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Culture potential of *Amblypharyngodon mola* with carps in polyculture in farmers' ponds of Northern regions of Bangladesh

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Abstract

To assess the culture potential of mola (*Amblypharyngodon mola*) along with carps in polyculture systems, an experiment consisted of three treatments each with five replications was conducted for 4 months in two villages of Parbatipur upazilla under Dinajpur district. In the first treatment (SS), catla, rohu, mrigal, grass carp, Thai punti, common carp and a higher density of silver carp (8 per $40m^2$) were stocked. In the second treatment (SM), stocking density of silver carp was reduced to half and mola was added at a stocking density of 12,500/ha with all other fishes used in SS. In the third treatment (MM), no silver carp was stocked and mola was added at a stocking density of 25,000/ha with all other fishes used in SS. All treatments were subjected to the same regime of feed and fertilizers. The yields of large carps were 2035 kg/ha, 1757 kg/ha and 1326 kg/ha for treatments SS, SM and MM, respectively. Catla, grass carp and carpio showed better growth and production performance in presence of mola at a higher density, while rohu, Thai punti and mrigal showed better performance when stocking density of mola was relatively low. Mola yield was almost two times higher (184 kg/ha) in absence of silver carp (MM) than (62 kg/ha) in presence of silver carp (SM). The result showed that there was a significantly ($p<0.01$) lower total fish production in treatment MM. But there were no significant difference in total production between treatment SS and SM.

Key words: *Amblypharyngodon mola,* Polyculture, Carps

Introduction

The small indigenous fish, such as mola, punti, chela, chapila, colisa etc. have now great demand in the rural as well as urban markets. There is a tendency that, farmers' once stock fingerlings at the culture season and sell their entire crop at the harvest season, keeping their family unfed. If small and large fish could be cultured together, farmers would have the opportunity to harvest small fish periodically round the year and feed the members of the family with nutrient rich small fish and could sell their large carps as cash crop.

Amblypharyngodon mola, locally known as mola or moia was once abundantly found in the rivers, canals, ponds and ditches etc. (Ahmed 1984, Rahman 1989). Mola is particularly important as the fish contains more available vitamin A than any other edible fish species in this country (Ahmed 1981). Over ten years, efforts have been made at Bangladesh Agricultural University to develop a carp-SIS polyculture technology including small indigenous species of fishes (mola, punti, chela, dhela etc.). As part of this effort, dissemination of the new technology and potentials of its introduction in different major agro-ecological zones have tried. Considering the many fold benefits, culture potential of mola with major carps in the polyculture in the farmers' pond of northern region of Bangladesh has been tried.

Materials and methods

The experiment was carried out in farmers' ponds at Nowdapara and Kalaighati village of Parbatipur Upazilla, Dinajpur from July to November 2005. Pond size ranging from 6 to 21 decimals (decimal = $40m^2$) with 1 to 1.5m water depth. All ponds were rain-fed, well exposed to prevailing sunlight and without an inlet or outlet.

Design of the experiment

The experiment was conducted with 3 treatments each with 5 replicates. Replicates of each of three treatment groups were assigned by stratified random selection of ponds. Stocking density Thai punti and all Indian major carps were same in all treatments. In the control treatment (SS) stocking density of silver carp was 8 per decimal which was partially replaced with mola (4 silver carp and 50 mola per decimal) in the second treatment (SM). Silver carp was fully replaced by mola (100 mola per decimal, no silver carp) in the third treatment (MM) (Table 1).

Table 1. Fish species composition and stocking density in each treatment

Species	Common name	SS (Ctr)	SM	MM
Catla catla	Catla	6	6	6
Hypophthalmicthys molitrix	Silver carp	8	4	–
Labeo rohita	Rohu	4	4	4
Ctenopharyngodon idella	Grass carp	3	3	3
Chirhinus cirrhosus	Mrigal	6	6	6
Cyprinus carpio	Carpio	3	3	3
Barbodes gonionotus	Thai punti	10	10	10
Amblypharyngodon mola	Mola	–	50	100

Pond preparation & stocking of fish

All predatory and other fishes were removed from the experimental pond by repeated netting. Ponds were prepared properly with lime at the rate of 1 kg per decimal and initial fertilization with urea, TSP and cowdung at the rate of 400 g, 400 g and 5 kg per decimal, respectively. Fingerlings of carps and Thai punti were collected from the hatchery of the Northwest Fisheries Extension Project (NFEP), Dinajpur. Mola fry was collected both from local farmers and NFEP hatchery ponds. Initial length and weight of fingerlings were measured before releasing into the pond.

Post stocking management

Mustard oil cake and rice bran were used as supplementary feed at the rate of 2% body weight of fish. After stocking of fish urea, TSP and cowdung were used at 10 days interval at the rate of 100 g, 100 g and 4 kg per decimal, respectively. Fishes were sampled monthly using a seine net. The length and weight of 20 individuals of each species were recorded in prescribed format. Length was taken by using a centimeter scale and weight by using a portable balance.

Water quality determination

Water quality parameters such as temperature (°C), transparency (cm), dissolved oxygen (mg/L) and pH were measured on the spot once in a month. Water transparency was measured with a secchi disc. Temperature and dissolved oxygen of water was measured by portable digital DO meter (YSI model 85-10 FT). pH was measured by direct reading with a digital pH meter (HANNA HI-98107) on spot.

Study of growth and production of fish

Fish were harvested at the end of experiment by repeated netting with seine net and were measured and weighed. The following parameters were used to evaluate the growth:

a) Average weight gain = Mean final fish weight- mean initial fish weight

b) Specific growth rate:

$$\text{Specific Growth Rate (\% day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

Where, W_1 = the initial live body weight (g) at time T_1 (day)

W_2 = the final live body weight (g) at time T_2 (day)

c) Survival (%) = $\frac{\text{No. of fishes harvested}}{\text{No. of fishes stocked}} \times 100$

e) Production of fishes:

Yield = No. of fish caught × Average final weight

Statistical analysis

The data obtained in the experiment were analyzed statistically by analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) as post-hoc test using SPSS (version 11.5) statistical software (SPSS Inc., Chicago, USA). Differences were considered significant at an alpha of 0.05, and means were given with ± standard error (SE).

Results

Water quality parameters

The result of water quality parameters in different ponds such as temperature, transparency, dissolved oxygen and pH are shown in Table 2. Water temperature over the study period was found to vary from 27.7 to 31.0 °C. The mean water temperature was 29.2±0.1 °C, 29.1±0.2 °C and 29.0±0.2 °C in treatment SS, SM and MM, respectively. The mean water transparency was 14.9±0.9 cm, 13.9±0.9 cm, and 15.1±0.9 cm in treatment SS, SM and MM, respectively. The ranges of water transparency varied from 9 to 26 cm. Dissolved oxygen varied from 2.6 mg/L to 8.2 mg/L without significant difference among the treatments. Overall mean of DO were found 4.20±0.19 mg/L, 3.93±0.26 mg/L and 4.25±0.23 mg/L in treatment SS, SM and MM, respectively. pH of pond water was found to be approximately neutral or slightly alkaline. The highest and lowest values of pH under treatment SS were 8.7 and 7.3 with an average of 7.94±0.09, treatment SM were 8.5 and 7.0 with an average of 7.54±0.08 and treatment MM were 9.2 and 7.2 with an average of 7.77±0.10.

Table 2. Mean values of water quality parameters of 15 ponds under three treatments

Parameters	SS	SM	MM
Temperature (°C)	29.2±0.1 (28.4-30.5)	29.1±0.2 (27.7-31.0)	29.0±0.2 (28.0-30.4)
Transparency (cm)	14.9±0.9 (10-26)	13.9±0.9 (9-23)	15.1±0.9 (9-26)
Dissolved oxygen (mg/L)	4.20±0.19 (2.6-6.6)	3.93±0.26 (2.6-8.1)	4.25±0.23 (3.3-8.2)
pH	7.94±0.09^{a} (7.3-8.7)	7.54±0.08^{b} (7.0-8.5)	7.77±0.10^{ab} (7.2-9.2)

* Mean values with different superscripts in the same row were significantly different ($P < 0.05$).

Fish growth and production performance

Details of growth parameters and production of fish are presented in Table 3. Among all species silver carp attained the maximum weight at harvest (531.13-632.29g). Among the two treatments where silver carp was stocked, better growth performance in terms of weight gain (624.77g) and SGR (4.75%) was observed in treatment SM, where it was stocked with mola. But survival of silver carp was higher in treatment SS (77.68%) than in treatment SM (73.98%). Yields of silver carp in treatments SS and SM were 794.32 kg/ha and 457.3 kg/ha, respectively.

Table 3. Growth and production performance of fish as obtained from treatments

Performance	SS	SM	MM
Silver carp			
STOCKING			
Mean weight (g/fish)	7.52	7.52	–
Stock biomass (kg/ha)	14.86	14.86	–
HARVEST			
Mean weight (g/fish)	531.13±80.7	632.29±49.85	–
Weight gain (g/fish)	523.6±80.17	624.77±49.85	–
Survival (%)	77.68±8.10	73.98±5.74	–
SGR (% bw/day)	4.55±0.16	4.75±0.09	–
Yield (kg/ha/4 months)	794.32±64.42[a]	457.3±21.48[b]	–
Catla			
STOCKING			
Mean weight (g/fish)	7.13	7.13	7.13
Stock biomass (kg/ha)	10.56	10.56	10.56
HARVEST			
Mean weight (g/fish)	224.72±26.72	250.92±8.84	330.34±53.39
Weight gain (g/fish)	217.59±26.72	243.79±8.84	323.21±53.29
Survival (%)	85.11±2.07	79.47±4.76	90.63±6.43
SGR (% bw/day)	3.70±0.12	3.83±0.04	4.09±0.18
Yield (kg/ha/4 months)	264.25±9.85[b]	295.46±20.23[b]	434.83±46.49[a]
Rohu			
STOCKING			
Mean weight (g/fish)	5.37	5.37	5.31
Stock biomass (kg/ha)	5.31	5.31	5.31
HARVEST			
Mean weight (g/fish)	227.58±8.82	270.24±76.57	194.07±29.47
Weight gain (g/fish)	222.21±8.82	264.87±76.57	188.70±29.47
Survival (%)	72.62±5.87	71.62±3.17	86.62±1.92
SGR (% bw/day)	4.03±0.04	4.13±0.28	3.83±0.16
Yield (kg/ha/4 months)	163.29±15.09	194.91±57.24	167.20±29.09
Grass carp			
STOCKING			
Mean weight (g/fish)	6.51	6.51	6.51
Stock biomass (kg/ha)	4.83	4.83	4.83
HARVEST			
Mean weight (g/fish)	121.46±13.74	119.33±24.50	206.44±73.21
Weight gain (g/fish)	114.94±13.74	112.82±24.50	199.93±73.21
Survival (%)	85.98±4.26	64.62±11.44	87.54±2.85
SGR (% bw/day)	3.13±0.12	3.09±0.21	3.57±0.40
Yield (kg/ha/4 months)	78.22±12.81	53.60±5.02	131.42±42.69
Thai punti			
STOCKING			
Mean weight (g/fish)	9.89	9.89	9.89
Stock biomass (kg/ha)	24.43	24.43	24.43
HARVEST			

Mean weight (g/fish)	136.87±18.10	155.29±14.09	140.71±30.16
Weight gain (g/fish)	126.98±18.10	145.40±14.09	130.82±30.16
Survival (%)	80.32±1.93[a]	61.60±6.89[b]	67.53±0.74[b]
SGR (% bw/day)	2.81±0.15	2.95±0.10	2.81±0.22
Yield (kg/ha/4 months)	270.92±33.55	237.90±41.61	233.91±48.33
Mrigal			
STOCKING			
Mean weight (g/fish)	1.95	1.95	1.95
Stock biomass (kg/ha)	2.89	2.89	2.89
HARVEST			
Mean weight (g/fish)	204.64±53.79	268.48±59.72	180.67±16.47
Weight gain (g/fish)	202.69±53.79	266.55±59.72	178.72±16.48
Survival (%)	77.25±8.01	62.39±7.70	77.10±6.97
SGR (% bw/day)	4.94±0.26	5.25±0.22	4.86±0.10
Yield (kg/ha/4 months)	221.71±32.15	242.59±44.17	203.04±1.87
Common carp			
STOCKING			
Mean weight (g/fish)	11.29	11.29	11.29
Stock biomass (kg/ha)	8.37	8.37	8.37
HARVEST			
Mean weight (g/fish)	170.79±25.99	266.86±59.76	256.77±3.80
Weight gain (g/fish)	159.50±25.99	255.57±59.76	245.48±3.80
Survival (%)	60.85±5.29	53.98±8.21	81.74±8.16
SGR (% bw/day)	2.89±0.18	3.35±0.22	3.36±0.02
Yield (kg/ha/4 months)	77.63±14.69[b]	99.96±7.10[b]	155.82±17.37[a]
Large fish			
Yield (kg/ha/4 months)	2035.01±111.84[a]	1757.24±92.08[a]	1326.21±16.04[b]
Mola			
Yield (kg/ha/4 months)	–	62.09±9.68[b]	183.67±21.45[a]
Total			
Yield (kg/ha/4 months)	2035.01±111.84[a]	1819.19±85.94[a]	1509.88±23.39[b]

Mean values with different superscripts in the same row were significantly different ($p < 0.05$).

Catla showed highest survival 85.11%, 79.47% and 90.63% in treatment SS, SM and MM, respectively. Among the treatments, highest weight gain (323.21g) and SGR (4.09%) were found in treatment MM, where no silver carp was stocked. Yield of catla was significantly higher ($p<0.05$) in treatment MM (434.83 kg/ha), than other two treatments 295.46 kg/ha and 264.25 kg/ha in treatment SM and SS, respectively. Highest weight gain 264.87g and production 194.91 kg/ha of rohu were found in treatment SM. SGR (%) value of rohu was 4.03, 4.13 and 3.83 in treatments SS, SM and MM, respectively. Highest production of grass carp 131.42 kg/ha obtained in treatment MM, where no silver carp was stocked, which was almost double compared to that of the other two treatments.

Thai punti survival was significantly higher ($p<0.05$) in treatment SS, than that in the other two treatments. However, growth in terms of weight gain was highest in treatment SM (145.40 g). Yield of Thai punti in treatments SS, SM and MM were 270.92 kg/ha, 237.90 kg/ha and 233.91 kg/ha, respectively. Compared to all other species specific growth rate of mrigal was higher in all three treatments (4.94%, 5.25% and 4.86% in treatments SS, SM and MM, respectively). Among the treatments, highest weight at harvest, SGR and yield were observed in treatment SM (Table 3). However, there were no significant differences in mrigal yield among the treatments. Common carp survival was remarkably low in the treatments, where silver carp was stocked. The lowest common carp survival was observed in treatment SM (53.98%), which was also the lowest survival among all species. Common carp yield was high in treatment, where no silver carp was stocked. Mola yield was almost two times higher (183.67 kg/ha) in absence of silver carp (MM) than in presence of silver carp (62.06 kg/ha), though the stocking ratio of mola between the two treatments was SM:MM::1:2. Total production of fish obtained in this experiment was 2035 kg/ha, 1819 kg/ha and 1510 kg/ha/4 months in treatment SS, SM and MM, respectively. The results showed that there was a significantly lower total fish production, when no silver carp was stocked with mola in carp-mola polyculture system. There were no significant differences in total production between the treatments where silver carp was stocked at a different ratio.

Discussion

Water quality parameters

The range of water temperature (27.7 to 31.0°C) as observed to prevail in the experimental ponds appeared to be suitable for fish culture, which agrees with the findings of Paul (1998) who recorded temperature range of 26.7-33.7°C in water of carp polyculture with silver and mola fish rearing ponds at the BAU Campus, Mymensingh. Kohinoor (2000) also recorded water temperature to vary from 18.5 to 32.9°C in the experimental ponds. The values of transparency range (9.0-26.0 cm) as recorded in the present study indicate that the ponds were productive and a little bit turbid. The turbidity that appeared might be due to presence of common carp which is reported to be the most common natural reason for turbidity apart from plankton population. Wahab *et al.* (2002) reported that common carp damages pond embankments by searching for food or burrowing to build nests which results reduced transparency. pH is an important factor in a fish pond and also called the productivity index of a water body. Kohinoor *et al.* (1998) observed the pH range 7.18 to 7.24 in carp-mola polyculture ponds at the Fisheries Field Laboratory, Complex, Bangladesh Agricultural University, Mymensingh. The significant difference in pH that was observed among the treatments might be due to interacting effects of different species composition and stocking densities to the water column.

The concentration of dissolved oxygen (DO) in the experimental ponds had generally fluctuated and ranged from 2.6 to 8.2 mg/L. DoF (1996) also reported the ranges of dissolved oxygen suitable for fish culture would be 5.0 to 8.0 mg/L. Ophenheimer *et al.* (1978) and Wahab *et al.* (1995) recorded similar dissolved oxygen values that ranged from 3.18-7.58 and 2.2-7.1 mg/L, respectively. Roy (2004) recorded

3.65 to 7.65 mg/L dissolved oxygen in carp-mola polyculture ponds in rural farmers pond.

Growth and production performance

Compared to all other species silver carp showed the best performance in terms of growth and production. Silver carp production ratio was similar to the ratio of stocking which implies that production of silver carp was not affected by stocking of mola. Roy (2004) also reported that silver carp production was not affected by the presence or absence of mola in carp-mola polyculture system. Survival of catla was higher (90.63%) in absence of silver carp. Wahab *et al.* (2004) reported reduced survival of catla in presence of silver carp. Wahab *et al.* (2004) also reported lower survival of catla in presence of silver carp due mainly to competition for food and space between these two species. Production of catla was significantly higher in carp-mola polyculture system in absence of silver carp (434.83 kg/ha/3 months). Roy (2004) reported that production of catla was higher in presence of grass carp and in absence of silver carp in his study on carp-SIS polyculture system.

Rohu production was lower in this study in presence of both higher stocking densities of silver carp and mola (163.29 kg/ha and 167.20 kg/ha, respectively). This might be due to interspecies competition between rohu and these two species. Roy (2004) reported lower growth of rohu in higher stocking densities of mola. Kohinoor *et al.* (1998) also stated that mola competed for food and space with rohu. Grass carp production and growth was highest at higher stocking densities of both silver carp and mola. Survival was highest where both silver carp and mola was stocked in the system. This species have antagonistic effect on more than one species in carp polyculture system. Roy (2004) found that grass carp production was not affected by the presence or absence of silver carp, but it performed better in presence of mola.

Highest Thai punti production was found in absence of mola. However, the increased stocking density of mola did not have much effect on production of Thai punti. Mrigal production was lower in absence of silver carp in carp-mola polyculture system (203.04 kg/ha). Presence of silver carp increased production of mrigal (Roy 2004). Milstein (1992) reported such synergistic effect between silver carp and common carp. However, the highest mrigal production in this study was also found in presence of mola (266.55 kg/ha). The performance of common carp both in terms of growth and production was higher in presence of mola in this experiment. Alim (2005) reported that presence of mola increased the performance of common carp. Production in this experiment was highest (155.82 kg/ha) where mola was stocked at a higher density, which also supports such relation. Mola production was three times higher where silver carp was absent (183.67 kg/ha) though the stocking density was double compared to the treatment where mola was stocked in presence of silver carp. Roy (2004) stated that mola production was better in presence of grass carp with other carps than silver carp plus other carps. Kohinoor *et al.* (1998) stated that the antagonisms between silver carp and mola was shown in their experiment.

The overall higher production of 2,035 kg/ha/3 months was obtained in that combination where only carps were stocked. The second best production (1,819 kg/ha/3 months) was observed where mola and silver carp were present in the system. But there were no significant difference in production between these two treatments. Roy (2004) recorded an overall production of 1,953 kg/ha/3 months in control pond, followed by 1,882 kg/ha/3 months in ponds where 100 mola were stocked per decimal with carps. In another experiment, he found 2,712 kg/ha highest production in 7 months of carp-mola polyculture. Roos *et al.* (1999) also recorded 2,500 kg/ha carp-mola polyculture during 7 months period in the Kishoreganj area, Bangladesh.

Economic analysis

The economic analysis of the proposed system was carried out to assess the economic return of carp-mola polyculture under low input management. The mean expenditures were higher for the carp-mola ponds with a higher mola density, than for the carp-mola ponds in presence of silver carp or only carp ponds because of the expenses for mola fry is included here. Mola is a self-recruiting species and once a mola stock is grown in pond, a regular natural stock of mola population can be created in farmers' pond by partial harvesting in every two to three months. This will reduce a major part of investment in such type of culture practices. The economics of three different combinations was analyzed on the basis of the expenditure incurred and total return from sale price of fish. The net benefits per hectare per 4 months for treatment SS, SM and MM were Tk. 102,709, 91,364 and 92,759, respectively. Roy (2004) reported Tk. 94,925, 88,330 and 68,270 as net benefits per hectare per 7 months for only carps, carps plus mola and carps plus chela polyculture systems, respectively. However, only carp polyculture system provided higher benefit, followed by carp-mola polyculture without silver carp. Roos (2001) reported that the net profit was Tk. 34,100/ha in carp-native SIS ponds and Tk. 28,100/ha per season in carp mola ponds, while Mymensingh Aquaculture Extension Project recorded the profit Tk. 32,000/ha for an 8 months production season in perennial ponds. Benefit-cost ratio (BCR) was obtained 3.16, 2.55 and 2.36 in treatment SS, SM and MM, respectively. Benefit-cost ratio was obtained higher in only carp polyculture. Roy (2004) reported higher benefit-cost ratio in only carp polyculture, followed by carp-mola and carp-chela polyculture systems.

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Health status of a snakehead (*Channa punctatus*) of two fish markets in Mymensingh, Bangladesh

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Abstract
An experiment was carried out for a period of six months during October 2008 to March 2009 to investigate the health status of a snakehead, *Channa punctatus* through clinical and histopathological technique. Fish were collected from two fish markets of Mymensingh district. Clinically and histopathologically, it was observed that fishes from both the markets were healthy in October and March but moderately affected in November and February. In the months of December and January, 7.5 - 8 % of the fishes were affected clinically and showing various clinical signs like, discolouration, deep ulcer, ill health, scale loss and rough skin. Histopathologically, in the month of December and January, major observed pathologies of skin and muscle were necrosis, vacuums, fungal granuloma and loss of dermis. Gills were affected having parasitic cysts, monogenetic trematode, clubbing, loss of primary and secondary gill lamellae, hemorrhage, necrosis and hypertrophy. Vacuoles, pyknosis, hepatic necrosis, hemorrhages and fungal granuloma were observed in liver. Renal pathology included necrosis and pyknosis of kidney tubules, hemorrhages, presence of bacterial colony and vacuoles. From present findings, it was found that, fishes from urban market were more affected with diseases than pre-urban market especially in the months of December and January when compared with other months. From overall observation, *C. punctatus* were severely affected by epizootic ulcerative syndrome (EUS), dactylogyrosis, protozoan and bacterial diseases during colder months of the year.

Key words: Health status, Snakehead, EUS, Clinical signs, Histopathology

Introduction

In Bangladesh there are about 50-60 small indigenous species (SIS) which grow to a maximum length of 25 cm or 9 inches (Felts *et al.* 1996, Hossain and Afroze 1991). These SIS are very important and good resources to our poor and low income groups in terms of nutrition and economics which are abundant in most of the freshwater areas of Bangladesh. Fishes have been suffering from many diseases such as epizootic ulcerative syndrome (EUS), tail and fin rot, bacterial gill rot, dropsy, various types of fungal, protozoan, parasitic and bacterial diseases (Chowdhury *et al.* 1999). With the outbreak of EUS in 1988 *Channa* sp and many other SIS were severely affected (Barua *et al.* 1989). During last few years the catfish and snakeheads are recorded as rare species from flood plains and *beels* due to diseases outbreak (Hossain and Mazid 1995). Fish of the local markets may have different health status, showing disease symptoms like scale erosion, tail and fin rot, ulcer etc. As we know, health condition of market fish is very much important when we consider public health. It is now become essential task of the scientists to investigate the types of symptoms (if any) and also whether the symptoms are already turned into diseases or not. In this regards clinical and histopathological techniques might be carried out which has been successfully used for diagnosis of fish diseases throughout the world. In Bangladesh, it has used in a limited extend to disease diagnosis in fish (Ahmed *et al.* 2000). Thus the present research work has been aimed to investigate health status of a snakehead *C. punctatus* from the fish markets of Mymensingh through clinical and histological measures.

Materials and methods

The study was conducted for a period of six months from October 2008 to March 2009. Live snakeheads were collected fortnightly from two fish markets of Mymensingh such as pre-urban site- Kamal-Ranjit (KR) Market (located at BAU campus) and urban site- Shankipara Rail Crossing Market (located at Mymensingh town) by separate plastic container filled with water and immediately transported to the Fish Disease Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The sampled fishes were clinically examined by naked eye and magnifying glass to record any external signs, injury and other abnormalities. Organs like skin and muscle, gill, liver and kidney were collected with the help of a sharp scalpel and forceps and fixed in 10% neutral buffered formalin for histopathological study. After 8 hours of fixation, the samples were trimmed in order to obtain a standard size of 1 cm^3 (maximum) and placed in automatic tissue processor for dehydration, clearing and infiltration. The samples were then embedded, sectioned (5μm thickness) and stained with Haematoxylin and Eosin. Then the sections were mounted with canada balsam and covered by cover slips and examined under a compound microscope. Photomicrograph of the stained sections was obtained by using a photomicroscope. Record of structural variations and pathologies were done from the slides and photomicrographs (Ahmed *et al.* 2009).

Results

Clinically, it was observed that, *C. punctatus* from both markets were apparently healthy and normal in appearance during the months of October and March. However, in November and February, mild signs like, lesions, rough skin, scale loss were observed. But, clinically, 7.5 - 8 % of the fishes were affected showing various signs like, discolouration, deep ulcer, ill health, scale loss and rough skin in the month of December and January (Table 1). Histopathologicaliy, it was seen that skin and muscle, gill, liver and kidney of *C. punctatus* were normal in the months of October and March from both the markets. However, in the month of November and February, pathological changes like mild necrosis, pyknosis, few vacuums and hemorrhages were observed and most of them are in healing stages. Pathologies of skin and muscle of fishes from both markets are includes partly loss of dermis and muscles, severe necrosis and presence of dense fungal granuloma during the month of December and January, (Figs. 1 and 2). In respect of gill pathology, loss of primary and secondary gill lamellae, hypertrophy, necrosis, haemorrhages, clubbing and monogenetic trematode were observed in the fishes of both markets during the month of December and January (Figs. 3 and 4). In liver, severe necrosis of hepatocytes, pyknosis, fat droplets, hemorrhages, fungal granuloma and wide vacuums were observed in liver of *C. punctatus* collected from Sankipara rail crossing market during the month of December and January (Fig. 5). In kidney of *C. punctatus*, collected from KR market, hemorrhages, severe necrosis, bacterial colony, pyknosis and vacuums were observed during the month of December and January (Fig. 6). From clinical and histopathological observations, it was seen that, fishes collected from Shankipara rail crossing market were more severely affected than fishes of KR market and more pathological symptoms were seen during the month of December and January, when compared with other months.

Table 1. Clinical signs and percentage of affected *Channa punctatus* in various months

Months		October	November	December	January	February	March
Species	Markets						
Channa punctatus	KR market (Prei-urban)	AN & HA (0.5 %)	rs & SL in some places (1.5 %)	rs & ulcer with SL (4.5 %)	ill body, Dc & DU in the body region (7.5 %)	rs & mild dermal lesion (2 %)	HA (0.0 %)
	Shankipara Market (Urban)	AN & HA (0.0 %)	AN & WB (2.0 %)	ill body & rs in 'v' & 'p' region (5 %)	Ulcer with SL in 'c' region (8 %)	rs & SL in some places (2.5 %)	AN & minor WB (0.4 %)

AN = almost normal	p = pelvic	c = caudal	rs = rough skin	HA = healthy appearance
DU = deep ulcer	v = ventral	Dc = discoloration	SL = scale loss	WB = weak body

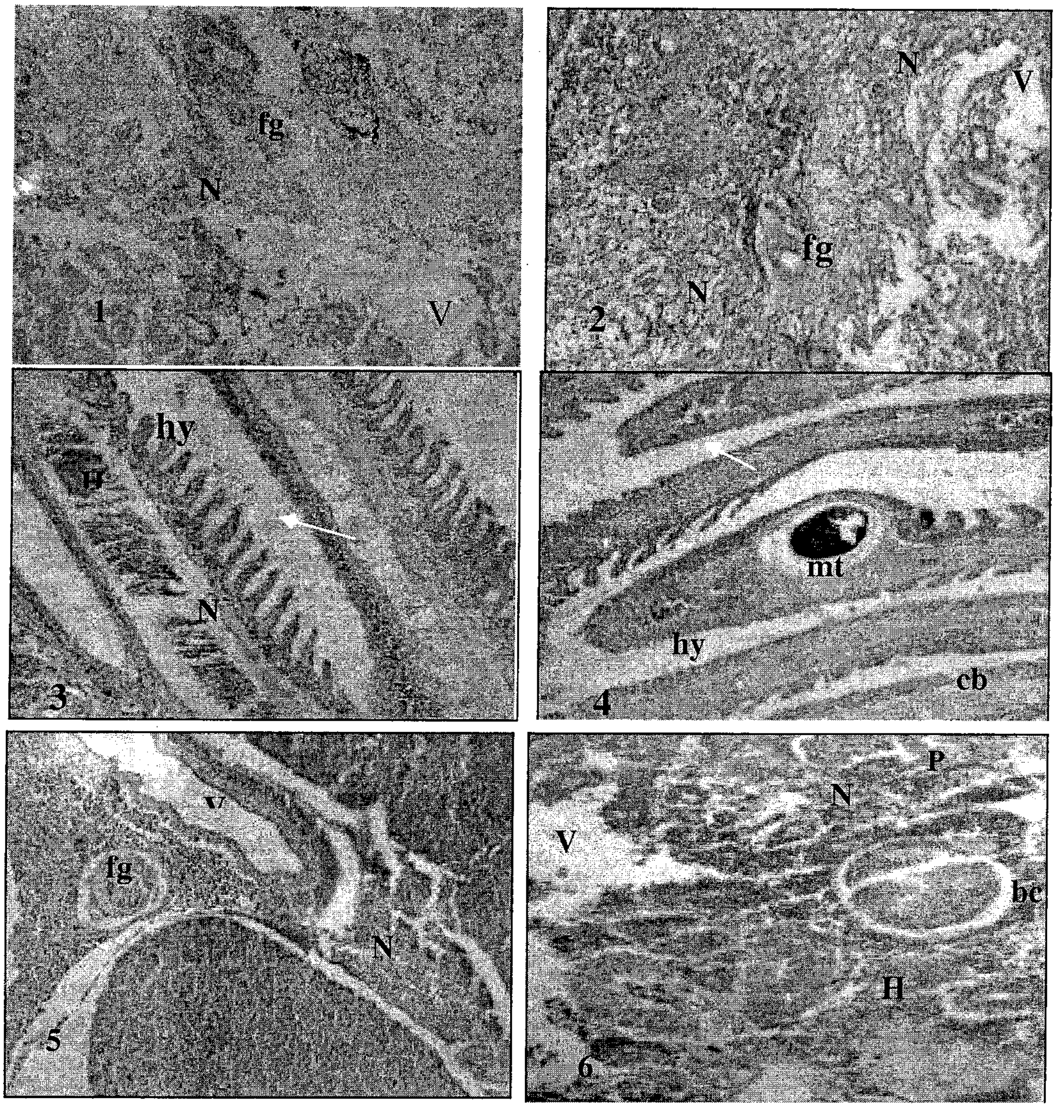

Fig. 1. Section of skin & muscle of Taki in December & January from peri-urban market. Dermis had necrosis (N), vacuums (V) and fungal granuloma (fg) were present in dermis & muscle. H & E x 215.

Fig. 2. Section of muscle of Taki in December & January from urban market. Necrotic muscle (N) with dense fungal granuloma (fg) and few vacumes (V) were found in epidermis & dermis. H & E x 215.

Fig. 3. Section of gill of Taki in December & January from peri-urban market. Secondary gill lamellae partly lost (↖ & primary gill lamellae were hypertrophied (hy), necrotic (N) & hemorrhagic (H). H & E x 215.

Fig. 4. Section of gill of Taki in December & January from urban market. Missing lamellae (↖), hypertrophy (hy), clubbing (cb) and monogenetic trematode (mt) were found. H & E x 215.

Fig. 5. Section of liver of Taki in December & January from urban market. Vacuums (V), necrosis (N) and fungal granuloma (fg) were found. H & E x 140.

Fig. 6. Section of kidney of Taki in December & January from peri-urban market. Hemorrhages (H), necrosis (N), vacuoles (V), pyknosis (P) and bacterial colony (bc) were observed. H & E x 330.

Discussion

From the result of the present study, clinically and histopathologically, it was observed that snakeheads from both the markets were healthy during the months of October and March. However, in November and February, mild clinical signs like, lesions, rough skin, scale loss and reduced pathological changes like mild necrosis, pyknosis, few vacuums and hemorrhages were observed. On contrast, severities were increased during the months of December and January, when compared with other months and clinical signs like, discolouration, deep ulcer, ill health, scale loss and rough skin were observed. Hossain (2008) mentioned that, clinical symptoms like scale loss, dermal lesion, loss of caudal fin were seen in December and January. Marma *et al.* (2007) mentioned that, in October and November, fishes were normal but severely affected during the months of December and January. These findings were almost similar with the works done by Patwary *et al.* (2008), Ahmed *et al.* (2007), Akter, *et al.* (2006), Ahmed *et al.* (2005), Ahmed *et al.* (2004), Ahmed *et al.* (2000) and Islam *et al.* (1999).

During the month of December and January, marked pathological changes like, partly loss of dermis and muscle, severe necrosis, presence of dense fungal granuloma were observed in skin and muscle of *C. punctatus* from both the markets. The presence of fungal granuloma in the organs indicate that the fishes were affected by epizootic ulcerative syndrome (EUS). Noga and Dykstra (1986) were of the opinion that marked granulomatous inflammatory response were shown by fish infected with *Aphanomyces* sp. Hoque *et al.* (1999) mentioned that partial loss of epidermis and dermis, muscle necrosis, pyknosis, vacuums and presence of fungal granuloma were the pathological changes in skin and muscles of EUS affected fishes of Bangladesh.

Major gill pathologies were included loss of primary and secondary gill lamellae, hypertrophy, necrosis, hemorrhages, clubbing and presence of monogenetic trematode during the month of December and January. Ahmed *et al.* (1998) observed loss of secondary gill lamellae, clubbing, hypertrophy, protozoan cyst in gill of juvenile Indian major carp when investigated through histolpathological measures. Roy *et al.* (2006) reported cysts, hyperplasia, lamellar clubbing and hypertrophy in EUS affected *C. punctatus*, *M. tengara* and *H. fossilis*. Parveen *et al.* (2005) also mentioned that in December and January marked hypertrophy and hyperplasia were observed in gill lamellae of *C. punctatus* and *N. nandus*.

During the month of December and January, severe necrosis of hepatocytes, pyknosis, wide vacuoles, fat droplets, hemorrhages and fungal granuloma were evident in liver of *C. punctatus.* Ram and Singh (1988) were observed various histopathogical changes in liver of fish like cytoplasmolysis, nuclear pyknosis and necrosis leading to complete exhaustion and disintegration of hepatocytes. Akter *et al.* (2006) observed vacuums, hepatic necrosis, fungal granuloma and pyknotic hepatocytes in liver of *Channa punctatus, Heteropneustes fossilis* and *Mystus tengara*. Almost similar findings were recorded by Joshi *et al.* (2007). Ahmed *et al.* (2004) found marked necrosis with blood cells, pyknotic cells and many fungal granulomas in liver of *C. punctatus* in the months of December and January. Kumar *et al.* (1991) observed marked pathological changes in the liver of EUS affected *Puntius, Mastacembelus* and *Channa* in India.

In kidney of *C. punctatus*, hemorrhages, necrosis, pyknosis, bacterial colony and vacuums were seen in December and January. Alam (2004) found that kidney, spleen and liver were swollen and enlarged during colder months. Ahmed and Hoque (1999) also reported that internal organs like kidney and liver were more affected and disease like EUS occurred during the months of December and January.

Most of the examined snakeheads from both of the markets were apparently healthy from external observations, but under histopathological observations it was found that a high percentage (%) of fishes was affected by pathogens especially by fungus. Clinically and histopathologically, the snakeheads of urban market (Shankipara Rail Crossing Market) were more severely affected with diseases than fishes of peri-urban market (KR market) during the months of December and January. The overall observed diseases of fishes from both the markets were epizootic ulcerative syndrome (EUS), dactylogyrosis and protozoan diseases. Ahmed *et al.* (2004) investigated health status of three SIS and found that all fishes were severely affected in the months of December and January.

Fish collected from distant *beels*, adjacent to rail line, dirty floor and unhygienic drainage system of urban market could influence to deteriorate the health condition of the fishes. So steps should be taken from all counterparts to overcome these problems. Infrastructure facilities of the market should be developed and hygienic condition should be updated. In such ways diseases in fish could be reduced and health status of fishes in the markets could be kept safe to a great extent.

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Enhancement of fish production in a reservoir after partitioning by dikes through community participation

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Abstract
A reservoir of 70 acres was portioned by dikes into four manageable big ponds to get more production of fishes at Basurhat, Noakhali, Bangladesh under the supervision of local community through a society of 40 people ownership. Pangus (*Pangasius hypophthalmus*) @ 20,000/acre, and then fry and fingerlings of different types of fishes such as catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhina mrigala*), grass carp (*Ctenopharyngodon idella*), bighead (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), common carp (*Cyprinus carpio*) and rajpunti (*Puntius gonionatus*) @ 500/acre were stocked. Feed containing 25% protein was used two times daily and feed was adjusted fortnightly. After 8 months, all the fishes were weighed 0.80-2.10 kg except rajpunti (150-200 g) and tilapia (150-220 g), and a total of 25 ton of fish was harvested which was five times higher than the previous production under signal ownership. The production of fishes were increased after partitioning the lake with dikes due to proper management and control.

Key words: Fish, Lake, Dikes, Community participation

Introduction

Aquaculture practice is gradually blooming in Bangladesh due to decrease of fish in natural habitats like rivers, natural lakes, and other open water bodies (Biswas *et al.* 2003, Habib *et al.* 2003). Therefore, people are assuming aquaculture practice is only the way for fish production to minimize the demand of fish in the country (Molla *et al.* 1990). For this reason, people are very keen to practice aquaculture even converting their paddy field (Habib *et al.* 2003).

The Al-Elahi Agricultural Complex was an agro-complex with aquaculture venture managed by the local people community. The complex was started under single ownership with 100 acres with agriculture crop for rice production with traditional fish culture in 70 acres water area in 2003. Approximately 5 tons of fish was producing every year. This single season crop and traditional fish culture did not provide enough revenue so that the owner gradually switching over to aquaculture with the help of local people through community participation. The complex with the name 'Elahi Aquaculture Farm' started within the agricultural complex covered water area around

70 acres under the management of a group of local 40 people. This 70 acres water area was partitioned with dikes and come under manageable culture system of 24 ponds. The present paper highlighted the aquaculture practice through community participation.

Materials and methods

To manage properly and to facilitate under controlled condition, the 70 acres water area (Elahi Aquaculture Farm) was artitioned by dikes into 24 ponds of which five were nursery, ten for rearing ponds and six for stocking ponds (Table 1). The area of ponds were varied from 1.0 to 8.0 acres. The entire aquaculture farm was divided into Block A, B and C for proper management with supervisor and labourers. Rest of the 30 acres land were used for crop production. There was a small dairy farm inside the complex where about 60 cows are farmed and resulted cow dung was used as organic fertilizer in the ponds and crop field. A community with 40 local people was formed to produce fish through modern aquaculture practice with the technical help of Agro-Based Industries and Technology Development Project II (ATDP-II), Dhaka. The Elahi Aquaculture Complex was found very suitable for fish culture and overall culture and production system were monitored and analysed in the laboratory of Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Table 1. Distribution of supervisors, laborers, ponds and area of ponds

Name of block	A	B	C
Supervisor	1	1	1
Labourer	3-4	3-4	3-4
No. of nursery ponds	2	2	1
Area of nursery ponds	1.5 acres	1.0 acre	1.0 acre
No. rearing ponds	3	3	4
Area of ponds	2.0 acres	2.0 acres	2.0 acres
No. of stocking ponds	2	2	2
Area of stocking ponds	6.0 acres	8.0 acres	8.0 acres

Hand on training

The supervisors, skilled labourers and labourers were trained for different aspects of fish culture managements. They were trained how to measure temperature, transparency (secchi reading), pH, dissolved oxygen, to observe plankton growth, to grow plankton in ponds as live food for fishes, fry weighing, to minimize oxygen deficiency, use of decomposed cow dung etc. A list of optimum ranges of different physico-chemical characteristics were supplied with tolerable and toxic levels (Table 2) so that the farm people could understand the quality of water.

Table 2. Optimum and toxic levels, and ranges of different physico-chemical properties of water of ponds for aquaculture (Pillay 2004)

Name of properties	Optimum levels	Symptom/effect	Toxic levels
Turbidity by suspended particles	> 20 000 mg/L	Bevavioural reactions Restrict light penetration Limits photosynthesis Destroy benthic communities and fish eggs	Mortality occurs above 175 000 mg/L
Turbidity by phytoplankton	No range	Not harmful to fish	-
pH	6.5-9	Desirable growth of fish	6.0-6.5 poor growth 4.0 – Acid death point 11.0- Alkaline death point
Dissolved Oxygen	> 5 mg/L 1.0 mg/L	Good growth Warm water carp can survive	Below 5.0 mg/L not good for shrimp more than few hours 3-4 mg/L Eel, carp and tilapia can tolerate Optimum level higher than this level
Free carbon dioxide	0 mg/L 5-10 mg/L	In the afternoon At daybreak	No ill effect on fish No ill effect on fish
Un-ionized ammonia-N	0.6-2.0 mg/L	Tolerable conc. 0.10 mg/L	Fish die
Nitrite-N	< 0.1 mg/L	Tolerable level	Fish survive
Nitrate-N	< 100 mg/L	Tolerable level	Fish survive
Un-ionized H_2S	Normal level	Untolerable	Very toxic
Ortho-Phosphate	45-100 mg/L	Tolerable	Not toxic
Phytoplankton bloom	Harmful phytoplankton Beneficial phytoplankton	Untolerable Good live food for fish	Toxic to fish Nutritionally rich health food
Pesticides (Insecticides)	5-100 mg/L	Extremely toxic to fish	Acute toxic level

Preparation of stocking ponds

Ponds were prepared with lime after drying. In respect to pH of pond bottom soil, it was suggested to apply 500g lime/dec.. However, according to the content of organic carbon and total N, 2kg/dec. cow dung and 1.5 kg/33 dec. urea were used in bottom soil and advised to use this doses fornightly during whole culture period. Then all the stocking ponds were filled with underground water. P:K at the ratio of 1.5: 0.75 kg/33 dec. were administrated monthly. Depending on water quality then N:P:K was administrated weekly at the ratio of 3.0:1.50:0.75.

Physico-chemical properties analyses of pond water and bottom soil

Water and soil samples were collected from ponds for analyses. Different physico-chemical properties of water were analysed following the standard methods (Clesceri *et al.*

1989). For convenience, samples were collected from nine locations of three blocks of the farm. The physico-chemical properties of water samples were analysed in site. On the other hand, soil samples were carried to the laboratory for process before analyses of chemical properties.

Water colour of ponds was recorded by eye estimation. Temperature of pond water was determined by centigrade thermometer. Turbidity (Transparency) was measured by turbidity meter. pH of water was measured by a digital pH meter (HANNA instruments, Model: HI 8314). Electric conductivity of water was analysed by conductivity meter after some chemical treatment. Dissolved oxygen was measured by digital oxygen meter (HANNA Instruments Model: HI-9142). Alkalinity of water was estimated using alkalinity meter after chemical treatment. Nitrate-N (ppm) was determined after filtering 100 ml water through glass microfilter paper using Nitrogen-5 powder pillow and then direct reading using Spectrophotometer, DR 2010. Similarly Phosphate-P (ppm) was determined from filtered water using reagent pillow Phosver-3 and then direct reading using Spectrophotometer, DR 2010.

Collection and identification of plankton

For collection of plankton, 10 litres of water from each location of farm was filtered through consecutive three nets of different mesh sizes (10, 30 and 120 μm). The collected plankton samples were preserved in 6% buffered formalin. These samples identified using Sedwich Rafter Counting Chamber under microscope with the help of keys given by Ward and Whipple (1959), Whitford and Schumacher (1973) and Yamagichi (1992).

Fifty ml of pond water was filtered through 0.45 μm mesh and the filter paper was mashed with 10 ml acetone in 25 ml plastic tube. The tube was wrapped with aluminium foil and brought to the laboratory and kept in the refrigerator. It was then centrifused at 5000 rpm for five minutes. The supernatant was taken in cuvette and readings at three different wavelengths were taken in spectrophotometer. Then chlorophyll a was estimated using the following formula:

$$\text{Chlorophyll } \underline{a}\ (\mu g/L) = 11.85\ (OD_{664}) - 1.54\ (OD_{647}) - 0.08\ (OD_{630}).$$

Chemical analyses of bottom soil of ponds

Pond bottom soil from nine location of whole site was collected. Texture of bottom soil was determined after treatment dry soil with 5% calgon solution using hydrometer. pH was measured by a digital pH meter (HANNA instruments, Model: HI 8314). Organic carbon was calculated following wet oxidation method. Total N was analysed by Microkjeldahl method. Phosphate-P was determined from filtered water using reagent pillow Phosver-3 and then direct reading using Spectrophotometer, DR 2010.

Collection and analysis of artificial feed

Commercial feed was analysed for proximate composition such as moisture, crude protein, crude lipids, crude fibre and nitrogen free extract in the laboratory using methods given by Horwitz (1984).

Release of fry in ponds

The spawn was collected from the local hatchery and released in nursery ponds. The nursery reared fish fry (3-8 mg/fish) of Thai Pangus (*Pangasius hypophthalmus*) @ 20,000/acre, and then fry and fingerlings @ 500/acre of different types of fishes such as catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhina mrigala*), grass carp (*Ctenopharyngodon idella*), bighead (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), common carp (*Cyprinus carpio*) and rajpunti (*Puntius gonionatus*) were stocked on the middle of May 2006. Artificial feed was used twice daily in these ponds.

Results and discussions

Overall water and bottom soil properties, and plankton population of ponds

Physico-chemical properties of water of Elahi Aquaculture Farm are presented in Table 3. Most of the ponds were turbid and very few ponds contained little amount phytoplankton. Only nursery ponds were greenish in colour. Temperature was ranged from 27.60 to 28.10°C during the study period. It was observed that the smell of decomposed feed was coming out from some ponds otherwise the pond were almost free from any other odours. Turbidity ranged from 10 to 58 cm. Electric conductivity was ranged from 201 to 398 μhos/sec which indicates good ionic exchange among different chemical factors and favorers good water quality for culture which agrees with the findings of Habib *et al.* (1991). pH of water was found within the alkaline which was favourable for fish culture. Usually there is direct relation among pH, electric conductivity and alkalinity which almost agrees with results of Habib *et al.* (1988). Dissolved oxygen, Nitrate-N and phosphate-P were within the suitable ranges of ponds of good quality water. It was found that chlorophyll-a content was ranged from 14.28 to 26.18μg/L which was very low in all the ponds and not good for fish culture if fish depend on natural food of ponds. However, artificial feed was used to feed fish.

Table 3. Average physico-chemical properties of water from different locations

Parameters	L1	L2	L3	L4	L5	L6
Temperature (°C)	27.8	27.6	28	28.1	28	27.9
Turbidity (cm)	13	43	15	10	58	45
pH	7.7	7.4	6.9	7.5	7.2	7.1
Electric conductivity (μhos/sec)	398	193	201	284	235	225
Alkalinity (ppm)	132	95	105	135	85	60
Dissolved oxygen (ppm)	3.5-5.5	5.8-6.0	3.5-5.5	5.5-6.5	3.5-4.0	2.5-3.0

NO_3-N (ppm)	3.2	2.7	2.2	2.4	1.0	1.8
PO_4-P (ppm)	0.23	0.77	0.34	0.34	2.80	0.57
Chlorophyll a (μg/L)	26.18	10.71	15.47	20.23	14.28	18.25

L1 = Location 1, L2 = Location 2, L3 = Location 3, L4 = Location 4, L5 = Location 5, L6 = Location 6.

Pond bottom soil was analysed for texture, pH, total N and Phosphate-P during culture (Table 4). Soil texture was found sandy clay which is suitable for fish culture (Habib *et al.* 1987). It was found that pH ranged from 6.7 to 7.5 which indicate that the water was almost alkaline in nature and favourable for fish culture. Organic carbon (0.40 to 0.67%), total N (0.25 to 0.35%) and available P (Phosphate-P) (10 to 12 ppm) were almost within the suitable for good quality water of pond. Among the phytoplankton, the blue-green algae such as *Microcystis* an *Anabaena* were found dominant but available in poor amount in all the ponds.

Table 4. Average chemical analyses of soil samples

Parameters	L1	L2	L3	L4	L5	L6
Texture	Sandy clay	Sandy clay	Sandy clay	Sandy clay	Sandy clay	Sandy clay
pH	7.4	7.4	6.7	7.4	7.5	7.5
Organic carbon (%)	0.58	0.47	0.67	0.40	0.58	0.54
Total N (%)	0.27	0.30	0.26	0.35	0.28	0.25
Available P (ppm)	10	11	12	11	10	10

L1 = Location 1, L2 = Location 2, L3 = Location 3, L4 = Location 4, L5 = Location 5, L6 = Location 6.

Feed and feeding

After analysis of proximate composition in the laboratory, it was found that the feed contained 28-29% protein, although the feed bag labeled 30% (Table 5). The actual amount of protein was not found after analysis which indicates that the feed industry sometimes give little bid less amount of protein in feed during preparation which agrees with the observation of Chakraborty *et al.* (2005). The percentage of crude protein, crude lipid, ash and nitrogen free extract (NFE) were varied from one sample of one lot to another. Each sample represented a lot of production so it is assumed that the nutritional quality of feed varied from one lot of production to another. So farm may not get good and uniform growth and good production of fish. Therefore, it is advised that the comer fish farm can manufacture feed through their own effort using fish meal with other locally available ingredients.

Table 5. Proximate composition of commercial feed samples

Sample	Moisture	Crude protein	Crude lipid	Ash	Crude fibre	NFE*
1 (Feb.)	11.43	29.0	7.63	12.20	5.55	35.10
2 (May.)	10.90	28.0	9.03	14.40	5.60	32.00
3 (July)	12.25	28.75	7.76	13.80	6.78	30.55
4 (Sept.)	11.17	29.0	8.02	13.14	6.85	31.75

Production of fishes

Different species of fish spawn were bought first from the nearby hatchery and released in nursery ponds of Elahi Aquaculture Farm inside the Al-Elahi Agricultural Complex. The fry of all the fishes were grown rapidly for first two months though only feed of Pangus was given. Weight of fishes were taken on July and September (Table 6). Increments of weight of fishes were satisfactory but not so promising because all species of fishes were not growing properly. It might be due to feed competition for feeding among fishes, suitability of feed and other related factors (Biswas *et al.* 2003, Habib *et al.* 2003, Jayathi *et al.* 2007). Fishes were first harvested from September and then ended at the end of October. A total of 25 ton of fishes were harvested which was almost five timed higher than the previous year (five ton) which might be due to proper management under controlled condition through partition of lake with dikes, vigilance and activity of community people, use of feed in time. Fishes were weighed 0.80-2.50 kg except rajpunti (150-200 g) and tilapia (150-220g).

Table 6. Average growth of different fish species cultured in the aquaculture farm (arranged according to culture of preference)

Sl: No	Cmmon/Species name	Initial wt. (mg/fish) May 15, 06	Av. wt. (g) on July 19, 06	Av. wt. (kg) on Sept. 24, 06
1	Pungus (*Pungasius sutchi*)	7-8	150-170	1.70-2.50 kg
2	Catla (*Catla catla*)	5-7	100-120	1.80-2.0 kg
3	Rohu (*Labeo rohita*)	4-6	80-90	1.0-1.20 kg
4	Mrigal (*Cirrhina mrigala*)	4-6	60-70	0.80-1.0 kg
5	Silver carp (*Hypophthalmichthyes molitrix*)	5-7	110-120	1.40-1.80 kg
6	Siver barb (*Puntius gonionatus*)	3-4	50-60	150-200 g
7	Mirror carp (*Cyprinus carpio*)	3-4	100-120	1.0-1.50 kg
8	Tilapia (*Oreochromis niloticus*)	4-5	50-70	150-220 g
9	Big head (*Aristhicthys nobilis*)	4-5	130-150	1.30-1.60 kg
10	Kalbaus (*Labeo calbasu*)	4-5	90-110	1.0-1.50 kg
Total production		25 ton		

Production of fishes was increased about 5 times than the past before partition of 70 acres lake with dykes and proper care taken by local community people. It means that the lake was unmanageable at the same time uncontrolled before partition. Usually very big water reservoir is not possible to give diets to the fish properly. Also it is not easy to take proper care. Therefore, if big lake or reservoir is partitioned with dykes then it is easily manageable to give feed and to take proper care by local people specially through community participation, and then the production of fish should be increased in manyfold like the present work.

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Assessment of impact of ten days fishing ban in the major spawning grounds of hilsa (*Tenualosa ilisha*, Fisher and Bianchi, 1984)

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Abstract
A study was undertaken to find out the impact of ten days fishing ban in the major spawning grounds of hilsa during October to December. The study revealed a positive impact of fishing ban during spawning season on reproduction success of hilsa. Proportionate distribution of male and female hilsa also showed a significant level of distribution in and around the spawning grounds where the ratio was 35:65. Percent of oozing hilsa during fishing ban period in the spawning grounds was observed 1.61%. About 5% spent hilsa was observed in the fish landing centers and was compared with the data of Global Environment Facility (GEF) and Bangladesh Fisheries Research Institute (BFRI) studies and was found about 2.80 - 3.57 times higher than that of the findings of 2002 and 2003. Estimated egg production value showed about 46,800 Kg of eggs could have been produced that indicating a positive impact of 10 days fishing ban in spawning season. Abundance of higher percentages of gravid hilsa was found which were not available in the same quantity and condition in the non-fishing ban period. During the present investigation, fairly higher amount of spent hilsa and juveniles were also observed in the spawning grounds. Along with the jatka fry, spawn and fries of other fishes were also found in higher quantity than the previous years and thus it is assumed that fishing ban also might have positive impact on the successful breeding of other fishes. Overall, the fishing ban was found effective for successful breeding of hilsa.

Key words: Hilsa, Spawning, Fishing ban

Introduction

Hilsa (*Tenualosa ilisha*) (Hamilton) (Fisher & Bianchi 1984) is the most widespread tropical shads found from north Sumatra in the east to Kuwait in the west and is the basis of important fisheries in Bangladesh, India, Burma, Pakistan and Kuwait (Al-baz and Grove 1995, Whitehead 1985, Blaber 2000). It is the national fish of Bangladesh and the largest single species fishery that accounts nearly half of the total marine catch and about 12-13% of total fish production of the country (Haldar 2008). The hilsa fishery in Bangladesh has been suffered by a combination of factors *viz.* serious recruitment over-fishing (indiscriminate harvest of gravid fishes) and growth over-fishing (indiscriminate catching of *jatka*).

Hilsa is caught and landed throughout the year, the majority of landing (60-70%) is found during the peak breeding season (September-October). In this season, about 60-70% hilsa are found to be sexually mature and ripe. At least 30% of the population appears to be ripening at any time in most areas. The BFRI and GEF studies, explored four main spawning grounds of hilsa *viz,* (1) surrounding of Dhalchar, (Char fashion, Bhola, 125 square kilometer, N-21^{0}42'-21^{0}55' and E-90^{0}53'-91^{0}05'), (2) Monpura (near Monpura island, 80 square kilometer, N-22^{0}00'- 22^{0}15'and 91^{0}12'-91^{0}20'), (3) Moulavirchar (near Hatia, 120 square kilometer, N-21^{0}53'-22^{0}03' and E-91^{0}17'-91^{0}27') and (4) Kalirchar (near Sandwip, 194 square kilometer) in the Meghna estuary. It has been identified that the highest number of ripe and running hilsa are being caught indiscriminately during five days before and five days after the full moon of September-October every year during their peak spawning time and thus their recruitment was being hampered. Hence, fishing ban is required for certain time specification for their successful breeding. In the above context, Government has enacted a new rule under the Protection and Conservation of Fish Act, 1950 banning the hilsa catch during this period for successful spawning. The rule is being implemented by Department of Fisheries (DoF) from 2009 involving different stakeholders, and law enforcing agencies including Navy and Coast Guards.

The study of the impact of fishing ban on breeding performance has not yet been conducted in Bangladesh, so literature on this aspect is scanty. Some authors worked on this subject sporadically like Haldar (2004) conducted research on many aspects of hilsa including impact of jatka fishing ban and closed fishing season on abundance of jatka and hilsa production. Some other authors like Mazid and Islam (1991) Shafi and Quddus (1976), Quereshi, (1968) and Islam *et al.* (1987) worked on sex ratio of hilsa. Besides, many authors (Ahmed *et al* 2008, Miah *et al.* 1999, Rahman *et al.* 1998 and Rahman *et al.* 1995) worked on reproduction and spawning ground of hilsa in Bangladesh. But particularly impact of fishing ban on reproductive success of hilsa has not yet been attempted in Bangladesh. So, to study the impact of fishing ban implementation on reproduction and spawning success, Riverine Station of BFRI, Chandpur was assigned by DoF and in the above background the study was conducted with the following objectives:

- to estimate the size, sex and percent composition of gravid hilsa;
- to determine the percent composition of oozing hilsa;
- to determine the percent composition of spent hilsa and spawning success;
- to assess the degree of abundance and distribution of spawn and juvenile hilsa,
- to determine the extent of alteration of previously identified spawning grounds of hilsa.

Materials and methods

The Hilsa Investigation Team of the Riverine Station, Chandpur carried out the investigations. Mechanized boat and speed boat were utilized for sampling and data collection. Major spawning grounds of hilsa and related areas *viz,* Ramgoti, Hatia, Dhalchar, Moulibirchar, Monpura, Kalirchar, Daulatkhan, Bhola, Dhulia, Patharghata, Kuakata, Mohipur, Moudubi, Galachipa, Kalapara were visited for comprehensive study. To determine the size of group, captured hilsa from the above mentioned area were measured by measuring scale. Sex was determined by external observation, gentle stripping at their belly along the ventral scute line from anterior to anal direction with the fore and first finger together was applied. While at stripping along the belly, white milky or creamy liquid for the male and eggs with blood strain or food particle for the female usually came out through the anus. Seeing the milky/creamy liquid (the milt) and the eggs, hilsa was identified as male or female. When such milky liquid or eggs do not comes out, and then the fish is either of immature or premature stage. The potbellied, reddish and bigger anus also identified the fishes as female. As such, the percent composition of gravid and oozing hilsa was determined.

The spent fishes were identified by observing their very lean and thin and elongated body and health condition and shrunken belly. While stripping at their belly, isolated and distorted eggs came out with watery liquid or with or without blood strain. The hilsa are the gonochoristic (Blaber *et al.* 2001) and single shedding fishes (Haldar 2004). After shedding usually they do not die, locally called *Pite* (spent) fishes and are caught with other hilsa. The number and % of spent fishes was determined by observing the catches of the commercial fishermen in and around the spawning grounds immediately at the opening of fishing after the ban period.

The amount of fertilized egg production in the spawning grounds due to fishing ban as an indicator of spawning success was estimated using the following formula.

Total No. of Hilsa excluded due to fishing ban (TN) = No. of fishing boat × Haul/day × Fish caught/Haul × No. of days-------------------------------------- (1)

Where, Total No. of fishing boat around the spawning areas: 12000 approximately

No. of haul per day : 2
Fish caught per haul : 60
No. of days : 10

$$\text{Total fertilized eggs (Kg)} = \frac{TN \times FF \times SF \times EF}{1000} \quad (2)$$

where, TN = Total No. of Hilsa excluded due to fishing ban;
FF = % of female fishes in the study area (65%);
SF = % of spent Fish (5%), and
EF = Average egg (g) per fish (100g).

Experimental egg/fry collection was done by a savar net (shrimp PL collecting net) prepared by fine meshed glass nylon in the spawning grounds and adjacent areas to see abundance and distribution of *jatka*. Finally, by the availability of immature and oozing hilsa statement about the previously identified spawning grounds were made.

Results and discussion

Estimation of the size, sex and percent composition of berried hilsa

During the river cruise gradually larger sized hilsa were found from Chandpur to the downstream (Table 1). In the upper region, most of the hilsa found were below 30 cm, whereas, more than 90% hilsa were above 30 cm in the downstream areas. In and around the spawning grounds among all the captured hilsa, male: female ratio was 35% and 65% respectively. Haldar (2004) also found male-female ratio almost 1:2 during 2002 and 2003. Although, there are conflicting views about the sex ratio of hilsa in earlier studies, Islam *et al.* (1987) found no significant difference of male-female ratio at four important landing centers *viz* Chittagong (1:1.04); Chandpur (1:1.08); Khepupara (1:0.8) and except Cox's Bazar (1:1.8). Similar observations also were made by Shafi and Quddus (1976) in respect of Padma and Meghna hilsa. Quereshi (1968) observed that although the sex ratio was 1:1 during the monsoon, the female dominated in October. Again Blaber *et al.* (2001) indicated that there is a bias in sex ratio and the male are more abundant among the smaller fishes. The majority of fishes over 30 cm are females and almost all over 40 cm are females and males are predominant between 10 and 25 cm length group, the present findings support these views.

Table 1. Region wise abundance (%) of different length group hilsa

Region	Length group (in cm)						
	Below 32 cm		Total	Above 32 cm			Total
	18-24	25-31	(%)	32-38	39-45	46-52	(%)
Char Bhairobi (%)	6.9	70.8	77.70	20.0	2.3	0.0	22.3
Kaliganj (%)	16.3	72.1	88.40	10.4	1.2	0.0	11.6
Char ludhua (%)	0.0	4.6	4.6	40.8	50.0	4.6	95.4
Ramgoti (%)	0.9	8.4	9.3	24.8	65.0	0.9	90.7
Hatia (%)	0.0	0.9	0.9	60.7	37.5	0.9	99.1
Monpura (%)	0.0	0.0	0.0	32.5	65.0	2.5	100

From the Table 1 it could be seen that, in the spawning ground areas (Monpura and Hatia) about 100% fishes are 32.0 cm and above sizes, which are breeder group of hilsa. These findings also reconfirm these areas as spawning grounds of hilsa.

The percent composition of oozing/berried hilsa

The hilsa fishes of the spawning grounds were found with higher maturity stages/berried (maturity stages V and VI) than the other adjacent areas and % of the mature hilsa were found higher with the higher length group of fishes due to fishing ban in the spawning grounds (Table 2).

Table 2. Maturity stages of hilsa of different length group

Length group	% of fishes at Maturity stages (Ms)					
	Ms I	Ms II	Ms III	Ms IV	Ms V	Ms VI
18-24	0.00	0.00	60.00	20.00	20.00	0.00
25-31	0.00	5.89	17.65	41.18	27.45	7.83
32-38	0.00	0.00	8.33	29.17	33.33	29.17
39-45	3.45	3.45	0.00	17.24	68.96	6.90
46-52	0.00	0.00	0.00	14.29	85.71	0.00

Percent composition of oozing hilsa during fishing ban period in the spawning grounds was observed 1.61% which was relatively higher. In the year 2002 and 2003 only few oozing hilsa were observed in Kaligonj, Sandwip spawning ground area (Haldar 2004).

Determination of the percent composition of spent hilsa and spawning success

Analysis of the fishers' catch composition obtained from the major spawning grounds revealed that more than 95% captured hilsa weighing around 1.0 kg were gravid. About 5% spent hilsa was observed in the fish landing centers and this data was compared with the data of GEF-BFRI studies (Haldar 2004) and was found about 2.80 - 3.57 times higher than that of 2002 and 2003 (Table 3). The increased quantity of spent hilsa might be due to fishing ban in the peak spawning time. To determine the breeding success, percentage of spent hilsa could be an indicator among other factors, Haldar (2004) investigated the spent hilsa in Ilishaghat, Bhola, where he found the highest 3.66% spent hilsa in October followed by November (1.93%) and February (2.86%).

Table 3. Comparative % of spent hilsa observed in the landing centre

Year	% of spent hilsa	% increase (time)	Remarks
2002	0.50	-	Without management
2003	1.40	2.80	Improved management
2007	5.00	3.57	Fishing ban period

Estimation of egg/fry production during fishing ban

About 46,800 Kg eggs were produced due to imposing of 10 days fishing ban in spawning season in 2007. During experimental spawn and juveniles' collection, approximately 5-25 days old fries were found in all the surveyed areas in and around the spawning grounds (Table 4).

Table 4. Size, weight and age of captured fries and jatka from the major spawning grounds

Location	Lowest size (cm)	Highest size (cm)	Av. size	Minimum weight (g)	Maximum weight (g)	Average weight (g)	No. of jatka/haul	Approx. age (day)
Hatia	1.6	2.6	1.99	0.01	0.15	0.07	20	10-15
Char jonaki	1.9	3.7	2.54	0.04	0.48	0.17	20	15-20

Sakuchia	0.9	3.8	2.05	0.04	0.45	0.17	30	5-10
Janata (ht*)	2.1	4.0	2.75	0.08	0.54	0.23	45	15-25
Janata (lt**)	1.9	4.2	2.70	0.05	0.52	0.19	30	15-20
Monpura	1.8	3.7	2.60	0.04	0.45	0.15	54	15-20
Dhalchar	2.4	2.8	2.57	0.11	0.22	0.15	45	20-25

ht* – high tide, lt** – low tide

Due to impose of 10 days fishing ban in the spawning grounds, comparatively higher percentage of gravid hilsa were found which were not available in the same quantity and condition in the previous years *i.e.* during non-fishing ban period (Table 2). The average increase in jatka abundance was 570%, with increases at Mohanpur and Ishanbala, Chandpur when comparing 2003 and 2004 data indicating the complete fishing ban has a strong positive impact on jatka abundance (Haldar 2004). Similarly, complete fishing ban for 10 days in the spawning grounds showed that availability of plenty of spent fish (5%) and huge number of fries and juveniles of hilsa in and around spawning grounds indicating a positive impact on successful reproduction of hilsa.

Determination of the extent of alteration of previously identified spawning grounds of hilsa

Previously BFRI and GEF studies identified four spawning grounds of hilsa by the occurrence of fully ripe/oozing, spent hilsa and also on the availability of fry. During the present investigation, fairly higher amount of spent hilsa and fries were observed in the spawning grounds and adjacent areas. Moreover, larger sizes and higher percentage of mature fishes (maturity stage V to VI) were also found in the identified spawning grounds which indicate little or no changes of the spawning grounds that were reported in the previous studies.

Conclusion and recommendations

From the present study the following conclusion and recommendations could be made:

- The fishing ban was found effective for successful breeding of hilsa;
- The impact of 10 days fishing ban on breeding success of other fishes needs to be assessed;
- The fishing ban should be continued for sustainable reproduction of hilsa, and jatka as well as hilsa production; and
- The impact of fishing ban on breeding success need to be studied in depth in the forthcoming years.

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Trend and growth analysis of marine fish production in Bangladesh

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Abstract

The study based on time series marine fish production data during the period of 1983-1984 to 2007-2008 in Bangladesh. For this growth analysis six deterministic time series models are considered. The estimated best fitting models are the cubic, quadratic and quadratic model is appropriate for industrial marine fish production, artisanal marine fish production and total marine fish production in Bangladesh respectively. The study attempts to provide forecasts of marine fish production in Bangladesh for the year of 2008-09 to 2012-13. The magnitude of instability in marine fish production was attempted by computing the coefficient of variation (CV) and the percentage deviation from three years moving average values. The study revealed that the total marine fish production was observed to be relatively stable (CV being 31.85%) compared to the artisanal marine fish production (CV being 32.04%) and industrial marine fish (CV being 47.20%). For the three components of marine fish production the growth rates were different over different time points. The variation of the growth rates in industrial marine fish production was -21.6% to 13.12%, in artisanal marine fish production was 2.39% to 5.29% and in total marine fish production was 11.23% to 24.85% during the study period.

Keywords: Marine fish, Growth model, Instability, Production and Forecasting

Introduction

Of the total fisheries sector 81 percent is inland and 19 percent is marine fisheries (DOF 2009). During last 40 years, traditional maritime fishing boats had engines fixed to them to gain greater mobility, yet marine fishing activity remained essentially coastal with only a few species being caught often leading to overexploitation. Nonetheless, the potential for developing Bangladesh's marine fishery is very high. The country has 200 nautical miles or 370 km of Exclusive Economic Zone in the Bay of Bengal, providing a wide fishery zone of over 200,000 sq km, which is about 1.4 times more than the total land area of Bangladesh. Marine Fisheries are of two categories: industrial (which use trawlers) and artisanal. The latter one is contributing to the total marine fish catch nearly 14 times more than the former (DOF 2009). Offshore fishing using trawl nets in the Bay of Bengal started in the late 1970s, and the catch includes both shrimp and finfish (including pomfret and salmon). Presently, more than 70 trawler vessels are engaged in offshore fishery (Rasheed 2008). The major output, however, comes from artisanal sources, where most of the fishes are caught by ordinary fishing boats (generally mechanized) – using fixed and drift gill nets, set bags and long lines (ASB 2003). Our marine sub sector has performed a steady growth rate compare to former two sub sectors. But it must have to be remembered that marine fishery is happened to be the main catching area around the world. The study was conducted with the objective to measure the instability and growth rate and also to estimate the best model of growth analysis using seven contemporary model selection criteria and forecast the marine fish production in Bangladesh.

Materials and methods

The present study was conducted time series data of marine fish production in Bangladesh for the period 1983-84 to 2007-08. The data were collected from the various issues of Statistical Yearbook and Agricultural Statistics Yearbook of Bangladesh Bureau of Statistics. The models those are used to describe the behavior of variables that vary with respect to time are termed as growth model. This type of model is needed in a specific area and in a specific problem that depends on the type of growth that occurs in the time series data. In general growth models are mechanism rather than empirical ones. A mechanical growth models usually arises as a results of making assumptions about the type of growth. On the other hand, an empirical model is chosen empirically to approximate an unknown mechanistic model. Typically the empirical model is a polynomial of some suitable order. However in this study Linear, Logarithmic, Inverse, Quadratic, Cubic and Exponential growth models are considered.

Model selection criteria & measures of instability

To identify the best model for a particular time series data the latest available diagnostic tools are R^2, Adjusted R^2, RSME, AIC, BIC, MAE and MAPPE. The measures of instability in time series data requires an explicate assumptions of what constitute the expectable and unacceptable components. A systematic component which can be predicted does not constitute instability and hence, it should be eliminated from data. The remaining unpredictable component represents the instability. Two methods, viz. moving average and trend fitting have been used in the literature to capture the predictable component. Here the preference is for three-year moving average since the form may more adequately keep in touch with influences on trend earnings, such as changing comparative advantage and policy changes. The estimate of the magnitude of instability in the time series data on productions has been attempt by computing the coefficient of variation (CV) and the percentage deviation from three-years moving average for each year.

$$CV = \frac{\sigma}{\overline{X_t}} \times 100$$

Where,

$$\sigma = \sqrt{\left(\frac{\sum X_t^2}{N} - \frac{(\sum X_t)^2}{N}\right)}$$

σ = Standard deviation, $\overline{X_t}$ = Period mean of X_t

N = Number of years in the period

$$\text{Percentage deviation} = \frac{X_t - X_t^*}{X_t^*} \times 100$$

X_t = Observed value

X_t^* = Three years moving average

Results and discussion

Marine fish production instability

The percentage deviation from three year moving averages, mean positive and negative deviation and coefficient of variation in marine fish production from industrial, artisanal and total marine fish production are presented in Table 1 .It reveals the year to year fluctuations in marine fish production from industrial, artisanal and total marine fish production in terms of percent change from three year moving average. For the total time series, a very high coefficient of variation was found for industrial, artisanal and total marine fish production, as during the initial year of the time series i.e., in 1983-84 merely 19484 metric ton of industrial marine fish production, 153000 metric ton of artisanal marine fish production and 172484 metric ton of total marine fish production produced which during the terminal year of the series (2007-08) increased 29264 metric ton of industrial marine fish production, 438,631 metric ton of artisanal marine fish production and 467,898 metric ton of total marine fish production respectively. However, during the period the total marine fish production was observed to be relatively stable (CV being 31.85%) compared to the artisanal (CV being 32.04%) and industrial marine fish production (CV being 47.20%). It is expected as over a long period of about 25 year lots of institution and technologies change must have taken place which should have influenced the production situation of industrial, artisanal and total marine fish production cultivation. Reduction of production instability would reduce area instability largely.

Table 1. Instability in marine fish production in Bangladesh

Year	Industrial	Artisanal	Total
1984	5.29	-14.41	-10.69
1985	-19.71	-4.19	-4.41
1986	-9.14	4.27	3.62
1987	9.66	6.37	6.15
1988	4.26	9.09	8.03
1989	12.99	8.25	7.39
1990	29.24	6.63	6.41
1991	-1.06	4.95	3.67
1992	3.79	2.19	1.37
1993	22.08	-.93	-.69
1994	12.76	-4.11	-3.85
1995	-4.91	-3.47	-3.76
1996	-13.34	-5.89	-6.23
1997	-12.17	-8.82	-8.81
1998	-11.25	-14.06	-13.57
1999	-17.00	-6.27	-6.40
2000	-22.17	-3.29	-3.85
2001	4.65	3.46	4.19
2002	1.93	8.46	8.70
2003	5.65	7.26	7.72
2004	16.00	7.22	8.22
2005	15.27	6.82	7.57
2006	10.38	3.34	3.71
2007	-11.24	-5.44	-6.22
2008	-10.43	-6.94	-7.92
Mean Positive Deviation (%)	11.00	6.02	5.90
Mean Negative Deviation (%)	-12.04	-6.49	-6.37
Mean of Absolute Value	11.52	6.25	6.14
CV (%)	47.20	32.04	31.85

The negative fluctuations in industrial marine fish production were deeper during 1984-85 (-19.71%). The large positive deviations were observed during 1989-90 (29.24%) and 1999-2000 (22.17%). Deviation around minus 12% point was seen in 1997-98 and around plus 12% point was seen in 1993-94. In other year the deviations were either small or moderate. In case of artisanal marine fish production the negative fluctuation more deep during 1983-84 (-14.41%) and 1997-98 (-14.06%) respectively. There are no large positive deviations were observed. Fluctuations around minus 12% point and around plus 12% point were nil. In the other years deviations were either small or moderate. Again, the case of total marine fish production there are no large positive deviations were observed. The negative fluctuations were deeper in the year 1997-98 (-13.57%). Fluctuations around minus 12% point and around plus 12% point were nil. In the other years deviations were either small or moderate the positive and negative fluctuations in marine fish production has more or less approximately similar trend over the year. If a comparison is made between mean negative and positive deviations of industrial, artisanal and total marine fish production, it is seen that mean negative deviations is more deep in industrial marine fish production (-12.04%) as compared to artisanal marine fish production (-6.49%) and total marine fish production (-6.37%) respectively. The mean positive deviation is large in industrial marine fish production (11.00%) as compared to artisanal marine fish production (6.02%) and total marine fish production (5.90%) respectively. In the absence of decomposition analysis the causes of instability in production may not be identified. However, the plausible explanation for the small fluctuations were observed in the study period may be introduced modern technologies. It was observed that after 1983-84 period, leveling 2008-09, the fluctuations of industrial, artisanal and total marine fish production in Bangladesh were of small magnitude indicating thereby some sort of stabilization.

Industrial marine fish production

All the models considered for this study, are estimated for the time series of marine fish production in Bangladesh during 1983-84 to 2007-08 and shown in Table 2. The parameters those are significant at 1% level are marked by double star and single star is used to show the coefficients those are significant at 5% level. We have to examine the model selection criteria discussed in the methodology section. All the diagnostic tools that have been used in this study to identify the best fitted model for forecasting purpose and also for explaining the growth pattern are calculated and give in Table 3.

Table 2. Parameter estimates of the models of industrial marine fish production in Bangladesh

	Parameter			
Model	α	β	γ	δ
Linear	5915.47**	933.95**		
Logarithmic	4723.41	5746.80**		
Inverse	19455.84**	-9165.56**		
Quadratic	15493.69**	81.87**	-1194.55**	
Cubic	22168.20**	-4003.44**	346.73**	-6.79**
Exponential	8721.41**	.048**		

(**, * denote estimated coefficient significant at 1% and 5% level of significance)

In interpreting the diagnostic tools we consider that the more the value of R^2 and $\overline{R^2}$ are the better is the fitness of the model. On the other hand, the smaller is the value of RMSE, AIC, BIC, MAE or MAPPE; the better is the fitness of the model. It is obvious that a better model yields smaller forecasting error. The analysis shows that all the coefficients of all the models are highly significant at 1% level except logarithmic model. From the results of model selection criteria, given in Table 3, it appears that the value of R^2 (0.914) and $\overline{R^2}$ (0.901) for the cubic model are the highest in comparison of other models. Moreover the value of RMSE (2674.79), MAE (2038.85) and MAPPE (11.57) in cubic model are the smallest value in comparison with other models and the value of AIC (-61.43) and BIC (-58.99) are smallest in the exponential model. So, for describing the growth pattern of industrial marine fish production in Bangladesh and making forecast with minimum forecasting error the cubic model is appeared to be the best. Although AIC and BIC are the smaller value of the exponential model so, we can not ignore the exponential model. For estimating the growth rate of industrial marine fish production the second best model may be considered as exponential model.

Table 3. Criteria of model selection for the industrial marine fish production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	.651	.635	5146.73	431.31	433.74	4050.55	26488796	25.99
Logarithmic	.316	.287	7197.59	448.08	450.51	6095.83	51805266	37.99
Inverse	.049	.008	8488.43	456.32	458.76	7393.24	72053405	45.44
Cubic	.914	.901	2674.79	402.58	401.02	2038.85	7154525	11.57
Quadratic	.875	.844	3361.17	412	412.44	2423.30	11297439	12.32
Exponential	.644	.629	4638.07	-61.43	-58.99	3595.38	.073	21.18

Artisanal marine fish production

All the models considered for this study, are estimated for the time series of artisanal marine fish production in Bangladesh during 1983-84 to 2007-08 and shown in Table 4. The parameters those are significant at 1% level are marked by double star and single star is used to show the coefficients those are significant at 5% level. The analysis shows that the coefficients of linear, inverse and exponential models are highly significant (at 1% level) except the logarithmic, quadratic and cubic models. It seems difficult at this stage to select the best model but looking at the diagnostic tools will be helpful. The diagnostic tools that have been used in this study to identify the best fitted model for forecasting purpose and also for explaining the growth pattern are calculated and given in Table 5. It appears form the table that the values R^2, $\overline{R^2}$, RMSE, MAE and MAPPE are in favor of the quadratic model but AIC, BIC are in favor of the exponential model.

Table 4. Parameter estimates of the models of artisanal marine fish production in Bangladesh

	Parameter			
Model	α	β	γ	δ
Linear	133871.5**	12190.36**		
Logarithmic	73707.04*	94235.16**		
Inverse	333414.9**	-269059**		
Quadratic	175454.4**	2949.72	355.41**	
Cubic	178105.2**	1834.15	460.60	-2.70
Exponential	161734.7**	0.042**		

(**, * denote estimated coefficient significant at 1% and 5% level of significance)

Table 5. Criteria of model selection for the marine artisanal fish production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	.918	.914	27476.52	515.05	517.49	22045.81	754959298	8.08
Logarithmic	.705	.692	52008.64	546.96	549.40	44795.43	2704898170	16.23
Inverse	.352	.324	77030.07	566.60	569.04	67702.87	5933630994	24.09
Cubic	.949	.943	22414.12	452.36	450.79	18167.57	502392596	6.44
Quadratic	.950	.945	21914.87	505.75	506.18	18100.76	480261339	6.36
Exponential	.947	.944	22255.90	-123.90	-121.46	18467.30	.006	6.38

So, here create a conflicting situation, in this situation we may place the cubic model in the first position of our choice for describing the growth pattern of culture inland fish production in Bangladesh and making forecast with minimum forecasting error and place the exponential model in the second best model of our choice.

Total marine fish production

The models considered for this study are estimated for the time series of total marine fish production in Bangladesh during 1983-84 to 2007-08 and shown in Table 6. The analysis shows that all the coefficients of all the models are highly significant (at 1% level) except the quadratic and logarithmic model. The constant term of the logarithmic model and coefficient of the quadratic model are insignificant.

Table 6. Parameter estimates of the models total marine fish production in Bangladesh

	Parameters			
Model	α	β	γ	δ
Linear	289660.3**	60888.09**		
Logarithmic	24472.75	455460**		
Inverse	1261067**	-1178348**		
Quadratic	492073.5**	15907.39	1730.03**	
Cubic	689462.3**	-67161.4**	9562.92**	-200.84**
Exponential	466011.5**	.058**		

(**, * denote estimated coefficient significant at 1% and 5% level of significance)

The diagnostic tools may reveal the picture more clearly. The tools that have been used in this study to identify the best fitted model for forecasting purpose and also for explaining the growth pattern are calculated and given in Table 7. It appears from the table that the value of R^2 (0.949) and $\overline{R^2}$ (0.944) are the highest for cubic model in comparison with other models. Further values of model selection criteria RMSE (24006.31), MAE (19497.55) and MAPPE (6.21) for the quadratic model are the smallest in comparison with other models. AIC (-123.90), BIC (-121.46) are smallest in the exponential model. But the only model that may be used for describing the growth pattern of total marine fish production in Bangladesh and making forecast with minimum forecasting error is the quadratic model.

Table 7. Criteria of model selection for the total marine fish production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	.907	.903	31600.28	522.05	524.48	25788.55	998577732	8.99
Logarithmic	.676	.662	58941.86	553.22	555.65	50862.52	3474142761	17.33
Inverse	.321	.291	85383.66	571.75	574.18	75094.73	7290368681	25.09
Cubic	.945	.942	24384.66	513.09	511.52	19785.51	594611518	6.51
Quadratic	.949	.944	24006.31	510.30	510.74	19497.55	576303054	6.21
Exponential	.946	.943	25299.41	-123.90	-121.46	20540.23	.006	6.43

The above discussion about the fitness of various models to the time series of marine fish production in Bangladesh reveals that cubic models are appropriate for different categories of marine fish production in describing the growth pattern. It also reveals that the selection of the best model for a particular category can sometimes be very confusing. However the discussion recommends a best model for a particular category as given in Table 8.

Table 8. Best estimated models for marine fish production in Bangladesh

Variety	The name of the best model	The functional form of the model
Industrial marine fish production	Cubic	$22168.20-4003.44t+ 346.73t^2- 6.79t^3$
Artisanal marine fish production	Quadratic	$175454.4+ 2949.72t+ 355.41t^2$
Total marine fish production	Quadratic	$492073.5+ 15907.39t+ 1730.03t^2$

Growth analysis

The growth rates are calculated using the three best selected models for each of the time series during the study period are given in Table 9. It appears from the table that the exponential growth rate of industrial, artisanal and total marine fish production in Bangladesh during the study period were 4.8%, 4.2% and 5.8% respectively. It means that the production grew on the average at this constant rate per year throughout the study period. This is the inherent assumption of the exponential growth model. But the best fitting model for industrial, artisanal and total marine fish production are the cubic, quadratic and quadratic model respectively, which assumes that the growth of the series was not constant throughout the study period, instead it was dependent on time with a quadratic nature of variation. Taking a close look at the annual growth rates of industrial, artisanal and total marine fish production in Bangladesh given in table will reveal a different picture of the growth scenario.

It appears from the table that the growth rate of industrial marine fish production varied from -21.69% to 13.12% and Fig. 1 reveals that the growth rate of industrial marine fish production was negative and minimum during the year 1983-84 to 1989-90. After 1989-90 the growth started to raise maintained increasing up to 13.12% in the year of 1995-96 and then positively decreasing in the year of 1996-97 to 2007-08. It appears from the table that the growth rate of artisanal marine fish production varied from -259.02% to -11.84% and figure reveals that the growth rate of artisanal marine fish production was negative and minimum during the whole period. It appears from the table that the growth rate total marine fish production varied from 11.23% to 24.85% and figure 01 reveals that the growth rate of total marine fish production was positive during the whole period.

Table 9. Cubic, Quadratic and exponential annual growth rates in %

Year	x		Artisanal		Total	
	Cubic	Quadratic	Cubic	Quadratic	Cubic	Quadratic
1984	-17.09	-11.84	1.80	2.39	-28.20	11.23
1985	-21.69	-37.75	2.08	2.50	-16.70	12.17
1986	-17.70	-59.55	2.31	2.60	-7.33	12.67
1987	-12.59	-76.68	2.63	2.82	-.14	13.67
1988	-10.06	-114.13	2.87	2.99	5.89	14.59
1989	-5.56	-137.67	3.17	3.24	11.10	15.72
1990	-1.29	-146.25	3.46	3.48	15.56	16.79
1991	2.75	-217.25	3.73	3.71	19.58	18.05
1992	6.11	-222.59	4.01	3.96	22.88	19.17
1993	7.31	-194.73	4.30	4.22	25.49	20.16
1994	9.31	-210.36	4.57	4.48	27.79	21.33
1995	11.82	-244.02	4.63	4.54	28.56	21.70
1996	13.12	-259.02	4.83	4.73	29.53	22.57
1997	12.63	-245.99	5.03	4.94	30.03	23.42
1998	11.89	-234.1	5.37	5.29	30.85	24.85
1999	11.87	-241.14	4.93	4.87	27.31	23.00
2000	11.64	-248.61	4.77	4.74	25.12	22.39
2001	7.86	-179.58	4.44	4.43	21.58	20.60
2002	7.23	-180.06	4.21	4.22	18.95	19.65
2003	6.14	-170.64	4.21	4.25	17.21	19.71
2004	4.83	-153.62	4.17	4.23	15.11	19.46
2005	4.09	-153.83	4.13	4.22	13.06	19.39
2006	3.43	-160.98	4.20	4.33	11.25	19.90
2007	3.20	-202.11	4.52	4.69	9.85	21.76
2008	2.06	-203.82	4.51	4.72	7.35	21.89
Exponential	4.8		4.2		5.8	

Forecasting

The best fitted models are used to make forecasts with 95% confidence interval for industrial, artisanal and total marine fish production and are given in Table 10. The prediction period extends from 2008-2009 to 2012-2013. An important limitation of making forecasts is that the forecasting error increases as the period of forecast increases. For this reason short-term forecast are more reliable compared to long term forecast. Close examination of the forecasted values and confidence intervals given in Table 10 would reveal that forecasting errors are sufficiently small and consequently the intervals are not too large.

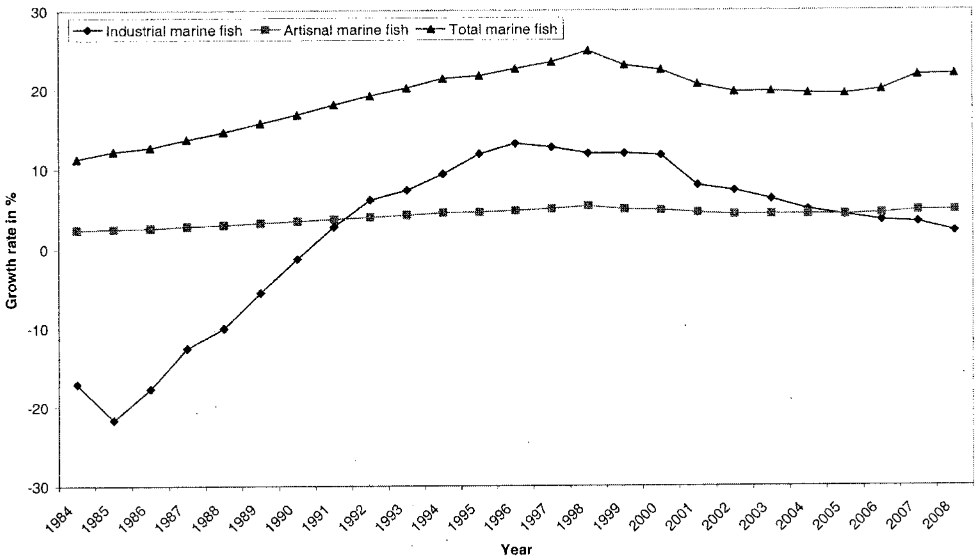

Figure 01: Growth functions of the Cubic and Quadratic models

Table 10. Forecast of marine fish production in Bangladesh for the period of 2008-09 to 2012-13 at 95% level

Variety	Description	Forecast year				
		2008-09	2009-10	2010-11	2011-12	2012-13
Marine industrial fish production	LPL	24666.72	26591.24	28266.68	29700.41	30913.63
	Forecast	40398.82	44516.42	49095.95	54166.56	59757.39
	UPL	56130.92	62441.59	69925.21	78632.71	88601.16
Marine artisanal fish production	LPL	279395.84	275381.01	269260.51	261008.04	250612.53
	Forecast	424451.12	426103.42	426668.85	426147.41	424539.10
	UPL	569506.41	576825.84	584077.19	591286.78	598465.67
Marine total fish production	LPL	300232.51	297077.73	291731.35	284164.69	274365.72
	Forecast	458226.22	461244.06	463179.96	464033.92	463805.93
	UPL	616219.93	625410.40	634628.58	643903.15	653246.15

In Table 10 stated that the forecasted total marine fish production in the year of 2008-09 was 458226.22 metric tons with a 95% confidence interval of (300232.51, 616219.93) whereas for industrial and artisanal marine fish production these values are 40398.82metric ton and 424451.12 metric ton with a 95% confidence interval of (424451.12, 56130.92) and (279395.84, 569506.41) respectively. The analysis found that if the present growth rates continue then the industrial marine fish production, artisanal marine fish production and total marine fish production in Bangladesh in the year of 2012-2013 will be 59757.39 metric tons, 250612.53 metric tons and 463805.93 metric tons with approximately plus/minus 57687.53 metric tons, 347853.14 metric tons and 378880.43 metric tons respectively.

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Environmental assessment of shrimp farming in relation to livelihoods in the south-west coastal Bangladesh

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Abstract
The study was designed to assess the environmental impact of shrimp farming and implications on local livelihoods at the south-west coastal area of Bangladesh. All the stakeholders reported that shrimp farming negatively affected on the environment at the coastal area. The soil and water, fish habitation, agricultural cropland, grazing land, indigenous fish, household vegetations, trees and plants, land fertility and mangroves are affected negatively by the shrimp farming in the coastal area. About 44 percent stakeholders agreed that mangroves were destroyed by the extension of shrimp farming in the study area. In the case of positive impact of shrimp farming on environment about 16 percent stakeholders agreed that the household vegetations increased due to alternate rice and shrimp-prawn farming.

Key words: Shrimp farming, Environment, Mangrove

Introduction

Shrimp farming has been the subject of warm debate and scrutiny as a result of the negative environmental and social impacts that have been documented around the world (Rosenberry 2006, Lebel *et al.* 2002, Patil *et al.* 2002). Since shrimp cultivation occurs in a closed or semi-closed system, there is potential for waterlogging and increased salinity levels to alter drainage patterns and the quality of the soil (Bhattacharya 2005). Furthermore, the use of fine seine nets to sieve for shrimp larvae for cultivation has been associated with the decline of other fish species that were naturally occurring in the river deltas of south-west Bangladesh. Finally, the loss of vegetative cover has also been attributed to increased salinization and salt water intrusion. Shrimp farming is not only earnings foreign exchange but also losses the gross domestic product (GDP) of Bangladesh examined by Bhattacharya 1999. While much of the loss of mangrove forest in Bangladesh occurred over the previous 50 years, some areas have been deforested as a result of shrimp aquaculture (Guimarães 2002). In the above aspects, the present study was carried out to report on the perceived environmental impact of shrimp farming and its implications for local livelihoods in the south-west coastal Bangladesh.

Methodology

Study area and selection of the shrimp farming stakeholders

The study areas were selected from the south-west part of Bangladesh, mainly in Satkhira and Khulna districts where the majority shrimp farming activities are concentrated. According to their involvement in different activities of the shrimp industry, nine categories of stakeholders were selected for data collections (Table 1).

Table 1. Sampling design and distribution of shrimp farming stakeholders

Sl. No	Stakeholder	Sample size	Description
1	Shrimp farmers	30	Year round only shrimp farming
2	Alternate rice and shrimp-prawn farmers	30	After rice culture; shrimp-prawn culture together
3	Rice farmers (control)	30	Rice farming in shrimp growing area
4	Depot owners	10	Depot: Local shrimp processing factory
5	Depot workers	10	Worker in the shrimp processing factory
6	Shrimp farm laborers	20	The laborers are working either whole day and night or part time
7	Faria-Shrimp traders	10	Buying shrimp from shrimp farm and selling it to depot
8	Land lessors	10	Leasing their land to the rich shrimp farm
9	Shrimp seed collectors	10	They collect the Post Larvae (PL) from the river
Total stakeholders		160	

Simple random sampling techniques were applied for selecting the respondents of rice farmers, shrimp farmers, and alternate rice and shrimp-prawn farmers. For applying the technique, at first the list of rice farmers, shrimp farmers and also the alternate rice and shrimp-prawn farmers were collected from the Upazila Agricultural office and Upazila Fishery Office of the selected upazila and then random number table was used for selecting the sample units. The sample of shrimp farm laborers, depot owners, depot workers, shrimp seed collectors and land lessors were selected by purposive method.

Questionnaire design and survey of the study area

One draft questionnaire was designed to survey the environmental issues due to shrimp farming and implications on local livelihood. During August-December 2007 the data were collected by the pre-tested draft questionnaire from the two respondents of each category. Then the questionnaire has been finalized for collecting the necessary data through interview method.

The survey method was followed through direct interview from the different stakeholders. For determining the environmental impact of shrimp farming "before and after" and also "with and without" methods were applied. The respondents were asked about what were the environmental situations were before and after the shrimp farming practice at the study areas. Data was collected through direct observation and transect walk (informal surveys and this participatory studies known as a walk over the transect of an area for the observation and documentation of the similarities and differences of environmental and bio-physical features described by PPM&E (2004).

The data were also collected by oral history method. Oral history is an interview method by which the researcher collects about the past events and ways of life. The beginning history of the shrimp farming, the mangroves were present at the shrimp farming area or not and also the agro-ecosystem gradually destroying or not were obtained from the very old aged people at the coastal areas by this oral history method. In this case the respondents were more than sixty years old. The selected respondents were different categories like shrimp farmers, shrimp seed collectors and shrimp farm laborers and land lessors of very near the mangroves region of the coastal area.

The effect of cyclone Sidr on the study area

In every year the coastal villagers are facing cyclones, storms and over flood. The cyclone *Sidr* struck at the South-west coastal part on November 15, 2007. It was the middle time of the author's research data collection from the *Sidr* struck area. At that moment the respondents were not interested to provide the information. After the *Sidr* attack author had collected data from the stakeholders by giving them some money so that they could get food in exchange for the interview. The shrimp farming stakeholders were facing their uncertain future after the *Sidr*. Bangladesh government estimates that around 8.5 million coastal people were affected of which 3400 people had died described by Larson (2008). Around 10,000 shrimp farms and hatcheries were washed away from the Satkhira, Khulna, Bagerhat and Patuakhali districts and about 36 million US Dollars lost due to the devastating *Sidr* (Rosenberry 2008).

Data analysis

The data from the questionnaire were grouped and categorized according to the different stakeholders of the shrimp farming. The whole data were entered into the MS Excel program and in the tabular form in the computer. Mainly the tabular and graphical methods were used for analyzing the data.

Result and discussion

Perceived positive impact of shrimp farming on environment

The positive impacts of shrimp farming on environment have been estimated from the collected data. About 7-10 percent respondents have been reported that mangroves and trees and plants have increased and about 16 percent respondents have reported that the household vegetations have increased due to shrimp farming because the farmers are cultivating different types vegetables on the bank (*Bheri*) of the shrimp ponds (Table 1). Some respondents have planted trees and plants surroundings their homestead areas, so they have reported that it has increased in the shrimp farming areas.

Table 1. Perceived positive impact of shrimp farming on environment in the study area

Different aspects of environmental issues/ Respondents	Shrimp farmers (n=30)	Alt. rice & shrimp prawn farmers (n=30)	Rice farmer (n=30)	Depot worker (n=10)	Shrimp farm laborer (n=20)	Faria (n=10)	Shrimp seed collec-tors (n=10)	Over all % n=160
Decreased soil and water salinization	0	0	0	0	0	0	0	0
Increase of mangrove	0	0	0	30	20	20	20	10
Increased mangrove goods and services	0	0	0	20	30	10	10	11.11
Increase of household vegetation	30	23.33	30	20	40	0	0	15.92
Increased Ag crop land (use for shrimp farm)	0	0	0	0	0	0	0	0
Increased land fertility	0	0	0	0	10	0	0	1.11
Increased grazing land	0	0	0	0	0	0	0	0
Increased trees and plants	0	0	0	0	30	20	20	7.77
Increased indigenous fish	0	0	0	0	0	0	0	0
Increased livestock production	0	0	0	0	0	0	0	0
Increased fish habitation	0	0	0	0	0	0	0	0
Increased Poultry production	86.66	90	93.33	100	100	100	100	96.66

About 97 percent respondents have been reported that the poultry production has increased due to shrimp farming at the coastal areas. The shrimp farmers and rice farmers are using the poultry excretion as manure of their shrimp and rice farms. On the other hand the poultry growth rate is very high and profitable so, the coastal peoples are encouraged to do the poultry farm. On the aspect of soil and water salinization, agricultural crop land, grazing land, indigenous fish and livestock production and in the case of fish habitation there have no positive impact due to shrimp farming at the coastal areas.

Perceived negative impact of shrimp farming on environment

About 89-93 percent stakeholders reported that agricultural crop lands and freshwater fish habitation has been decreased due to saline water in the study areas, because freshwater fishes and agricultural crops cannot grow well in saline water. The agricultural crop lands are decreasing gradually because they are using their lands for shrimp farm.

More than 80 percent respondents have been reported that the livestock production especially cow, goat, buffalos and other domestic animals has decreased simultaneously with the decreasing of agricultural land and grazing land. The rest part of the paddy trees and the grass of the grazing lands have been used for the main feed of the livestock. Islam *et al.* (2002) have found that the main feed of livestock are paddy straw has the acute shortage due to convert the rice farming to shrimp farming and also the shortages of gazing lands the livestock have decreased from the coastal areas have reported by the 63 percent respondents. Only 3 percent stakeholders have reported that the poultry production have the negative impact due to shrimp farming which is ignorable. And more than 60 percent respondents has been reported that the mangroves goods and services, household vegetations, land fertility, trees and plants also have affected due to shrimp farming at the coastal area.

About 44 percent of the stakeholders have reported the mangroves are destroying due to shrimp farming, but 60 percent respondents have agreed that the mangroves are destroying with other causes such as cyclone, storms, cutting by thieves, fire wood and guard shed. For the causes of mangroves destroying the spawning grounds of fishes are going to extinct gradually. According to the research data about 66 percent respondents have reported that the household vegetations have decreased due to shrimp farming in these areas. The native plants, trees and mangroves forest have been destroyed due to the extension of shrimp farming in the coastal areas (Islam *et al.* 2002). They also have found that the shrimp farming also have damaged the household vegetation and social forestry, particularly in the Khulna and Satkhira region. The indigenous fish and freshwater fish habitation have not decreased significantly in the rice farming areas because it is salinity protected very small area, whereas all the shrimp farmers and other stakeholders have reported that it has decreased due to shrimp farming in their region.

Causes of mangroves destruction

The '*Sundarban*' mangroves of Bangladesh are situated at the coastal areas which are gradually decreasing by the different causes. About 75 percent respondents have been reported that the nearer villagers are using mangroves as their fire wood, the guard shed of shrimp farms and about 69 percent stakeholders have agreed that the roof of the house of villagers are also using by the mangroves/*golpata* (Fig. 1). The coastal peoples are also using the mangroves as the timber, firewood and thatching material (Rahman 2007). Around 60 per cent stakeholders have told that thieves are cutting the mangroves, cyclones and storms are also destroying the mangroves have agreed by 50 percent respondents. About 44 percent stakeholders have reported that mangroves are destroying by the extension of shrimp farming; they also have told that mangroves could be grown if the shrimp farm were not present here. The respondents whose are not living near the mangroves some of them (25 percent) have been reported that they do not know about the mangroves are destroying or not.

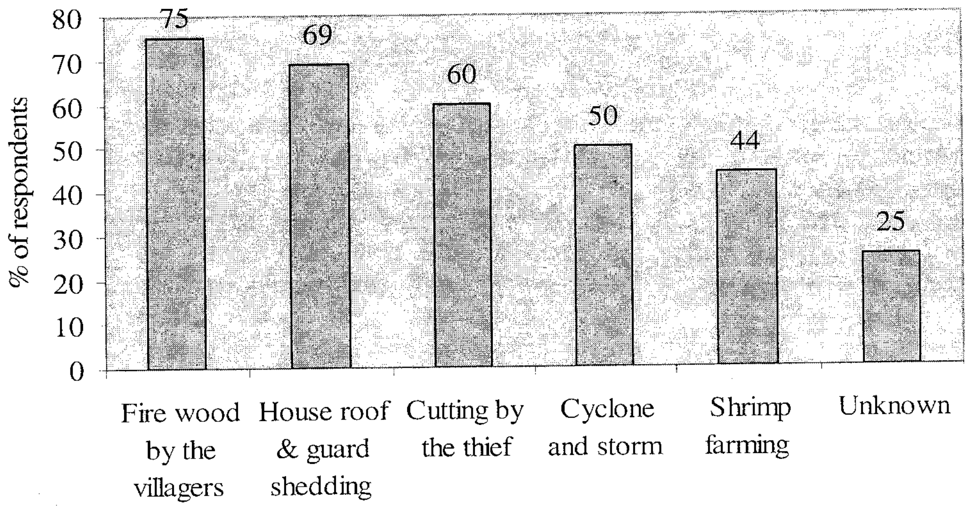

Fig 1. Causes of mangrove destructions at the south-west coastal area.

The shrimp fry collectors are also destroying the mangroves. When the shrimp seed collectors collect the post larvae by the net the young mangroves are rooted out from the clay. The coastal forest *Sundarban* mangrove has decreased from 12,328 acres in 1993-94 to 1996-97 about 44 per cent decline during this period (Islam *et al.* 2002). In the case of extensive shrimp farm sometimes a vast area of mangrove are cleared thus reducing the biodiversity. The total global mangrove losses of the past 2 decades, as much as 38% is attributed to shrimp farm development (EJF 2008). The illegal political leaders are grabbing the mangroves and using for shrimp farms in the South-east coastal areas of Bangladesh (Rosenberry 2006). Shrimp farming is not the major factor responsible for the destruction of mangroves; the traditional agricultural expansion including agricultural encroachment (81 percent), aquaculture (12 percent) and urban development (2 percent) causes the mangroves destruction in the Tsunami affected areas including Bangladesh (Rosenberry 2007).

Water pollution due to shrimp farming

All the shrimp farms at the southwest coastal area are discharging the waste water into the connected canal and occurs environmental degradation and finally destroying the ecological balance. These waste waters also contain a vast amount of antibiotics, pesticides and also chemical fertilizers which are the causes of environmental pollution. The farmers are using antibiotic drugs and chemicals to combat disease (Larson 2008) and Thai environmental governance is driving to change shrimp farming practices by reducing antibiotic use (Lebel *et al.* 2004). About 36 per cent stakeholders have been reported that the shrimp farms are affecting and water pollution are causes by the toxic chemical pollution from the untreated industrial effluents.

Perception of causes of viral disease of shrimp

The shrimp farmers are losing a lot due to the viral disease in their farms. The viruses are attacking at least two times in a year and after attacking the virus within one week all the shrimps have died and it takes 45-60 days to become the previous situation again. Disease is the single most important factor limiting production in the shrimp industry (Lebel *et al.* 2002). The causes of viral disease have been estimated by asking to the shrimp farmers and the results have depicted in the Fig. 2 in percentage term. All the shrimp farmers have reported that the main causes of attacking the viral disease is contamination by water, crabs, birds, snakes and nets. The birds, crabs, snakes, frogs are contaminating the viral disease from one pond to others. The virus also contaminated by the nets and water. About 95 percent respondents have agreed that initially the viral contaminated Thai shrimp fry are the first causes of viral disease in Bangladesh. Recently some Bangladeshi hatchery owners are buying secretly the low quality and virus-infected post larvae (of West Bengal, India) from the smugglers and selling it to the unsuspecting farmers as locally produced fry at high prices (Rosenberry 2008).

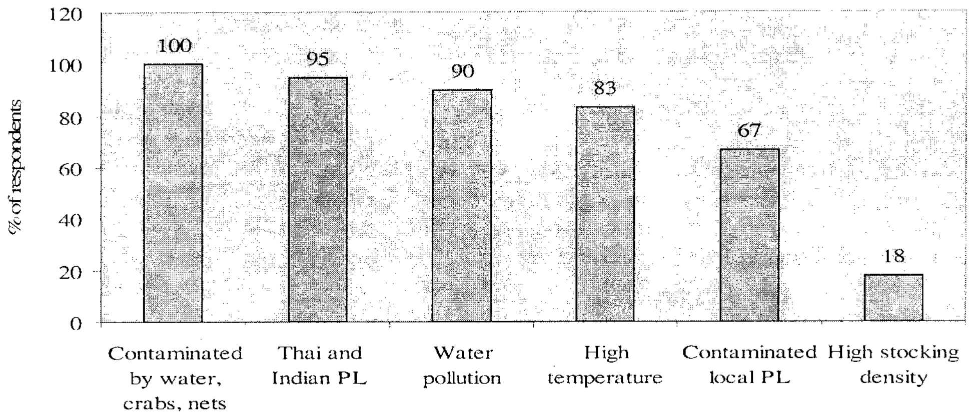

Fig 2. Causes of viral disease reported by the respondents.

Shakil (2006) has found the causes of viral disease of shrimps are adverse weather, heavy rain and flooding, contaminated water rolling down from the hills, unplanned and unscientific farming practices, imported seed stock infected with viruses and indiscriminate use of drugs and chemicals. About 90 percent farmers have reported that water pollution making the favorable conditions for viral disease. Water is polluted by the shrimp waste products, uneaten feed, dead algae and other faunas, and rich effluents. In summer when the temperature is very high and the depth of shrimp ponds are low, the shrimp fry becoming weak and for this reason the virus is attacking; have reported by 83 percent shrimp farmers. And only 18 percent stakeholders have reported that the causes of viral disease are the high stocking density of shrimp fry in the pond.

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Environmental impact of wild shrimp seed collection with non-selective gears on coastal aquatic biodiversity

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Abstract

Collection of wild tiger shrimp (*Penaeus monodon*) seed with non-selective gears and its impact upon the coastal aquatic biodiversity has been investigated. Loss of undesired species as by-catch was estimated to be 1,075 individuals for collection of every desired shrimp seed which amounted to be 132 billion in a study area stretching 3 km long coastline of the Sagar Island under the Sunderban Biosphere, West Bengal, India. Non-penaeid shrimp seed and crab larvae accounted to be maximally destroyed as their overall contribution towards the by-catch were 56.5% and 29.44%, respectively. Though, rate of by-catch loss was found to be inversely correlated with the rate of shrimp seed collected per gear ($r=-0.82$, $p<0.05$) during the peak season (May – September), the overall relationship between them exhibited a linear relationship ($r=0.73$, $p<0.05$). By-catch loss for every shrimp seed collection tended to increase up to a daily collection of 2,500 numbers of shrimp seeds per gear followed by a decline. Coastal aquatic community was maximally damaged when the heterogeneity and stability as reflected by different diversity indices were higher.

Key words: Shrimp seed, Gear, By-catch loss, Diversity indices

Introduction

Seed is the first and foremost requirement in any of the farming practices including shrimp farming also. On record, there are 260 shrimp hatcheries in India with a total annual production capacity of 10.8 billion shrimp seed as 20-day-old post larvae (PL 20). Though, it is sufficient to meet up the demand in the culture sector, shrimp aquaculture in India still depend substantially upon the wild shrimp seeds collected from shallow coastal waters because of the higher preference of the wild natural seeds over the hatchery bred ones by the farmers. As a result, around 50,000 coastal poor people used to collect and supply wild shrimp seeds to 33,000 ha. shrimp farms in West

Bengal, India (Alagarswami 1995). The scenario is almost similar in neighbouring Bangladesh where, 1-1.2 million persons used to collect natural shrimp post-larvae from the coastal waters. Unfortunately, the desired species of culture, *P. monodon* constitutes a very small portion of juvenile and even adult populations in the wild (Primavera 1995) and it was estimated as 0.25-0.27% of the total catch (Sarkar and Bhattacharya 2003). The undesired constituents of the total catch collected traditionally through non-selective gears like shootnet, '*chakni jal*', dragnet, barrier net etc. are simply discarded on the open shore and ultimately destroyed during the sorting out of *P. monodon* seed from the wild heterogeneous collection. The environmental impacts of shrimp farming has been emphasized (Paez-Osuna 2004) and several authors tried to quantify the impact of coastal shrimp seed collection in different countries (Nath and Banerjee 1991, Mahapatra *et al.* 1995, Deb *et al.* 1994, Islam *et al.* 1996, Primavera 1998, Islam *et al.* 2004).

The present work has been envisaged to quantify the collateral loss of valuable coastal aquatic biodiversity in the process of wild shrimp seed collection. Coastal areas of Sagar Island, West Bengal, India under the Sunderban biosphere have been selected because the intensity of natural shrimp seed collection by the local poor fishers was found to be maximal there.

Materials and methods

The investigation was carried out during May'03 to April'04 in the coastal areas of the Sagar Island (21.4° N and 88.1° E) situated within the world's largest mangrove habitat, the Sundarban biosphere in South 24 Parganas district, West Bengal, India. As the study area was located in the confluence zone of the River Muriganga in the Bay of Bengal, it was thickly covered with mangroves and harbored a luxuriant biodiversity of living marine resources.

Five sampling sites located at nearly equal intervals stretching around 3 kms. of the coastline were selected because of intensive shrimp seed collection in that region. For every sampling, 10 seed collectors with shoot-nets were randomly selected at each location. The discard volume containing the undesired organisms as 'by-catch' per haul per shootnet was collected on spot from each seed collector following sorting out of the desired *P. monodon* seed. Sub samples (100 ml) from each of the fifty samples thus collected from the five locations were mixed to make it 5 l. Finally from the mixed sample, one litre of the homogenous mixture was sieved with a fine mesh and the contents were preserved in 4% formaldehyde solution on spot and subsequently carried to the laboratory for qualitative and quantitative estimation of different organisms as by-catch. Sampling was done fortnightly during the one-year cycle from May'03 to April'04 except from November '03 to February '04 when natural abundance and collection of shrimp seed was negligible.

The collected preserved sample of by-catch was sorted for different groups of organisms. The sample was taken in a petridish, placed under a dissecting binocular and different groups of organisms were quantified after proper identification.

Quantification of by-catch loss was done by applying the modified equation of (Bhaumik *et al.* 1992). Therefore, annual average by-catch loss =

$$\left[\left\{\left(\frac{N_P + N_L}{2} \times A\right)\left(\frac{B_P + B_L}{2}\right)\left(\frac{S_P + S_L}{2}\right)\left(D_P + D_L\right)\right\}\right]$$

Where,

N_p = Average number of nets km^{-1} during peak season
N_L = Average number of nets km^{-1} during lean season
A = Total area in km
B_p = Average number of by-catch shrimp $seed^{-1}$ during peak season
B_L = Average number of by-catch shrimp $seed^{-1}$ during lean season
S_p = Average number of shrimp seed catch day^{-1} $shootnet^{-1}$ during peak season
S_L = Average number of shrimp seed catch day^{-1} $shootnet^{-1}$ during lean season
D_p = Total number of days in operation during peak season
D_L = Total number of days in operation during lean season

Different indices for estimation of diversity in the by-catch were calculated following the methods of Pielou (1975). The data were subjected to statistical analyses following appropriate methodologies, where necessary. The results of the determinations were accepted at 5% level ($P<0.05$).

Results

By-catch composition

The by-catch of organisms was comprised of non-penaeid seeds, young and juveniles of finfishes, larvae of crabs as well as a few lobsters along with substantial number of unidentified ichthyoplankton and invertebrates predominantly represented by the annelids. The non-penaeid shrimp seed community in the by-catch was composed of *Metapenaeus brevicornis*, *M. monoceros*, *M. ensis*, *Parapenaeopsis sculptilis, Palaemon styliferus and Acetes indicus* whereas, the finfish community was composed of *Anguilla* sp., *Therapon jarbua*, *Lates calcarifer, Harpodon nehereus*, *Mugil cephalus, M. cunnesius, Liza parsia, Rhinomugil corsula, Eleutheronema tetradactylum*, *Polynemus indicus*, *P. sextarius*, *Trichiurus* sp., *Scatophagus argus, Cynoglossus* sp. The crab larvae are mainly dominated by the megalopa larval stage of the pelagic coastal crabs.

Temporal trend of seed availability and by-catch loss

The number of seed collected per day per shoot net attained peak during June whereas, loss of by-catch for every shrimp seed collection tended to increase and attained peak during August followed by a sharp decline thereafter. During November to February, there was no seed collection activity as well as no loss of aquatic diversity as by-catch loss. Consequent with the onset of seed collection activity from next March, the loss of by-catch again tended to increase. There was more than 7 times variation in the amount of by-catch loss for collection of every shrimp seed during the study period (Fig. 1).

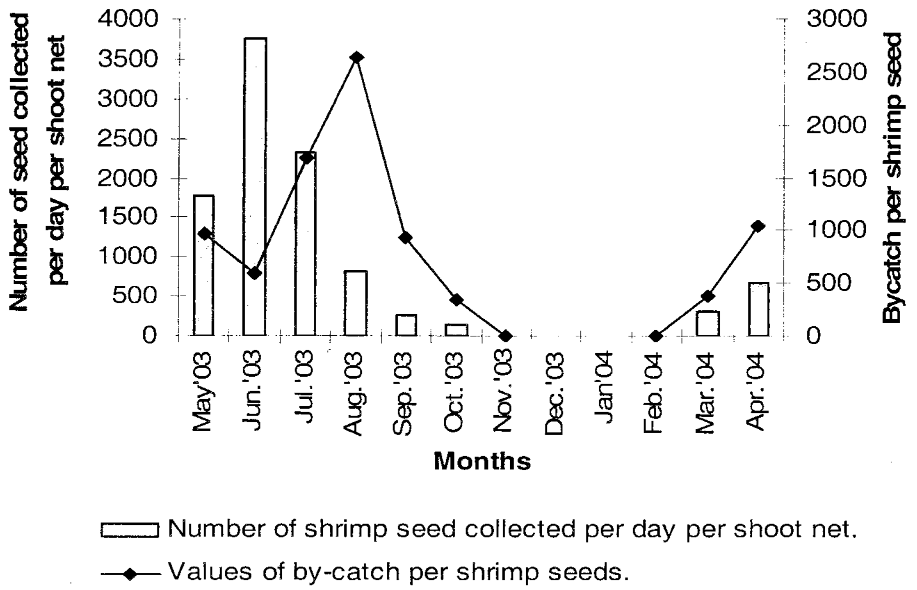

Fig. 1. Temporal trend in the values of by-catch per shrimp seed.

Quantification of loss

The total by-catch loss (130 billion) as estimated during the peak season (May – September) was 65 times higher compared to the cumulative loss (2 billion) during two lean seasons (October – November and March – April). The annual average loss was estimated as 76 billion in a study area of 3 km stretch. Again, it has been computed that to meet the present seed requirement of West Bengal (4.9 billion), 5,262 billion number of undesired variety of coastal aquatic biota as by-catch will be lost if the total seed is collected from the open coastal waters.

Relative abundance of different groups

The major groups in the by-catch composition *viz.* non-penaeid shrimps and crab larvae exhibited similar peaks during the month of August. As clearly discernible the quantity of non-penaeid shrimps in the by-catch continued to be maximal that was followed by crab larvae, finfishes, unidentified organisms and lobsters (Fig. 2).

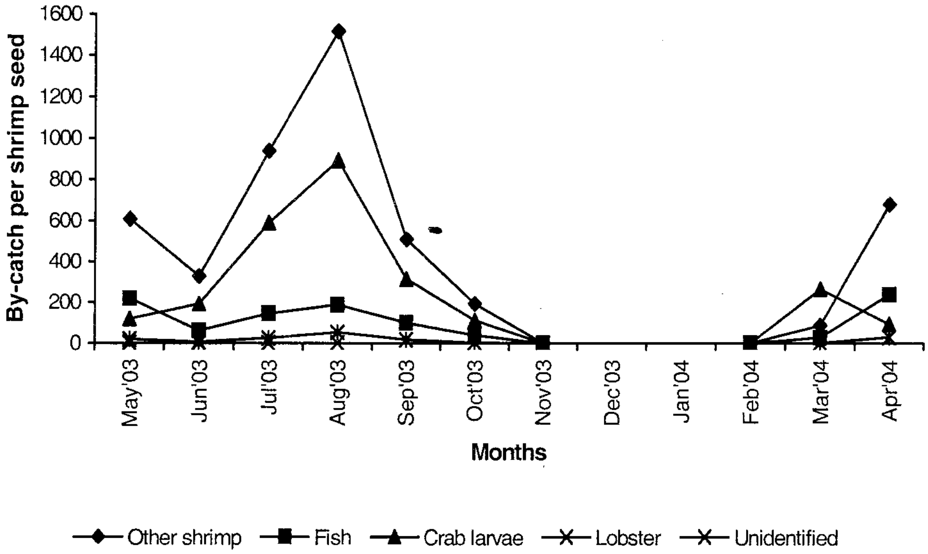

Fig. 2. Temporal variation of differen' groups of organisms in the by-catch.

The relative abundance of different groups in the by-catch exhibited a strong seasonal variation (Fig. 3). The abundance of non-penaeid shrimps was maximal during April to May (63 – 65%) and minimal during March (22.66%). Though such trend was identical in case of finfishes, crab larvae were conspicuous by their relatively steady abundance (22.46 – 34.74%) from June to October. However, the maximal contribution during March (69-70%) was in clear contrast either to that of non-penaeid shrimps or finfish that exhibited their minimal presence during that period. Presence of lobster in the by-catch was scanty (0.02 – 0.25%) and discontinuous (Fig. 3). A substantial quantity of by-catch (0.4 – 2.7%) remained unidentified. In totality, the relative contribution of different groups of organism was: non-penaeid (56.5%), crab larvae (29.44%), finfish (11.8%), lobster (0.04%) and unidentified (1.72%).

The overall average value for different groups of organisms (Fig. 4) indicated that more than half of the by-catch was comprised of non-penaeid shrimps (607.06) followed by crab larvae (321.75), finfish (126.81), lobster (0.44) and unidentified organisms (18.44).

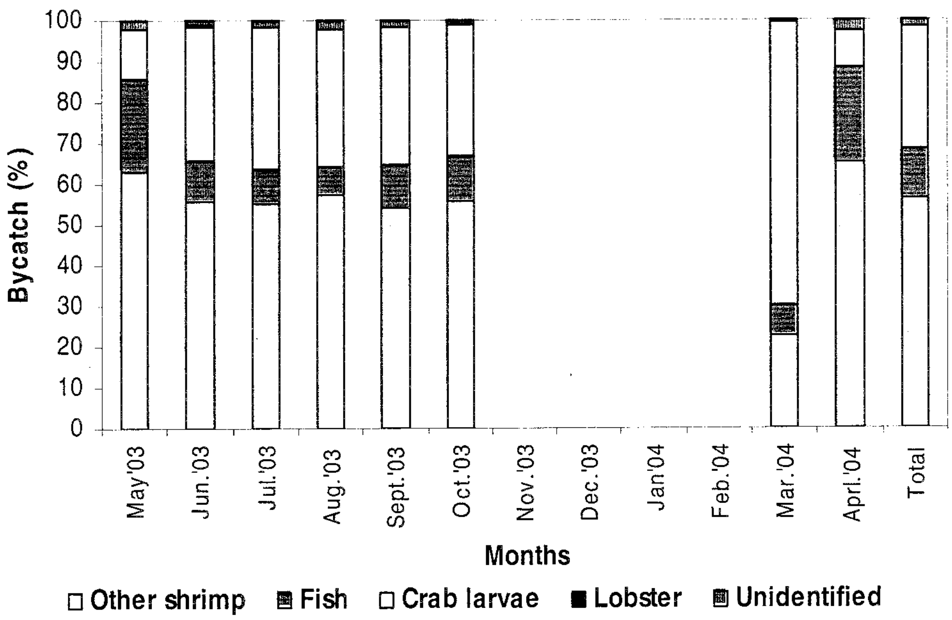

Fig. 3. Temporal variation in the percent contribution of different groups of organisms in the by-catch.

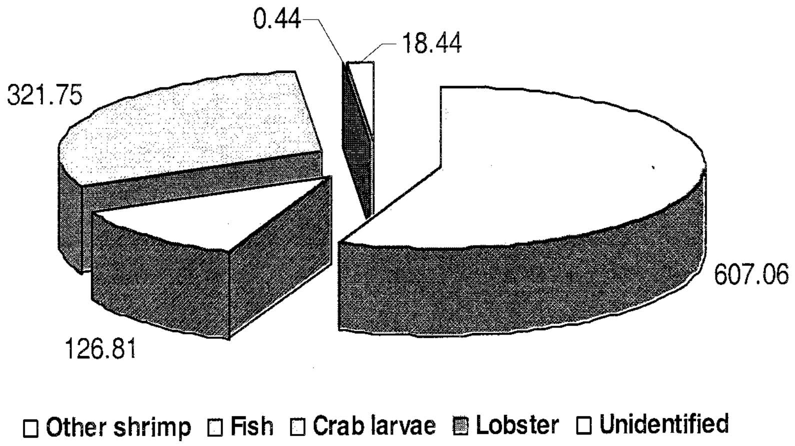

Fig. 4. Pie chart showing monthly average contribution of different groups of organisms per shrimp seed in the by-catch during the period of observation.

Diversity indices of the by-catch

Diversity indices tended to increase and attended maximum values during the month of June followed by a declining trend in all the cases. The values tended to increase from next March onwards. The maximum value attended for Shannon-Wiener index and Evenness index were 1.445 and 0.289 respectively (Figs. 5 & 6). It is clearly evident that the index values were found to be maximal during the month of June and September, which indicated more heterogeneity of the population during that period.

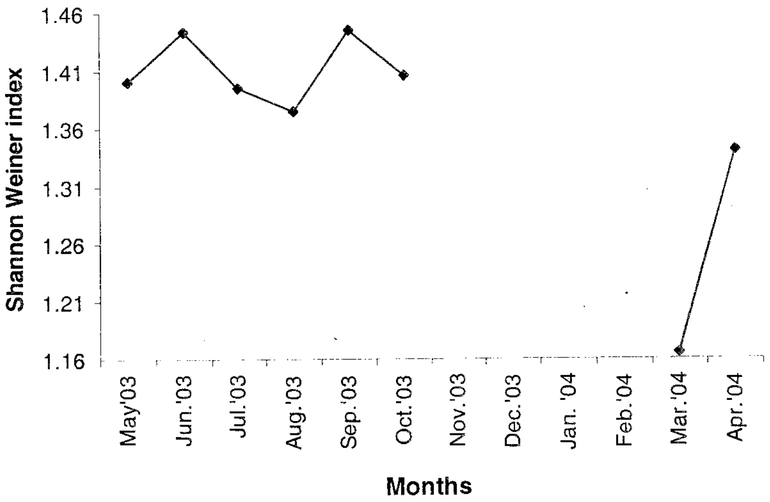

Fig. 5. Temporal variation in the values of Shannon-Weiner index.

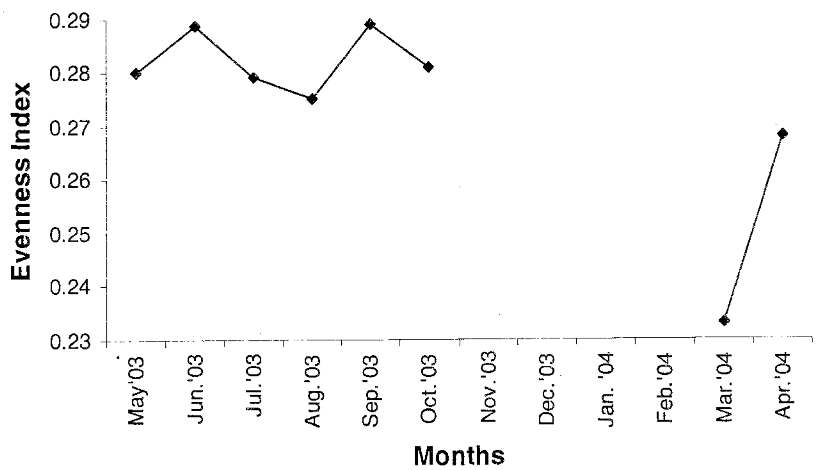

Fig. 6. Temporal variation in the values of Evenness index.

Discussion

The present investigation quantified the collateral damage of coastal aquatic biota during traditional collection of wild shrimp seeds through non-selective gears. The quantum of by-catch loss (1,074.5 per shrimp seed) was amounted to be 132 billion in a study area of 3 km long coastline. Seasonal variability was well marked as 130 billion organisms as by-catch were estimated to be lost during the peak season against 2 billion during the lean season. This estimate is in contrast to earlier studies (Mahapatra *et al.* 1995, Naylor *et al.* 2000) where such loss had been estimated with a much lower intensity. This might be due to variations in the sampling procedures, temporal changes in the intensity of seed collection, difference in the seasonality of study period, above all the water quality and other environmental variables. However, estimated loss of by-catch in the process in Bangladesh (Deb *et al.* 1994) and Honduras (DeWalt *et al.* 1996, Stanley and Alduvin 2002) was staggering and parallel with the present observation.

The dominance of non-penaeid shrimps in the by-catch was because of their seasonality of breeding in parallel with the penaeid shrimps. Besides, the environmental conditions favoured the larvae of such in respect to water quality parameters like dissolved nutrients, temperature and salinity. The maximum presence of finfish seeds in the by-catch was observed during April to May. This corresponds with breeding season of most of the brackish water fishes (Basu and Pakrasi 1979, Ghosh *et al.* 1990). The scanty presence of lobster larvae was expected because the coastline of the study area was non-rocky which did not favoured the abundance of lobsters.

The overall seasonal relationship between the rate of shrimp seed collection per gear and loss of by-catch ($r=0.73$, $p<0.05$) was not followed when considering the peak season in separate ($p>0.05$). Also, direct relationship between such variables was prominent ($r=0.97$, $p<0.05$) during the lean season of seed availability. The deviation of such trend during the peak season might be explained as though both the density of desired shrimp seed and undesired by-catch population were maximal during the peak season; the relative abundance of the former became significantly higher. This explanation was conclusively established as during peak season the rate of by-catch loss was found to be inversely correlated with the rate of shrimp seed collected per gear ($r=-0.82$, $p<0.05$). Moreover, such relationship during the whole study period taking into accounts both the lean and peak season together exhibited a polynomial equation. By-catch loss for every shrimp seed collection tended to increase up to a daily collection of about 2,500 numbers of shrimp seeds per gear followed by a decline. Such modular relationship was explained by a significant value of 65%.

As the maximum abundance of by-catch was simultaneous to that of maximum availability of shrimp seeds, availability of shrimp seed was a direct function of the more heterogeneity of the coastal biota. As the study area was situated at the river mouth, during the monsoon months the delta was enriched by heavy influx of surface run-offs, which favoured the enrichment of biodiversity during that period (Ghosh *et al.* 1990, Nath and Sinha 1996, Nath 1998). Loss of biodiversity as by-catch loss was maximally impacted during the late monsoon months when the biodiversity indices exhibited peak values. Therefore, impact of seed collection by non-selective gears upon the coastal aquatic biota was mostly detrimental when the heterogeneity as well as the stability of the population was at its peak.

It is obvious that the on-going practice of wild shrimp collection not only is detrimental to the shrimp fishery and the regional aquatic community itself but also disturbing the feeding niche of the other organisms linked through the particular food web. Indiscriminate exploitation of seed resources from the coastal waters resulted in significant reduction of not only shrimp seed but also *Hilsa* and crab fishery as well in northeastern coast of India (Bhattacharya and Sarkar 2002) and Bangladesh (Hoq *et al.* 2001).

Conclusions

It is clearly evident that the on-going practice of shrimp seed collection through non-selective gears is exerting tremendous pressure upon the coastal biota and resulting in alteration of the community structure at the site of investigation. The heterogeneity of the community is getting altered and biodiversity is getting lost.

Acknowledgements

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Organoleptic and microbiological quality changes of catla (*Catla catla*) in immediate and delayed ice storage and at ambient temperature

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Abstract

An investigation was carried out on the quality changes of Catla (*Catla catla*) stored immediately (0 h) in ice, after six (6) hours in ice and at ambient temperature. The samples were examined for organoleptic and microbiological parameters in summer. Organoleptically, the acceptability of fish varied between 16-20 days in both the iced storage conditions and 12-13.5 hours at ambient temperature (28^{0}C). When fish were organoleptically just acceptable on the 16th day of storage, bacterial load were 6.23 and 6.17 log10 cfu/g, respectively for 0 hour and after 6 hours iced fish. But on the 20th day of storage, when fish were just unacceptable SPC were 6.51 and 6.62 log10 cfu/g. In case of ambient temperature storage condition standard plate count was 8.36 log10 cfu/g on 13.5 hours, when fish were organoleptically just unacceptable. At the time of rejection for fish stored in ice (0 hour and after 6 hours) on 20th day, gram negative and gram positive values were 55.45%, 44.55% and 44.52%, 55.48% respectively. While fish were rejected after 13.5 hours at ambient temperature gram negative and gram positive bacteria were found as 43.02% and 56.98%. The differences in SPC, gram positive and gram negative bacteria between the storage times were statistically significant ($p<0.05$).

Key words: Delayed ice storage, *Catla catla*

Introduction

Catla (*Catla catla*), a major carp is one of the most popular fish in Bangladesh for its big size, glamorous look and marvelous taste. After catch, several strains of terrestrial bacteria find their way on to the fish from several sources like boat decks, fish boxes, ice including air with which they come in contact (Govindan 1985). These may at times even include organisms of public health importance like *Escherichia coli, Strepotococcus, Staphylococcus, Salmonella* and *Vibrio* presence of which in the fish muscle beyond certain limits renders it unfit and dangerous for human consumption.

Icing is a very effective way of reducing fish spoilage and it is particularly effective for the tropical fish (Hattula *et al.* 1993). The International Code of

Practice for fresh fish prepared by the Codex Alimentarious Commission (FAO/WHO 1977) recommends that fish should be chilled to the temperature of melting ice (0°C) as soon as possible after capture and should be maintained at this temperature until it reaches the consumer. The practice of icing immediately after capture and throughout the distribution chain retards spoilage and the shelf life of fresh fish can be extended quite considerably. A considerable information is available on the post harvest quality changes in fish from temperate and cold waters (Adebona 1982, Howgate 1996, Siang and Kim 1992, Surendran *et al.* 1985, Shewan and Ehrenberg 1977), but few studies exist on the spoilage pattern of tropical fish, particularly Indian major carps which are commercially very important fish in this region. Only limited information is available on the spoilage pattern of tropical fish stored in ice immediately, delayed icing and at ambient temperature. Considering this, the study was carried out to investigate the effect of immediate icing (0 h), delayed icing (after 6 h) and exposure to ambient temperature on the overall quality of Indian major carp, Catla (*Catla catla*).

Materials and methods

Collection and preparation of samples: Fish samples (S_1) were brought from Chucknagor, Khulna, Bangladesh around 8 am when the water temperature of the water pond was between 26^0-27^0C and air temperature 28^0C. Another lot of fish samples (S_2) were collected from a commercially poly-cultured pond adjacent to Khulna University around 6 am. Water temperature was then between 28°C-30^0C and average air temperature was 32°C. Ice was collected from Gollamary Fish Market.

Experimental design: The S_1 were divided into two lots (25fish/lot). One lot was iced (1:1 ice to fish ratio) and stored in an insulation box at the site (0 h) while the other lot was transported uniced in a bamboo basket to the Quality Control Laboratory, FMRT Discipline, Khulna University, Khulna. The uniced batch was iced after 6h of harvesting. Storage conditions were maintained by draining the insulated fish boxes of melted ice intermittently and more ice added to keep the temperature at 0°C throughout the entire storage period. The samples from both containers were withdrawn at intervals of 3-4 days to determine the overall quality by organoleptic and microbiological analyses. The S_2 fishes were collected as the same way of S_1 fishes and S_2 fishes were also divided into two lots (28fish/lot) and both batches were transported to the Quality Control Laboratory to determine the overall quality by organoleptic and microbiological analyses.

Organoleptic assessment: The organoleptic assessment of fish for this study involved a score sheet, which was mainly based on the score sheets of Shewan and Ehrenberg (1977). In the sensory score technique, the fish were judged by following quality factors: General appearance (eye, pupil, gill, body surface, flesh, belly wall and viscera), odor, texture. Each of the factor was given 10-0 scores and the highest being the best. In addition overall acceptability was measured by the taste panel. Eleven trained panels of three members evaluated the organoleptic quality of the fish samples. They were made familiar with the objective of the study and the method of scoring each of the criteria used.

Microbiological analysis: Microbiological analyses were done according to the Bacteriological Analytical Manual of the United States Food and Drug Administration (FDA 1998). All the tests were done in triplicate.

Data analysis: All the statistical analyses (mean, SD, correlation co efficient, and ANOVA) among different variables were calculated and graphically presented by using the SPSS and Microsoft Excel.

Results and discussion

Organoleptic changes: The results show that Catla iced immediately (0 h) and after 6 hours were acceptable according to taste panel between 16^{th} and 20^{th} days (Table 1). The initial total score was 97.67 and it decreased to 62.67 and 52.33 respectively on the 16^{th} h and 20^{th} days during 0 h-iced storage. While in case of delayed icing (6 h), the initial total score was 93.33 and decreased to 62.33 and 52.00 respectively on 16^{th} and 20^{th} days. For fish stored in ice after 6 h, the initial score was lower than that of immediate iced fish. This was due to the exposure of the batch to the room temperature (28 ^{0}C-30 °C) for 6 hours before icing. At the end of the 24 days of storage, the score decreased to 36 and 35.33 for fish stored in ice immediately and after 6 h respectively. During storage trials, taste panel acceptability is used to determine the quality changes of fish. Taste panel, visual and olfactory assessments are subjective in nature although they are essentially the most important methods for determining quality since they are the basis on which a consumer accepts or rejects the fish.

Table 1. Organoleptic changes of *Catla catla* stored in ice (0 h and after 6 h)

Storage day	Organoleptic score	
	0h	6h
0	97.67±2.08	93.33±0.58
4	85.00±2.00	78.67±1.53
8	73.33±1.53	72.67±1.53
12	68.67±1.53	68.67±2.08
16	62.67±1.53	62.33±2.08
20	52.33±1.53	52.00±1.00
24	36.00±1.00	35.33±1.53

The results obtained from the taste panel clearly indicated that fish stored immediately in ice showed a gradual deterioration during the storage period and almost similar result was obtained in case of delayed icing. But delay of icing up to 6 hours did not have adverse effect on quality of fish. Nair *et al.* (1974) had reported that delay up to 7 h before icing did not affect storage life. Dawood *et al.* (1986) also had reported similar finding about rainbow trout. The changes occurred in the organoleptic quality during this period can roughly be divided into four phases corresponding to periods of 0 to 4, 4 to 12, 12 to 16 and over to 16 days in ice depending on acceptability level. In phase 1, the fish were very fresh with a species-specific taste and natural flavour and odour. At this stage, fish had the characteristics of excellent quality indicating highly acceptable. In phase 2, there was a little deterioration apart from some slight loss of natural flavour. At this stage there was little loss of the characteristic odour and the flesh was neutral but had on off odour; fishes at this stage remained at both the acceptable and moderately acceptable level. In phase 3, there were signs of early spoilage with off-flavour. In the beginning of this phase, the off-flavour was slightly sour, sickly sweet, fruity or like dried fish but the fish were judged as just acceptable quality. In phase 4, the fish began to taste stale, its appearance and texture began to show obvious signs of spoilage and the gills and belly cavity had an unpleasant smell clearly indicating unacceptability. At the beginning of this stage, the fish samples were at just unacceptable range and later on at unacceptable range.

The gill condition and odour would appear to be the most useful of the visual and olfactory parameters. The odour to be detected gives an indication of the quality of the *Catla catla*. Gills colour changed gradually from bright red to dark pale colour. The condition of the flesh and walls were also useful since these soften gradually and gave an indication of quality. The skin showed a noticeable change especially with the presence and colour of the slime, which developed. The eyes changed from clear, protruding to opaque, and sunken, but not bloody. All of these parameters were considered at the same time with the aid of the taste panel and when considered together, they give a good indication of the qualities of the fish samples.

Regression analysis between total organoleptic score and storage time for the batches proved to be linear with negative correlation (r values -0.985 and -0.975 for 0 h and 6 h delayed icing respectively) (Fig. 1) and statistically highly significant ($p<0.05$).

There is lots of information on the shelf life and spoilage patterns of the fish particularly from the temperate and cold waters but very little are known on the fish of Bangladesh. In the present study, organoleptic quality of 0 h and 6 h (delayed) iced storage Catla fish was acceptable between 16^{th} and 20^{th} days. This change in the organoleptic characteristic pattern was almost similar to that reported by some other researchers (FAO 1975, Kamal *et al.* 1994).

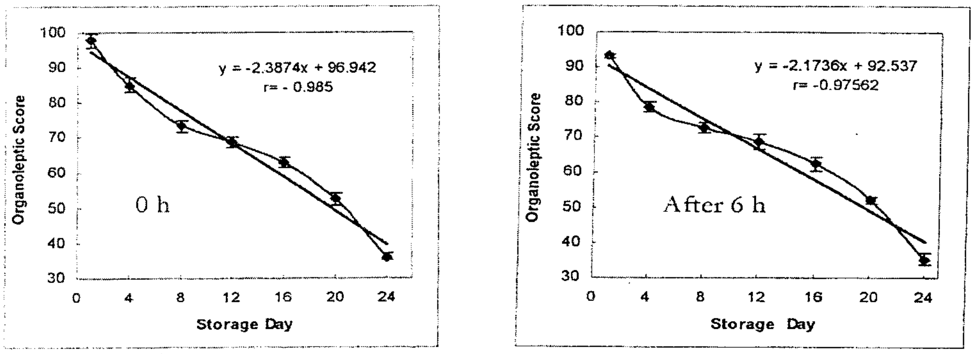


Fig. 1. Organoleptic evaluation of *Catla catla* stored in ice (0 h and after 6 h).

Microbiological changes at immediate and delayed icing

Standard plate count: The results of the standard plate count (SPC) of the samples stored in ice (0 h and after 6 h) are presented in Table 2 and Fig. 2. The results are expressed in $\log_{10}$ cfu/g fish muscle.

Table 2. Standard plate count (Log_{10} cfu/g) of *Catla catla* stored in ice (0 h and after 6 h).

Storage period (Day)	SPC			
	0 h		6 h	
	Log_{10} cfu/g	cfu/g	Log_{10} cfu/g	cfu/g
0	5.27±0.43	2.42 x10^5	5.58±0.23	2.42 x10^5
4	5.05±0.52	1.6 x10^5	5.40±0.02	2.53 x10^5
8	4.33±0.07	2.14X10^4	4.44±0.10	2.82X10^4
12	5.80±0.47	8.4 x10^5	5.88±0.14	7.8 X10^5
16	6.23±0.19	1.8 x10^6	6.17±0.38	1.97 x10^6
20	6.51±0.15	3.3 x10^6	6.62±0.12	4.25 x10^6
24	7.61±0.16	4.2 x10^7	7.63±0.27	4.8 x10^7

The initial log number of bacteria in ice (0 h and after 6 h) were 5.27cfu/g and 5.58 cfu/g respectively. The bacterial load in the 4th day of storage when the fish were started to relax from the rigor state were Log_{10} 5.05 and 5.4 cfu/g respectively for both samples. However, these populations decrease over a period of 8 days and then a gradual increased to 7.61 cfu/g and 7.63 cfu/g on 24th day. After death of fish quality of fish gets reduced because of enzyme (autolysis) and microbial activity. Icing is an effective means of reducing microbial activity and rate of autolysis but autolysis continues slowly even after icing. After several days of icing slower rate of autolysis produce various volatile and polluting substance and provides opportunity to the bacterial population to increase.

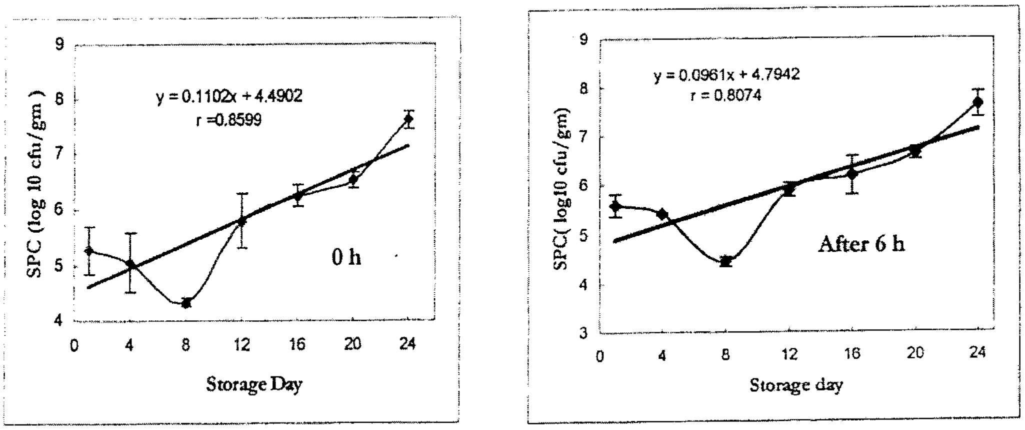


Fig. 2. Standard plate count (Log_{10} cfu/g) of *Catla catla* stored in ice (0 h and after 6h).

The standard plate count of the muscle of fish stored in delayed icing (6 h) showed an initial higher number of bacteria than those fish stored immediately (0 h). The bacterial population of both the batches between 16th and 20th days stood at 1.8×10^6 and 3.3×10^6 cfu/g of fish stored immediately in ice (0 h). While the number was $1.9X10^6$ and $4.25t10^6$ for fish stored in ice after 6 h (Table 2). These values are nearly similar as laid down by the (ICMSF 1986 and IFST 1997) which stipulate that the SPC should be less than 10^6 cfu/g and not exceed 10^7 cfu/g. Statistical presentations also support the results because r values of both the batches were 0.8599 and 0.807 respectively for 0 h and 6 h iced storage fish; clearly indicating a moderately strong positive correlation of bacterial load with the passage of storage period (Fig. 2). The differences of the results were also statistically significant ($p<0.05$). The results highlight the fact that there is a little difference between the two batches that are in agreement with the paper on the preservation of some Indian freshwater fish (Durairaj and Krishnamurthi 1986).

Gram negative bacteria and gram positive bacteria: Table 3 and 4 shows gram negative and gram positive bacteria in log number and their percentage present in *Catla catla* stored in ice immediately (0 h) and after 6 hours. The initial percentage of gram negative and gram positive bacteria were 55.92% and 44.08% respectively in immediately iced fishes. Gram negative bacteria present were higher when fish were stored in ice immediately while the initial percentage of gram positive bacteria was higher than the gram negative bacteria (43.97% and 56.03%), when stored in ice after 6 h.

Table 3. Load of gram negative bacteria of *Catla catla* stored in ice (0 h and after 6 h)

Storage period (Day)	Gram Negative Bacteria			
	0 h		6 h	
	Log_{10} (cfu/g)	Percentage (%)	Log_{10} (cfu/g)	Percentage (%)
0	5.02±0.41	55.92	5.22±0.21	43.97
4	4.77±0.53	52.39	5.06±0.06	45.69
8	4.06±0.06	54.47	4.12±0.08	47.83
12	5.56±0.46	58.16	5.57±0.14	48.37
16	5.95±0.17	53.55	5.85±0.37	47.47
20	6.26±0.11	55.45	6.26±0.14	44.52
24	7.35±0.15	54.45	7.29±0.26	46.27

Table 4. Load of gram positive bacteria of *Catla catla* stored in ice (0 h and after 6 h)

Storage period (Day)	Gram Positive Bacteria			
	0 h		6h	
	Log_{10} (cfu/g)	Percentage (%)	Log_{10} (cfu/g)	Percentage (%)
0	4.92±0.46	44.08	5.33±0.25	56.03
4	4.73±0.50	47.61	5.14±0.01	54.31
8	3.99±0.08	45.53	4.16±0.11	52.17
12	5.42±0.49	41.84	5.59±0.14	51.63
16	5.89±0.21	46.45	5.89±0.40	52.53
20	6.16±0.20	44.55	6.36±0.12	55.48
24	7.27±0.17	45.55	7.36±0.27	53.73

Chinivasagam and Vidanapathirana (1985) isolated 59% gram negative and 41% gram positive bacteria in Trench Sardines (*Amblygaster sirm*) stored in ice immediately (0 h) and 43% gram negative and 57% gram positive bacteria after a delay of 5 hours. The lower number of gram negative bacteria in fish iced after 6 h delay at ambient temperature (43.97°C) may explain why delayed icing by 6 h had no effect on fish quality. The remaining micro-flora had been dominated by gram positive bacteria. Another possible reason for lower rate of spoilage on delayed icing of fish was explained by (Poulter *et al.* 1981). They suggested that when warm water fish are kept at high temperature, the onset of rigor is slow and of a longer duration, but when preserved in ice immediately, it is of a shorter duration resulting in delayed bacterial growth till rigor is resolved.

The gram negative and gram positive bacteria were dropped over a period of 8 days in both the storage condition probably due to cold-shock or leaching of surface flora. After 8th day onwards, the gram negative and gram positive bacteria in both the batch gradually increased in numbers.

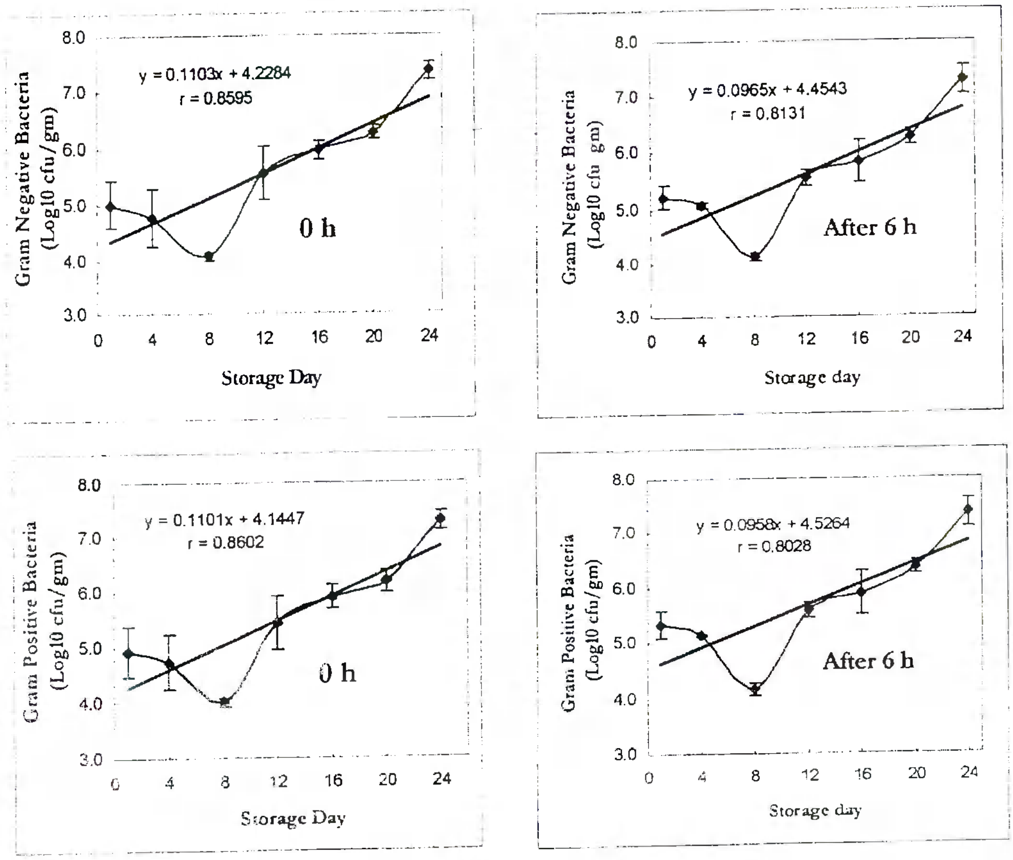


Fig. 3. Gram negative and gram positive bacteria ($\log_{10}$cfu/g) of *Catla catla* sorted in ice (0 h and after 6 h).

Regression analysis (Fig. 3) clearly indicates a positive correlation of gram negative and gram positive bacteria with their subsequent storage period. ANOVA analysis shows a significant differences ($p<0.05$) in both the cases.

Quality changes in Catla catla stored at ambient temperature

Changes in standard plate count: Table 5 revealed that SPC count increased with storage period. At the initial stage of the experiment, the SPC value was 4.28 cfu/gm which increased rapidly to 9.62 cfu/gm after 16.5 hours of storage. A positive correlation (r=0.9812) was found between standard plate counts and storage time (Fig. 4)

Table 5. Standard plate count (Log_{10} cfu/g) of *Catla catla* stored at ambient temperature

Storage time							
0 h	3h	6h	9h	12h	13.5h	15.5 h	16.5h
4.28 ±0.83	5.25 ±0.15	6.66 ±0.66	7.74 ±0.32	7.96 ±0.58	8.34 ±0.96	8.85 ±0.46	9.62 ±0.45

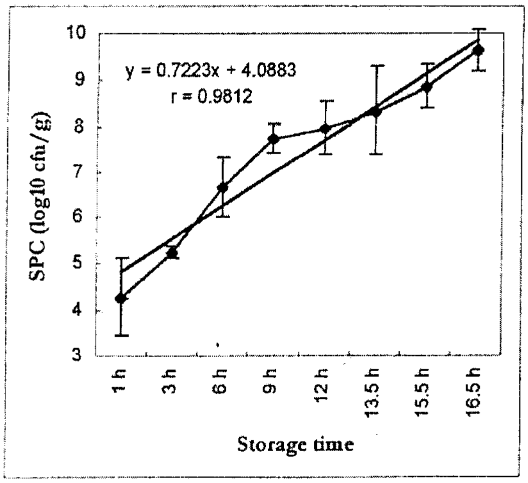


Fig. 4. Standard plate count ($\log_{10}$ cfu/g) of *Catla catla* stored at ambient temperature.

A comparison of organoleptic score and SPC data obtained in the present study indicated that acceptability for Catla showed a value of 7.96 cfu/g after 12 hours of storage when the fish was just acceptable. It was extended to 8.34 cfu/g after 13.5 hours when the fish was rejected organoleptically. Bacterial population increases with the increase of storage time but the result did not indicate any definite limit of acceptability and showed a lot of fluctuation (Rahman 1980). Present findings are confirmatory with work of many authors (Disney *et al.* 1969, Nair *et al.* 1970).

Gram negative bacteria and gram positive bacteria

Table 6 illustrates the gram negative and gram positive bacteria of *Catla catla* stored at ambient temperature during the period of 16.5 hours. Initially, the percentage of gram negative and gram-positive bacteria was 54.16% and 45.84% respectively. After 16.5 h of storage period, gram negative bacteria decreased (45.15%) while gram positive bacteria increased (54.85%).

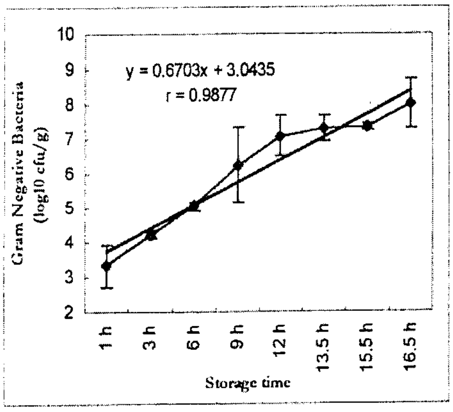
Table 6. Load of gram negative bacteria and gram positive bacteria (Log_{10} cfu/g) of *Catla catla* stored at ambient temperature

Storage hour	Gram Negative Bacteria		Gram Positive Bacteria	
	Log_{10} cfu/g	Percentage (%)	Log_{10} cfu/g	Percentage (%)
0 h	4.01±0.81	54.16	3.94±0.86	45.84
3 h	5.02±0.13	52.82	4.86±0.17	47.18
6 h	6.35±0.65	48.79	6.37±0.66	51.21
9 h	7.42±0.32	47.84	7.45±0.33	52.16
12 h	7.37±0.58	45.57	7.80±0.59	54.43
13.5 h	7.93±0.95	43.02	8.12±0.97	56.98
15.5 h	7.75±0.43	41.92	8.78±0.48	58.08
16.5 h	8.94±0.48	45.15	9.45±0.43	54.85

On the 12 h of storage, the gram negative and gram positive bacteria showed a value of 7.37 and 7.80 (cfu/g) respectively. While on the 13.5 h of storage, the results were 7.93 and 8.12 (cfu/g). The differences in gram negative bacteria between the storage times were statistically highly significant ($p<0.05$). Gram positive were also statistically different ($p<0.05$). Fig. 5 represents the regression line with the subsequent storage time and bacterial load were highly correlated with the time.

Conclusions

From the investigation, it can be concluded that there is apparently no beneficial effect of using ice on fish immediately. The shelf life of fish stored in ice immediately and after 6 hours remained almost similar. Thus it would rather be wastage to use ice immediately as found in the present investigation. However, shelf life reduced drastically when stored at ambient temperature. Thus, the fishes should be preserved at ice as for the cheapest and easiest method to maintain the quality of fishes for a considerable amount of time.



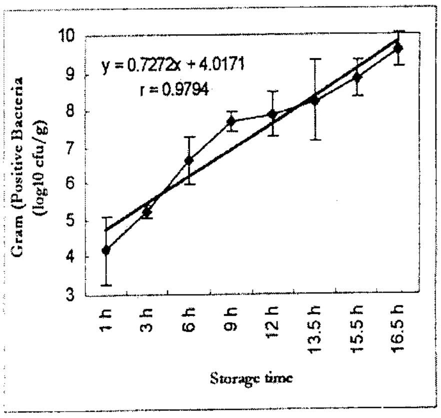


Fig. 5. Gram negative bacteria and gram positive bacteria (log_{10} cfu/g) of *Catla catla* stored at ambient temperature.

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Study on shelf life of fish cake prepared from surimi of silver carp (*Hypophthalmichthys molitrix*) during frozen storage

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Abstract
Surimi was prepared from silver carp with an aim to put this underutilized fish for profitable use. The mince prepared was washed twice with chilled water (5^0C) using mince to water ratio (w/v) of 1:2 for 5-6 minutes each. After final dewatering to moisture content to about 80%; half the quantity of washed minced meat was mixed with cryoprotectants (4% sorbitol, 4% sucrose and 0.3% sodium tripolyphosphate) to produce surimi. The prepared surimi and the dewatered minced meat were packed in LDPE bags, frozen using a plate freezer and stored at -20^0C. Surimi and dewatered minced meat from frozen storage were used as base material for production of fish cakes. These were fried at 160^0C for 3 to 4 minutes before serving for organoleptic test. Changes in salt soluble nitrogen, total volatile base nitrogen, non-protein nitrogen, peroxide value and free fatty acid of surimi and dewatered mince were estimated at every ten days interval during the storage period of 3 months. The study has indicated that frozen storage of surimi could be a potential method for effective utilization of silver carp. This surimi when incorporated in fish cakes yielded products which retained the shelf life even up to 90 days of storage.

Key words: Silver carp, Surimi, Cryoprotectant, Frozen storage

Introduction

Silver carp (*Hypophthalmichys molitrix*), which is widely grown in the composite cultures due to its quick growth and resistance to stress, disease and rough handling are seldom processed or preserved. In India, the consumer acceptance of silver carp is poor as compared to the Indian major carps in spite of its year round availability and cheaper price. An attempt has been made for the production of surimi from silver carp and to incorporate it in fish cakes keeping in view the value addition of this fish. With the discovery of cryoprotectants, mainly sucrose, sorbitol and sodium tripolyphosphate, the surimi industry was able to produce frozen surimi on a commercial scale. Hence, a study was initiated to produce surimi with the addition of these above mentioned cryoprotectants from this fish and study quality changes during frozen storage (-20^0C) and correlate the changes with the sensory quality of fish cakes prepared from it.

Materials and methods

Five silver carps caught from a culture pond with an average weight of 1600g were brought to the laboratory for processing within an hour of harvest. The fishes were washed well, dressed and then the meat was separated using a drum type fish meat picking machine. The picked meat was then minced and washed twice with chilled water (5^{0}C), using a mince to water ratio of 1:2 for 5 minutes. After washing, the meat was gently squeezed in a muslin cloth to remove as much water as possible. Final dewatering was done using screw press and the moisture content of the meat was reduced to about 80% level.

The partially dehydrated meat was divided into two equal batches of 1500g each. The first batch was mixed with 4% sorbitol, 4% sucrose and 0.3% sodium tri-polyphosphate in a bowl chopper for five minutes to produce surimi. Surimi was packed in LDPE bags of 100g each, frozen at -35^{0}C and stored at -20^{0}C temperature. The second batch of dewatered minced meat (DWM) was packed similarly in LDPE bags without any further treatment which was similarly frozen and stored. The effect of freezing and frozen storage on DWM and surimi was assessed.

Moisture content, total protein and ash content were determined according to the methods of AOAC (1995). Total lipid was estimated by solvent extraction method in soxhlet apparatus as described by Nambudiri (1985). Total volatile base nitrogen (TVB-N) was estimated by the method recommended by EIC (1995). For estimation of salt soluble nitrogen (SSN), the method of Dyer *et al.* (1950) was used. Non-protein nitrogen (NPN) and free fatty acid (FFA) were estimated by the method as described by Nambudiri (1985). The peroxide value (PV) was determined iodometrically (Jacobs 1958). To study the gel strength of the washed meat, folding test was performed as described by Lee (1984).

Table 1. Recipe used for fish cake

Paste	Percentage
Surimi	60
Potato	25
Onion	10
Garlic	1.0
Ginger	1.0
Green chili	0.3
Cumin	0.3
White pepper	0.3
Salt	1.5
Chili powder	0.3
Batter	Egg albumin
Breading	Toasted bread crumbles

Sensory quality of surimi stored for three months, was assessed by using it in the production of fish cakes as outlined by Gopakumar (1997). The recipe used for the preparation of fish cake is presented in Table 1. Surimi is mixed with boiled and peeled potato, salt and spice ingredients fried with oil in a bowl chopper till the ingredients are uniformly mixed. The paste is then formed into rectangular shaped cakes each of 20g weight which were battered with egg albumen and breaded with finely ground toasted bread crumbles. The products were fried at 160^{0}c for 4 minutes and evaluated for sensory attributes such as colour, flavour, texture and overall acceptability on an 8-point hedonic scale (Keeton 1983). The results were analysed statistically (Snedecor and Cochran 1967).

Results and discussion

The raw material characteristics that include the physical and freshness parameters and the proximate composition are presented in Table 2. The dressing yield of silver carp was 68.3% which was fairly good and this may be attributed to the efficient meat picking operation as well as to fairly large size of the fish used in the experiment.

Table 2. Raw material characteristics

Physical Parameters		Values±SD
1	Round weight of fish (g)	1600.0±207.4
2	Weight of dressed fish(g)	1093.0±76.9
3	Yield of dressed fish (%)	68.3±4.4
4	Yield of picked meat(g)	707.0±107.8
5	Yield of picked meat (%)	44.2±1.2
6	Weight of picked meat after washing(g)	580.0±51.9
7	Folding test after first wash*	AA
8	Folding test after second wash*	AA
Proximate composition		
1.	Moisture (%)	74.4±0.30
2.	Protein (%)	16.8±0.10
3.	Ash (%)	1.5±0.09
4.	Fat (%)	2.9±0.05
Freshness parameters		
1.	TVB-N (mg %)	2.6±0.03
2.	SSN (% OF TOTAL NITROGEN)	77.4±0.42
3.	NPN (g/100g)	0.3±0.01
4.	FFA (% of oleic acid)	2.0±0.06
5.	PV (milliequivalent of O_2 /kg)	13.4±0.35
6.	pH	6.9±0.04
Microbiological characteristics		
1.	TPC/g of sample	$2.04x10^5$

* Folding test grading- AA-no breakage on folding twice; A- breaks on second folding; B- breaks on folding once; C- breaks to finger touch.

The proximate composition of DWM and surimi are presented in Table 3. After washing procedure the protein content was found to be 15.4 % in the washed mince. Crawford *et al.* (1989) reported similar observation in whiting washed mince. In the present study, the number of washing cycles was reduced to two, which helped in minimizing unnecessary loss of myofibrilar proteins. Lin and Park (1996) indicated that most sarcoplasmic proteins are removed in the initial washing steps and subsequent washing removed the residual sarcoplasmic proteins along with a small amount of myofibrilar proteins (Lin and Park 1996).

Table 3. Proximate composition and microbiological characteristics of DWM and surimi at 0 day storage

Parameters*	DWM	Surimi
Moisture (%)	80.8±0.16	78.1±0.31
Protein (%)	15.4±0.28	15.9±0.08
Lipids (%)	0.8± 0.03	0.82± 0.02
Ash (%)	0.98±0.008	1.12±0.07
TPC/g	$1.64x10^5$	$1.04x10^5$

*Values are mean of three determinations with S.D.

The fat content of washed mince was 0.8%. Lin and Morrissey (1995) reported a 39% reduction of lipid in freshwater squawfish mince after third washing. The high level of lipid reduction in the present study (72.02%) may be attributed to the characteristic of the meat that contained less fatty muscles. Cryoprotectants in the present study were sucrose (4%), sorbitol (4%) and tripolyphosphate (0.3%) as suggested by Lee (1984). Regenstein and Regenstein (1991) also reported similar formulation. The mixing of the cryoprotectants with washed mince was achieved using a bowl chopper within two and a half minutes as suggested by Park and Morrisey (2000). Care was taken to keep the temperature of the mix within 10°C as at a higher temperature protein functionally could be damaged.

In the present study the TVB-N value for DWM and surimi was found to be 17.03mg% and 12.92mg% respectively, after 90 days of storage (Table 4). As per the EEC directive TVB-N should not be more than 30mg% and thus both the samples were found to be within the acceptable limits. The result is in concurrence with the result obtained by Dora and Chansrasekhar (1998) and Siddaiah *et al.* (1999). SSN was observed to decrease gradually for both the DWM and surimi, the decrease being more in the former and this could be because of the cryoprotective action of sucrose, sorbitol and tri polyphosphate used in the experiment. Dora and Chandrasekhar (1998) observed similar results in pink perch where the decrease in SSP was more in the control samples as compared to the polyphosphate treated one. The NPN content had a decreasing trend in both the samples, which is in confirmation with the result reported by Siddaiah *et al.* (1999).

Table 4. Changes in chemical parameters of DWM and surimi during frozen storage

Days	TVB-N (mg%)		SSN (% of total nitrogen)		NPN (g/100g meat)		FFA (g/100g meat)		PV (milliequivalent of O_2/kg of fat)	
	DWM	Surimi	DWM	Surimi	DWM	Surimi	DWM	Surimi	DWM	Surimi
10	8.05	4.62	80.52	82.65	0.17	0.21	2.49	2.82	14.65	9.10
20	9.06	5.58	78.21	81.15	0.16	0.20	3.41	3.65	15.60	10.23
30	10.23	6.58	76.22	80.22	0.16	0.20	4.43	4.48	16.54	11.66
40	11.31	7.63	74.12	78.98	0.15	0.19	5.26	5.32	17.49	12.62
50	12.40	8.65	73.01	76.32	0.14	0.19	6.18	6.15	18.40	13.83
60	13.48	9.65	70.13	74.95	0.13	0.18	6.64	6.71	19.79	15.78
70	14.19	10.05	76.73	74.02	0.12	0.18	8.03	7.72	21.16	16.14
80	15.76	11.67	63.29	72.87	0.12	0.18	9.85	8.71	22.60	17.31
90	17.03	12.92	61.78	71.33	0.11	0.17	11.76	9.58	23.50	17.76

The increase in PV was observed to be lower in surimi as compared to DWM sample after 90 days of storage. This could be explained due to the application of polyphosphates in surimi, which may indirectly retard lipid oxidation. Higher values of FFA were obtained for DWM as compared to surimi during the storage period which is in confirmation with the result of Verma and Srikar (1994).

The mean panel score for overall acceptability of fried fish cakes prepared from DWM indicates a sudden drop after 60 days (Table 5). The products from surimi were acceptable even after 90 days of storage. The results of ANOVA for flavour showed a significant variation between days ($p<0.05$) as well as between the treatment ($p< 0.05$). As far as texture is concerned there was a significant variation between the days of storage ($p<0.05$) whereas between the treatments variation was insignificant.

Table 5. Mean panel score of sensory attributes of fried fish cakes from frozen stored raw materials

Days	Samples	Colour & Appearance	Flavour	Texture	Overall Acceptability
0	DWM	6.0±1.18	6.6±0.66	6.6±0.66	6.6±0.66
	Surimi	6.6±0.66	7.0±0.45	6.6±0.92	6.8±0.4
30	DWM	5.8±0.4	6.2±0.6	6.2±0.6	6.2±0.4
	Surimi	6.4±0.49	6.4±0.49	6.6±0.91	6.0±1.18
60	DWM	5.6±0.48	5.8±0.6	6.0±0.63	5.4±0.48
	Surimi	6.2±0.6	6.2±0.6	6.4±0.66	6.0±0.77
90	DWM	5.6±0.66	5.8±0.75	5.4±0.66	5.0±0.63
	Surimi	6.0±0.63	6.0±0.89	6.0±0.89	5.8±0.87

*Values are mean scores of 10 panelists with SD

Sensory Evaluation Rating Scale: Like extremely=8; Like=7; Like moderately=6; Like slightly=5; Dislike slightly=4; Dislike moderately=3; Dislike=2; Dislike extremely=1.

Thus, surimi with such a prolonged storage life can be used as a base material to produce diversified products. The silver crap is available locally in good quantity and the products processed out of surimi are found be acceptable after reasonable storage period. Therefore it can be conveniently be concluded that this method, if commercialised shall fetch a good return to the entrepreneurs and silver carp can be put to better and effective use.

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Standardization of setting temperature and time for fish meat

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Abstract

Meat to water ratio used for washing was 1:3 for oil sardine and mackerel; but for pink perch and croaker, it was 1:2. Again the washing process was repeated three times for oil sardine and mackerel; but two times for pink perch and croaker. The washed meat was mixed with 2.5% NaCl and set at +5^{0}C and +40^{0}C for 1, 2 and 3 hr. The gel strength and expressible water content was measured. Basing on this study, setting temperature at +40^{0}C was selected and with respect to time 1hr for sardine and mackerel and 3 hr for pink perch and croaker was selected.

Key words: Fish meat, Gel strength, Marine fish

Introduction

When salt is added to surimi and ground paste is left for a certain period of time, a slightly translucent gel is formed which is celled a "suwari". This phenomenon is known as setting (Lanier 1986). Setting is a gel-forming phenomena which occurs when salted meat paste is incubated below 40^{0}C (high temperature setting) for 2-4 hr or following an extended period (12-24hr) at lower temperatures of 0-40^{0}C (low temperature setting) reported by Wu *et al.* 1985. Setting enhances surimi gelling properties in a great extent (Kamath *et al.* 1992, Seki *et al.* 1998). Kamath *et al.* (1992) suggested non-disulphide covalent cross-linking of myosin heavy chain in setting of Allaska pollack and Atlantic croaker surimi. They observed Myosin heavy chain (MHC) content of cooked gels of pollack and croaker surimi decreased during preincubation ("setting") at temperatures ranging from 4-50^{0}C. Decreases in MHC content were attributed to either non disulfide covalent cross-linking or proteolysis. Maximum production of cross-linked polymers occurred at the optimum setting temperature, i.e., at 25^{0}C for pollack surimi and 40^{0}C for croaker surimi In the present study standardization of setting temperature and time was done by setting the fish meat at +5^{0}C and +40^{0}C for 1, 2 and 3 hr. The fishes used for this purpose are Indian oil sardine (*Sardinella longiceps*), Indian Mackerel (*Rastrelliger kanagurta*), Pink perch (*Nemipterus japonicus*) and Croaker (*Johinus dussumieri*).

Materials and methods

In the laboratory fishes were washed and dressed by removing scales, skin, viscera and head. After washing and dressing, the meat was picked by meat picking machine and the picked meat was minced by mincer. Minced meat of each species was then washed with chilled potable water. Meat to water ratio used for washing was 1:3 for fatty fish like oil sardine and mackerel; but for lean fish like pink perch and croaker, meat to water ratio was 1:2. Again the washing process was repeated three times for oil sardine and mackerel; but two times for pink perch and croaker. Each washing was done for 2 minutes only. The p^H of used water for water washing was 7. After each wash the meat was gently squeezed in a cotton cloth to remove excess water.

About 100g of the treated/untreated fish mince was taken and macerated in a mortar with pestle for 10 minutes at 5^0C. Then 2.5 g of NaCl was added, grinding was continued for another 10 minutes till a viscous paste was obtained. The viscous paste was immediately stuffed into krehlon casings of size 3.0x15 cm (diameter x length). The stuffed casings were kept for settings at 5^0C and 40^0C for 1, 2 and 3 hrs without disturbance. The set meat was used for preparation of gel. Then the stuffed casings were kept in a temperature controlled water bath for 20 min at 90^0C. The gels were then immediately cooled in iced water and stored at 4^0C for 24 hrs before the measurement of gel strength and expressible water.

Gel strength was measured by using Rheotex (Sunshine) instrument A piece of about 25 mm thickness taken from gel was placed under the plunger of gellometer. The pressure on gel piece was applied by the plunger. The gel strength was calculated by the following formula:

Gel strength(J) = Stress x Strain g-cm

Expressible water was determined by the method of Okada (1963). A known weight of gel piece of 2 mm thickness was placed between two pre weighed filter papers. A pressure of about 10 kg/cm^2 was applied for 20 seconds on the filter paper by putting an iron weight of 10 kg. After scrapping all the meat from the filter paper, the weight of filter paper was recorded. The expressible water was expressed as percent of meat based on the quantity of water absorbed by the filter paper.

Results and discussion

Washed fish meat with salt treatment was mixed with 2.5% NaCl and was set at $+5^0$C and $+40^0$C for 1hr, 2hrs and 3 hrs. The effect of setting in different time on gel strength and expressible water for different fishes are presented in Table 1 for $+5^0$C and in Table 2 for $+40^0$C. Generally, setting can be performed at low (0-$+4^0$C), medium($+25^0$C) and high($+40^0$C) temperature (Lanier 1992). Different species have a different optimum setting temperature undetermined by the heat stability of myosin. Pollack and croaker have optimum setting temperature of 25 and 40^0C respectively

(Kamath *et al.* 1992), where as croaker surimi showed no setting response at +4°C. So in the present study setting was done 1, 2 and 3 hrs for +5°C and +40°C . The positive effect of setting on final quality of gel and gel strength is advocated by a number of workers (Niwa *et al.* 1981, Numakura *et al.* 1985, Roussel and Cheftel 1990). For such a gel strengthening the bonds involved may be hydrogen bonds, hydrophobic interactions, disulphide linkages and various other interactions, which takes place during setting such as cross-linking of myosin heavy chain. However the role of hydrogen bonds in setting with conclusive evidence is not given as in presence of water the mutual interaction between polar residues of protein and water molecules compete with that between residues (Hamaguchgi 1967). The role of hydrophobic interaction in setting is very important (Miyazima 1974, Niwa 1975).

Table 1. Effect of setting temp. at +5°C on gel strength & expressible water content of fish meat

Treatment	Gel strength (g-cm)			Expressible water (%)		
	1hr	2hr	3hr	1hr	2hr	3hr
Sardine	372.25 (±5.45)	428.17 (±5.87)	475.28 (±7.58)	25.68 (±0.12)	25.12 (±0.19)	24.65 (±0.27)
Mackerel	498.56 (±5.71)	563.42 (±6.89)	623.38 (±7.76)	24.42 (±0.10)	23.77 (±0.16)	23.17 (±0.26)
Pink perch	615.86 (±12.52)	703.27 (±10.75)	805.19 (±10.34)	23.25 (±0.35)	22.37 (±0.24)	21.35 (±0.35)
Croaker	633.67 (±11.56)	727.43 (±11.72)	836.24 (±10.89)	23.07 (±0.21)	22.13 (±0.15)	21.04 (±0.15)

*values in parenthesis indicate standard deviation, n=3

Table 2. Effect of setting temp. at +40°C on gel strength & expressible water content of fish meat

Treatment	Gel strength (g-cm)			Expressible water (%)		
	1hr	2hr	3hr	1hr	2hr	3hr
Sardine	506.57 (±14.36)	471.32 (±14.36)	489.26 (±14.3)	24.34 (±0.27)	24.69 (±0.16)	24.51 (±0.24)
Mackerel	676.28 (±8.43)	636.31 (±11.78)	657.21 (±11.78)	22.64 (±0.09)	23.04 (±0.29)	22.83 (±0.25)
Pink perch	623.45 (±10.78)	645.28 (±10.57)	687.45 (±10.69)	23.17 (±0.43)	22.95 (±0.53)	22.53 (±0.26)
Croaker	642.17 (±10.81)	675.43 (±11.35)	724.13 (±10.24)	22.98 (±0.29)	22.75 (±0.19)	22.16 (±0.24)

*values in parenthesis indicate standard deviation , n=3

The gel strength in 1 hr setting was 372.25, 498.56, 615.86 and 633.67 g-cm in sardine, mackerel, pink perch and croaker meat respectively at +5°C. But at +40°C the gel strength in 1 hr setting it was 506.57, 676.28, 623.45 and 642.17 g-cm in sardine, mackerel, pink perch and croaker meat respectively. Again when time was increased to 3 hrs at +40°C the gel strength changed to 489.26, 657.21,687.45 and 724.13 g-cm in sardine, mackerel, pink perch and croaker meat respectively and the respective expressible water % was 24.51, 22.83, 22.53 and 22.16 %. Figs. 1 and 2 represents that as the setting time increased the gel strength was increased in case of setting temperature +5^{0}C ; where as in case of +40^{0}C setting the gel strength was varied for different hrs in different species. The croaker meat set at +5^{0}C for 3 hrs represented highest gel strength as 836.24 g-cm. But at +40^{0}C the sardine and mackerel meat showed 506.57 and 676.28 g-cm in 1 hr; where as in pink perch and croaker meat in 3 hrs the highest gel strength was 687.45 and 724.13 g-cm respectively.

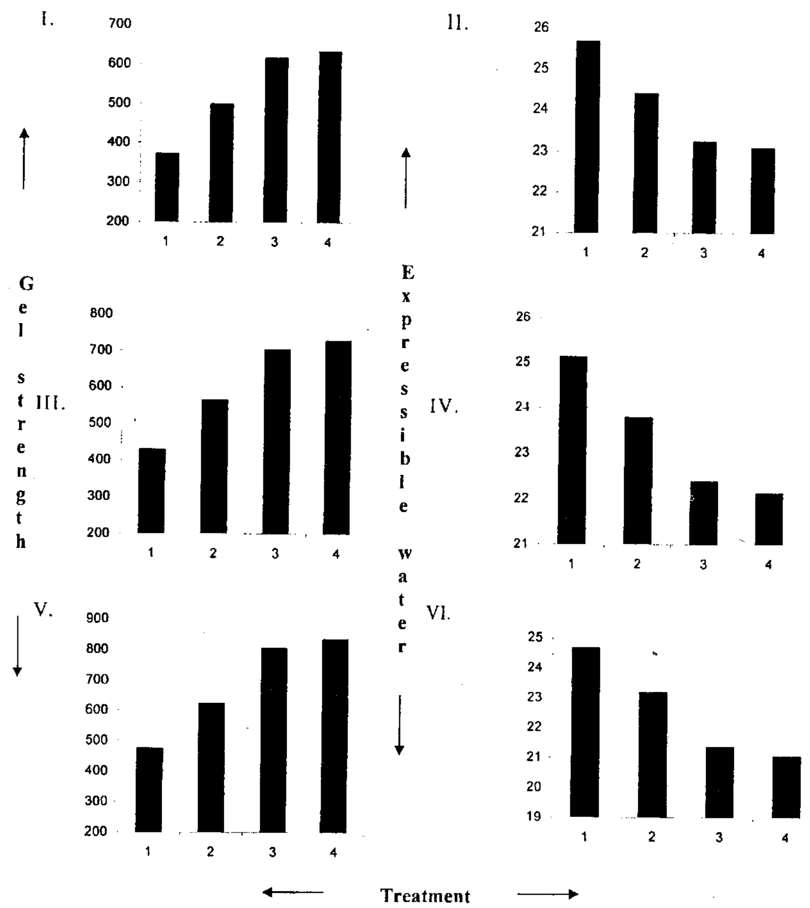

Fig. 1. Effect of setting temperature at on the gel strength and expressible water of mackerel meat set at +5^{0}C.
II & I. for 1 hr.; III & IV. for 2 hr.; V& VI. for 3 hr. 1- control, 2- treatment of $CaCl_2$

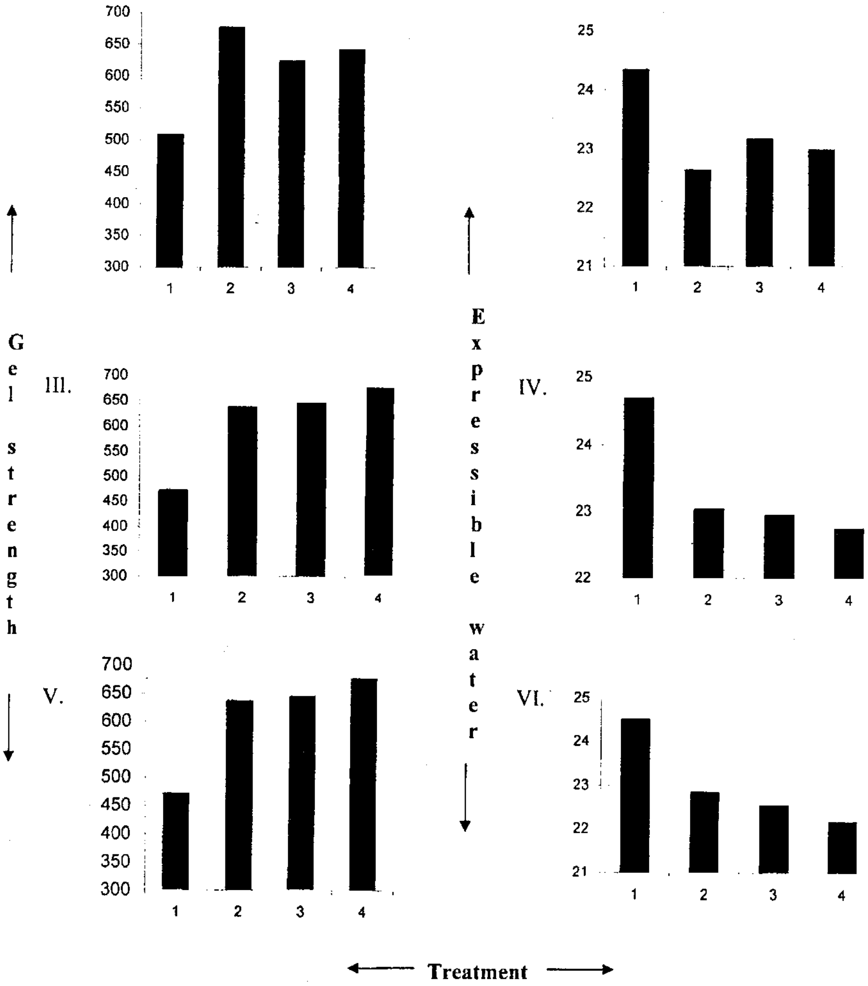

Fig.2. Effect of setting temperature at on the gel strength and expressible water of mackerel meat set at $+40^0C$
II & I. for 1 hr.; III & IV. for 2 hr.; V& VI. for 3 hr
1- control, 2- treatment of $CaCl_2$, 3- treatment of $MgCl_2$, 4- treatment of CH_3COONa

Results of gel strength and expressible water content as effected by setting time for washed meat indicate that setting had a profound effect on gel strength of the heat processed gel. The gel strength was increased as the time increased in case of setting temperature $+5^0C$; Where as in case of $+40^0C$ setting the gel strength was varied for different hrs in different species. Highest gel strength and lowest expressible water content was observed in 1hr for sardine and mackerel washed salted meat. Like wise for pink perch and croaker washed meat it was 3hr. Similar type of result was observed by Benjakul et al. 2004 in the fish species like threadfin bream, bigeye snapper, barracuda and big eye croaker.

In the preparation of surimi and surimi-based products higher gel strength is necessary as to get the best texture and good acceptability of the product. So among the setting temperature +40^{0}C was selected and with respect to time 1hr for sardine and mackerel and 3 hr for pink perch and croaker was selected.

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Impact assessment of Farakka barrage on environmental issues at Bheramara Upazila, Bangladesh

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Abstract

Different problems have been created on the downstream territory, especially on Bheramara on the bank of mighty river Padma. The study is preferred to assess the impacts on river flow of Ganges water, and on fisheries, agriculture, irrigation, groundwater, livelihood, and biodiversity because of Farakka Barrage. Information were collected from various respondents among which 42% is farmer, 12% is fisherman, 36% is businessman and 10% is service holder. It is evident from this study that 65% of crops production were directly affected by Farakka Barrage, in which 34% crops were damaged due to scarcity of water, lowering the ground water level, less access to rainwater, etc. and 66% crops were invent for increasing char land, increasing soil fertility for the use of agrochemicals. Irrigation has been adversely affected because of 35% insufficient flow of water and 65% lowering the ground water level.

Key woods: Farakka Barrage, Ganges River, Bheramara

Introduction

Bangladesh lies at the receiving end of the tributaries of the Ganges and Brahmaputra rivers. At least 57 international rivers flowing on Bangladesh which leads 93% of the total water flow over the Bangladesh. The Ganges is one of the major rivers in Bangladesh. It is an international river shared by China, Nepal, India and Bangladesh. With regard to the distribution of the 109.5x106 ha basin area, India has 79%, Nepal 14%, Bangladesh 4% (this is equivalent to 37% of Bangladesh) and China 3%. The Ganges-Brahmaputra delta, of which Bangladesh is a part, has been created by deposition of river-borne sediments (Singh 1987). The river has great importance for the socio-economy of the co-basin countries (Verghese and Iyer 1993).

In 1975, India completed the Farakka Barrage about 11 miles from the borders of Bangladesh to divert 40,000 cfs of the Ganges water into the Bhagirati-Hoogly River with the ostensible purpose of flushing the accumulated silts from the bed of the river and thereby improving the navigability at the Calcutta Port (Banerjee 1999). Near about 79 rivers and canals remain dry throughout the year by the impact of Farakka Barrage. Also 75 thousands ponds, lakes and haors suffer from scarcity of water throughout the half-time of a year. The monsoon discharge in the Ganges in Bangladesh has increased while in the dry season it has decreased (Asafuddowla 1993). The inadequate supply of water in the Ganges system during the dry season has caused significant socio-economic impacts through disrupting agriculture, fisheries, forestry, navigation and enhancing salinity intrusion further inland from the coast (MOEF 1995). Due to the continuous withdrawal of water through Farakka Barrage for the last 31 years a significant number of rivers in the Ganges (Padma) basin of Bangladesh has already turned into dead rivers (Ahmed 2005). From the record book of Water Development Board, in 1974, the flow of in the Hardinge Bridge point was 100500 Cusec. At present, it has downed in 59 thousand Cusec. For the impact of Farakka Barrage, within the 230 rivers there are 80 rivers of Bangladesh has been waterless. After the 12th December 1996, 30 year Water Treaty, during the lean period, for the last few years, the flow of water at Hardinge bridge points comes down to 10 thousand cusec, even sometimes as low as 5 thousand cusec (Ahmed 2005). In post Farakka period the ground water in many places of these regions is registering very high Arsenic content. To assess several important consequences of Farakka Barrage on Bheramara, a study was made- i) to know the physio-hydrological condition of Ganges river, ii) to identify the consequences on fisheries, agriculture, livelihood, and biodiversity due to Farakka Barrage.

Materials and methods

Primary data about the various types of impacts were collected through survey and observation. FGD, PRA, and RRA techniques were also used in collecting data. Qualitative and quantitative data about the hydro-morphological condition, agricultural, livelihood and biodiversity conditions were also collected by semi-structure questionnaires and field observation, and also information about these aspects were collected by personal interview as a secondary data from the Ganges-Kobotak (G-K) irrigation project; Bangladesh Water Development Board, Kustia; respectively. Finally, the data were arranged reflecting the objectives of the study.

Results and discussion

The key consequences of Farakka Barrage on fisheries, agriculture, livelihood, river flow, and biodiversity are given in Table 1.

Impacts on river flow

River navigation, the heart of Bangladesh's transport network was seriously affected. Due to upstream withdrawal of water, the country already lost about 15,600 km inland navigational route and another 3,300 km has become risky for navigation. Presently Bangladesh has only about 6,000 km inland navigational route (Ahmed 2006). The study results revealed that 93% of the local people of the study area argued that 100% flow of the Ganges river water has changed seriously during post Farakka periods and they were directly or indirectly affected by it because adversely effected on riverine and estuarine fisheries.

Impacts on agriculture

The findings revealed that 65% of crops were directly affected by Farakka Barrage because it has changed the agricultural pattern of the region in which 34% crops were extinct due to scarcity of water, lowering the ground water table, minimum access to rainwater, etc. and 66% crops were invent for increasing char land, increasing soil fertility for the use of agrochemicals and 5% of the total crop production (including alternative crops such as corn) was increased. In 1999-2000, the country produced 23.07 million tons of rice in about 26.46 million acres of land of which about 11.15 million acres land was under navigation. If the irrigation process totally stop due to non-availability of ground water, the rice production will almost come to an end (Ahmed 2006).

During the dry season when water is much needed in all areas of Bangladesh in particular for the irrigation of 200 thousand hectres of land in the Ganges-Kobotak (G-K) project. It provides the source of water for irrigation for the Kustia, Jessore, Magura and Chuadanga. The G-K project is the largest irrigation project of Bangladesh. It supplies water from the Ganges to 3 lakh acres of land. The project consists of 120 miles long main canal, 292 miles long branch canals and 62 miles long sub-branch canal. But scarcity of Ganges water has made the project ineffective. As the country will have to depend solely on ground water for irrigation, the ground water level will go down every year. For replenishment of ground water, rain contributes about 20% and river flow about 80%. If the river flow decreases and ultimately stops totally, the 80% of the replenishment process would also stop and if the ground water level goes down by about 5 meter from the present level all the shallow tube-wells will become non-functional. During the dry season when water is needed in all areas of Bangladesh, in particular for the irrigation of 200 hectres of land under the Ganges-Kobotak project, water becomes almost unavailable (Ahmed 2006). The 94% respondent has strongly represented the scarcity of water during the cultivation period that is adversely affecting the irrigation because of the insufficient flow of water through their main sources i.e., Ganges river water (surface water) 35% and 65% lowering the ground water table.

Impacts on livelihood

The study revealed that 65% of the fisherman, 24% of boatman, 3% of businessman and 8% of the farmer has changed their livelihood pattern during post Farakka period.

Impacts on biodiversity

The results revealed that 71% of the respondents would believe the population growth is responsible for the loss of floral composition due to the excessive utilization of resources and 29% also mentioned the scarcity of water or the insufficient flow of water is responsible for decreasing floral composition in this region. The result of the study also revealed that, 68% respondents would believe the loss of habitat is responsible for decreasing fauna and 32% also mentioned that the scarcity of water or the insufficient flow of water is responsible for decreasing floral composition in this region.

Table 1. Key consequences with percentages of Farakka Barrage in the study area

Impact on issues	Key causes	Percentages (%)
River flow	Farakka Barrage	100
Crop production (increasing)	Increasing Charland	61
	Using more agrochemicals	39
Irrigation	Shortage of surface water	35
	Lowering the groundwater table	65
Crop variations	Invention	66
	Extinction	34
Livelihood	Fisherman	65
	Boatman	24
	Businessman	3
	Farmer	8
Flora	Shortage of surface water	29
	Increasing population	71
Fauna	Loss of habitat	68
	Shortage of surface water	32
Local climate	Shortage of surface water	33
	Global climate	67

Conclusions and recommendations

The unilateral diversion of the Ganges water by India at Farakka Barrage has caused a series of adverse environmental and ecological problems in Bangladesh. Only it would not affect on irrigation but also on biodiversity, agriculture, fisheries including livelihood, mangrove ecosystem etc. and increase the seriousness of major environmental problems such as drought, flood, salinity intrusion, dry disease of mangrove forest, scarcity of fresh water etc. A long-term solution to water sharing problems between Bangladesh and India is urgently needed for existence of Bangladesh. This issue is extremely tremendous environment, economic and humanitarian concern to Bangladesh.

Following recommendations may be considered to improve and prevent the present and future consequences of Farakka Barrage for saving the environment and survival of Bangladesh:

- The government should make decision, sets national strategies, implements policies and enforces compliance
- Bangladesh has many internationally reputed experts on Environment, Water resources management, Agriculture, Economics and Bio-diversity and also Water Rights activists including those of International Farakka Committee in home and abroad, government should incorporate those experts for the planning, management and solve the problems.
- The government should immediately form a Regional and National Committee including experts for assessing the impacts and monitoring legal water diversion that was signed in the Treaty.
- The government should facilitate research to assess the consequences and should open to all in home and abroad.

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Problem of access and rights of fishermen to water bodies in *Haor* areas: A case study

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Abstract
This article is focused mainly on the problems of access of fishermen to the water bodies and policy recommendations for ensuring the rights over the water bodies in *haor* areas of Bangladesh. It is found that the genuine fishermen do not have legal access to the water bodies as they are not leaseholders. The water bodies are controlled by the leaseholders who are mostly politicians and local power structure groups, and the fishing is totally depended on the wishes of lease holders. Many of the fishermen do not have concrete knowledge about leasing system. There is a political influence over fishermen in general and water bodies in particular. The rights of the water bodies should go to the genuine fishermen as the occupation is occupied by them ancestrally. The Government, NGOs, environmentalists, researchers, members of civil society should come forward in establishing the rights of fishermen and preserving the fishes by maintaining the bio-diversity in *haor* areas.

Key words: Hoar, Fishermen, Leaseholders

Introduction

Exercising power on fisheries is a common characteristic in tropical fisheries, which leads to conflict in this sector. Rich or influential are able to take lease by their power and influence (Thompson *et al.* 1999). Toufique (1999) pointed out that fishermen have failed to gain fishing rights under the leasing system mainly because of having right of transaction cost and are less able to enforce property rights than are socially powerful lease holders who can prevent unauthorized fishing by threat and social pressure. The landowners and local influential try to control the water bodies arguing their close proximity to the water bodies. There problems regarding access to water bodies are identified by Bennett and Cattermoul (1998), these are political influences, economic influences, kinship relations and authority-which is acquired by the basis of legal or illegal leadership. With the help of the above characteristics, some people in rural areas, especially in fishing areas pose social position. This process makes leaseholders influential in the fishing communities and landless and poor fishermen are deprived from their fishing rights. This power dimension acts as cause of conflicts in water bodies (Bob,1996).

It is commonly seen that the lease holders create a role like *Jaminder* and make fishermen as their tenant. Most of the water bodies are leased to the highest bidder purely as a source of revenue (Capistrano *et al.* 1999). After getting right over water bodies, leaseholders used to collect taxes from fishermen to cover the government lease cost as well as to make a profit (Rahman 1991). This process continued up to 1960s. From the mid 1960s there was an attempt to reduce exploitation of fishers. A new leasing system introduced by which preference was given to fishermen co-operative societies for leasing. But in many cases the fisherman cooperative fail to raise funds did not needed to pay for a lease, nor could they enforce their right over a water bodies. So, the same class of powerful individuals maintained and control over leased water bodies (Capistrano *et al.* 1999). As a result, poor fishermen are exploited and declining fisheries of Bangladesh in day-by-day. Nevertheless the trend of profit maximization of leaseholders has created sustainability and ecological problems in many fisheries.

There is always conflict between fishermen and lease holders. Conflict also exists between land owner and lease holders. Now a day water bodies have become attractive sources to many people in respected areas. There is no doubt that this process creates different setback on the advancement of fish resources as well as the fishermen communities whose livelihood is dependent on fishing. Without restoration of access to water bodies for fishermen community; the preservation of fish resources, bio-diversity and proper utilization of wetland shall remain at stake. Given this, a study was conducted with a aim to explore different challenges and setbacks regarding the access of fishermen communities to the water bodies. Existing policies on water bodies have also been critically reviewed on the basis of the findings. A new set of policy is also recommended in order to ensure the rights of genuine fishermen to water bodies.

Methodology

To explore the patterns of accessing power among the fishery groups and communities, case study method has been adopted for this study. The study was conducted at Nasirnagar Upazila in Brahmanbaria district. There are many *Haors* adjacent to Upazila *Parishad.* Among the *Haors*, "*Ador*" has been selected for this study. It is situated around 40 kilometers far from the distinct headquarters. In the east, Madhabpur upazila of Habijong district and in the north Lakhai upazila of the same district is located. In the west, Astagram upazila of Kisorgang is also located.

The study is based on primary data, which is collected from some specific groups associated with the subject matter of the study. The fishermen are the main sources of information for this study. There are some other people who engaged in establishing fishermen's rights also included in the population. That includes civil society groups, NGOs representatives, leaseholders and local government officials. There is no exact number of fishermen in the study area. More over, fishermen are living in different places of the locality. Due to these reasons, purposive sampling technique has been chosen. Seventeen fishermen were directly interviewed from the study area. Three Focus Group Discussions (FGDs) were conducted participating in fifteen fishermen each living adjacent to the *Ador Haor*. The main objectives of FGDs were to observe the fishermen in their activities, problems and the overall attitude toward their profession. The main themes included and highlighted were the access and access problems, ideas about leasing and ownership process, relations between and among the communities involved in the leasing and fishing, influences of political and power structure over the land leasing and the conditions of biodiversity.

Two FGDs were conducted in the *Nasir Nagar Gangkul Para* and one was in the *Nasir Nagar Kashi Para*. Both of the villages were close-distanced and all the fishermen catch fishes in the same *Haor* areas. All of the members were male and scheduled religious caste of Hindu community. Most of the members were at the age of 20 to 60 years old. Except one or two, all the members have taken fishing as their only profession. All the members of the group expect one person who has some education. He is not directly depended in fishing. He has been leading the community through conducting the activities of the association for a long time. Apart from the FGDs, two NGO representatives, one journalists and one local fisheries officer were interviewed through checklist. For case study method both qualitative and quantitative data are collected. For fulfilling the objectives of the study, interview schedule, checklist and focus group discussion have been administrated.

Results and discussion

Personal and demographic information

The fishermen are found in different ages. Since fishing is an ancestor's profession so all aged groups are involved in fishing. About 50 per cent of the fishermen interviewed belong to above fifty years old. It is assumed that due to their ancestor's profession, fishermen may not interest to change their profession. Almost all fishermen belong to minority community and mostly from the backward classes. They are not conscious about their education. More over, due to their poor economic background, they were away from their formal education. Almost all are illiterate but one respondent was found who completed diploma. No difference is reported between past and present occupation. The majority of respondents were married. The highest yearly income of fishermen was found to be 60,000 and the lowest was 20,000. The average family size of the fishermen was seven. They are more or less dependent on fishing.

Involvement in fishing and leasing process

It is found that the fishermen can not catch fish for the whole year. Even though, lease holders may not allow all the fishermen for fishing in whole year. Lease holders also encourage non-fishermen for fishing. It is assumed that fishermen earn only few amounts through fishing. The study found that the lease holders are not genuine fishermen. The fishermen catch fish by the token (one piece of metal considered as pass for entrance into the water body) provided by the lease holders. In past, fishermen used to get lease through DC (Deputy Commissioner) office in the name of their association. For the last three years, lease holders (mostly politicians, local leaders) have been controlling the water body and they are the original lease holders. They form Fishermen Association (mainly fake) and get lease in the name of that association. The study found none of the fishermen who have direct control over the water body. The respondents were asked who are the more beneficial from the present leasing system. All respondent uttered that leaseholders are the sole beneficial of fishing. They are being exploited by the leaseholders in many ways. Those are: they have to catch fish on the will of the leaseholder; they are compelled to sell fish to the leaseholder's people and they have to collect token at the cost of nine hundred takes for two times only for the access to water body.

Political involvement, local leadership and the mussel power are the main criteria for getting lease of the water body. The more the political power more the access to water body. As genuine fishermen are not the leaseholders of the water body, they cannot catch fish at any time. There are some other reasons like barricade of water body by leaseholders, lack of strong fishermen association, poor economic conditions of fishermen, political influences, conditions imposed by the leaseholder etc. responsible for not catching fish in all the time. The government control the water bodies that are associated both government and private lands during rainy season. In rainy season both government and private lands merged into a single water body which does not have any demarcation of land. During this time landowners whose lands are merged with government land do not have access to the water body. This is the provision and conditions of leasing process of water body. If the landowners go to the water body for catching fish, leaseholders resists them and snatches their net and other fishing materials. As a matter of fact, landowners do not have full access over the water body. Despite having ponds or *Kua* inside their land and that are naturally worked as preservers of fishes, the land owner cannot catch fish in their respective ponds and *Kua*. No conflict is reported while digging pond or *Kua*. As landowner can't catch fish in his own land so conflict did not appear between landowner and leaseholder. As mentioned earlier that fishermen are very poor. They do not have active association on their own. More over, bidding requires huge money. Due to these reasons, original fishermen may not have access to leasing. There are some other reasons like financial crisis; ineffective association; political influences; lack of administrative supports; not having political power; good relationship between local leaders and administration are also responsible for not getting lease.

The study found that the leaseholders usually do not catch fish. They mostly catch fish through the fishermen with some conditions. The fishermen wishing to catch fish have to take *token* from the leaseholder. More over, fish is to be sold to the person fixed by the leaseholder. Sometimes, they determine the price based on the amount of fish. Respondents claimed that leaseholder catches fish through fishermen from distanced water bodies. Sometimes leaseholder ignores genuine fishermen due to some reasons. They encourage non- fishermen who are mainly Muslim. The genuine fishermen consider it as punishment for them. They do not have any initiative to tackle this kind of situation. Rather, many of them are getting frustrated towards their ancestral profession.

Respondent were asked about the reason of non-fishermen engagement in fishing process. As financial success can be achieved quickly through fishing activities, most of the people from majority community involve themselves in this profession, they observed. More over, as the fishermen community is materially poor and have less or no political and administrative connection, these people take the opportunity, easily can gain government water bodies for exploiting and depriving fishermen community who has real indigenous knowledge regarding preserving, protecting as well as harvesting of fish.

Ideas about leasing and ownership process

The study found a very poor understanding of genuine fishermen regarding government leasing laws. But only thing they know and that is leasing procedures, which have been maintained by the DC office. The fishermen community observes that there are abuses of power and resources in this process. According to the Water body Management Policy 2005, if the water body is 20 acres or more than that, the office of the district commissioner arranges its leasing process. The leasing law follows the rule to give the lease to any fishermen association. This provision works negatively in achieving fishermen's access in water bodies. In the name of fisherman association, local influential and solvent people of majority Muslim community take lease. According to the policy, individual fishermen do not have access to leasing authority/administration and therefore they have to go for access through the fishermen's association. We found the fishermen association as inactive and naturally fishermen of the study area do not have communication with the administration. We asked the fishermen why there is no function of the fishermen's association; they responded that the lack of money is the main problem. Money collected from the members of the association for bidding lease was not sufficient. Usually, they have no money in their hand in the month of March when bidding is made because there is not enough fishing opportunity then. In 1214 Bengali year they applied to the government to get lease in favor of them allowing credit money for two month but the prayer was denied and the bid was given to the non-fishermen, local elite leaseholders and the fishing land (*Jolmohal*) was out of their hand.

The general fishermen are found to be so unaware that they did not know the current status of the water body. They only know that the bidding has been held in the month of March. Since 2005, the water body is occupied by the non-fishermen local elites through leasing. The local elite participate in bidding in the name of few fishermen, in few cases most of this people do not know that their name was used to get the lease. A member of the local civil society reported that the fishermen community is not conscious about the bidding. So, many of the *touts or cheats* in the towns buy the lease with a very small amount of money and they sell it in a higher prices to the village stakeholders.

The continuous loosing ownership of the *Haor* is diverse and destructive for the fishermen community. They are gradually becoming bonded labor of the local elites. On the other hand being deprived and exploited, these people are psychologically forced to be migrated and getting into contact with employment in the other fields instead fishing. This reality is known to the government official also. But due to legal barriers they have nothing to do. Collecting revenue is their obligation and therefore they apply all possible measures to leasing process if it is essential.

Community relationship in leasing and fishing

The relationships from the point of the fishermen's view with the other stakeholders have different and asymmetrical. The fishermen maintain quite peaceful, non-confliction and amiable relationship with the Muslim community living nearby to them. They have very few conflicts of interest with them. However, they have some intra-community conflict regarding the conducting their own association.

Though the richer section of the common villagers do not go for any kind of fish related involvement, poorer section of population have interest in leasing and all other fishing activities although they belong to Muslim community. These people are recruited as fishing labor by the lease holders. They are called *Maimal*. Their number is increasing in *Haor* areas day by day. The relationships between the fishermen and the leaseholders and their clients are diverse and complex. The relations depend on the opportunity of fishing, possessing and holding the fishing equipments, some secret transactions due to sharing of leasing and so on. On the part of the fishermen, who have no alternatives except fishing are comply with the wish and necessity of the leaseholders for their survival.

Many of the fishermen argued that the leaseholder never assists the fishermen. They don't give money to buy fishing-nets or boats. However, they have to keep relation with leaseholders for the shake of livelihood. They have to bear all kinds of oppression and outrage. Sometimes, some people of them keep liaison with them and spoil relation with their own community members. Despite this they are being tortured both mentally and materially by the leaseholders. They (leaseholders) frequently deprive them in different ways.

Access and access problems

Following a dispute on the ownership of leasing of the *haor* in the name of their association, the fishermen community of the study area has been barred from getting access to the *haor*. They failed to hold the leasing ownership because of shortage of money in contesting the bidding and reasonably the ownership of the water body have gone to the local rich and elite people who are not fishermen. At present, the actual fishermen are working as day laborer of the leaseholders. Only one-third price of the sold fish is distributed among the fishermen who engaged in fishing directly as wage.

The contract of fishing between lease holders and fishermen is arbitrary and restricted. The will of the leaseholders play a vital role here. They have made an advanced coupon system. After availing the coupon in exchange of a big amount of money only then, they permit to go for fishing. Moreover, the fishermen are severely levied and burdened through extra amount of money-paying for getting coupon.

The respondents were asked about the nature and types of access, uses of access, problems faced to get access and resolving the problems of access. Before introducing leasing system the fishermen were independent and could catch fish freely without any control from any corner. They also had active fishing cooperative society at that time. Now they have cooperative also but do not have full access to the water bodies. Preferences were given to genuine fishermen in leasing system before 2005. After enactment of *Sarkari Jalmohal Babastapana Nithimala* 2005, genuine fishermen were deprived from the water body. Lease holders are not genuine fishermen but they take lease in the name of fishermen. Non-fishermen earn lease through political as well as mussel powers. The study area are not an exception, it was leased to the influential Muslim people in 2005. We found local administrations' positive attitudes towards the lease holders. Due to shortage of money the genuine fishermen association fails to gain access to water bodies.

Those are economically poor also poor from psychologically. Religious minority status also expedites not to go forward for justifying their demand. More over, political victimization is also equally important here.

Influences of political and power structure over the leasing

There are number of apparatuses through which the leaseholders or their middlemen press influences over the fishermen. Those include; intimidation, beating, verbal threats and abusing, threatening for killing, crumbling down the hand or legs or threats to push back to India etc.

The political influence works in accordance with what political party is in power nationally. They control the whole mechanisms of leasing, capture the areas through their youth groups, and consolidate power by excluding the opponents from the area trough their political slogan. The government officials maintains only submissive role to comply with the local political power. But, the influences of the political parties in the *Haor* are not direct. They only participate in the bidding process. They also try to resolute the disputes through arbitration rather than litigation. In few cases, the fishermen go to the police station.

The pitfall of the local arbitration is that the results of the dispute usually go to in opposition to the interests of the fishermen. Thus, the net result is zero for the fishermen. There is no direct influence over the fishermen from political and power structure but they influence though their relatives and middlemen. Political leaders control bidding process through party cadres. Weak party like fishermen may not get support from any corner, the respondents viewed. By keeping their net, the fishermen usually freed. There is no arbitration while dispute between two communities. There is a patron-client relationship. It creates with local youth, *mastan* (mostly youth) and local chairman. There is a close nexus between politicians and their middlemen. Politicians try to do everything behind the door so that others can't understand their hidden activities. Lease holders' influences are very cruel. Fishing materials usually thief by their people. In fact, fishermen are severely being tortured by the lease holders. There is a litigation, quarrel with water body. The influential people usually get benefit through this litigation.

Major Findings and Policy Recommendations

Despite being ancestrally knowledgeable and experienced in fishing profession, the fishermen community continuously detest from fishing. In fact they bear the poorest socioeconomic conditions in comparison to other people of their locality. They do not have income other than fishing. They remain unemployed almost half of the year. It is only because of deprivation from the leaseholder. This poor economic condition is connected with non-involvement in bidding process.

The fishermen have made some recommendations in order to ensure the access over water body. To survive as real fishermen, it is urgently needed to define and establish the lawful rights of the fishermen into the water body. As the pronouncement of this, they must be owned with the lease permanently or in long-term basis. They should also be provided with loan facilities as payment of bid money. If they get the lease of *Haor* permanently then all of the problems will be solved. The fishermen are ready to pay money for that. Government and non-government financial institutions should come forward with financial assistance in this regard. Loan is given to the farmer, industrialist and others. Why not for the fishermen? In this way, fishermen can participate in bidding and can lead a better life.

The existing legal process of leasing is faulty because it only serves the interests of the leaseholders as they are only capable of contesting the bidding and the fishermen are gradually evicted from their possession. The laws of leasing have been prepared and enacted without the consideration of the capability of the genuine fishermen. There is no scope of identification of real fishermen. In this process, politicians, local leaders and other influential involve in bidding process. Present leaseholders usually get maximum benefit from the water body. Given this reality only the genuine fishermen should get access of the water body. Local administration e.g. upazila administration should part of the bidding process. There is a need to change existing leasing policy in this regard. The role of government and civil societies are very much needed to overcome this problem. The civil society should be a part of lobbying to the government. They may pressure to the policy maker to rectify the existing policy so that fishermen's benefit can be ensured properly.

There is a harmful effect on fishing like destroying seed fish, flora-fauna of *haor* areas etc. It is argued by the fishermen that the fishes of many species have been decreasing for last twenty years. Even, some of the big-sized fishes are rarely found during the whole year. The chance for reproducing has also been seriously damaged because the land sizes are increasing and the deep or shallow water zones are gradually getting reduced. All kinds of fishes including the small fishes have been caught due to the use of current fishing nets. It can be predicted that fish will be disappeared in course of time. To protect the fish, government officials, fishermen themselves have a crucial role. The government officials should be very strict in implementing the existing fishing polices in this regard. The bio- diversity is destroying gradually in the *haor* areas. Many of the water species and plants, such as, *Katabon, Kagra, Shapla, Salouk,* and the natural ecological flora and fauna have been destroyed. If there is *Katabon* no one can use current fishing nets. For reserving the *Katabon*, planting and nurturing their natural growth is needed. To protect all these, it is an emergency to declare the *Haor* as sanctuary of reserved zone and implement necessary action to realize them. In restoring ecological balances, nurturing of waterweeds and shrubs should be kept and maintain properly so that reproduction and feeds of fishes would be enhanced gradually. The fishermen are genuine stakeholders in this connection. Less than nine inches fish should be banned from catching. More over, during the breeding season like in the month of April to June, fishing should be totally banned from the *haor* areas. Concern government officials should strictly monitor the matter with their personnel.

Alternative livelihood projects for the fishermen community should be introduced by the Government and non-government organizations. There is a need to reduce the over dependency and over utilization of water bodies. It is essential to arrange some provisions so that breeding of fish varieties can be freed from any kind of unwanted interruption i.e. destruction of mother fishes and over fishing through de-watering process. To protect mother fishes, a grand hole should be dug in the middle of the *haor*. Special livelihood project should be introduced for the fishermen and people whose livelihood is heavily dependent on water bodies, by the government and non-government sides with a view to expedite them less involvement in fishing.

The genuine fishermen's association is not active now. It is a body in which fishermen can fight with the opponents. Their association should be strengthened within a short span of time. The unity of fisherman communities is very much needed to get their rights. Fishermen's personal initiative and the support of civil societies and NGOs are most important in this connection.

Fishermen feel that fishing is their genuine right as they belong to this profession traditionally. On the other hand, landowners claim their right over the water body. In addition, Government argued that water body is the property of the government. To remove the controversy over the ownership of water bodies, the rights should go to the genuine fishermen as fishermen have no alternatives but to fishing. To utilize the right of the water body, fishermen should play an important role. They should feel that water body is the property of the people of Bangladesh.

It is found from the study that fishermen may not get proper justice while litigation and arbitration. The fishermen claimed that government employees work in favor of the leaseholders. To establish the right of the fishermen and social justice, coordination is needed and strengthened among government employees, NGOs professionals working in the locality and fisherman community.

There is no involvement of rural power structure in leasing policy directly. The policy is constituted with government officials only. They know the bad and good of the water body. Their active participation in bidding process should be ensured. In fact local power structure can identify the genuine fishermen. Apart from power structure, local non-government and voluntary organizations also should involve in this process. The organizational capacity of the fishermen community needs to be strengthened.

More and more organization should come forward in helping and establishing the rights of the fishermen. NGOs and civil society can play an active role in this regard. There is a demand from the fishermen like *Jal Jar Jol Tar*. This slogan should be implemented properly.

Hoar has much importance in terms of fish, natural view, environment preservation, ecology and ever sources of revenue. Fish is a major source of protein which comes mostly from *haor* areas. Therefore, *haor* has to be protected not only for fulfilling the demand of our protein but also protecting our bio-diversity. In order to protect the water bodies of *haor* areas, concern people and organizations should come forward so that country can be benefited. Government should enact and exercise such policies and provisions that can benefit fishermen and local dwellers as well as the state. The proper supervision and coordination among different departments of the government are very much needed to protect the right of the fishermen and protection of water bodies. Human right organizations, civil society and environmentalists should extend their hands in favor of fishermen and protection of fishes in the *haor* areas. The fishermen are directly involved with the water body. Opportunities should be created in a way so that the fishermen can play a vital role in protecting the *haor*, fish and the dry land. Fishermen community also has huge responsibilities. They should follow the fishing policies so that disappearance of fish can be protected and ultimately, if it is ensured, their livelihood and ancestral occupation shall be protected. The whole initiatives regarding the protection of *haor* ecology needs to be converted as a social movement.

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