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Population Dynamics of Mud Crab (*Scylla serrata*) in the Southeastern Coastal Region of Bangladesh

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Abstract

Population parameters of male and female *Scylla serrata* were estimated using FiSAT software with length-frequency data collected from different areas of Cox's Bazar, southeastern part of Bangladesh (Chakaria Sundarban, Moheshkhali and Kutubdia channel) to evaluate the growth parameters, mortality rates and exploitation levels. Asymptotic length ($L\infty$) was 105.9 mm and 105 mm, and growth co-efficient (K) was 0.28/yr and 0.36/yr for male and female *S. serrata*, respectively. The natural mortalities of *S. serrata* were 0.49/yr and 0.58/yr and fishing mortalities were 0.35/yr and 0.38/yr for male and female accordingly. Recruitment of this species into the fishery takes place throughout the year. The exploitation level for *S. serrata* was found to be 0.41 for the male and 0.39 for the female. This study showed that the stocks of male and female *S. serrata* were not under fishing pressure (E< 0.50) in the Southeastern part of Bangladesh.

Introduction

Scylla serrata (mud crab) locally known as *Jati kakra* or *haba kakra*, is found abundantly in the mangrove areas, estuaries and coastal regions of Bangladesh. It is widely distributed in the mangrove area of the Indo-Pacific, including the inshore waters of the Bay of Bengal, and is consumed in Bangladesh (Ahmed 1991). It is most popular because of its size, meat quality, high price and export potential (Raj 1991). It is fast growing, hardy, adapts itself to various aquatic conditions, and is used as aquaculture and poultry feed. It is being considered as an important aqua-species in terms of economic and export potential for Bangladesh (Zafar and Siddiqui 2000). Crabs are good source of protein for human and marine life (Khan 1992; Siddiqui and Zafar 2002).

For the planning and management of *S. serrata* resources, knowledge of various population parameters and exploitation levels (E) of that population is necessary. The coastal community of the Southeastern part of Bangladesh is exploiting *S. serrata* for their domestic consumption and selling them in the local market for their livelihood. But, their status of present exploitation level has yet to be assessed. Therefore, estimation of population parameters and exploitation levels (E) of economically viable population from the coast of Bangladesh is a maiden initiative.

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At present, *S. serrata* is successfully cultivated in earthen ponds and cages of Bangladesh coastal areas based on natural source of seed, and the country has been earning a good amount of foreign currency over the years. However, works on population dynamics of *S. serrata* is absent in Bangladesh. Due to the importance of this crab, the present work on the population dynamics of male and female *S. serrata* was undertaken to estimate the key parameters of population dynamics and stock assessment such as asymptotic length ($L\infty$), growth co-efficient (K), total mortality (Z), natural mortality (M), fishing mortality (F) and virtual population analysis (VPA). This information is necessary in formulating management and conservation policies as well as in the further development of the fishery for this species in Bangladesh.

Materials and Methods

The present investigation was conducted in Chakaria Sundarban and its adjacent areas of Moheskhali and Kutubdia channel of the Southeastern part of Bangladesh. Sampling was done monthly over a 12 month period from March 2003 to February 2004. Random measurement of length and weight for the male and female *S. serrata* was taken immediately after catch. The total carapace length of male and female was measured using a meter scale and weighed using an electronic balance.

The data were then pooled monthly from different landing sites and subsequently grouped into classes at four-millimeter intervals. The recorded data were analyzed using the FiSAT (FAO-ICLARM Stock Assessment Tools) as explained in details by Gayanilo Jr et al. (1996).

Asymptotic length (L_∞) and growth co-efficient (K) of the von Bertalanffy equation for growth in length were estimated by means of ELEFAN-I (Pauly and David 1981; Saeger and Gayanilo 1986), which was incorporated in the FiSAT Software. The fitting of the best growth curve was based on the ELEFAN-I program, which allowed the fitted curve through the maximum number of peaks of the length-frequency distribution. With the aid of the best growth curve, the growth constant (K) and asymptotic length ($L_{\infty)}$ were estimated.

The growth performance index (ϕ') of *S. serrata* in terms of growth in length was estimated using the formula of Pauly and Munro (1984).

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

Total mortality (Z) was estimated by length converted catch curve method (Beverton and Holt 1956), which has been incorporated into the FiSAT program (Gayanilo Jr et al. 1996).

Natural mortality (M) was estimated using the empirical relationship derived by Pauly (1980). Fishing mortality (F) was estimated by subtracting M (natural mortality) from Z (total mortality) and exploitation rate (E) was calculated from F/Z.

Recruitment pattern was obtained by backward projection on the length axis of a set of length-frequency data as described in the FiSAT routine. This routine reconstructed the recruitment pulse from a time series of length-frequency data to determine the number of pulses per year and the relative strength of each pulse. Input parameters were L_∞, K and t_0. The t_0 value was taken as zero.

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 (Pauly and Soriano 1986). The Y/R and B/R calculations were carried out using the FiSAT software.

The length-weight relationship of *S. serrata* was estimated from the formula: $W = aL^b$ given by Le Cren (1951), where 'a' is a constant and 'b' is an exponent.

The estimated length structured virtual population analysis and cohort analysis were carried out from the FiSAT routine. The values of L_∞, K, M, F, a (constant) and b (exponent) were used as inputs to a VPA analysis. The t_0 value was taken as zero. The method was published by Fry (1949) and subsequently modified by many authors. Practical reviews of VPA methods were, among others, given by Pauly (1984) and Jones (1984).

Results

Growth parameters

Asymptotic length (L∝) of the von Bertalenffy was 105.9 mm and 105 mm, and growth co-efficient (K) was 0.28/yr and 0.36/yr for male and female *S. serrata* respectively. The computed growth curves produced with using those parameters were shown over its restructured length distribution (Figs. 1a and 1b). Estimated growth performance index (ϕ′) was found to be 3.497 for male and 3.599 for female respectively.

Mortalities

Length converted catch curve analysis produced total mortality estimates of Z = 0.84/yr and 0.96/yr for male and female *S. serrata* respectively (Figs. 2a and 2b). Natural mortalities (M) were 0.49/yr and 0.58/yr, and fishing mortalities (F) were 0.35/yr and 0.38/yr for male and female *S. serrata* accordingly (Table 1). Natural mortality between the male and female varied from 0.49 to 0.58/yr, but fishing mortality between the male and female was almost similar.

Table 1. Population parameters of male and female *S. serrata* in the Southeastern part of Bangladesh

Parameters	Male	Female
Asymptotic length (L∝)	105.9 mm	105 mm
Growth co-efficient (K)	0.28/yr	0.36/yr
Natural mortality (M)	0.49/yr	0.58/yr
Fishing mortality (F)	0.35/yr	0.38/yr
Total mortality (Z)	0.84/yr	0.96/yr
Exploitation level (E)	0.41	0.39
Maximum permissible limit of exploitation (E_{max})	0.40	0.39

Exploitation levels (E)

Exploitation levels (E) for male and female *S. serrata* were 0.41 and 0.39. The maximum permissible limits of exploitation (E_{max}) values were 0.40 and 0.41for male and female respectively. It was found from the analysis that exploitation values (E) for male and female were very close to its E_{max} values.

Recruitment pattern:

The recruitment pattern (Fig. 3a) for the male *S. serrata* in the study area suggested a continuous recruitment with major peak from May to August. Recruitment of female *S. serrata* was also continuous with two major peaks in a year; the highest peak was observed in May and a second peak occurred in August-October (Fig. 3b).

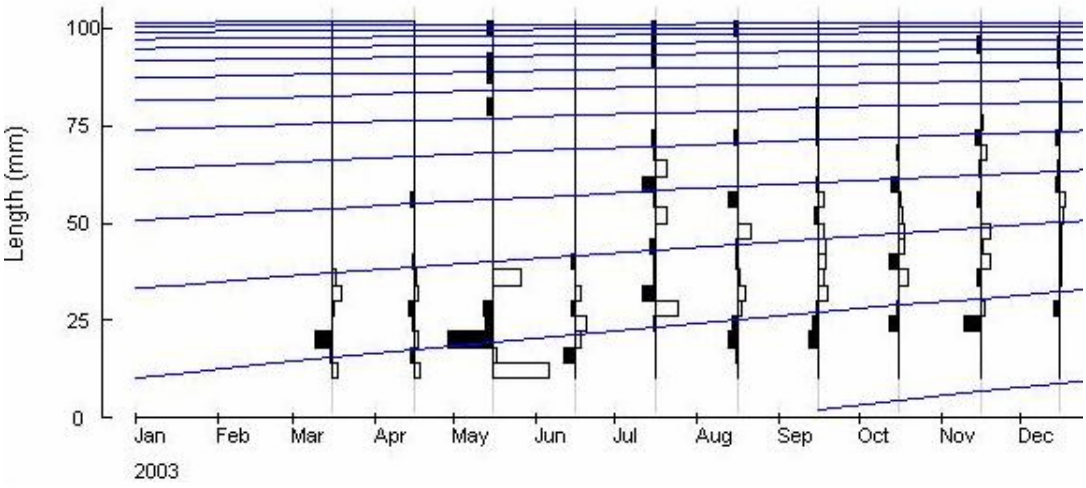

Fig. 1(a). Growth curves of male *S. serrata* drawn over their restructured length distribution in the Southeastern part of Bangladesh

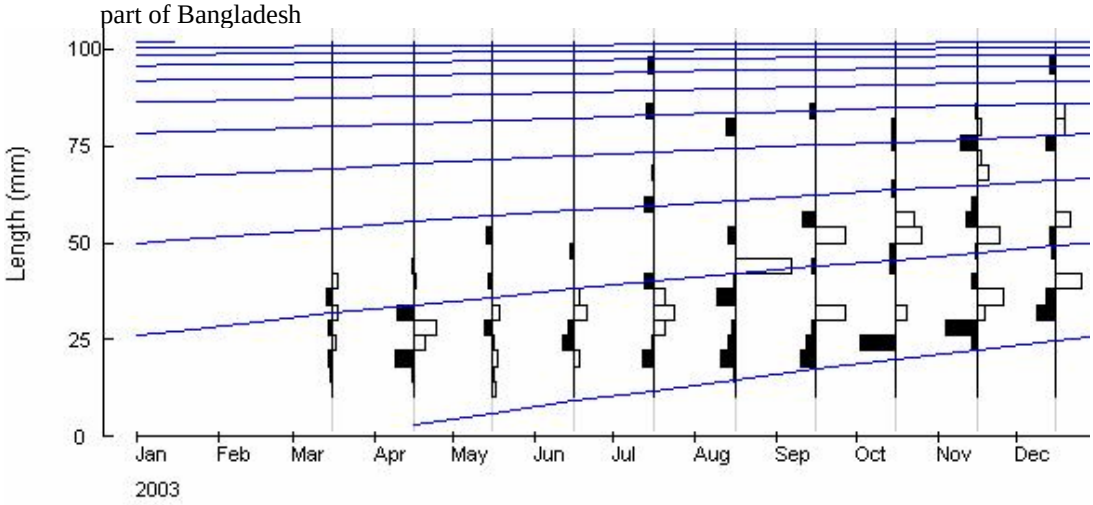

Fig. 1(b). Growth curves of female *S. serrata* drawn over their restructured length distribution in the Southeastern part of Bangladesh

Fig. 1. Growth curves of (a) male and (b) female *S. serrata* drawn over their restructured length distribution in the Southeastern part of Bangladesh

Length-weight relationship

The length-weight relationships of male, female and both sex of *S. serrata* have been presented in Table 2. The length-weight relationship was established in the logarithmic form LogW = Loga + bLogL. Figures 4a and 4b showed the scattered diagram obtained by plotting the values of total carapace lengths against their respective weights on an arithmetic scale exposing a curvilinear relationship. The calculated value of the weight when plotted against the total carapace length of the male and female *S. serrata* showed parabolic curves, while linear lines were obtained by plotting the values of log total carapace length against their log calculated weight (Figs. 5a and 5b). The exponent 'b' estimated and values were 2.87 and 2.75 for the male and female respectively. The correlation co-efficient (r) values were above 0.99

and 0.98 for male and female respectively, which indicated that the relationships between total length and weight of this species were highly significant. The present results agreed with the findings of Ahmed and Saha (1996) and ARG (1986).

Table 2. Length–weight relationship of *S. serrata* in the Southeastern part of Bangladesh

	Sample size (N)	Length range (cm)	Constant (a)	Exponent (b)	Correlation Co-efficient (r)
Male	647	1.50-13.50	0.25139	2.870309	0.99
Female	457	1.50-13.50	0.28558	2.755061	0.98

Virtual population analysis (VPA)

The results of length based VPA analysis were depicted in Figures 6a and 6b. These figures showed the fishing mortality in relation to mean length. The VPA results indicated that a maximum number of crabs of both sexes were caught between 16 mm and 28 mm length and after 92 mm length. The highest peak of F for female occurred in the length range 48 to 56 mm with vales of F exceeding 0.5/yr (Fig. 6b).

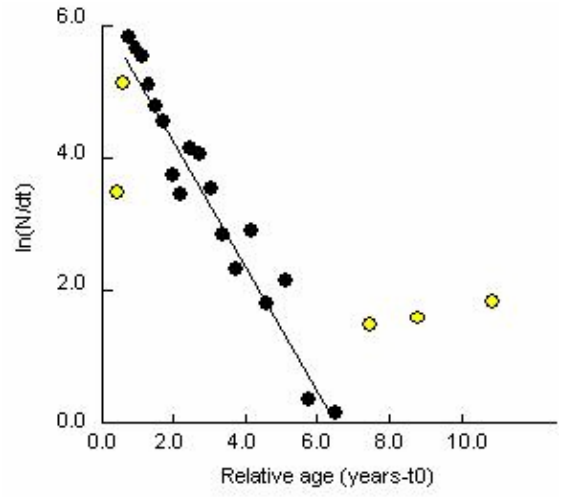

Fig. 2(a). Length converted catch curve of male *S. serrata* in the Southeastern part of Bangladesh

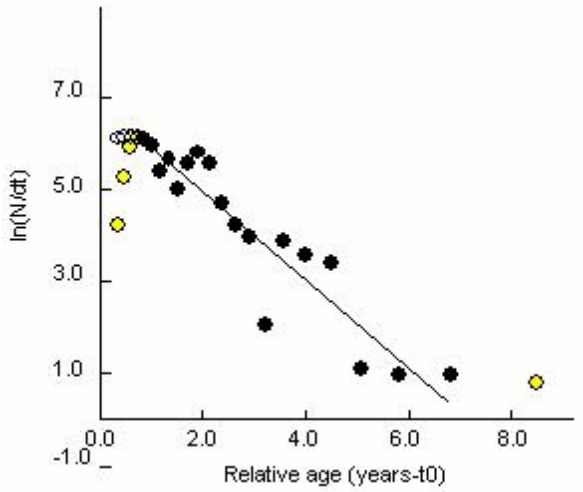

Fig. 2(b). Length converted catch curve of female *S. serrata* in the Southeastern part of Bangladesh

Fig. 2. Length converted catch curve of (a) male and (b) female *S. serrata* in the Southeastern part of Bangladesh

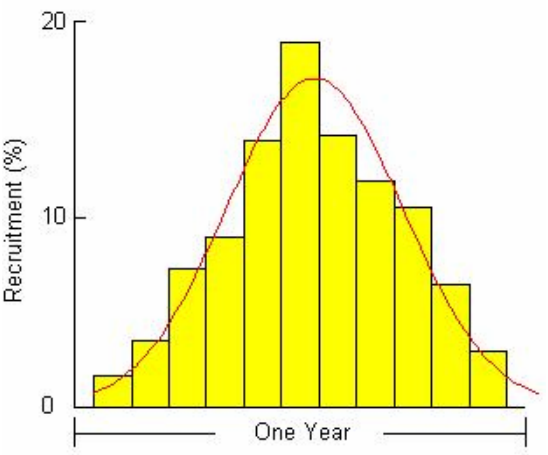

Fig. 3(a). Annual recruitment pattern of male *S. serrata* in the Southeastern part of Bangladesh

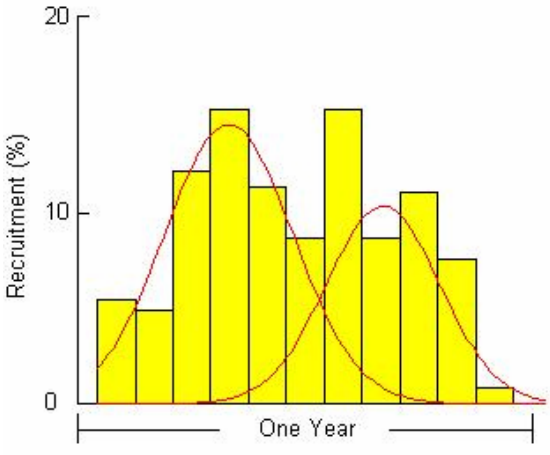

Fig. 3(b). Annual recruitment patterns of female *S. serrata* in the Southeastern part of Bangladesh

Fig. 3. Annual recruitment patterns of (a) male and (b) female *S. serrata* in the Southeastern part of Bangladesh

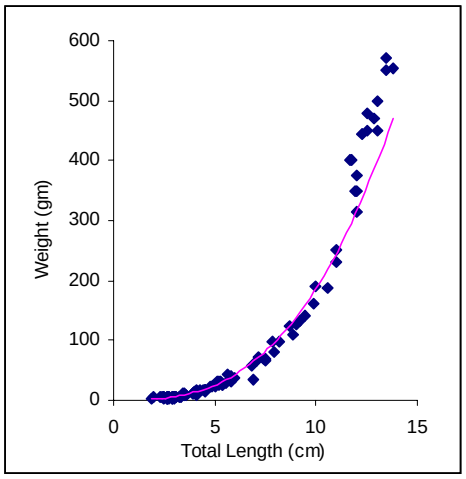

Fig. 4(a). Scatter diagram showing the relationship between total carapace length and weight of male *S. serrata*

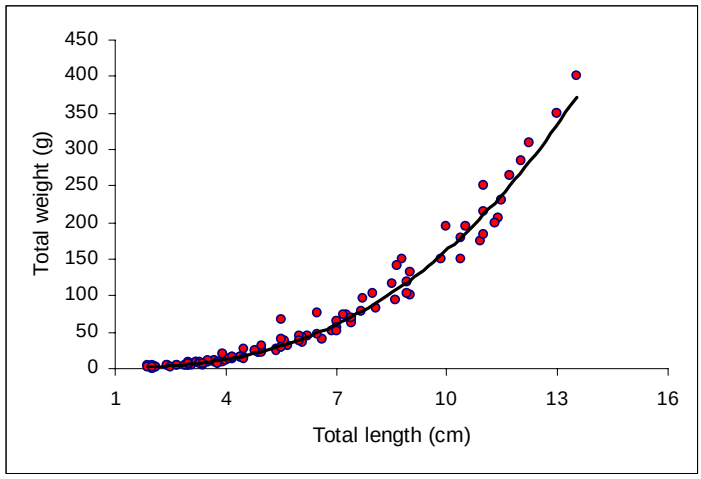

Fig. 4(b). Scatter diagram showing the relationship between total carapace length and weight of female *S. serrata*

Fig. 4. Scatter diagram showing the relationship between total carapace length and weight of (a) male and (b) female *S. serrata* in the Southeastern part of Bangladesh

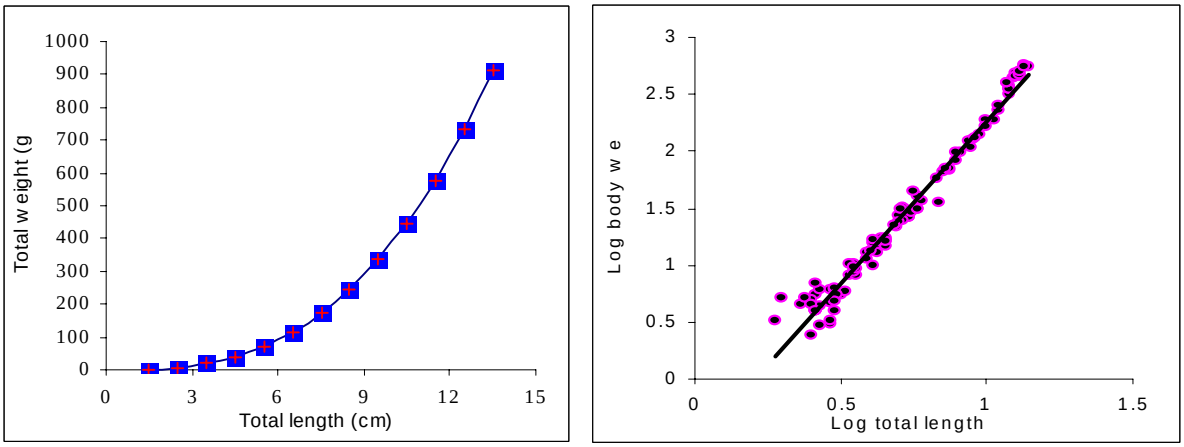

Fig. 5(a). Length weight relationship of male *S. serrata* (arithmetic and logarithmic)

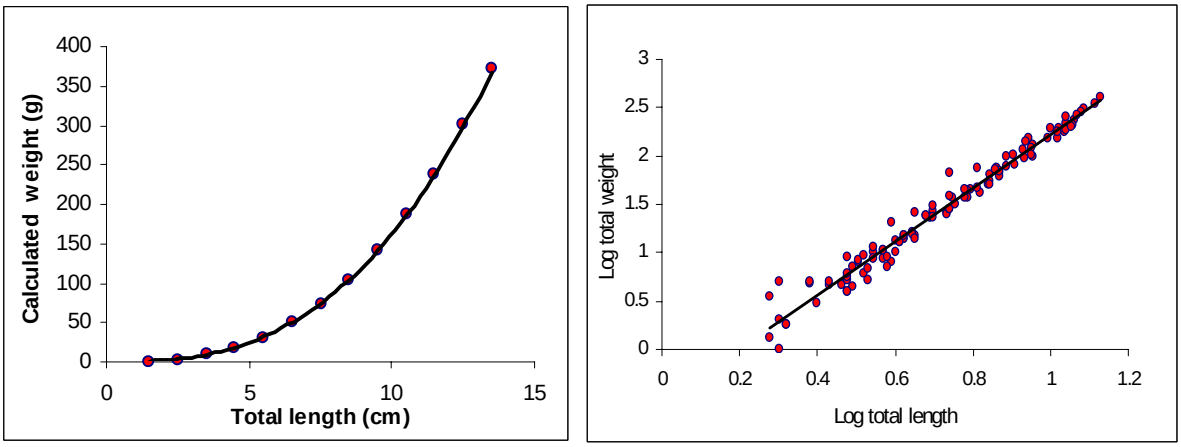

Fig. 5(b). Length weight relationship of female *S. serrata* (arithmetic and logarithmic)

Fig. 5. Length weight relationship of (a) male and (b) female *S. serrata* in the Southeastern part of Bangladesh

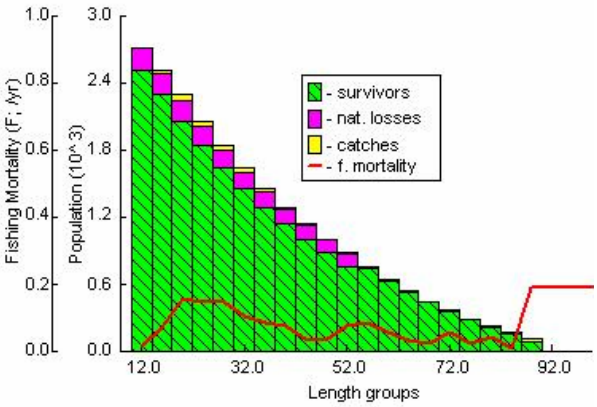

Fig. 6(a). Length structured virtual population analysis (VPA) of male *S. serrata* in the Southeastern part of Bangladesh

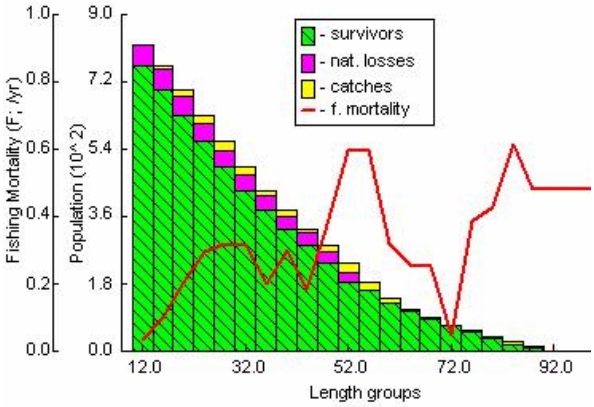

Fig. 6(b). Length structured virtual population analysis (VPA) of female *S. serrata* in the Southeastern part of Bangladesh

Fig. 6. Length structured virtual population analysis (VPA) of (a) male and (b) female *S. serrata* in the Southeastern part of Bangladesh

Discussion

Growth curves (Figs. 1a and 1b) were drawn directly upon the length-frequency sample such that majority of the peaks were on or close to the line for the male and female *S. serrata*. The estimates of the asymptotic lengths were 105.9 mm and 105 mm and growth coefficient (K) were 0.28/yr and 0.36/y for male and female *S. serrata* respectively.

Higher natural mortalities (0.49/yr and 0.58/yr) were observed than fishing mortalities (0.35/yr and 0.38/yr) for the male and female *S.serrata* respectively, which indicated the non-equilibrium position in the stock. The yield was optimized when F = M (Gulland 1971).

The lower values of E indicated under fishing condition during the study period for the male and female *S. serrata*. Theoretically, when E = 0.50, then the stock of any aquatic species is at optimum level. According to Gulland (1971), the yield was optimized when F = M; therefore, when E was more than 0.5, the stock was over fished. Sparre and Venema (1992) advocated the use of Beverton and Holt's E_{max} (E_{MSY}) to decide the state of under or over exploitation and suggested management measures, if necessary, because the hypothetical ideal E value of 0.5 was only possible if natural and fishing morality was equal, which in any exploited fish population generally never occured. From the present study, it could be concluded that male and female *S. serrata* were under fishing condition and more exploitation was possible.

Male *S. serrata* in the study area suggested a throughout the year recruitment with major peak from May to August. Recruitment of female *S. serrata* was also throughout the year. Kathirvel and Srinivasagam (1991) reported that the breeding of *S. serrata* occurred throughout the year. This supported the recruitment pattern of *S. serrata* throughout the year in the present study.

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