∞ and hence it was avoided. The high Z value for jatka fishery was not a good sign to obtain a sustainable yield. From the Z value it was calculated that the survival rate of jatka fishery in the riverine nursery ground was $S = e^{-Z} \times 100 = e^{-2.78} \times 100 = 6.2\%$, which was very low, which indicating that the hilsa population catch will be seriously hampered in the long run.

Natural and fishing mortality

The natural mortality was calculated by the Pauly's empirical formula (1980b) and it was shown in Table 3. Where L_∞ = 30.69 cm and K= 1.2 yr⁻¹ were used in the calculation.

Mean natural mortality M was found to be 1.37 yr⁻¹ was found. The instantaneous rate of fishing mortality as derived from the values of Z and M, was obtained $F=Z-M=1.41\text{yr}^{-1}$.

Table 3. Natural mortality calculated by Pauly's empirical formula (1980b) for various ambient water temperature (month-wise, during the jatka season)

L _∞	K	Ambient water temperature (T ⁰ C)					
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
30.69	1.2	23	19	17	20	22	24
	M=	1.45	1.33	1.28	1.39	1.36	1.48

$$\text{Mean } M = 1.37\text{yr}^{-1}, M = 0.8 * \exp [-0.0152 - 0.279 * \ln L_{\infty} + 0.6543 \ln K + 0.463 \ln T^{\circ}C]$$

Exploitation ratio

Exploitation ratio, $E = 0.51$ has been estimated on the basis of the relationship $E = F/Z$, which tends to overexploitation for the jatka fishing. Tends of overexploitation is not a good sign for any open water fishery.

Discussion

Length-frequency analysis of jatka population reveals that major share of jatka fishery in the riverine nursery ground were caught between the sizes of 8-12 cm in November to April and the peak were 9-10 cm size group. In the riverine nursery ground, the abundance of jatka was found from November to April and peak in March in each year (Rahman *et al.* 1995) which supports the present findings.

The first capture age (T_c) was calculated as $T_c = 0.5$ yr (6 months). and the recruitment size was 8-9 cm, so the recruitment age was $T_r = 0.70$ yr (8.4 months). It was seen that the differences between T_c and T_r was very small (2.4 months). The results for T_r and T_c showed that T_c age was smaller than T_r age, which was not true for the proper management. Therefore, to obtain a sustainable hilsa population, T_r age must be less than T_c age. Beverton and Holt (1957) reported that in the open water system the fish population are affected by the natural mortality during the ages between T_r and T_c . But in case of jatka fishery in the Meghna river T_r to T_c period suffers from both by natural (M) and fishing mortality (F). So, it can be said that due to fishing pressure at the recruitment phase, the total mortality might be high for jatka population.

A stock is supposed to be optimum when $E_{opt} = 0.51$ but when E value is more than 0.5, the stock of a fish population is overfished (Gulland 1965). So, it appears that the stock of jatka fishery tends to cross the overfished level in the riverine nursery ground of the Meghna river.

Csirke and Sharp (1984) opined that if any population affected by high mortality in their recruitment phase the population might be seriously hampered in the long run. So, as the fishing pressure on the jatka fishery was on the way to cross the optimum fishing condition, it is urgently needed to control fishing at their recruitment phase.

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