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Physiological observations on a diatom *Skeletonema costatum* (Greville) Cleve

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Abstract

A chain-forming diatom *Skeletonema costatum* (Greville) Cleve collected from Yatsushiro Sea, Japan was cultured to determine the optimum level of some physico-chemical factors for their growth under laboratory conditions. Filtered and sterilized aged sea water enriched by adding nutrient solution (Provasoli 1968) was used as the culture medium. The plankton could tolerate a wide range of salinities (3-55 ppt). Optimum growth was observed at salinities of 20-35 ppt, temperatures of 20-25°C, light intensities of 80-120 $\mu E\ m^{-2}\ sec^{-1}$ and pH between 7.5 and 8.0. Growth did not occur at salinities below 3 ppt and at temperatures above 30°C. From the present study, it is concluded that *S. costatum* was extremely euryhaline and tolerable to very low salinities.

Key words : Diatom, *Skeletonema costatum*, Physico-chemical factors, Euryhaline

Introduction

Mass culture of marine microalgae has received much attention recently due to their potential use as live feed in the culture of zooplankton and rearing larval forms of commercially important crustaceans, molluscs, and fishes. Diatoms have for many years been recognized as an extremely important source of food for planktonic animals. It provides one of the few practical means of feeding aquatic filter feeders and, without doubt, is the most important food for the pelagic copepods and indirectly for the fish larvae.

Skeletonema costatum is widely distributed, euryhaline and abundant in estuaries, particularly in the spring. In both fresh and marine waters, this species is ingested by lower animals (protozoa, insect larvae, copepods and rotifers) which in turn are eaten by higher animals such as fish. In many countries this diatom is considered as one of the best algae for feeding prawn larvae. This species is also very important due to its potential use as valuable assay organism for examining water quality. Sanchez *et al.* (1995) suggested that *S. costatum* can serve as a good biological source of proteins and fatty acids.

S. costatum, in some situations, can have a negative effect, forms heavy blooms when gets suitable environment due to eutrophication and causes economic losses to aquaculture. This microalga is a major component of most plankton blooms, observed in eutrophic waters, particularly associated with toxic microorganisms in USA, Romania, France, Norway, Uruguay, China, Japan and Hongkong.

The abundance of phytoplankton in nature is regulated by a multitude of environmental factors such as nutrients, light, temperature, salinity, and grazing. Iwasaki (1979) mentioned that knowledge of the physiological characteristics of phytoplankton is indispensable for understanding their growth mechanism.

Ecological and physiological parameters may vary for different strains of same species of algae. Honjo (1993) reported five different optimum salinities for five different strains of *Heterosigma akashiwo* (Hada) Hada. There are some studies on the occurrence, morphology and autecology of *S. costatum* (Medlin 1991, Blanchemain *et al.* 1994). There is no published report on the effects of physico-chemical factors on the growth of *S. costatum* in Yatsushiro Sea, Japan. The purpose of this study was to determine the effects of temperature, salinity, light intensity and pH on the growth of Yatsushiro Sea's strain of *S. costatum*.

Materials and methods

Skeletonema costatum used in this study was collected in 1991 from Yatsushiro Sea, Japan. An axenic culture was established by using the micropipette washing method. Stock cultures were grown in Provasoli's ES medium (Provasoli 1968) at 25 ± 1°C, light intensity 60 $\mu E\ m^{-2}\ sec^{-1}$ and photoperiod 12:12-h, L:D cycle.

Growth was determined at temperatures from 15-40°C in 5°C intervals, salinities from 0-65 parts per thousand (ppt), pH from 6.5 to 9.5 in 0.5 intervals and with irradiance adjusted to 10, 20, 40, 80, 120 and 200 $\mu E\ m^{-2}\ sec^{-1}$. Two salinity series (one spanning 0-5 ppt in 1 ppt intervals to determine minimum salinity for growth, and the other 5-65 ppt in 5 ppt intervals) were established by evaporating filtered Kagoshima Bay water (34.6 ppt) to get higher salinity media and by diluting with deionized water to get lower salinity media. The pH of the medium was adjusted by addition of 1 N HCl or 1 N NaOH.

Culture media were autoclaved for 15 min at 121°C, and aged for several days prior to inoculation. Before starting the experiment the algae were acclimated to the experimental condition for at least two generations. Cells of mid logarithmic growth phase were used for inoculation to ensure that the cells were nutritionally replete. Sterilized micropipette were used to transfer the inocula. Individual growth medium in the culture tubes was gently shaken once a day for accelerating growth and to avoid settlement of algal cells. All growth studies were done in triplicate. The cell concentration was determined by direct counting by using a Sedgewick-Rafter chamber. Counts were made immediately after inoculation and then each other day up to 10 days. For reducing errors due

to possible synchronous divisions counts were made at the same time each day. The average number of cell divisions per day (K) for the 6-day growth period was calculated from:

$$K = \ln \frac{C_t}{C_0} \left(\frac{1}{t \ln 2}\right)$$

where, C_t and C_0 are cell concentrations at times t and 0, respectively (Guillard 1973).

Division rates under different conditions were subjected to analysis of variance (ANOVA) (Statview S.E. + Graphics, Abacus. Concepts, Inc.). Significant differences among the means were determined using Duncan's multiple range test (DMRT) (Gomez and Gomez 1984).

Results

Growth of *Skeletonema costatum* at different salinities and at constant temperature (25°C), irradiance (60 µE m^{-2} sec^{-1}) and pH (8.2) is shown in Figs. 1-3. The plankton could tolerate a wide range of salinities (3-55 ppt). It grew well at the salinity range of 20-35 ppt. The maximum cell density 11.46 $x10^5$ cells ml^{-1} was found at 20 ppt on the 6th day (Fig. 2). No lag phase was exhibited at salinities from 10-45 ppt with the exponential growth from the 2nd to 6th day. The alga failed to grow below 3 ppt but cells were able to survive up to 8 days at 2 ppt. At 0 and 1 ppt no living cells were found after 2 days and 5 days, respectively (Fig. 1). Cultures at higher ranges of salinity (50-55 ppt) exhibited a short lag phase (2 days). The exponential growth was found from the 4th to 8th day with maximum growth on the 8th day at higher salinities (Fig. 2). Neither increase nor decrease in cell numbers occurred in the media at 60 ppt by the 4th day and thereafter the number of cell started to decline. No growth was observed at 65 ppt and the rate of survivability was transient.

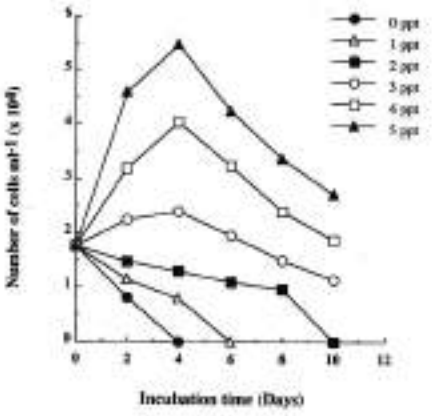

Fig. 1. Growth curves of *S. costatum* in media of low salinities (0-5 ppt).

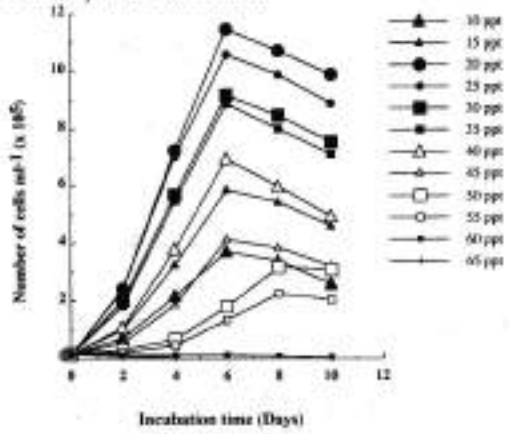

Fig. 2. Growth curves of *S. costatum* in media of medium (10-45 ppt) and high salinities (55-65).

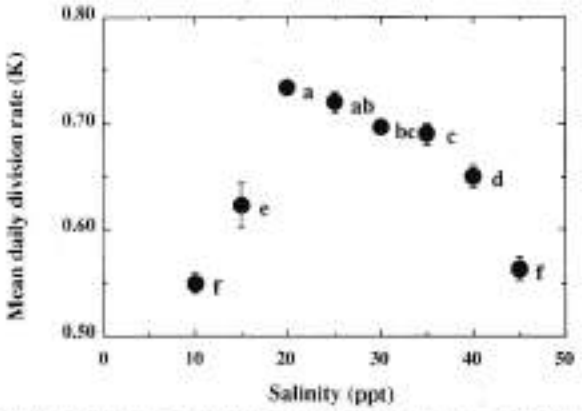

Fig. 3. Mean daily division rate of *S. costatum* at different salinities. Each point and vertical line represent mean ± SD for three replicates. Means with different letters are significantly different (Duncan's multiple range test, $p < 0.05$).

Analysis of variance (ANOVA) showed that the difference in mean daily division rate at various salinities were highly significant. The highest mean daily division rate (0.73 divisions day^{-1}) was observed at 20 ppt which was not significantly higher than at 25 ppt (Fig. 3). The division rate of the plankton in relation to different salinities showed that the growth tends to increase from 10 to 20 ppt and showed a slow declining trend up to 40 ppt then a rapid declining trend from 40 ppt (Fig. 3).

The relationship between growth and temperature at constant salinity (30 ppt), irradiance (60 µE m^{-2} sec^{-1}) and pH (8.2) is presented in Figs. 4 and 5. The plankton was cultured at different temperatures from 15 to 40°C in 5°C intervals. The maximum cell density 9.80 x 10^5 cells ml^{-1} was at 20°C on the 6th day. No lag phase was exhibited at temperatures from 20 to 25°C with the exponential growth from the 2nd to 6th day. The alga failed to grow at 35°C but cells were able to survive up to 6 days. At 40°C, no living cells were found on the second day after inoculation.

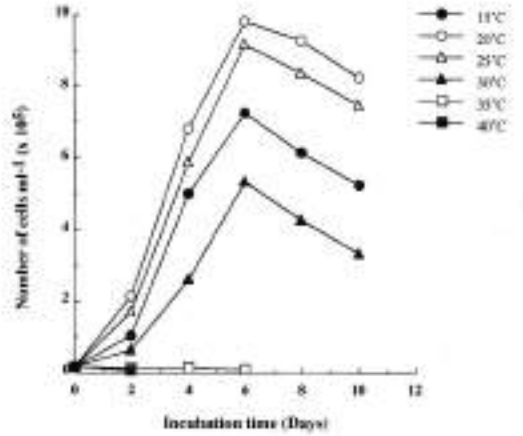

Fig. 4. Growth curves of *S. costatum* at different temperatures.

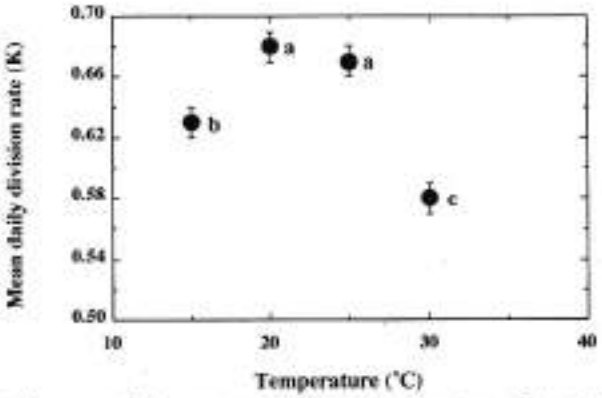

Fig. 5. Mean daily division rate of *S. costatum* at different temperatures. Each point and vertical line represent mean ± SD for three replicates. Means with different letters are significantly different (Duncan's multiple range test, $p < 0.05$).

The division rate of the plankton in relation to different temperature levels shows that the growth tends to increase from 15° to 20°C and then shows a declining trend (Fig. 5). The highest division rate 0.68 divisions day^{-1} was observed at 20°C which was not significantly higher than at 25°C. The mean division rate decreased significantly with increasing temperature of above 25°C.

Growth of *S. costatum* at different pH's with the fixed temperature (25°C), salinity (30 ppt) and light intensity (60 µE m^{-2} sec^{-1}) is shown in Figs. 6 and 7. During the course of the experiment, the final pH of the culture media changed slightly (within 0.05 pH units) from the initial pH. The maximum cell density (10.37 x 10^5 cells ml^{-1}) was recorded at pH 7.5 on the 6th day. The rapid growth was found at pH 7.0-8.5 without passing any lag phase. The highest division rate (0.73 ± 0.01 divisions day^{-1}) was observed at pH 7.5 which is not significantly higher than at pH 8.0 (0.72 ± 0.01 divisions day^{-1}) (Fig. 7). Again pH 7.0 and 8.5 were equally effective. Slower growth was found at pH 9.0 and 9.5 with maximum cell yields of 5.77 x 10^5 and 4.89 x10^5 cells ml^{-1}, respectively on 6th day of culture. Poor growth was found at pH 6.5 with 2 days of lag phase.

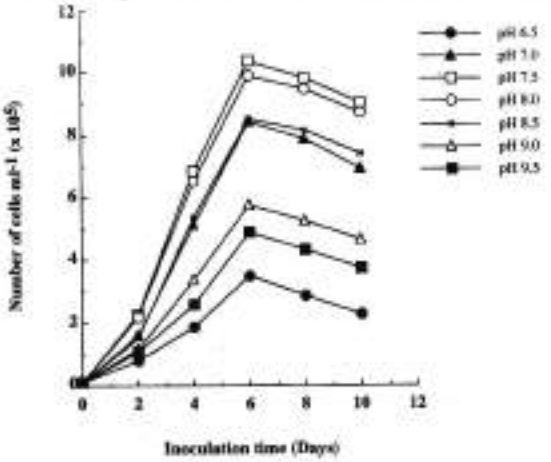

Fig. 6. Growth curves of *S. costatum* at different pH.

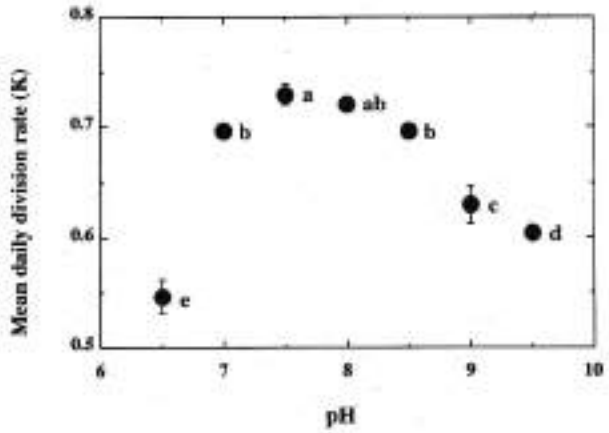

Fig. 7. Mean daily division rate of *S. costatum* at different pH. Each point and vertical line represent mean ± SD for three replicates. Means with different letters are significantly different (Duncan's multiple range test, $p < 0.05$).

S. costatum was cultured at different light intensities, from 10-200 µE m^{-2} sec^{-1} for 10 days. The plankton grew well with light intensities more than 40 µE m^{-2} sec^{-1} (Fig. 8). The optimum light intensity for its growth was 120 µE m^{-2} sec^{-1}. The growth was comparatively slower and poorer at 10 µE m^{-2} sec^{-1} and the growth curve tends to increase up to the 4th day and then entered into the stationary phase (Fig. 8).

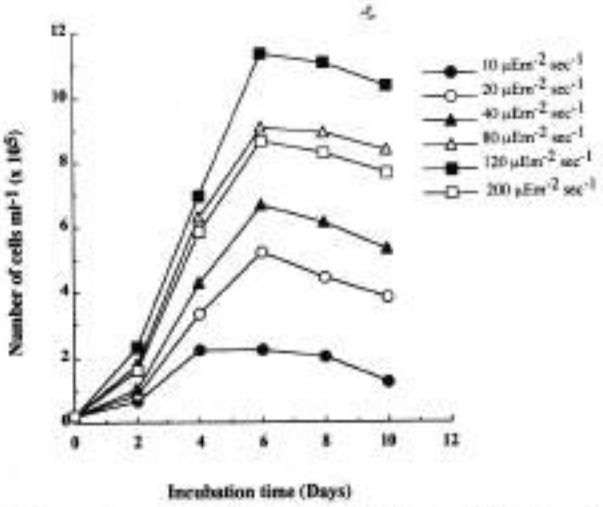

Fig. 8. Growth curves of *S. costatum* at different light intensities.

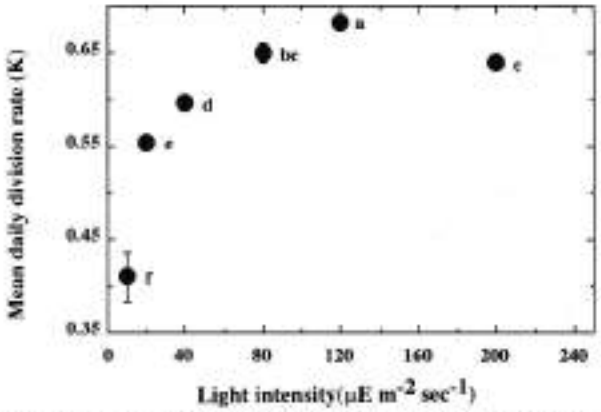

Fig. 9. Mean daily division rate of *S. costatum* at different light intensities. Each point and vertical line represent mean ± SD for three replicates. Means with different letters are significantly different (Duncan's multiple range test, $p < 0.05$).

Analysis of variance (ANOVA) showed that the difference in mean daily division rate at various light intensities were highly significant. The highest division rate (0.73 divisions day^{-1}) was observed at 120 μE m^{-2} sec^{-1} which was significantly higher than all other light intensities (Fig. 9). No significant difference in division rate was observed between 80 and 200 μE $m^{-2}sec^{-1}$.

Discussion

In the experiments it was found that within a range of 10-45 ppt salinity the exponential growth began without passing any lag phase and that might be due to the inoculation of the culture at its exponential phase of growth. According to Spencer (1954) the length of the lag phase is least when the inoculum is in its exponential phase of growth. Ammini (1984) and Gopinathan (1984) have observed similar results in microalgal culture.

The salinity tolerance of phytoplankton varies with species and strains. Table 1 summarizes the data reported by several investigators on the range of salinity tolerance and the optimum salinity for growth of some marine diatoms. Shimura *et al.* (1979) reported that the optimum salinity for the growth of Harima Nada's strain of *S. costatum* was 25 ppt which was within the optimum salinity range (20-35 ppt) in cultures of the present study. *S. costatum* of Yatsushiro Sea could tolerate a wide range of salinities, ranging down to 3 ppt or up to 55 ppt and it does not agree with that reported by Shimura *et al.* (1979) for Harima Nada's strain (4.4-40 ppt). Other diatoms were found to be less euryhaline than our strain of *S. costatum* (Table 1). On the otherhand, red-tide producing dinoflagellates and phytoflagellates are generally highly sensitive to lower (< 15 ppt) salinities (Khan *et al.* 1995, 1996). White (1978) reported that a red-tide producing dinoflagellate *Gonyaulax excavata* (Braarud) Balech did not grow

below 10 ppt. Similar observations were found for raphidophycean flagellates *Fibrocapsa japonica* (Toriumi and Takano) (Khan *et al.* 1996) and *Chattonella antiqua* (Hada) Ono (Khan *et al.* 1995).

Table 1. Range of salinity tolerance and optimum salinity for the growth of some marine diatoms

Diatoms	Salinity tolerance (ppt)	Optimum salinity (ppt)	Author
Skeletonema costatum	3.0-55	20-35	Present study
S. costatum	4.4-40	25	Shimura *et al.* (1979)
Cerataulina pelagica	6.0-45	20	Takano (1963)
Chaetoceros radians	6.0-48	15	Takano (1963)
Cyclotella criptica	3.4-51	11.2	Liu & Hellebust (1976)
Cyclotella nana	5.0-32	16	Guillard & Ryther (1962)

In the present study, optimal growth of *S. costatum* occurred under a narrow temperature range (20-25°C), which agrees fairly well with those previously reported for *Chaetoceros armatum* T. West (Lewin and Mackas 1972) and *Gymnodinium catenatum* Graham (Ellegaard *et al.* 1993). Although many phytoplankton species are very resistant to temperature change (Tomas 1978, Watanabe *et al.* 1982), *S. costatum* is very sensitive to high temperature. The temperature tolerance range observed in the present study does not agree with those reported by Admiraal (1977) for three estuarine benthic diatoms *Nitzschia* c. f. *dissipate* (Kützing) Grunow, *Amphiprora* c. f. *paludosa* W. Smith and *Nitzschia sigma* (Kützing) W. Smith. All of them were found to be more tolerant to high temperatures than *S. costatum* and optimum temperature of these three species were 25°C or higher. In the present study, the plankton failed to grow at 35°C, although cells were able to survive up to 6 days and were found to be either severely damaged or died rapidly at 40°C, in agreement with previous reports of Saks *et al.* (1974) who found that temperature above 36°C stress many marine and estuarine algae and tend to inhibit growth. The temperature tolerance range of *S. costatum* was different from the description of Tomas (1978) for some coastal phytoplankton species, who found them to tolerate a wide range of temperatures and reported to be eurythermal.

Though most marine and estuarine phytoplankton studied in laboratory conditions have a similar pH tolerance, an optimum pH at around 8.0 and a decrease in growth rate at more acidic and alkaline pH values (Kain and Fogg 1958), but it has sometimes been observed that growth of some species was enhanced in acid media. Some strains of *Chlorella kessleri* and *Chlorella saccharophila* could tolerate pH as low as 3.0 (Kessler 1980). Ikemori and Nishida (1967) suggested that microscopic algae showed decreasing growth rates with increasing pH values. Goldman *et al.* (1982), while studying the effect of pH in intensive continuous microalgal cultures using pH range from 7.6-10.6, observed that although *Chlorella vulgaris* Beij grew up to pH 10.6, it was

adversely affected by alkaline pH. In our study, the optimum pH for the growth of *S. costatum* was found to be between 7.5-8.0. Adequate growth was also found at pH 7.0 and 8.5. Even at pH 9.0 and 9.5, growth rates were 0.63 and 0.60 divisions day^{-1}, respectively. Nishijima and Hata (1986) reported that a raphidophycean flagellate *C. antiqua* grew well at pH 8.0-8.2, could not grow at pH 6.5 and adversely affected at pH 7.0-7.5. From these results, it is concluded that *S. costatum* can tolerate broader ranges of pH.

Algae being mostly photoautotrophic require light for their growth and the effect of light depends on the quality and intensity of light. The optimum light intensity for the growth of the plankton (*S. costatum*) was 120 $\mu E\ m^{-2}\ sec^{-1}$. Cell division was limited at low light intensity (Fig. 9). Similar results were found by Lewin and Mackas (1972) for *Asterionella socialis* Lewin and Norris.

From the present experiment, it is concluded that *S. costatum* from Yatsushiro Sea, Japan is extremely euryhaline and tolerable to very low salinities. Optimum growth occurred under a narrow range of temperature and it was strongly inhibited at high temperatures. Nutrients are one of the most important environmental factors that influence growth of any alga. The nutrient dynamics in Yatsushiro Sea, Japan and their effects on growth of *S. costatum* and other phytoplankton are needed to be studied.

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Effect of mola (*Amblypharyngodon mola* Ham.) on the growth and production of carps in polyculture

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Abstract

The effect of introduction of mola (*Amblypharyngodon mola*) in polyculture with rohu (*Labeo rohita*), catla (*Catla catla*) and mirror carp (*Cyprinus carpio* var. specularis) was studied in semi-intensive culture system in the pond complex of the Fisheries Faculty, Bangladesh Agricultural University, Mymensingh. Mola, a small indigenous fish was found to exert a negative impact on growth and production of carps. After four months' rearing, significant difference ($P<0.05$) was observed in the net production between the treatments.

Key words : *A. mola*, Poluculture, Indian major carp, Common carp

Introduction

While fish production in the country from the natural sources is gradually declining, intensive efforts are being directed towards polyculture of Indian major carps and some exotic carps (Kohinoor *et al*. 1996). However, despite the active support of the Government of Bangladesh to boost fish culture, the nutritional intake of the rural people remains poor. Fish farmers normally grow fish as a cash crop and sell all their produce in the market saving little fish for their own consumption. This tendency could be changed by producing small indigenous fish along with carps in the polyculture system.

The small indigenous fishes are a chief source of animal protein and micro-nutrients for the rural poor in Bangladesh. Sixteen species of small indigenous fishes are considered suitable for aquaculture (IFADEP 1996). Among those, mola (*Amblypharyngodon mola*) is of special interest to the fish farmers because of its good taste. Its high nutritional value has created an equally great interest among the scientists. Thilsted *et al*. (1997) recorded that 100g mola contain approximately 1960ug, 1071mg and 7.0mg of vitamin A, calcium and iron respectively. Though the small fishes have always been regarded as competitors of carps in the polyculture system and therefore invariably eliminated but no studies have so far been made on the effect of small indigenous fish such as mola, chela, punti etc. on the growth and production of carps in the system. The present study was, therefore, undertaken to assess the effects of mola (*A. mola*) in the carp polyculture system.

Materials and methods

Study area

The experiment was conducted in six earthen ponds of 75m^2 each with a depth of 1.5m in the pond complex of Faculty of Fisheries at the Bangladesh Agricultural University, Mymensingh , during August '96 to January '97.

Preparation of ponds

All the ponds were treated with lime at the rate of 250 kg/ha. After three days of liming,the ponds were fertilized with cow manure at the rate of 1000kg/ha.

Stocking of fish

The ponds were stocked after three days of fertilization. The experiment consisted of two treatments with three replicates. In both the treatments, rohu (*L. rohita*), catla (*C. catla*) and mirror carp (*C. carpio var. specularis*) were stocked at a stocking density of 10,000/ha in the ratio of 1:1:1. A small indigenous species, mola (*A.mola*) was stocked as an additional component in treatment II at a stocking density of 25,000/ha.

Post stocking management

Both the treatments were subjected to the same regime of feed and fertilizer application. Commonly available agricultural by-products such as rice bran (60%) and mustard oil cake (40%) were used as supplementary feed at the rate of 3-4 % of standing crop of fish. Fish were sampled at fortnightly intervals to assess their growth and health. Feeding was adjusted on the basis of estimated fish biomass. All the ponds were also regularly fertilized with cattle manure at the rate of 1000 kg/ha at 15 days interval.

Water sampling and analysis

Water quality parameters transparency, p^H, dissolved oxygen(DO) and chlorophyll-a were estimated at weekly intervals between 0800 to 0900 hrs, while total hardness, PO_4-P and NH_3-N analysed at fortnightly intervals. Standard procedures and methods were followed (American Public Health Association 1989) for analyses of water samples.

Plankton enumeration

Plankton samples were collected at fortnightly intervals following Dewan *et al.* (1991). Using a Sedgwick-Rafter cell, identification and enumeration of plankton were done following Bellinger (1992).

Harvesting of fish

At the end of the experiment, the fishes were recovered by repeated netting and de-watering the ponds. About 40% fish were measured to

determine the final growth and all the fishes were weighed for the estimation of total production.

Statistical analysis

For statistical analysis of the data, ANOVA was applied following Sokal and Rohlf (1991).

Results

Water quality

The values of water quality parameters such as temperature, transparency, p^H, DO, total hardness, total ammonia, phosphate and chlorophyll-a are presented in Table 1. These values were not found to be significantly different (P>0.05) when compared between the treatments.

Table 1. Mean values of water quality parameters under two treatments

Treatment	Treatment-I	Treatment-II	F ratio	Significance Lable
Water Temperature (°c)	27.55±0.25	27.72±0.01	1.49	NS*
Transparency(cm)	32.10±3.50	32.50±2.40	0.03	NS*
pH	7.20±0.13	7.18±0.06	1.01	NS*
DO (mg/l)	4.45±0.10	4.20±0.12	7.51	NS*
Total Hardness(mg/l)	114.54±16.84	104.81±8.12	0.84	NS*
PO_4-P (mg/l)	0.24±0.04	0.292±0.03	1.72	NS*
NH_3+NH_4 (mg/l)	0.15±0.10	0.14±0.02	0.03	NS*
Chlorophyll-a (µg/l)	69.75±29.83	44.57±3.53	2.10	NS*

**NS= Not significant (P > 0.05)*

Plankton

Phytoplankton population mainly comprised four major groups: Bacillariophyceae, Chlorophyceae, Cyanophyaceae and Euglenophyceae (Table 2). Chlorophyceae was the most dominant group and was represented by a large number of genera in both the treatments. Cyanophyceae was the second largest group of plankton while the third largest group was the Euglenophyceae. The phytoplankton population did not show any significant difference (P>0.05) in the two treatments.

Table 2. Mean abundance of plankton ($x10^4$) in two treatments

Treatment	Treatment-I	Treatment-II	F ratio	Significance
Phytoplankton				
Bacillariophyceae	3.50±0.66	3.250.25	0.390	NS*
Chlorophyceae	11.08±1.61	8.83±0.38	1.730	NS*
Cyanophyceae	7.25±4.56	5.42±0.381	1.150	NS*
Euglenophyceae	6.0±1.04	5.0±0.66	0.875	NS*
Zooplankton	6.34±1.04	5.20±1.28	1.700	NS*
Total plankton	33.17±7.34	27.70±2.52	1.590	NS*

**NS-Not significant (P > 0.05)*

The abundance of zooplankton comprising Crustacea and Rotifera was low in both the treatments. The mean abundance of zooplankton was 6.34 ± 1.04 x 10^4 cells /l and 6.33 ± 1.28 x 10^4 cells/l in treatment I and treatment II respectively. Though ozooplankton population was appeared high in treatment I but there was no significant difference (P>0.05) between the two treatments.

Growth and production of fish

The details of fish growth and production are presented in Table 3. The average survival of rohu in four months was 88% and 80% in treatment I and treatment II respectively. The mean final weights of fish were found to be 122.06 g and 109.73 g in treatment I and treatment II respectively. The net yield of fish in treatment I was 344 kg/ha, which was significantly higher(P<0.05) than that of treatment II (244 kg/ha).

Catla showed insignificant difference in growth (P>0.05) between the two treatments with survival rates of 92% and 88 %, average final weights of 147.60g and 135.30g and the net yields of 425.36 kg/ha and 352 kg/ha in treatment I and treatment II respectively, which showed significant differences (P<0.05) between the treatments.

Table 3. Growth, survival and production of fish under two treatments

Treatment	Fish species	At stocking			At harvest				Survival (%)		Net production (Kg/ha/4 months)
		Average initial wt. (g)	No. of fish	Total wt. (Kg)	Average final wt. (g)	No. of fish recovered	Total wt. (Kg)	Species wise	Average	Species wise	Total
T-I	Rohu	4.85	25	0.12	122.06	22	2.70	88	86.22	344.00	1,448
	Catla	4.79	25	0.11	147.60	23	3.30	92		425.36	
	Mirror carp	5.25	25	0.13	266.70	20	5.22	80		678.64	
T-II	Rohu	4.85	25	0.12	109.73	20	1.95	80	85.70	224.00	1,127
	Catla	4.79	25	0.11	135.30	22	2.75	88		352.00	
	Mirror carp	5.28	25	0.13	224.37	19	3.67	76		472.00	
	Mola	1.59	159	0.30	0.74	991	0.74	-		58.67	

** Mola reproduced during the experiment*

For mirror carp, the survival rates were 80% and 76%, average final weights of 266.7g and 224.37 g and net yields of 678 kg/ha and 472 kg/ha in treatment I and treatment II respectively. These values when tested statistically, showed significant differences ($P<0.05$).

In all the ponds under treatment II, the number of mola was higher than the initial number, as most of the mola had bred in the ponds. The average net production of mola was 58.67 kg/ha/4 months.

The monthly growth rate and specific growth rate (SGR) of fish in treatment I and treatment II are presented in Table 4. The specific growth rate (SGR) of mirror carp was the highest among all the species in both treatments whereas that of rohu was the lowest. All the species in treatment I showed higher growth than that of treatment II. The average net production of carps in polyculture without mola in treatment-I was 1448 kg/ha, while it was 1126 kg/ha in treatment-II with mola, where the contribution of mola was 58.67 kg/ha only. The total production was 29.41% higher in treatment-I where only carps were stocked. When the total net productions between the treatments were compared using ANOVA, there was a significant difference ($P<0.05$) between the treatments.

Table 4. Monthly average growth of fishes (wt.) in the two treatments

Treatment	Species	Initial	Growth (g)				SGR
		Weight (g)	Sept.	Oct.	Nov.	Dec.	(%)
I	Rohu	4.85	47.73	68.43	102.67	122.06	2.7
	Catla	4.79	56.63	88.63	121.27	147.60	2.8
	Mirror carp	5.28	40.30	91.20	124.70	266.70	3.3
II	Rohu	4.85	39.50	62.70	96.53	109.73	2.6
	Catla	4.79	58.06	81.13	102.67	135.30	2.8
	Mirror carp	5.28	51.10	90.23	119.73	224.37	3.1

Discussion

The water quality parameters were found within acceptable ranges in all the ponds and the fish were not found in a distressed condition at any time during the experimental period. However, dissolved oxygen and P^H were relatively low in all the ponds throughout the experimental period. Application of cattle manure and supplementary feed might have reduced dissolved oxygen to some extent and affected the p^H levels too. Ahmed (1993) also reported low dissolved oxygen and P^H levels from the fertilized and fed carp fingerlings ponds in Bangladesh. Total hardness, phosphate and total ammonia were within the ranges for semi-intensive fish culture and similar with the findings of Wahab *et al.* (1994), Dewan *et al.* (1991) and Azim *et al.* (1993).

With the four families of phytoplankton were represented by a number of genera found in tropical ponds as reported by Mollah and Aminul Hoque (1975), Dewan *et al*. (1991), Wahab and Ahmed (1991), Wahab *et al*. (1994) and Azim *et al*. (1995). Representatives of both chlorophyceae and cyanophyceae were present in higher numbers indicating a positive bearing on the greater survival of fish in general (Wahab *et al*.,1995). Both phyoplankton and zooplankton were decreased in numbers/liter in treatment-II where mola (*A .mola*) was introduced, as its main food consists of blue green and green algae, crustaceans and rotifers (Mustafa 1990).

Both fertilization and application of supplementary feed, resulted in better survival of all species in both the treatments. With the introduction of mola, the growth of rohu, catla and mirror carp was reduced to some extent. This might be due to the fact that mola competed for food and space with all of them. Miah and Dewan (1977) observed that rohu is an omnivore with preference for debris and decaying vegetation. Dewan *et al*. (1977) have reported that fry and fingerlings of catla were absolutely zooplankton feeders and showed a greater preference for animal food with increase in size. They also found that catla was strictly a surface feeder when small in size but fed in the middle and bottom layers as the size increased. Common carp prefers to feed on different food items at different sizes. Smaller fish prefer to feed on debris, animal and plant foods. Intermediate size fish are omnivore with a marked feeding preference for animal foods (Uddin 1981). It is clear from the present experiment that with stocking of mola, the growth of rohu and mirror carp is affected severely. It is suggested that mola may not be cultured with carps.

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Predatory behaviour of a snakehead fish (*Channa striatus* Bloch)

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Abstract

The predatory behaviour of a snake-head, *Channa striatus* (Bloch) on *Labeo rohita* fingerlings was studied in the laboratory. The study was conducted with six *C. striatus* (120 to 210 g and 22 to 28 cm) over 24h a day for 3 weeks. Three different sizes prey of large (2.00g and 5.8cm), medium (1.30g and 4.5cm) and small (0.72g and 3.5cm) were used for the first week and then medium size prey for 2nd and 3rd weeks. All the predators preferred eating the small group of *L. rohita* although all three size groups of *L. rohita* offered were available. It was found that the prey fishes remained together aside of the aquarium from the predator. Predator first targeted a prey, drove fast towards it, the prey tried to escape from the predator's attack using a specific route and finally the predator grasped the prey on head first and then engulfed. The handling time ranged between 45 and 50 sec. The time of peak feeding was found in the morning and in the evening of day. When 2 or 3 predators were kept in one aquarium, they engaged in fighting, head on, followed by an attack on the mouth region by the dominant one, and subsequently on the pectoral fin and caudal fin of the defeating one. After 2-3 days they became habituated to remain together and did not involve themselves in fighting.

Key words : *Channa striatus, Labeo rohita,* Predator

Introduction

Predatory fish have got their preference due to their compact muscle, and less bony structure. They have got both desirable and undesirable effects on the community structure of an ecosystem depending on their specific role. Predatory fish may compete for the space with the most desirable fish. Besides, predatory fish prey on desired fish directly. Such a predatory fish decreases the production of desirable fish if entered into the fish pond or if their occurrence increases in comparison to their food fish in the natural population. In controlled fish farming, it is essential to remove predatory fish from the water body. In the contrary the presence of predatory fish is accepted for a limited period in an overpopulated water body with small undesirable fishes.

It is important to know the predator itself and predatory behaviour from the academic, aquaculture and fisheries management purposes. It is believed that predatory fish hampers the fish production in the waterbody, but they are less well studied experimentally (Paszkowski and Tonn 1994). *Channa striatus* (commonly called shol), a snake headed fish distributed widely throughout the Indian subcontinent and are often the most common predator in fresh water bodies. From the beginning of aquaculture in this region most of the fish pond had been intruded by *C. striatus* from wild source causing a great economic loss by eating fish fry/fingerlings of culture species. There have been various reports on the feeding behaviour of different predatory fishes all over the world (Savino and Stein 1982, Tonn and Paszkowski 1986 & 1987, Hoyle and Keast 1987, Tonn *et al.* 1989, Hambright 1991, Paszkowski and Tonn 1994) but information regarding predation and predatory behaviour of *C. striatus* (Bloch) is absent.

The present work was thus designed to study the predatory behaviour of *C. striatus* over 24h period of the day to provide a basis for future management programme of Indian carp culture, by offering the fingerlings of *Labeo rohita* as prey animal with following objectives of determining the preference of the prey size by the predator, studying the diel feeding pattern of the predator and the feeding behaviour of the predator.

Materials and methods

The present study was conducted in the laboratory of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, for 21 days in the month of August, 1995. Six glass aquaria (120cm x 60cm x 45cm) marked as aquarium No. 1, 2, 3, 4, 5 and 6, were used to conduct the experiment. The aquaria placed in a row on a table were filled with clean tap water up to the level of 40cm. Aerator (Daivo 8400) were used for aeration in the aquarium water over 24h.

Experimental fish and acclimatization

The disease free predatory fish, *C. striatus* caught by cast net from a beel (large natural depression filled with water), were collected from a fish trader. The healthy prey fingerlings of *L. rohita* commonly called rui, were collected from Bangladesh Fisheries Research Institute, Mymensingh.

The collected predators were placed immediately into a stocking-tank in the laboratory and the saturated dissolved oxygen level in water was maintained by continuous aeration. Predators were then treated with salt (2% dip for 1 hour) and malachite-green (1 ppm) as a prophylactic treatment. The predators were kept in the stocking-tank for seven days and one prey for each predator was given as food into the tank on the first day and the number of prey in the tank were gradually increased upto the satiation of predators for the next 6 days. On the other hand, the collected prey (*L. rohita*) were transferred into the laboratory and placed into another large stocking-tank. They were also given prophylactic treatment. Water in this tank was aerated by an aerator continuously. They were kept into the tank without supplying any food for first two days. After that supplementary food at the rate of maintenance ration (about 1% body weight) was supplied to the fingerlings.

Behaviour of predator

To observe the predatory behaviour six *C. striatus* (22-28 cm and 120-210 g) were selected and numbered as P_1, P_2, P_3, P_4, P_5, P_6 and each fish was released into the aquarium bearing corresponding number. Each of the aquarium was provided with one predator for first 7 days; then two predators in each aquarium for another 7 days and three predators in each aquarium for the last 7 days. Prey were grouped into three as large, medium and small having mean length, weight and body depth of 5.8cm, 2.0g, 0.98cm; 4.5cm, 1.3g, 0.84cm and 3.5cm, 0.72g and 0.71cm respectively. Thirty prey (10 from each size-class) were offered "as sufficient" to each aquarium for the first week and the medium size prey of 60 were offered to the predators in each aquarium for the next two weeks. Continuous aeration in each aquarium was maintained for dissolved oxygen. The temperature of the water ranged between 28° and 30°C. Faecal matters from the aquarium was cleaned regularly by the method of siphoning in the morning and the water inside the aquarium was then replaced (about 1/3) with fresh clean aerated tap water without disturbing the fish.

Predatory behaviour was observed for 24h regularly during the study period. The time and method of prey-capture were observed and recorded. At the start of the experiment total length (cm), body weight (g), jaw length (cm) and mouth gape (cm) of predators were measured and recorded (Table 1). Data, on prey eaten by predators were recorded quantitatively and qualitatively. Movement pattern of the predator as well as that of the prey were observed by naked eyes over 24h period during the experiment.

Table 1. Information about experimental predators (*C. striatus*)

Predator	Total length (cm)	Body weight (g)	Jaw length (cm)		Mouth gape (cm)	
			Upper jaw	Lower jaw	Vertical	Horizontal
P_1	22.0	120	2.9	3.0	4.8	3.5
P_2	22.2	122	2.9	3.0	4.8	3.5
P_3	24.1	130	3.0	3.1	5.0	3.6
P_4	24.5	135	3.0	3.1	5.0	3.6
P_5	26.4	166	3.1	3.2	5.2	3.7
P_6	28.0	210	3.2	3.3	5.3	3.8

P_1 = Predator number 1 *P_4 = Predator number 4*
P_2 = Predator number 2 *P_5 = Predator number 5*
P_3 = Predator number 3 *P_6 = Predator number 6*

Results and discussion

Prior to start the experiment, predators (*C. striatus*) were adjusted into the tank with supplied prey. It was observed that the predation by predators was lower at the beginning of the acclimatization and then it increased day by day. Less predation at the start by the predators might be due to the new environment in the laboratory. It was found that predators were acclimatized to the new environment

Table 2. Predation of *C. striatus* on *L. rohita* during first week of the experiment (each aquarium was provided with 30 fish comprising 10 small, 10 medium and 10 large size prey)

Day	Number and biomass of prey (g) eaten by predator											
	P_1				P_2				P_3			
	S	M	L	Total	S	M	L	Total	S	M	L	Total
Day 1	7 (5.04)*	4 (5.2)	2 (4.0)	13 (14.24)	8 (5.76)	4 (5.2)	2 (4.0)	14 (14.96)	7 (5.04)	4 (5.2)	2 (4.0)	13 (14.24)
Day 2	7 (5.04)	3 (3.9)	3 (6.0)	13 (14.94)	8 (5.76)	3 (3.9)	3 (6.0)	14 (15.66)	8 (5.76)	3 (3.9)	3 (6.0)	14 (15.66)
Day 3	8 (5.76)	3 (3.9)	3 (6.0)	14 (15.66)	7 (5.04)	4 (5.2)	2 (4.0)	13 (14.24)	8 (5.76)	5 (6.5)	2 (4.0)	15 (16.26)
Day 4	9 (6.48)	3 (3.9)	2 (4.0)	14 (14.38)	9 (6.48)	3 (3.9)	3 (6.0)	15 (16.38)	9 (6.48)	3 (3.9)	3 (6.0)	15 (16.38)
Day 5	7 (5.04)	4 (5.2)	2 (4.0)	13 (14.24)	8 (5.76)	4 (5.2)	1 (2.0)	13 (12.96)	8 (5.76)	3 (3.9)	2 (4.0)	13 (13.66)
Day 6	6 (4.32)	5 (6.5)	1 (2.0)	12 (12.82)	8 (5.76)	5 (6.5)	2 (4.0)	15 (16.26)	9 (6.48)	3 (3.9)	3 (6.0)	15 (16.38)
Day 7	8 (5.76)	4 (5.2)	2 (4.0)	14 (14.96)	8 (5.76)	5 (6.5)	2 (4.0)	15 (16.26)	8 (5.76)	5 (6.5)	2 (4.0)	15 (16.26)
Total	52 (37.44)	26 (33.8)	15 (30.0)	93 (101.24)	56 (40.32)	28 (36.4)	15 (30.0)	99 (106.72)	57 (41.04)	26 (33.8)	17 (34.0)	100 (108.84)
**	4.457	4.022	3.571	12.052	4.721	4.262	3.512	12.496	4.509	3.714	3.736	11.96

Contd...

Table 2. Contd.

Day	Number and biomass of prey (g) eaten by predator											
	P_4				P_5				P_6			
	S	M	L	Total	S	M	L	Total	S	M	L	Total
Day 1	8 (5.76)*	5 (6.5)	2 (4.0)	15 (16.26)	9 (6.48)	5 (6.5)	2 (4.0)	16 (16.98)	9 (6.48)	5 (6.50)	5 (10.0)	19 (22.98)
Day 2	9 (6.48)	2 (2.6)	3 (6.0)	14 (15.08)	8 (5.76)	6 (7.8)	3 (6.0)	17 (19.56)	10 (7.20)	5 (6.50)	5 (10.0)	20 (23.70)
Day 3	9 (6.48)	4 (5.2)	2 (4.0)	15 (15.68)	8 (5.76)	5 (6.5)	4 (8.0)	17 (20.26)	9 (6.48)	6 (7.80)	5 (10.0)	20 (24.28)
Day 4	7 (5.04)	2 (2.6)	4 (8.0)	13 (15.64)	10 (7.20)	5 (6.5)	4 (8.0)	19 (21.7)	11 (7.92)	7 (9.10)	4 (8.0)	22 (25.02)
Day 5	8 (5.76)	5 (6.5)	2 (4.0)	15 (16.26)	9 (6.48)	5 (6.5)	2 (4.0)	16 (16.98)	10 (7.20)	7 (9.10)	4 (8.0)	21 (24.30)
Day 6	7 (5.04)	7 (9.1)	2 (4.0)	16 (18.14)	8 (5.76)	6 (7.8)	3 (6.0)	17 (19.56)	10 (7.20)	6 (7.80)	5 (10.0)	21 (25.00)
Day 7	8 (5.76)	6 (7.8)	2 (4.0)	16 (17.56)	8 (5.76)	6 (7.8)	2 (4.0)	16 (17.56)	9 (6.48)	7 (9.10)	5 (10.0)	21 (25.58)
Total	56 (40.32)	31 (40.3)	17 (34.0)	104 (114.62)	60 (43.2)	38 (49.4)	20 (40.0)	118 (132.6)	68 (48.96)	43 (55.9)	33 (66.0)	144 (170.86)
**	4.266	4.264	3.597	12.129	3.717	4.25	3.442	11.411	3.33	3.802	4.489	11.623

* *The figures within the parenthesis represent the weight of the prey eaten by predator.*

** *Amount of food (prey) eaten by predator per day (% body weight of the predator).*

S = Small prey, M = Medium prey, L = Large prey; P_1, P_2, P_3, P_4, P_5 & P_6 = Predators.

within 7 days. During the last 3 days in acclimation similar number of prey was eaten by predator which indicated the acclimatization of fish with the new environment. The basic information of the selected experimental fish are shown in Table 1.

Feeding pattern

The daily food preference by all the predators were firstly small size prey followed by medium and large size prey respectively (Table 2). Paszkowski and Tonn (1994) reported that large yellow perch ingested significantly more small fathead minnows than medium or large fathead minnows, even though the size-classes were equally available. Similarly, Lawrence (1958) found piscivores tend to consume prey sizes that are much smaller than the maximum possible. The largest predator (P_6) ate a total of maximum number of prey of 144 (170.9g) during the first week, followed by P_5, P_4, P_3, P_2 respectively and the minimum predation 93 (101.2g) was found incase of the smallest predator (P_1) (Table 2). Similar feeding pattern was observed during the 2nd and 3rd weeks of the experiment (Table 3, 4). The feeding pattern indicated that whatever may be the density of predator (1,2,3) in an aquarium the prey consumed was directly related to the size of the predator.

Table 3. Predation of *C. striatus* on *L. rohita* during second week of the experiment (Supplied prey: Medium size; Number: Perday/Aquarium = 60)

Day	Number and biomass of prey (g) eaten by predator					
	Aquarium - 1		Aquarium - 2		Aquarium - 3	
	P_1	P_6	P_2	P_3	P_4	P_5
Day 1	11 (14.3)*	20 (26.0)	12 (15.6)	13 (16.9)	14 (18.2)	15 (19.5)
Day 2	11 (14.3)	19 (24.7)	11 (14.3)	13 (16.9)	13 (16.9)	16 (20.8)
Day 3	10 (13.0)	18 (23.4)	13 (16.9)	12 (15.6)	13 (16.9)	15 (19.5)
Day 4	10 (13.0)	18 (23.4)	11 (14.3)	12 (15.6)	12 (15.6)	15 (19.5)
Day 5	10 (13.0)	19 (24.7)	12 (15.6)	12 (15.6)	14 (18.2)	15 (19.5)
Day 6	11 (14.3)	20 (26.0)	13 (16.9)	13 (16.9)	12 (15.6)	16 (20.8)
Day 7	10 (13.0)	19 (24.7)	11 (14.3)	12 (15.6)	13 (16.9)	15 (19.5)
Total	73 (94.9)	133 (172.9)	83 (107.9)	87 (113.1)	91 (118.3)	107 (139.1)
**	11.298	11.762	12.635	12.429	12.519	11.971

* *The figures within the parenthesis represent the weight of predator eaten by predator.*

** *Amount of food (prey) eaten by predator per day (% body weight of the predator). P_1, P_2, P_3 P_4, P_5 & P_6 = Predators*

Table 4. Predation of *C. striatus* on *L. rohita* during third week of the experiment Supplied prey: Medium size; Number: Perday/Aquarium = 60)

Day	Number and biomass of prey (g) eaten by predator							
	Aquarium - 1				Aquarium - 2			
	P_4	P_5	P_6	Total	P_1	P_2	P_3	Total
Day 1	14	16	19	49	11	12	13	36
	(18.2)*	(20.8)	(24.7)	(63.7)	(14.3)	(15.6)	(16.9)	(46.8)
Day 2	13	15	20	48	10	11	13	34
	(16.9)	(19.5)	(26.0)	(62.4)	(13.0)	(14.3)	(16.9)	(44.2)
Day 3	14	16	19	49	10	12	12	34
	(18.2)	(20.8)	(24.7)	(63.7)	(13.0)	(15.6)	(15.6)	(44.2)
Day 4	13	14	19	46	10	12	13	35
	(16.9)	(19.5)	(24.7)	(61.1)	(13.0)	(15.6)	(16.9)	(45.5)
Day 5	13	15	19	47	11	13	12	36
	(16.9)	(19.5)	(24.7)	(61.1)	(14.3)	(16.9)	(15.6)	(46.8)
Day 6	12	15	20	47	10	11	12	33
	(15.6)	(19.5)	(26.0)	(61.1)	(13.0)	(14.3)	(15.6)	(42.9)
Day 7	13	16	19	48	10	13	12	35
	(16.9)	(20.8)	(24.7)	(62.4)	(13.0)	(16.9)	(15.6)	(45.5)
Total	92	107	135	-	72	84	87	-
	(119.6)	(140.4)	(175.5)	-	(93.6)	(109.2)	(113.1)	-
**	12.656	12.083	11.939	-	11.143	12.787	12.429	-

* *The figures within the parenthesis represent the weight of prey eaten by predator.*

** *Amount of food (prey) eaten by predator per day (% body weight of the predator). P_1, P_2, P_3, P_4, P_5 & P_6 = Predators*

Handling of prey by predator

In the present study it was observed that the predator and prey always took their place in aquarium just to the opposite corner of the aquarium instead of living together. It was clearly observed that the prey tried to escape from the predator's attack using a characteristic pattern of movement (Fig. 1A). Predator usually rests on one corner of the bottom region of the aquarium, targeted a specific prey at the opposite corner of upper region of the water column. The prey came downwards while the predator moved towards it. After reaching at the bottom region, the prey drove for the upper region in the clockwise direction and moved towards another corner of the aquarium. The prey became tired and caught by the predator. The predator firstly grasped the head of the prey and finally engulfed by taking it wholly into the mouth. Winemiller and Taylor (1987) noted that *Esox* and *Micropterus* both piscivores swallow prey headfirst, *Micropterus* achieves this by orienting its body toward the front of the prey and drawing into the mouth by a suctorial action. Whereas *Esox* caught the prey with its sharp teeth.

In some cases, the predator failed to capture the prey in first attempt and then took second attempt to capture it after a short rest in between.It was also observed that the predator of upper region of the water column, moved downwards and grasped directly to the head of the prey in the bottom region (Fig. 1B).

Time taken to manipulate and swallow prey from capture to the cessation of pharyngeal movement is called handling time (Hoyle and Keast 1987). In this study, the average handling time was found to be 45-50 sec. Hoyle and Keast (1988) reported that the handling time of largemouth bass, *Micropterus salmoides* was about 50 sec which is related to this study.

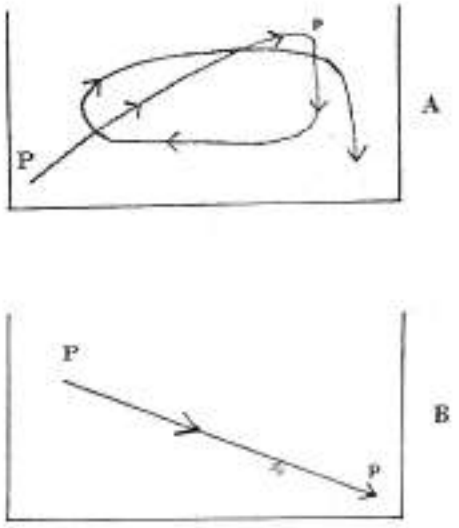

Fig. 1. Method of prey capture by the predator (A. Capture of prey by chasing; B. Capture of prey by direct drive); P = predator, p = prey.

Behavioral study

In this experiment, it was found that when 2 or 3 predators were kept in an aquarium, the larger predator attacked the smaller one immediately after 5-7 minutes of introduction into the aquarium and tried to push out from the aquarium. As a result the smaller predator wanted to come out from the aquarium but become failed and involved itself in fighting (Fig. 2). At a later stage it was found that the smaller predator usually took the position away from the large predator. When prey were offered to them smaller one was chased by the larger one and it came upward quickly, engaged in fighting and then moved downward being failed in fighting. Due to this type of dominancy by larger predator, the smaller one became deprived of engulfing sufficient prey immediately after offering the prey to the predator.

The predators usually attacked one another with head on (Fig. 2A). Larger predator chased the smaller one and tried to bite on the eye region. The smaller predator wanted to escape and left the place quickly. When the smaller one tried

to escape the large predator with its mouth attacked the pectoral fin and caudal fin of the small predator (Fig. 2B & 2C). At this stage the smaller predator wanted to come out and sometimes jumped and struck on the aquarium cover (Fig. 3). After two to three days they became habituated to live together and did not involve themselves in fighting. The scale of many places of the smaller predator were peeled off due to the attack of the larger predator. Injuries were also found on the mouth of the predator involved in fighting. When the differences in size between predators was less then the intensity of fighting was lower.

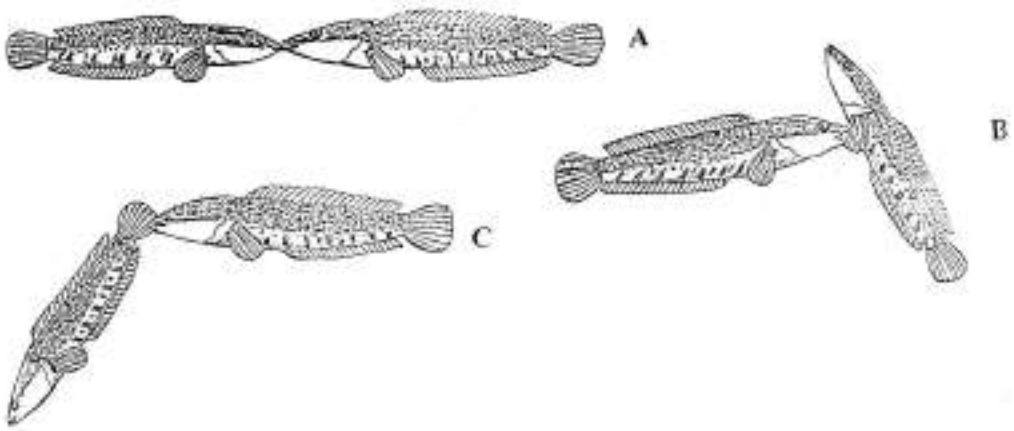

Fig. 2. Fighting of two predators kept in an aquarium;(A: Stage 1. Head on fighting; B: Stage 2. Biting on the eye region and pectoral fins; C: Stage 3. One moved downward being failed in fighting and the stronger one is biting on the tail).

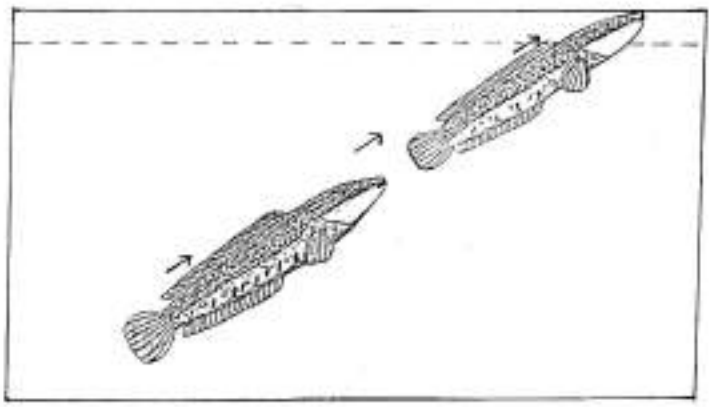

Fig. 3. Dominancy: The larger predator is chasing the smaller one and the smaller one is trying to escape from the aquarium.

The prey fishes usually remained in school and moved to the opposite direction of the predator fish. The predators preferred small prey and in a large quantity. Selection of suboptimal, small size prey by the largemouth bass has been reported by Hoyle and Keast (1987). Fish commonly take a considerable portion of prey of a size less than they are capable of handling (Keast 1985). The predation of larger prey was low which may also because of the more required time to grasp the prey and to swallow as has been reported by Hoyle and Keast (1987) in case of largemouth bass.

Just after feeding, the predator became quiet. At that time the predator's tail was observed to be undulated and the fins remained erect. This situation continued for 4 to 6 minutes after which it became prepared for next attempt. Although the predators engaged in fighting when kept two or three fish together in one aquarium but the food taken interms of their respective body weight was more or less the same when kept in single. Two peaks of the predation were occurred one at the morning (9-10h) and the other at the evening (18-19h) and two troughs were occurred one at around mid day (13-14h) and the other at around mid night (23-24h) respectively over the 24h a day (Fig. 4).

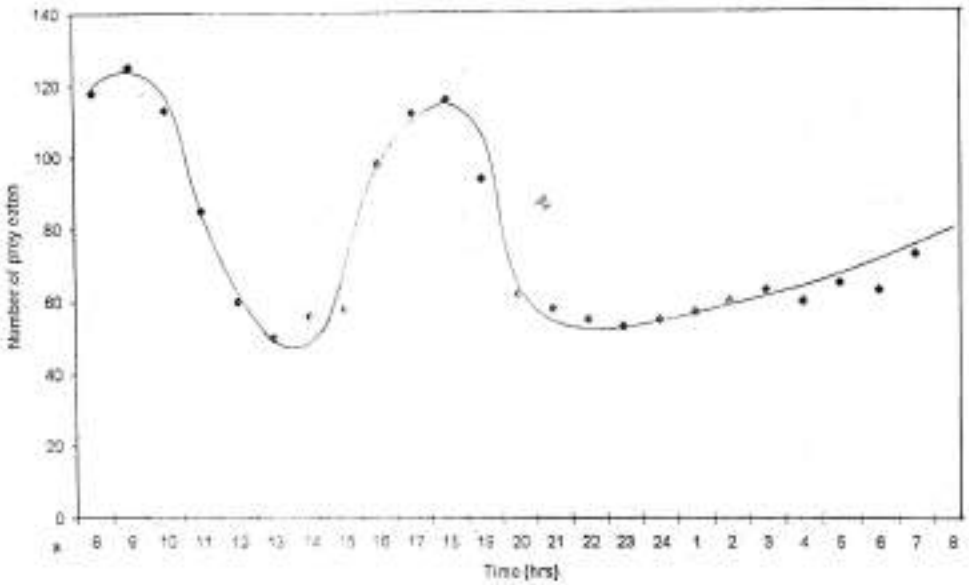

Fig. 4. Predation pattern of *C. striatus* over 24h cycle during 3 weeks experimental period.

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Studies on the induced breeding and post-larval rearing of shing (*Heteropneustes fossilis* Bloch)

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Abstract

An experiment was conducted on induced breeding and fry rearing of shing ,*Heteropneustes fossilis* (Bloch) in the Department of Aquaculture, Bangladesh Agricultural University for a period of four months from April to July 1994. Hatching rate was calculated at 21.50 hrs and was found to be 45 to 55 % and the survival rate of larvae was 30 to 40 % at 26 to 29^{0}C. Survival rate and growth rate of post larvae were found to be 50 to 60 % and 96.6 to 117.2 % respectively. Feed-3 (F_3) showed the highest survival rate and growth rate of post larvae.

Key words : *H. fossilis*, Induced breeding, Larvae rearing

Introduction

The technique of induced fish breeding found its application in fish culture where it turned out to be very promising. Induced breeding is currently gaining importance in composite fish culture (Saha 1995). *Heteropneustes fossilis* (Bloch) locally known as "shing" is an important air breathing catfish in Bangladesh. The nutritive and medicinal value of this fish has been recognized from time immemorial. Shing is a popular fish in Bangladesh and generally grows in pond, lake, baor, beels, and floodplains with natural care. It has been drawing the attention of more and more fish farmers in Bangladesh day by day due to its high market values, profitable culture and hardy nature. Shing breeds in natural waterbodies but natural habitats have alarmingly declined due to ecological changes. So collection of shing fry from natural source is difficult for fish culturist.

Recently scientists have started to breed the fish artificially by using HCG (Human Chorionic Gonadotropin and Pituitary gland (Rahamatullah *et al.* 1983, Islam *et al.* 1986, Mollah 1987, Naser *et al.* 1990). However, induced breeding and rearing of larvae of shing are facing various problem for the expansion of its culture. So we should take proper initiative to meet the demand of fry requirement for its culture by induced breeding through HCG. HCG was used because it is more economical than carp pituitary gland extract (Naser *et al.*

1990). The main problem in larval rearing in the lack of suitable feed of appropriate size and quality particularly at the stage of first feeding just after utilization of yolk-mass. The present studies were undertaken with the following objectives : a) to develop an appropriate technique of induced breeding of *H. fossilis* and b) to formulate an artificial feed from the indigenous ingredients for fry rearing of shing.

Materials and method

Brood fish maintenance

Male and female brood fishes of shing (*H. fossilis*) were stocked in the ponds of the Department of Aquaculture and Management in March 1994.The size of the stocking ponds were 60 m^2 and fishes were kept at a density of 20,000 fish/ha. The broods were given artificial feed (10% fish meal + 10% soya meal + 80% wheat bran) at the rate of 12 to 15% body weight twice a day. The water depth of the ponds were 1.22 to 1.53 m in the rainy season and 0.46 to 0.61 m in the winter. Ponds have outlet to prevent the overflow of the water in the rainy season. The ponds were treated with lime (at the rate of 100kg/ha) twice a year first in May and second in November and subsequently fertilized with urea (30 kg/ha), triple super phosphate (30 kg/ha), cowdung (4,000 kg/ha) and mustered oil cake (20 kg/ha) twice a year first in May and Second in November. In the rainy season, ponds were surrounded by net as a precaution of escaping of fish from the ponds. The fishes were collected by seine net and carried to the laboratory and kept in the trays (30.48 cm x 60.96 cm x 15.24 cm).

Induced breeding and post-larval rearing

Properly ripe males and females shing (milt and eggs come out with very gentle pressure on the abdomen respectively) were selected from the brood stock. Fish were injected intramuscularly with HCG extract at a dose of 500 I.U./100g body weight. The total dose was divided into two equal doses and was injected to males and females at 6 hours interval. Male and female of a pair were kept together after each injection and aeration of water was maintained in aquaria. Care was taken to prevent fish loss by jumping. After 4 to 5 hours of 2nd injection natural ovulation was noted. Brood fish were separated from the aquaria. Fertilized eggs were incubated in trays in three replications at room temperature (26-29°C) and the aeration of water was maintained. About half of the water of each trays was changed after every six hours during incubation. The hatchling came out after 20-22 hours and dead eggs ,egg shells were picked up by means of a dropper. After the completion of hatching, spawn was transferred to other trays and kept there for 4 days until the larval period was completed without feeding. After completion of the larval period, the post larvae were transferred to the polythene covered trays (30.48 cm x60.96cm x15.24cm) at

two densities of 10 post larvae/tray and 20 post larvae/tray in three replication. Three different kinds of feeds were provided to post larvae of two different densities. Therefore, a total of eighteen trays were used for the rearing of post larvae. Three different types of foods were regarded as F_1, F_2 and F_3.

Feed composition

F_1	F_2	F_3
100g, powdered milk	100g, powdered milk	100g, powdered milk
One egg	One egg	One egg
100g, boiled potato	100g, boiled potato	100g, boiled potato
100g, raw fish muscle without skin	100g, raw fish muscle with skin	100g, boiled fish with skin, viscera and bone

The feed was prepared in paste form. Feeds were given twice a day in the form of dough of paste at 10% of body weight. Excess feeds and wastes were removed by dropper after one hour of feeding. Half of the water along with faecal wastes from each tray was changed daily and aeration was maintained by air stones. Growth rate of post larvae was studied for two weeks, for which the length of fish were measured to nearest mm after each week and side by side mortality was recorded.

Statistical analysis

The experiment were conducted in Randomised Block Design (RBD) with three replication and two way analysis of variance (ANOVA) in RBD was done to study the effect of different feed and density on survival and growth rates. Duncun's Multiple Range Test (DMRT) was used for mean separation of 5% level of significance. The percentage data was arcsine transformed before statistical analysis. Data was analysed with a statistical package called stategraphic version 7.

Results and discussion

Hatching time and larval period of shing

Hatching time was found 21.50 hours and hatching rate was 45 to 55%, larval period was found 94 to 96 hours and survival rate of larvae was found to be 30 to 40% at 26-29°C (Table 1). Hatching and yolk of fish eggs were reported to be temperature dependent (Margulies 1989 and Clarke 1989). Mukhopadhyay (1972) reported that hatching time of *H. fossilis* ranged from 20 to24 hours and larval period from 4 to 5 days at 25°C. Thakur *et al.* (1974) noted the hatching period of shing to vary from 18 to 20 hours while the larval period was 96 hours at temperature ranging from 26 to 29°C.

Table 1. Hatching time and rates, yolk absorption time and survival rates of larvae at room temperature (26-29°C)

Replication No.	Time required for 50% hatching (hr)	Hatching rates (%)	Yolk absorption time (hr)	Survival rates (%)
1	22.00	45-55	94-96	30-40
2	21.30	45-55	94-96	30-40
3	20.00	45-55	94-96	30-40
Mean	21.50	45-55	94-96	30-40

Survival rates of post-larvae of shing

The different artificial feed (three different types) showed significant effect ($P<0.01$) upon the survival rates of *H. fossilis*. The highest survival rates recorded at F_3 (60%) and lowest survival rates recorded at F_1 (50%) are shown in Table 2. Findings of this experiment indicated that the F_3 gave better survival rate for shing larvae. Which might be due to the high mineral content of the F_3 than other feeds. As F_3 contained boiled fish including bone-masses. Mineral play vital role in metabolism and growth of fish (White *et al.* 1959). It was found that when fishes were fed a phosphorus deficient diet the growth is retarded and their mortality is increased (Andrews *et al.* 1973, Watanabe *et al.* 1980,Yone and Toshima 1979). Density 1 (10 post larvae/tray) and density 2 (20 post larvae/tray) indicated the similar survival rates 50 to 60% (Table 2). Survival rates of shing post larvae was perhaps not density dependent. Woiwode and Adelman (1989) noted that survival rates of channel catfish (*Ictalurus punctatus*) were not significantly influenced by fish density, same results were obtained in Atlantic salmon (Soderberg and Meade 1987, Soderberg *et al.* 1987). Karjalainen (1991) reported 60% survival rate of vendace (*Caregonus albula*) at all densities.

Table 2. Effects of feed and density on the survival rates and growth rates of post larvae of shing for two weeks

PL/tray	Feed	Survival rates (%)	Initial length (mm)	1st week growth (mm)	2nd week growth (mm)	Net growth (mm)	Growth rates (%)
10	1	50.00^{b}	5.8	7.0^{c}	11.5^{c}	5.7^{c}	98.27
	2	50.00^{b}	5.8	7.5^{b}	12.0^{b}	6.2^{b}	106.89
	3	60.00^{a}	5.8	8.2^{a}	12.6^{a}	6.8^{a}	117.24
Mean		53.33	5.8	7.57	12.03	6.23	107.46
20	1	50.00^{c}	5.8	7.0^{c}	11.4^{c}	5.6^{c}	96.55
	2	55.00^{b}	5.8	7.4^{b}	11.9^{b}	6.1^{b}	105.17
	3	60.00^{a}	5.8	8.2^{a}	12.6^{a}	6.8^{a}	117.24
Mean		55.00	5.8	7.53	12.0	6.17	106.32

Separation of mean was done within column at 5% level of DMRT

Growth rates of post-Larvae of shing

The different feed showed significant effect ($P<0.01$) upon the length of shing. The highest length increment was recorded in F_3 (6.8 mm) and the lowest length increment was 5.6 mm in F_1. However, significant differences in length was noted among the different feed. On the other hand highest growth rate (117.24%) was showed with F_3 and the lowest growth rate (96.55%) recorded with F_1 (Table 2). Growth data indicated that the F_3 was suitable feed for post larvae of *H. fossilis*. The highest growth was recorded in F_3 because it contained more fish fat, protein and fish bone which contain various minerals such as calcium and phosphorus. Fishes require mineral as essential factors in their metabolism and growth, however, it was also important from a nutritional point of view. Andrews *et al.* (1973) noted that dietary phosphorus requirement was 0.8% for maximum growth of channel catfish (*Ictalurus punctatus*). Cho and Schell (1980) reported that calcium and phosphorus requirement were 6g/kg dry diet and 7g/kg dry diet respectively for growth of fishes.

The different densities showed that there was no significant effect on the growth rate of shing. Similar growth rates (highest 117.24% and lowest 96.55 to 98.27%) were recorded at both densities (Table 2). The result of this study showed that the stocking density has no definite effect on the growth rate of *H. fossilis*. Same results was obtained in Atlantic salmon (Soderberg and Meade 1987, Soderberg *et al.* 1987). Karjalainen (1991) reported 60% survival rate of vends (*Caregonus albula*) at all densities.

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Rearing of catfish (*Clarias batrachus* Lin.) larvae with live and prepared feeds

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Abstract

Provision or live feed (Tubificid worms) attributed significantly better weight gain in the five days old *Clarias batrachus* larvae when reared for another 28 days compared to those fed mixed feed (live and artificial) and artificial feed only. Larvae fed mixed feed showed significantly better weight gain compared to those fed only artificial feed and the survival rate was similar to those fed only live feed. Both the weight gain and survival rate were the lowest for the larvae reared only on artificial feed.

Key words : *C. batrachus*, Larvae, Live feed

Introduction

In Bangladesh, *C. batrachus* is commonly known as 'magur' and is available in all types of freshwater habitats such as rivers, canals, beels, swamps and ponds. It attains maturity within the first year of life and spawns in both open and confined waters. The spawning period of *C batrachus* is very short and distinct, and occurs once in a year during the month of July-August (Thakur 1987). It is highly popular fish and due to its good taste and easy digestibility it is often recommended as diets for the patients and as such it fetches high market price.

C. batrachus is an omnivorous fish and can be stocked more densely than many other species. But its culture practices have not been standardized and the production is not sustainable. Inspite of the above suitability of the species, there are some problems for its intensive culture. The supply of fry from the natural sources is not sufficient and it is irregular also. However, use of pituitary extracts (Devaraj *et al.* 1972, Khan 1972, Rahmatullah *et al.* 1983), Prostaglandin F_2 a (Tikare *et al.* 1983) and human chorionic gonadotropin (Mollah 1987 a, b) brought about considerable and dependable success in fry production of *C. batrachus*. But larval feed for successful rearing of fry exists as the main impediment for its intensive culture. Mollah and Nurullah (1988) successfully reared *C. batrachus* larvae with live feed (*Tubifex spp.*). However, there remains several unavoidable problems associated with the availability and culture of

natural live feed organisms. Artificial feed, on the other hand can be manufactured on a large scale basis and used for the larval rearing of fish.

Formulation of quality fish feed from indigenous raw materials for *C. batrachus* fingerlings has been reported by Sanaullah *et al.* (1986). some preliminary works on the formulation of artificial feed for *C. batrachus* larvae have been done by Alam and Mollah (1988). However, a suitable artificial diet to ensure better growth and higher survival of the larvae is yet to be developed.

In view of above facts, an experiment was conducted in order to get the preliminary idea as to how live feed, mixed feed and only artificial feed affect the growth and survival of *C. batrachus* larvae depending on which further research to wean them gradually from live to artificial one can be initiated.

Materials and methods

Source of fry

C. batrachus larvae used in the experiment were produced by induced breeding technique using human chorionic gonadotropin (HCG) at a dose of 2IU g^{-1} body wt. and 1 carp pituitary gland (PG) kg^{-1} body wt. of female. Nine female and six male broods of *C. batrachus* were used for this experiment. Hatching completed by 30 hrs of fertilization. When the yolk sac was completely absorbed, the larvae were fed ground whole chicken egg mixed with semi-boiled water. The whole ground egg turned into fine particles when mixed with semi-boiled water and larvae fed it wistfully. The experiment was started with 5 days old larvae with average total length of 8.9 ± 0.99 mm and weight of 3.7 ± 1.15 mg.

Plan of experiment

The experiment was conducted in the Wet Laboratory of Fisheries Faculty, Bangladesh Agricultural University, Mymensingh. Thirty plastic bowls, each of 17-L capacity, were used for this experiment. Each bowl, however, contained 10-L of water to avoid jumping out of larvae. Each of the bowls was stocked with 40 *C. batrachus* larvae. The bowls were divided into three treatments i.e., (T_1, T_2 and T_3) for each treatment, 10 replications were used. All of the fry were fed two times (at 0600 hrs. and at 1800 hrs.) daily. The larvae of T_1 were fed live feed (chopped tubificid worms), while those of T_2 were fed both chopped tubificid worms and starter (Saudi Bangla Fish Feed Ltd., Bhaluka ,Mymensingh) and T_3 starter only (Table 1). Water level of each bowl was controlled by an inlet and an outlet. Each of the bowls was cleaned once a day in the morning by siphoning out one third of the water with the dirt at the bottom before feeding. At this time the dead fry were removed, counted and recorded. During experimental period the water temperature ranged between 25.8°C and 27.5°C. Dissolved oxygen content ranged between 5.5 and 7 ppm and PH between 7.3

and 7.7 Deep well water stored in an overhead reserve tank was supplied in each of the bowls by perforated plastic pipe at the same rate of all the replicates.

Table 1. Proximate composition (%) of the experimental feeds

Feed	Moisture	Protein	Fat	Fibre	Ash
*Starter 1	12	39	3	6	18
** Tubificid worms	-	72.2	22.2	-	5.5

**As feed basis*
***As dry matter basis*

Procedure of sampling

Sampling was performed at seven days interval. Ten fry were caught from each bowl by the scope net. Then length (mm) and weight (mg) were recorded by a graph-paper attached petridish and an electric balance (Model no. Mettler Toledo PB 303 Delta range) respectively.

Analysis of data

Analysis of variance (ANOVA) test supporting the principles of Completely Randomized Design was applied to compare the data obtained on growth among three treatments (Van 1972, Fundamentals of Biostatistics).

Results

The growth patterns of 5 days old *C. batrachus* larvae in terms of length and weight during the 28 days of experimental period are shown in Tables 2 and 3. The final weight of larvae under treatment I was significantly higher compared to that of treatment II while the final weight of larvae under treatment II was significantly higher than treatment III. Specific growth raet also showed the same sequence. Weight gain by the larvae of treatments II was significantly lower to compared to those of treatment I and higher compared to those of treatment III (Table 3). Survival rate of the larvae were 92.25%, 94%, and 16% of three treatment (I, II and III) respectively. Survival rate (94%) of the larvae fed mixed feed (tubificid worms + starter 1) wax similar to those fed only live feed (tubificid worms) and significantly better than those reared only on artificial feed.

Table 2. Mean growth of *Clarias batrachus* larvae in terms of leagth (mm) and weight (mg) at different times of the experimental period

Sampling	Treatment I		Treatment II		Treatment III	
Days	Length (mm)	Weight (mg)	Length (mm)	Weight (mg)	Length (mm)	Weight (mg)
0	8.9 ± 0.99	3.7 ± 1.15	8.9 ± 0.99	3.7 ±1.15	8.9 ± 0.99	3.7 ± 1.15
7	18.51 ± 0.40	201.2 ± 5.8	15.83 ± 0.23	208.7 ±66.5	10.85 ± 0.16	12.4 ± 0.9
14	28.3 ± 0.19	404.2 ± 10.4	22.9 ± 0.36	212.0 ± 40.8	12.79 ± 0.34	20.7 ± 2.0
21	37.7 ± 0.16	599.4 ± 14.5	29.85 ± 0.54	306.4 ± 14.33	13.76 ± 0.32	28.0 ± 3.4
28	47.63 ± 1.52	796.8 ± 68.06	37.37 ± 2.14	403.9 ± 56.37	16.48 ± 2.21	38.6 ± 11.73

Table 3. Growth performance of *Clarias batrachus* larvae in different diets

	Treatment I	Treatment II	Treatment III	± SE[1]
	Tubificid worms	Tubificed worms + Starter 1	Starter 1	
Initial weight (mg)	3.7[a2]	3.7[a]	3.7[a]	00
Final weight (mg)	796.8[a]	403.9[b]	38.6[c]	16.3
Initial length (mm)	8.9[a]	8.9[a]	8.9[a]	00
Final length (mm)	47.6[a]	37.4[b]	16.5[c]	0.7
Weight gain	793.1[a]	400.2[b]	34.9[c]	16.8
Specific growth rate (SGR% day)	19.2[a]	16.7[b]	8.13[c]	0.3
Survival rate (%)	92.3[a]	94.0[a]	16.0[b]	7.2

1 Standard error of treatment mean calculated form the residual mean square in the analysis of variance.

2 Figures in the same row having the same superscripts are not significantly different (P>0.05).

Discussion

In the present study best growth rate of *C. batrachus* larvae was obtained with live feed (treatment 1). On the other hand, larvae fed starter-1 only showed very poor growth and survival. Mollah and Nurullah (1988) successfully reared *C. batrachus* larvae with live feed (*Tubifex* spp.) In rearing the fry of *C. batrachus* in aquaria using supplemental feed during the first four weeks of life with live *Artemia salina* nauplii, zooplankton in live and frozen forms and with artificial feed, live *Artemia salina* nauplii was proved the best (Bairage *et al.* 1988). Fermin and Bolivar (1991) reported that the specific growth rate of *C.*

macrophalus after 14 days rearing period was higher for fish fed *Artemia* plus a dry feed than for other treatment groups fed either live zooplankton or a dry feed than for other treatment groups feed alone. *C. macrocephalus* larvae could directly take dry feed during the early day of exogenous feeding. However, continued feeding on dry artficial feed resulted in poor fish growth and survival. Similar was the case in the present study where 16% survival was recorded in the larvae fed only artificial feed compared to 94% and 92.25% for those fed live plus artificial and only live feed. Alam and Mollah (1988) reported *C. batrachus* larvae fed on live feed (*Tubifex* spp.) exhibiting significantly superior growth than artificial feeds. However, the survival rate (80.2%) obtained with artificial feed containing 56% fish meal, 19% baker's yeast and 14% wheat flour was comparable to those feed on *Tubifex* spp. (91.5%). Kestemont and Statmans (1992) reported best survival rate, growth and feed utilization of *Phoxinus phoxinus* larvae when reared with the frozen *Artemia* nauplii or mixed diet (50% *Artemia* and 50% dry feed). From an initial body weight of 1.86 mg at hatching, *phoxinus phoxinus* larvae reached about 30 mg in 4 weeks time and survival rate was higher than 96%. On the other hand, the dry feed was not suitable for the *Phoxinus phoxinus* larvae and mortality increases. According to Hirano and Hanyu (1990) all developmental stages of *C. gariepinus* can adopt to dry compound feeds. The best growth was, however, obtained for fish fed on *Artemia*.

Conclusions

It is clear from the result of present study and the discussion made so far that *C. batrachus* larvae can be reared successfully with live feed while artificial feeds give poor growth and very fluctuating survival rates. So, the question is how these larvae can be weaned gradually to an artificial diet keeping the growth and survival rates in the acceptable range. This is of tremendous importance from catfish larvae culture viewpoint. Therefore, further study under the appropriate experimental design to wean the *C. batrachus* larvae to the artificial feed needs to be conducted.

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Growth and survival of *Clarias batrachus* (Lin.) larvae fed on formulated diets

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Abstract

An experiment was conducted for a period of 28 days using 7-day old *C. batrachus* larvae of initial total length (±S.D.) of 7.4 ± 0.49 mm and weight (±S.D.) of 2.8 ± 0.75 mg. Five test diets *viz.* diets I, II, III, IV and V were prepared. Diet I was formulated using 30% fish meal (FM), 20% soybean meal (SM) and 20% Baker's yeast (BY), diet III using 15% FM, 20% SM, 15% cotton seed meal and 30% BY and diet IV using 20% FM, 30% BY and 30% powdered milk. The remaining two diets (diets II and V) were prepared using minced clam meat (96%) and BY (90%) respectively as the sole source of protein. Three replications were used for each treatment. The larvae fed on diet II exhibited significantly ($P<0.05$) better length gain and specific growth rate (SGR) than those of the larvae fed on diet III and there was no significant difference among the length gain and SGR of the larvae fed on diet I,II,IV and V. The larvae fed on diet II also showed significantly better weight gain and survival than those of the larvae fed on other diets. There was no significant difference between the condition factor of the larvae fed on diet II and IV. However, the larvae fed on diet II showed better condition factor than those of the larvae fed on other diets.

Key words : *C. batrachus* larvae, Feed, Rearing

Introduction

In order to mitigate the protein deficiency, semi-intensive and intensive fish culture are necessary in Bangladesh. Intensive culture depends on regular supply of fish fry. This calls for the development of appropriate larval feed. *Clarias batrachus* locally called 'magur' is a suitable species for intensive culture because it grows in haors, baors, paddy fields and exhibits remarkable growth performance within short time even in waste water. Though the fry of *C. batrachus* are produced successfully through induced breeding yet larval feed for successful rearing of fry exists as one of the main impediments for its intensive culture. Mollah (1987) and Mollah and Nurullah (1988) reported that *C. batrachus* larvae were successfully reared with live feed (*Tubifex* sp.). But there are several unavoidable problems associated with natural live food organisms. Availability of live food organisms depends on environmental factor, as a result

they have not been found round the year and their collection from natural habitat is laborious, unpredictable as well as time consuming. Artificial diets, appropriate for this purpose, on the other hand, can be manufactured on a large scale and can be distributed easily to ensure regular supply.

Works of Alam and Mollah (1988, 1989) on larval feed development and that of Sanaullah *et al.* (1986) on fingerling rearing of *C. batrachus* need mentioning. But the result were not conclusive enough compared to the works of (Hect 1981 & 1982, Hogendoorn *et al.* 1983, Uys and Hecht 1985, Verreth *et al.* 1987) on *Clarias gariepinus*. Therefore, the present experiment was designed to observe the growth and survival of *C. batrachus* larvae fed on formulated diets.

Materials and methods

The study was conducted in the indoor laboratory of the department of Fisheries Biology and Limnology, Bangladesh Agricultural University, Mymensingh. Larvae of *C. batrachus* used in the present study were produced by induced breeding with the use of human chorionic gonadotropin (HCG) at a dose of 3 and 2 IU/g body weight of female and male respectively. When the yolk sac was completely absorved, the larvae were fed with hard-boiled chicken egg yolk. The experiment was conducted using 7-day old larvae having an initial total length of 7.4 mm and weigth of 2.8 mg.

The experiment was carried out in glass aquarium of size 44 X 24 X 22 cm^3. Each aquarium was partially filled with 10 litre of water. Each of the aquaria was stocked with 100 *C. batrachus* larvae at a rate of 10 larvae/l of water. The aquaria were divided into five treatment groups (groups A, B, C, D and E) each having three replicates. Fishes of treatments A, B, C, D and E were fed respectively with diets I, II, III, IV and V.

The larvae of group A, C and D were fed with formulated diets containing fish meal, soybean meal, cotton seed meal, powdered milk, Baker's yeast, wheat flour, cod liver oil, attractant, vitamin and mineral premix (Table 1). The solid dietary ingredients were dried in the sun and ground to powder form. Fish protein concentrate of "lata fish" (*Channa striatus*) was used for this study. The required amount of powdered ingredients and oil were then measured and mixed thoroughly. The water was added to the mixture in such an amount that the feed was in paste form. The larvae of group B and E were fed with minced meat of freshwater clam (*Unio* sp.) and Baker's yeast respectively (Table 2). After removing the shells of clam, the meat was minced by using meat chopper and then supplemented with vitamin and mineral premixes. Attractant, vitamin and mineral premixes were diluted in water to make the Baker's yeast into paste form which was used as feed for group E (Table 2). All the feeds were in wet condition and were stored in deep freeze.

Table 1. Percentage composition of ingredients of the test diets and their proximate composition (% dry weight)

Ingredients[1]	Diets				
	I	II	III	IV	V
Fish meal	30.0	-	15.0	20.0	-
Soybean meal	20.0	-	20.0	-	-
Cotton seed meal	-	-	15.0	-	-
Baker's yeast	20.0	-	30.0	30.0	90.0
Powdered milk	-	-	-	30.0	-
Wheat flour	20.0	-	10.0	12.0	-
Cod liver oil	3.0	-	3.0	3.0	3.0
Attractant[2]	1.0	-	1.0	1.0	1.0
Vitamin premix[3]	3.0	2.0	3.0	2.0	2.0
Mineral premix[4]	3.0	2.0	3.0	2.0	4.0
Minced clam meat	-	96.0	-	-	-
Proximate composition (%)					
Crude protein	44.21	53.16	47.89	52.24	39.58
Lipid	9.33	4.82	15.30	13.04	7.52
Ash	7.40	38.03	14.75	9.50	9.50
NFE	39.06	3.99	22.06	25.22	43.40
Energy (Kcal/100g)	417.05	271.08	417.50	427.20	399.60

[1] *g/100g dry diet*
[2] *Sodium aspartate (salt of aspartic acid)*
[3 and 4] *Composition has been given in Table 3 and 4 respectively.*

Proximate composition of the dietary ingredients and test diets were determined by the method discribed by A.O.A.C. (1965) with slight modification (Table 2). The caloric content of the test diets were estimated by methods of Hastings (1979).

Table 2. Proximate composition of dietary ingredients used in five different experimental diets (% dry matter basis)

Ingredients	Dry matter	Crude protein	Lipid	Ash	Crude fibre	NFE*
Fish meal	93.00	78.91	10.56	10.53	-	-
Soybean meal	88.92	36.30	18.33	4.97	06.89	3.51
Cotton seed meal	86.60	25.20	16.86	6.50	26.25	25.19
Baker's yeast	94.60	37.87	6.59	3.21	0.08	2.25
Powdered milk	97.30	27.13	28.98	5.90	-	7.99
Wheat flour	92.14	12.48	1.32	2.11	02.14	81.95
Minced clam meat	53.16	4.82	38.03	0.43	3.56	22.80

NFE (Nitrogen free extract) = 100 - (crude protein + lipid + ash + crude fibre)

Table 3. Composition of the vitamin premix used in experimental diets.

Vitamin	g/kg of premix*	Vitamin	g/kg of premix*
Thiamin(B_1)	2.50	Choline	200.00
Riboflavin (B_2)	2.50	Niacin (Nicotinic acid, B_3)	10.00
Pyridoxin (B_6)	2.00	Cyanocobalamin (B_{12})	0.005
Pantothenic acid	5.00	Retinol palmitate (A)	100,000 IU
Inositol	100.00	α - tocopherol acetate (E)	20.10
Biotin	0.30	Ascorbic acid (C)	50.00
Folic acid	0.75	Menadione (K)	2.00
Para aminobenzoic acid	2.50	Cholecalciferol (D_3)	500,000 IU

**This mixture was made up to 1 kg with a- cellulose*

Table 4. Composition of mineral premix used in experimental diets (Jauncey and Ross1982)

Minerals	Chemical formula	g/kg
Calcium orthophosphate	$CaHPO_4.2H_2O$	727.7775
Magnesium sulphate	$MgSO_4.7H_2O$	127.5000
Sodium chloride	NaCl	60.0000
Potassium chloride	KCl	50.0000
Iron sulphate	$FeSO_4.H_2O$	25.0000
Zinc sulphate	$ZnSO_4.4H_2O$	5.5000
Manganese sulphate	$MnSO_4.4H_2O$	2.5375
Copper sulphate	$CuSO_4.5H_2O$	0.7850
Cobalt sulphate	$CoSO_4.7H_2O$	0.4775
Calcium iodate	$CaIO_3.6H_2O$	0.2950
Chromic chloride	$CrCl_3.6H_2O$	0.1275

The experiment was conducted for 28 days. The larvae were fed thrice daily between 0800 hr. and 2000 hr. The diets supplied in excess of satiation were settled at the bottom of each aquarium. The faeces in aquaria were removed by siphoning and the dead larvae (if any) were removed and counted in the morning and in the evening prior to each feeding. About two-third of the water was replaced after each cleaning. The water in the aquaria was aerated by laboratory air pump. Larval growth in length (mm) and weight (mg) were measured when the experiment was terminated after four weeks. The data expressed as percentage on survival rates were made arcsine transformation (Zaman *et al*. 1982) before statistical analysis. Statistical analysis of the data were done by one-way analysis of variance (ANOVA) and Duncan's multiple range test (Gomez and Gomez 1984) to determine differences in treatment means.

Results

The growth and survival rates of *C. batrachus* larvae in response to different formulated diets are presented in Table 5. The results showed that the larvae fed on diet containing cotton seed meal (group C) exhibited significantly lower length gain ($P<0.05$) and specific growth rate than those of the larvae of other groups. However, no significant difference was observed among the length gain and specific growth rate of the larvae of groups A, B, D and E. The larvae of group B attained better length gain and specific growth rate than those of the rests. The larvae of group B showed significantly better weight gain ($P<0.05$) than those of the larvae of other groups. However, the larvae of groups A, D and E showed significantly better weight gain than those of the larvae of group C and no significant difference ($P>0.05$) was observed among the weight gain of the larvae of groups A, D and E. The larvae of group B showed better condition factor than those of the larvae of other groups. There was no significant difference between the condition factor of the larvae of group B and D and same was the case among groups A, C, D and E (Table 5).

Table 5. Growth parameters and survival rate of *C. batrachus* larvae fed on five different diets at the end of the 28 days experimental period

Treatment Parameters	Group A	Group B	Group C	Group D	Group E	± S.E.
Initial total length (mm)	7.40	7.40	7.40	7.40	7.40	-
Final total length (mm)	22.42$_a$	23.42$_a$	13.17$_b$	21.99$_a$	20.72$_a$	1.36
Length gain (mm)	15.02$_a$	16.02$_a$	5.77$_b$	14.59$_a$	13.32$_a$	1.36
Initial weight (mg)	2.80	2.80	2.80	2.80	2.80	-
Final weight (mg)	100.67$_a$	152.92$_a$	20.17$_c$	104.18$_a$	78.40$_b$	12.17
Weight gain (mg)	97.87$_a$	150.12$_a$	17.37$_c$	101.38$_a$	75.60$_b$	12.17
Specific growth rate (%/day/fish)	10.90$_a$	13.83$_a$	6.74$_b$	12.82$_a$	11.52$_a$	1.12
Condition factor	0.88$_b$	1.11$_a$	0.84$_b$	0.99$_a$	0.85$_b$	0.05
Survival (%)	11.38$_b$	39.23$_a$	10.07$_b$	22.66$_b$	15.33$_b$	4.60

Figures in the same row with same letters are not significantly different at $P<0.05$.

The larvae fed on minced clam meat (group B) showed significantly higher ($P<0.05$) survival rate than those of the rests and there was no significant difference among the survival rates of the larvae of group A, C, D and E. The growth and survival rate of the larvae which were fed with diet containing cotton seed meal was very low.

The mortality of the larvae of groups A, B, C, D and E were 3, 25, 29, 18 and 6% respectively during 1st 7 days. The mortality of the larvae of four groups (group A, C, D and E) ranged from 56-81% during 14 days whereas the larvae fed on minced clam meat (group B) showed only 9.67% mortality.

But mortality of the larvae of group B was highest (60.77%) on 28 days of observation. The larvae fed on diet containing cotton seed meal showed 81.67% mortality at day 14. The larvae of other three groups (group A, D and E) showed higher mortality. The larvae of groups A, C, D and E showed similar trend in mortality upto the end of the experiment.

Discussion

Five diets were tested for a period of 28 days to develop a suitable artificial feed for *C. batrachus* larvae. Except the cotton seed meal based diet (group C), all the diets were readily accepted by the larvae. However, the minced clam meat was accepted more by the larvae than the other diets. The larvae fed on minced clam meat (group B) exhibited better growth response and survival rate followed by the larvae fed on diet containing yeast and powdered milk (group D). The larvae of group B showed an average weight gain, specific growth rate and condition factor of 150.12, 13.83 and 1.11mg respectively. This result contradicts with the findings of Alam and Mollah (1989). In their study they found that minced clam meat gave an average weight gain, specific growth rate and condition factor of 27.50, 7.45 and 0.86mg respectively in 20 days feeding trial (25 days after hatching). The causes of such better growth rates in the present study might be due to supplementation of clam meat with growth factors such as vitamins and minerals, better acceptability of the food to the larvae and also the duration of the feeding trial. However, the weight gain of the larvae of group B was comparable to the findings of Dabrowski *et al.* (1984). According to the authors, coregonid larvae fed on *Artemia* attained an individual weight of 161 mg within 35 days. But the weight gain of the larvae of group B was better than the findings of Verreth *et al.* (1987) and Bairage *et al.* (1988). The survival rate of the larvae fed on minced clam meat was higher than the survival rate reported by Alam and Mollah (1989). Coregonid larvae fed on single cell protein based dry diets showed individual weight of 98-107 mg (Dabrowski *et al.* 1984) which was comparable to weight gain of the larvae of group D of the present study. But the growth rates of the larvae of group D was better than the findings of Verreth *et al.* (1987) and Bairage *et al.* (1988).

The diet containing 30% yeast and 30% milk (group D) gave survival rate of 22.66% which was comparable to the result reported by Dabrowski *et al.* (1978) and Dabrowska *et al.* (1979) and inferior to the survival rate reported by Winfree and Stickney (1984), Dabrowski *et al.* (1984), Uys and Hecht (1985) and Alam and Mollah (1989). The larvae fed on diet containing cotton seed meal showed

very poor growth and higher mortality. The cause of such poor growth and higher mortality was perhaps due to lower acceptability of the diet to the larvae from the starting of the feeding trial. Dorsa *et al.* (1982) reported that diet containing more than 17.4% cotton seed meal inhibited the growth of channel catfish. The larvae of groups A, D and E exhibited higher mortality although their feeds were readily accepted by the larvae.

Madhury and Mollah (1990) assumed that lack of growth factor in yeast diet might be responsible for lower survival at the end of the feeding trial. But in the present study, yeast supplementd with vitamins and minerals gave better growth rates than the larvae fed on yeast only reported by Madhury and Mollah (1990). However, the survival showed a decreasing trend in this study.

The larvae fed on minced clam meat showed 22.33% mortality at day 21. Highest mortality was observed between day 15 and 20 may be due to deficiency of growth factors such as vitamins in the clam (Alam and Mollah 1989). Although the minced clam meat were supplemented with vitamins and minerals in the present study, the larvae showed highest mortality between day 21 and 28. It is, therefore, an indication that supplementation of growth factors although increased the growth of the larvae, it had no significant effect on the mortality of the larvae. It was also true for the larvae fed on yeast only.

During 28 days of experimental period, it was observed that the larvae fed on minced clam meat showed least mortality up to 14 days (9.67%). However, mortality in all treatments showed increasing from 14 days up to the end of the experiment. The cause of such higher mortality at the end of the experiment could not be ascertained. Future experiment may be carried out to investigate the cause of such higher mortality.

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Effect of different rice brans on the growth of Thai silver barb (*Puntius gonionotus* Bleeker) in seasonal ponds

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Abstract

An experiment was conducted for a period of 110 days to study the effect of different rice brans on the growth of Thai silver barb (*Puntius gonionotus*, Bleeker) in rainfed seasonal ponds (30 m^2 each). Each of the pond was stocked with 150 fish with the mean initial body weight of 2.03 ± 0.03 g. There were three treatments namely R_1, R_2 and R_3 each having four replicates. Three types of rice bran namely coarse, auto (fine) and red were applied to the treatments R_1, R_2 and R_3 respectively. Fish received different types of rice bran at a rate of 5% of body weight daily. The water quality parameters were found within the productive range. The results showed that treatment R_1 produced significantly ($p<0.05$) highest growth and treatment R_2 produced the lowest growth. The survival rates varied between 77 and 84% with treatment R_3 producing the highest survival. However, the overall best production (1530 kg/ha) and economic return for the culture period was obtained in treatment R_1 receiving coarse rice bran. The results of the present study demonstrated that the coarse rice bran resulted in better growth and production of *P. gonionotus*.

Key words : *Puntius gonionotus*, seasonal ponds, rice bran.

Introduction

To increase the fish production, culture of Thai silver barb (*Puntius gonionotus*) has added a new direction in Bangladesh. On-farm trails have indicated the feasibility of raising sharpunti in seasonal ponds and ditches which can retain water for 4 to 6 months. Silver barb (*P. gonionotus*) is one of the best suited species for bringing the unutilized or underutilized waterbodies under semi-intensive culture. It has been introduced in many Asian countries including Bangladesh not only for its palatability and marketability but also for high yield potential (Hussain *et al*. 1987).

Feed cost generally constitute the highest single operating cost of semi-intensive farming operation (Shang 1983). It is therefore of major importance to the low-income farmers to utilize their investments in feed as optimal as possible. It must be emphasized that the benefits of supplemental feeding will

depend on the composition and physical form of the feed used, the stocking density of fish cultured and the natural productivity of the waterbody in question.

As Bangladesh is mainly an agro-based country, a large variety of agricultural by-products, such as rice brans, pulse brans, oilcakes and molasses are being used as fish feeds. Usually there are three types of rice brans *viz.* coarse & auto/fine obtained from rice mills and red/brown obtained from paddle husk are available in Bangladesh. Rice bran is the cheapest and most commonly available feed ingredients in Bangladesh. For this reason, it is widely used as supplemental feed in extensive and semi-intensive aquaculture practices. In Bangladesh annually about 15 million metric tons of rice grain are produced. Sixty six percent of rice grain is rice and remaining 34% is hull-mixed bran. In this hull-mixed bran only 1/3 portion is bran (Bhuiyan *et al.* 1989). However, there is no information whether the rice bran used is directly consumed by fish as feed or it indirectly acts as fertilizer for increasing the primary productivity of water which ultimately enhance the growth of fish. Thus, the present study was undertaken to determine the effect of different types of rice bran on the primary productivity of pond as well as on fish growth.

Materials and methods

Experimental system

The experiment was carried out in 12 earthen miniponds, for a period of 110 days commencing from 19th July to 6th November '96. The size of each of the pond used for the growth trial was $30^{-4}m^2$ (6x5 m). The water depth was maintained to a maximum of 1.2 m using fine meshed PVC over flow pipe on the bank fixed at 1.2 m above the pond bottom. All the ponds were drained out and lime was applied at the rate of 1 kg/decimal. No fertilizer was applied. The ponds were arbitrarily numbered as 1 to 12 for the convenience of experimental work.

Collection of supplemental feed

Three types of rice bran used as supplemental feed were collected from Mymensingh local market. These were a) coarse- rice bran from rice mills containing both coarse hull and bran, b) auto- very fine rice bran from automatic rice mills and c) red- fine brown paddle husked rice bran without hull. The rice brans were analysed for proximate composition and the results are presented in Table 1. To findout the particle size distribution the rice brans were sieved through 0.5 mm, 1.0 mm and 1.4 mm mesh using Endecotts Test Sieves (England) and the results are shown in Table 2.

Table 1. Proximate composition of rice brans (% dry matter basis)

Name of rice brans	Dry matter	Protein	Lipid	Ash	Crude fibre	NFE*
Coarse rice bran	89.59	8.08	10.82	16.49	28.94	35.67
Auto rice bran	89.47	11.62	18.29	13.94	20.13	36.02
Red rice bran	90.44	10.94	17.23	21.81	23.09	26.93

* *Nitrogen free extract (NFE) calculated as 100 - % (moisture + protein + lipid + ash + crude fibre)*

Table 2. Particle size distribution (percentages) of different rice brans

Name of rice brans	Particle size (mm.)	% of total
Coarse rice bran	<0.5	38.98
	0.5-1.0	38.25
	1.0-1.4	18.25
	1.4-2.0	4.51
Auto rice bran	<0.5	75.68
	0.5-1.0	28.82
	1.0-1.4	0.39
	1.4-2.0	0.08
Red rice bran	<0.5	49.69
	0.5-1.0	32.91
	1.0-1.4	14.95
	1.4-2.0	2.45

Experimental procedure

Experimental ponds were divided into three treatments namely R_1, R_2 & R_3 each having four replicates. Three types of rice bran namely coarse, auto and red were applied to the treatments R_1, R_2 and R_3 respectively. Rice brans were broadcasted on the pond water surface. The supplementary feed were given twice daily at the rate of 5% of fish biomass. Fingerlings of silver barb (*P. gonionotus*) were collected from local fish vendors. Each of the pond was stocked with 150 (5/m^2) fish with a mean initial body weight of 2.03 ± 0.03 g. Fortnightly random sampling was done using a seine net to ascertain fish growth and also to adjust feeding rate. At the end of the experiment harvesting was done by total draining out of pond water.

Water quality parameters

The water quality parameters such as temperature, dissolved oxygen (DO), pH and alkalinity were monitored weekly. The temperature and dissolved oxygen of the pond water were determined by DO meter (YSI, model 58, USA).

Water pH was recorded by pH meter (Jenway, model 3020, UK) and alkalinity was measured by titrimetric method.

Estimation of plankton

Water samples were collected from all ponds for the quantitative and qualitative study of both phytoplankton and zooplankton. Five litres of water samples were taken from different areas and depths from each pond and then passed through a plankton net of 65 micron mesh size. The samples were studied using a Sedgewick-Rafter (S-R) counting cell and binocular microscope (Olympus, model BH-2). All planktonic organisms were counted as plankters present on 10 squares of the cell, chosen randomly and were enumerated to phytoplankton and zooplankton groups. Plankton was expressed as cells or units per litre of water of each pond.

Carcass composition

At the beginning of the experiment 25 fish from the stock were randomly sacrificed and used for proximate composition analysis which was considered as initial composition. At the end of the experiment 12 fish per treatment (3 per replicate) were sampled for proximate composition analysis and considered as the final sample.

Analytical methods

The proximate composition of different types of rice bran and fish samples were analysed in triplicate according to standard procedure given in Association of Official Analytical Chemists (AOAC, 1980).

Statistical analysis

One way analysis of variance (ANOVA) was used to determine the effect of different rice brans on the growth of fish. This was followed by Duncan's New Multiple Range Test (Duncan 1955) to identify the level of significance of variation among the treatment means. Standard error (± S.E.) of treatment means were calculated from the residual mean square in the analysis of variance.

Economic analysis

A simple economic analysis was performed to estimate the net profit from this type of culture operation. The cost of production was based on the Mymensingh whole sale market price (1996) for the inputs used. The cost (Tk/kg) of different types of rice bran were: coarse rice bran Tk. 2.25/-, auto rice bran Tk. 4/- and red rice bran Tk. 7/-. The selling price for silver barb was estimated as 50 Tk/kg. However, cost of leasing the ponds was not included. An additional 7.5% on the top of total inputs has been included towards operating cost (ADCP 1983).

Results

Water quality parameters

The ranges of water quality parameters in different ponds monitored during the study period were: temperature 29.2-30.7°C; pH 6.46-7.04; alkalinity 43.38-78.63 mg/l. Dissolved oxygen was measured at morning (9:00 hours) and the ranges were 4.21-7.47 mg/l. The dissolved oxygen content during early morning (6.00h) varied between 0.31-2.12 mg/l while in the afternoon it varied between 7.82-15.78 mg/l.

Plankton

The mean abundance of plankton and their different groups have been shown in Table 3. Cyanophyceae was found to be the most dominant phytoplankton throughout the study period and its abundance varied between $61x10^4$ to $75x10^4$/l. Bacillariophyceae was the least abundant plankton and its mean abundance varied between $19x10^4$ and $28x10^4$/l. Cyanophyceae was dominant phytoplankton group in treatment R_2 followed by R_3 and R_1 respectively.

Table 3. Group wise mean plankton (x 10^4) count in per litre of water in different treatments

	Treatments		
	R_1	R_2	R_3
A. Phytoplankton			
Bacillariophyceae	28	22	19
Chlorophyceae	66	56	52
Cyanophyceae	61	75	69
Euglenophyceae	38	33	40
B. Zooplankton			
Crustacea	31	22	27
Rotifera	24	19	24
Total	248	227	231

The zooplankton population consisted of Crustacea and Rotifera. The highest mean zooplankton population was recorded in treatment R_1 while the lowest was observed in treatment R_2. The mean abundance of Crustacea varied from $22x10^4$ to $31x10^4$/l while abundance for Rotifera varied from $19x10^4$ to $24x10^4$/l. The overall mean abundance of plankton (phytoplankton + zooplankton) varied between $227x10^4$ to $248x10^4$/l. Treatment R_1 showed the highest while treatment R_2 showed the lowest abundance of plankton during the study period.

Growth performance of fish

The growth performance of silver barb in terms of initial weight, final weight, weight gain, specific growth rate (SGR), food conversion ratio (FCR), survival rate and total production are shown in Table 4.

Table 4. Growth parameters of silver barb fed on different rice brans for 110 days

Parameters	Treatments			
	R_1	R_2	R_3	± S.E.[1]
Initial weight (g)	2.01[a2]	2.05[a]	2.04[a]	.0223
Final weight (g)	37.70[a]	33.25[c]	36.29[b]	.2387
Weight gain (g)	35.69[a]	31.20[c]	34.25[b]	.2439
Specific growth rate (% day)	2.66[a]	2.53[c]	2.61[b]	.0223
Food conversion ratio (FCR)	3.37[b]	3.93[a]	3.26[b]	.0894
Survival rate (%)	81[a]	77[a]	84[a]	6.7724
Total production of fish (kg/treatment)	4.59[a]	3.85[a]	4.58[a]	0.3286
Total production (kg/ha/110 days)	1530	1283	1527	

[1] *Standard error of treatment means calculated from the residual means square in the analysis of variance*

[2] *Figure in the same row having same superscripts are not significantly different (P >0.05)*

Among the treatments the weight gain of fish was significantly ($p<0.05$) highest in treatment R_1 receiving coarse rice bran while the growth was lowest in treatment R_2 receiving auto rice bran (Table 4).

The specific growth rate (SGR) of fish in different treatments ranged from 2.53 to 2.66 and treatment R_1 produced significantly ($p<0.05$) the highest SGR (Table 4).

The mean food conversion ratio (FCR) values in different treatments varied from 3.26 to 3.93 with treatment R_2 producing significantly ($p<0.05$) the poorest FCR (3.93). Treatments R_1 & R_3 produced better FCR. However, there was no significant ($P>0.05$) difference between the FCR values of treatment R_1 and R_3 (Table 4).

The survival rate of fish was estimated after harvesting of fish by draining out of the ponds. The fish survival rate in different treatments ranged between 77 to 84%. There was no significant ($p>0.05$) difference between the survival of fishes in different treatments.

The highest fish production was recorded in treatment R_1 (4.59 kg/treatment) receiving coarse rice bran and the fish production in different treatments ranged from 3.85 to 4.59 kg/treatment and 1283 to 1530 kg/ha over a period of 110 days (Table 4). A simple cost and return analysis showed that the highest net profit was obtained in treatment R_1 (Tk. 36,333/- per ha/110 days) followed by treatment R_2, R_3 respectively (Table 5).

Table 5. Cost and return analysis of fish production

Line item	Treatments		
	R_1	R_2	R_3
A. Investment			
i) Lime (Tk)	3	3	3
ii) Fingerling (Tk)	75	75	75
iii) Feed cost (Tk)	35	61	105
iv) Operational cost (Tk)*	8	10	14
Total cost	121	149	197
B. Gross profit (Tk) (from fish sale):	230	193	229
Net profit (Tk/ha/110 days)	36,333	14,667	10,667

1 US $ = 44 Taka, Sale price: Silver barb = 50 Tk/kg
** Operational cost is considered as 7.5% of total cost (ADCP, 1983)*
*** Leasing cost for pond is not included.*

Carcass composition

The proximate carcass composition (% fresh matter basis) of fish at the start and at the end of the experiment is presented in Table 6. The final carcass moisture content ranged between 69.79 to 72.01%. The highest carcass protein was observed in treatment R_3 and the carcass protein content in different treatments ranged between 16.42 and 17.29%. The carcass lipid content varied between 7.17 and 9.67% with treatment R_3 showing the highest. There was no wide variation between the carcass ash content in different treatments which ranged between 3.11 and 3.61%.

Table 6. Carcass composition of experimental fishes at the start and end of the growth trial (% fresh matter basis)

Components	Initial	Final		
	all fish	R_1	R_2	R_3
Moisture	77.04	72.01	71.54	69.79
Crude protein	15.17	17.05	16.42	17.29
Lipid	5.37	7.17	8.49	9.67
Ash	2.38	3.61	3.43	3.11

Discussion

Growth, feed efficiency and feed consumption of fish are normally governed by a number of environmental factors such as temperature, dissolved oxygen and pH (Brett 1979). Environmental factors exert an immense influence on the maintenance of a healthy aquatic environment and production of sufficient fish food organisms. In this study, the water quality parameters such as temperature, pH, dissolved oxygen and alkalinity were within the normal range of fish farming. Rahman *et al.* (1982) recorded 26.5-32.2°C water temperature, dissolved oxygen values of 0.40-8.60 mg/l, total alkalinity range of 22.90-82.68 mg/l in four selected ponds. Hossain *et al.* (1997) observed the temperature range of 27-35°C, pH from 6.7-8.3, alkalinity of 47.5-105.0 mg/l and dissolved oxygen levels of early morning and afternoon at surface water ranged between 0.6-3.3 and 6.0-16.0 mg/l respectively throughout the study period in mixed culture of fishes in seasonal ponds through fertilization and feeding.

The ranges of temperature and pH values recorded in the present study are more or less similar to that reported by *Hossain et al.* (1997). In the present study, the range of dissolved oxygen values was 4.21-7.47 mg/l and the range of DO values were more or less similar to that reported by Rahman *et al.* (1982). The range of DO values recorded at surface water in the present study in the early morning was very low (0.31-2.12 mg/l). However, the range of DO values at surface water during afternoon was quite high ranging from 7.82-15.78 mg/l. The low DO level in the early morning might be due to the consumption of dissolved oxygen by fish biomass since no oxygen is produced by photosynthesis during night and high biochemical oxygen demand (BOD) for decomposition of organic matter in pond bottom.

Total alkalinity is an important factor controlling the productivity of a water body. Moyle (1946) reported that ponds and lakes with the range of total alkalinity of 40-90 mg/l are of medium to high productivity. The range of alkalinity values in the present study varied between 43.38-78.63 mg/l and the range of alkalinity values seems suitable for fish culture.

Plankton abundance in different treatments in the present study indicated that the primary productivity of water was good for fish culture. Dewan *et al.* (1991) and Wahab *et al.* (1994) identified 21 genera of phytoplankton belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and 9 genera of zooplankton belonging to Hydrozoa, Crustacea and Rotifera in the tropical fish pond which are more or less similar to the present study. However, the plankton abundance in different treatments recorded in the present study was much lower than that reported by Dewan *et al.* (1991) and Wahab *et al.* (1994). This may be due to the fact that no fertilizer (organic or inorganic) was used in the present study, as a result the plankton biomass in the treatments were comparatively low.

The highest weight gain (g) of fish was observed in treatment R_1 followed by treatments R_3 and R_2 (Table 4). The variation in weight gain of fish in different treatments might be due to the different particle size of rice brans used. Although there is very little information available regarding the ingestion of food on the basis of particle size. Hasan and Macintosh (1992) reported that carp fry prefer greater food particle size with the increase of fish size. Northcott *et al.* (1991) reported that ingestion rate increased with the increased particle size in the case of *Oreochromis niloticus*. This findings more or less agree with the present study. This suggests that the observed fish growth was probably due to direct ingestion of rice bran rather than increasing pond natural productivity.

The SGR values in the present study is lower than the values (3.3) reported for common carp when fed a prepared diet using rice bran, groundnut oilcake and fish meal fed at the rate of 3% fish biomass in natural tanks (Sehgal and Toor, 1991) but higher than the values (1.24) reported by Sumagaysay *et al.* (1991) for *Chanos chanos* fed rice bran diet.

Since the fish received the nutrition from supplemental feed as well as from natural food in the pond, the FCR of supplemental feed was gross as nutrition from the two sources was not separated. The highest and lowest food conversion ratio (FCR) were observed in treatments R_2 & R_3 respectively. The highest FCR value observed in treatment R_2 might be due to the smallest particle size and moderate protein content of rice bran used. The FCR values in the present study are lower than the value (4.2) reported for *Puntius gonionotus* fed fine rice bran by Kohinoor *et al.* (1994).

The higher survival rate observed in the present study might be due to the comparatively favourable culture condition prevailed in the ponds. The survival values are more or less similar to the values reported by Santiago *et al.* (1989). They found mean survival rates of the milkfish in ponds, ranging from 77 to 93%, were not significantly different ($p>0.05$) among treatments when fed combination of *Spirullina* powder and formulated diet, formulated diet alone and rice bran alone. Sumagaysay *et al.* (1991) found survival rate of 76% for milkfish in brackish water ponds when fed rice bran.

The highest total production in treatment R_1 in the present study might be due to significantly higher weight gain of individual fish in treatment R_1. Kohinoor *et al.* (1993) reported that feeding treatment resulted significantly better production of *P. gonionotus* (2384 kg/ha/6 months) than that with fertilization (2129 kg/ha/6 months) treatment. Kohinoor *et al.* (1994) also reported an average fish production was 2075 kg/ha/6 months for *P. gonionotus* as compared to 1304 kg/ha for *P. sarana* in ponds receiving regular fertilization and rice bran as supplemental feed. The production obtained in the present study are similar to that reported by Kohinoor *et al.* (1993) and Kohinoor *et al.* (1994).

Although the total fish production in treatments R_1 and R_3 are more or less similar, the cost benefit analysis showed that treatment R_1 generated higher

profit than that of treatment R_3 (Table 5). This might be due to the low cost of coarse rice bran (2.25 Tk/kg) used which is almost 3 times cheaper than that of red rice bran (7 Tk/kg). Kohinoor *et al.* (1993) reported that the net income of raj punti under semi-intensive culture was 75,098 Tk/ha/6 months which was higher than the profit obtained with the present study. In another study Kohinoor *et al.* (1994) stated that the net profit of *P. gonionotus* was 54,920 Tk/ha/6 months under semi-intensive culture system (when fed fine rice bran) which is slightly lower than that obtained with treatment R_1 in the present study.

The proximate carcass composition of fish was influenced by different rice brans. There was a marked increase in lipid content of fish fed on different rice brans compared to the initial lipid content of fish (Table 6). The carcass lipid content was directly influenced by the dietary (rice bran) lipid. An inverse relationship between lipid and moisture could be observed as reported earlier (Hossain *et al.* 1994).

The results of the present study demonstrated that the coarse rice bran resulted in better production of *P. gonionotus*.

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Investigation on bacterial flora of farmed freshwater prawn (*Macrobrachium rosenbergii* de Man) in Bangladesh

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Abstract

Total bacterial load in the haemolymph of freshwater prawn *Macrobrachium rosenbergii* varied from $6.2x10^4$ to $1.9x10^7$ CFU/ml whereas in the hepatopancreas, bacterial load varied from $1.9x10^3$ to $2.9x10^5$ CFU/g. The total bacterial load in the pond water varied from $2.6x10^2$ to $4.1x10^5$ CFU/ml. The isolated bacterial genera in the haemolymph and the hepatopancreas of prawn were *Streptococcus, Acinetobacter, Micrococcus, Aeromonas, Vibrio, Flavobacterium, Staphylococcus* and *Pseudomonas,* whereas the detected bacterial genera in pond water were *Micrococcus, Streptococcus, Vibrio, Flavobacterium, Staphylococcus, Pseudomonas* and *Aeromonas.* Among the detected genera, *Vibrio* and *Staphylococcus* were found to be dominant genera in the haemolymph of the sampled prawn throughout the study period whereas *Staphylococcus* and *Pseudomonas* were dominant in pond water.

Key words : *M. rosenbergii*, Haemolymph, Hepatopancreas, Bacterial flora

Introduction

Now-a-days freshwater prawn farming has turned to be a promising sector in Bangladesh since return from export earning of this commodity is considerable high. With the rapid development in *Macrobrachium* hatchery production and number of prawn grow-out farms, good husbandry and environmental problems developed as prawn were stressed and weakened under adverse conditions. Moreover, shrimp is a highly putrescent fishery commodity as microbial activity is the most effective in producing undesirable odours and appearance in shrimp. Considering the importance of prawn fishery and the recent outbreak of shrimp disease in the country, a preliminary investigation was designed to investigate the bacteriological status in farmed prawn, *Macrobrachium rosenbergii* to know the monthly distribution pattern of bacteria in different organs of prawn.

Materials and methods

Water and prawn samples

Grow-out ponds under Jhalak Fish Farm- a private entreprenuer at Gouripur in Mymensingh were selected for sampling of freshwater prawn, *Macrobrachium rosenbergii*. Prawn samples were collected twice in a month and carried to the Fish Disease Laboratory of BAU in a plastic container containing the same pond water of the respective prawn samples.

Prawn organs for bacterial isolation

The prawn were stopped their movement by a simple hurt to the head. A disposable syringe was inserted into the cephalo-thorax region under the carapace to collect haemolymph from the heart of the prawn. An amount of 0.3 ml haemolymph was mixed with 2.7 ml of physiological saline solution (0.85% NaCl) to make a stock suspension. Samples of hepatopancreas were collected with a sterile loop in a pre-weighted test tube. Suspension of hepatopancreas containing bacteria was made in physiological saline solution with the help of a vortex mixer. Necessary dilution were made by ten-fold dilution method. Inoculum (0.1 ml) was spread on TSA plates, incubated at 25^{0}C and colonies were counted after two days of incubation.

Determination of bacterial isolates

Total number of bacteria were determined by counting the developed colonies on the triplicate plates of the same dilution after incubation. For determination of percentage composition, twenty colonies were seperated unbiasly from the total colonies grown in each of the plate having the number within 30 to 300 to obtain the pure culture and to characterize the isolates. From these plates of pure culture the isolates were preserved on TSA agar slant at a temperature of 4^{0}C and successive studies were performed for characterization of the isolates to identify them upto genus/group level according to the methods described by Cowan and Steel (1975) and Thoesen (1994) with slight modification. After the identification of bacterial genera/groups the percentage composition were determined on the basis of twenty isolates from pond water, haemolymph and hepatopancreas of the sampled prawn.

Results and discussion

The total bacterial load during the sampling period as varied from $6.2x10^4$ to $1.9x10^7$ CFU/ml of haemolymph, $1.9x10^5$ to $2.9x10^8$ CFU/g of hepatopancreas and $2.6x10^2$ to $4.1x10^5$ CFU/ml of pond water (Table 1). Total number of bacteria in the haemolymph of prawn varied with the months. The bacterial load of pond water was found to vary with months but they did not differ distinctly among the ponds studied. In pond water highest number of bacterial population was found in the month of July and the lowest in the month of November.

Table 1. Monthly variation of the total bacterial load in the haemolymph, hepatopancreas of *M. rosenbergii* and pond water

Months	Total load of the bacterial genera					
	Pond-1			Pond-2		
	Haemolymph (CFU/ml)	Hepatopancreas (CFU/g)	Water (CFU/ml)	Haemolymph (CFU/ml)	Hepatopancreas (CFU/g)	Water (CFU/ml)
July	$1.7x10^{5}$	$4.9x10^{6}$	$2.5x10^{4}$	$1.9x10^{7}$	$2.9x10^{7}$	$4.1x10^{5}$
August	$7.0x10^{6}$	$3.0x10^{5}$	$1.6x10^{3}$	$2.6x10^{6}$	$3.7x10^{4}$	$1.9x10^{4}$
September	$1.3x10^{5}$	$4.6x10^{4}$	$2.2x10^{3}$	$1.3x10^{6}$	$3.6x10^{4}$	$8.5x10^{3}$
October	$2.3x10^{6}$	$4.6x10^{3}$	$1.7x10^{3}$	$9.6x10^{6}$	$4.2x10^{4}$	$2.4x10^{3}$
November	$6.2x10^{4}$	$5.0x10^{3}$	$8.6x10^{2}$	$4.6x10^{5}$	$8.4x10^{3}$	$2.6x10^{2}$
December	$3.9x10^{6}$	$1.9x10^{3}$	$2.3x10^{3}$	$2.7x10^{4}$	$3.3x10^{6}$	$1.6x10^{3}$

The bacterial genera/groups detected in the haemolymph and hepatopancreas of the prawn were tentatively *Streptococcus, Acinetobacter, Micrococcus, Aeromonas, Vibrio, Flavobacterium, Staphylococcus* and *Pseudomonas* (Table 2), whereas the detected bacterial genera in pond water were *Micrococcus, Streptococcus, Vibrio, Flavobacterium, Staphylococcus, Pseudomonas* and *Aeromonas* (Table 3). The identified bacterial genera recovered from the haemolymph were found throughout the study period except *Acinetobacter*, and *Vibrio* was found to be dominant genera in the month of August. *Flavobacterium* and *Staphylococcus* were found to be dominant in the hepatopancreas of prawn.

Table 2. Monthly distribution of bacterial genera in the haemolymph and hepatopancreas of cultured *M. rosenbergii*

Months	Prevalence of the bacterial genera															
	Haemolymph								Hepatopancreas							
	Str.	Aci	Mi.	Ae.	Vi	Fl.	Sta	Ps.	Str	Aci	Mi.	Ae	Vi	Fl	Sta	Ps.
July.	11	Nd	14	14	20	19	08	12	15	03	13	12	03	24	26	08
Aug.	12	Nd	13	14	37	03	20	05	17	05	13	13	07	13	23	13
Sep.	09	12	11	10	19	18	20	07	09	15	19	13	Nd	14	21	10
Oct.	11	24	03	11	10	Nd	20	24	09	13	19	17	15	14	22	11
Nov.	08	12	13	17	14	07	10	20	18	09	13	12	07	13	24	13
Dec.	10	03	12	20	23	05	20	09	15	03	11	13	03	23	24	11

Str : *Streptococcu* Aci : *Acinetobacter* Mi : *Micrococcus*
Ae : *Aeromonas* Vi : *Vibrio* Fl : *Flavobacterium*
Sta : *Staphylococcus* Ps : *Pseudomonas* Nd : Not detected

Table 3. Monthly distribution pattern of bacterial genera in pond water

Months	Prevalence of the bacterial genera											
	Pond-1						Pond-2					
	Mi.	Str.	Vi.	Fl.	Sta.	Ps.	Mi.	Ae.	Vi.	Fl.	Sta.	Ps.
July	07	06	20	07	30	30	22	12	Nd	28	38	Nd
August	35	10	12	13	15	15	12	08	10	30	40	Nd
September	20	08	12	15	22	23	13	15	08	27	32	05
October	13	22	08	12	23	22	15	23	Nd	27	27	08
November	15	30	10	15	15	15	03	22	05	20	25	25
December	10	12	18	20	20	20	10	27	Nd	22	18	23

Mi : *Micrococcus* Str : *Streptococcus* Vi : *Vibrio*
Fl : *Flavobacterium* Sta : *Staphylococcus* Ps : *Pseudomonas*
Ae : *Aeromonas* Nd : Not detected

Qualitative and quantitative composition of bacteria in different organs of the prawn investigated were found to vary with months, organs and pond water also. In the study period, the bacterial load in the haemolymph of prawn were higher than those in hepatopancreas or pond water. Environmental factors such as water temperature, pH, dissolved oxygen, nutrients, organic substances etc. might be the causal factors of these variations. Besides these supplementary feed to prawn were the sources of organic substances. Bacterial growth in water was influenced by availability of carbon and energy source (Marshal 1985). Udea *et al.* (1992) mentioned that the microflora associated with the growing prawn significantly influenced by the environmental conditions. Total load of bacteria in the haemolymph of prawn was higher in summer than in winter due to the differences in the ambient temperature (Zuberi *et al.* 1992, Fonseka and Ranjini 1995).

Poor water quality and high organic loading are associated with shell lesion including bacterial growth in grow-out prawn. A variety of bacteria, producing extracellular lipases or protease such as *Aeromonas, Pseudomonas, Vibrio, Benekea* spp. have been implicated in shell disease (Cook and Lofton 1973). Organic matter supplied as feed to pond and manure increased the bacterial load in pond water (Moriarty 1986). In most of the months, *Vibrio* and *Pseudomonas* were high in the haemolymph of prawn investigated which is similar with the findings of Lombardi and Labao (1991a and 1991b), mentioned *Pseudomonas, Vibrio* etc. as the possible causative agents of prawn diseases. Although pathogenicity and antibiotic test were not performed in the present study, the isolated bacteria *Pseudomonas, Vibrio* and *Aeromonas* could be pathogens to the cultured prawns which needs further study.

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Estimation of maximum sustainable yield (MSY) of hilsa (*Tenualosa ilisha* Ham.) in the Meghna river of Bangladesh

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Abstract

MSY per recruit of *Tenualosa ilisha* in the Meghna river was predicted as 112 g per recruit at the F_{msy}=0.6 /yr and at T_c=0.6 /yr. But Y/R=95 g per recruit was obtained at the existing fishing level, F=1.14 /yr and at T_c = 0.6 /yr. Existing F level was nearly double than the F_{msy} level. Fishing pressure should be reduced immediately from F=1.14 /yr to F_{msy}=0.6 /yr. F_{msy}=1.14 /yr was the same at first capture, T_c=1.0, 1.2 and 1.4 /yr, and MSY could be obtained as 142 g, 162 g and 176 g per recruit respectively. It is easier to change the first capture age (T_c) rather than changing of F level. So, hilsa fishery manager may adopt F_{msy}=1.14/yr while age at first capture must be increased from T_c=0.6 /yr (3 cm size group) to T_c=1.4 /yr (25 cm size group), by which 1.8 times production could be increased than the present production. MSY also possible to obtain as 201 g and 210 g per recruit at F_{msy}=2.0 /yr and 4.0 /yr at T_c=1.7/yr and 1.9 /yr respectively. Under both the situations, hilsa production could be increased 2 times than the present production. To obtain the MSY=210 g per recruit the fishing level could be increased upto F = 4.0 /yr at T_c = 1.9/yr (34 cm size group). Economic point of view, hilsa fishery managers may choose to obtain the economic MSY as 201 g per recruit at F_{msy}=2.0 /yr and T_c=1.7 yr (31 cm size group) in the Meghna river of Bangladesh.

Introduction

Maximum Sustainable Yield (MSY) is the peak yield of optimum exploitation level (F_{msy}). The optimum exploitation level is that fishing level at which MSY could be obtained without causing damage of a stock in the long run from an open water body. On the other way, if any fishery is situated in such a position that either the fishery is in under fished or over fished condition than the F_{msy} level, both the conditions are not desirable. The MSY also predicts a yield model at a particular fishing level, which gives the highest steady yield year after year. Estimation of maximum sustainable yield for a fish population, Yield per recruit (Y/R) model has been developed by Beverton and Holt (1957). When reasonable estimates are available of the total yield (by species), MSY is estimated by using yield and CPUE through "Surplus Production Model" which

was introduced by Gramhan (1935) but often referred to as Schaefer model. Recently another programme has been developed by Sparee and Willmann on Bio-economic Analysis Method (BEAM) for economically biomass estimation but still it is not popular method. So, Beverton and Holt model is the most popular model to estimate MSY through yield per recruit analysis of a fish population in the open water system. Furthermore, for the estimation of MSY, yield per recruit model (Beverton and Holt model) has been applied in fish population management by some earlier workers (Gulland 1973, Pauly 1984, Pauly and Soriano 1986, Silvestre 1986).

Yield per recruit (Y/R) is the measurement unit (in g) of yield of fish population in the open water system. Shortly it can be expressed, Y/R is a yield measurement index for the open water fishery. Yield basically depends on the rate of recruitment pattern, age at first capture, fishing strategies and environmental condition. Recruitment is a continous process and a crucial phase for a fish population in the open water system.

Hilsa (*T. ilisha*) is a wild fish species and most important exploited fishery which is contributing about 22-25% to the total fish production in Bangladesh. Being such an important exploited fishery in the open water system, knowledge about its MSY, F_{msy} level is necessary for judicious management and at the same time the hilsa population has to be managed in such a way that the fishery is ready to give the MSY for long term condition. Moreover, estimation of MSY also helps to indicate the present fishing level of any fish population either the fishery is under fished or over fished. This paper mainly deals with the MSY per recruit under various F and T_c levels of *T. ilisha* in the Meghna river.

Materials and methods

The research program was designed for the estimation of maximum sustainable yield per recruit following the Beverton and Holt model. The experiment was undertaken at the Bangladesh Fisheries Research Institute, Riverine Station, Chandpur, during July '93 to June '95. For the estimation of MSY of hilsa population in the Meghna river, length-frequency data were collected through experimental fishing as well as from commercial fishing. The Meghna river was selected under this study as the Meghna river is a major migratory route and nursery ground of *T. ilisha* in the riverine system of Bangladesh.

Length-frequency data of 8040 specimens of hilsa of the river Meghna were analyzed for the estimation of maximum sustainable yield (MSY) per recruit. Length-frequency data were randomly collected in each month during the period of study. Sample was collected by using 'F.B. ilish gobeshona' boat of FRI, Chandpur. Mesh sizes of the experimental fishing gear were 8.5 cm, 10.0 cm and 11.0 cm which are usually used by the commercial fishermen. Samples were collected from both day and night fishing. Commercial jaggat ber jal with mesh size of 0.5 to 1.5 cm and experimental ber jal with mesh size of 1.0 cm were used to catch jatka (juvenile hilsa). Samples from artisanal fisherman's net (a kind of monofilamentous gill net locally called *current jal* with mesh size 3.5 cm to 7.0 cm) were also considered for the purpose. Length-frequency data of

the specimens of hilsa were analyzed through length-based stock assessment method with the help of computer package programme of XL-staistica and Microstate Data management. The results of the growth parameters (L, k,& t_0), mortality parameters (Z, M,& F), asymptotic weight (W), relative condition factor (K_n), recruitment age (T_r) and age at first capture (T_c) are necessary to calculate the yield per recruit (Y/R). So, the growth parameters were calculated by using the following Von-Bertalanffy (1934) growth equation model.

$L(t) = L_\alpha * (1-\exp(-K*(t-t_o))$ ----------(i)

Here, the model expresses the length L, as a function of the age of the fish t, K is the curvature parameter and L_α is the asymptotic length of fish.

Total mortality (Z) was calculated by Length Converted Catch Curve method. Natural mortality (M) was estimated by following Pauly's empirical relationship (Pauly 1980) of L_α, k and mean annual temperature, T°C.

$\ln M = -0.0152 - 0.279*\ln L_\alpha + 0.6543*\ln T$ ----------(ii)

Asymptotic weight was calculated by using the following formula (Sparre and Venema 1992).

$W_\alpha = K_n x L^3$----------(iii)

Recruitment age (T_r) and age at first capture (T_c) were also calculated by the Inverse von-Bertalanffy growth equation model (Sparre and Venema 1992).

$t(L) = t_o - 1/k*\ln(1-L/L_\alpha)$----------(iv)

The yield per recruit (Y/R) were calculated by using the Beverton and Holt model such as :

$Y/R = F * \exp.(-M*(T_c-T_r)*W_\alpha *(1/z-3S/(z+k) +3S^2/(z+2k)-S^3/(z+3k).$----------(v)

Where $S= \exp.(-M*(T_c-t_0)$ and $Z=F+M$.

Finally, the Y/R and MSY per recruit under various fishing levels (F) and age at first capture (T_c) of *T. ilisha* in the Meghna river were calculated.

Results and discussion

The length-frequency analyses by different methods gave the following calculated populational parameters of hilsa *viz*; asymptotic length, L_α = 57 cm, curvature character, k=0.66 /yr , initial age, t_o= 0.5 yr, total mortality, Z= 2.03/yr, natural mortality, M=0.89/yr, fishing mortality, F= 1.14/yr, asymptotic weight,W =2981 g, when the average relative condition factor of the hilsa population in the Meghna river was K_n=0.0145 g per cubic cm. The age at first capture (T_c) of hilsa in the Meghna river was T_c=0.6 yr and when hilsa is recruited at the Meghna river their age was calculated as recruitment age T_r=0.58 yr. So, it was observed that the difference between the age at recruitment (T_r) and age at the first capture (T_c) having a very little difference which was not a good sign for hilsa population to obtain a sustainable yield.

Y/R was calculated by the derived formula of Beverton and Holt model and it was obtained Y/R=95 g per recruit at the existing fishing pressure, F=1.14 /yr and age at first capture of T_c=0.6 /yr (3 cm size i.e. catch starts from juvenile hilsa). If it is not possible to protect the catch at their juvenile stage i.e. if it is

continued to catch jatka (T_c=0.6 yr), maximum sustainable yield could be possible to obtain MSY= 112 g per recruit at the F_{msy} = 0.6 /yr. But the present fishing level is F=1.14 /yr which is nearly double fishing pressure than the F_{msy} level (Fig-1a). So , fishing level (F) should be reduced from F=1.14 /yr to F_{msy}=0.6 /yr immediately. Moreover, the probable MSY and F_{msy} were also calculated under the combinations of various fishing levels (F) and age at first capture (T_c) which were shown in Figures 1a, 1b and 1c.

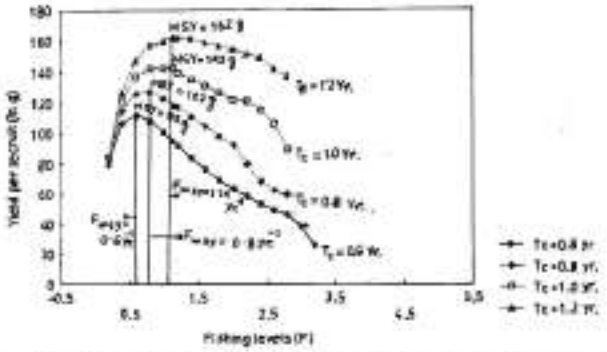

Fig.1a. Probable MSY per recruit and F_{msy} under the combinations of various F and T_c levels of *T. ilisha* (i.e. F=0.2 to 4.0 /yr and T_c=0.6, 0.8, 1.0 & 1.2 /yr).

From Fig.1a, it was observed that the MSY=127 g per recruit and F_{msy}=0.8 /yr at T_C=0.8 yr (10 cm size group), MSY=142 g per recruit and F_{msy} =1.14 /yr at T_C=1.0 yr (18 cm size group), and MSY=162 g per recruit and F_{msy}=1.14 /yr at T_C=1.2 yr (22 cm size group) were obtained.

The probable MSY were calculated at T_C= 1.14, 1.5, 1.6 and 1.7 yr were shown in Fig.1b.

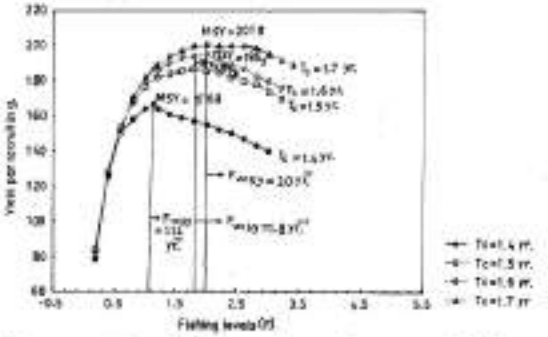

Fig.1b. Probable MSY per recruit and F_{msy} under various combinations of F and T_c levels of *T. ilisha* (F=0.2 to 4.0 /yr and T_c=1.4, 1.5, 1.6 & 1.7 yr).

From Fig.1b, the probable MSY per recruit and F_{msy} were calculated under various ages at first capture T_c=1.4 yr (25 cm size group), T_c=1.5 yr (27 cm size group) T_c=1.6 yr (29 cm size group) and T_c=1.7 yr (31 cm size group). The probable MSY=176 g, 187 g, 195 g, and 201 g per recruit at F_{msy}=1.14 /yr, 1.8

/yr, 2.0 /yr and 2.0 /yr at the first capture age T_c= 1.4, 1.5, 1.6, and 1.7 yr respectively. F_{msy} is the same as 2.0 /yr for both at first capture age T_c=1.6 and 1.7 yr (Fig.1b).

From Figs.1a and 1b, it was observed that F_{msy}=1.14 /yr was the same in case of T_c=1.0 yr,1.2 yr and 1.4 yr age groups of hilsa. It might be said that if it is not possible to change (i.e. either increase or decrease) the present fishing level, F=1.14 /yr , first capture age of hilsa definitely should be increased from T_c=0.6yr to 1.4 yr and then the probable MSY would be obtained as 176 g per recruit at F_{msy}=1.14 /yr. In the management point of view, it is difficult to change the fishing level (F) but it might be easier to change the first capture age (T_c) by mesh size regulation through fish conservation law. It was also observed that the probable maximum sustainable yield MSY=201 g per recruit at F_{msy}= 2.0 /yr and age at first capture T_c= 1.7 yr (31 cm size group) could be possible to obtain 2 times production than the present yield (consideraing the yield measurement index as, present Y/R = 95 g at F=1.14 /yr and T_c=0.6 /yr.). Therefore, in this case, age of first capture definitely should be increased from T_c=0.6 yr. to T_c=1.7 /yr. and thereby fishing pressure also could be increased from F=1.14 to F_{msy}= 2.o /yr for hilsa fishing in the Meghna river.

From Fig.1c, similarly the probable MSY and F_{msy} were calculated at the age of first capture (T_c) = 1.8 yr (33 cm size group), 1.9 yr (34 cm size group) and 2.0yr (36 cm size group). It will be possible to obtain MSY= 206 g, 210 g, and 201 g per recruit at the F_{msy}=3.0 /yr, 4.0 /yr and 2.6 /yr at T_c=1.8,1.9 and 2.0yr respectively. Thereby, MSY=210 g per recruit could be possible to obtain at the F_{msy} = 4.0 /yr.

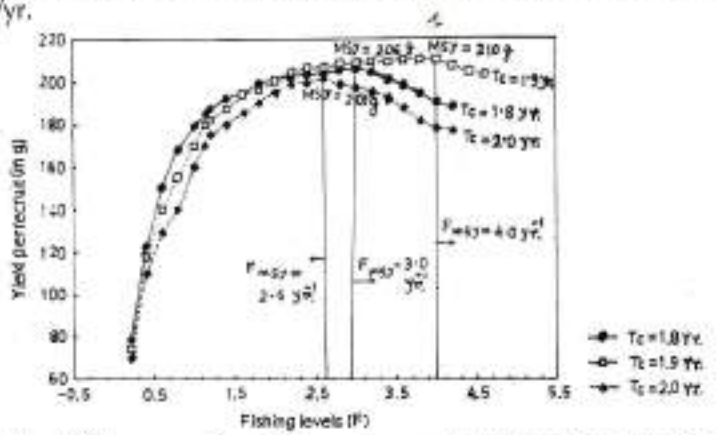

Fig.1c. Probable MSY per recruit and F_{msy} under combinations of various F and T_c levels of *T. ilisha* (F=0.2 to 4.0 /yr and T_c=1.8, 1.9 & 2.0 yr)

So, fishing pressure could have been increased from F=1.14 to F_{msy} = 4.0 /yr at the age of first capture T_c=1.9 yr In that case, fishing pressure could have been increased 4 times than the present fishing level and hilsa production could have been obtained 2 times than the present production level. But in the long

run growth overfishing might occur and as a result parent hilsa might be affected. From Fig-1b and 1c, it was seen that yield per recruit is the decreasing trends at the age at first captures, T_c=2.0 yr. Yield of hilsa could be obtained 2 times at both the fishing levels, F_{msy}= 2.0 /yr and 4.0 /yr at the T_c=1.7 yr and 1.9yr. So, economic point of view, hilsa fishery managers may choose to obtain the economic MSY as 201 g per recruit at F_{msy}=2.0 /yr instead of F_{msy}=4.0 /yr. The calculated yield with a combined effect of various F and T_c levels which would be maintained as the long term condition and which do not change (Sparre and Venema 1992).

Conclusions

So, for the proper management as well as economical fishing, it might be concluded that fishing pressure should be maintained at the level of F_{msy}=2.0 /yr and the probable MSY would be obtained in MSY=201 g per recruit at the age of first capture T_c =1.7 yr, which will be more economically viable level of F_{msy} for hilsa fishing at the same time hilsa production will be double.

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Increasing farm income by introducing fish culture in deepwater rice environment

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Abstract

Fish culture in deep-water-rice (DWR) environment using net pen and polder systems was evaluated. In net pen rohu and Thai silver barb were cultured, whereas a 5-species combination (rohu, mrigal, common carp, grass carp and Thai silver barb) were cultured with BR3 rice variety and DWR. Boro-fish production system produced 2.8 t/ha of fish and 7.33 t/ha of rice in polder system with 5-species combinations.

Key words : Polder, Net pen, Deep water rice, Fish culture

Introduction

In Bangladesh, about 73 percent of rural people are engaged in either full or part time fishing which supplies about 80 percent of animal protein of their diets. Fishing also provides poor rural families with income (ODA 1995). But presently, natural catches have declined drastically due to degradation of fish habitat. The situation has aggravated by imbalance use of fertilizer and pesticides for modern Boro rice cultivation. Moreover, in recent years fish diseases have significantly reduced fish production. All these contribute to low fish consumption and malnutrition among rural population. In order to maintain the level of fish consumption (7.9 kg/person/year), fish production has to be increased from 0.8 million ton to 1.2 million ton (Gupta and Mazid 1993). To meet the demand of this increased fish production, rice fields could be explored since marine fisheries and fish production from open water bodies are declining as a result of over fishing and degradation of fish ecology.

An estimated area of 2.86 million hectares of medium lowland and lowland are annually inundated to a water depth of 1-3 m for a period of 4-6 months in a normal flooding year. This area usually remains fallow after the harvest of irrigated boro rice or a few farmers practice of growing DWR either transplanted or direct seeded when flood occurs at least 20-30 days after boro harvest (Ali *et al*. 1993). DWR ecosystem is highly fertile due to silt deposition and decomposition of organic matter which favours the growth of flora (phytoplankton) and fauna (zooplankton). The phytoplankton provides fish feed which is enough for fish rearing for a period of 4-5 months (Ali *et al*. 1993, Das

et al. 1990). Therefore, the experiment was conducted to evaluate the biological and economic performance of different production systems involving fish culture with and without DWR in seasonally flooded areas of Bangladesh.

Materials and methods

Deepwater rice (DWR) seedling were raised in the farmers homestead area. Sixty days old DWR seedlings (Hijolidigha) were transplanted in the field immediately after the harvest of Boro rice (BR3) where DWR+fish experiment was conducted.

Two nylon net pen, one with DWR and another without DWR were installed at Mirzapur, Bangladesh immediately after flood water entered into the field. The size of net pen was 20 m x 20 m each. Under the polder system, two sides of the plot were closed by roads and one side by raised homestead. Only one side was open where 250 m net was installed to made the plot like a pond. The area of polder measured 6000 m^2. For all cases, the height of the nets were 3.5 m. Bamboo poles were placed 2 m apart and the bottom end pushed into the soil approx. 0.5 m deep. The poles were 7 m high to facilitate increasing net heights with the rise of flood water. The poles were also tied horizontally with the upright ones to protect against waves and wind. At the bottom the nets were pushed into the soil. The nets were also tied up with the help of bamboo pegs pushed into the soil, so that there was no scope of fish to escape from the pens. Fingerlings of the selected fish species were released in net pens and polder on June and July '93, respectively. The size of the fingerlings varied from species to species depending on the availability. The initial length and body weight were recorded. The growth of fish species depended on availability of feeds within the pens and the supply of aquatic weeds at weekly interval. Fish were harvested from the net pens and polder on November '93, when the depth of water in the field was about 50 cm. The length and gain in body weight were recorded at harvest. The cost of nets and bamboo poles were computed based on depreciation value determined by straight line method. All collected data were analyzed for statistical comparison and for economic performance of different production systems.

Results and discussion

Net pen with and without DWR

The body weight gain and fish yield of rohu (*Labeo rohita*) and silver barb (*Puntius gonionotus*) were higher when reared without DWR in net pen than that of with DWR (Table 1). Similar results were also observed in case of recovery percentage. The yield of rice was not affected but the fish yield was reduced by 43 percent when reared in association with DWR. Perhaps, dense canopy of DWR restricted fish movement, suffocation which results in lower recovery

percentage, body weight gain as well as fish yield. Results further indicates that after the harvest of Boro rice, an additional fish yield can be obtained if fish is cultured with and without DWR in net pens. Lightfoot *et al*. (1989) shown an increased rice yield of 5-30 percent from rice-fish system, but he also reported some negative effects of rice yield in Asian countries.

Table 1. Body weight gain, recovery percentage and yield of rohu and silver barb in net pen with and without deepwater rice

Fish species	At release			At harvest			Recovery (%)	Yield (t/ha)
	Length (cm)	Weight (g)	No.	Length (cm)	Weight (g)	No.		
With DWR								
Rohu	9.1	20.03	200	18.17	87.58	130	65	0.44
Silver barb	10.4	23.35	200	18.87	108.90	104	52	0.50
Without DWR								
Rohu	9.1	20.03	200	20.70	127.75	140	70	0.75
Silver barb	10.4	23.35	200	21.05	164.10	130	65	0.91

Stocking density = 1 fingerling/m^2

Table 2. Productivity of different production systems in deepwater rice environment.

Production systems	Rice yield (t/ha)		Fish yield (t/ha)			Prodn. cost Tk/ha		Gross return (Tk/ha)		Net return (Tk/ha)	BCR
Boro -DW	Boro -	DWR	Rohu	Silver barb	Total	Rice	Fish	Rice -	Fish		
BR3 -Fallow	6.25	-	-	-	-	14300	-	31250	-	16950	2.19
BR3 -Fish	6.25	-	0.75	0.91	1.66	14300	26650	31250	56750	55150	2.29
BR3-DWR+Fish	6.25	1.52	0.44	0.50	0.94	14300 +3500	26650	38850	37600	30450	1.72
BR3 -DWR	6.25	1.45	-		-	14300 +3500		36500	-	20700	2.16

Price (Tk/kg): Fish=40, Rice=5, Fingerlings = Tk 1 each

Cost (Tk/ha): Fingerlings = 10000; Net= 4000 (Total value = 32000 (Tk 32/1m length x 1.96 m height net), salvage value = 4000, useful life = 7 years); Bamboo = 2000 (Total cost = 6200, salvage value 200, useful life = 3 years) and Labour (installation, care taking, ropes, harvesting of fish etc.) = 10600.

Table 2, revealed that BR3-fish pattern had the highest net return (Tk 56,750/ha) and higher benefit cost ratio (BCR) followed by BR3-fish+DWR (Tk 30,450/ha). This study suggests that 70 percent contribution of the total net returns comes from fish component in the BR3-fish production system which

justify the importance of fish culture after Boro rice harvest in the DWR ecosystem.

Polder system

Silver barb, common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), rohu and mrigal (*Cirrhinus mrigala*) cultured in the polder system performed better compared to net pens (Table 3). However, grass carp gave the highest fish yield (1.3 t/ha) followed by common carp (0.61 t/ha), but the individual body weight gain was the highest in common carp (712 g) followed by grass carp (680 g) having almost similar recovery percentage. The increased fish yield of grass carp came from the high fish density with supply of natural aquatic weeds. Silver barb, rohu and mrigal performed relatively poor. This might be due to common carp and grass carp are fast growing compared to rohu, mrigal and silver barb.

Table 3. Performance of different fish species in polder system

Fish species	At release		At harvest		Number released	Number harv-ested	Reco-very (%)	Yield (t/ha)
	Length (cm)	Weight (g)	Length (cm)	Weight (g)				
Silver barb	7.1	6.0	23.7	270.2	1000	627	63	0.28
Common carp	9.62	6.8	32.7	712.2	1000	536	54	0.61
Grass carp	6.5	5.0	37.5	680.0	2000	1164	58	1.31
Rohu	10.5	14.3	28.2	290.8	1000	743	74	0.35
Mrigal	11.0	12.5	29.1	291.0	1000	546	55	0.25

Polder area (m^2) = 6000, Stocking density = 1 fingerling/m2

Boro-fish production system produced 2.8 t/ha of fish and 7.33 t/ha of rice (Table 4). This production system gave a net return of Tk 109,955/ha while BR3 alone gave the net return of Tk 21,150/ha. BCR also followed similar trend. The higher net return from rice-fish production system is mainly derived by the contribution of fish yield.

Table 4. Economic performance of Boro-fish production system in polder

Season	Yield (t/ha)		Production cost (Tk/ha)		Gross return (Tk/ha)		Net return (Tk/ha)	BCR
Boro - DWR	Rice	Total fish	Rice	Fish	Rice	Fish		
BR3 - Fallow	7.33	-	15500		36650		21150	2.36
BR3 - Fish	7.33	2.80	15500	23195	36650	112000	109955	3.84

Prices (Tk/kg): Rice = 5, Fish = 40, Fingerlings = Tk 1 each.

Cost (Tk/ha): Fingerlings = 10,000; Net = 1666 (Total cost = 13333 (Tk 32/1 m length x 1.96 m height net), salvage value = 1666, useful life = 7 years); Bamboo poles = 1029 (Total cost = 3187, salvage value = 100, useful life = 3 years); Labour (Installation, care taking, weed supply as feed, fish harvesting etc.) = 10,500.

Fish growth under net pen and polder system

The body weight gain for both rohu and silver barb were more or less similar in net pen culture with and without DWR (Fig. 1). But in polder system, the l body weight gain were higher for rohu and silver barb than that of net pen culture with and without DWR (Fig. 1). However, body weight gain in polder system was the highest in case of common carp and grass carp. The higher body weight gain as well as fish yield in polder system might be attributed to larger space for fish movement and availability of natural fish food.

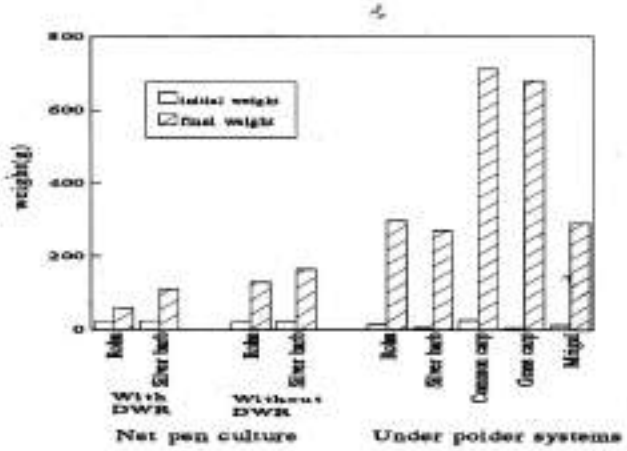

Fig-1 : Body weight gained by different fish species under net pen and polder systems.

Conclusions

Based on growth performance, the present study indicates that fish culture in polder system was found more profitable then net pen culture. If farmers are provided with necessary training and credit to adopt the rice-fish production system, the net return could be higher. Community approach will reduce cost of production, provide employment opportunity and ensure better utilization of the potential resources of the ecosystem.

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Suitability of rich-fish culture under mono and polyculture systems in the boro rice ecosystem

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Abstract

An experiment was conducted in farmers' fields under Paikgacha thana, Khulna to study the suitability of integrated rice-cum-fish culture. Three treatments namely T_1 (*Puntius gonionotus*), T_2 (*Puntius gonionotus* and *Cyprinus carpio*) and T_3 (*Cyprinus carpio*) were included for the study each having three replicates. The fish were stocked at a density of 3750/ha in all the rice plots. The physico-chemical parameters of water *viz.*, water depth, temperature, dissolved oxygen, pH, salinity, nitrate and phosphate etc. recorded during the study period were found within optimum range. Of the two cultured species *C. carpio* attained the highest average individual weight (160g) and survival (81.06%). With respect to biomass and income, highest average fish production and net profit per hectare (306.74kg and Tk. 8177.91) were obtained in T_2 and the lowest (184.17kg and Tk. 2049.41) obtained in T_1 and a significant variation ($p<0.05$) in fish production was observed among the treatments while for rice production, it was insignificant. The cost benefit ratio of fish production found were 1:1.29, 1:2.14 and 1:1.90 for T_1, T_2 and T_3 respectively.

Key words : Rice-fish farming, Boro crop

Introduction

Traditional capture of fish from the rice fields is very common in Bangladesh (Gupta and Mazid 1993). The yield of which is around 37 Kg/ha (MPO 1985). Introduction of fish into the rice fields in a managed way have a number of advantages, such as it helps in increasing yield of rice by take up harmful insects, pests and weeds (Coche 1967 and China Freshwater Fish Committee 1973) and increase the farm fertility by adding organic excreta.

The total area of rice fields in Bangladesh is about 10.14 million hectare which can play an important role in increasing fish production (Rahman 1995). A rice field suitable for fish culture ought to have impervious and strong dikes to retain water upto desired depth, usually between 10 and 60cm (Haroon 1986), that also needs require careful manage of water levels by irrigation or drainage, avoiding over flooding/ droughting. Though integrated rice-fish farming is a common practice in many countries of the world (SEAFDEC/AIA 1980) but a few

attempts had been made in Bangladesh (Dewan 1992, Haroon and Alam 1992 and CARE 1992). So, attempt was undertaken to study the suitability of integrated system by using mono and mixed species of fish in the rice plots of a particular area.

Materials and methods

The experiment was carried out during boro season in 1997 in nine farmer's fields at different villages of Ghodaipur and Horidhali union under Paikgacha thana, Khulna. The experimental plots were laid out in Randomized Completely Block (RCB) design with three replicates.

All the plots were raised by 50cm high and 30cm wide border. A ditch with 8m long and 5m wide having 60.0-70.0cm deep was constructed in each plot to take shelter for fingerlings during high temperature, pesticides use and also facilitates of fish harvesting. In addition, a peripheral trenches with 45cm wide and 35cm deep was dug around the paddy growing area (except one side) to link the ditch to the rest of the field. The plots were ploughed thoroughly and levelled. Urea, triple superphosphate and muriate of potash at the rate of 30-60-40Kg NPK/ha were applied at the time of last ploughing. Thirty seven days old seedling of BR 29 having 15cm x 10cm spacing were transplanted on February '97.

In all the plots, fishes were stocked with a density of 3750/ha after 2 weeks of planting. Three plots were stocked with fingerling of rajputi (*Puntius gonionotus*) (monoculture, T_1). Fingerling of rajputi (*Puntius gonionotus*) and common carp (*Cyprinus carpio*) were released in three plots and ratio for the fishes was 1:1.14 (polyculture, T_2) and other three plots were stocked with fingerling of common carp (*Cyprinus carpio*) (monoculture, T_3).

About 2-3cm water depth was maintained up to 15 days after transplanting (DAT) and then increased gradually upto 11.0-17.8cm. Urea at a rate of 25.0 kg N/ha was dissolved in water and applied in the plots at 20 and 45 DAT, respectively and about 4-5cm water depth was remained at the time of urea applying.

The physico-chemical parameters of water in terms of water temperature, depth, dissolved oxygen, p^H, salinity, nitrate and phosphate were measured once in a week. Rice was harvested on May '97 followed by harvesting of fish after 1-2 days. The rice was threshed, cleaned, sun dried and adjusted to 14-16% moisture content at the time of weighed. The number and weight of the individual fish at harvest were also recorded. Net income and cost benefit ratio were also calculated.

Statistical analysis were done by Duncan's New Multiple Range Test (DMRT) for treatments comparisons.

Results and discussion

The values of physico-chemical parameters of water of rice-fish plots under different treatments are presented in the Table 1. Average water temperature recorded were 29.5 ± 1.5°, 29.3 ± 1.6° and 29.4 ± 1.5°C for T_1, T_2 and T_3,

respectively. The mean water temperature differed little within the treatments. The lowest temperature (26.1°C) during the experiment was recorded in T_1 and the highest (32.2°C) was recorded in T_2. For rice-fish culture a favourable temperature range for sub-tropical water fishes was described by Ghosh (1992) as 25.5 to 29.8°C preferably in the month of March to June. So, the temperature range recorded in the above experiment may consider as quite favourable. The mean values of water depth in rice plots recorded in T_1, T_2 and T_3 were 14.4 ± 2.5, 14.6 ± 2.4 and 14.9 ± 2.6cm, respectively. The water depth in the ditches and trenches were recorded between 70.0-80.0cm and 40.0-45.0cm, respectively. Little variations were observed in dissolved oxygen content. The mean values recorded in T_1, T_2 and T_3 were 5.3 ± 0.81, 5.5 ± 0.72 and 5.6 ± 0.50mg/l, respectively. Ali (1990) reported that the dissolved oxygen range between 4.1 to 8.9mg/l in the rice fields of Bangladesh which is almost similar to the present findings without any remarkable variations among the treatments. The mean p^H values for all the plots were found within the range described by Michael (1969) and Ghosh (1992). The mean values of salinity in T_1, T_2 and T_3 were found 0.89 ± 0.77, 0.93 ± 0.81 and 0.83 ± 0.72 ppt, respectively. The nitrate-nitrogen values recorded in the present study were 0.164 ± 0.016, 0.168 ± 0.020 and 0.160 ± 0.021mg/l in T_1, T_2 and T_3, respectively. Ghosh *et al.* (1984) recorded nitrate concentration to range 0.14 to 0.28ppm in water of rice fields. Alikunhi (1957) reported that a good pond water for fish culture should have nitrate level of 0.06mg/l. The mean values of phosphate content of water in T_1, T_2 and T_3 were 0.080 ± 0.044, 0.066 ± 0.041 and 0.062 ± 0.022, respectively. However, the low content of phosphate in the water of rice field is in agreement with the findings of Ghosh (1992) for the summer months, where as Alikunhi (1957) stated that a good pond water should contain phosphate within the range of 0.2 to 0.4mg/l.

Table 1. Average values of water parameters during the study period

Parameters	Treatments		
	T_1	T_2	T_3
Water temperature (0°C)	29.5 ± 1.5	29.3 ± 1.6	9.4 ± 1.5
Water depth (cm)	14.4 ± 2.5	14.6 ± 2.4	14.9 ± 2.6
Dissolved oxygen (mg/l)	5.3 ± 0.8	5.5 ± 0.7	5.6 ± 0.5
p^H	7.8 ± 0.5	7.7 ± 0.5	7.8 ± 0.6
Salinity (ppt)	0.9 ± 0.8	0.9 ± 0.8	0.83 ± 0.7
Nitrate (mg/l)	0.2 ± 0.2	0.12 ± 0.02	0.2 ± 0.02
Phosphate (mg/l)	0.1 ± 0.04	0.1 ± 0.04	0.1 ± 0.02

The average growth, survival, production and net profit data are presented in the Table 2. The survival rate of *P. gonionotus* and *C. carpio* were found to vary from 60.17 to 75.56% and 60.61 to 81.06%, respectively. Highest survival

(81.06%) of *C. carpio* was recorded in T_2 and the lowest was (60.61%) in T_3. In case of *P. gonionotus*, higher survival (75.56%) was observed in T_1 and the lower was (60.17%) in T_2. Muddanna *et al.*(1970) reported that the survival rate of *C. carpio* varied from 15-60% based on 71 days of observation, where as Jhingran (1975) stated that the range of survival rate for major carps were 71-76%. But Ahemed *et al.* (1995) reported that the range of survival rate of *P. gonionotus, Oreochromis niloticus* and *C. carpio* in combined culture in rice field was 50-60%. In the present study, the average final weight of *P. gonionotus* and *C. carpio* were recorded to vary from 45.0-65.0g and 120.0-160.0g, respectively. Between two species, *C. carpio* showed higher growth (160.0g) in T_2 and higher growth (65.0g) of *P. gonionotus* was recorded in T_1 and lower was (45.0g) in T_2, respectively. Hossain *et al.* (1987) recorded the growth rate of *P. gonionotus, C. carpio, L. rohita* and *C. mrigala* was 95.2-135.0, 133.0-189.0, 69.0 and 115.0g, respectively in the rice field after 90 days of cultivation. Rahman (1995) obtained an average weight of 100-120g and 250-400g for *P. gonionotus* and *C. carpio*, respectively in mixed culture in the rice field within 3-4 months. Akhteruzzaman *et al.* (1993) reported that fish attained average sizes at harvest were 38.0g for *P. gonionotus* and 63.0g for *C. carpio* after 84 days of culturing in the rice plots which lower than the findings of the present study.

Table 2. Average growth, survival and production of fish and rice production under different treatments

Treatments		Body weight		Survival (%)	Yield		Gross return	Net income	Cost: Benefit
	fingerling/ha	Initial (g)	Final (g)		Fish (kg/ha)	Rice (t/ha)	(Tk./ha)	(Fish) (Tk./ha)	(Fish) (Tk./ha)
Rajputi (Monoculture)	3750	10.0	65.0	75.56	184.17[b]	4.20	9208.50	2049.41	1:1.29
Rajputi+ common carp	1750 +	10.0+	45.0 +	60.17+	306.74[a]	3.83	15337.00	8177.91	1:2.14
(Polyculture)	2000	15.0	160.0	81.06					
Common carp (Monoculture)	3750	15.0	120.0	60.61	272.73[a]	4.39	3636.50	6477.41	1:1.90

Mean followed by common letter did not difference at 5% level.
Average price of fingerling was Tk. 1.00/piece. The price of urea, TSP and MP was TK. 7.00, 13.00 and 3.75/Kg. respcetively. The fishes were sold at the rate of Tk. 50.00/Kg.

Fish yield and net profit per hectare obtained for T_1, T_2 and T_3 were 184.17kg, 306.74kg and 272.73kg, and in money Tk. 2049.41, Tk. 8177.91 and Tk. 6477.41, respectively. The highest yield (306.74kg) and net profit (Tk. 8177.91) were found in T_2 where *P. gonionotus* and *C. carpio* were raised in the rice fields. Muddanna *et al.*(1970) recorded a production of 17.5-152.5kg/ha of *C. carpio* in rice-fish culture. Hickling (1962) recorded 100-200kg/ha of the same in Japan. A yield of 80-1000kg/ha in summer and 100-152kg/ha in monsoon was

recorded by Coche (1967) for *C. carpio*. Akhteruzzaman *et al.*(1993) recorded the yield of 14.75 to 222.5kg/ha for *C. carpio* with an average of 99.75kg/ha. Grover (1979) also recorded the yield of 69-208kg/ha by stocking *Tilapia mossambica* and *C. carpio* in the rice field. Rahman (1995) recorded the yield of 325-375kg/ha by stocking *P. gonionotus* and *C. carpio* in the rice fields. Dewan (1992) reported that the additional income from raising fish in rice fields in different experiments were ranged from Tk. 1200.00 to Tk. 5360.00/ha. CARE (1992) noted that farmers made an average profit of Tk. 4912.00 and Tk. 1607.00/ha by stocking hatchlings and fry of common carp in the rice field.

The average rice production from T_1, T_2 and T_3 were recorded 4.20tons(t), 3.83t and 4.29t/ha, respectively (Table 2). The soil of the plots under T_2 was slightly sandy. Growth of seedling and no. of tillers were comperatively lower the others plots. These might the cause for low yield of rice in T_2. Rajputi and common carp prefer upper layer and bottom layer, respectively (Srisuwantach, 1981 and Bardach *et al.* 1972). The micro-oganisms which consider as fish feed were used more properly than the other plots. On the other hand, the fishes enjoyed more space for movement in T_2. Possibly for this reason, growth and yield of fish were higher than the other treatments. Sevilleja (1992) reported that the rice production obtained by the farmers from the integrated rice-fish farming in Philippines ranged from 3.85t to 5.15t/ha. Rahman (1995) also recorded the rice production in rice-fish farming was ranged from 3.0t to 5.0t/ha which is almost similar to the present findings.

The variations in fish production exhibited by different treatments were found statistically significant. Comparisons of mean production between the different treatments using DMRT showed that the mean production in T_1 was significantly lower. The mean production of two fish species under T_2 was significantly higher than the others. The highest cost benefit ratio (1:2.14) was calculated for T_2 and the lowest (1:1.29) was for T_1. So, among three treatments, better production and net profit per hectare were found in T_2 where *P. gonionotus* and *C. carpio* were raised in the rice fields. As the study has demonstrated that mixed culture of *P. gonionotus* and *C. carpio* in paddy fields without feeding and fertilizers is more profitable and as the seeds of these species are available, so it can be recommended to undertake such integrated rice-fish farming activities in the suitable area of the country.

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Studies on the gonadosomatic index and fecundity of chapila (*Gudusia chapra* Ham.)

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Abstract

The study was conducted in pond to determine the fecundity and gonadosomatic index of chapila, *Gudusia chapra*. The male fish was found to attain sexual maturity at 7.7 cm and 7.41 g and that of the female at 9.3 cm and 14.65 g by standard-length and body-weight respectively. The investigated fishes were found to be male and female at the ratio of 1:3 and generally female was found to be larger than male. The fish was found to spawn for several months with two spawning peaks, one in April and another in August as indicated by the peaks of gonadosomatic index and ova diameter. Fecundity of the fish ranged from 25,220 to 154,528 with an average value of 72,383 and was found to increase with the increase in length and weight of the fish. The relationships between fecundity and standard-length, body-weight, gonad-length and gonad-weight of the fish were found to be linear and significant.

Key words : *Gudusia chapra*, Fecundity, Gonadosomatic index

Introduction

Gudusia chapra, belongs to the family Clupeidae is a prolific breeder and one of the most favorite, tasty and commercially important fish in Bangladesh. Fecundity is one of the most important biological aspects of fish. This must be known to assess the productive potential and to evaluate the commercial potentialities of a fish stock (Das *et al.* 1989). For efficient fish culture and effective management practices it is prime important to know the fecundity of fish (Miah and Dewan 1984). Moreover, study is also essential to determine the index of density dependent factor affecting population size (Simpson 1951).

Notable works have been done on the fecundity of some species of fishes in Bangladesh (Doha and Hye 1970, Karim and Hossain 1972, Shafi *et al.* 1979, Dewan and Doha 1979, Miah and Dewan 1984 and Das *et al.* 1989). But so far, no work has been done on the fecundity of *G. chapra*. In view of that the present study was undertaken to determine the fecundity and gonadosomatic index of chapila and also to establish a relationship between the fecundity and standard length, body weight, gonadal length and gonadal weight of the fish.

Materials and methods

The experiment was conducted for a period of seven months from March to September'95 in three earthen ponds each covering an area of 800 m^2 and with an average depth of 1.5 m. Twenty matured fishes were collected randomly during each sampling from the ponds to determine the standard length and body weight. The male and female fishes were differentiated and data were recorded after dissecting out the gonad of the individual fish. Then the ovary and testis of each fish was taken out very carefully and preserved in a well labeled vial containing 5% buffered formalin for subsequent studies. Gravimetric method was used to determine the fecundity of fish.

In using this method, the external connective tissues were removed from the surface of ovaries. Moisture of the ovaries was removed with the help of a blotting paper. Weight of the ovaries of each fish so treated was recorded in gram with the help of a fine electric weighing balance. Then 0.01 g of each ovary were taken separately from anterior, middle and posterior portions of each lobe. The number of matured and immature eggs for each portion were sorted out separately and counted. The mean number of eggs in 0.01 g was determined and then multiplied by the total weight of the ovary, which gave the total number of eggs i.e., the fecundity of respective fish.

Gonadosomatic index (GSI) of the male and female fishes of the collected samples were determined separately by using the following method.

$$GSI = \frac{\text{Weight of the gonad (g)}}{\text{Weight of the fish (g)}} \times 100$$

Diameter of the eggs at different stages of maturity was measured with the help of an objective micrometer. In this study, 12 ova were taken randomly from the mixed sample of eggs of three portions of each ovary. Measurements of ova diameter were taken along the longest axis of the ova. Sex ratio of the collected fishes was estimated. The relationship between fecundity and standard length, body-weight, gonad-length and gonad-weight were determined with the help of a computer following SPSS programme.

Results and discussion

In the present study, 280 male and female *Gudusia chapra* were examined to determine the gonadosomatic index and fecundity. Sex ratio of the examined fishes were recorded 1:3. De-Silva and Chandrasoma (1980) and Islam and Hossain (1990) was recorded the male and female sex ratio 1:2 in *Sarotherodon mossambicus* and *Puntius stigma* respectively. The standard-length and weight of the male and female fishes were found to range from 7.7 cm - 11.5 cm and 7.41 g - 24.60 g, and 9.3 cm - 17.0 cm and 14.65 g - 64.90 g respectively. Here , the female was found to be larger than the male. Month-wise average highest

length and weight of testis were 3.65 cm and 0.85 g respectively in the month of April and next to the same were 3.11 cm and 0.34 g respectively in the month of August which indicated that there were two peak periods of sperm production of male *G. chapra* (Table 1).

Table 1. Month-wise gonadosomatic index of male *G. chapra*

Month	No. of fish examined	Standard length(cm)	Body weight (g)	Testis		Mean GSI
				Mean length (cm)	Mean weight (g)	
March	12	8.0 - 9.5	9.01 - 15.00	2.50Ò0.09 (2.4-2.6)	0.22Ò0.16 (0.09-0.50)	1.92Ò1.08 (0.66-3.33)
April	04	9.8 - 10.5	17.45-21.95	3.65Ò0.07 (3.6-3.7)	0.85Ò0.11 (0.77-0.92)	4.30Ò0.16 (4.19-4.41)
May	12	7.9 - 10.8	10.11-20.51	2.87Ò0.37 (2.5-3.4)	0.25Ò0.08 (0.15-0.33)	1.69Ò0.28 (1.48-2.19)
June	16	7.7 - 11.5	7.41 - 24.60	2.87Ò0.48 (2.2-3.5)	0.25Ò0.13 (0.13-0.44)	1.72Ò0.56 (1.08-2.90)
July	14	9.2 - 10.3	10.95-20.10	3.10Ò0.57 (2.7-3.5)	0.31Ò0.31 (0.04-0.79)	1.84Ò1.64 (0.30-3.93)
August	04	9.5 - 10.1	13.52-16.14	3.11Ò0.36 (2.7-3.8)	0.34Ò0.08 (0.25-0.46)	2.17Ò1.75 (0.93-3.40)
September	04	9.7 - 10.0	15.69-15.78	2.85Ò0.07 (2.8-2.9)	0.31Ò0.14 (0.16-0.52)	2.13Ò0.06 (2.09-2.17)

Figures in parentheses indicate ranges of different parameters

Table 2. Month-wise gonadosomatic index of female *G. chapra*

Month	No. of fish examined	Standard length(cm)	Body weight (g)	Ovary		Mean GSI
				Mean length (cm)	Mean weight (g)	
March	28	9.8 - 12.7	19.50-35.12	3.38Ò0.57 (2.5-4.1)	0.93Ò0.51 (0.45-1.60)	4.20Ò1.75 (2.04- 8.21)
April	36	9.3 - 12.8	16.21-46.72	4.15Ò0.63 (3.2-5.8)	1.56Ò0.68 (0.52-2.96)	5.58Ò2.00 (2.84-11.20)
May	28	9.9 - 15.0	16.82-64.15	3.96Ò0.39 (3.2-4.8)	1.43Ò0.67 (0.74-3.35)	5.20Ò2.01 (2.35- 8.30)
June	24	9.3 - 15.0	14.88-63.04	4.20Ò0.22 (3.8-4.4)	1.51Ò0.92 (0.47-3.90)	5.08Ò2.47 (2.11-10.51)
July	26	10.6-12.5	19.73-30.85	4.33Ò0.65 (3.2-5.7)	1.95Ò0.95 (0.72-3.52)	7.38Ò3.27 (3.55-13.01)
August	36	9.8 - 17.0	16.97-64.90	4.56Ò0.49 (3.9-5.8)	2.48Ò1.02 (0.83-4.98)	8.07Ò2.59 (3.76-12.61)
September	36	9.3 - 13.7	14.65-44.14	4.33Ò0.53 (3.6- 5.3)	2.24Ò1.01 (1.07-4.03)	7.34Ò3.21 (2.93-13.32)

Figures in parentheses indicate ranges of different parameters

Length of ovaries of the mature females were ranged from 2.5cm to 5.8cm and the weight of the same from 0.45g to 4.98g, showed two spawning peaks, the lowest peak was recorded in April and the highest in August (Table 2). The mature ova were randomly distributed throughout the ovary. Similar findings

were also reported by Otsu and Uchida (1959), Doha and Hye (1970) and Miah and Dewan (1984).

Gonadosomatic index were ranged from 0.37 - 4.41 in male and 2.04 - 13.32 in female and also showed two peaks, one in April and another in August (Tables 1 & 2). Ova diameter were found to range from 350 -1250 µm and also showed two peaks, one in April and another in August (Table 3). Therefore, the fish spawned for several months with two spawning peaks, highest in August and lowest in April as indicated by the values of both ova diameter and gonadosomatic index. Miah and Dewan (1984) recorded three spawning peaks in *Sarotherodon nilotica*.

Table 3. Month-wise fecundity and ova diameter of *G. chapra*

Month	No. of fish examined	Mean standard length(cm)	Mean body weight (g)	Mean fecundity (no.)	Mean ova diameter (µm)
March	28	10.97Ò0.95	23.79Ò5.66	45494Ò15141.48	565.97Ò63.81
		(9.8-12.7)	(19.50-35.12)	(25650-70400)	(450-700)
April	36	10.96Ò0.95	26.16Ò8.54	62434Ò16177.19	648.40Ò118.51
		(9.3-12.8)	(16.21-46.72)	(39104-99280)	(400-900)
May	28	11.68Ò1.18	30.58Ò11.66	56930Ò20006.34	618.43Ò87.12
		(9.9-15.0)	(16.82-64.15)	(25220-99960)	(450-850)
June	24	11.75Ò1.46	30.37Ò12.71	56350Ò22793.42	656.06Ò145.42
		(9.3-15.0)	(14.88-63.04)	(25380-94809)	(350-1000)
July	26	11.30Ò0.61	25.91Ò3.87	91702Ò42606.64	693.75Ò155.24
		(10.6-12.5)	(19.73-30.85)	(33984-154528)	(350-1000)
August	36	12.07Ò1.50	31.19Ò10.33	96907Ò28643.36	768.75Ò171.00
		(9.8-17.0)	(16.97-64.90)	(38595-149898)	(400-1250)
September	36	11.98Ò1.27	32.01Ò8.88	76447Ò20883.44	716.44Ò147.05
		(9.3-13.7)	(14.65-44.14)	(38695-103635)	(350-1000)

Figures in parentheses indicate ranges of different parameters.

Fecundity and standard length, body weight, and gonad length and gonad weight relationships

Fecundity of the *G. chapra* was found to range from 25,220-154,528 with an average of 72,383 during the period of study (Table 3) and indicated a linear relationship with its standard-length, body-weight, gonad-length and gonad-weight (Figures 1, 2, 3 and 4). The relationship between fecundity and standard length, body weight, gonad length and gonad weight were found statistically significant ($P<0.01$). Das *et al.* (1989) recorded highly significant relationship between fecundity and gonad weight in *H. fossilis*.

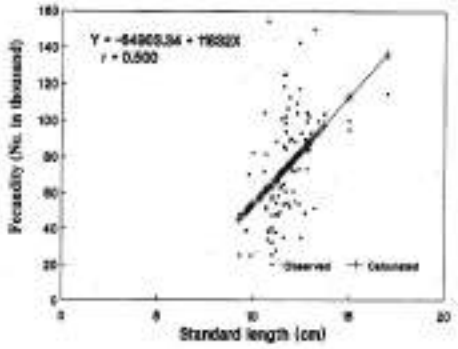

Fig. 1. Showing the relationship between fecundity and standard-length of *G. chapra*.

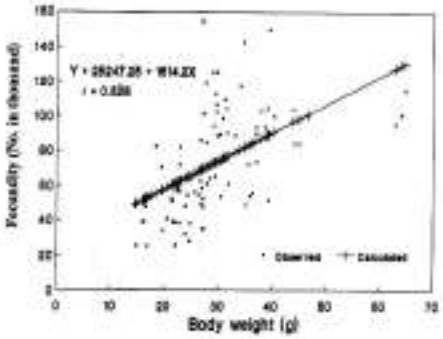

Fig. 2. Showing the relationship between fecundity and body weight of *G. chapra*.

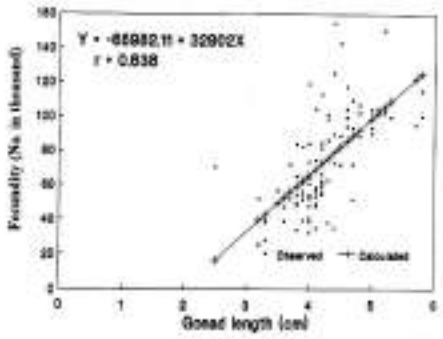

Fig. 3. Showing the relationship between fecundity and gonad-length of *G. chapra*.

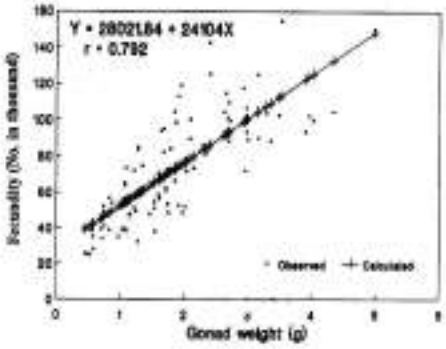

Fig. 4. Showing the relationship between fecundity and gonad weight of *G. chapra*.

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Seasonal variation in the occurrence of some zooplankton in a fish pond

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Abstract

Observations were made on the seasonal variation in the occurrence of some zooplankton in a fish pond. A total of 31 genera were recorded, out of these, 8 belongs to Rotifera, 5 to Copepoda, 112 to Cladocera, 3 to Protozoa, 2 to Nematoda and 1 to Oligochaeta. The role of temperature, dissolved oxygen, free Co_2, pH, turbidity and alkalinity in the occurrence of different genera is discussed.

Key words : Zooplankton, Physico-chemical parameter

The abundance of zooplankton in a water body is regarded as an indicator of potential productivity. Their abundance is greatly related with water qualities. The present study was made on the seasonal variations and occurrence of some zooplankton in respect to physico-chemical parameters in a pond.

The present investigation was conducted for a period of one year in a fish pond within Rajshahi University campus from January '95 to December '95. Water and zooplankton samples were collected at weekly interval in morning (0th), noon (12h) and evening (18h) from surface, middle and bottom layer. Water temperature, turbidity and pH were measured by a water quality checker (20A, TOA-Japan). CO_2, DO and alkalinity were measured by titration method (Welch 1948). Zooplankton were collected by a plankton net of no. 20 count bolting cloth and preserved in Transeau's solution. The numerical assessment of zooplankton was done by Sedgewick-Rafter counting cell and identified by the keys given by Ward and Whipple (1959), Mellanby (1963) and Bhuiyan and Asmat (1992).

The water temperature vaired from 17 ^{0}C (January) to 36 ^{0}C (May) and the yearly mean was 27.26±3.85. The pnod water showed somewhat alkaline in nature with small variation. The p^H was noted to fluctuate between 6.0 (May) to 8.2 (February) and the mean was 7.30 ± 0.35. The DO content of water varied from 0.62 mg/l (September) to 6.85 mg/l (December) and the mean was 4.34 ± 0.55. The free CO_2 fluctuated between 0.0 mg/l (January and March) to 15 mg/l (September). The mean value of free CO_2 was 6.36 ± 0.9. The bicarbonate

alkalinity varied between 30 mg/l in March and 95 mg/l in January and the mean was 53.83 ± 13.8.

The major groups of zooplankton were rotifers, copepods and cladocerans. Protozoans, crustacean larvae and insect larvae were found to be seasonal and nematodes and oligochaetes were found very rare. The seasonal variation in density of dominant groups of zooplankton is shown in detail in Fig. 1.

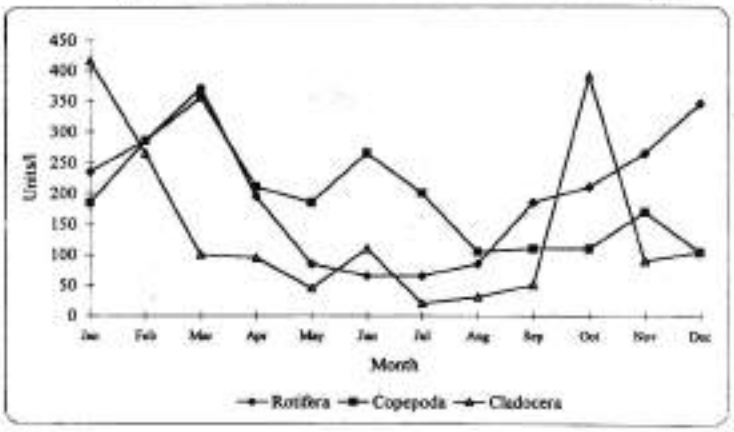

Fig. 1. Monthly fluctuation of rotifera, Copepoda and Cladocera (units/l).

During the study period, rotifers were the dominant fauna (2390 units/l). Similar observation was made by Habib *et al.* (1984) and Ali *et al.* (1985). *Brachionus falcatus* was the dominant species. The highest density of rotifers was found (345 units/l) in June and July. The peak in winter might be due to the favourable conditions of physico-chemical parameters and the availability of nutrients in the ponds. Rotiers feed on phytoplankton (Krishnamoorthi and Visweswara 1964). In winter season due to the higher degree of photosynthesis the number of phytoplankton increased and in trun resulted in the higher production of nutrients for multiplication of rotifers. Besides this, pH (7.0-7.1) and DO (5.16-6-85 mg/l) values of the pond during winter were supposed to be productive for plankton growth. Copepods were the second dominant fauna (2225 units/l). Its density ranged between 335 units/l in March to 105 units/l in August and December. Among them *Cyclops scutifer* was the dominant. Cladocerans were third in dominance (1715 units/l). The highest (415 units/l) was in January while the lowest (20 units/l) was in July. The *Diaphanosoma leuchten* was the dominant. The total yearly abundance of protozoans was 95 units/l and maximum number (50 units/l) was found in September and the minimum (15 units/l) in November.

Monostyla spp. and *Rhabditis* spp. of nematodes were identified and they were less in abundance. Only *Nais* spp. of oligochaetes was identified and found very rare. Nauplius and may-flies were found among crustacean and insect larvae.

The correlation coefficient between the different groups of zooplankton and physico-chemical parameters of water were calculated and are given in Table 1. Rotifers, copepods and cladocerans showed positive correlation with water temperature. Ali (1980) found similar result. The co-efficient of correlation between rotifer fauna and temperature was observed to be significant at 5% level (r=0.75).

Table 1. Co-efecient of correlation between physico-chemical parameters and the different dominant groups of zooplankton

Relationship	Co-efficient of correlation	Relationship	Co-efficient of correlation
Water temperature vs Rotifera	0.75**	Water temp. vs Cladocera	0.74**
Water turbidity vs Rotifera	-0.33	Water turbidity vs Cladocera	-0.26
pH vs Rotifera	0.16	pH vs Cladocera	0.15
DO vs Rotifera	0.31	DO vs Cladocera	0.19
Bicarbonate vs Rotifera	-0.12	Co_2 vs Cladocera	-0.21
CO_2 vs Rotifera	-0.17	Bicarbonate vs Cladocera	0.18
Water temp. vs Copepoda	0.22	Water temp. vs Protozoa	-0.09
Water turbidity vs Copepoda	-0.10	Water turbidity vs Protozoa	0.02
pH vs Copepoda	0.12	pH vs Protozoa	0.03
DO vs Copepoda	0.25	DO vs Protozoa	0.06
CO_2 vs Copepoda	-0.28	CO_2 vs Protozoa	-0.04
Bicarbonate vs Copepoda	0.26	Bicarbonate vs Protozoa	0.08

*** Singificant at 5% level.*

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Effect of supplementary feed on the growth of shinghi (*Heteropneustes* fossilis Bloch)

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Abstract

Effect of two supplementary feed (food A and food B) on the growth of shinghi, *Heteropneustes fossilis* was observed for 3 months period during winter and summer. Food B containing rice bran 2g, wheat bran 2g and blood 10 ml, showed better growth. The net gain in length was 70.04 mm and in weight was 13.82 g. Total net production of the was observed as 254.00 g/m^2 with feed A and 345.50 g/m^2 with feed B.

Key words : *H. fossilis*, Feed

Supplementary feed is one of the most prime exogenous requisite for proper fish culture. The supplementary fish feed may either be vegetable foods (e.g. pulse, cereals, grains, yeast, plant parts etc.) or of animal origin (e.g. fish meal, meat meal, blood, cheese, internal parts of animal body etc.) (Huet 1979). Whatever the food type may be, the criteria for a successful fish feed are, (i) readily acceptable, (ii) having high conversion rate (iii) availability (iv) high keeping quality and (v) low cost.

Among the commercially important fishes of Bangladesh shinghi, *Heteropneustes fossilis* is rich in protein and minerals (Basu and Gupta 1939, Ahmed 1957, Sahidullah 1964). According to FAO report (1991) the chemical composition of the fish is 72% water, 19% protein, 8% fat, 0.15% calcium, 0.25% phosphorus and 0.10% vitamin A, B, C and D. The fish fetches a high market price because of its therapeutic value. In natural habitat *H. fossillis* is known to be carnivorous, but in intensive culture the fish responds to supplementary feeds, *viz.*, slaughter house waste, trash fishes, silk worm pupae, oil cake, rice and wheat brans, compost, bio-gas slurry, etc., in various proportions and combinations (Dehadri 1978). Sengupta *et al.* (1969) reported the possibility of intensive monoculture of the fish reared on supplementary feed. The present work is an attempt to study the growth of *H. fossilis* both in terms of length and weight with two types of supplementary feeds.

Experiment was carried in two cement cisterns, each of them having a surface area of 4.86 m^2 and a depth of 2.5 to 3 m. Water sources were tap water and rain water. *H. fossilis* of average 75 to 90 mm in total length were collected from the market and acclimatised for 40 hours before release. Healthy

160 fish were released in each tank and provided with supplementary feed once in every 24 hours. One kind of food was supplied in one tank at a rate of 6% of the total body weight of the fishes which increased subsequently 7 to 8% as the fishes gain in weight. The experiments were carried for three months, once in the winter (December to February) and once in the summer (May to July).

The supplementary feeds consisted of Food A mixture of rice bran (40%), wheat bran (40%), chicken entrails (20%). The chicken entrails were cut into small pieces and boiled till soft. Food B: the mixture consisting of rice bran (2g) wheat bran (2g) and blood (10 ml). The blood was collected from slaughterhouse. The mixture was kept in an airtight container for 15 days and then refrigerated. Food A was used in the tank I and food B in tank II.

Before stocking the initial total length and weight of the fry were recorded. In every 30 days 10 fishes were randomly collected and measured to record the subsequent growth in terms of length and weight. The coversion rate of the food supplied was determined from the formula used by Huet (1979) and Jhingran (1982).

$$\text{Conversion rate} = \frac{\text{Food fed (dry)}}{\text{Fish live weight gain}}$$

The survival rate of the fishes after three months was 95 to 100% in winter and summer respectively in both the tanks. Both the food types resulted increase in length and weight of the fishes and the monthly growth was gradual with both foods (Table 1). The length weight relationships of the fishes fed on either type resulted increase in length and weight of the fishes and the monthly growth was gradual with both foods (Table 1). The length weight relationships of the fishes fed on either type of feed, were positively correlated. Moreover, the growth rate was higher in the summar than in winter (Table 2). The 't' test showed significant difference between the weight of the fishes fed on two different feeds ($p<0.05$).

The present result showed gradual increase in growth of *H. fossilis* with supplementary feeds. The growth rates were similar as occurs in the natural habitat though the net gain in length and weight were not satisfactory. Stocking of fry at a rate of 25/m^2 with supplementary feed yielded a production equivalent to 440 g/m^2 in 4 months (Jhingran 1982) and 480 g/m^2 in 6 months (Sengupta *et al.* 1979). Whereas, in the present experiments the net gain in weight were only 52.26 g/m^2 (food A) and 71.09 g/m^2 (food B). Higher stocking rate (32 fry/m^2) and lesser rearing period might be the causes of lower growth rates as observed in the present study. Moreover, the temperature and soil condition also affecting factors of growth in *H. fossilis* (Macan et al. 1942, Ahmad 1957 an Jhingran 1982). The water depth (2.5 to 3.0 m) which maintained in the experiment is not suitable for proper fish culture.

The present results revealed that *H. fossilis* can be cultured in cemented tanks with supplementary feeds in 4 to 6 months time.

Table 1. Growth of *H. fossilis* during 3 months feeding on supplementary feed

Feed type	Day-wise increase in body length (mm)					Day-wise increase in body weight (g)					Total net
	Initial	30	60	90	Net gain	Initial	30	60	90	Net gain	production g/m^2
A	80.46	91.00	111.40	139.30	58.84	4.57	6.59	10.30	14.73	10.16	254.00
Gain in length		13.54	18.40	27.90		Gain in weight	2.02	3.71	4.43		
B	80.46	96.67	122.27	154.50	70.04	4.57	8.34	13.13	18.39	13.82	345.50
Gain in length		16.21	26.83	31.80		Gain in weight	3.77	4.79	5.26		

Table 2. Length-weight relationship of *H. fossilis* fed on supplementary feed

Tank/food type	No of obs.	value of 'a'	value of 'n'	value of 'r'	Mean condition factor K=TW/TI^3
I/Feed A	10	1.25^{-05}	2.83	0.976	0.54
II/Feed B	10	1.47^{-06}	3.23	0.979	0.45

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