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Effects of periphyton grown on bamboo substrates on growth and production of Indian major carp, rohu (*Labeo rohita* Ham.)

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Abstract

The effects of periphyton, grown on bamboo substrates, on growth and production of Indian major carp, rohu, *Labeo rohita* (Hamilton), were studied in 10 ponds during July to October'95 at the Bangladesh Agricultural University, Mymensingh. Five ponds were provided with bamboo substrates (treatment I) and the rests without bamboo substrates (treatment II). It was revealed that there had been no discernible difference in the water quality parameters between treatments. A large number of plankton (30 genera) showed periphytic nature and colonized on the bamboo substrates. The growth and production of fish was significantly ($p<0.05$) higher in the ponds with bamboo substrates as compared to the ponds without substrates. The net production of rohu in treatment I was about 1.7 times higher than that of treatment II. Fish production was as much as 1899 kg/ha over a culture period of 4 months in the periphyton-based production system.

Key words : Periphyton, Bamboo Substrate, *Labeo rohita*

Introduction

Pond production systems in Bangladesh or elsewhere in the region are becoming increasingly reliant on external resources (feed, fertilizers) to supplement or stimulate autochthonous food production for pond fish. Moreover, most production systems, especially the more intensive types, are inefficient, only about 30% of nutrient inputs being converted into harvestable products, the remainder being lost to the sediments, effluent water and the atmosphere (Acosta-Nassar *et al.* 1994, Beverdge *et al.* 1994, Olah *et al.* 1994). Intensive pond production systems are also reliant on the environment at large to disperse and assimilate wastes (Beveridge & Phillips 1993).

An improved technique of fish culture based on the natural production could be a solution for the poorer country like Bangladesh. Periphyton-based fish culture may offer a new direction in this regards which deserves attention of the fisheries scientists. Periphyton is a preferable food materials for many fishes, especially Indian major carps, tilapia etc. If periphyton is grown on artificial substrates like bamboo poles, then these will be major food sources for fishes cultured in a pond. Fishes, whose feeding habit is sucking algae, diatom and other plankton, may easily graze on periphyton. Hem and Avit (1994) explored the possibility of increasing fish production through periphyton production enhancement in the Ivory Coast, Africa, and reported tilapia (*Sarotherodan melanotheron*) production of 8 metric tones/ha/year when bamboo poles were "planted" vertically in the bottom of grow-out systems. This increased fish production was attributed to the bamboo providing a substrate for the growth of periphyton on which tilapia was observed to graze.

This technique has been tried to adapt in Bangladesh in collaboration with Northwest Fisheries Extension Project (NFEP) where bamboo mats called "chatai" were used for tilapia production. Tilapia (*Oreochromis niloticus*) production were 0.64 and 0.60 metric tones/ha in four months for ponds with and without bamboo mats, respectively, which were not statistically different (Faruk-ul-Islam 1996). Through an initial screening of the local species, rohu *Labeo rohita* (Ham.), has been considered as a suitable species for periphyton-based culture system. The importance of carp culture in Bangladesh and in the region and lack of easy and profitable means of culture system have driven the researchers to explore the potential of periphyton-based aquaculture with the indigenous fish species. With this idea in view, the present study has been designed to observe if increased production of rohu could be achieved using periphyton grown on bamboo substrates.

Materials and methods

Experimental design and pond preparation

This trial was conducted for a period of 4 months from July to October, 1995 at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Ten earthen ponds with an area of 75 m^2 and an average depth of 1.5 m were used for this study. Ponds were rain-fed, well exposed to sunlight, and without any inlet or outlet. Two treatments were considered in this trial each with five replications. Among ten ponds, 5 were regarded as treatment I which were provided with bamboo poles as substrates and the rest 5 were treated as treatment II without substrates (control). Before starting the experiment, ponds were prepared following Dewan *et al.* (1991). Ponds were initially cleaned and treated with rotenone at the rate of 50 g/dec/feet water. After 5 days, lime was applied at the rate of 250 kg/ha and left for 5 days. About 1.5 meter long bamboo poles were inserted into the pond bottom vertically at a density of 9 poles per m^2. Then inorganic fertilizers (urea and TSP) were used at the rate of 200 and 100 g/dec, respectively. The ponds were left for 15 days to allow sufficient production of periphyton on the substrates.

Fish stocking and pond management

After sufficient growth of periphyton on the substrates, all ponds were stocked with same sized (average weight 9.96 g each) fingerlings of rohu, *Labeo rohita* (Ham.) at a density of $1/m^2$. During the entire experimental period, dilute urea and TSP were sprayed fortnightly at the rate of 400 and 500 g/dec, respectively.

Assessment of water quality, plankton and periphyton

Water quality measurements were made between 0900-1000 h on each sampling day. Water temperature (°C), dissolved oxygen (mg/l) and pH were measured at the pond site. Chlorophyll-a (µg/l) were measured in the Water Quality and Pond Dynamics Laboratory, Faculty of Fisheries.

Water temperature was recorded using a Celsius thermometer. Dissolved oxygen was determined by a portable DO meter (YSI model 58), pH of water were determined with a pH meter (Jenway, model 3020). Chlorophyll-a was determined after filtering water sample through Whatman filter paper (46 cm) using a spectrophotometer (Milton Roy Spectronic, model 1001 plus).

To enumerate plankton population, 10 samples (5 liters of water in each sample) of water were collected from different areas and depths from each pond fortnightly and were filtered through a fine mesh (25 µ) phytoplankton net. Then the filtered samples were taken in a measuring cylinder carefully and made up to a standard volume of 100 ml with distilled water. Buffered formalin (5%) was added as a preservative and stored in small sealed plastic bottles until examination. Using a Sedgewick-Rafter cell, a 1 ml sub-sample was examined from each sample. All organisms present in 10 cells chosen at random were counted and identified following Bellinger (1992).

Periphyton samples from bamboo poles were taken by scraping with the help of blunt razor blades. Scrapings were kept in 1000 ml water and vigorously shaken. Then the samples were preserved in 5% formalin for future study. The periphyton concentrations were determined by a Sedgewick-Rafter cell (S-R cell) as done for phytoplankton. Identification of periphyton was also done according to Bellinger (1992).

Fish harvesting

Ponds were drained at the end of experiment and all fishes were harvested and measured in total length (cm) and weight (g). Total weight of fish per pond was also determined.

Statistical analysis

For statistical analyses of data, a one way ANOVA and *t*-test were applied using the statistical package, STATGRAPHICS Version 7 on a personal computer IPC.

Results

Water quality parameters

Water quality parameters of a large number of samples were analysed in this experiment to observe any appreciable changes that might have occurred in response to bamboo substrates. Physical parameters like temperature, transparency and chemical parameters such as pH and dissolved oxygen (DO) have been measured throughout the experiment. Water quality parameters are presented in Table 1.

Table 1. Mean (+ SD) of water quality parameters in two treatments

Water quality parameters	With substrates (T_1)	Without substrates (T_2)
Water temperature(°C)	29.3 ± 0.18	29.7 ± 0.16
Transperancy (cm)	40.55 ± 3.10	35.96 ± 4.81
pH	6.0-9.0	6.9-9.2
Dissolved oxygen (mg/l)	7.11 ± 0.28	7.24 ± 0.74
Chlorophyll-a (mg/l)	76.0 ± 14.56	72.6 ± 11.30
Phytoplankton (units/l)	140,045± 3,235	140,825 ± 7,965
Zooplankton (units/l)	21,750 ±3,154	21,250 ± 1,455
Periphyton (units/cm²)	27,754 ± 3,674	-

Water temperature varied a very little over the entire period. Mean values were 29.3 ± 0.18 and 29.7 ± 0.16°C in treatment I and treatment II, respectively. Mean values of transparency of water in treatment I and treatment II were 40.55 ± 0.31 and 35.96 ± 4.81cm, respectively. pH of water was almost neutral. pH values varied from 6.0 to 9.0 in treatment I and from 6.9 to 9.2 in treatment II. Mean values of dissolved oxygen in treatment I and treatment II were 7.11 ± 0.28 and 7.24 ± 0.74, respectively. The mean values of chlorophyll-a of pond water under treatment I and treatment II were 76.00 ± 14.56 and 72.60 ± 11.30, respectively.

Plankton and periphyton

The mean (± SD) values of phytoplankton in treatments I and II were 140,045 ± 3,235 and 140,825 ± 7,965 units/l, respectively (Table 1). On the contrary, the mean (± SD) values of zooplankton were 21,750 ± 3,154 and 21,250 ± 1,455 in treatment I and treatment II, respectively. Planktonic organisms were mainly consisted of 5 groups of phytoplankton and 3 groups of zooplankton (Table 2). Some 32 genera of phytoplankton belonging to Bacillariophyceae (6), Chlorophyceae (17), Cyanophyceae (6), Euglenophyceae (2) and Rhodophyceae (1) were found. Eleven genera of zooplankton were also identified belonging to Cladocera (2), Copepoda (3) and Rotifera (6).

Table 2. List of plankton and periphyton community recorded from the experimental ponds

Groups	Plankton	Periphyton
Bacillariophyceae	*Cymbella* *Diatoma* *Mepsira* *Nitzschia* *Navicula* *Tabellaria*	*Cymbella* *Navicula* *Nitzschia* *Melosira*
Chlorophyceae	*Actinastrum* *Ankistrodesmus* *Arthrodesmus* *Botryococcus* *Characium* *Chlorella* *Closterium* *Cosmarium* *Gloeocystis* *Gonatozygon* *Oocystis* *Pediastrum* *Scenedesmus* *Spirogyra* *Spirulina* *Ulothrix* *Volvox*	*Ankistrodesmus* *Botryococcus* *Ceratium* *Chlamydomonas* *Cladophora* *Closterium* *Draparnaldia* *Gloeocystis* *Gonatozygon* *Oedogonium* *Rhizoclonium* *Stigeoclonium* *Ulothrix* *Volvox*

Cyanophyceae	*Anabaena* *Aphanocapsa* *Chrococcus* *Merismopedia* *Microcystis* *Oscilatoria*	*Anabaena* *Aphanizomenon* *Oscilatoria* *Nodularia*
Euglenophyceae	*Euglena* *Phacus*	*Euglena* *Phacus*
Rhodophyceae	*Audouinella*	*Audouinella*
Rotifera	*Asplanchna* *Brachionus* *Filina* *Hexarthra* *Keratella* *Polyarthra*	*Brachionus* *Filnia* *Keratella*
Copepoda	*Cyclops* *Diaptomus* Nauplius	*Cyclops*
Cladocera	*Daphnia* *Diaphanosoma*	*Diaptomus*

Periphyton organisms were mainly consisted of 5 groups of phytoplankton and 3 groups of zooplankton. Thirty genera of periphyton under 5 groups of phytoplankton belonging to Bacillariophyceae (4), Chlorophyceae (14), Cyanophyceae (4), Euglenophyceae (2) and Rhodophyceae (1). Five genera of zooplankton were also identified belonging to Cladocera (1), Copepoda (1) and Rotifera (3) (Table 2). The mean values of periphyton concentration under treatment I were 27,754 ± 3,674 cells/cm^2 (Table 1). The trends of periphyton grown on bamboo substrates on fortnightly basis are shown in Fig. 1.

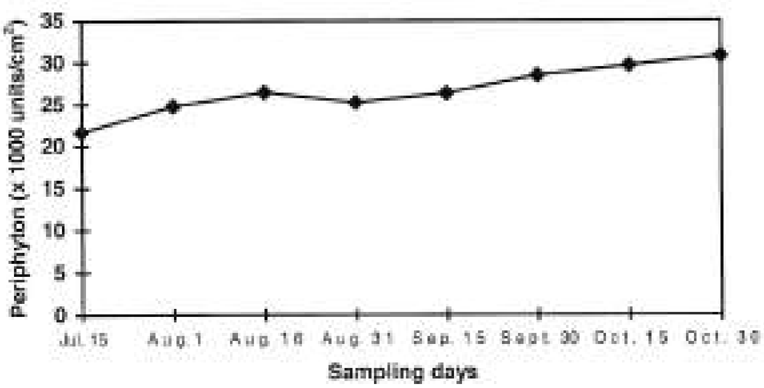

Fig. 1. Fortnightly concentration of periphyton in the ponds with bamboo substrates.

Survival and production of fish

Based on numbers harvested by the end of the experiment, fish survival rates were 85.60 and 76.26% in treatment I and treatment II, respectively (Table 3). The survivorship of rohu was significantly ($p<0.05$) higher in treatment I with bamboo substrates than treatment II. The average weight gain per fish was 222.53 g in treatment I and 143.27 g in treatment II. When compared using a *t*-test there was a significantly higher ($p<0.05$) average gain in weight per fish in treatment I. The net production of fish under treatment I and treatment II were 1,898.88 and 1,089.30 kg/ha, respectively. As much as 1.7 times higher production of fish was obtained from the ponds having bamboo substrates for growing of periphyton.

Discussion

All water quality parameters were within the limits suitable for fish production. Variations of some parameters in different ponds in some occasions were apparent, but there was no discernible changes in any parameter. During the study, mean temperatures were 29.3 ± 0.18 and 29.7 ± 0.16^{o}C in treatment I and treatment II, respectively. The highest and lowest temperatures were recorded in July and October 1995, respectively. Dewan *et al.* (1991) recorded similar temperatures in the BAU fish ponds. The transparency of a water body normally indicates its productivity. It is usually affected by several factors such as silting, microscopic organisms, suspended organic matter, latitude, the season, and the intensity of sunlight (Reid 1964). In the present study, the highest and lowest transparencies were recorded in the month of July and October'95, respectively. pH values were in alkaline range in all the ponds which indicated good pH conditions for biological production. According to Boyd (1992), suitable pH range for fish pond should be 6.5 to 7.5. The mean values of dissolved oxygen were 7.11 ± 0.28 and 7.24 ± 0.74 mg/l in treatment I and treatment II, respectively. These ranges of DO are indicative of good ponds at the standard set out by Boyd (1992).

Table 3. Average yield parameters of rohu in different treatments

Treatment/ Pond	With substrate (T_1)					Without substrate (T_2)					Mean*	
	3	5	6	8	9	1	2	4	7	10	T_1	T_2
Stocking density/pond	75	75	75	75	75	75	75	75	75	75	75'	75'
Average initial weight (g)	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96'	9.96'
Density at harvest	62	65	66	64	63	58	55	56	59	57	64'	57'
% Survival	8[illegible]	8[illegible]	8[illegible]	8[illegible]	8[illegible]	7[illegible]	7[illegible]	7[illegible]	7[illegible]	71	85	76

Average final weight (g)	244.5	244.2	167.3	213.7	192.5	142.4	155.1	136.4	113.7	209.3	232.45	153.23
Weight gain/fish (g)	234.6	234.2	257.4	203.8	182.5	132.5	145.2	126.4	103.7	199.4	222.53	143.27
Net yield (kg/ha)	1938.6	2030.0	2265.1	1739.2	1533.2	1024.5	1064.7	944.2	816.3	1515.5	1898.88	1089.30

* *Figures in the same column having the different superscripts are significantly different (p<0.0.5) from each other.*

Plankton population indicates the productive status of a waterbody, because these are the direct and basic source of food for most of the animals in aquatic habitat. Phytoplankton belonging to 5 families, including Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Rhodophyceae were found. Phytoplankton composition was represented by the usual nature of plankton in tropical fish ponds as reported by Mollah and Haque (1978), Dewan *et al.* (1991), and Wahab and Ahmed (1992). Both Bacillariophyceae and Chlorophyceae were represented by the higher number and this might have a positive bearing on the higher survival of fish in general.

Thirty genera of periphyton community were identified from which 25 genera were phytoplankton and 5 genera were zooplankton. Most dominant genera were *Stigeoclonium, Gonatozygon, Cladophora, Rhizoclonium, Botryococcus, Closterium, Nitzschia* and *Volvox*. These large number of periphyton have colonized on the bamboo substrates. Eminson and Phillips (1978) and Cattaneo (1987) stated that the hard substrates such as bamboo poles were the most suitable substrates for periphyton growth.

In this trial, fish were regularly observed grazing on the periphyton grown on the surface of the bamboo substrates in the treatment ponds. It is hypothesized that the periphyton grown on the bamboo surface was a readily available feed which might have enhanced the growth and production rate of *Labeo rohita* in the treatment ponds compared to that of the control ponds. This has been reflected in the higher gain in weight of fish in the ponds having bamboo substrates.

The survival rate of rohu was higher in treatment I than that of treatment II. Possibly this was due to the fact that periphyton grown on bamboo substrates have influenced the better survival of stocked fishes by providing protection from fish eating birds. The average weight gain of rohu was found to be significantly higher ($P<0.05$) in the ponds where bamboo substrates were introduced. This may be due to the availability of rich food, periphyton grown on substrates for which fish require less energy to graze on. It is a fact that in normal grow out system, fish spend lot of energy in search of - and filtering of food organisms.

The average net production in treatment I (with bamboo poles) was 18,998.88 kg/ha/120 days and in treatment II (without bamboo poles) was 1,089.30 kg/ha/120 days. It was found that fish production of treatment I was 1.7 times higher than that of treatment II. Enclosed acadja systems, with no external feed inputs, only capitalize on periphyton were reported to yield 8 MT per ha per year (Hem and Avit 1994).

This production of fish from the periphyton-based aquaculture is higher than that of country's average production from the polyculture system which is 10,000 kg/ha (Gupta, pers.com.). Therefore, periphyton based fish production technology offers a tremendous potential for a resource constraint country like Bangladesh.

Finally, it may be concluded that a locally available substrates found all over the country and in this region like bamboos can increase production of rohu (*Labeo rohita* Ham.) in the fish ponds. There may be other sources of cheap and locally available substrates which may be of worth looking in future. However, an economic evaluation of this new culture system is pre-requisite to develop a sustainable periphyton-based aquaculture technology for the rural people.

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Growth and production performance of red tilapia and Nile tilapia (*Oreochromis niloticus* Lin.) under low-input culture system

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Abstract
Comparative production potential of red tilapia (a mutant hybrid of *Oreochromis niloticus*x*O. mossambicus*) and nile tilapia (*Oreochromis niloticus*) under low-input aquaculture was studied in six ponds of 360 m^2 each with an average water depth of 90 cm. Three ponds were stocked with fingerlings of *O. niloticus* (average weight 11.4±3.48 g) while three other ponds were stocked with red tilapia (average weight 10.72±2.5 g) at a density of 20,000 fingerlings/ha. Supplementary feed consisting of rice bran was given daily at 4-6% of standing biomass. Ponds were fertilized at fortnightly intervals with cattle manure @ 750 kg/ ha. After six months of rearing, gross fish productions of 3,218 and 3,017 kg/ha were obtained from *O. niloticus* and red tilapia ponds, respectively. Of this, table size fish (>80 g in size) production amounted to 2,366 and 2,823 kg/ ha from *O. niloticus* and red tilapia culture, respectively. Analysis of cost and benefits showed higher benefit from red tilapia culture.

Key words : Red tilapia, Nile tilapia

Introduction

Bangladesh abounds in large number of seasonal ponds, ditches, borrow pits and road side canals, which retain water for five to six months and are hitherto lying fellow. Studies undertaken in recent years have indicated the economic viability of culturing short cycle species such as Nile tilapia (*Oreochromis niloticus*) and Silver barb (*Puntius gonionotus*) in such seasonal waters, using agricultural wastes and bi-product as supplementary feed and fertilizers (Gupta 1992, Gupta *et al.* 1994, Hussain *et al.* 1989, Kohinoor *et al.* 1993). One of the problems faced by farmers with regard to the culture of Nile tilapia is its prolific pond breeding resulting in over population leading to stunted growth (Gupta and Shah 1992). Subsequently, red tilapia, a hybrid mutant of *Oreochromis niloticus* and *Oreochromis mossambicus* was introduced into Bangladesh in 1988 from Thailand. Studies undertaken to assess the economic viability of its culture indicated that gross production of 4,255 kg/ha in 6 months rearing could be obtained using rice bran and mustard oil cake as supplementary feed, accompanied by fertilization of ponds (Akhteruzzaman *et al.* 1993). Fry and fingerlings contributed only 1.3 - 10.8% of total gross production as compared to 11.2 - 41.5% in the case of Nile tilapia (*Oreochromis niloticus*) by Gupta *et al.* (1994), indicating less fry production in the case of red tilapia, resulting in higher production of table size fish. Mustard oil cake though good as supplementary fish feed because of its high protein content , is expensive and its use in aquaculture is beyond the means of resource poor rural farmer. Hence, studies were undertaken to assess the production of red tilapia using only rice bran as supplementary feed and the advantages of its culture, if any, over that of Nile tilapia (*Oreochromis niloticus*) under similar culture management. The results of these studies are presented in this paper.

Materials and methods

The study was undertaken in drainable earthen ponds of 360m^2 each, with an average water depth of 90 cm during October'92 through March '93. The ponds were prepared by draining and application of lime to the pond bottom at the rate of 250 kg/ha. Three days after the application of lime, ponds were filled with ground water and fertilized with cattle manure at the rate of 750kg/ha .

Five days after the application of cattle manure, inorganic fertilizers - urea and triple super phosphate (TSP) were applied at the rate of 8.0 and 17.0 kg/ha, respectively. Three days subsequent to application of inorganic fertilizers, stocking was done: three ponds with fingerlings of Nile tilapia (*Oreochromis niloticus*) of average weight 10.4 (±3.48)g and another three ponds with red tilapia fingerlings of average weight 10.72 (±2.5)g. Stocking density of fingerlings in all ponds was maintained at 20,000/ha. Rice bran (with 5.95% protein) was applied in ponds every day as supplementary feed at the rate of 6% of the standing fish biomass. During December and January months when the temperature of water dropped from 24 to 16 °C, feeding was reduced to 4 % of standing fish biomass. Subsequent to stocking, all the ponds ware fertilized regularly at fortnightly intervals with cattle manure at the rate of 750 kg/ha. The ponds were sampled at fortnightly intervals to assess growth and condition of fish and feeding was adjusted on the estimated fish biomass in ponds.

Two month after stocking, ponds were netted at fortnightly intervals using a 0.5 cm mesh seine net and the fry/fingerlings caught in the net were harvested. Records were maintained on the number and weight of fry harvested. All the ponds were completely harvested after six months of rearing, first by seining and later by draining the pond. Dissolved oxygen, pH and temperature of water were measured at weekly intervals using a HACH kit. Student's t-test was used to compare the treatment means at 5% level of significance.

Results and discussion

Temperature and secchi disk transparency of water in ponds during the study period ranged from 18 to 31°C and 16-46 cm, respectively. Dissolved oxygen and pH varied from 2.1 to 6.1 ppm and 7.1 to 8.3 respectively, during the months (Table 1). There was no significant differences ($P<0.05$) in physicochemical characteristics of water in different ponds.

Table 1. Physio-chemical characteristics of pond water during study period

Parameter	October	November	December	January	February	March
Water temperature (°C)	25-31	23-27	18-24	16-22	20-26	22.5-29.0
Secchi disk transparency (cm)	26-46	16-40	16-42	18-28	24-46	16-30
Dissolved Oxygen (mg/l.)	2.8-6.2	2.6-4.8	2.3-6.2	2.1-6.6	2.2-4.8	2.3-5.1
pH	7.5-8.2	7.1-8.0	7.5-8.2	7.1-8.3	7.3-8.3	7.7-8.2

Average growth of fish ranged from 0.40 to 1.37g/day in the case of red tilapia and 0.37 to 1.20 g in the case of Nile tilapia, during different months, the growth decreasing with increase in rearing period. As could be seen from Figure 1, red tilapia grew at a faster rate as compared to Nile tilapia, from the first month of rearing (Table 2). At the end of six months of rearing Nile tilapia attained an average weight of 125 g as compared to 151 g attained by red tilapia.

Growth of fish during the first month after stocking was high in the case of both red tilapia and Nile tilapia, being 1.37 and 1.20 g/day, respectively (Table 2). Subsequently, daily growth decreased and was in the range of 0.40-0.99 g/ day in the case of red tilapia and 0.37 - 0.63 g/ day in the case of Nile tilapia. Growth pattern in both the species was more or less same (Fig.1).

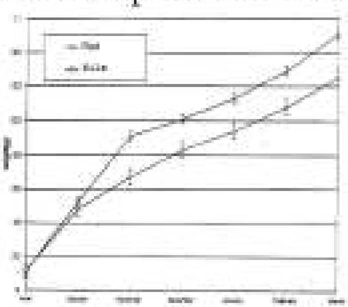

Fig. 1. Average growth of red and Nile tilapias during October'92 to March'93.

Table 2. Average weight and growth rate (g/day) of red tilapia and Nile tilapia in different months during rearing period

Month	Red tilapia		Nile tilapia		t-statistic
	Average weight (g)	Growth/day (g)	Average weight (g)	Growth/day (g)	
Initial	10.72	-	11.40	-	
October	52.00	1.37	48.00	1.20	
November	91.00	0.99	67.00	0.63	
December	101.00	0.67	83.00	0.53	0.64 NS
January	113.00	0.40	94.00	0.37	
February	129.00	0.53	108.00	0.42	
March	151.00	0.73	125.00	0.59	

NS= Not significant

Number and weight of fry and fingerlings harvested from red tilapia and Nile tilapia ponds during different months of rearing are presented in Table 3. Fry of Nile tilapia started coming in the nets from the second month after stocking, while in the case of red tilapia, fry harvesting started three months after stocking, indicating early breeding in the case of Nile tilapia. Fry/fingerling production was considerably higher in all months in the case of Nile tilapia as compared to that of red tilapia. In case of Nile tilapia, number and weight of fry/fingerlings harvested amounted to 181,639 nos. and 852.78 kg/ha, respectively in six months rearing period, while it was 41,139 nos. and 193.33 kg/ha in the case of red tilapia, indicating that the production of fry/fingerlings in the case of Nile tilapia 4-5 times higher (P<0.01) as compared to that of red tilapia.

Table 3. Fry and fingerlings production of red tilapia and Nile tilapia

Species	Fingerlings production (no. and kg/ha)													
	October		November		December		January		February		March		Total	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
Red tilapia	-	-	-	-	14972	70.42	7194	35.80	5195	24.41	13778	64.70	41139	193.33
Nilotica	-	-	34944	152.78	29278	137.50	14917	81.25	13611	63.89	88889	417.36	181639**	852.78**

**Significant at 0.01 level*

Details of fish production and feed conversion in the case of red tilapia and Nile tilapia are presented in Table 4. Average gross production was found to be lower amounted to 3,017 kg/ha in the case of red tilapia, while it was higher, 3,218 kg/ha (P<0.01), in the case Nile tilapia of after six months rearing. Such higher gross production in the case of Nile tilapia seemed to be due to higher (P<0.01) production of fry /fingerlings. Table size fish (> 80 g size) was higher (P<0.01), 2,823 kg/ha in the case of red tilapia as compared to Nile tilapia, 2,366 kg/ha. The feed conversion ratio (FCR) in the case of red tilapia was 5.61 while it was lower, 4.68 ($P<0.01$) in the case of Nile tilapia .Observed better feed conversion ratio in the case of Nile tilapia might be related to higher production of fry/fingerlings, resulting in higher biomass.

Table 4. Production and FCR of red tilapia and Nile tilapia

Treatment	Stocking density (no./ha)	Culture period (month)	Production (kg/ha) Marketable size fish (> 80 g)	Fry / fingerlings	Gross production	FCR
Red tilapia	20,000	6	2,823.33**	193.33	3,026.66	5.61**
Nile tilapia	20,000	6	2,365.55	852.78**	3,218.33**	4.68

** *Significant at 0.01 level*

Cost of production and returns from culture of red tilapia and Nile tilapia are presented in Table 5. While estimating cost of production, variable costs such as, lime, feed, fertilizer and fingerlings were taken into consideration. Since low-cost tilapia will be practiced mostly in homestead ponds, cost of pond lease and labor for management of the pond have not been taken into consideration for estimating production economics. Cost of production amounted to Tk. 35,880/ha in six months rearing in the case of red tilapia, while it was Tk. 30,978/ ha in the case of Nile tilapia. Selling price was of red tilapia fry Tk. 300/1000 nos. as compared to those of Nile tilapia (Tk. 200/1000 nos.). At the same time, table size (>80 g) red tilapia commands a higher price in the market (Tk. 45/kg) as compared to Nile tilapia (Tk. 35/kg). This resulted in higher gross revenue from red tilapia culture even though gross production was less. Gross revenue from red tilapia culture amounted to TK. 139,391/ha , leaving a net benefit of Tk. 103,511, while gross revenue from Nile tilapia culture amounted to Tk. 119,122, leaving a net benefit of Tk. 88,144/ha indicating higher profitability from red tilapia culture.

Table 5. Cost and benefits from culture of red tilapia and Nile tilapia in six months

Input	Red tilapia Quantity (kg)	Cost (Tk.)	Nile tilapia Quantity (kg)	Cost (Tk.)
A. Cost				
Lime	250	750.00	250	750.00
Cattle manure	9,000	3,600.00	9,000	3,600.00
Inorganic fertilizers	25	125.00	25	125.00
Fingerlings	20,000 nos.	6,000.00	20,000 nos.	4,000.00
Rice bran	16,937	25,405.00	15,002	22,503.00
Total cost		35,880.00		30,978.00

B. Benefits				
Marketable size fish				
Red tilapia : Tk. 45/kg	2,823.33	127,049.85	2,365.55	82,794.25
Nile tilapia :Tk. 35/kg				
Fingerlings				
Red tilapia : Tk.0.3 each	41,139 nos.	12,341.70	181,639 nos.	36,327.80
Nile tilapia :Tk. 0.2 each				
Gross benefit		139,391		119,122
Net benefit (B-A)		103,511		88,144

Akhteruzzman *et al.* (1992) reported gross production of 4,235 kg/ha/6 months from culture of red tilapia using rice bran and mustard oil cake as supplementary feed, along with fertilization of ponds with organic and inorganic fertilizers. In the same study they observed that fish production was only 3,121kg/ha in 6 months when fish were provided with supplementary feed, but ponds were not fertilized. Gross production of 3,017 kg/ha/6 months obtained in the present study using low-cost supplementary feed, rice bran and fertilization of ponds, compares well with production obtained using rice bran and mustard oil cake. Gupta *et al.* (1994) reported an average gross production of 2,738 kg/ha/6 months from Nile tilapia (*O. niloticus)* culture using only rice bran as supplementary feed. Gross production of 3,554 kg/ha/6 months was obtained with Nile tilapia (*O. niloticus)* when rice bran and mustard oil cake were used as supplementary feed (Hussain *et al.* 1989).

Tilapia culture in Bangladesh is being undertaken by resource-poor rural farmers as a low-cost, homestead enterprise and in this context culture of tilapia, either it to be red tilapia or Nile tilapia using rice bran as supplementary feed, will be viable as a low-cost technology. Though the present study indicated that Nile tilapia performs well in terms of feed conversion efficiency, its relatively low growth and higher fry production makes it less promising than red tilapia in overall production potential. However, low breeding intensity in case of red tilapia could be a constraint for large-scale seed production.

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Growth and production of Nile tilapia (*Oreochromis niloticus* Lin.) in irrigated Boro rice under floodplain environment

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Abstract

The experiment was conducted at BRRI Regional Station, Habiganj during 1994-95 to evaluate the growth and economic performance of Nile tilapia, *Oreochromis niloticus*, fish reared in the field of irrigated boro rice with different fertilizer levels. Grain yield of rice was not affected by fish culture. It was observed that fifty percent of recommended fertilizer was enough to produce increased rice yield (8-10 t/ha) at floodplain environment and additional yield was obtained with the increasing fertilizer rates. Results further indicated that *O. niloticus* could successfully be reared in the field of irrigated boro rice with recommended fertilizer level. Larger size of fingerlings at release had improved recovery percent, body weight gain and higher fish yield. Results also revealed that rice + fish production system produced higher net return than the system with rice alone.

Key words : Nile tilapia, Rice-fish farming

Introduction

Rice is the main food of the majority people in Asia, but rice is not a complete food. It must be supplemented by animal protein. Fish is the common and cheapest source of animal protein in the region (Huat and Tan 1980). Fish supplies about 80 percent of animal protein for rural people of Bangladesh (ODA 1995, Karim 1978). However, Bangladesh which was once abound with fishes, is now facing an acute shortage of fish due to rapid growth of human population, the degradation of fish habitat and more recently fish diseases have significantly reduced the fish production which lead to concomitant malnutrition among children and women. In order to improve the sombre situation Gupta and Mazid (1993) estimated that fish production has to increase to some 1.2 million tons from the present 0.8 million tons to maintain a low level per capita consumption of 7.9 kg per year. They also reported that this increased production has to come from aquaculture, specifically from rice field since marine fisheries and fish production from open water bodies are declining as a result of over fishing and degradation of aquatic habitat.

Lightfoot *et al.* (1990) noted that adoption of integrated rice-fish culture could dramatically increase fish production.

The country has 2.35 million hectare of land where irrigated boro rice is cultivated (BBS 1993). During rice growing period water remains at 10-15 cm in most rice fields. *Moss* and *Azolla* are available in this rice field which are excellent fish feeds. To explore the possibilities of fish rearing in the rice field an experiment was conducted to determine the bio-economic performance of Nile tilapia species with different fertilizer levels under floodplain environment during 1994-95 boro season.

Materials and methods

The experiment was conducted at the farm of BRRI Regional Station, Habiganj situated in floodplain environment, during boro season 1994-95. The experimental plots were laid out in Randomized Complete Block Design with 3 Replications each having different fertilizer treatments, i) 0-0-0, ii) 40-30-20 and iii) 80-60-40 kg N-P_2O_5-K_2O/ha. The plots size were 20 m x 15 m. Plots were levelled to maintain uniform water depth in the plot. The border of the individual plots were raised to 50 cm high and 50 cm wide to prevent fingerlings movement from one plot to the other. In addition, 75 cm wide and 50 cm deep drains were made at the two sides of each plots for fingerlings to take shelter at the time of splits application of N and weeding for rice (Fig. 1). This drain helped fingerlings survive for few days when the irrigation pump broke down. Half of N and all P_2O_5 and K_2O were applied before the final land preparation. Forty five and 40-day old seedlings were transplanted on February 11, 1994 and February 01, 1995 respectively. Fingerlings of Nile tilapia (1 fingerling/m^2) were released 2-weeks after (Feb. 25, 1994 and Feb. 15, 1995) boro transplanting in both the years. Rest half of N was applied at 25 days after transplanting (DAT) followed by weeding. Except for the time of weeding and fertilizer application (only for top dressing) about 10-15 cm water depth was maintained throughout the rice growing period. Fish was harvested on June 03, 1994 and June 05, 1995 respectively before the harvest of boro rice for both the years. Data of fish and rice were recorded for comparing the bio-economic performance of the different studied parameters.

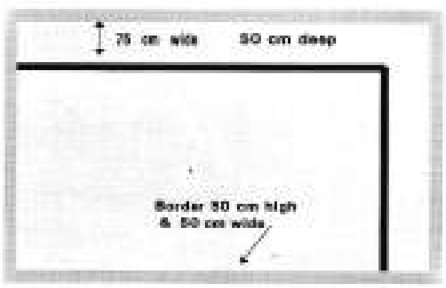

Fig. 1. Lay out of an individual plot.

Results and discussion

Rice yield

The study indicated that yield of boro rice was not affected by fish culture. But the increased fertilizer rate of 80-60-40 kg/ha N-P_2O_5-K_2O produced the highest rice yield in both the years (Table 1). Similarly, 40-30-20 kg/ha N-P_2O_5-K_2O produced significantly higher rice yield than crops grown without fertilizer. The yield of rice did not vary within the fertilizer rates. Rice yield was higher in 1994 than 1995. Higher panicle/m^2 and more grain number/m^2 might have contributed this higher grain yield in 1994. Heslehust (1982) reported an increase grain yield with the relative increase of grain number. Individual grain weight is the only yield component influenced by genotype (Green and Dawkins 1985). In both the years, thousand grain weight remained unaffected by the treatments.

Table 1. Grain yield and yield components of boro rice (BR3) as influenced by fish culture at different fertilizer levels, BRRI Regional Station, Habiganj

Production systems	Fertilizer levels (kg/ha) N-P_2O_5-K_2O	Yield (t/ha)	Panicle/m^2 (No.)	Grain/ panicle (No.)	1000-grain wt.(g)
1994					
Rice alone	0 - 0 - 0	6.95	379	66	27.74
Rice+Fish	0 - 0 - 0	7.06	374	67	28.25
Rice alone	40 - 30 - 20	8.29	403	74	27.90
Rice+Fish	40 - 30 - 20	8.61	417	74	27.92
Rice alone	80 - 60 - 40	9.23	442	75	27.77
Rice+Fish	80 - 60 - 40	9.10	458	68	28.46
1995					
Rice alone	0 - 0 - 0	4.25	192	79	27.43
Rice+Fish	0 - 0 - 0	4.33	164	96	27.73
Rice alone	40 - 30 - 20	6.28	257	78	27.50
Rice+Fish	40 - 30 - 20	6.41	261	89	27.43
Rice alone	80 - 60 - 40	6.46	241	98	27.52
Rice+Fish	80 - 60 - 40	6.75	244	102	27.33

Means followed by common letter did not differ significant at 5% level by DMRT.

Fish yield

Body weight grain, recovery percentage and fish yield were similar between plots fertilized with 80-60-40 and 40-30-20 kg/ha N-P_2O_5-K_2O but these parameters from these two fertilized treatments were significantly higher ($P<0.05$) than the treatment without fertilizer (Table 2). Fertilized plots probably had more feed like *Azolla*, *Lemna spp.* and various kinds of phytoplankton etc. which might have enhanced the body weight gain of the fishes reared in those plots. Kim *et al.* (1992) reported 92 percent survivability of *O. niloticus* fish species in rice field. The body weight gain, recovery percentage and fish yield in 1995 were higher than that of 1994. Larger size fingerlings that were released in 1995 might have contributed to this higher recovery percentage and body weight gain and greater fish yield. However, results indicated that 136-320 kg/ha fish was harvested when Nile tilapia/was reared in boro rice field with and without fertilizer level. Haroon *et al.* (1992) reported fish yield of 400 kg/ha when *O. niloticus* was reared in the transplanted Aman rice field with 60-40-40 kg N-P_2O_5-K_2O/ha. Dela Cruz *et al.* (1988) harvested a fish yield of 300 kg/ha of which 180 kg/ha was Nile tilapia and 120 kg/ha of common carp from irrigated rice crop. Results of this trial suggest that *O. niloticus* fish could be profitably reared in the irrigated boro rice field with recommended fertilizers without affecting rice yield.

Table 2. Body weight gain, recovery percentage and yield of *O. niloticus* with boro rice under different fertilizer levels, BRRI regional station, Habiganj

Fertilizer (kg/ha)	At release		At harvest		Number released	Number harves- ted	Reco very (%)	Yield (t/ha)
N-P_2O_5-K_2O	Length (cm)	Weight (g)	Length (cm)	Weight (g)				
1994								
0 - 0 - 0	4.18	1.40	9.70^b	26.00^b	300	156	52	0.13^b
40- 30 - 20	4.18	1.40	10.27^a	29.53^a	300	183	61	0.17^a
80- 60 - 40	4.18	1.40	10.23^a	28.09^{ab}	300	186	62	0.17^a
1995								
0 - 0 - 0	5.60	10.85	13.33	46.11^b	300	184	62	0.22^b
40- 30 - 20	5.60	10.85	15.50	61.43^a	300	190	63	0.32^a
80- 60 - 40	5.60	10.85	14.67	60.13^a	300	192	64	0.31^a

Means followed by common letter did not differ significant at 5% level by DMRT.

Economic analysis

Economic analysis of the production system showed that rice+ fish at 80-60-40 kg/ha N-P_2O_5-K_2O gave the highest net return followed by 40-30-20 kg/ha N-P_2O_5-K_2O in both the years whereas rice+ fish gave the lowest net return when the crops was grown without fertilizers (Table 3). Results also indicated that growing fishes with rice had profoundly helped to obtain a higher economic return than a system without fish.

Table 3. Economic analysis of integrated rice-fish production system during boro season under floodplain environment, Habiganj

Production system	Fertilizer (kg/ha)	Yield (Tk/ha)		Production cost (Tk/ha)		Gross return (Tk/ha)		Net return (Tk/ha)
	N- P_2O_5 - K_2O	Rice -	Fish	Rice -	Fish	Rice -	Fish	
1994								
Rice alone	0 - 0 - 0	6.95		13651		34750		21099
Rice+Fish	0 - 0 - 0	7.06	0.13	13651 -	3000	35300 -	5200	23849
Rice alone	40 - 30 - 20	8.29		14276		41450		27174
Rice + Fish	40 - 30 - 20	8.61	0.17	14276 -	3000	43050 -	6800	32574
Rice alone	80 - 60 - 40	9.23		15500		46150		30650
Rice + Fish	80 - 60 - 40	9.10	0.17	15500 -	3000	45500 -	6800	33800
1995								
Rice alone	0 - 0 - 0	4.25		13651 -		21250 -		7599
Rice+Fish	0 - 0 - 0	4.33	0.22	13651 -	3000	21650 -	8800	13799
Rice alone	40 - 30 - 20	6.28		14276 -		31400 -		17124

Rice+Fish	40 - 30 - 20	6.41	0.32	14276 -	3000	32050 -	12800	27574
Rice alone	80 - 60 - 40	6.46		15500 -		32300 -		16800
Rice+Fish	80 - 60 ? 40	6.75	0.31	15500 -	3000	33750 -	12400	30350

Price (Tk/kg): Urea=5, TSP=8, MP=7.57, Fish=40, Rice=5, Fingerlings = Tk 300/1000.

Conclusions

The results of two years study revealed that in the floodplain environment Nile tilapia could be reared successfully in the irrigated boro rice field without sacrificing rice yield. This rice-fish systems provide a great source of protein and add additional income to the farmers. Results also suggests that larger size of fingerlings at stocking release could increase the recovery percentage and body weight gain and higher fish yield and consequently higher net return. The rice-fish production systems if practised with careful management would make much needed protein easily available to the resource poor farmers and would raise their income, as well.

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Study on fishing gears, species selectivity toward gears and catch composition of BSKB beel, Khulna, Bangladesh

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Abstract

An investigation on the types of fishing gear used and their species selectivity and effects on fishes of BSKB beel in Khulna was conducted from June'95 to January'96. Fishermen were found to follow 6 fishing techniques *viz.*, netting, trapping, angling, spearing, dewatering and hand picking. Among them 23 types of the fishing gear was recorded to be used by the fishermen of which 7,8,4 and 4 are nets, traps, hooks and lines, and hand harpoon respectively. A total of 47 species of fish were identified in the catches of different gears used by the fishermen in BSKB beel. Particulars, mode of operation, fishing season and catch composition of different fishing gears were determined. Seine, cast and lift-net, traps (charo, arinda and ghuni), and hooks and lines (dhawn and nol broshi) were recorded as non-selective gear considering the fish species caught. However, gill nets (punti, koi and fash jal), clasp nets (bhuti jal), some traps (khadom, tubo), hooks and lines (chip borshi, chasra) and all spears were used as more or less selective gear. With respect to species and its size fash jal, bhuti jal, trap (khadom, ramani), and koach, juti and jhupi among spears were regarded to be more or less large-species-gear. But punti jal, koi jal, trap (koi dughair, charo, tubo, arinda and ghuni), nol borshi and spear (ful-kuchi) were small-species-gear. Among all gears seine net, cast net, lift net, koi dughair and ramani were recorded deleterious for carps specially for stocked fingerlings. For relatively small sized wild fishes koi jal, punti jal and ghuni traps were identified as detrimental gear.

Key Words : Fishing gear, Floodplain, Species selectivity, Regulations

Introduction

Beels are depressed low lying areas that carry perennial water even during dry season. It constitutes one of the most lucrative sources of fisheries in Bangladesh. Beels generally possess high potential for *in situ* fish production. The average fish production from beels area is about 487 kg/ha/yr and from the flood lands is 127 kg/ha/yr (DOF 1994). During the last decades natural migratory patterns of fishes have been largely interrupted by construction of dikes, regulators etc. The flood control and irrigation programme with no provision for the passage of fish has alarmingly declined the fish production from floodplain sources (Islam 1996). In order to overcome such crisis, the Department of Fisheries (DOF) have undertaken a massive stocking program with carp fingerlings to augment fish production. To safeguard the early growth stage of stocked fingerlings from the exploitation is one of the key factors to the success of stocking program as well as the wild fisheries.

A fairly large number of types and forms of gear are being operated in the floodplains to exploit wild fishes since time immemorial. The intensity of use of any form of gear in a beels dependent on the intensity of target fish population presumed to be available in that beel. Among them, many of these have been known to catch carp fingerlings before they grow to legal size and many of these are responsible for sharp decline in the population of wild species of the floodplain of the country. However, operation of all types of gear can not be kept suspended to allow the stocked fingerlings and also wild fishes to grow.

Considering the above circumstances, the present study was undertaken with the objectives i) to identify the types and characteristics of fishing gears operated in BSKB beel, ii) to determine their catch composition of gears during different season and iii) to find out probable reasons for sharp declination in the abundance of wild fish species from the beel.

Materials and methods

The study was conducted on the fishes of Barnal, Salimpur, Kola and Bashukhali (BSKB) beel located at Terokhada, Rupsha and Dighalia Thana of Khulna district and Kalia Thana of Narail from June '95 to January '96. The total area of BSKB beel is 26,040 ha, represents a poldered enviornment.

Monthly collection of catch data were done at fish landing centers (galas), bazars, hats and at the fishing spot individually with the help of field staffs. The particulars of fishing gears (mesh size, length, width, materials, etc.) and the catch data were collected from fishermen at the fishing spot through interview and direct observation. Then detail description (mesh size, length, wide, height, materials etc.) of each and every type of fishing gear was recorded from the fishermen during fishing. Mode of operation of the gear (time, place, habitat, lure, accessories etc.) was also recorded. Catch composition by each type of gear was recorded either by examining the total catch or 10 to 20% random of the total catch, incase of large catch. The samples were then sorted out species wise and the total length of individual fish of each species were measured.

Results and discussion

The fishermen were found to follow six fishing techniques *viz.*, netting, trapping, angling, spearing, dewatering and hand picking. However, within these fishing techniques 23 types of fishing gear was recorded to be used by the fishermen. Among them 7 were nets, 8 traps, 4 hooks and lines and 4 hand harpoons. The particulars of different types of net, trap, hook and line and hand harpoon are given in Tables 1(a), 1(b) and 1(c). BCAS (1989) recorded 13 types of fishing gears in 4 beels of Netrokona and Sunamganj districts. The fishing techniques that were followed by the fishermen in BSKB beel were similar to those reported by Ahmed (1954).

Table 1(a). Particulars of different types of net used for fishing in BSKB beel

Type of net	Name of gear	Description (m)		Mesh size (cm)	Materials used	Nature of Gear	Fishing period
		Length	Depth				
Gill net	Punti jal	10-12	0.6-1	2.5-3.18	Nylon twine or double cotton twines or tier cord	More or less selective	June -January
	Koi jal	10-12	0.6-1	3.18-3.8	Nylon twine or double cotton twines or tier cord	More or less selective	June -January
	Fash jal	10-12	0.6-1	8.0-9.0	Nylon twine or double cotton twines or tier cord	Selective	August-January
Seine net	Ber jal	50-67	1.5-2	0.5-2.5	Nylon twine or double cotton twines or tier cord	Non-selective	September - January
Lift net	Vashal jal	12-15	10-12	0.5(centre)-1.5 (front)	Nylon/cotton twine, bamboo frame	Non-selective	June - Aug. & Oct.- Dec
Cast net	Khepla jal	8-10 diameter		1.0-1.5	Cotton/Nylon	Non-selective	Jul.-Sep. & Dec. -Jan.
Clasp net	Bhuri/ Bhuti jal	1.5-2.0 diameter (Mouth) and 0.5-0.6 diameter (opening)		2.5-4.5	Nylon/cotton twine & bamboo pole	More or less selective	October - November

Table 1(b). Particulars of different types of trap used for fishing in BSKB beel

Different type of trap	Description (cm)			Mesh size (cm)	Material used	Fishing period
	Length	Height	Breadth			
Koi Dughair	45-90	15-30 diameter (mouth portion)		1.0-2.0	Split of bamboo and cane	June – January
Khadam (u-Shaped)		100-150	50-60 (front)	1.5-2.5	Split of bamboo and cane	September – January
Ramani	100-150	60-80	30-40	1.5-2.5	Split of bamboo and cane	September – January
Arinda	45	25	25	0.8	Split of bamboo and cane	Jully – January
Charo	40	25	15	1.0-1.5	Split of bamboo and cane	June – January
Ghuni	25-60	25-40	9-20	0.2-0.5	Thin bamboo stick and cane	June – January
Tubo	20-25	25-30	15	0.2-0.2	Thin bamboo stick and cane	June – January

Table 1(c). Particulars of different types of hook and line and spear/ harpoon used for fishing in BSKB beel

Hook and line				Hand harpoon		
Name of hook And line	Number of hook per line of lift	Bait used/ not used	Fishing period	Name of spear/ harpoon	Materials used	Fishing period
Dhawn borshi	Several hundred	Bait used	August-December	Koach	Split-bamboo pieces, pointed end covered with iron cap	September-January

Nol/Dhap borshi	Several hundred	Bait used	June-Janurary	Juti	Split-bamboo pieces with barbed iron point, which attached to the shaft by cords	September-January
Chip borshi	1 hook	Bait used	All season	Jhupi	Iron rods with/ without barb	September-January
Chasra	Bamboo made pin probe (both end pointed)	Bait used	July-November	Fulkuchi	Sharp-pointed steel wires (umbrella stick/ rickshaw spoke) without barb	September-January

The fishing period of different gears varied with the types of gear. In this study area of BSKB beel, the fishing was found starting from early monsoon with some hooks and lines and small meshed gill net, but more extensively with fine mesh traps (ghuni, arinda, charo, tubo and koi-dughair) which continued till the end of fishing season. Fishing pressure was found to increase gradually after stocking of fingerlings in the beel that is, from late August with the use of different types of gears *viz*., fash jal (larger meshed gill net), ber jal (seine net), kephla/jhaki jal (cast net), veshal/ khora jal (lift net), bhuti jal (clasp net), large meshed traps (ramani and khadom) and wounding gears (koach, juti, juppi and ful-Kuchi). Fine-mesh traps were used mainly at shallow depth area by non-professionals to catch small size fishes mainly for family consumption and occasionally by regular fishermen for their livelihood. Besides these fishing gears, fishermen were also found to catch fish by dewatering the water body and by hand picking during the last monsoon period.

A total of 47 species of fish were identified in the catches of different gears used by the fishermen in BSKB beel. The catch composition of different nets, traps, hooks and lines and spears/ harpoons are presented in Tables 2, 3 and 4, respectively. Among the different types of nets operated highest number of species was recorded in the catches of seine net (35), followed by the catches of lift net (32) and cast net (30). Relatively less number of species were recorded in the catches of the gears- koi jal (17), punti jal (14), clasp net (7) and fash jal (7). Among the traps, charo (28), arinda (26) and ghuni (18) were found to catch a variety of species of fish. But only 5 species of fish were recorded in the catches of tubo, whereas, in the catches of ramani and koi dughair 11 species of fish were recorded. Dhawn borshi (16) and nol borshi (17) caught more species of fish than the rest of the hooks and lines. Lowest number of species were recorded in the catches of chasra of which *Anabas* sp. alone contributed about 95.8% of the catch (Table 4). However, the hand harpoons were recorded to be more or less selective towards a few no. of fish species.

Among these gears, punti jal was found to catch mainly *Puntius* sp. (49.61%), and koi jal mainly *Anabas* sp. (45.62%) along with other resident species to a lesser extent. Fash jal is used by the fishermen to catch mainly the stocked carp (99.72%) (Table2). Choudhury (1989) also stated in his study that punti jal and koi jal are used for *Puntius* sp. and *Anabas* sp. respectively, whereas fash jal was used mainly to catch large and medium size carp and catfishes. Similar to fash jal, clasp net (bhuti jal) is another gear which was identified to catch mainly stocked carp (88.33%) (Table 2). BCAS (1991) recorded 19 species of fish other than shrimp and small sizes fishes in the catches of seine net and that of cast net were caught 20 species in Chanda beel. But in the present study recorded catches for seine net and cast net were 35 and 30 species, respectively. The name of different species listed in the catches are shown in Table 2 which were similar to the study of BCAS (1991). Similar to cast net, lift net was also found to be effective in catching different species of fish (Table 2).

Table 2: The catch composition of seine net, lift net, cast net, clasp net and gillnets (punti , koi and fash jal) operated at BSKB beel.

Species	Catch composition (% by number)						
	Seine net	Lift net	Cast net	Clasp net	Punti jal	Koi jal	Fash jal
	%	%	%	%	%	%	%
Catla catla	3.12	4.92	2.0	14.16	0.42	0.21	27.67
Cyprinus carpio	5.49	0.70	1.89	4.17		0.37	31.89
Labeo calbasu	0.20	0.23	0.06			0.16	0.38
Cirrhina mrigala	3.82	8.28	5.93	19.17	0.85	6.94	4.32
Labeo rohita	6.85	15.4 4	9.11	50.83	0.64	7.79	34.52
Puntius gonionotus	0.57	0.26	0.20		1.84	0.64	0.94
Glossogobius giuris	1.8	1.13	4.68	5.83	8.86	2.83	
Mastacembelus armatus	3.52	3.33	2.07		6.24	0.64	
Pseudeutropius atherinoides	0.10	0.41	0.18				
Nandus nandus						0.10	
Mystus tengra	2.86	2.32					
Ambassis nama	9.94	2.40	3.51				
Oxygaster phulo	3.32	2.64	2.28				
Channa gachua	1.06		0.45				
Colisha channa	6.88	4.43	4.56				
Esomus danricus	1.56	2.37	5.75				
Notopterus notopterus	0.13	0.09	0.18				
Channa marulius	0.20	0.35	0.09				
Lepidocephalus guntia	1.2	0.61	1.38				
Xenentodon cancila	3.36	9.36	1.89		0.21		
Aplocheilus panchax	1.96	0.67	0.78				
Colisha faciata	3.56	1.71	2.88		5.39	4.75	
Anabas testudineus	1.06		1.98		8.01	45.62	
Clarias batrachus	0.53	0.06	0.36			0.43	
Ompok pabda	0.17	0.09	0.18				
Puntius sp.	15.3 9	23.9 3	25.9 9		49.61	2.51	
Heteropneustes fossilis	2.29	0.78	1.35		10.70	19.69	
Channa striata	1.1	1.65	0.69	1.67	0.71	0.59	0.28
Channa punctatus	2.96	0.98	2.13		2.41	6.30	
Mystus vittatus	6.55	7.27	12.0 2		4.11	0.43	
*Others	2.86	0.87	1.23	4.17			
Macrobrachium sp.	5.59	2.72	4.20				

*'Others' *Danio devario, N.chitala, Gadusia chapra, M. puncalus, Ctenopharyngodon idella, M. bleeker, Amblypharyngodon mola, Badis badis, Hypophthalmichthys molitrix, Macrognathus aculeatum, T. cucutia and Botia dario.*

Table 3. The catch composition of traps (koi dughair, khadom, charo, tubo, ramani, arinda and ghuni) operated at BSKB beel

Species	Catch composition (% by number)						
	Koi dughair	Khadom	Charo	Tubo	Ramani	Arinda	Ghuni
	%	%	%	%	%	%	%
Catla catla	1.13	29.5 7	0.18		8.13	1.66	
Cyprinus carpio		2.49				0.17	
Labeo calbasu			0.04			0.17	
Cirrhina mrigala	6.60	21.3 8	1.6		24.74	5.48	
Labeo rohita	12.0 8	40.4 1	2.04		37.8	7.48	

Puntitus gonionotus		0.59	0.40			0.74	
Myystus aor			0.04				
Glossogobius giuris	0.22	0.73	4.0		7.97	5.31	0.73
Mastacembelus armatus			5.78			11.05	3.78
Pseudeutropius atherinoides			0.13			0.25	
Wallago attu		0.15					
Mystus tengra			1.73			1.41	1.42
Ambassis nama							5.67
Oxygaster phulo				1.02			1.63
Channa gachua			0.31		0.85	0.25	0.04
Colisha channa			0.62	11.41		1.58	23.68
Esomus danricus				0.17			12.35
Notopterus notopterus						1.41	
Channa marulius	0.13	0.15			0.34		
Macrognathus aculeatum			1.06				0.15
Lepidocephalus guntia			2.89			1.82	3.45
Aplocheilus panchax							5.48
Colisha faciata	2.04		13.3 7		1.02	9.63	0.18
Anabas testudineus	39.7 5	0.29	7.77		2.71	6.98	2.76
Clarias batrachus	0.13	0.73	1.91		0.17	0.41	
Amblypharyngodon mola			0.31				
Ompok pabda			0.09			0.25	
Puntius sp.			19.5 4	65.36		13.05	28.08
Heteropneustes fossilis	1.39		5.95		1.69	5.90	
Channa striata	2.78	2.63			2.37		0.47
Channa punctatus	33.7 5	0.88	5.82	0.34	10.51	10.30	0.80
Mystus vittatus			23.5 4		1.53	9.22	0.76
*Others			0.30			4.07	6.97
Macrobrachium sp.			0.58	21.70			

*'Others' *B. badis, M. puncatus,T. cutcutia, Hypophthalmichthys molitrix, Awaous grammepomus*

Table 4. The catch composition of hook and line and spear/harpoon (wounding gear) operated at BSKB beel

Species	Catch Composition (% by number)				
	Dhawn Borshi	Nol Borshi	Chip Borshi	Chasra	Hand harpoon
	%	%	%	%	%
Catla catla	0.20		3.19		15.0
Cyprinus carpio	3.25		1.2		19.55
Cirrhina mrigala	1.67	0.23	9.96		12.27
Labeo rohita	3.25	0.63	47.01		24.09
Puntius gonionotus	0.49				
Glossogobius giuris	5.31	6.43			
Mastacembalus armatus	4.23	1.82			4.55
Pseudeutropius atherinoides		0.03			
Wallago attu					0.46
C. gachua	2.17	0.27			
Notopterus chitala					0.45
Notopterus notopterus		0.50			0.91
C. marulius	0.79	0.36			6.36
X. cancila	5.22	2.09			
A. testudineus	0.89	8.58	20.72	95.8	
C. batrachus	1.18	0.40			
Ompok pabda	0.10	0.03			
Puntius sp.		0.10	9.16		
H. fossilis	8.37	8.29	1.99		
C. striata	15.94	14.98	1.59	0.76	14.09
C. punctatus	43.50	51.48	2.39	3.44	2.27
M. vittatus	3.44	3.44	2.79		

With respect to species selectivity ber jal, khepla jal and vashal jal (net), charo, arinda and ghuni (trap), dhawn and nol borshi (hook and line) were recorded non-selective gear both for species and size. Punti jal, koi jal, fash jal and bhuti jal (net), khadom and tubo (trap), chip borshi and chasra (hook and line) and all hand harpoons were recorded more or less selective gears. But fash jal, bhuti jal (net), khadom, ramani (trap) and koach, juti and jhupi (spears) were regarded as large species gear. On the contrary, punti jal, koi jal (nets), koi dughair, charo, tubo, arinda and ghuni (trap), nol borshi (hook and line) and ful-kuchi among spears were found to be small species gear. However, bamboo made hook-chasra was recorded as a gear of restricted species (koi, lata and shol) among all the gears studied.

The intensity of use of some gears in BSKB beel increased due to stocking. Thus, the intensity of use of cast net, koi dughair, ramani and seine net increased remarkably. Cast net was operated mainly in the canal, where fingerlings were stocked. Therefore, carps were found to fish by cast net. Koi dughair and ramani is operated in canals situated near the paddy fields or weedy fields at shallow depth. Fishes when attempted to move from canal to beel, got trapped into different traps. Besides, the mode of operation of seine net is such that destroyed the normal habitat of resident species, possibly of stocked carp as well. A large quantity of fingerlings have been caught by this gear. On the reverse, the intensity of use of clasp net, fash jal and harpoon increased due to its increasing catch of larger carp. Clasp net is operated at a spot through which beel water runs from one part to another. The use of net was found to start when water was receding from beel through canal. The intensity of use, operation period (when water receding: October-November) and the location (setting place) of clasp net indicated that it is operate to catch stocked carp as well as existing carps. Because, during this period fishes attempt to move from beel to canal. Fash jal, because of its larger mesh, was successful in catching medium size to larger size carp. Spears/harpoon is used by professional or non-professional fishermen. Intensive use of these types of gear was observed when slurry/stuffy weather remains during which fishes move near the surface water. Then fishermen can easily understand the movement of fish and attempts successfully. It is locally called "Niri" fishing. But the intensity of use of these gears increase considerably during the period between September and January. Sometimes, these types of wounding gears are operated at night using light as attractant with the bow of the boat which is locally called "Alo fishing". Thus, large size fish are caught by these gears but full-kuchi was found to be used to catch small species.

Again, the catches of primary fishing gear like fine mesh traps (ghuni, arinda, charo, tubo and koi-dughair), some hooks and lines and small meshed gill net, almost were the floodplain resident species i.e., *Puntius* sp., *Colisha fasciata* sp., *Heteropneustes* sp., *Anabas* sp., *Mystus vittatus*, *Channa punctatus* and *Glossogobius* sp, which begins breeding at the onset of inundation and grows during the monsoon flood season were dominant species while *Mastacembelus armatus*, *Channa striata*, *Clarias* sp., *Xenentodon* sp., were common and *Ompok pabda*, *Ambassis nama*, *Notopterus notopterus*, *Lepidocephalus guntia*, *Wallago* sp., *Colisha channa* and *Esomus danricus* were the minor. Among these primary fishing gears, except chasra (bamboo made hook), rest of all hooks and line were found to hook carnivorous fishes like snake head etc. but small mesh of gill net and fine mesh ghuni trap were found to use extensively during early monsoon to catch small size floodplain resident species which grow at the onset of inundation.

Though small mesh gill nets are considered to be detrimental gears for carp fingerlings, these net such as punti jal and koi jal were not found to be detrimental to carp fingerlings in the present study. Because these gears were found to entangle mostly wild resident species with negligible quantity of carp fingerlings. Similarly, ghuni trap were also recorded harmful gear for wild fisheries. Thus, seine net, cast net, koi dughair and ramani were found to be detrimental gear for major carps. The total length of carp fishes recorded in the catches of fash jal were around the limit of legal size, these can be regarded detrimental gear for carps as it seemed to catch fishes below the legal size at the beginning of fishing season. Considering their detrimental effect on fish stocks it is suggested to restrict the use of these gears for certain period from June to October for effective management of beel fisheries.

Conclusions

To get optimum yield without affecting the future fishery, a guideline of operating fishing gear and to pass judicial decision banning the use of harmful gear needs to be strictly followed. However, for proper and effective management, it is suggested to ban or restrict the use of all types nets and traps from June to September-October depending upon the onset of the monsoon. This will help to grow of stocked carp and increase fish production through safe recruitment. Besides, kua (ditches dug by land owners inside the floodplain) fishing and kata/komor (brush parks placed in flowing canals running through the floodplain or rivers) fishing should also be greatly discouraged along with the restriction of the above gears as these fishing methods were recorded highly detrimental to the stocked fish as well as to wild fishes. Furthermore, extension program is necessary for the fishermen which will enhance the fish production.

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Studies on some physico-chemical factors of Kaptai lake

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Abstract
The present investigation dealt with the climatic and some physico-chemical conditions of the Kaptai lake with respect to their monthly variation. Air temperature was found always higher than water temperature. Vertical variation in temperature (0.8-4.7°C) was observed in all months. The water level fluctuate appreciably throughout the year. Wide seasonal fluctuations were also noted in water transparency. The lake was found to be slightly hard and alkaline pH. Dissolved oxygen (DO) (6.4-9.1 mg/l) and free carbondioxide (4.7-6.0 mg/l) contents showed favourable condition for aquatic lives. DO at different depth showed no wide variation (1.0-2.4 mg/1). Conductivity ranged between 91.9± 7.1 and 106.4 ±5.2 mS/cm.

Key words : Kaptai lake, Water quality

Introduction

The lake Kaptai was created by damming the river Karnafuli in 1961. Occupying an average area of 58300 ha (ARG 1986), it is one of the largest reservoirs in southeast Asia (Fernando 1980). Although the lake was created primarily for hydro-electric power generation, it has also paved the way for substantial contribution to the national economy through freshwater fish production, navigation, irrigation and flood control. To formulate a sound management policy for Kaptai lake fishery, a long term study of various physico-chemical characteristics of lake water is very much needed along with other investigations.

Information on the physico-chemical aspects of the lake is very scanty. The first limnology and primary production of the lake was done by Sandercock (1966), the limnology and primary production of the lake were studied by Chowdhury and Mazumder (1981) and Haldar *et al.* (1992) and the hydrobiology of the lake was studied for one year by the Aquatic Research Group (ARG 1986). Rahman (1988) reported the morphometric details of the reservoir. With a view of evaluating productivity potential and to provide information for sound management policy, the present work was undertaken.

Materials and methods

The present study was conducted from May'90 to April'91. Water samples from three depth i.e. surface, mid and bottom (up to 18m) were taken from five sampling stations (Rangamati, Balukhali, Subalong, Kaptai and Naniarchar) fortnightly using a Kemmerer water sampler between 9 and 10 am. Rainfall and water level data were recorded from the Power Development Board (PDB), Kaptai. Air and water temperatures were measured with a centigrade thermometer. Visibility was determined with a standard Secchidisc. pH-value was determined colorimetrically by means of Lovibond comparator. Conductivity meter (HANNA HI-8033, England) was used to measure specific conductance. Dissolved oxygen was estimated by the azide modification of the Winkler method (APHA 1981). Free carbondioxide content was determined by phenolphthalein indicator method (Welch 1948). Total alkalinity was estimated by using phenolphthalein and methyl orange indicator method (Welch 1948). Total hardness was determined by EDTA titrimetric method (APHA, 1981). HACH test kit (Model-FF-1A, USA) was used to measure ammonium nitrogen and chloride ion only.

Results and discussion

Impoundment waters have their own peculiarities as biotopes. The various physico-chemical properties of impoundments vary widely at different times of the day and in different seasons. A proper understanding of these characteristics, therefore, calls for intensive investigation of such water bodies in different parts of the globe. The average values (three depths of all stations) of different climatological, physico-chemical factors recorded during the study period is furnished in Table 1 and Figure 1 (water temperature and dissolved oxygen only) and discussed under the following heads.

Table 1. Monthly fluctuations of climatological and physico-chemical factors of the Kaptai Lake

Factor / Month	Air temp. (°C)	pH	Free Carbon-dioxide (mg/l)	Total hardness (mg/l)	Total alkalinity (mg/l)	Conductivity µS/cm	Chloride (mg/l)	Ammonium nitrogen (mg/l)	Water level (MSL)	Secchi depth (m)	Total rainfall (mm)
Jun'90	280±10*	81±01	47±03	513±0	605±32	-	167±19	04±0	774	16±04	398**
Jul	319±07	80±02	53±03	513±0	601±24	-	140±77	04±0	836	18±01	659
Aug	313±10	84±02	59±01	499±40	517±47	-	180±40	04±0	939	16±07	174
Sep	321±07	82±01	60±02	476±44	519±43	-	133±19	04±0	965	21±05	193
Oct	300±15	79±05	68±03	513±0	557±30	931±64	149±75	04±0	1030	27±03	128
Nov	302±22	77±04	58±03	564±47	551±36	919±71	117±38	04±0	1038	30±03	181
Dec	276±09	77±02	60±02	547±76	541±28	1001±34	145±75	04±0	1018	30±04	047

Jan/91	276±24	77±02	60±0	650±47	546±25	1065±27	137±78	04±0	943	34±04	000
Feb	250±16	76±01	60±0	564±46	539±07	1064±52	133±52	04±0	955	31±02	000
Mar	306±18	80±02	55±03	547±76	476±116	1031±36	135±24	04±0	895	28±04	013
Apr	320±19	79±01	56±02	530±39	537±07	1016±16	127±36	04±0	836	18±02	174
May	338±07	75±00	51±01	520±12	560±22	1020±22	152±74	04±0	874	15±03	478

* *Values represent monthly aven ge ± S.D. for all stations for three depths (surface, mid and bottom).*
** *Values represent mo.thly total (one station).*

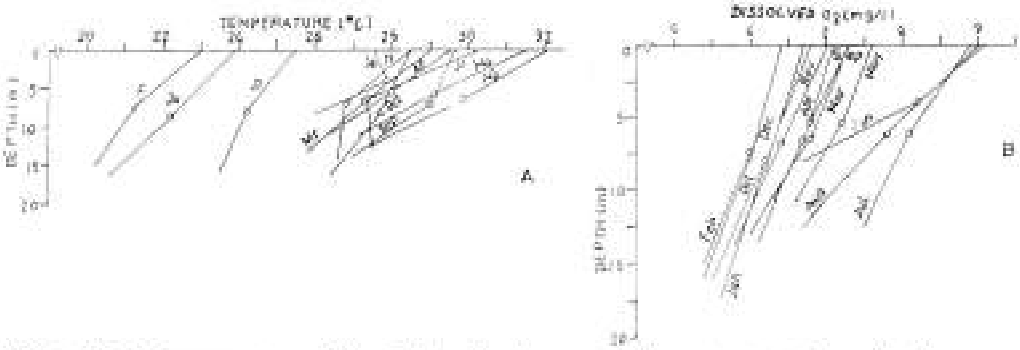

Fig. 1. Water temperature (A) and dissolved oxygen (B) contents at three depths (surface, mid and bottom regions) of Kaptai lake.

Climate of the lake region

Though Chittagong Hill Tracts is a hilly region no special weather condition was noticed. Only in winter months, sometimes morning fog and heavy dew were observed and in monsoon, occasionally gasty wind prevails in this area. The mean maximum air temperature (33.8±0.7°C) was recorded in May while minimum (25.0±1.6 °C) was recorded in February. Air temperature in the study area was found always higher than water temperature except in a few cases. A similar relationship between air and water temperature was also reported by Macan (1958), Patra and Azadi in Halda River (1985) and Haldar *et al.* (1992) in Kaptai lake. The annual rainfall in the area was 2365 mm, received mainly from May to July. Winter was usually dry. The rainy period spread over winter and spring months. During summer air temperature varies between 30.6 and 33.8°C. The mean winter temperature was 26.7±0°C. Monthly total rainfall ranged from 10 mm (February) to 659 mm (July) with no rainfall in January. The average rainfall in this area was about 197 mm. The water level is regulated largely by the Power Development Board (PDB), Kaptai maintaining rule curve for Kaptai lake. Variation (93.0 ± 9.0 MSL) in water level in different months of the year was observed. It followed increasing trend from June (77.4 MSL) till November (102.8 MSL) and then decreased gradually with few exceptions (Table 1). The water level was largely dependent on rainfall and the extent of discharge for hydroelectric power generation.

Water transparency and thermal structures

The limit of secchi-disc visibility was found to fluctuate in different months of the year. High visibility was found in winter while low visibility prevailed pre-monsoon and monsoon months. The lowest value of visibility (1.5±0.3 m) was recorded in May and the highest (3.4±0.4 m) in January. The inflow from hill streams carries suspended matter and silt, which causes a sharp rise in turbidity. Chowdhury and Mazumder (1981), ARG (1986) and Haldar *et al.* (1992) also reported the occurrence of high turbidity in the same lake during the monsoon period.

One of the most outstanding and biologically significant phenomena of lakes is the temperature characteristics of water and seasonal variations of the same. Temperature showed marked fluctuations in different months of the year (Fig. 1 A). The surface water temperature of the reservoir ranged between 23.0 (February) and 32.1°C (August) while mid-water temperature fluctuated from 21.3 (February) to 29.9°C (August). Vertical variation in temperature was observed in all months. It has been found that the variation in temperature from surface to mid-water was 0.6-2.8°C except in June when mid-water temperature was above by 0.4°C only. Bottom water temperature ranged from 20.5 (February) to 27.9°C (March). Variation in temperature from mid-water to bottom water ranged between 0.2 and 2.5°C except in July when bottom water temperature was above by 0.1°C only. A wide difference of 0.8-4.7°C was noted between surface and bottom temperatures (Fig. 1 A), indicating some tendency towards thermal stratification. This can not be stated conclusively because temperature was recorded only at three depths (Surface, mid-water and bottom). However, during two years study period (covering all depth at 1 and 2 m intervals) at Kaptai lake ten temporary epilimnial and one typical thermocline was observed by Azadi (1996). Thermal stratification in lakes is related to the difference between the surface and bottom temperature and the presence or absence of strong winds (Vashist 1968). Accordingly, with a large area, high depth, presence of moderate to strong winds in different months of the year and consequent wave action afforded a suitable condition for possible thermal stratification for Kaptai Lake.

Chemical features of the lake waters

Dissolved oxygen at the surface of the reservoir ranged between 6.4 (December) and 9.1 mg/l (June). The higher values occurred during monsoon. Maximum concentration of oxygen in the rainy months may be attributed due to wind action and other surface agitation allowing maximum oxygen from air to go into solution at the surface water. However, Chowdhury and Mazumder (1981) and Haldar *et al.* (1992) reported the maximum concentration of oxygen in the winter months. Dissolved oxygen at different depths showed no wide variation (1.0-2.4 mg/l) from surface to bottom (Fig. 1B). Dissolved oxygen at the bottom of the reservoir ranged between 5.4 and 7.5 mg/l. Sreenivasan (1970) and Timms (1970) considered dissolved oxygen deficit at the bottom as a characteristic feature of productive lake.

The pH of the lake water was found within alkaline range (7.5 ±0 - 8.4±0.2). It exhibited a narrow range of fluctuation during the study period (Table 1). Present findings is in close agreement with Haldar *et al.* (1992) and ARG (1986) but differ significantly with Chowdhury and Mazumder (1981).

Free carbondioxide varied between 4.7 ± 0.3 and 6.0 ± 0.3 mg/l in the lake. Carbondioxide contents never exceeded 6.2 mg/l and was found almost uniform in an annual cycle. Free CO_2 is present even in the surface waters of soft and medium-hard-water reservoirs, but is absent in hard-water lakes (Sreenivasan 1992). Since Kaptai lake is a slightly hard water lake, present observations for CO_2 accept the above mentioned rule.

Total hardness in water is the sum of the concentrations of alkaline earth metal cations. Value of total hardness varied between 47.6 ± 4.4 and 65.0±4.7 mg/l in the reservoir. The highest value was found in January and the lowest value in September (Table 1). ARG (1986) and Haldar *et al.* (1992) reported a wide range of hardness but Chowdhury and Mazumder (1981) reported a narrow range from the same reservoir. Lake water registering hardness as calcium carbonate below 24 mg/l is generally regarded as soft (Clegg 1974). According to Brown *et al.* (1970) a soft water body contains 0-60 mg/l calcium carbonate. Accordingly, the water of the Kaptai lake may be regarded as slightly hard.

The alkalinity or acid combining capacity of impounded waters is generally caused by carbonates and bicarbonates of calcium and magnesium. Combining with dissolved CO_2 these carbonates and bicarbonates form an equilibrium which plays an important role in the productivity of the system. The total alkalinity content in the lake water exhibited a little variation among different months (47.6±11.6 - 60.1±2.4 mg/l) during the course of the present study. It recorded high values from May up to July. In the subsequent months values were more or less similar and declined on March only. Haldar *et al.* (1992) found the highest values in March and April and the lowest value in August. The lake water was found to have an increasing trend value in August. The lake water was found to be an increasing trend of alkalinity value comparing with the findings of the above authors. Jhingran (1989) Observed that alkalinity values of more than 50 mg/l are most productive and those of less than 10 mg/l do not produce large crops. He added that total alkalinity values up to 20 mg/l indicate poor production and values above 40-90 mg/l show high production. Accordingly, Kaptai lake may be regarded as productive lake.

Conductivity was monitored from October to May only during the investigation period. Average range of conductivity of lake water was between 91.9 ± 7.1 and 106.4 ± 5.2 mS/cm. The minimum and maximum being found in November and February respectively. High values of conductivity occurred in winter months (Table 1). Similar phenomenon was also reported by Patra and Azadi (1985) from Halda river, Chittagong.

The mean monthly chloride content in the lake water varied between 11.7 ± 3.8 and 18.0 ± 4.0 mg/l. The maximum chloride content was recorded in August and the minimum in November. Zafar (1964) and Munawar (1970) observed that in fish ponds chlorides increase in summer and decrease in winter depending upon the water level. As per lake is concern the present study partially accept this view.

The nitrogenous compounds in water are derived to an appreciable degree directly or indirectly from the atmosphere, whereas ammonia is the chief decomposition product from plant and animal proteins (Ruttner 1953). Ammonium nitrogen content recorded was not high and occurred the same value in different months (0.4 ± 0 mg/l) (Table 1). Jhingran (1989) reported that dissolved nitrogen concentration of 0.2-0.5 mg/l is favourable for fish life. On the basis of above mentioned conditions water body of Kaptai lake was found to be suitable for fish culture.

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Limnological conditions of naturally turbid ponds and its effects on fish growth

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Abstract
An experiment was conducted on six naturally turbid ponds in the village of Salakandi situated to the south-west corner of Bangladesh Agricultural University, Mymensingh for a period of three months from July to September'96. The experiment was performed by studying the physico-chemical factors of water and soil, the biological factors such as densities of phytoplankton and zooplankton, and the growth of fishes. During the experimental period water turbidity varied among ponds. The highest value of turbidity was found to be 679±183.6 FTU in pond 1 and the lowest was 158±23.31 FTU in pond 4. The maximum and the minimum water transparency were recorded in the month of July and September respectably. The lowest net weight of fishes was found 28.8 kg/ha/year in pond 1 due to high turbidity and the highest was 35.8 kg/ha/year in pond 4 due to low turbidity. Most of the correlations between turbidity and transparency, phytoplankton, and zooplankton were significant at 1% and 5% levels.

Key words : Turbidity, Water quality, Fish growth

Introduction

Aquaculture depends almost completely on different qualities of water. Fisheries and other aquatic organisms perform all kinds of their life processes in water, so it is apparent that the water quality play an indispensable role for life in water. Turbidity is an important factor on which the productivity of a pond depends. Turbidity caused by plankton is generally desirable in fish ponds but turbidity due to suspended inorganic substances, such as silt and clay, is harmful for fish culture (Rahman *et al.* 1982). Ponds with clay bottoms are likely to have high turbidity. A good number of works have been performed on physico-chemical and biological characteristics of aquatic habitats in different countries in the world. Among those some noteworthy ones of Banerjea (1967), Dewan (1973), Islam *et al.*

(1978), Kim and Cho (1985), Lin *et al.* (1992), Tanaka (1992), Cyrus (1992), Vinyard and Yuan (1996) etc. They worked on turbidity and turbidity related experiments. But very little work has been done on water turbidity and its effects on fish culture in Bangladesh. So, considering the importance, the present investigation was undertaken on limnological conditions of six naturally turbid ponds and its effects on fish growth.

Materials and methods

The experiment was conducted on naturally turbid ponds in the village of Salakandi situated to the south-west corner of Bangladesh Agricultural University, Mymensingh for a period of three months from July to September'96. Trials were carried out in six naturally turbid ponds of area about $120m^2$ and average depth of 2m of each pond. All ponds were rainfed, well exposed to sunshine without inlet or outlet. Six naturally turbid ponds were selected from three household at least two ponds from each household.

Sampling of water quality parameters

Water quality parameters such as turbidity (FTU), transparency (cm), temperature (^0C), carbon-dioxide (mg/l), dissolved oxygen (mg/l), total alkalinity (mg/l), pH, phosphate phosphorus (mg/l) and nitrate nitrogen (mg/l) were measured fortnightly following standard methods (APHA 1971). Water quality measurements were made between 9.00 to 11.00 a.m. Textural classes of pond soil were determined by Finger Feel Method (Sattar and Rahman 1987).

Sampling of plankton

Plankton samples were collected and preserved for further study following Dewan *et al.* (1991). The plankton concentrations were determined by using a Sedgewick-Rafter Cell (Rahman 1992). Identifications of plankton were performed according to Prescott (1962), Needham and Needham (1962), and Ward and Whipple (1952).

Growth of fish

Neither fertilizer nor any kind of fish feed was used in the experimental ponds. Four kinds of fishes, such as catla, rohu, mrigal and silver carp were released in each pond at a density of 195 fish/pond ($120m^2$). The ratio of fish was catla 45, rohu 45, mrigal 45 and silver carp 60 in number. During the study period initial and final lengths and weights of fish were determined to observe the effects of turbidity on fish growth. Fish growth was determined by measuring total length (cm) and weight (g) of ten fish of each species from each pond.

Statistical analysis

For statistical analyses of data, ANOVA was applied following Sokal and Rohlf (1981) and statistical package, Statgraphics version 7.

Results and discussion

The results of all physico-chemical and biological parameters are presented in Table 1. Turbidity of the experimental ponds varied among the ponds and also within the ponds fortnightly. The highest value of turbidity (679±183.6 FTU) in pond 1 and the lowest value (158±23.31 FTU) was found in pond 4. The maximum and the minimum values of water transparency were found in pond 4 and pond 1 respectively. The mean value of air temperature was 29.2±1.84°C. The highest and the lowest mean values of water temperature of the experimental ponds were found in pond 5 and pond 6. The mean values of dissolved oxygen content of pond 1, 2, 3, 4, 5 and 6 were 4.02±1.0, 5.84±1.49, 5.15±1.99, 5.23±1.34, 5.71±0.93 and 3.75±1.22 mg/l respectively. The maximum (5.33±1.43mg/l) and the minimum (3.46±0.75mg/l) mean values of free CO_2 were found in pond 3 and pond 5.

Table 1. Limnological conditions of naturally turbid experimental ponds

Parameters	No. of sampling ponds with Mean±sd					
	1	2	3	4	5	6
Turbidity (FTU)*	679±183.60	264±77.43	236±35.43	158±23.31	218±25.97	296±103.7
Trans. (cm)	9.41±2.08	20.66±3.29	20.88±4.45	21.75±1.40	21.30±2.05	19.50±4.04
Air temp. (°C)	29.20±1.84	29.21±1.84	29.20±1.84	29.20±1.84	28.03±0.80	29.20±1.00
Water temp. (°C)	28.03±0.68	28.40±1.10	28.03±0.90	28.03±0.90	28.64±0.85	28.03±0.78
Free CO_2 (mg/l)	4.20±0.28	4.10±1.05	5.33±1.43	5.03±1.41	3.46±0.75	4.50±1.31
DO (mg/l)	4.02±1.00	5.84±1.49	5.15±1.99	5.23±1.34	5.71±0.93	3.75±1.22
Alkalinity (mg/l)	80.8±13.98	125±24.60	142±25.01	120±22.00	124±26.00	110±18.20
NO_3-N (mg/l)	0.58±0.05	0.51±0.02	0.62±0.13	0.58±0.11	0.61±0.07	0.52±0.07
PO_4-P (mg/l)	0.19±0.05	0.28±0.05	0.25±0.03	0.25±0.08	0.19±0.05	0.25±0.07
$_pH$	7.02±0.45	7.39±0.15	7.12±0.45	7.35±0.17	7.12±0.45	7.21±0.23
Phytoplankton (cell/l)	722±159.9	676±123.7	755±72.0	807±96.55	738±120.1	734±110.2
Zooplankton (cell/l)	626±131.3	560±87.5	644±69.54	782±79.5	693±102.9	615±117.7
Soil texture	Clay	Silty clay	Silty clay	Silty clay	Silty clay	Clay

* *FTU=NTU*

The mean values of total alkalinity, nitrate nitrogen and phosphate phosphorus of the experimental ponds are shown in Table 1. The highest mean value of pH (7.39±0.15) was recorded from pond 2 and the lowest (7.02±0.45) was recorded from pond 1. The mean values of phytoplankton concentrations of pond 1, 2, 3, 4, 5 and 6 were 722±159.9, 676±123.7, 755±72.0, 807±55.0, 738±120.1 and 734±110.2 cells/l respectively. The highest and the lowest mean values of zooplankton concentrations were found in pond 4 and pond 2 respectively. The textural classes of bottom soils of 4 turbid ponds were silty clay but those of pond 1 and 6 were clayey (Table 1).

During the present experiment, the growth in terms of net weight gain/ha/year of fishes of all ponds studied are presented in Table 2. The lowest and the highest net weight of fishes were found in pond 1 (28.8 kg/ha/year) and pond 4 (35.8 kg/ha/year) respectively. Most of the correlations between turbidity and transparency, phytoplankton, and zooplankton were significant at 1% and 5% levels (Table 3).

Table 2. Growth of fishes in six naturally turbid ponds

Pond Nos.	Fish spp.	Initial		Final		Net weight gain		
		Av. len. (cm)	Av. wt. (g)	Av. len. (cm)	Av. wt. (g)	g/ month	g/ year	kg/ha/ year
	H. molitrix	11	25	15	45	6.7	80.4	
1	*C. catla*	8	26	13	49	7.7	92.4	28.8
	L. rohita	8	18	12	41	7.7	92.4	
	C. mrigala	10	23	14	43	6.7	80.4	
	H. molitrix	11	25	15	50	8.4	100.8	
2	*C. catla*	9	26	14	45	6.4	76.8	31.8
	L. rohita	8	18	13	45	9.0	108.0	
	C. mrigala	10	22	14	46	8.0	96.0	
	H. molitrix	11	25	15	51	8.7	104.4	
3	*C. catla*	9	26	14	46	6.7	80.4	30.5
	L. rohita	9	19	13	42	7.7	92.4	
	C. mrigala	10	21	14	43	7.4	88.8	
	H. molitrix	11	25	16	49	8.0	96.0	
4	*C. catla*	9	25	17	50	8.4	100.8	35.8
	L. rohita	10	18	15	48	10.0	120.0	
	C. mrigala	10	21	18	49	9.4	112.8	
	H. molitrix	10	25	15	48	7.7	92.4	
5	*C. catla*	9	24	14	44	6.7	80.4	30.5
	L. rohita	9	19	13	48	9.7	116.4	
	C. mrigala	9	21	14	40	6.4	76.8	
	H. molitrix	11	24	15	47	7.7	92.4	
6	*C. catla*	9	25	14	48	7.7	92.4	31.1
	L. rohita	10	19	12	43	8.0	96.0	
	C. mrigala	10	21	13	44	7.7	92.4	

*Area of each pond 120m^2

Table 3. Simple correlation coefficients (r) between turbidity and other factors

Parameters	No. of ponds					
	1	2	3	4	5	6
	Turbidity	Turbidity	Turbidity	Turbidity	Turbidity	Turbidity
Transparency	-0.676	-0.937**	-0.903*	-0.942**	-0.341	-0.51
W. temperature	-0.775	-0.434	-0.953**	-0.699	-0.021	-0.41
DO	-0.142	-0.004	-0.052	-0.698	-0.751	-0.242
CO_2	-0.084	-0.179	-0.094	-0.085	-0.181	-0.042
Alkalinity	-0.144	-0.063	-0.262	-0.001	-0.734	-0.729
$_pH$	-0.303	-0.309	-0.031	-0.481	-0.219	-0.678
Phytoplankton	-0.881*	-0.808	-0.959**	-0.950**	-0.974**	-0.940**
Zooplankton	-0.886*	-0.726	-0.961**	-0.904*	-0.972**	-0.941**

*n=6, df=4, * P<0.05 ** P<0.01*

Higher values of turbidity in all the ponds were found in the month of August and lowest in September, though the higher turbidity was most probably due to higher rainfall in August as after heavy rainfall runoffs carry the clay or silt particles into the water bodies which might have increased the turbidity. Buck (1956) divided a series of Oklahoma farm ponds depending on turbidity into three categories : clean ponds with average turbidities below 25 mg/l, intermediate ponds with turbidities from 25 to 100 mg/l and muddy ponds with turbidities above 100 mg/l. Boyd (1979) reported that the turbidity range of 19 to 40 NTU as light to moderate and that from 625-860 NTU as heavy. On that basis, all the experimental ponds were moderately turbid except pond 1 which was highly turbid. Tanaka (1992) reported that the turbid waters were formed by the bottom sediments resuspension induced from storm waves or tidal stirring. Cyrus (1992) stated that turbidity range in the south-east coast of Africa was 2 to 568 NTU, where different turbidity patterns were observed during summer and winter.

Lower value of water transparency is always favourable for fish culture if it is due to plankton. But during this experimental all the ponds showed lower values of transparency due to turbidity resulting from silt and clay particles. Mumtazuddin (1982) found the range of transparency of pond water 23 to 55 cm. Jhingran (1975) stated that turbidity due to plankton was an indication of pond productivity but that caused by silt or mud beyond certain limit was harmful to fish and fish food organisms.

The highest and the lowest air temperature were recorded in August and July but those of water temperature were in July and August respectively.

With a few exception water temperature always showed lower values than air temperature in all the ponds. Dewan (1973) observed the highest temperature of water in the month of August and lowest in winter season. Azadi (1987) found that average temperature of the Kaptai reservoir was 27°C. Rahman *et al.* (1982) found that pond water temperature 26 to 33°C at the surface and 27 to 32°C at the bottom.

The lower dissolved oxygen level in pond 1 was most probably due to high turbidity and low concentration of phytoplankton resulting less photosynthesis. Alikunhi (1957) stated that good pond water for fish culture should have a fair amount of dissolved oxygen with a range of 5 to 7 ppm. Rahman *et al.* (1982) found dissolved oxygen in the range of 4 to 8.5 mg/l in pond water. pH value of all the surveyed ponds were in favourable range throughout the experimental period. Rahman (1992) reported that pH range for productive pond should be 6.5 to 7.5. Khalaf and MacDonald (1975) observed that the pH of ponds fluctuated with the change of dissolved oxygen concentration and heavy rainfall. Swingle (1967) observed pH ranging from 6.5 to 9.0 is suitable for pond fish culture and that above 9.5 is unsuitable.

All the experimental ponds were medium to high productive with respect to their total alkalinity. Banerjea (1967) reported that total alkalinity of ponds ranging from 20 to 200 mg/l were highly productive. NO_3-N and PO_4-P of the experimental ponds were in favourable range. Azadi (1987) found that NO_3-N and PO_4-P levels were 1.63 mg/l and 0.53 mg/l in the Kaptai reservoir. Bhuyan (1970) reported that NO_3-N and PO_4-P levels from 0.06 to 0.1ppm and 0.2 to 0.4 ppm respectively in the productive range.

The occurrence of phytoplankton was irregular but phytoplankton densities were higher than zooplankton in all the experimental ponds. Both the density and variety of phytoplankton were very limited in the ponds probably due to high turbidity. Because turbid water reduces light penetration which decreases photosynthetic activity as well as phytoplankton production.

The net weight of fishes in the six experimental ponds have been found to be very low due to high turbidity and low densities of plankton. In the experimental ponds neither fertilizer nor any kind of fish feed was used. In the present study, the highest net weight of fishes were found 35.8 kg/ha/year in pond 4 due to low turbidity. Gupta *et al.* (1990) showed that the total production of fish were achieved 491 kg/ha/year and 2583 kg/ha/year with and without supplementary feed respectively and using cattle manure in the ponds which were not turbid. In the present study, net weight of fishes were found very low due to high turbidity. However, further studies are necessary to investigate the turbidity of water bodies and its effects on fish growth in Bangladesh context.

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Effects of cowdung application on the production of mud crab(*Scylla serrata* Forskal) in brackishwater pond

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Abstract
A culture experiment of mud crab for 84 days was conducted in earthen pond at Brackishwater Station, Bangladesh Fisheries Research Institute, Paikgacha, Khulna. The aim of the experiment was to study the effects of cowdung application on crab production and water quality. There were three treatments as without cowdung (T_1), 500 kg cowdung/ha/fortnight (T_2) and 750 kg cowdung/ha/fortnight (T_3) with three replicates for each. The result was evaluated on the basis of growth, production, survival rate etc. The experimental months was mid April '96 to mid July '96. To maintain a good water quality, water was exchanged in every spring tide. The range of salinity during the experiment was 8-19 ppt. Trash fish and fresh shrimp head were used as feed on raw basis in every alternate week at a rate of 8% body weight of crab at the same time rice bran and wheat flour were used at a rate of 2% body weight as a source of carbohydrate. The production of T_1, T_2 and T_3 were 720.35 kg, 862.16 kg and 669.19 kg/ha respectively. Though the effects of cowdung on production of crab is insignificant but in terms of production, survival rate and growth, the study suggest that the application of cowdung in addition to feed can be recommended for mud crab culture at a rate of 500 kg/ha/fortnight.

Key words : *Scylla serrata*, Cowdung

Introduction

Along with shrimp, mud crab (*Scylla serrata*) also plays a significant role in the export earnings of Bangladesh. In coastal areas mud crab is grown up in shrimp ghers as an undesired species and farmers captured these crab as a source of additional income. Mud crab grows better at salinity range of 15-30 ppt and year round occurrence of crab larvae in Mathamuhury estuary even at 2 ppt salinity (Ahmed 1992) which supports the culture of the animal in the coastal areas of Bangladesh. Due to its rapid increasing demand in the world market in live form, export of mud crab from Bangladesh also increasing rapidly when the major part of such export comprises of wild collection only. This kind of increasing pressure on the nature may be a threat to the wild stock and biodiversity protection in near future. Commercial culture of mud crab was reported as a profitable venture by many workers (Escritor 1970, Varikul *et al.* 1972, Raphael 1970 and Marichamy 1980) in different countries. Despite having a culture favour brackishwater environment, proper technique for culture of mud crab has yet been established in Bangladesh. So with a view to increase its production through an ideal technique this study was carried out to know the effects of cowdung as organic manure on production of mud crab and water quality of its culture environment.

Materials and methods

The experiment was conducted in the brackishwater ponds of Bangladesh Fisheries Research Institute at its Paikgacha Station, Khulna. The area of each pond was 500 m^2. After construction of dikes and gates , the ponds were allowed for sun drying for 15 days. All the ponds were fenced by bamboo slits at about 0.5 m deep in the soil to prevent escaping and burrowing of crab. Lime was applied at a rate of 125 kg/ha in all the ponds and the ponds were filled by tidal water of nearby Kapotaksha river. Crablings were stocked in the mid April '96 at a density of 10000/ha.

To study the effects of cowdung as organic manure for culture operation of mud crab, there were three treatments with two replications of each. No organic manure was applied in T_1 which was treated as control. Organic manure was applied fortnightly at a rate of 500 kg and 750 kg/ha in T_2 and T_3 respectively. Details of feeding rate of this experiment are given in Table 1. The experiment was continued for 84 days. Crablings were acclimatized in the laboratory condition for 7 days prior to stocking in the experimental pond.

Water depth was maintained at 0.6-0.8 m. Water was exchanged (50%) for 3-4 days of each full and new moon throughout the experimental period. Sampling for growth performance and monitoring of water quality parameters such as water temperature, p^H, salinity, transparency and dissolved oxygen were done in every week. Plankton samples were collected by using plankton net with a mesh size of 100μm. The collected samples were preserved in 5% formalin in the field and later analyzed in the laboratory. The result was evaluated on the basis of specific growth rate, total production, survival rate etc. followed by the guide lines of European Inland Fisheries Advisory Commission (1980). After completion of experiment, all crabs were harvested by using bait and scoop net, repeated netting followed by complete drain-out of the ponds. Comparison of treatments was carried out using one-way analysis of variance (ANOVA) and Duncan's Multiple Range Test (Steel and Torrie 1960). For comparison of mortalities among the treatment values, percent mortality was subjected to arcsin transformation (Zar 1974) and the resultant data was subjected to analysis of variance as above.

Table 1. Details of feeding rate during the experiment

Day	Time	Ingredients	Daily amount
7 days after new and full moon (after water exchange)	18:00-20:00	Trash fish	8% BW*
	05:00-06:00	Wheat flour + Rice bran	1% BW
7 days during new and full moon (during water exchange)	18:00-20:00	Fresh shrimp head (except carapace)	8% BW
	05:00-06:00	Wheat flour + Rice bran	1% BW

* *Body weight*

Results

The growth responses and production data of three different treatments are presented in Tables 2 and 3 respectively. Differences in the initial weights of the crablings used in three treatments were insignificant but at the termination of the experiment the performance differed significantly ($P<0.05$). Weekly growth trend was similar between T_1 and T_2 during the whole experimental period but comparatively slow growth trend was noted from the fifth week (Table 2). No significant difference was observed among the production of three treatments but the best production was recorded in T_2 (862.16 kg/ha) followed by the T_1 (720.35 kg/ha) and T_3 (669.19 kg/ha). The survival rate of T_2 (69%) was highest followed by the T_3 (59%) and T_1 (58%). The lowest weight gain was recorded in T_3 (88.33g) followed by T_2 (99.57g) and T_1 (99.25g). The change in carapace width during the experiment were homogeneous and similar among all treatments. Though the specific growth rate in T_3 (0.78) was lowest but the variation is insignificant ($P>0.05$) among all treatments.

Table 2. Growth responses of *Scylla serrata* crablings at different doses of cowdung over the 84 days experimental period

Treatments	Mean body weight (g)												
	Initial								Culture period (Weeks)				
	wt.(g)	1	2	3	4	5	6	7	8	9	10	11	12
T_1	24.98	32.1	39.3	45.2	52.1	58.3	67.2	74.2	81.8	88.9	99.3	113.4	124.23
T_2	25.38	34.3	45.1	54.2	59.8	66.9	71.5	77.3	83.7	89.2	97.3	112.7	124.95
T_3	25.15	33.1	50.0	56.7	60.2	63.0	69.5	73.4	79.6	84.2	90.2	101.3	113.48

Table 3. Growth, production and survival rate of mud crab

Parameters	Treatments			
	T_1	T_2	T_3	± SE
Initial weight (g)	24.98^a	25.38^a	25.15^a	0.014
Final weight (g)	124.23^a	124.95^a	113.48^b	0.991
Weight gain (g)	99.25	99.57	88.33	-
Initial carapace width (cm)	3.2^a	3.25^a	3.23^a	0.012
Final carapace width (cm)	6.215^a	6.23^a	5.93^a	0.037
Specific growth rate (%)	0.83^a	0.825$^{a}_{ab}$	0.78^a	0.02
Survival rate (%)	58.00	69.00	59.00	6.141
Production/ha	720.35^a	862.16^a	669.19^a	77.461

Figure in the same column with same superscripts are not significantly different (p>0.05).

Plankton production in all treatments were recorded. Zooplankton was found highest in T_2 (2562/litre) followed by T_3 (1659/litre) and T_1 (1469/litre). The phytoplankton was recorded highest in T_3 (1318/litre) followed by T_2 (719/litre) and T_1 (465/litre). The range of water temperature, p^H and salinity was 25-31°C, 7.1-7.6 and 8-19 ppt respectively. Water transparency range was found higher in T_1 (36-42 cm) followed by T_2 (29-35cm) and T_3 (24-30 cm). Dissolved oxygen decreased with increasing apply of organic manure and the range during the experimental period was 1.5-6.5 mg/l.

Discussion

Organic manure like cattle dung, poultry manure were used by different workers for increasing plankton in nursery and rearing ponds with varying results (Anon 1969, Saha *et al.* 1974, Shigur 1974, Govind *et al.* 1978, Banerjee *et al.* 1979, Hepher and Pruginin 1981 and Mamtazuddin and

Khaleque 1987). In this experiment a clear relationship was observed among weight gain, survival rate and production. Although the variation of production among all treatments were insignificant (P>0.05) but apparently lowest production was noted for T_3 . A relationship between quantity of organic manure, dissolved oxygen and plankton concentration was observed. Due to the presence of greater amount of filamentous algae in one pond of T_3 survival rate and production were found to decreased that resulted high standard error in the production. A direct relation between average plankton and fish production was also reported by Smith and Swingle (1939). Other than such relationship, an inverse relationship between the plankton types were also observed which is in agreement with the findings of Saha *et al.* (1989) where the authors observed an increased proportion of phytoplankton production with low concentration of zooplankton and vise versa.

The findings of this experiment further indicate that crab is an animal of omnivorous nature and like fleshy feed and at early stage of grow out operation they generally fed a resonable quantity of zooplankton that can be produced by the application of organic manure like cowdung.

Conclusions

Though the effects of cowdung on production of crab is insignificant but considering growth, survival and production, the application of cowdung in addition to feed can be recommended for mud crab culture at a rate of 500 kg/ha/fortnight.

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Environmental parameters and incidence of white spot disease in *Penaeus monodon* (Fab.) farming

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Abstract

An investigation was carried out to monitor management practices and to find out whether there is any relationship with occurrence of deadly white spot disease and environmental parameters. Three semi-intensive and a improved traditional shrimp farms were selected in which mass mortality of shrimp (*Penaeus monodon*) by white spot disease occurred previously. The farms were situated at two different geographical locations. Two ponds from each farm at random were selected for the study. Out of eight investigated ponds, 6 ponds in three farms were affected by the disease during investigation period. The non-affected ponds had relatively lower stocking density, slightly different management practice and were located at different geographical area. There were no significant variation in water quality parameters among the affected and non-affected ponds. No significant variations were recorded in pond preparation, source of Post Larvae (PL), water and feed management among the affected and non-affected ponds. The observation indicated that pond micro-organisms in a farm may not the only cause of the disease but some external factors also might be responsible for the outbreak of this disease.

Key words : *P. monodon*, Disease, Environment

Introduction

Brackishwater shrimp culture in Bangladesh is export oriented and developed in an unplanned and unregulated ways which mostly depends on repeated single species culture on the same soil. It also depend on the natural seeds of variable qualities and reclamation of culture lands through distribution of mangroves (Hossain 1995). Indiscriminate exploitation of natural post larvae together with destruction of the marine life through harvesting and handling process of post larvae and destruction of delicate mangrove ecosystem, created an environmental situation, the effect of which was already started to some extent in the recent years. Modern aquaculture requires maximum out put of fish/shrimp per unit area. Over feeding, over crowding lead to malpractice's of the aquatic environment and ultimately caused diasters to shrimp farming (Hossain 1996).

During 1994-95, most of the semi-intensive shrimp farms were affected by the white spot disease. The out break of disease occurred during early stage of culture. It is usual phenomenon that aquatic disease is generally caused by the degradation of environmental and ecological condition as well as faulty management practices with the interaction of pathogens. In this study attempts were taken to find out whether water quality parameters were responsible for the out break of the white spot in shrimp farming or not.

Materials and methods

Three semi-intensive and an improved traditional shrimp farms were selected for this investigation during winter crop in which mass mortality of shrimp (*Penaeus monodon*) caused by white spot disease. From each farm two grow out ponds were selected for the study. The area of these ponds in selected farms were as follows: Beximco Fisheries Ltd. ($5800m^2$, $8400m^2$), Meghna Shrimp Culture Ltd. ($6000m^2$, $5920m^2$), Aquaculture Farms Ltd. ($5464m^2$, $3926m^2$), Demonstration Farm and Training Centre (DFTC), FRI ($3368m^2$, $4940m^2$). First three farms located in Khuruskul, Cox's Bazar area on the bank of the river Bakhkhali and the other farm at Teknaf area by the side of Naf river. Water depth in all investigated ponds ranged between 1.0-2.4 meters. Ponds were rectangular in shape except one at DFTC, FRI pond, the shape of the pond was irregular. Ponds had leading slope to the outlet. All farms had water intake and discharge facility, small laboratory, electricity, paddle wheel and pump facilities. Reservoir facility is available in all farms except DFTC, FRI.

From pond preparation to harvest, all management practice were observed carefully. Drying, pond preparation, stocking particulars are shown in Table 1. Water intake in each pond were done through screening by either micro mesh or mosquito nets to avoid the entrance of eggs, larvae or juveniles of undesirable species. The water in each pond was allowed to remain 3-4 days for hatching of eggs that might have accidentally entered into the ponds. Then tea seed cake was applied to eradicate the unwanted species of fin fish except Aquaculture and DFTC, FRI farm. Then ponds were fertilized and waited till plankton bloom (Table 1). Then Post larvae(PL) stocked which were collect from natural source.

Table 1. Pond preparation and stocking particulars in the investigated farms

Farms	Beximco		Meghna		Aquaculture		DFTC,FRI	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
Black soil removal*	partial	partial	partial	partial	partial	partial	Nil	Nil
Drying (d)	7	7	3	4	5	5	12	10
Liming $CaCO_3$ (kg/ha)	600	600	600	600	370	370	250	250
Water intake	24.7.95	24.7.95	30.8.95	30.8.95	9.8.95	9.8.95	3.9.95	12.9.95
Aerator	8	8	8	8	6	6	0	0
HP	12	16	16	16	12	12	0	0
Tea seed cake (ppm)	12	12	14	10	Nil	Nil	Nil	Nil
U+TSP+Pot kg/ha	5+10+0	5+10+0	13+13	13+13	Nil	Nil	Nil	Nil
Stocking PL/m^2	25	23.4	15	15	17.8	18	3.6	4.5
PL size (mm)	12-18	12-18	20-25	20-25	20-25	20-25	15-20	15-20

* *Black soil was removed by mixing with water and discharged through out-let to the river.*

All farms used dry commercial formulated pelleted feed in addition to natural live foods produced in the pond. Feeding started at the second day of stocking except at DFTC, FRI. They started using feed after one month of stocking due to low stocking density, higher water depth and availability of natural food. Feed was spread at all front sides of the pond adjacent to the dikes. After one month of PL stocking, feed was checked from time to time by using lift nets to control under or over feeding.

All farms tried to maintain optimum water quality by applying lime(Calcium carbonate) and fertilizer as well as through water exchange. During high tide water was allowed to enter directly to the reservoir or into the feeder canal through main sluice gate and axial pump. Stored water was treated with lime ($CaCO_3$) and settled, except at DFTC, FRI farm. Throughout the culture period Water temperature measured by centigrade thermometer, salinity by refractometer, transparency by secchi disk, pH by pH meter on daily basis and alkalinity, ammonia at weekly basis and dissolved oxygen (DO) at an irregular basis by Hach Kit. Paddle wheels were operated whole day and night except during feeding time.

Shrimp in each selected pond of all investigated farms were weighed weekly to monitor their average growth. For the purpose, 50 or 100 shrimps were harvested at random and weighed and released to the same pond. During sampling shrimps were closely observed to examine their gills, eye, intestine, antennae, appendages etc. Occurrence of disease was also recorded where it occurred.

Results and discussion

In the present study the highest salinity ranged between 16-24 ppt and lowest between 4-17 (Table 2) in all investigated farms. In all farms salinity increased gradually as culture period progressed. Lowest salinity at DFTC,FRI was very severe (4 ppt) during stocking. This was due to Naf river which carries vast amount of water from hilly areas of Bangladesh and Mayanmer and salinity turned at zero level annually during June-august period. However 4 ppt salinity was retained by not exchanging water during rainy season. Salinity increased when culture progress and rain fall stopped.

Table 2. Water quality parameters of selected ponds in four semi-intensive farms

Daily basis								
Farms	Beximco		Meghna		Aquaculture		DFTC,FRI	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
Salinity (ppt)								
Highest	18	18	21	21	24	24	16	16
Lowest	11.5	11	16	15	12	13	4	4
Temp. (°C)								
Highest	34.0	34.0	32	32	34	34	34	34
Lowest	27	27.0	25	26	25	25	25	25
pH								
Highest	8.9	8.8	8.5	8.8	8.8	8.9	8.3	8.2
Lowest	7.5	7.5	7.5	7.6	7.7	7.9	7.3	7.3
Transparency (cm)								
Highest	80	75	90	90	65	65	95	97
Lowest	34	26	28	22	34	25	29	30

	Weekly basis							
DO(ppm)								
Highest	9.5	9.0	9.5	9.5	9.0	9.5	7.5	7.5
Lowest	5.0	5.0	5.0	5.5	4.5	4.0	3.5	3.5
Ammonia(ppm)								
Highest	0.3	0.4	0.3	0.2	0.4	0.4	0.5	0.5
Lowest	trace	trace	trace	trace	trace	trace	0.1	trace
Alkalinity (ppm)								
Highest	114	120	120	138	111	99	84	87
Lowest	89	76	81	78	87	90	60	51

The highest temperature in all investigated farms were ranged between 32 -34°c and lowest were recorded in between 25-27°c (Table 2). pH level was almost similar in all investigated farms where the highest range was 8.2-8.9 and the lowest was 7.3-7.9. The highest transparency in all investigated farms ranged between 65-97 cm and the lowest 22-34 cm. transparency were relatively higher at early stage and gradually decreased as culture period progressed. This due to the fact that, with the advancement of culture period, organic deposition increased at pond bottom which leads to an increase in plankton production. Highest range of DO in all investigated farms varied from 7.5-9.5 ppm and the lowest range was 3.5-5.5 ppm (Table 2). Ammonia was variable in all investigated farms and ranged from trace to 0.5 ppm. Highest alkalinity range was 84-138 ppm and the lowest was 51-90 ppm in all the farms. pH, alkalinity, DO, ammonia were recorded to decrease gradually which might be due to increased biomass in the investigated ponds. However, the recorded water quality parameters could be considered as suitable for the culture of *P. monodon*. Similar diversion were also recorded by Larkins (1995), except for salinity at DFTC,FRI farm. Kibria (1985) and Islam (1983) were at the opinion that routine checking of pond conditions are necessary for physico-chemical parameters and the authors further mentioned that optimum range of temperature, pH, DO and salinity were 28-33°C, 8-9, 8-9ppm and 15-25 ppt respectively. Chanratchakool *et al*. (1995) mentioned the optimum range of pH, salinity as 7.5-8.5 and 10-30 ppt respectively.

Three of four investigated farms were affected by disease which situated in same area and disease outbreak occurred during 2nd half of September to 1st half of November at the age of shrimp was 51-78 day (Table 3). Disease may be transmit from one farm to another by water through carrier. Three affected farm drained out water to river after disease out break. All farm use similar fry which were collected from nature but one farm harvested disease free shrimp which indicated that fry may not responsible for the disease. Disease outbreak occurred during September to November when weather terns dry and cool which may create stress condition on shrimp. In Teknaf region temperature remained relatively higher than Cox's Bazar.

Table 3. Sign or out-break of disease in investigated ponds of different farms

Farms	Beximco		Meghna		Aquaculture		DFTC,FRI	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
1st Disease detected	(22.9.95)	(22.9.95)	(27.10.95)	(30.10.95)	(10.11.95)	(10.11.95)	No	No
Out break on culture day	58	57	48	51	78	77	No	No
Average body wt(g) when disease outbreak	8.1	8.5	13.3	8.2	17.7	15.7	*9.9	*12.3
Harvest on culture day	67	66	78	80	81	79	75	75
% Survival	48.6	30	41.7	62.7	34.1	31.6	52.5	47.73

* *When shrimp harvest with out disease.*

Total feed used, production of shrimp and FCR for each pond as a whole in all investigated farms had considerable variations. This is due to variable stocking date, time of disease outbreak, percent of survival and size of the shrimp. Growth of shrimp in all the farms were more or less at a satisfactory level before incidence of disease out break.

The average weight of shrimp were 8.1 and 8.5 g, 13.3 and 8.2 g, 17.7 and 15.7 g, 9.9 and 12.3 g in pond no. 1 and 2 of Beximco, Meghna, Aquaculture and DFTC,FRI farms respectively on the day of disease outbreak/harvest (Table 3). Here it may be mentioned that through the shrimp at DFTC,FRI was not affected by the disease, but it was harvested due to winter.

The recorded Food Conversion Ratio(FCR) were 1.51 and 1.67, 1.03 and 1.02, 1.13 and 1.52, 1.52 and 1.43 in pond no. 1 and 2 of Beximco, Meghna, Aquaculture and DFTC,FRI farms respectively on the day of harvest (Table 4). The average production were 791, 860, 989, 360 kg/ha of Beximco, Meghna, Aquaculture and DFTC,FRI farm respectively.

Table 4. Production and apparent feed efficiency in investigated ponds during culture period

Farms	Beximco		Meghna		Aquaculture		DFTC,FRI	
	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2	Pond-1	Pond-2
Source of feed	President	President	CP	CP	SBFFL	SBFFL	SBFFL	SBFFL
Total Feed (Kg)	865	835	610	445	666	540	160	290
Production (Kg)	571	502	590	437	587	355	105	203
FCR	1.51	1.67	1.03	1.02	1.13	1.52	1.52	1.43
Production /ha (kg)	984	598	983	738	989	904	311	410

SBFFL = Saudi Bangla Fish Feed Ltd. (Bangladesh).
CP = Charoen Pokphand Feed (Thailand).
President = President Feed (Taiwan).

However, a highest production of 989 kg/ha was obtained by Aquaculture farm due to the fact that the farm had a longer culture of 81 days. Chowdhury *et al.* (1991) obtained 18154kg/ha with in a 126 day culture period in the same farm with out disease. However in the present experiment, DFTC, FRI farm had a period of 75 days and culture had to terminate due to winter season with lower production of 360 kg/ha. This is due to a lower stocking density of 4 pc/m^2. Further, it may be mentioned that DFTC,FRI ponds were under a project to look after environment friendly semi-intensive shrimp farming and deliberately maintained lower density to find out sustainability of shrimp farming.

The present study is a preliminary one to find out whether water quality parameters are responsible for the outbreak of disease or not. There is no significant variation in water quality parameters among the affected and non affected ponds. As Bangladesh earns a significant amount of foreign exchange by exporting shrimp, due attention should be given to control this shrimp disease. However, emphasis should be given to carry out more research work to improve disease free shrimp farming and to make it a sustainable venture suitable to socio-geographical and climatic conditions of Bangladesh.

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Study on the intestinal bacteria of *Labeo rohita* (Ham.)

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Abstract

The quantitative and qualitative aspects of intestinal bacteria of rohu fish (*Labeo rohita*) showed that total viable count of bacteria ranged from 9.9×10^{5} to 1.4×10^{7} CFU/g of intestine in different age groups of fish. The bacterial load was highest in the month of July and lowest in January. The genera of the isolates from intestine included Coryneform, *Micrococcus*, *Flavobacterium*, *Cytophaga*, *Achromobacter*, *Aeromonas* *Enterobacteriaceae* and *Vibrio*. Coryneform was the dominant group throughout the study period followed by *Micrococcus* and Enterobacteriaceae. Marked variations in the bacterial load and generic composition of intestinal bacteria were evident during the study period in different age groups of rohu fish.

Key words : Intestinal bacteria, *Labeo rohita*

Introduction

It is now generally recognized that the digestive tract of fish particularly the intestine contains a large number of bacteria. Bacteria enter into the fish with food and drinking water and accumulate in the intestine. Some of them retain there for a relatively longer period but most of them can stay very temporarily due to incompatible environment produced from physical and chemical conditions, lethal interactions between bacteria and immune responses of the gut (Sugita *et al.* 1987). Various studies have suggested that intestinal microflora were responsible for of various food spoilage (Kaneko 1971) and contamination of fish due to enteric bacteria of human or animal origin (Geldrich and Clarke 1966).

Rohu fish (*Labeo rohita*) is the most demanded and widely distributed fresh water fish species in the Indian sub-continent. Since the aquatic bacterial flora plays a significant role in the productivity of water and there are also some potent organisms responsible for fish diseases, it is of importance to know the activity of microflora in the water body as well as in intestine of fish of that environment. Moreover, identification of the normal intestinal flora of fish would be of great value in correct interpretation of physiology and nutritional requirements of fish. Considering these factors the present study was undertaken to investigate the presence of bacterial flora in the intestine of rohu of different sizes during different seasons.

Materials and methods

Collection of fish and water samples

Rohu fish of different age groups and sizes were collected from Bangladesh Agricultural University fish farm, located near the Faculty of Fisheries. Three sampling were done between January and July'95. Length, weight and age groups of fish were recorded. Water samples in triplicate were collected during sampling from the same pond by clean, sterile glass stoppered bottles of 250 ml capacity and were protected from light and carried to the laboratory for bacteriological analysis.

Quantitative and qualitative study of bacteria

Intestines of the fish were removed aseptically by opening the body cavity, weighed and finely chopped by sterile scissors and ground in a sterile morter-pestle. For quantitative study, 1.0g of finely ground fish intestine was diluted in 9.0 ml 0.2% peptone water. Standard plate count (SPC) of the intestinal contents of fish and water samples was done by consecutive decimal dilution technique. Plate Count Agar (Hi Media) was used as culture media.

For the qualitative study, all the colonies from a spread plate (obtained during SPC) were picked up and streaked on nutrient agar plate and incubated at 30°C for 48 h, from which discrete colonies were transferred on nutrient agar slants. After 48 hours of incubation, smears were prepared on glass slides and stained by Gram's method. Each of the culture was examined microscopically for their purity. The generic classification and distribution of the isolates were done according to an outline of the sequence of tests as described by Shewan *et al.* (1960). Isolates in nutrient agar slants were maintained in the laboratory at 4-6°C throughout the study period.

Results and discussion

Length, weight and age groups of fish are shown in Table 1. Results of the quantitative estimation of intestinal bacteria in different age groups of rohu fish and pond water are given in Table 2. The mean number of bacteria in the intestine varied in the range of 9.9×10^6 to 1.42×10^7 CFU/g and in the water, 7.26×10^4 to 7.95×10^5 CFU/ml. In both intestine and water body lowest count was obtained during January and highest in July. On the other hand, count was comparatively lower in intestines of small fishes (fingerlings) than that of juvenile or adult fish.

Table 1. Length, weight and intestinal weight of different age groups of rohu fish

Sampling date	Age group of fish	Sample No.	Length of fish (cm)	Mean length (cm)	Wt. of fish (g)	Mean wt. of fish (g)	Wt. of intestine (g)	Mean wt. of intestines (g)
1st Jan.	Fingerling	1	8.0		4.4		0.5	
		2	7.3	7.5	4.5	4.2	0.3	0.33
		3	7.2		3.7		0.2	

1st Apr.	Juvenile	1	12.0		20.0		1.1	
		2	19.5	17.8	83.7	78.6	5.0	4.17
		3	22.0		132.0		6.4	
1st Jul.	Adult	1	60.0		2800.0		292.0	
		2	57.0	53.2	2400.0	2066.7	163.0	173.97
		3	42.5		1000.0		66.6	

Table 2. Total count of bacteria in intestine of rohu fish and water samples

Sampling date/ Fish age group	Sample. No.	Total aerobic intestinal count (CFU/g)	Average count (CFU/g)	Average count in water (CFU/ml)
1st Jan. Fingerling	1	1.23×10^7		
	2	1.25×10^7	9.90×10^6	7.26×10^4
	3	4.90×10^6		
1st Apr. Juvenile	1	1.35×10^7		
	2	1.49×10^6	1.23×10^7	7.90×10^4
	3	2.18×10^7		
1st Jul. Adult	1	1.45×10^7		
	2	1.30×10^7	1.42×10^7	7.95×10^4
	3	1.52×10^7		

The increasing trend in the bacterial population in the intestine and water sample with the approach of summer season indicated a possible seasonal variation of bacterial population in the environment. Generally, water temperature sharply increases during summer time in the tropical and sub-tropical regions (weather report as collected from the weather yard of Agri-Varsity, Mymensingh). Average water temperature in January was 15.5°C and in July, 25°C. Many workers suggested that bacterial load might be increased with the increase of temperature of water body (Uddin *et al.* 1990 and 1991). Besides that, primary productions are usually higher in warmer seasons. Presence of higher bacterial load in the intestine of fish during the months of April to July might be due to high metabolic activities of the fish which initiated them to take larger quantities of food during that period.

A total of 150 isolates were obtained from the intestine of different age groups of rohu fish and they were identified as *Achromobacter, Micrococcus,* Enterobacteriaceae, Coryneforms, *Flavobacterium/Cytophaga, Aeromonas* and *Vibrio.* The percentage-wise distribution of these bacteria in different age groups in different seasons is shown in Table 3. There were wide variations in distribution pattern and types of bacteria in different age groups of rohu fish during different sampling months. Among the seven groups of bacteria identified, Coryneform was the most dominant one followed by *Micrococcus* and Enterobacteriaceae. This phenomenon has not been well understood but it is likely that most of them were derived from water. The composition of intestinal bacteria may vary from fish to fish. Sakata *et al.* (1988) reported that *Vibrio* and *Aeromonas* were the dominant groups in the intestine of Grey mullet (*Mugil cephalus*). The minor groups of bacteria found in the intestine of rohu fish at different stages of growth are reported to be the common intestinal bacteria are different fresh water fish (Sugita *et al.* 1983, Trust 1974, Shewan *et al.* 1960, Sugita *et al.* 1985 and Newman *et al.* 1972). The groups of bacteria identified in the present study are representatives of most of the genera of heterotrophic true bacteria. The occurrence of such types of bacteria are also important from the point of sanitary and public health hazards.

Table 3. Distribution (%) different groups of bacteria in intestine of rohu fish

Age group	No. of isolates	Coryneform	*Micrococcus*	*Aeromonas*	Enterobacteriaceae	*Flavobacterium/ Cytophaga*	*Achromo-bacter*	*Vibrio*
Fingerling	49	58.06	25.81	0	9.67	3.23	3.23	0
Juvenile	50	70.96	22.58	0	3.23	0	0	3.23
Adult	51	76.32	7.89	2.63	10.53	2.63	0	0

Representative strains from the isolated organisms from intestine of rohu fish were used to study their metabolic capability (data not shown). Most of the strains were able to ferment large number of sugars (carbohydrates) both aerobically and anaerobically. They were also found positive in proteinase test, gelatin liquifaction test and catalase activity. These properties indicated that most of the isolates are associated with the spoilage activity which is a matter of great concern, because they can actively contribute to the quality deterioration during post-harvest handling, preservation and transportation of the fish.

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Toxic effects of dimecron to fingerlings of *Labeo rohita* Ham.) during acute and chronic exposures

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Abstract

The toxic effects of dimecron on growth, body composition and oxygen consumption of fingerlings of *Labeo rohita* were studied. Dimecron concentrations of 4 and 8 mg/l were used. Both acute (3-h) and chronic (15-42 d) exposure schedules were followed. Compared with the control fish, both 4 and 8 mg/l dimecron treatment significantly suppressed weight gained in fish by 9.71 % and 30% respectively during a 42 day exposure period. However, the length of fish was suppressed by 11.46% significantly only in fish group exposed to 8 mg/l dimecron. Similarly, the protein content was also significantly reduced in the above group of fish. The oxygen consumption of fish was elevated considerably, but not significantly in both group of treated fish (8.5% and 26.07%) during acute exposure. However, after 15 days of exposure the rate decreased by 18.98% significantly only in fish exposed to 8 mg/l dimecron. The threshold level of DO at low oxygen environment found to be slightly higher in fish at 8 mg/l dimecron. The survival time at the above oxygen condition was reduced during acute exposure (3-h) and that was extended during chronic (15-d) exposure.

Key words : Toxicity, Dimecron, *L. rohita*

Introduction

Bangladesh is mainly an agricultural country and a large amount of agrochemicals are used to enhance rice production from limited land to meet the ever increasing demand of rice for increasing population. About 25% of the total pesticide used in Bangladesh is thought to enter into the open water bodies (Anonymous 1992). There is a growing concern about their possible harmful affects on flood plain fish and people (Bashar and Reazuddin 1990, World Bank 1991). In fact, pesticides have been recognized as environment pollutants of potential toxicological concern for fishery as diagnosed by their acute and chronic toxicities (Sprague 1971, Alabaster and Lloyed 1982, Rand and Petrocelli 1985).

Three main categories of pesticides *viz.* chlorinated hydrocarbons, organophosphorus and carbonates are used in the country at present time, of them chlorinated hydrocarbon is known to be highly toxic to all forms of aquatic life. Due to the persistent nature of organochlorine and its long-term effects in the environment, in recent years, emphasis has been placed on the use of organophosphate compounds (Henderson *et al.* 1985, Rao *et al.* 1967). Organophosphate rapidly breakdown in the environment and do not persist in animal tissues. Nevertheless some of these insecticides are extremely toxic for short periods after application, during which they inhibit neurotransmitter enzyme causing death from paralysis (Mehrle and Mayer 1985).

Of the organophosphorus group of pesticides, dimecron (phosphamidon) is widely used as a crop protectant in agriculture and as an ectoparasite in poultry and Livestock. The abuses of this chemical causes contamination of water ways affecting aquatic fauna (Gopal and Dwivedy 1978). The recent trend in pesticide research is the use of sublethal concentrations that do not kill the fish but may impair growth and reproduction (Rand 1985). Therefore, the present investigation was carried out to study the chronic effects of dimecron rather than mortality or acute lethal test. Moreover, fish was exposed to different dimecron concentrations for varying periods of exposure and their oxygen consumption rates and tolerance level of oxygen (threshold oxygen concentrate) were monitored.

Materials and methods

The experimental system consisted of six circular earthen tumblers and were of 40 litres capacity each. The tumblers were arranged in rows on wooden frames and provision was made such that they could be gravity fed from a tap-water source and similarly could be drained easily by siphoning. Oxygenation of individual tumbler was done by using airstones connected to a air compressor.

Immediate after arrival of fish (fingerlings of *Labeo rohita*, length 5.99±0.24 cm) at the laboratory, the fish were transferred to a large concrete tank under flow-through water condition. On the next day, they were randomly divided into six groups and were transferred to the six experimental tumblers (one group in each tumbler) and were acclimatized there for a period of seven days. During the acclimation period water of fish holding tumblers was renewed daily. The fish were fed twice daily at the rate of 2% body weight. Any uneaten feed particle was siphoned out immediately. Feeding was stopped two days before the commencement of actual experimental trial. Two nominal concentrations of the above pesticide, 4 mgl^{-1} and 8 mgl^{-1} were used. Each concentration was tested in duplicate.

The dimecron concentrations in the tumblers were achieved by adding calculated amount of freshly prepared stock solution of the toxicant directly into the respective tumblers. Aeration of water by using airstones ensured the through mixing of toxicant as well as adequate supply of oxygen. The exposure media was changed daily usually after feeding the fish. The experiment was run for 42 days. The fish was inspected several times a day and any dead found was removed immediately. A natural phtoperiod of approximately 12 hours dark : 12 hours light was available. At the termination of the experiment, each group of fish netted out separately, and lengths and weights of individual fish were measured. The fish were sacrificed and muscle tissue of the fish were collected for proximate analysis. Further, the kidney, liver, intestine and stomach of fish were dissected and were preserved for histopathological study.

After a 7-day acclimation in the out door tank facility, the fish was brought to the laboratory and was further acclimatized for one day in glass jar (each containing one litre water) under laboratory conditions with several changes of water in a day. Aeration of water in the jar was maintained by using airstones. After one hour, aeration of water was suspended and an initial water sample was taken and then each jar was sealed air tight. Caution was so taken that no air was trapped inside the jar. After 2 hours of exposure, the experiment was terminated. The jar was shaken for mixing of water column. Pebbles kept at the bottom of the jar helped in the mixing of water. Thereafter the jar was unsealed and final water sample was taken for the determination of oxygen. Adjustment of time was so made that it allowed the compensation of time lasped during handling of experimental jars and water sampling. The experiments were repeated thrice (on 3 consecutive day) and started at the same time of the day. Determination of oxygen contents in water samples were done by using a HACH kit. Total oxygen consumption by fish was obtained by subtracting oxygen content in the final samples from that of initial samples and then oxygen consumption /h/g body weight was calculated. A total of 5 fish (total weight approx. 30 g) were exposed simultaneously in each jar and the exposure was continued until the death of all the fishes in each jar. The time at which each individual fish died was recorded and survival period for individual fish was calculated. When the death of all the fish was completed in the jar the experiment with that particular jar was terminated and the mean survival time of the group was calculated for each jar. Initial and terminal water samples were taken for the purpose of determination of oxygen contents in the samples.

The difference between control and treatment groups of fish was tested by t-test. The level of significance was accepted at P=0.0.5. The data have been reported as arithmetic mean ± standard deviation.

Results and discussion

It is evident from the results that values for any water quality parameters did not differ significantly among various treatment tumblers (Table 1). However, values for temperature measured in the morning and in the afternoon varied greatly. The measured water quality parameters remained within normal range (Alabaster and Lloyd 1982) throughout the experimental period and did not vary among different experimental tumblers.

Table 1. Recorded data on the water quality parameters of the experimental media during 42 days exposure period

Treatments	Temperature (0^0C)	pH		Dissolved	Free carbon
	Morning	Afternoon		Oxygen (ppm)	dioxice (ppm)
Control	12.71 ± 1.71	18.20 ± 1.61	7.85 ± 0.15	6.01 ± 0.62	10.86 ± 2.32
4 mgl^{-1} dimecron	12.88 ± 1.42	18.13 ± 1.66	7.87 ± 0.16	6.08 ± 0.42	11.15 ± 2.56
8 mgl^{-1}	12.80 ± 1.61	18.43 ± 1.59	7.91 ± 0.36	6.05 ± 0.36	9.58±3.28 dimecron

No mortality occurred in the fish group exposed to 4 mgl^{-1} dimecron during the exposure period. However, seven fish died in fish groups treated by 8 mgl^{-1} dimecron (from both the tumblers). The 1st death occurred on the day 20 while others died after day 35 of exposure. Such a low mortality rate (5%) observed in the study appears to be natural and acceptable considering the fish size, duration of experiment and laboratory handling of fish. Higher mortality rate at the highest concentration occurred probably due to stress induced by the toxicant. Contrary to this, Khan & Ahmed (1966) observed no mortality in fish at a much higher concentration of 100 ppm dimecron as a safe concentration for fish. This discrepancy might have been resulted from the erroneous calculation of dosages applied. In the present study the concentrations of the toxicant used were determined on the basis of active ingredient in "Dimecron 100 SCW".

The protein and moisture content of *L. rohita* exposed to dimecron was presented in Table 2. The crude protein content in control fish group found to be 18.37 g/100g muscle tissue whereas that of 4 and 8 mgl^{-1} dimecron treated fish were 16.76 and 12.70 g/100 g muscle tissue, respectively. Although, 4 mgl^{-1} dimecron treatment reduced protein content considerably, in comparison with control fish, however, this was not found statistically significant. In contrast, the reduction in protein content in 8 mgl^{-1} dimecron treated fish was found to be highly significant ($P>0.001$). Unlike protein contents, the moisture content in both groups of dimecron treated fish increased compared to control fish. The terminal values for moisture contents in control fish, 4 and 8 mgl^{-1} dimecron treated fish were 78.30, 79.90 and 83.27 g/100 g muscle tissue, respectively. The observed increases in tissue moisture contents in the 8 mgl^{-1} dimecron treatment groups of fish were significant compared with the control fish.

Table 2. Changes in protein and moisture contents in *L. rohita* exposed to dimecron for a period of 42 days

Concentration of dimecron	Protein content g/100g muscle tissue	% change in protein content compared to control	Moisture content g/100 muscle tissue	% change in moisture content compared to control
0 mgl^{-1} (control)	18.37 ± 1.09	0	78.30 ± 2.21	0
4 mgl^{-1}	16.76 ± 1.56	8.76	79.90 ± 2.13	2.04
8 mgl^{-1}	12.70 ± 1.92	30.86	83.27 ± 2.45	6.35

It is also evident from the present study that muscle contents were greatly reduced by dimecron treatment. In consistent with the present study, a few studies have also shown to impair muscle composition in fish induced by organic chemicals. Somanath (1991) invéstigated the changes in protein and lipid content in *Labeo rohita* exposed to 59 ppm tannic acid for 4 days in various tissues of the fish including body muscle. Both the contents were found to be affected. The maximum depletion (71%) protein being at the brain tissue. In another study with *Catla catla*, Rao (1989) found that endosulfan at sublethal level reduced protein, glycongen and lipid contents in various tissues of the fish. Depletion in protein content may be due to interference in protein synthesis caused by chemical pollutants (Shukla and Pandey 1986). It is well known that aquatic organisms mobilizes it body reserves (both protein and fat) under condition of starvation and stress to cope with additional energy requirements (Pickering 1981). Therefore, the observed depletion in protein content in dimecron treated fish may be due to stress and less food consumption as assessed by visual observations. In the present study, protein content was reduced but not significantly in fish exposed to 4 mgl^{-1} dimecron. It is, however, not known whether such exposure may bring about some significant changes on further extended period of exposure. The highest concentration used in the present study proved lethal on prolonged exposure (>30 days in this case) and it also appears that all the fish would have been died if the exposure period had been extended. In such a situation, the reduction in protein content or respectively. Although the terminal oxygen value in 8 mgl^{-1} dimecron treated experimental jar was slightly higher compared to controls, but t-test revealed no significant difference.

Table 4. Effects of dimecron exposure on survival time and threshold dissolved oxygen concentration at low dissolved oxygen environment during acute exposure

Dimecron concentrations	Average wt. of fish (g)	Initial DO content in the media (ppm)	Terminal DO content in the media (ppm)	Average survival time (min)
0 mgl^{-1}	5.60 ± 0.30	6.7 ± 0.15	1.35 ± 0.05	89.0 ± 6.84
4 mgl^{-1}	5.70 ± 0.18	6.6 ± 0.22	1.27 ± 0.20	84.0 ± 1.95
8 mgl^{-1}	5.48 ± 0.36	6.7 ± 0.08	1.60 ± 0.05	79.4 ± 3.40

Table 5. Effects of dimecron exposure on survival time and threshold dissolved oxygen concentration at low dissolved oxygen environment during chronic exposure

Dimecron concentrations	Average wt. of fish (g)	Initial DO content in the	Terminal DO content in the media (ppm)	Average survival time of fish (min) media (ppm)
0 mgl^{-1}	5.12 ± 0.24	6.82 ± 0.12	1.22 ± 0.20	84.30 ± 2.60
4 mgl^{-1}	4.97 ± 0.20	6.80 ± 0.07	1.10 ± 0.30	105.1 ± 3.87
8 mgl^{-1}	5.06 ± 0.28	6.60 ± 0.24	1.52 ± 0.18	124.67 ± 3.82

The oxygen tolerance value (1.52 ± 0.18 ppm) for fish at 8 mgl^{-1} was slightly and insignificantly higher over the control value (1.22 ± 0.20). Contrary to the above, the value for fish exposed to 4 mgl^{-1} dimecron (1.10 ± 0.30 ppm) was slightly below the control value. However, compared with the control fish, none of the differences was statistically significant.

It is evident from the results of the present study that dimecron treatment increased oxygen consumption rate in carp fingerlings during acute exposure. Although oxygen consumption rate increased during acute exposure but the rates decreased after 15 days of exposure, being greatly reduced at the highest dimecron concentrations. In agreement, Rath and Misra (1980) observed decreased oxygen uptake in gills, brain and muscle tissue (hence whole body) in tilapia after a 15 - d exposure to 0.05 mgl^{-1} dichlorovos, an organosphosphate pesticide.

In disagreement with the results of the present, Mount (1966) observed increased oxygen consumption in pumpkinseed fish even after 12 weeks of exposure to aqeuous dieldrin concentration of 1.7 mg/1. This differences in the results may be attributed to the lower concentration of pesticide used in the later studies and differences in the fish species.

Decreased oxygen consumption by the fish after a 15-d exposure observed in the present study again could be the consequences of several factors. First, the fish probably became exhausted due to stress effect caused by toxicant (as assessed by visual observation and locomotor measurements). The fish became lethargic and found to remain at the bottom of the aquarium for most of the time. This behavior of fish signify the hypoactivity resulting in the less oxygen consumption. Alternatively, this may also be attributed to decreased activity of oxidative enzymes. Several, organophosphate and organochlorine found to interfere with oxidative enzyme is chronically exposed fish (Mayer 1970, Natarajan 1984, Ranke and Rybicks 1975). Natarajan (1984) found hypoactivity of LDH, SDH enzymes during a 30-d exposure period to metasystox. Similarly, in vitro exposure to endrin reduced activity of lactate dehydrogenase (LDH), succinate dehydrogenase and cytochrome oxydase. Similar phenomenon might have occured in the present case. The reduced activity of the above oxidative enzyme usually means that less oxygen being used in the body and probably being reflected in the oxygen consumption by the fish. The fish exposed to lower concentration (4 mgl^{-1}) of dimecron showed essentially the same trend in oxygen consumption data but changes in the response was little but not significant. With further extended exposure the trend may change. The fish may either adapt to the altered environment by modifying its homostatic mechanism or the situation may further deteriorate leading to death of fish.

The mean survival time of fish and oxygen tolerance (oxygen threshold) level, were also affected by dimecron exposure. Various chemicals have shown that under conditions at low dissolved oxygen fish either die earlier or lower levels of poisons are required to cause lethality of fish (Aldelman and Smith 1972, Cairns and Scheier 1957). In the present study, during acute exposure, the fish exposed to dimecron died earlier than control fish, although oxygen threshold values were almost similar for all treatment groups. This indicates that the fish at the highest dimecron concentration consumed oxygen at a higher rate depleting oxygen level in the jar quickly and consequently the fish died earlier. The observed oxygen consumption data confirms the view.

By contrast, after 15 days of exposure (chronic exposure) the survival time of fish at the highest dimecron concentration was extended. The reason for this again is not understood but probably relates to less oxygen consumption by this group of fish as observed during oxygen consumption experiment. Therefore, it took probably longer time to deplete the oxygen respectively. Although the terminal oxygen value in 8 mgl^{-1} dimecron treated experimental jar was slightly higher compared to controls, but t-test revealed no significant difference.

Table 4. Effects of dimecron exposure on survival time and threshold dissolved oxygen concentration at low dissolved oxygen environment during acute exposure

Dimecron concentrations	Average wt. of fish (g)	Initial DO content in the media (ppm)	Terminal DO content in the media (ppm)	Average survival time (min)
0 mgl^{-1}	5.60 ± 0.30	6.7 ± 0.15	1.35 ± 0.05	89.0 ± 6.84
4 mgl^{-1}	5.70 ± 0.18	6.6 ± 0.22	1.27 ± 0.20	84.0 ± 1.95
8 mgl^{-1}	5.48 ± 0.36	6.7 ± 0.08	1.60 ± 0.05	79.4 ± 3.40

Table 5. Effects of dimecron exposure on survival time and threshold dissolved oxygen concentration at low dissolved oxygen environment during chronic exposure

Dimecron concentrations	Average wt. of fish (g)	Initial DO content in the	Terminal DO content in the media (ppm)	Average survival time of fish (min) media (ppm)
0 mgl^{-1}	5.12 ± 0.24	6.82 ± 0.12	1.22 ± 0.20	84.30 ± 2.60
4 mgl^{-1}	4.97 ± 0.20	6.80 ± 0.07	1.10 ± 0.30	105.1 ± 3.87
8 mgl^{-1}	5.06 ± 0.28	6.60 ± 0.24	1.52 ± 0.18	124.67 ± 3.82

The oxygen tolerance value (1.52 ± 0.18 ppm) for fish at 8 mgl^{-1} was slightly and insignificantly higher over the control value (1.22 ± 0.20). Contrary to the above, the value for fish exposed to 4 mgl^{-1} dimecron (1.10 ± 0.30 ppm) was slightly below the control value. However, compared with the control fish, none of the differences was statistically significant.

It is evident from the results of the present study that dimecron treatment increased oxygen consumption rate in carp fingerlings during acute exposure. Although oxygen consumption rate increased during acute exposure but the rates decreased after 15 days of exposure, being greatly reduced at the highest dimecron concentrations. In agreement, Rath and Misra (1980) observed decreased oxygen uptake in gills, brain and muscle tissue (hence whole body) in tilapia after a 15 - d exposure to 0.05 mgl^{-1} dichlorovos, an organosphosphate pesticide.

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Decreased oxygen consumption by the fish after a 15-d exposure observed in the present study again could be the consequences of several factors. First, the fish probably became exhausted due to stress effect caused by toxicant (as assessed by visual observation and locomotor measurements). The fish became lethargic and found to remain at the bottom of the aquarium for most of the time. This behavior of fish signify the hypoactivity resulting in the less oxygen consumption. Alternatively, this may also be attributed to decreased activity of oxidative enzymes. Several, organophosphate and organochlorine found to interfere with oxidative enzyme is chronically exposed fish (Mayer 1970, Natarajan 1984, Ranke and Rybicks 1975). Natarajan (1984) found hypoactivity of LDH, SDH enzymes during a 30-d exposure period to metasystox. Similarly, in vitro exposure to endrin reduced activity of lactate dehydrogenase (LDH), succinate dehydrogenase and cytochrome oxydase. Similar phenomenon might have occured in the present case. The reduced activity of the above oxidative enzyme usually means that less oxygen being used in the body and probably being reflected in the oxygen consumption by the fish. The fish exposed to lower concentration (4 mgl^{-1}) of dimecron showed essentially the same trend in oxygen consumption data but changes in the response was little but not significant. With further extended exposure the trend may change. The fish may either adapt to the altered environment by modifying its homostatic mechanism or the situation may further deteriorate leading to death of fish.

The mean survival time of fish and oxygen tolerance (oxygen threshold) level, were also affected by dimecron exposure. Various chemicals have shown that under conditions at low dissolved oxygen fish either die earlier or lower levels of poisons are required to cause lethality of fish (Aldelman and Smith 1972, Cairns and Scheier 1957). In the present study, during acute exposure, the fish exposed to dimecron died earlier than control fish, although oxygen threshold values were almost similar for all treatment groups. This indicates that the fish at the highest dimecron concentration consumed oxygen at a higher rate depleting oxygen level in the jar quickly and consequently the fish died earlier. The observed oxygen consumption data confirms the view.

By contrast, after 15 days of exposure (chronic exposure) the survival time of fish at the highest dimecron concentration was extended. The reason for this again is not understood but probably relates to less oxygen consumption by this group of fish as observed during oxygen consumption experiment. Therefore, it took probably longer time to deplete the oxygen content in 8 mgl^{-1} treated jar to a lethal level. Interestingly, the lethal threshold level of oxygen for the later group of fish was higher than control level. This probably signify the difficulty in extracting oxygen from low oxygen environment by the stressed (hence weak) fish.

Under the present experimental conditions dimecron was found to be deleteriously toxic to *L. rohita*. The higher concentration of dimecron (8 mgl^{-1}) used in the present study proved lethal on chronic exposure. The lower concentration also produced mild toxic effects.

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Nutritional value of some small indigenous fish species (SIS) of Bangladesh

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Abstract

Twenty three small indigenous fish species (SIS) in the size range of 3-18 cm were analysed for proximate composition and minerals (Ca and P) content to evaluate their nutritive value. The moisture content of different species ranged between 71.00 and 81.94%. In general, small sized fishes showed higher moisture content. The muscle protein content among the species varied widely (16.16-22.28%). In general, the muscle protein content of fishes showed higher value than the whole carcass protein content. The carcass lipid content varied between 1.87 and 9.55% and showed an inverse relationship with the moisture content. The gross energy content ranged from 19.51-27.30 KJ/g on dry matter basis. In the present study, the calcium and phosphorus contents ranged between 0.85-3.20% and 1.01-3.29% respectively. The calcium and phosphorus ratio (Ca/P) varied between 0.44 and 2.00. From the nutritional point of view, it shows that the SIS are good source of protein and minerals especially calcium and phosphorus.

Key words : Small fish, Proximate composition, Ca, P

Introduction

The Small Indigenous Fish Species (SIS) of Bangladesh are generally considered to be those fish which grow to a length of approximately 5-25 cm at maturity (Felts *et al.* 1996). These fish are commonly referred to as "Chhotomach" in contrast to the large and commercially important large fish "Baromach". Although small in size they constitute a major part of fish caught in the inland fisheries due to their large numbers and abundance.

Small indigenous species of fish are valuable and easily available source of food rich in protein, vitamin and minerals, not commonly available in other foods in Bangladesh. Many SIS are eaten whole contributing calcium, phosphorous and vitamins to the human diet. Hossain *et al.* (1994) mentioned that among the fishing communities, small fish occupy an important position as a popular food item. In a country with a population suffering from malnutrition and protein deficiency, consumption of these fish species may have positive effects in improving the health of the nation.

Small fish provide food and nutrition, subsistence and supplemental income to the great majority of people in this country, particularly the poor and disadvantaged. There is considerable demand for small indigenous fishes *viz.* mola (*Amblypharyngodon mola*), chapila (*Gudusia chapra*), tengra (*Mystus vittatus*), pabda (*Ompok pabda*), colisha (*Colisa fasciata*), punti (*Puntius sophore*) and chela (*Chela cachius*) both in rural and urban markets. Landless and marginal farmers and people with low income are unable to afford costly species such as carp.

The need for thorough and long-term investigation on the nutritional value of small indigenous fish is urgently needed. Considering the importance of the small indigenous fish, this study was undertaken to assess the nutritional value of some small fishes available in Bangladesh.

Materials and methods

Fish samples of 23 different small indigenous fish species (SIS) were collected from the local market of Mymensingh during the month of August to September, 1996. Physical data in respect of length and weight of individual fishes were recorded which are shown in Table 1. The fish were then cleaned and ground whole by using a morter and pastel. The ground whole fishes were kept in a deep freezer in air tight container for chemical analysis. Fish muscles were also collected separately from fishes of each species to determine muscle protein content. Triplicate samples of each fish species were used to determine the following chemical compositions.

Moisture : Moisture was determined by keeping fish samples in a thermostat oven at 105°C for 24 hours.

Crude protein : Samples (0.5 g) were digested in digestion unit (Digestor, model 2020) for 45 minutes. The digesta was then distilled in distillation unit (Kjeltec System, Distilling unit, model 1026). Finally it was titrated with 0.2 N HCl and crude protein was obtained by multiplying the total nitrogen by a conversion factor of 6.25.

Crude lipid : Crude lipid was determined by extracting a weighed quantity of sample with acetone in Soxhtec Extraction Unit (model 1045).

Ash : Ash content was determined by igniting fish samples in a muffle furnace at 450°C for overnight.

Gross energy : The gross energy content was calculated from the chemical composition using values of 5.65 and 9.45 Kcal/g for protein and lipid respectively according to Brody (1945). The data are expressed in Kilojoules per gram (1 Kcal = 4.184 KJ)

Calcium : Calcium content of fish carcass was determined by Flame Photometer (Jenway, RFP 7, England) by the method of EDTA titration (Black, 1965).

Phosphorus : Phosphorus content was determined by following the method described by Olsen *et al.* (1954).

Results

The data of average length and weight and proximate analyses of various small indigenous fish are shown in Table 1 and 2 respectively. The results indicate that the range of muscle protein content among the species varied widely (16.16-22.28%). The highest muscle protein was found in Taki, *Channa punctatus* (22.28%) while the lowest value was found in Gulsha, *Mystus cavasius* (16.16%). In general, the muscle protein content of different fishes were higher than there of whole carcass proteins.

Table 1. Average length and weight of various small indigenous fishes used in this study

Sl. No.	Local name/ Common name	Scientific name	Average body length (cm)*	Average body weight (g)*
1	Puti	*Puntius sophore*	8.40 ± 0.5	9.24 ± 1.86
2	Tit puti	*Puntius ticto*	6.30 ± 0.1	3.59 ± 0.35
3	Madhu pabda	*Ompok pabda*	14.30 ± 1.06	19.53 ± 3.72
4	Gulsha	*Mystus cavasius*	9.67 ± 0.76	5.97 ± 2.05
5	Tengra	*Mystus vittatus*	6.67 ± 0.74	2.71 ± 1.22
6	Batashi	*Pseudeutropius atherinoides*	5.70 ± 0.44	1.40 ± 0.26
7	Kajoli	*Ailia coila*	10.97 ± 0.85	6.42 ± 1.22
8	Taki	*Channa punctatus*	15.17 ± 0.45	32.79 ± 4.60
9	Kholisha	*Colisa fasciata*	8.76 ± 0.22	13.36 ± 2.81
10	Boicha	*Colisa sota*	3.90 ± 0.10	1.20 ± 0.06
11	Kakila	*Xenentodon cancila*	16.73 ± 1.18	8.32 ± 1.38
12	Mola	*Amblypharyngodon mola*	5.80 ± 0.44	1.93 ± 0.49
13	Chela	*Chela cachius*	6.27 ± 0.49	1.64 ± 0.08
14	Lamba chanda	*Chanda nama*	4.80 ± 0.26	1.09 ± 0.14
15	Gol chanda	*Chanda ranga*	5.57 ± 0.35	3.57 ± 0.35
16	Chapila	*Gudusia chapra*	9.93 ± 1.43	10.30 ± 3.99
17	Tara Baim	*Mastacembelus aculeatus*	12.43 ± 0.89	6.84 ± 0.29
18	Guchi Baim	*Mastacembelus pancalus*	12.13 ± 3.62	9.79 ± 4.37
19	Bhagna	*Cirrhinus reba*	11.90 ± 0.96	15.21 ± 3.79
20	Kachki	*Corica soborna*	3.47 ± 0.45	0.35 ± 0.12
21	Rani	*Botia dario*	6.80 ± 1.06	4.83 ± 0.93
22	Bheda	*Nandus nandus*	11.43 ± 0.57	23.19 ± 4.49
23	Bialia	*Glossogobius giuris*	-	-

**Mean ± S.D.*

Table 2. Muscle protein, proximate carcass composition and gross energy content of various small indigenous fishes available in Bangladesh (% fresh matter basis)

Sl. No.	Scientific name	Muscle protein	Moisture	Protein	Lipid	Ash	Gross energy (KJ/g)
1	*Puntius sophore*	17.64	71.59	15.77 (55.50)*	7.62 (26.83)	4.84 (17.04)	6.74 (23.73)
2	*Puntius ticto*	19.46	71.00	16.43 (56.66)	7.12 (24.56)	5.22 (18.03)	6.70 (23.10)
3	*Ompok pabda*	16.63	78.67	15.34 (71.91)	3.56 (16.70)	2.35 (11.02)	5.03 (23.60)
4	*Mystus cavasius*	16.16	78.99	13.81 (65.72)	2.26 (10.78)	4.77 (22.68)	4.16 (19.80)
5	*Mystus vittatus*	17.59	79.45	13.07 (63.60)	2.76 (13.44)	4.30 (20.92)	4.18 (20.35)
6	*Pseudeutropius atherinoides*	16.91	76.06	13.92 (58.15)	6.54 (27.53)	3.34 (13.96)	5.88 (24.55)
7	*Ailia coila*	17.57	74.21	13.81 (53.56)	9.55 (37.02)	2.33 (9.02)	7.04 (27.30)
8	*Channa punctatus*	22.28	75.43	17.15 (69.81)	1.87 (7.60)	5.49 (22.34)	4.79 (19.51)
9	*Colisa fasciata*	17 14	74.44	14.14 (55.31)	7.25 (28.40)	3.97 (15.56)	6.21 (24.30)
10	*Colisa sota*	17.10	78.41	13.50 (62.53)	3.26 (15.10)	4.44 (20.57)	4.48 (20.75)
11	*Xenentodon cancila*	21.00	77.98	16.21 (73.60)	2.23 (10.11)	3.48 (15.80)	4.71 (21.40)
12	*Amblypharyngod on mola*	17.04	76.59	14.75 (63.02)	5.15 (21.99)	3.28 (14.02)	5.52 (23.51)
13	*Chela cachius*	18.17	78.09	14.47 (66.03)	4.27 (19.50)	3.15 (14.39)	5.10 (23.32)
14	*Chanda nama*	18.22	78.17	14.40 (66.00)	4.03 (18.50)	3.38 (15.48)	5.01 (22.92)
15	*Chanda ranga*	17.95	77.01	13.41 (58.32)	4.47 (19.44)	4.96 (21.56)	4.94 (21.47)
16	*Gudusia chapra*	18.90	76.68	13.90 (59.61)	4.79 (20.52)	4.50 (19.28)	5.18 (22.20)
17	*Mastacembelus aculeatus*	22.05	78.12	15.32 (70.03)	4.12 (18.82)	2.25 (10.30)	5.25 (24.01)
18	*Mastacembelus pancalus*	19.75	74.68	17.41 (68.77)	4.85 (19.15)	2.82 (11.14)	6.03 (23.83)
19	*Cirrhinus reba*	21.77	71.82	16.62 (59.00)	8.75 (31.06)	2.83 (10.04)	7.39 (26.23)
20	*Corica soborna*	ND	81.94	12.49 (69.15)	3.48 (19.28)	2.08 (11.51)	4.33 (23.97)
21	*Botia dario*	17.02	75.59	14.54 (59.57)	6.55 (26.82)	3.30 (13.52)	6.03 (24.69)
22	*Nandus nandus*	17.69	75.52	14.86 (60.72)	4.86 (19.85)	4.71 (19.24)	5.43 (22.20)
23	*Glossogobius giuris*	17.36	80.43	14.32 (73.19)	1.93 (9.88)	2.94 (15.02)	4.14 (22.21)

*Figures in the parentheses indicate values on dry matter basis.

ND = Not determined

The ranges of carcass moisture content ranged between 71.00 and 81.94%. The highest moisture content was observed in Kachki, *Corica soborna* (81.94%) and the lowest in Tit puti, *Puntius ticto* (71.00%). The moisture content in Madhu pabda (*Ompok pabda*), Boicha (*Colisa sota*), Chela(*Chela cachius*), Lamba chanda (*Chanda nama*) and Tara baim (*Mastacembelus aculiatus*) were more or less similar (78.29 ± 0.25%). The protein content of fish carcass ranged between 12.49 and 17.41% (Table 2). The highest carcass protein content was found in Guchi baim (*Mastacembelus aculeatus*) and the lowest was in Kachki (*Corica soborna*). The carcass protein content in Mola (*Amblypharyngodon mola*), Chela (*Chela cachius*), Lamba chanda (*Chanda nama*), Rani (*Botia dario*) and Bele (*Glossogobius giuris*) were more or less similar (14.50 ± 0.16%). The lipid content varied widely from 1.87 to 9.55%. The carcass lipid content in Chela (*Chela cachius*), Lamba chanda (*Chanda nama*), Chapila (*Gudusia chapra*), Gol chanda (*Chanda ranga*), Tara baim (*Mastacembelus aculeatus*), Guchi baim (*Mastacembelus pancalus*) and Bheda (*Nandus nandus*) were more or less similar (4.48 ± 0.35%). Kajoli (*Ailia coila*) showed the highest (9.55%) and Taki (*Channa punctatus*) showed the lowest (1.87%) carcass lipid content. The ash content of all the fish ranged between 2.08 and 5.22% (Table 2). The highest ash content was observed in Tit puti, *Puntius ticto* (5.22%) and the lowest in Kachki, *Corica soborna* (2.08%). The gross energy content of fish carcass varied between 19.51 and 27.30 KJ/g on dry matter basis. The highest value was obtained in Kajoli (*Ailia coila*) and the lowest was observed in Taki (*Channa punctatus*). The gross energy content in Puti (*Puntius sophore*), Madhu pabda (*Ompok pabda*), Mola (*Amblypharyngodon mola*), Guchi baim (*Mastacembelus pancalus*) and Kachki (*Corica soborna*) were more or less similar (23.74 ± 0.16 KJ/g).

Results of the calcium and phosphorus content of various small indigenous species (SIS) are shown in Table 3. The range of calcium was from 0.85 to 3.20%. The highest calcium content was found in Gol chanda, *Chanda ranga* (3.20%) and Madhu pabda (*Ompok pabda*) showed the lowest value (0.85%). Calcium content in Puti (*Puntius sophore*), Kajoli (*Ailia coila*), Boicha (*Colisa sota*), Bhagna (*Cirrhinus reba*) and Bele (*Glossogobius giuris*) were more or less similar (2.33 ± 0.05%). The phosphorus content ranged between 1.01 and 3.29%. Colisha (*Colisa fasciata*) fish had the highest value (3.29%) and Gulsha (*Mystus cavasius*) showed the lowest (1.01%). Tengra (*Mystus vittatus*), Chela (*Chela cachius*), Chapila (*Gudusia chapra*), Kachki (*Corica soborna*) and Rani (*Botia dario*) had similar phosphorus content (2.39 ± 0.06%).

Table 3. Carcass calcium and phosphorus content of various small indigenous fish available in Bangladesh (% dry matter basis)

Sl. No.	Scientific name	Calcium (Ca)	Phosphorus (P)	Ca/P
1	*Puntius sophore*	2.34 (0.66)*	2.17 (0.62)	1.08
2	*Puntius ticto*	2.87 (0.86)	2.60 (0.78)	1.10
3	*Ompok pabda*	0.85 (0.18)	1.59 (0.22)	0.53
4	*Mystus cavasius*	1.45 (0.30)	1.01 (0.21)	1.44
5	*Mystus vittatus*	2.09 (0.43)	2.39 (0.49)	0.87
6	*Pseudeutropius atherinoides*	1.45 (0.35)	1.77 (0.42)	0.82
7	*Ailia coila*	2.30 (0.59)	2.72 (0.70)	0.85
8	*Channa punctatus*	1.30 (0.32)	1.79 (0.44)	0.73
9	*Colisa fasciata*	2.08 (0.53)	3.21 (0.84)	0.63
10	*Colisa sota*	2.42 (0.52)	1.21 (0.26)	2.00
11	*Xenentodon cancila*	0.94 (0.21)	2.14 (0.47)	0.44
12	*Amblypharyngodon mola*	1.17 (0.27)	1.87 (0.44)	1.34
13	*Chela cachius*	1.84 (0.40)	2.36 (0.52)	0.78
14	*Chanda nama*	2.01 (0.44)	2.14 (0.47)	0.94
15	*Chanda ranga*	3.20 (0.74)	2.78 (0.64)	1.15
16	*Gudusia chapra*	1.43 (0.33)	2.39 (0.56)	0.59
17	*Mastacembelus aculeatus*	1.75 (0.38)	2.56 (0.56)	0.68
18	*Mastacembelus pancalus*	1.70 (0.43)	2.04 (0.52)	0.83
19	*Cirrhinus reba*	2.30 (0.65)	2.78 (0.78)	0.83
20	*Corica soborna*	1.94 (0.35)	2.49 (0.45)	0.78
21	*Botia dario*	1.90 (0.46)	2.34 (0.57)	0.81
22	*Nandus nandus*	2.10 (0.51)	3.09 (0.76)	0.68
23	*Glossogobius giuris*	2.28 (0.45)	1.76 (0.34)	1.29

*Figures in the parenthesis indicates values on fresh matter basis.

The Ca/P ratio varied from 0.44 to 2.00. The highest ratio was observed in Boicha, *Colisa sota* (2.00) and the lowest in Kakila, *Xenentodon cancila* (0.44). Tengra (*Mystus vittatus*), Batashi (*Pseudetropius atherinoides*), Kajoli (*Ailia coila*), Guchi baim (*Mastacembelus pancalus*), Bhagna (*Cirrhinus reba*) and Rani (*Botia dario*) showed the similar values (0.84 ± 0.02).

Discussion

The concentration of protein, lipid, ash and minerals (calcium and phosphorus) are extremely variable among the small indigenous species (SIS). Different species of fish and even strain within a species vary significantly in the nutritional content of the carcass (Refstie and Austreng 1981). The carcass composition is also influenced by housing conditions in cultured species, especially by water temperature (Huisman *et al.* 1979). Research work on the evaluation of proximate composition of SIS of

Bangladesh have not so far been undertaken in detail. Only a few species are reported to subject to analysis of vitamin A and minerals such as calcium, magnesium and iron (Thilsted *et al.* 1997).

The moisture content in the present study ranged between 71.00 and 81.94%. Since the moisture has an inverse relation with size of the fish, the fishes in the present study being small showed comparatively higher moisture content than that obtained by Rahman *et al.* (1982) in small zeol fishes of Bangladesh (70.60 to 80.44%).

The carcass protein content of SIS in the present study varied between 12.49 and 17.41%. CSIR (1962) reported the protein content of some selected fish species in India to be 14.32 -19.8%, which are more or less similar to the values obtained in the present study. The protein content of SIS are also similar to that found in other large carp fish species (rohu, *Labeo rohita*) and the value was 17.91% (Humayun *et al.* 1987). Hossain *et al.* (1997) reported similar protein content (16.7%) in Thai sharpunti (*Puntius gonionotus*). Felts *et al.* (1996) reported 16. 6-19.59% protein content in 100g Indian carp.

The lipid content of SIS in the present study ranged between 1.87 and 9.55%. The carcass fat content was inversely correlated with moisture contents. Such inverse relationship between lipid and moisture has also been reported earlier (Andrews and Stickney 1972). Rahman *et al.* (1982) reported that crude fat content in some Bangladeshi zeol fish was 2.18 - 9.38% which are more or less similar to the values obtained in the present study.

The ash content of all the fish species in present study ranged between 2.08 and 5.22%. The highest ash content was found in Tit puti (5.22%) which is slightly lower than the values reported by Rahman *et al* (1982) in Koi (6.79 ± 1.26%). CSIR (1962) reported that the ash content of some selected fish species in India ranged between 1.53 and 2.60%.

The gross energy content of small indigenous fish species in the present study ranged between 19.51 and 27.30 KJ/g. The calculated gross energy content of Puti, Madhu pabda, Mola, Guchi baim and Kachki were more or less similar to that reported by Henken *et al.* (1986) in African catfish, *Clarias gariepinus* (24.12 ± 0.40 KJ/g). Craig *et al.* (1978) reported that the gross energy content of somatic tissues of *Perca fluviatilis* was 26.04 ± 1.29 KJ/g which are similar to the values obtained with Kajoli, Bhagna and Rani (26.07 ± 1.31 KJ/g).

Minerals such as Ca and P are closely related to metabolism especially in bone formation and the maintenance of acid-base equilibrium in fish. Almost the entire store of calcium (99%) and most of the phosphorus (80%) in the body of are in the form of bones, teeth and scales. The remaining small portions are widely distributed throughout the organ and tissues. Moreover, it has been established that the fish derived inorganic elements such as Ca and P from the surrounding water as well as from diets. Some minerals are easily absorbed by fish from environmental water (Phillips *et al.* 1958). In the present study, the calcium content ranged between 0.85 and 3.20% with the highest in Gol chanda (3.20%) which might be due to its bony structure. Thilsted *et al.* (1997) reported Ca content of 1.06 to 1.26% in 5 minor carps. Ogino and Takeda (1978) found that Ca content of rainbow trout in different experimental group was 0.81-0.82% which are similar to the values obtained in the present study.

The phosphorus content in the present study ranged between 1.01 and 3.29%. The highest value was obtained in Colisha (3.29%). CSIR (1962) reported phosphorus content of 1.20% in sharpunti, *Puntius sarana*. Yone and Toshima (1979) reported that phosphorus content of vertebrae of carp fish was 1.90 ± 0.06% which is more or less similar to the values obtained with minor carps like puti, *Puntius sophore* in the present study.

In Bangladesh, fish is an important source of protein as well as mineral and vitamins. Some SIS fish are very small (<10 cm) and they are typically eaten whole. All small fish contain large amounts of calcium and phosphorous. Big fish like silver carp (*Hypophthalmicthys molitrix*) and rohu (*Labeo rohita*), which are promoted in aquaculture do not contribute significantly to calcium and phosphorous input since the bones are not eaten (Thilsted *et al.* 1997). In countries like Bangladesh where milk and milk products make up only a small amounts of the diet, small fish can be an important calcium and phosphorus source.

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Energetics of resting metabolism in an Indian major carp (*Catla catla* Ham.)

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Abstract

Resting metabolism in Indian major carp, *Catla catla* Ham. fingerlings was investigated. For this purpose a water recirculatory system in the laboratory was used. The metabolic energy losses were determined by the indirect method of oxygen consumption by the fish and was then multiplied by an oxycalorific coefficient (Q_{ox}). Five metabolism chambers in the experimental system were used where there were two same treatment runs in quadruplicate of mean total weight of fish fingerlings of 109.5, 110.4, 112.8 and 111.6g/chamber. The water temperature in the system was 28±0.5°C. The mean metabolic rate in the replicates showed no significant variation ($p>0.05$) and was found to be 151.66, 153.91, 150.25, 152.74 mgO_2/kg/h respectively. This showed an equivalent energy loss 5.40, 5.52, 5.51 and 5.56 KJ/chamber/day (35.60, 35.92, 36.67 and 36.40 KJ/kg/day) respectively.

Key words : Resting metabolism, *Catla catla*

Introduction

A large proportion of the energy budget of a fish is required to maintain metabolic costs needed for maintaining basic bodily functions, activity, digestion, absorption, processing of food etc. It is open to question whether the term "basal metabolism" like in "mammalian species" should be used when referring to measurements of 'minimal' metabolic rates of fish species. In practice, most estimates of the 'minimal metabolism' in studies with fish have been obtained using experimental protocols that are similar to those fasting metabolic rates in domestic animals. However, metabolic rates in fish is usually termed as resting or resting routine metabolic rate where the fish should be post-absorptive with low levels of spontaneous swimming movement in respirometer chamber (Jobling 1994).

Four metabolic rates - standard metabolism, feeding metabolism, routine metabolism and active metabolism can be distinguished in fishes. However, for fish the real standard rate is not often measured, because laboratory fish are rarely motionless. It is better to use resting metabolism for standard rate when the fish is restricted unfed with minimum activity in a minimum confined area with insignificant stress (Chakraborty *et al.* 1992a). Unlike mammals, fishes can not be kept at full rest condition. Thus, it is customary to consider resting metabolism as equivalent to basal metabolism and measured in fishes by keeping them motionless as much as possible. The resting metabolism, results in thermo-neutral environment accompanying the energy cost of maintenance.

Different methods exist in determining the standard or resting metabolism in many fish (Winberg 1956, Holiday and Blaxter 1964, Brett and Zala 1975, Ross and Mckinney 1988, Chakraborty *et al.* 1992a). The energy fish needs comes from the energy stored in the chemical bonds of the food they eat through ingestion or from energy stored in the body. The energy spent for resting metabolism can be estimated by indirect method of calorimetry by measuring oxygen consumption by the fish in water (Brafield 1985). This method is based on the assumption that energy production in fish is an aerobic process and requires oxygen for oxidizing nutrients either from food or the fishes own tissues, although insignificant anaerobic metabolism may also exist in fish (Blazka 1958). Hourly measurement of oxygen consumption of post-absorptive fish over 24 hour periods gives an estimate of total daily energy expenditure.

There have been no report about the study of energetics of resting metabolism on Indian major carp, *Catla catla* which is a delicious and favourite fish throughout the sub-continent. This study as a part of energy budget experiment was designed to determine the pattern and amount of loss of energy in *Catla catla* through resting metabolism in metabolism chamber.

Materials and methods

Experimental fish and acclimatization

Fingerlings of Indian major carp, *Catla catla* Ham. from a single stock of 10 -11g size were collected from Freshwater Station of Bangladesh Fisheries Research Institute, Mymensingh. They were then acclimatized in a plastic pool with adequate water having continuous aeration by an aerator (Daivo, 8200 aerator). The fingerlings were given prophylactic treatment with 3% NaCl dip for 10 minutes and 0.5 mg/l methylene blue. Faecal matters produced by fingerlings were removed by siphoning everyday morning and water of the pool was partly (about 40%) changed with fresh aerated water in order to avoid any environmental stress on fishes. After first two days in unfed condition in the pool the fingerlings were given pelleted diets having 30% crude protein at the rate of about 1% of body weight as maintenance ration. The acclimation of the experimental fish in the pool continued for three weeks. The experiment was conducted in metabolism chambers in a water recirculatory system in the laboratory of Fisheries Technology department of Bangladesh Agricultural University.

The experimental system constructed for this purpose was according to the design made by Chakraborty *et al.* (1992b) where five "slope-partitioned" metabolism chambers of rectangular shape connected with faecal column were used. The third chamber was used as reference chamber and contained no fish whereas the other four chambers contained experimental fishes. The water recirculatory system comprised one sumptank, one header tank and two filtration tank connected by one inch diameter PVC pipe. Water from the sumptank was pumped by an immersion pump to the header tank to distribute the water through a half inch pipe into each of metabolism chambers. The flow of water through this pipe to the metabolism chambers was regulated by ball valves. Each metabolism chamber was provided with a hole at the bottom corner of the upper part so that a 5 mm hole could support an outlet. One, 5mm plastic pipe was fitted through this hole from inside of each of the metabolism chamber and made water tight. This served as an outlet of the chambers. The water entering into the faecal column passed directly either in the filtration or via a flow-meter into the oxygen cuvette to lead into the filtration tank. All the water flow was controlled by three-way-valve. The water being filtered entered into the sump tank. Each of the metabolism chambers received a good supply of air saturated water from the header tank through a small diameter PVC pipe. The continuous and constant water supply was controlled by valves. Normal photoperiod of 12h light and 12h dark was maintained during the experimental period.

Experimental procedure

Ten fishes in four replicates (each fish weighing 10 - 11g) in metabolism chambers were randomly selected from the acclimation pool by a scoop net and weighed by a sensitive balance and then released in the metabolism chamber. Two days before the start of the experiment, fishes in chambers were not fed. The metabolism chambers were named as A, B, R, C and D. The chamber 'R' was used as reference to determine the dissolved oxygen content in the system water and had no fish in it. Whereas, the other four chambers A, B, C and D contained fish. A constant water flow rate of 30 L/h through the flow meter was maintained in all metabolism chambers during direct monitoring of oxygen consumption. After the first day in unfed condition for acclimation in the chambers, fish were subjected to measure the resting metabolic rate for another three unfed days. Twenty four hours hourly measurement of oxygen consumption by the fish in metabolism chambers was done directly by an oxygen probe (Check:Mate, Mettler Toledo Ltd.) set inside the flowing water in cuvette in the system. The oxygen consumption by fish in each chamber was directly measured as mg\l. The values were expressed as $mgO_2/kg/h$ using the following formula :

$$mgO_2/kg/h = \frac{(O_2sat - O_2out) \text{ X water flow rate (l/h) x 1000}}{\text{Weight of fish (g)}}$$

Where, O_2sat = Dissolved oxygen (mg/l) in the reference chamber
O_2out = Dissolved oxygen in the outlet of the metabolism chamber containing fish.

The values were then converted into energy (KJ) by multiplying with suitable oxycalorific equivalent (Brafield 1985). An oxycalorific value of 13.56 J/mgO_2 oxygen (Brett and Groves 1979) was used in determining the resting metabolic rate in this case for starved fish. Hourly mean values over 24h period were calculated in order to obtain the pattern of daily resting metabolic rate and the total amount of energy lost in this respiration.

Results

Table 1 represents the mean oxygen consumption of unfed *Catla catla* in four different replication of the two experimenal runs during normal 12h light and 12h photoperiod. It is seen that the mean oxygen consumption over 24 hours were 151.66 (±4.86), 153.91 (±6.23), 150.26 (±5.69) and 152.74 (±6.06) $mgO_2/kg/h$ for replication A, B, C and D respectively. No significant variation ($p > 0.05$) of resting metabolic rate was found among the four replicate groups during unfed condition. In normal photoperiod of 12 hour light and 12 hour dark regime, *Catla catla* showed a small variation in oxygen consumption. The oxygen consumption over 24 hours period shows a rhythmic respiratory pattern with comparatively higher rate in day light than in the dark (Fig. 1). In the day time the mean values of oxygen consumption were 155.58 (±7.38), 158.75 (±6.71), 163.08 (±9.69) and 159.32 (±8.65) $mgO_2/kg/h$) in the replicates A, B, C and D respectively and were not significantly ($p > 0.05$) different, whereas, the mean values of oxygen consumption during night were less than that in day light (Table 1). The maximum oxygen consumption values were 162, 164, 165 and 161 $mgO_2/kg/h$ in contrast to minimum values of 142, 143, 142 and 143 $mgO_2/kg/h$ in four replicates respectively. However, no significant variation ($p>0.05$) between maximum and minimum values were observed. Considering the oxycalorific (Q_{ox}) value of 13.56J/mgO_2 (Brett and Groves, 1979), the obtained values were converted into energy and found 5.40, 5.52, 5.51 and 5.56 KJ/chamber/day in replication A, B, C and D respectively. This energy when recalculated was found to be 35.60, 35.92, 36.67 and 36.40 KJ/kg/day respectively.

Table 1. Different features of resting metabolism in Indian major carp, *Catla catla* during the experimental peiod

Sl No.	Mean total weight of fish (g) in metabolism chamber	Mean oxygen consumption over 24 hrs (mgO_2/kg/h)	Mean oxygen consumption in light (mgO_2/kg/h)	Mean oxygen consumption in dark (mgO_2/kg/h)	Expended energy in resting metabolism (KJ/chamber/day)	Max. value (mgO_2/kg/h)	Min. Value (mgO_2/kg/h)	Difference (mgO_2/kg/h)
1	109.50 (±2.8)	151.66 (±4.88)	155.58 (±7.38)	148.75 (±4.41)	5.40	162.00	142.00	20.00
2	110.40 (±2.8)	153.91 (±6.23)	158.75 (±6.71)	149.08 (±3.84)	5.52	164.00	143.00	21.00
3	112.80 (±3.0)	150.26 (±5.69)	163.08 (±9.69)	148.74 (±3.46)	5.51	165.00	142.00	23.00
4	111.60 (±2.6)	152.74 (±6.06)	159.32 (±8.65)	144.54 (±4.54)	5.56	161.00	143.00	18.00

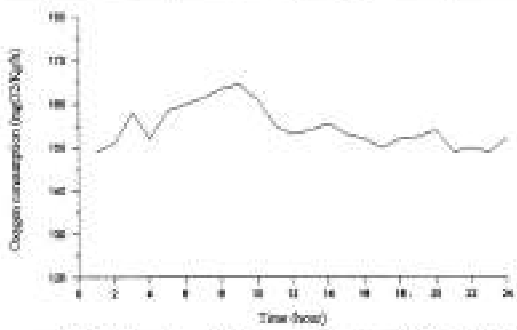

Fig. 1. Mean resting metabolic rate of *Catla catla* over 24 hour period in normal 12h light and 12h dark photoperiod. Time starts at 6.00 am as light period starts (n = 8).

Discussion

The variation in mean metabolic rate in unfed condition during the 24 hours cycle is evident in this study under normal day and light length. The expenditure for resting metabolic rate was found comparatively higher with much larger values during 10 a.m. to 12 am. Many authors have described a single daily peak in the resting metabolic rate (Swift 1962 in *Salmo trutta*, Hirata 1973 in *Salmo salar*, Hamada and Maeda 1983 in *Cyprinus carpio*, Ross and Mckinney 1988 in *Oreochromis niloticus*). Some authors however, have shown crepuscular with two respiratory peaks at dawn and dusk rhythm (Nagarajon and Gopal 1983 in *Sarotherodon mossambicus*, Kumari and Nair 1979 in *Neomocheilous triangularis*). This work has shown a single daily respiratory peak under normal photoperiod.

Water quality in the experimental system has a large influence on metabolic rate of fish (Winberg 1956). In this study the temperature did not vary beyond 28±0.5°C and oxygen concentration was kept about 7.5 mg/L (Values obtained from reference chamber). Moreover ammonia accumulated in the system water was far below the toxic level because a part of water was changed every day in the sump tank and there were two biological filters in the filtration tanks with the main recirculatory system.

It can be seen from the Table 1 that the mean metabolic rate in the light was not much different from that recorded during the dark period. Similar observations were reported by other authors (Winberg 1956 and Chakraborty *et al.* 1992a). There have been reports about the values for oxygen consumption for resting metabolism in different fish species and a large variation is evident (Hamada and Maeda 1983 and Chakraborty *et al.* 1992a). There have been some correlation between the unfed respiratory rates and fish weight used at different environmental condition. Beamish (1964) recorded 48, 104 and 117.3 mgO_2/kg/h of 146, 100 and 134g size respectively in largemouth bass, *Micropterus salmoides*. In other experiment conducted by Kausch (1969) it was found that 10±5g size carp, *Cyprinus carpio* had resting metabolic rate of 80, 136 and 214 mgO_2/kg/h at 10, 15 and 20°C respectively. Huisman (1976) in another experiment with 31 - 47 and 2 - 16g size common carp obtained a resting metabolic rate of 48 and 83 mgO_2/kg/h respectively. Comparatively higher value of 173 mgO_2/kg/h for resting metabolic rate of 318g size common carp were obtained by Hamada and Maeda (1983) whereas Chakraborty *et al.* (1992a) obtained mean resting metabolic rate for unfed common carp of 70±10g size as 152 mgO_2/kg/h. This experiment for mean resting metabolic rate of *Catla catla* was found to be 151 mgO_2/kg/h which shows a quite reasonable value among the reported values.

The mean difference between maximum and minimum oxygen consumption during day light and night in this experiment was 20 mgO_2/kg/h, whereas, a variation of 35 mgO_2/kg/h in *Cyprinus carpio* (70 ±10g) was recorded by Chakraborty *et al.* (1992a). This difference of oxygen consumption may be due to the size and species difference used in the experiment.

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Effect of gibbing on protein hydrolysis during the ripening of salted herring at 4°C in polypropylene barrels

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Abstract

Effect of gibbing process on the protein hydrolysis in terms of free alpha amino nitrogen (FAN) content during the ripening of barrel salted herring at low temperature (4°C) was investigated. For this purpose North Sea herring (*Clupea harengus*) from north-east British coast was salted in polypropylene barrels and allowed to ripen at 4°C. This process of barrel salting was carried out for whole fish in one batch and gibbed fish in another batch. The investigation was performed by using new salt and used salt in separate barrels for each batch of experimental fish. Results of the present study show that protein hydrolysis was significantly higher in the ripened salt-herring produced from whole fish which was found to have more characteristic sensory properties than those produced from gibbed fish. Similar result (proteolysis) was obtained when the investigation was repeated for the spent herring although the spent herring fails to produce a ripened product with the desired characteristic sensory attributes, compared to those of pre-spawning herring.

Key words : Salted herring, Protein hydrolysis, Gibbing

Introduction

Salt preservation of fish is followed by many countries of the world. Fatty fish species, which are difficult to preserve by other processes, produce a characteristic aroma and flavour on salting which is liked by the consumers. Salting is suitable for preserving fish in humid climate too. In Europe salt preservation is practiced for cod, herring and anchovies. Herring (*Clupea harengus*) is preserved by salt in two days, lightly salted 'Maattje herring' and heavily salted herring in barrels. 'Maattje herring' is quite a common commodity in some parts of Europe (notably, The Netherlands) and heavily salted herring is mainly produced in the Scandinavian countries and to a less extent in some parts of Europe.

For the preparation of barrel salted herring the fish is first 'gibbed'. Gibbing denotes a process of removing gill, intestine and stomach in such a way that the pyloric caeca remain in fish. These pyloric caeca contain proteolytic enzymes which are believed to play a role in the development of the desired characteristic flavour of the barrel salted herring. The present study was undertaken to find out the effect of gibbing on the ripening process in terms of characteristic sensory properties, proteolysis taking place during that time, and ripening time. The study was carried out on the ground that, usually pelagic fish eg. herring is caught as schools (several hundred tones per trip) and gibbing of such huge quantity is laborious as well as time consuming. If the fish do not need to be gibbed before barrel salting, this step of processing may be omitted/avoided to save time and labour. The results of the present study was, thus, expected to provide information whether `gibbing' process is necessary during barrel salting of herring.

Materials and methods

Source of fish and salt

Pre-spawning herring (*Clupea harengus*) used in this study was caught from the piper field, Scotland in July. After capture, the fish were pumped from the net through a dewatering device into RSW tanks at -2°C and were brought in polypropylene tanks of about 1 m^3 capacity to the processing factory where the fish were kept chilled until processing by salt.

The post-spawning (spent) fish were caught from off Scarbrough and were carried to the factory as were pre-spawning fish. Morphometric and meristic characteristics of the pre-spawning and post-spawning fish are represented in Table 1.

Table 1. Initial composition and other characteristics of raw herring (*Clupea harengus*)

Parameter	Pre spawning herring	Post spawning herring
Temperature	0.2°C	0.8°C
P^H	6.33	6.21
Moisture	63%	69%
Fat	17%	9%
Histamine	0.29 mg/100g	0.1 mg/100g
Average length	27 cm (22-30)*	29 cm (26-33)*
Average weight	231 g (165-290)*	212 g (143-367)*
Colour	Silvery	Silvery
Flesh/Texture	Firm and Elastic**	Firm and elastic**

* *The range is shown in parenthesis.* ** *By finger feel*

New salt was obtained from Denholm Sea Foods and the used salt was collected from Cawoods Fish Curers of Hull, which had previously been used for dry salting of Cod.

Barrel salting of fish

The herring were divided into two groups: whole herring and gibbed herring. Gibbing was done manually by inserting a knife at the gills and by a very quick and dexterous movement the gill, long gut and stomach were removed. The milt or roe and pyloric caeca remained in fish. The other steps were the same for whole herring and gibbed herring. A ratio of 1 part of salt to 4 parts of fish, by weight, was followed during the process. Rousing, i.e., proper mixing of salt and fish was done in a rectangular plastic container placed on a steel framed table. The rousing box was finely cleaned between each batch preparation of salted herring by whole fish + new salt; whole fish + used salt; gibbed fish + new salt; gibbed fish + used salt. The fish was then packed in poly propylene barrels in the traditional manner. First, a layer of salt was put on the bottom of the barrel, then a layer of fish was placed with belly uppermost and head to tail until the layer was complete. A layer of salt was placed on top and a new layer of fish was laid at right angles to the layer beneath. These alternate layers of salt and fish were continued until the barrel was full. An extra two layers of fish and salt were laid on the top of the filled barrel. After two days, the herring inside the barrel had shrunk due to pickle formation by the body fluids and salt dissolving in it, so the extra layers immersed in the pickle. Then the barrel was finally closed with lid on and made airtight with a galvanized steel collar. In each barrel 100kg fish and 25kg salt was packed. For pre-spawning batch 4 barrels were packed with whole fish+new salt, whole fish+used salt, gibbed fish+new salt, gibbed fish+used salt. Another 4 barrels were similarly packed for post-spawning (spent) herring. The barrels thus prepared were transported to the laboratory by refrigerated vehicle and stored in chill room. All of the processing steps and storage were done in chill room (4°C). During storage chill room temperature was regularly monitored. At the beginning of storage the barrels were periodically rolled on the floor of chill storage. This step is followed by the processors with the belief that the fish ripening will be appropriate, probably by the fine mixing of top layer and bottom layer of brine.

Sampling procedure

Sampling was done once in three months. During each sampling 15-20 fish were taken out from the middle of the barrels for analysis. The long gap of three months between two sampling serve to keep the entry of O_2 to a minimum.

Analytical techniques

Protein hydrolysis: Free alpha amino nitrogen and peptide level during ripening were taken as a measure of protein hydrolysis. Determination of free alpha amino nitrogen was carried out according to the EBC-Ninhydrin method described by Lie (1973). Peptide content was calculated as the difference between the results of TNBS (Tri-nitro-benzene-sulphonic acid) method and EBC- Ninhydrin method. TNBS method was a modification of the method reported by Satake *et al.* (1960). Lie (1973) stated that both the methods give a low response to proline, whereas TNBS, in contrast to ninhydrin, gives a substantial colour yield with peptides. During the experiments for method selection of the present study the TNBS method always gave higher values than the EBC-Ninhydrin for the same sample. This was due to the difference in reactivity towards peptides. Therefore the difference between the results of TNBS and EBC-Ninhydrin was taken as peptide.

Composition of raw unprocessed fish: Moisture and crude protein content was determined according to the methods of AMC (1979), and fat the method described by Bligh and Dyer (1957). Histamine was determined according to the colorimetric method of Hardy and Smith (1976). Horiba compact pH meter C-1 was used to assess the pH of fish and temperature was recorded by the use of an ordinary spear shaped (metallic spear) thermometer.

Salt content (NaCl): NaCl content was determined by the titration of an aliquot of filtered fish homogenate (blended with distilled water) against 0.1 N $AgNO_3$ solution using potassium chromate (5% solution in water) as indicator (AMC 1979).

Results and discussion

Extents of protein hydrolysis during the ripening of pre-spwaning and post-spawning herring are shown in Figs. 1.1 to 1.4. Free alpha amino nitrogen (FAN) increased gradually until ripening of pre and post spawning fish. However, the level was always higher in the whole fish than in the gibbed fish (Figs. 1.1 and 1.2). Peptide content in the pre-spwaning fish decreased during the first half (6 months) of the ripening period then increased gradually until the fish were ripened. In the spent batch the pattern was slightly different, the peptide content slowly increased until 12th months of storage but soon after it decreased until ripening (Figs. 1.3 and 1.4). Whatever the pattern was the peptide content always remained in higher concentration at the whole fish than in the gibbed fish.

FAN in the whole fish and gibbed fish differed considerably during the ripening period. This was expected because the gut enzymes contributed to a higher degree of protein hydrolysis together with the muscle enzymes in the whole fish. Alm (1965) and Voskresensky (1965) suggested that visceral enzymes contribute to proteolysis, although the muscle enzymes play a role (Siebrt 1962). Uyenco *et al.* (1952) observed a higher amino nitrogen content in patis a salted/fermented fish product prepared from whole anchovies than in that prepared from the gutted fish. He, therefore, concluded that the visceral enzymes are the main agents of protein hydrolysis. Results of the present study show again the role of gut enzymes in protein hydrolysis. Among the experimental fish samples gibbed fish always contained a lower concentration of FAN than the whole fish. This suggests that gibbing during the barrel salting of herring reduces the rate of protein hydrolysis during ripening. Organoleptically the muscle of the whole fish was more tender and possessed more characteristic sensory properties than those of the gibbed fish.

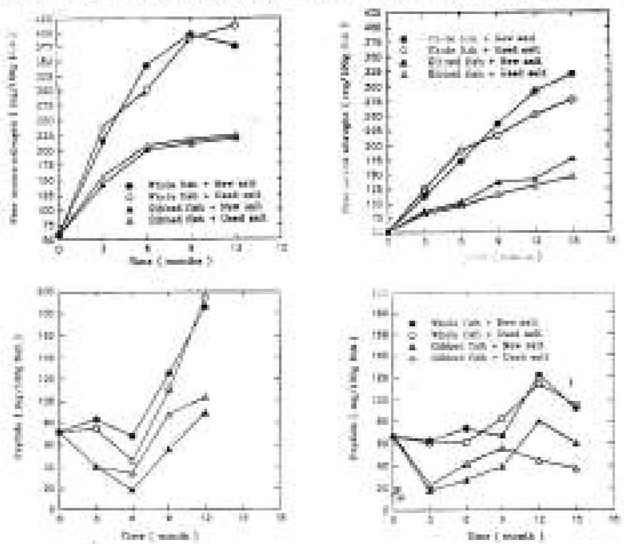

Fig. 1.1. Levels of free alpha nitrogen during the ripening of pre-spawning herring (barrel salted).

Fig. 1.2. Levels of free alpha nitrogen during the ripening of post-spawning herring (barrel salted).

Fig. 1.3. Levels of peptide during the ripening of pre-spawning herring (barrel salted).

Fig. 1.4. Levels of peptide during the ripening of post-spawning herring (barrel salted).

The levels of FAN in the barrel salted with new salt and used salt were almost the same. The used salt was previously used for dry salting of cod and is likely to be contaminated with halophiles. Yet the fish barrel salted with such used salt did not show any significant difference in the level of FAN during ripening. This indicates that salt purity had no significant role in the protein hydrolysis during ripening. Studies on the role of bacteria in proteolysis during the ripening of barrel salted herring are few. However, Orejana and Liston (1981) studied the role of bacterial proteolytic enzymes during salting/fermentation of patis and found that these bacterial enzymes do not play any significant role in the proteolysis. They concluded that the endogenous fish enzymes are the major and perhaps the sole agents responsible for the proteolysis in the fish sauce process. During barrel salting, the fish muscle is neither liquefied nor digested and the degree of proteolysis is not as much as in the salted/fermented fish preparations but the principle of protein hydrolysis is likely to be the same. The role of bacterial proteolytic enzymes in ripening would be similarly the least. The salt concentration in the fish samples during ripening were between 12-22% and bacteria clearly do not flourish in such high salt environment (Orejana and Liston 1981).

It has been mentioned that the pattern of peptide level was slightly different than that of the FAN. In the pre-spawning fish the levels of peptide declined during the first six months of ripening and then increased gradually until the samples were ripened. This suggests that the rate of peptide hydrolysis to amino acids during the first six months of ripening exceeded the rate of protein hydrolysis to peptides. Orejana and Liston (1981) reported that, in patis fermentation, the apparent initial inhibition of trypsin-like activity might be due to inhibitors in fish blood or substances produced by bacterial flora of the fish. In the present study inhibition due to factors in fish blood is more likely because the salt concentration inhibits bacterial activity. Again peptide concentration, like FAN concentration, was higher in the whole fish than the gibbed samples. This suggests the involvement of proteolytic enzymes from the gut. Salt purity seemed to have little effect on the levels of peptide during the ripening time. In the spent batch the peptide concentration increased gradually until ripening, although there was slightly decline in the level of peptide immediately before ripening. The reason may again be the rate of peptide hydrolysis exceeded the rate of protein hydrolysis to peptide. However, peptide content was always higher in the whole fish than in the gibbed fish. Salt purity did not have any significant effect on peptide content. The peptide content, like the FAN, in the different groups of samples were significantly influenced by the inclusion of gut, i.e. by gibbing in the way that 'gibbed' process reduces the rate of protein hydrolysis during the ripening of barrel salted herring at 4°C in polypropylene barrels.

Organoleptically the whole fish samples were found to ripen quicker and possessed more characteristic sensory properties eg. flavour and texture, than those of the gibbed fish. In general the phenomenon 'protein hydrolysis' is believed to play a role in the development of characteristic sensory properties of ripened herring. Since the rate and extent of protein hydrolysis was higher in the whole fish samples, so it gave better sensory properties in the ripened herring produced from the whole fish samples. Results of the present study lead to the conclusion that the gibbing process reduces the rate of protein hydrolysis during the ripening of salted herring at 4°C in polypropylene barrels which ultimately reduces the rate of ripening and characteristic sensory properties. However, it should be mentioned here that the spent herring failed to produce a ripened product with the desired sensory attributes compared to those of prespawning herring.

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Scientific Notes

Length-weight relationship and condition factor of black carp (*Mylopharyngodon spiceus* Richardson) in Bangladesh

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Abstract

The length-weight relationship and condition factor of *Mylopharyngodon spiceus* were determined. The result of the study showed the dependence of weight (W) on the total length (L) in the following form: $W = 0.006L^{3.06}$ or in the logarithmic form Log W = - 2.1851 + 3.156 Log L. Standard errors of length and weight were 0.674 cm and 3.214 g respectively. The co-efficient correlation "r" was found to be 0.972 which indicated that the relationship between length and body weight of the fish was highly significant. The t - test also indicated that the correlation between length and weight was significant. The range and mean value of condition factor (K) were 0.865 to 1.041 and 0.958 respectively.

Key words : Length-weight relationship, Condition factor, Black carp

Mylopharyngodon spiceus is a indigenous foodfish of China, locally known as " black carp " or "snail carp". The fish is well adopted in the integrated fish farming systems in China and it is the largest species with an observed weight of 70 kg among the Chinese major carps (Peirong 1989). It has been introduced in many Asian countries including Bangladesh and among 5 commercially important exotic species, black carp is one of them (Rahman 1985). According to Medawar's First Law of growth (1945) size is a monotonic increase function of age. Among the different biological aspects of fish, length-weight relationship and condition factor are very important for scientific culture and management of the fish and great biological interest of it. There are many published reports on the length-weight relationship of different species of fishes which are important in fishery management and culture. But no work had been done on length-weight relationship of black carp in Bangladesh. Considering the above importance, the present experiment had been undertaken.

The samples were randomly collected from the selected ponds with the help of seine net at seven and fifteen days intervals. A total of 61 fishes were taken for the study. The total length of each fish was measured from the anteriorly projecting part of the head to the farthest tip of the caudal fin. The length was recorded in cm and weight in g. The length-weight relationship was determined by the equation of $W = aL^n$ -------------------------- (1)

where, W=weight, L=length, a=constant and n=exponential value.

The value of n and a were calculated using the log-log relation in the formula :

$$\text{Log } W = \text{Log } a + n\text{Log } L \quad \text{------------------} \quad (2)$$

The value of n will be exactly 3.0 when growth is isometric in the length-weight relationship of fish (Ricker 1963). But the value of n in fish usually lies between 2.5 to 4.0 (Hile 1936). The value of Log a and n in formula (2) were calculated by using the following mathematical relationship:

$$n = \frac{\Sigma \text{LogW. LogL} - N\,\overline{\text{LogW}}.\,\overline{\text{LogL}}}{\Sigma(\text{LogL})^2 - N\,(\overline{\text{LogL}})^2} \quad \text{------} (3)$$

$$\text{and Loga} = \overline{\text{LogW}} - n\overline{\text{LogL}} \quad \text{------} (4)$$

where W = weight in grams, L = length in cm and N = sample size.

The co-efficient of correlation "r" was calculated with formula :

$$r = \frac{\Sigma xy - \frac{(\Sigma x \Sigma y)}{N}}{\sqrt{[\{\Sigma x^2 - \frac{(\Sigma x)^2}{N}\}\{\Sigma y^2 - \frac{(\Sigma y)^2}{N}\}]}} \quad \text{------} (5)$$

The standard error for regression of y on x and vice versa was calculated by the formulae :

$$Sx = \delta x\sqrt{(1 - r^2)} \quad \text{------} (6)$$

$$Sy = \delta y\sqrt{(1 - r^2)} \quad \text{------} (7)$$

t - test was done by the formula :

$$t = \frac{r\sqrt{(N - 2)}}{\sqrt{(1 - r^2)}} \text{ with d. f.} \quad \text{------} (8)$$

The condition factor, K was calculated for determining the condition of fish such as the degree of well being. The values of K were determined with the help of the formula :

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

where, W = weight in gram, L = length in cm and K is the factor of proportion (Dewan and Doha 1973). Table 1 represented the length-weight relationship. The values of n and Log a obtained were 3.156 and -2.1851, respectively. Therefore, the logarithmic form of the equation for the total length and body weight relationship is Log W = -2.1851 + 3.156Log L. The value of n obtained in this experiment was above 3 which indicated that the growth of *Mylopharyngodon spiceus* was allometric and weight increased at a rate higher than the cube of their growth.

Table 1. Length-weight relationship and condition factor of *Mylopharyngodon spiceus*

Sample size	Mid point of TL (cm)	Log of mid point =LogL	Mean weight W (g)	Log W	Calculated Log W	Calculated weight W (g)	Condition factor $K=\frac{W.10^3}{L^3}$	Value of K for calculated W $K=\frac{W.10^3}{L^3}$
10	7.5	0.8750	3.80	0.5798	0.5764	3.47	0.900	0.82
10	8.5	0.9294	5.88	0.7694	0.7481	5.15	0.957	0.84
5	9.5	0.9777	7.84	0.8943	0.9005	7.31	0.914	0.85
9	10.5	1.0212	10.02	1.0009	1.0378	10.02	0.914	0.85
6	11.5	1.0607	15.08	1.1784	1.1625	13.36	0.991	0.88
3	12.5	1.0969	18.83	1.2749	1.2767	17.38	0.964	0.89
3	13.5	1.1303	22.83	1.3585	1.3821	22.16	0.927	0.90
7	14.5	1.1614	30.78	1.4883	1.4802	27.76	1.009	0.91
5	15.5	1.1903	38.80	1.5883	1.5715	34.26	1.041	0.92
3	16.5	1.2175	45.67	1.6596	1.6573	41.74	1.016	0.93

The calculated values of co-efficient of correlation and standard error of length (Sx) and weight (Sy) were 0.972, 0.674 cm and 3.214 g, respectively. The value of correlation co-efficient indicated that the relationship between total length and body weight was very strong. The calculated value of "t" obtained was 11.743 and tabulated values of "t" at 1% and 5% level of significance with 8 degree of freedom are 3.355 and 2.306, respectively. So, the calculated value of "t" is greater than the tabulated values which indicated that the correlation between length and weight was highly significant.

The mean values of observed weight and calculated weight (Table 1) were plotted against the means total length. A slightly fluctuating and almost regular curves were found for the observed and calculated weights, respectively (Fig. 1). Slight differences between observed and calculated weight in certain length were obtained but the correlation between observed weight and calculated weight was good. The fluctuations obtained in certain length group might be due to variation in sample size, time of collection and gut contents. Again, the curves A and B (Fig. 1) were found to increase more or less rapidly at an unusual rate from the lower left to the upper right during the remainder of the curve which might be due to much gain in weight with the increase in length of the fish. Similar observations were also stated by Quddus *et al.* (1987) in their study with *Labeo rohita*.

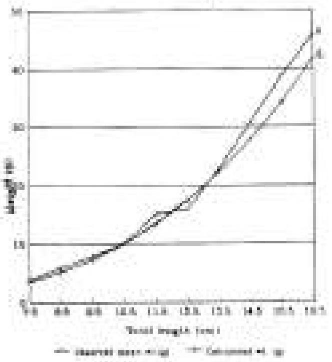

Fig. 1. Relationship between total length and body weight.

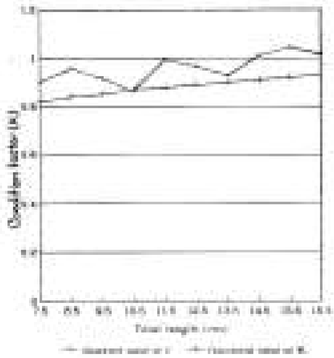

Fig. 2. Relationship between mean lengths and K values.

The mean value of condition factor, K was obtained to be 0.958. Plotting the values of K against the total length, a fluctuating curve was found (Fig. 2). The curve showed certain variations in different lengths. A nearly straight line was obtained when the calculated values of K were plotted against the mean values of total length and the line gradually increases from the left to upper right with the increase in length (Fig. 2).

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Scientific Notes

Colossal loss of shell and fin-fish larvae during collection of *Penaeus monodon* (Fab.) fry in the rivers of Satkhira

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Abstract

This study was conducted in five river-estuaries of Satkhira from January to December'96. It was found that during the collection of each *Penaeus monodon* postlarva (PL), about 45 larvae of other shrimps, 12 individuals of fin-fishes and 530 macro-zooplankters were mercilessly destroyed. It was also recorded that about 11.6 million of *P. monodon* PLs were harvested annually from the study area. The study implies that colossal loss of shell and fin-fishes and other plankton resources is done by tiger shrimp fry collectors, and such massive destruction adversely affect the natural productivity and ecological balance of the coastal environment.

Key words : Colossal loss, *P. monodon* fry, Finfish larvae, Shellfish larvae

Traditional or extensive shrimp farming being practiced in the greater Khulna region of Bangladesh mainly depends on the availability of wild tiger shrimp fry. The common culturable shrimps in the vicinity of the Sundarbans are *Penaeus monodon*, *P. indicus*, *Metapenaeus monoceros* and *Macrobrachium rosenbergii* etc. (Nasker and Chakraborty 1984) but particularly in Khulna region, *P. monodon*, locally known as "bagda" is considered to be the most important culturable species. Due to horizontal expansion of shrimp cultivation and shortage of hatchery produced shrimp fry in the country, wild *P. monodon* postlarvae (PL) are collected extensively from the natural stock throughout the coastal area. High demand of tiger shrimp fry, low investment but high income have stimulated thousands of poor coastal people to be engaged in shrimp fry collection. Push net and set bag net are extensively used in shrimp fry collection, after every haul the whole catch along with debris is taken in bowls made of plastic, aluminium or clay by splashing water on the net. The *P. monodon* PLs are sorted out quickly from the catch by the collectors themselves or their family members and the rest is discarded and thrown along the shore.

Some interesting information on zooplankton with emphasis on shrimp and fin fish larvae were given by various authors (Funegaard 1986, Begum 1984, Hossain 1984, Elias 1983 and Ahmed 1981). Mahmood (1990) followed by others (Islam *et al.* 1996 and Rahman *et al.* 1997) gave the first information on the quantum of damage caused to zooplankton while fishing *P. monodon* fry in the estuarine waters of Chakaria, Sundarbans, Satkhira, Khepupara, Bhola and Barguna. Considering the importance of this topic of research, a year-round study was undertaken to assess the distribution of *P. monodon* PL and to quantify the damage done to different shrimp and fin-fish larvae and macro-zooplankton during collection of *P. monodon* PL in the five rivers of Satkhira district.

Samples were collected from three selected spots of each of the five rivers of Satkhira district from January to December 1996. Fortnightly sampling was done by a fine meshed (1.0 mm) push net made of nylon with bamboo split frame (1.6m x 0.6 m) locally called "Tana jal". The net was manually operated in the shallow water against the current for about 10 minutes (for each haul). Sampling was done twice per day during low and high tides. Samples were immediately stored in a plastic pot and preserved with 5% buffered formalin solution after collection. Laboratory analysis was done within two weeks from the date of collection, penaeid shrimp larvae were identified upto species level following Muthu (1978) and Motoh and Buri (1980). Macro-zooplankters including other shrimps and fin-fishes were identified as major taxonomic groups following George (1969) and Fischer and Witchead (1974). Salinity of water was recorded with the help of a hand refractometer (model, Atago, S/Mill, 0-100%o) and temperature of water was measured by an alcohol thermometer.

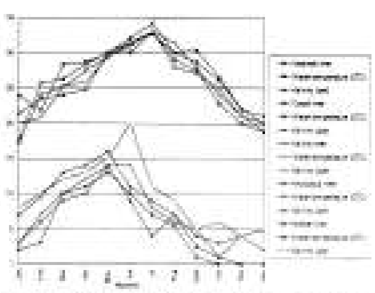

Fig. 1. Water temperature and salinity of five rivers of Satkhira.

Average monthly values of water temperature and salinity are presented in Figure 1. Water temperature were found to vary between 17.3 and 34.2°C in the five rivers. The highest temperature (34.2°C) was recorded in the Mother river in July and the lowest (17.3°C) in the Kholpatua in January. Salinity varied from 0 to 20 ppt in different rivers having different patterns, possibly due to monsoon effect, river run-off and land drainage. However, salinity was found to increase gradually during post monsoon.

Monthly distribution (individual/unit effort) of *P. monodon* PL, larvae of other shrimps, fin-fishes and macro-zooplankters in different rivers of the Satkhira district has been shown in Table 1. Data reveal that during freshwater regime in the Ichamati and Coxali rivers *P. monodon* PL was absent, became poorly available during December through June in other rivers except in Mother. On the other hand, abundance of other shrimp species were found to increase during the months of August through December and maximum was recorded in December. But, in March no larvae of other shrimp was found in Kholpatua river. During postmonsoon comparatively higher abundance of fin-fishes and other zooplankton were observed than the other part of the year which is in agreement with the finding of Rahman *et al.* (1997) in the Barguna area where the authors indicated that low salinity and temperature are probably the vital factors influencing greatly the larval distribution of aquatic organisms.

Table 1. Monthly distribution (Individual/unit effort)* of *Penaeus monodon*, other shrimp seeds, fin fishes and other macrozooplankton in different rivers of Satkhira region'96

Major groups	Month												Yearly total	%
	J	F	M	A	M	J	J	A	S	O	N	D		
Ichamati river														
P. monodon	1	-	-	-	1	1	-	-	-	-	-	-	3	0.06
Other shrimp	11	6	2	1	4	7	5	13	17	76	60	61	264	5.18
Fin fishes	1	9	2	5	1	4	2	10	1	1	23	21	80	1.57
Other macrozoo plankton	951	2	10	6	19	112	25	384	44	23	1385	1788	4749	93.19
Total number	964	17	14	12	25	124	32	407	62	100	1468	1870	5096	100.00
Coxali river														
P. monodon	-	1	1	-	-	-	-	-	-	-	-	-	2	0.33
Other shrimp	2	4	2	2	2	30	4	10	15	8	15	3	97	16.03
Fin fishes	3	1	1	2	-	1	2	4	1	1	2	6	24	3.97
Other macrozoo plankton	85	3	3	7	12	23	19	91	6	11	105	117	482	79.67
Total number	90	9	7	11	14	54	25	105	22	20	122	126	605	100.00
Kalindi river														
P. monodon	1	-	-	-	-	-	-	1	-	1	-	1	4	0.18
Other shrimp	11	10	15	2	3	8	4	15	21	33	43	55	220	9.84
Fin fishes	2	1	-	8	3	4	3	4	2	2	7	10	46	2.06
Other macrozoo plankton	593	5	6	5	38	58	31	102	102	30	45	950	1965	87.92
Total number	607	16	21	15	44	70	38	122	125	66	95	1016	2235	100.00
Kholpatua														
P. monodon	1	1	-	-	-	-	-	-	-	-	-	1	3	0.05
Other shrimp	11	10	15	2	3	8	4	15	21	33	43	55	220	9.84
Fin fishes	2	1	1	6	5	3	2	4	1	2	12	14	53	0.92
Other macrozoo plankton	550	3	-	6	57	211	101	591	10	840	1298	1924	5591	96.565 591
Total number	586	10	1	13	70	223	110	605	26	846	1333	1997	5790	100.00
Mother river														
P. monodon	1	1	-	-	1	2	-	-	-	-	-	1	6	0.24
Other shrimp	2	5	7	3	6	11	7	8	16	27	8	11	111	4.46
Fin fishes	1	4	2	2	1	2	4	17	1	1	5	9	51	2.05
Other macrozoo plankton	285	2	4	4	36	46	37	364	28	816	343	360	2323	93.25
Total number	289	12	13	9	44	61	48	389	45	844	356	381	2491	100.00

* *Operating a drag net (1.60 × 0.6 m) for about 10 minutes as a unit effort.*

P. monodon PL was found to occupy a very small portion of the zooplankton community, such as 0.06% in Ichamati, 0.33% in Coxali, 0.18% in Kalindi, 0.05% in Kholpatua and 0.24% in Mother river. Other shrimps (*P. indicus, Metapenaeus monoceros, M. brevicornis, Palaemon styliferus, Macrobrachium rosenbergii, M. rudi* and other palaemonid species) including fin fishes (*Liza parsia, L. tade, Rhinomugil corsula, Lates calcarifer, Setipina phasa* and *Glossogobius* spp. etc) occupied 6.75, 20.00, 11.90, 3.39 and 6.51% in Ichamati, Coxali, Kalindi, Kholpatua and Mother river, respectively.

The catch composition and the extent of damage caused to macrozooplankton as a result of indiscriminate exploitation of *P. monodon* PL are presented in Table 2. It was found that on an average in the total catch composition, *P. monodon* PLs occupied 0.17%, other shrimp 7.60%, fin-fishes 2.11% and other macro-zooplankton 90.12%. Considerable variations in monthly as well as yearly catch composition is in different rivers are evident (Table 1). The results obtained revealed that for catching a single postlarva of *P. monodon*, the fry collectors destroy about 45 other shrimp, 12 fin fish and 530 other macro-zooplankton. According to Mahmood (1990) for fishing a single "bagda" fry, 14 other shrimp, 21 fin fishes and 1631 zooplanktons were destroyed. The cause of such great variation was possibly due to use of nets having difference in mesh sizes. Mahmood (1990) used a rectangular nylon net with smaller mesh size (0.5 mm). The mesh size of the net used in the present study was 1.0 mm which is similar to that used by shrimp seed collectors. Thus, smaller zooplankton escapes through large meshes (1.0 mm) of net used in present study. The tremendous loss of valuable larval fish resources was also reported by BOBP (1992) and Khan *et al*. (1988).

Table 2. Average catch composition of *P. monodon*, other shrimp spp, fin fishes and other macrozooplankton in five different river-estuaries of Satkhira

Major taxa	Yearly average catch (%)	Number of other species destroyed for each *P. monodon* PL collection
P. monodon	0.17	
Other shrimp spp.	7.60	45
Fin fishes	2.11	12
Other macrozooplankton	90.12	530
Total	100.00	587

Observation on the number of seed collectors/Km, length of the river, number of boat and hour of engagement reveals that 0.56 million man days/year are involved in shrimp fry fishing activities in Satkhira district. Variable information on the same due to the variation in place and season/time was referred by several authors. Funegaard (1986) stated that

20,000-25,000 people were engaged in shrimp fry collecting in Satkhira district while according to Chowdhury (1990) about 75,000 fry collectors were observed only in Satkhira district. It was found that about 11.60 million *P. monodon* fry were collected in Satkhira during 1996 while it was more (18.0 million) in 1992 (BFRI 1997). Funegaard (1986) reported that about 2000 shrimp fry/net/day were collected by catchers of Satkhira district in 1982 which was found to decline at 200 fry/net/day in 1986 (Alam 1990). So, the findings of the above studies and the present study reveal that there has been a trend of gradual reduction in the abundance of different kinds of PL of crustacean, fin-fish larvae and other zooplankton in neritic and inshore waters which may be due to over harvesting and indiscriminate fishing of zooplankton that hinder the usual recruitment pattern to the original mother stock, and it is a great threat to the natural biodiversity protection mechanism

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