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Biology and Fishery of Banded Gourami, *Colisa fasciata* (Bloch and Schneider 1801) in a Floodplain Wetland of Ganga River Basin

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Abstract

The banded or giant gourami, *Colisa fasciata* (Bloch and Schneider 1801) has high food as well as ornamental value in India and its neighbouring countries. The natural resources of this species are declining due to over exploitation. Food habits, condition, reproductive biology, length–weight relation, population parameters and fishery resource status of the species in a floodplain wetland in the Ganga River basin, India, were studied to provide inputs for conservation of the natural populations of the species. The fish subsisted mainly on phytoplankton. Sex ratio was in favor of males. Fecundity ranged from 1095 to 19291. Females matured at 5.7 cm in total length. The breeding period was March–September. The regression model for length and weight of the fish was established. Catch was maximum during October-February, the post spawning period, and lower during March-September, the breeding period. The estimates obtained for von Bertalanffy growth coefficient (K) =1.3 year^{-1}, total mortality (Z) = 2.8 year^{-1}, natural mortality (M) = 2.3 year^{-1}, fishing mortality (F) = 0.5 year^{-1}, exploitation ratio (E)= 0.18, exploitation rate for maximum yield per recruit (E_{max})= 0.6, asymptotic length (L_∞) = 10.4 cm, length at maturity (L_m) = 7.0 cm and length at maximum possible yield (L_{opt}) = 6.1 cm. Ten percent of the fishes caught were immature and 37% were in the length at maximum possible yield. Closed or less intense fishing during March–September and selective catch of specimens of 6 cm length would help in the conservation of the natural stock of the fish and to obtain maximum possible yield.

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Introduction

The giant or banded gourami, *Colisa fasciata* (Bloch and Schneider 1801), is one of the common species of fishes of the family Belontidae found in Asia. The species is naturally distributed in Bangladesh, India, Myanmar, Nepal and Pakistan and widely transported around the world (Welcomme 1988). It commonly inhabits freshwater pools, ditches, ponds, marshes (Rahman 1989) and rivers as well as lakes with vegetation (Menon 1999). Although this species is considered a weed/unwanted fish in fisheries and aquaculture circles, it in fact plays an important role in meeting the nutritional requirement of poor fishers in India and its neighboring countries such as Bangladesh, Myanmar and Sri Lanka. In eastern and northeastern India, the fish has very high consumer demand, fetching INR 30-60 per kg. The species has also gained importance for its ornamental value as an indigenous aquarium fish and is being exported to Bangladesh, China, Germany, Hong Kong, Japan, Malaysia, Republic of Korea, Singapore, Taiwan, Thailand and USA (Sugunan et al. 2002; Tripathi 2004). The natural resources of this species are, however, fast declining in India, due to modification of its habitats and over exploitation for human consumption as well as aquarium trade. The demand for this fish in aquarium trade in India is entirely met through collection from the wild. Although the species is not listed in the IUCN Red Data Book (Anonymous 2006), it is included under 'Lower Risk-near threatened' category in India (Anonymous 1998). Unregulated exploitation of wild populations of the species might endanger them. Although considerable work has been done on their mass breeding and rearing for aquarium purposes, sufficient information on the biology and fishery of natural populations and life history parameters is not available to provide necessary inputs to conservation of the natural populations of the fish. This study deals with the biology of the natural populations of the species (food habits, fecundity, condition, maturity and spawning), length weight relationships, fishery and resource status in an oxbow lake in Ganga River basin, India.

Materials and Methods

Monthly samples of *C. fasciata* were collected from a floodplain wetland, situated in the Ganga river basin at North 24 Parganas district of West Bengal, India. Locally known as *Borti beel,* the wetland has a maximum water spread of 5000 ha during monsoon floods and remains water logged for August-March. Thereafter the water recedes and the wetland remains as a channel, connected to the Ganga River from April to July. *Colisa* spp. contributes significantly to the fishery from the wetland. The fish samples for this study were caught through experimental fishing, using a dragnet of fine mesh and fixed size (5 x 1.5m), operated by two persons. The net was operated 10 times at randomly selected stations of the wetland on sampling days, every month, for a period of 12 months, during 2003-2004. The frequency of sampling was once a month and the time of collection was fixed during the morning hours. After blotting off the water from their body, the total length, from the tip of the snout to the longest caudal fin ray was measured to the nearest 0.1 cm and the weight (g) was recorded on an electronic balance sensitive to 0.001 g. This information was used for fisheries and length frequency study. A subsample comprising about 20-30 fish, representing the available length range of the catch, were used every month for studies on biological parameters. The specimens were preserved in 10% formalin and brought to the laboratory for subsequent analysis. Sexes were separated by external morphology (Swarup et al. 1972): the upper lip of the male is more pronounced and the dorsal ventral fins are more pointed at the posterior end as compared to the female, and by examining the gonads.

Guts of the specimens were dissected out and subjected for food analysis. The food items were identified up to major taxonomic groups. The period of intense feeding of the fish was arrived at by following the monthly gastro somatic index expressed as weight of gut divided by weight of fish x 100.

Sex ratio of the fish was studied through Binomial Proportion test (Snedecor and Cochran 1967) following the equation given below:

$$Zc = \frac{(|r - np| - \frac{1}{2})}{\sqrt{(npq)}}$$

Where r= number of males, n=total number of samples. It was assumed that the ratio of male to female in the population was 1:1.

The fecundity was estimated by counting the number of mature ova (opaque and larger in size) from known weights of subsamples collected from both the ovaries and calculating the total number of mature ova in the ovary following Grimes and Huntsman (1980). The condition factor K was calculated using the formula:

$$K = \frac{W}{L^3} \times 10^5$$

where W is weight (in g) of fish, L is the total length (in cm) of fish and the number 10^5 is introduced to bring the value near unity. The relative condition factor was calculated as:

$$Kn = \frac{W_0}{\overline{W}}$$

where W_0 is observed weight and $\overline{W}$ is calculated weight from the length-weight relation. The length at first maturity was determined directly by plotting the percentage of mature females against their length and the length at which 50% of the females were mature (with developed ova in ovaries) was considered as the length at first maturity. To determine the spawning season and breeding periodicity, the ova diameter progression was recorded monthly (an ocular micrometer was used for the measurement of diameter) and by plotting the mean percentage frequency of ova of different diameter in mature ovaries, against different months (Hickling and Rutenberg 1936). Small and transparent ova were considered as immature; medium sized and less transparent were considered as maturing and the large opaque ova were considered as mature or ripe. The relationship between fecundity and total length of fish, weight of fish and ovary weight were calculated by ordinary least square regression analysis (Bagenal 1967). Gonadosomatic index (GSI) of females was estimated following June (1953). The relation between length and weight of the fish was established following the formula of Le Cren (1951) as $W = aL^b$ and parameter 'a' and the exponent 'b' were estimated by the least square by transforming the equation into a straight-line equation, $\log W = \log a + b \log L$ (Lagler 1956). A total of 402 specimens with 3.3-9.7 cm length and 1.74 - 21.13 g weight were used to estimate the length-weight relationships for male and female. The regression curves of the length-weight equation obtained for male and female were compared using Covariance test (Bernard 1966) to see whether they vary from each other. To see whether the species followed the cubic law the values of the exponent 'b' of the regression equation was tested against '3' applying Student's 't' test (Snedecor 1961).

The population parameters *viz*. growth coefficient (K), total mortality (Z), natural mortality (M), fishing mortality (F), exploitation ratio (E) and exploitation level for maximum yield/recruit (E_{max}) were estimated using the FiSAT II (FAO-ICLARM Fish Stock Assessment Tools) software package. The asymptotic length (L_∞), length at maturity (L_m) and length at maximum possible yield (L_{opt}) were estimated following Froese and Binohlan (2000) using the 'popdynJFB' spreadsheet downloaded from http://www.fishbase.org. To assess the fishery status, length frequency of the fish caught during the experimental fishing was plotted in a frame work of L_∞, L_m and L_{opt} (Froese and Binohlan 2000) and the relative yield per recruit (Y/R) as a function of E were determined from the estimated growth parameters and probability of capture by length using the FiSAT II software package. The landing of the species from the wetland was studied by estimating the market arrival in Neelganj fish market, 24 Parganas North district, West Bengal, where fishes caught from the wetland are mostly sold. The landing was recorded through eye estimation on random days, every month and total monthly landing was calculated taking into account the number of fishing days in each month.

Results

The mouth of the fish is bordered by thick lips, the upper being protrudable and more pronounced in the male. Small and feeble teeth are present in the mouth and buccal cavity. The intestine is long and coiled; length varied from 14.6 to 52.0 cm in fishes of 3.3-9.7 cm length. Ninety-one percent of the gut contents were of plant material and the rest were animal matter (Fig. 1). Among the plant material, bacillariophyceae (51 %) and chlorophyceae (25 %) were the major food components. The food items were *Anabaena* sp., *Anomoinies* sp., *Closterium* sp., *Diatoma* sp., *Microsystis* sp., *Navicula* sp. and *Nitzchia* sp. among plant matter and *Brachionus* sp., *Chironomus* sp. larvae, *Cyclops* sp., *Cypris* sp. and *Notholca* sp. among animal matter. The gastrosomatic index of both the sexes was low during May-July. From August onwards it gradually increased and reached its peak in October, then declined gradually (Fig. 2).

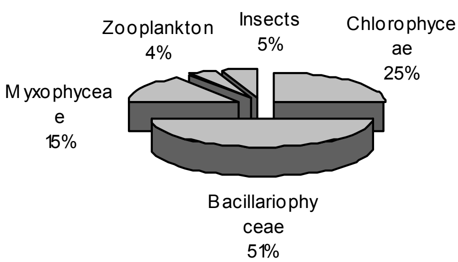

Fig. 1. The composition of gut contents of *C. fasciata*

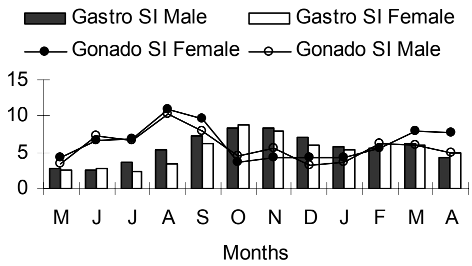

Fig. 2. Gastrosomatic index and gonadosomatic index of male and female *C. fasciata*

The sex ratio of the fish showed significant variation from the expected ratio of 1:1 (Binomial test, $p \leq 0.05$), with 0.1 to 2.1 female for every male. The sex ratio for the pooled monthly observations was also significantly different from the expected ratio, with 0.4 females for every male (Table 1). The paired gonad was mostly off-white in colour and elongated leaf like in female and slender thread like in male. Fecundity ranged from 1095 (6.1 cm and 5.3 g size) to19291 (8.6 cm and 13.9 g size). The relative fecundity (number of ova per gram of body) was 206-1392. The monthly variation in mean fecundity, calculated as mean of fecundities of monthly samples, is shown in figure 3. Fecundity was low during October-March. The regression relation of fecundity with length, weight and ovary weight of the fish is shown in figure 4 and the models obtained for relations of fecundity (F) with length (L), weight (W) and gonad weight (G) were $F= 1.5535 \times 10^{-5} L^{4.5788}$ ($R^2=0.5533$, $df=63$, $P \leq 0.01$), $F= 6.1830 \times 10^{-3} W^{1.6437}$ ($R^2=0.5572$, $df=63$, $P<0.01$) and $F= 6.2560 \times 10^{-5} G^{1.0827}$ ($R^2=0.9113$, $df= 63$, $P \leq 0.01$), respectively.

Table 1. Monthly variation in sex ratio (male: female) of *C. fasciata*

Months	Male	Female	Sex ratio	*P*
May	14	29	1:2.1	2.13498*
June	3	4	1:1.3	--
July	35	15	1:0.4	2.68701*
August	43	11	1:0.3	4.21857*
September	28	3	1:0.1	4.31053*
October	64	4	1:0.1	7.15480*
November	45	7	1:0.2	5.13098*
December	46	5	1:0.1	5.60112*
January	40	5	1:0.1	5.06842*
February	26	21	1:0.8	0.58346
March	5	10	1:20	1.03279
April	16	9	1:0.6	1.2
Overall	365	133	1:0.4	7.03779*

*$P \leq 0.05$

Monthly mean condition factor (K) and the relative condition factor (Kn) values are shown in figure 5. The values did not show marked variations; fluctuation range being K=1.87-2.37 and Kn=1.46-1.87. The maturity curve plotted for the fish by direct observation of ovaries showed that 50 % of the females matured at length 5.7 cm (Fig. 6).

Monthly progression of ova diameter (Fig. 7) showed that immature ova (0.07-0.23 mm) were present in the ovaries during December-June. The maturing ova (0.38-0.56 mm) and the ripe ova (0.66-0.78 mm) were present during March-September. The frequency of mature ova began to build up from March (25 %) and reached its peak during July-September (40-48 %) and disappeared from October then again reappeared from March onwards.

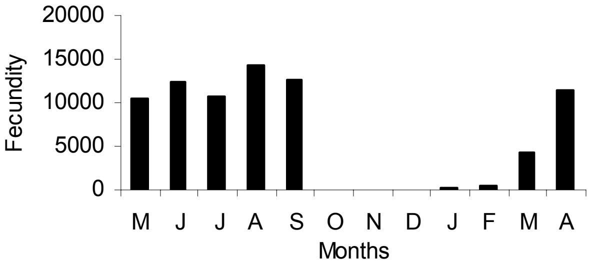

Fig. 3. Mean monthly variations in fecundity of *C. fasciata.*

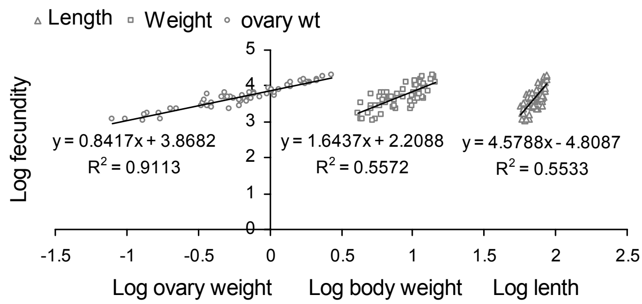

Fig. 4. Relation between fecundity and body length, body weight and ovary weight of *C. fasciata.*

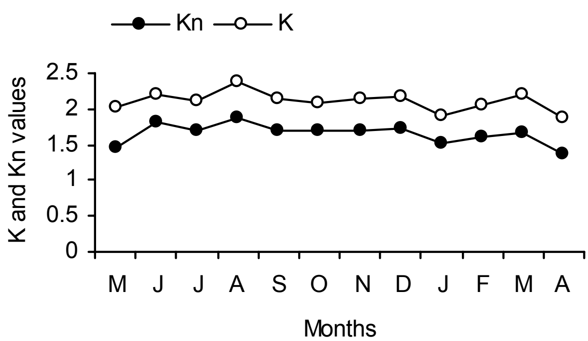

Fig. 5. Monthly variation in *K* and *Kn* values of *C. fasciata*

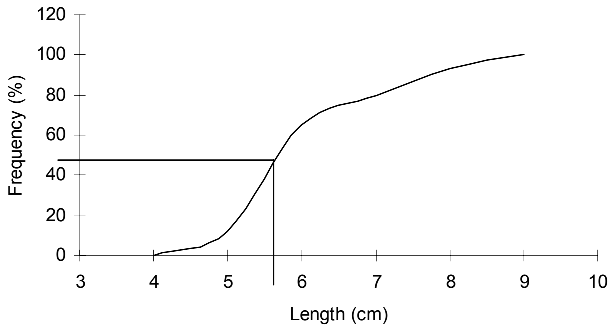

Fig. 6. Percentage occurrence of mature female *C. fasciata* at different lengths

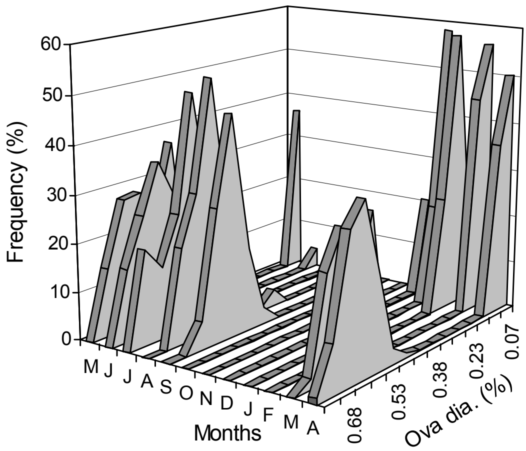

Fig. 7. Monthly progression of ova diameter frequency of *C. fasciata*

The gonadosomatic index (*GSI*) of both male and female also showed its peak during March-September, with fully grown ovary (Fig. 2). The values of *GSI* began to drop sharply after September. The lowest values of *GSI* were during October-February. The feeding intensity reduced during May-August, the breeding period, as inferred from figure 2. The feeding gradually intensified from September and remained higher than that of the breeding season until April, the beginning of breeding.

The length-weight regression relations established for male and female are given in figure 8. The length and weight of the species in both the cases showed significant relation. Covariance test (Table 2) revealed that the regression line for male and female differed significantly from each other (P=≤0.05), hence regression models were fitted separately for male and female. The regression models obtained were $W=5.1701\text{x}10^{-5}L^{2.7868}$ (R^2=0.9272, df=244, $P\leq0.01$) for male and $W=1.9333\text{x}10^{-5}L^{3.0207}$ (R^2=0.92, df=160, $P\leq0.01$). The value of exponent '*b*' for female followed the cubic law (t= 0.29313, df=160), whereas that of the male did not follow the cubic law (t=3.4425, df=244, $P \leq 0.01$).

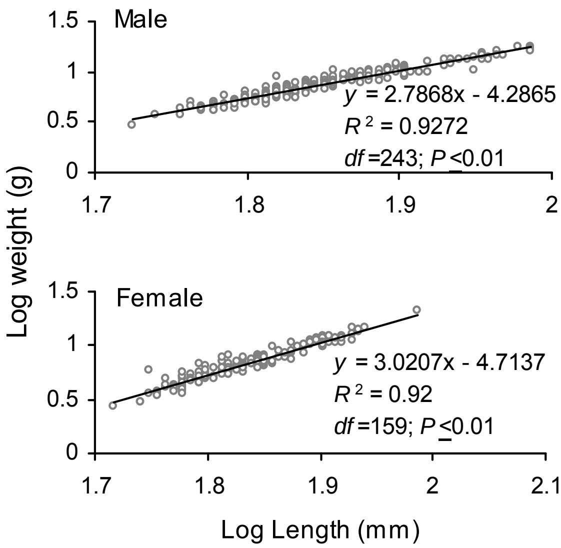

Fig. 8. Length-weight relation of male and female *C. fasciata*

Table 2. Covariance test performed to compare the length weight regression curve of male and female *C. fasciata*.

Sample	df	$\sum X^2$	$\sum XY$	$\sum Y^2$	RC	df	$\frac{\Sigma y^2 - (\Sigma xy)^2}{\Sigma x^2}$	*Mean square*	F
Female	160	0.4231	1.2780	4.1963	3.0207	159	0.3359	0.0021	6.1673*
Male	243	0.6124	1.7066	5.1294	2.7868	242	0.3733	0.0130	
Total	403	1.0356	2.9846	9.3257	5.8075	401	0.7092		

RC: Regression Coefficient: *=$P \leq 0.05$

The estimates obtained for growth coefficient (K) =1.3 year^{-1}, total mortality (Z) =2.8 year^{-1}, natural mortality (M) = 2.3 year^{-1}, fishing mortality (F) = 0.5 year^{-1} and exploitation ratio (E) = 0.18. Exploitation level for maximum yield per recruit (E_{max}) obtained through the relative yield per recruit (Y/R) estimates for the fish at M/K of 1.769 and L_c/L_∞ of 0.384 is 0.6 (Fig. 9). The estimate obtained for length at infinity (asymptotic length) L_∞ = 10.4cm (s.e range 8.7-12.3cm); length at maturity L_m= 7.0cm (s.e. range 5.3-9.3cm) for the fish and length at maximum yield was L_{opt}= 6.1cm (s.e. range 5.2-7.2cm). Figure 10 depicts the length-weight data plotted in the frame work of L_∞, L_m and L_{opt}.

The abundance of the fish in different months, revealed by the fixed effort per gear experimental fishing, is shown in figure 11. The abundance ranged from 10 fish, 100 g in June and 68 fish, 435 g in October. The abundance was maximum during October-February (18 to 68 fish and 191 to 435 g), the period of post spawning. The abundance was lower during breeding period (March-September). The estimated monthly landing of the species at Neelganj fish market is shown in figure 11, which was high during October-January (2700-3150 kg) and lower during April-July (75-150 kg).

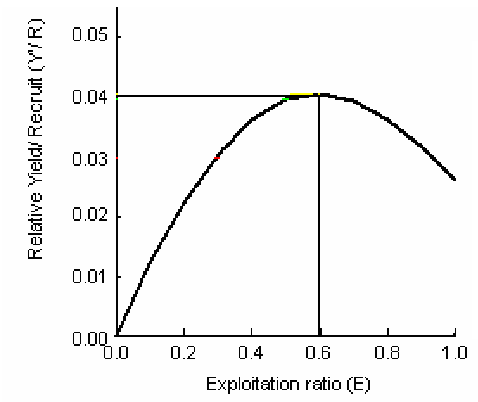

Fig. 9. Relative yield per recruit for *C. fasciata*

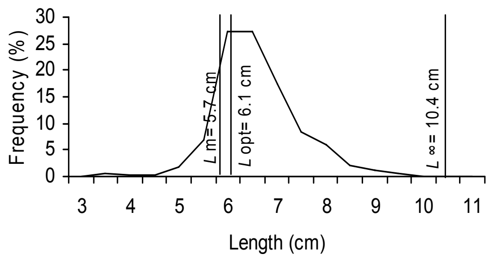

Fig. 10. Length frequency data of *C. fasciata* plotted in a framework of L_∞, L_m and L_{opt}

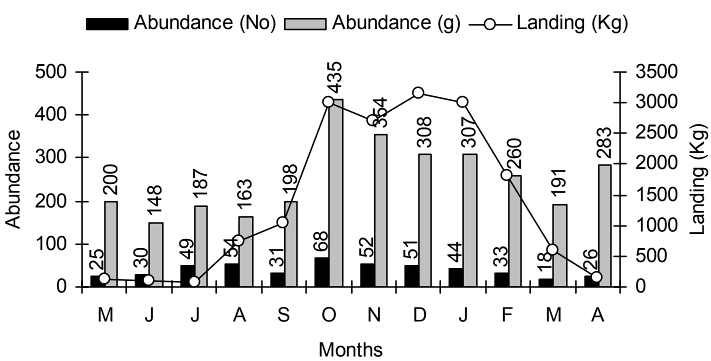

Fig. 11. *C. fasciata* in number and weight (g) in experimental fishing and estimated monthly landing (kg) from the wetland during May 2003-April 2004

Discussion

The long and coiled alimentary canal of the fish indicated its herbivorous nature. The presence of >90% plant matter in the gut of the fish showed that the fish feed predominantly on plant matter and herbivorous in nature in the wetland. Mookerjee et al. (1946) reported the herbivorous nature of the fish. Dasgupta (2004) also reported predominance of plant matter in the gut contents of the fish (84.66 %). While Das and Moitra (1963) described the species as a typical omnivore, feeding on almost equal quantities of plant (49.4 %) and animal (44.6 %) matter. Describing the structure of the alimentary canal of the species, Moitra and Ray (1977) also indicated its omnivorous feeding habits. It seemed that the species may be choosing its food depending on the prevalence of materials in the habitat and can subsist on a wide range of food items. Low gastrosomatic index during May-August indicated low feeding intensity, while September-December was the most intense feeding period with high gastrosomatic index, which corresponded with the post spawning period. This might be related to the increased intake of food after spawning during March-September as discussed in reproductive character elsewhere in this paper.

The monthly sex ratio was mostly in favor of males indicating more males than females in the population. Fecundity was high during April-September (Fig. 3), the breeding period and the fecundity range recorded in this study were higher than that reported earlier by Behra et al. (2005) for the species (599-5522 at 5.9-7.2 cm and 7.3-10.8 g size). This might be due to the larger size range of the specimens in this study (6.1-8.6cm and 5.3-13.9 g). This was supported by the regression relation showing that fecundity increased significantly (P<0.01) with an increase in length, weight and ovary weight of the fish (Fig. 4). This indicated that egg production increases with the increase in size of the mature female. The condition factor K and relative condition factor Kn indicate the physiological state of fish involving maturity, spawning, environmental condition and availability of food (Brown 1957).The K values fluctuated between 1.9 and 2.37; lowest being in April coinciding with the breeding and low feeding periods (Fig. 5). The relative condition values (1.37-1.87) also showed similar trend. The length at first maturity worked out through direct method by plotting the maturity curve for females was 5.7cm (Fig. 6), which was lower than the values estimated following Froese and Binohlan (2000) nevertheless, it fell within the s.e. range of the estimate. The high frequency of occurrence of mature ova (40-48%) in the ovaries during March-September and absence of maturing and mature ova during October-February (Fig. 7) is an indication that the fish breeds during March-September and by October the spawning was over. This was also supported by the high GSI values of both male and female during March-September (Fig. 2). The values of GSI began to drop sharply after September indicating that spawning was over, which corroborated the breeding period inferred from ova diameter progression (Fig. 7). The reduced gastrosomatic index during May-August (Fig. 2), the period of breeding, indicated that feeding intensity was reduced during breeding.

Knowledge of length-weight relation of fish helps in predicting potential yield and determination of size at capture for obtaining optimum yield, as these parameters are directly related to weight of the fish. The relationship is also useful in differentiating populations as variations occur in populations of different localities (Le Cren 1951; Chonder 1972). The exponent '*b*' and regression (R^2) obtained in the length weight relation for male and female separately were highly significant (Fig. 8). When the values of the exponent '*b*' were tested against '3' following Student's *t*-test, only females followed the cube law. For a fish, which maintains shape proportion throughout its life, the value of exponent '*b*' will be '3'; deviation from this indicates allometric growth (Verghese 1961; Talwar 1962). Beverton and Holt (1957), while discussing the merits of allometric formula (W=aL^b) with the cube formula (W=aL^3), stated that instances of deviation from isometric growth in adult fishes are rare. According to Hile (1936) and Martin (1949) the values of the exponent '*b*' usually remain between 2.5 and 4.0 and in majority of the cases the value was not equal to '3'. Therefore considering the closeness of the value and the possible influence of sex and other internal and external factors on growth, as described by Le Cren (1951), it may be considered that the fish followed fairly isometric growth. The maximum length reported for the fish is 12.5 cm (Menon 1999). In this study the maximum length recorded was 9.7 cm.

The estimated exploitation ratio of the fish in the wetland is E = 0.18, while the estimated exploitation level required for obtaining maximum yield per recruit (E_{max}) is 0.6 (Fig. 9) indicating that the fishing effort can be increased to obtain maximum yield/recruit. Plotting the length frequency data obtained from the fixed gear/effort experimental fishing in a L_∞, L_m and L_{opt} framework (Froese and Binohlan 2000) revealed that 10% of the fishes caught was smaller than their length at first maturity (observed 5.7 cm). A fishery would obtain the maximum possible yield (L_{opt}) if it were to catch only fish of this size (Beverton 1992). Fisheries managers or conservationists need to attempt to see that the exploitation rate be kept within the level of E_{max} and the size of fish caught are at mean lengths nearer to L_{opt} to optimize the catch. The length at maximum possible yield for this fish in the wetland being L_{opt}= 6.1cm, the frequency of catch at this size for the fish in the wetland was only 27.3% (Fig. 10). This indicated that the yield could be increased if fishes at 6.1cm (say 6 cm) are caught, which is above the size at first maturity (5.7cm). Although the length at first maturity obtained for the fish is 5.7 cm, the minimum length recorded for specimens with spent ovaries were 6 cm. Hence selective capture of fishes of 6 cm size would give maximum yield and curb growth over fishing. Hence modification of fishing gear for selective fishing of this size would help in optimizing yield at the same time help in the conservation of the natural stock as the fish must have attained sexual maturity at this size and is expected to have completed breeding at least once.

The catch was maximum during October-February (18 to 68 fish and 191 to 435 g), the period of post spawning (Fig. 11). The fishery in the wetland intensifies with the onset of monsoon by July-August and continues until the end of March. Then fishing intensity declines as the water recedes. However fishing for small species like *C. fasciata* continues unabated from the channel and isolated pools throughout the year even after the flood water recedes. The estimate of market landing showed intensive fishing for this small species with maximum catch as high as 100 kg day^{-1}. The landing in market exhibited similar trend of the catch from experimental fishing (Fig. 11). These results indicated that the most productive fishing period for the species is October–February. The status of the ovary of the fishes caught during October–February also revealed that most of the ovaries were spent (Fig. 7) during this period. Hence closed or less intense fishing during March–September, when the fish breeds and selective catch of specimens of 6 cm length would help in the conservation of the natural stock of the fish and help attain the maximum possible yield.

Conclusion

Colisa fasciata feeds mainly on phytoplankton in the wetland, attains sexual maturity at 5.7 cm in total length and breeds during March–October. About 10 % of the fish caught were smaller than their lengths at first maturity and 37 % were in the length at maximum possible yield. Selective capture of 6-7 cm size group would give maximum yield from the fishery. Closed or less intense fishing during March–September and selective catch of specimens of 6 cm length would help in the conservation of the natural population of the fish and help attain maximum possible yield.

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