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Dynamics of the Population and Stocks of the Gangetic Major Carps from the Mymensingh Floodplains, Bangladesh

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Abstract

Length-based key parameters of the populations of Gangetic major carps' population, their stocks, and maximum sustainable yield were determined and compared with earlier findings. The fishery for *Labeo rohita, L. calbasu*, and *L. gonius* in the Mymensingh floodplain wetlands are definitely in a state of overexploitation. Even the stock of *L. gonius*, which was being exploited more or less on optimal level in 1999, is now being overexploited, though marginally. In case of *L. calbasu* the fishing pressure appears to be high even on smaller size groups of 19-21 cm (70-100 g). The situation is worst for *L. rohita* where lengths at first capture, Lc value has significantly gone down. It is imperative that proper regulatory measures are taken soon to increase the mesh size of the prevailing major gears and regulate fishing. Regular supplemental stocking of closed type beels (natural depressions) and large-scale pen culture in these floodplain can help in increasing their fish production potential and stabilize their stock.

Introduction

Mymensingh floodplain wetland (22,889 ha), situated in the northeastern region of Bangladesh has 25.8% of the total area under beels and is a part of the greater Sylhet-Mymensingh basin (62,106 ha out of countrywide 114,161 ha of beels). This makes this region very rich in fishery resource contributing about 26.2% of the total fish production from beels (69,850 t) out of total inland openwater fish production of 1.24 million t during 1998-99 (Anonymous 2001).

This region used to be famous for its fish production. With the passage of time, this basin has lost most of its fishery resources particularly, the lucrative Gangetic major carps, due to various man-made alterations of the basin (CIDA 1993).

Considering the importance of this basin in beel fish production, the Riverine Station of the Bangladesh Fisheries Research Institute has taken up a long term project, since 1993, to estimate the length-based key parameters of the Gangetic major carps' population dynamics and stocks. By this time Haroon et al. (1999), Alam et al. (2000), Alam et al. (2001); Haroon et al. (2001a), Amin et al. (2001), Amin et al. (2003), Haroon et al. (2001b) and Haroon et al. (2002) have shed some lights on the status of the fishery and stocks of the Gangetic major carps from this basin. This paper includes the results of 2000 and attempts to compare the growth, population parameters, and present status of the fishery with the abovementioned and other works of this region (Pantulu et al. 1967; Khan 1972; ARG 1986; BCAS 1989; Azadi and Kuddus 1995; Goswami and Devraj 1995; Ahemd and Saha 1996; Azadi et al. 1996; Sayduzzaman 1997).

Materials and Methods

The length-frequency data of *Labeo rohita* (Ham.), *L. gonius* (Ham.) and *L. calbasu* (Ham.) were collected from the commercial catches of purse seine nets at the landing center of Bhairab bazar, Mymensingh of the Myemensingh floodplain during January through December 2000. It is presumed that all fish in this floodplain belong to a single stock and the length groups represent only that part of the stock which is under full exploitation.

Length-based stock assessment was used in the present study. The collected length frequency data were pooled month–wise in 2.0 cm class intervals and analyzed using the FiSAT (FAO–ICLARM Stock Assessment Tools) computer-based model as explained by Gayanilo Jr. et al. (1996). Initially length–weight relationship for each species was calculated, using Le Cren's (1951) formula of W = a Lb (Log W = Log a + b Log L), where 'a' and 'b' are intercept and slope respectively, of the relationship curve.

The ELEFAN–I computer model (Pauly and David 1981, Saeger and Gayanilo 1986) was used to estimate asymptotic length (L_∞) and growth coefficient (K) of the von Bertlanffy equation of growth in length. Additional estimates of L_∞ and Z/K values were obtained following the equation of Wetherall (1986), as modified by Pauly (1986). The growth performance index (ϕ') of the fish population, in terms of length growth was compared using the index of Pauly and Munro (1984) which is given by:

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

Annual total mortality (Z) was calculated by making use of the dark points of the length converted catch curves and fitting a least square regression line to them, as incorporated in FiSAT routine. Z is assumed to remain constant for all length groups. The estimate of annual natural mortality (M) was determined using the empirical relationship of Pauly (1980):

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

where L_∞ was expressed in centimeters and T (mean annual water temperature) in 0C, which was taken as 27ºC.

Subtracting M from Z gave F, the fishing mortality. Fishing mortality is assumed to be proportional to the effort, the more effort engaged the more will be the fishing mortality. The exploitation rate (E) was calculated by Gulland's (1971) formula of E = F/Z = F/(F + M). Length at first capture, Lc (length at which 50% of the fish entering the gear are retained and 50% escape) was estimated by Beverton and Holts' (1956) equation of:

$$Z = \frac{K\left(L_\infty - \overline{L}_c\right)}{\overline{L}_c - L_c}$$

where Z is total mortality, K is growth coefficient, L_∞ is asymptotic length and Lc is average length of the entire catch.

The recruitment pattern of the stock was determined by backward projection on the length axis of the set of available length-frequency data as described in FiSAT routine. The midpoint of the smallest length group in the catch was taken as length at recruitment, Lr (Murty et al. 1992). Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) were obtained, as a function of E for different levels of Lc and M/K, incorporating probabilities of capture at different size classes (Pauly and Soriano 1986).

The length structured virtual population analysis (VPA) and cohort analysis were done according to the FiSAT routine. The calculated values of the L_∞, K, M, F, a (intercept) and b (slope), of the concerned species, were used as inputs for carrying out its VPA. The t0 value was taken as zero. The method was first developed by Fry (1949) and subsequently modified by many authors. Pauly (1984) and Jones (1984) gave practical reviews of VPA methods.

The total yields, annual stock, average standing stock and maximum sustainable yield (MSY) were then estimated for each species. For this purpose, at first exploitation rate (U) was determined using the relation of Beverton and Holt (1957) and Ricker (1975): U = F/Z (1 – e-z). Then by using the values of U, F and estimated annual yield (Y) the total annual stock (Y/U) and average standing stock (Y/F) were determined. The approximate MSY was then calculated using following relation proposed by Gulland (1979):

$$\text{MSY} = \text{Zt} \times 0.5 \times \text{Bt}$$

where, Zt is the exponential rate of total annual mortality in the year 't' and Bt is the average standing stock in the year 't'.

Results

The asymptotic length values, L_∞ obtained during the year 2000 was 94.6 cm for *L. rohita*, 62.3 cm for *L. calbasu* and 58.0 cm for *L. gonius* the corresponding K values were respectively 0.40, 0.48 and 0.30 (Table 1). The L_∞ values were lower than what was obtained in the year 1999 (Haroon et al. 2002), except for L_∞ of *L. gonius*. The L_∞ values of *L. rohita* recorded by ARG (1986) in the Kaptai lake, Bangladesh was 105.7 cm and by Kahan (1972) in the Indian waters was 101.5 cm. The L_∞ value of L. calabsu were more or less similar to the values as reported by ARG (1986) and Azadi and Kuddus (1995) from the Kaptai lake. The L_∞ values obtained for *L. rohita* and *L. calbasu* in this floodpalin were higher than the values in the neighboring Sylhet floodplain (Haroon et al. 2002). ARG (1986) reported higher values of L_∞ for *L. gonius* in the Kaptai lake. While L_∞ value of *L. gonius* was higher in the neighboring Sylhet floodplain than in this floodplain (Haroon et al. 2002). Figs. 1a, 1b and 1c shows the growth curve of the three species, respectively, drawn over their restructured length distribution with calculated values of L_∞ and K.

The Powell-Wetherall fit gave L_∞ and Z/K values of 94.71 cm and 3.23 for *L. rohita*, 67.71 cm and 5.29 for *L. calbasu* and 53.63 cm and 2.94 for *L. gonius*, respectively with under mentioned regression line values:

L. rohita: Y = 21.91 + (-0.23) x (r2 = 0.98)
L. calbasu: Y = 10.77 + (-0.16) x (r2 = 0.93)
L. gonius: Y = 13.59 + (-0.25) x (r2 = 0.79)

Table 1. Population parameters of *Labeo rohita* (Ham.), *L. calbasu* (Ham.) and *L. gonius* (Ham.) from Myemensingh floodplains, Bangladesh during 2000.

Parameters	*Labeo rohita*	*Labeo calbasu*	*Labeo gonius*
1. Asymptotic length (L_∞) in cm	94.62	62.30	58.00
2. Growth coefficient (K)	0.40	0.48	0.30
3. Total mortality (Z/yr)	1.78	2.30	2.18
4. Natural mortality (M/yr)	0.71	0.88	0.66
5. Fishing mortality (F/yr)	1.07	1.42	1.52
6. Exploitation rate (E)	0.60	0.62	0.70
7. Exploitation level for maximum Y/R, (Emax)	0.515	0.573	0.662
8. Response surface (Rn)	0.100	0.141	0.132
9. Length at first capture (Lc) in cm	27.40	21.94	23.20
10. Length at first recruitment (Lr) in cm	20.00	14.00	15.00
11. Growth performance index (ϕ')	3.55	3.27	3.00
16. Length–weight relationship, W =	0.0092L3.087	0.0066L3.164	0.00385L3.287
17. Sample size (n)	924	2,341	1,616
18. Length range in cm	20.0 – 91.0	14.0 - 60.0	14.0 - 50.0

Length converted catch curves of *L. rohita*, *L. calbasu* and *L. gonius* are shown in Figs. 2a, 2b and 2c respectively. Total annual mortality, Z was 1.78 yr-1 for *L. rohita*, 2.30 yr-1 for *L. calbasu* and 2.18 yr-1 for *L. gonius* in 2000 (Table 1). The natural mortality, M and corresponding fishing mortality, F were 0.71 yr-1 and 1.07 yr-1 for *L. rohita*, 0.88 yr-1 and 1.42 yr-1 for *L. calbasu* and 0.66 yr-1 and 1.52 yr-1 for *L. gonius* (Table 1). The goodness of fit of the fitted regressions to the length converted catch curves were 0.95 for *L. rohita*, 0.99 for *L. calbasu* and 0.98 for *L. gonius*.

Annual recruitment of *L. rohita* and *L. gonius* showed a continuous pattern with a single peak in August-September, while *L. calbasu* showed two spells of recruitment with peaks in June-July and September-October.

The exploitation level (E) value was determined to be 0.60 for *L. rohita*, 0.62 for *L. calbasu* and 0.70 for *L. gonius* during the year 2000 (Table 1). The Emax values of these species, calculated from a plot of relative yield per recruit (Figs. 3a, 3b, and 3c) were 0.51, 0.57 and 0.66 respectively.

The exponential form of equations obtained for the length-weight relationships of these three species are shown in Table 1. The r values for all these three species were >0.9 and almost equal to 1.0 indicating a highly significant

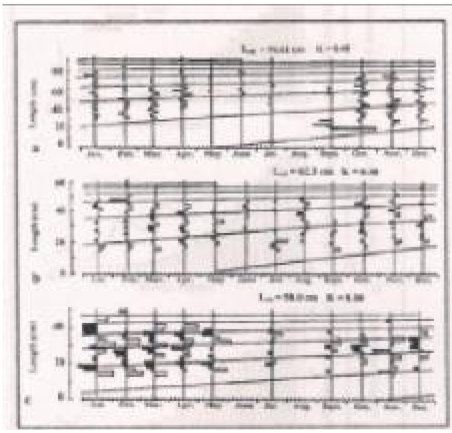

Fig. 1. Growth curves of (a) *Labeo rohita* (Ham.), (b) *L. calbasu* (Ham.) and (c) *L. gonius* (Ham.) drawn over their restructured length distribution from Mymensingh floodplains, Bangladesh during 2000.

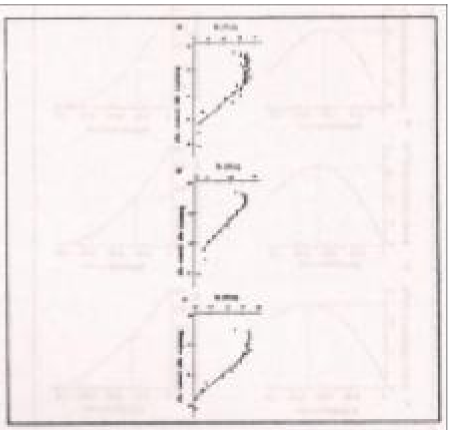

Fig. 2. Length converted catch curve of (a) *Labeo rohita* (Ham.), (b) *L. calbasu* (Ham.) and (c) *L. gonius* (Ham.) from Mymensingh floodplains, Bangladesh during 2000.

Table 2. Comparison of exploitation rate, E with exploitation level for maximum Y/R, Emax of *Labeo rohita* (Ham.), *L. calbasu* (Ham.) and *L. gonius* (Ham.) from Mymensingh floodplains, Bangladesh during 2000.

Species	E	Emax	E > Emax (%)
Labeo rohita	0.60	0.515	16.50
Labeo calbasu	0.62	0.573	8.20
Labeo gonius	0.70	0.662	5.74

relationship. The exponent 'b' value of these species were, 3.087 for *L. rohita*, 3.164 for *L. calbasu* and 3.287 for *L. gonius* and indicated allometric growth pattern. Similar values of 'b' of the length-weight relationship were also reported for *L. rohita* by Pantulu et al. (1967) in India and Ahmed and Saha (1996) and Sayduzzaman (1997) in Bangladesh. ARG (1986) and Ahmed and Saha (1996) reported similar 'b' values for L. calabsu. However, the 'b' values of *L. gonius* was lower than the value obtained by ARG (1986) and higher than the value reported by BCAS (1989).

The mean annual stock, standing stock, and MSY were respectively 360.02 t, 167.83 t and 149.36 t for *L. rohita*, 135.63 t, 53.28 t and 61.30 t for *L. calbasu* and 56.64 t, 23.14 t and 25.22 t for *L. gonius* (Table 3).

The VPA (Figs. 4a, 4b, and 4c) shows higher fishing mortality in the size groups of 57-73 cm of *L. rohita*. The stocks are being fished, right from 19 cm upward with higher fishing mortality in the size ranges of 29-39 cm in case of *L. calbasu* and 17 cm upwards with maximum fishing in the size ranges of 27-39 cm in case of *L. gonius*.

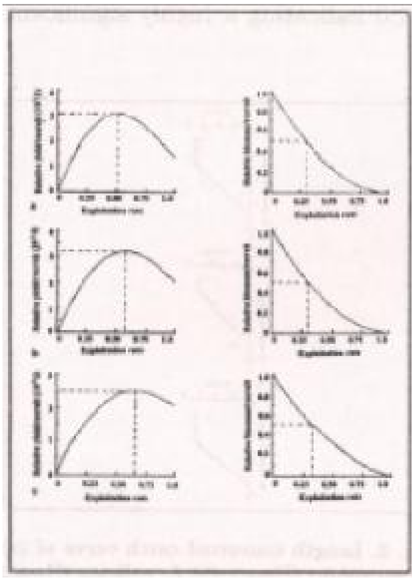

Fig. 3. Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) of (a) *Labeo rohita* (Ham.), (b) *L. calbasu* (Ham.) and (c) *L. gonius* (Ham.) from Mymensingh floodplains, Bangladesh during 2000.

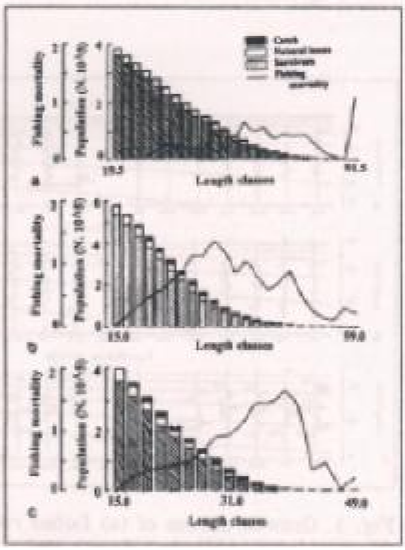

Fig. 4. Length structured virtual population analysis (VPA) of (a) *Labeo rohita* (Ham.), (b) *L. calbasu* (Ham.) and (c) *L. gonius* (Ham.) from Mymensingh floodplains, Bangladesh during 2000.

Table 3. Estimated catch, annual stock, average standing stock and maximum sustainable yield (MSY) of *Labeo rohita* (Ham.), *L. calbasu* (Ham.) and *L. gonius* (Ham.) from Mymensingh floodplains, Bangladesh during 2000.

Species	Estimated catch (t)	Annual stock (t)	Av. standing stock (t)	MSY (t)
Labeo rohita	179.58	360.02	167.83	149.36
Labeo calbasu	75.66	135.63	53.28	61.30
Labeo gonius	35.17	56.64	23.14	25.22

Discussion

Total annual mortality rate showed decreasing trend in contrast to the previous years (Haroon et al. 2002). In all the three species annual fishing mortality values were higher than the natural mortalities. In general, higher fishing mortality than the natural indicates intense fishing pressure. It could be concluded that all these three species were under heavy fishing pressure. Fishing mortality for these three species were higher in this floodpalin than the neighboring Sylhet floodplain (Haroon et al. 2002). ARG (1986) reported lower values of natural mortality for *L. rohita* and *L. calbasu* from the Kaptai lake. Natural mortality value of *L. rohita* was 0.56 yr-1 and total mortality, Z was 0.92 yr-1 from the neighboring Dhir beel of Assam, India (Goswami and Devraj 1995).

Haroon et al. (2001a) found a continuous recruitment pattern with one major peak in all these three species in this floodplain. Annual recruitment pattern of the major carps into the floodplains of Bangladesh often consisted of two uneven seasonal pulses of which first occurred more or less in the early monsoon and the second occurred in the late monsoon (Haroon et al. 2002). Azadi and Kuddus (1995) and Azadi et al. (1996) also reported similar recruitment patterns of major carps in Kaptai lake.

Present exploitation rate when compared with the theoretical 'ideal E' value of 0.5 for desirable fishing effort indicated overexploitation in all cases. The stocks of all these three species are being overexploited, by 16.5%, 8.2% and 5.7%, respectively (Table 2) in respect to their Emax. The status of *L. gonius* exploitation level, being just marginally higher than desirable, is better than the other two species. The situation is worst for *L. rohita* where the Lc value (27.40 cm) has also significantly gone down than the previous years. Haroon et al. (2001a and 2002) also drew similar conclusions for the Gangetic carps' stock from this floodplain.

It can be seen from table 3 that for all the three species the mean annual catches were much higher than their estimated MSY. The quantity of fish harvested (in terms of weight) was 20.2%, 23.4% and 39.4% in excess of their MSY respectively. This indicates that the stocks of these three species are definitely being overexploited. Their E and corresponding Emax (see Table 1) value also supports overexploitation situation.

Conclusion

Population dynamics studies revealed that the fishery of *L. rohita, L. calbasu* and *L. gonius* in the Mymensingh floodplain wetlands is deteriorating and in a state of overexploitation. Even the stock of *L. gonius* which was being exploited more or less on optimal level in 1999 (Haroon et al. 2001a) is now being overexploited. In case of *L. calbasu* the fishing pressure appears to be high even on smaller size groups of 19-21 cm (70-100 g). The condition is worst in the case of *L. rohita* where length at first captures, Lc value (27.40 cm) has significantly gone down in relation to the previous years. It is imperative that proper regulatory measures (increase the mesh size of the prevailing major gears and regulate fishing) are taken soon. Regular supplemental stocking of closed type beels and large-scale pen culture in this floodplain can help in increasing their fish production potential and stabilize their stock. Large-scale pen culture can also be undertaken to raise their fingerlings to a desired size locally before stocking them in the vast beels.

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