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Catch assessment of indigenous and exotic carp species of Nasti baor

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Abstract

An investigation on length-weight relationship, length-frequency distribution, catch per unit of effort (CPUE) and stocking and harvesting status of three Indian major carps: rohu *Labeo rohita*, catla *Catla catla* and mrigal *Cirrhinus mrigala* and three exotic carps: silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idella*) and common carp *Cyprinus carpio* was carried out in Nasti baor (oxbow lake) for the harvesting season from August to December 1995.

The length-weight relationship for six carp species was established for the harvesting months of November and December 1995. The b values for different species respectively for the months of November and December were 2.95 and 2.58 for ruhu, 3.06 and 2.98 for catla, 2.84 and 2.90 for mrigal, 2.75 and 2.60 for silver carp, 2.51 and 1.97 for grass carp and 2.38 and 2.50 for common carp. In CPUE study, the CPUE was 0.58 kg/ha/hr while the catch per gear was 0.08 kg/ha/hr/purse-seine. The recovery percentage of mrigal was highest (63.57%) and it was lowest (16.81%) in case of silver carp. The density of submerged macrophytes (*Hydrilla*, *Utricularia*, *Ceratophyllum* and *Vallisneria*) was highest (4.39 kg/sqm) in November and was lowest (0.76 kg/sqm) in September.

Key words : Carps, Catch per unit effort, Macrophytes, Oxbow lake

Introduction

An oxbow lake (local names: *baor*) is a dead river loop cut-off when the river changed its course (Hasan *et al.* 1998b). A baor normally is still part of the floodplain of the river, to which it is connected by inlets and outlets. Baors are not very deep and the rooted vegetations are very common feature of a baor. Fish culture in baors is a practice by which an open water fisheries is converted by screening the inlets and outlets into a culture-based fisheries (Middendorp *et al.* 1996). All the baors in Bangladesh are situated in the moribund delta of the Ganges in southwestern Bangladesh. There are approximately 600 baors in southwestern Bangladesh with an estimated combined water area of 5448 ha (Hasan 1990).

The management situation in the baors are neither strictly comparable to those in the truly open water environment of the rivers and natural depression *(beels)* where the fishery is a 'capture fishery' (BCAS, 1989), nor to the completely controlled closed water system of a pond. A baor is a potential area of fish production and a source of income generations of fishers. The Government of Bangladesh had completed a Pilot

Project for the development of baor fishery with the financial support of World Bank during 1978-1985. Under this pilot project six carp fingerling under direct management of Department of fisheries (DOF). In 1991, second phase of Oxbow Lakes Project (Oxbow Lakes Small Scale Fishermen Project Phase II) was initiated by the DOF with financial support from International Fund for Agricultural Development (IFAD) and with technical assistance from Danish International Development Agency (Danida). Further twenty two baors located in five districts (Jessore, Jhenaidah, Chuadanga, Kushtia and Faridpur) of southwesten Bangladesh were brought under culture-based fisheries management through Oxbow Lakes Project (OLP II) (Hasan and Middendorp 1998, Apu and Middendorp 1998). Oxbow lakes are stocked with three major carps (rohu *Labeo rohita;* catla *Catla catla* and mrigal *Cirrhinus mrigala* and three exotic carps: silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idella* and common carp Cyprinus carpio) (Hasan *et al.* 1998a). Stocking largely takes place during July-October and fishing starts from November and continues up to June. The present study reports the stocking and harvesting status, recovery of stocked six carp species, the length-weight relationship and the catch per unit of effort of six carp species and submerged macrophytes density in one selected baor, Nasti baor.

Materials and methods

The study was conducted in Nasti baor. The baor is situated in Moheshpur thana of Jhenaidah District. The total area of the baor is 66 ha. The average depth of the baor is 2.64 m during winter and 4.32 m during monsoon. The study was conducted from August to December'95.

Data for water quality parameters

Water quality parameters (temperature, Secchi depth, water colour, water depth, p^H, TDS and conductivity) were recorded once a week at three selected sample sites. Water temperature were taken by holding a thermometer under water for 3 minutes to the nearest °C. Representative water sample was collected by bottom water sampler for the estimation of bottom water temperature. The bottom water sampler was hand made by the authors. The sampler was nothing but a bottle with a cork connected to each other by ropes. The operational technique was very simple. The bottle, shut down with the cork, was dipped under water (with the help of a weight) and loosen the cork with a sudden and forceful pull. The bottle was then filled with bottom water and then pulled out of water quickly.

Secchi depth was measured by lowering the Secchi disk into undisturbed water until it disappears and was recorded to nearest cm. Water colour was also recorded as clear, brown, green etc. as was seen by the naked eye. Water depth was measured with the help of a graduated bamboo pole adjacent to fish landing complex in cm. p^H, TDS (Total dissolved solids) and conductivity were measured by p^H meter, TDS and conductivity meter (M-90 CIBA CORNING, UK) respectively.

Data on macrophyte

By dipping a wooden quadrant (0.25 sqm) at random in aquatic vegetation area a minimum of six samples were collected and lifting all plant within the quadrant were weighed on a spring balance (SALTER 235 65, UK) after species-wise sorting of macrophytes. Data were taken for the period from September to November'95.

Stocking and harvesting data

Stocking and harvesting data of three Indian major carps: rohu *Labeo rohita*, catla Catla catla and mrigal *Cirrhinus mrigala* and three exotic carps: silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idella* and common carp *Cyprinus carpio* were collected from Baor Record Book prior to the start of the research project for the analysis of stocking and harvesting data of the period of 15 months. Stocking data were recorded for the period from July'94 to September'95 and harvesting data for the period from October'94 to December'95. The stocking data from July to September'95 and the harvesting data during November and December'95 were collected during the present study. Data recorded for stocking analysis were: total weight (kg), total number, no/kg, size range and weight range, mean size and mean weight.

Lenght-weight data

A total 2196 fishes of different species were collected randomly from the catches of fishermen, of which 248 were ruhu, 386 were catla, 243 were mrigal, 1013 were silver carp, 56 were grass carp and 252 were common carp. The total length in nearest cm and weight in nearest gram of individual fish of each species were measured by using a scale and spring balance (SALTER 235 65, UK) respectively. Total length was measured from the tip of the snout to the end of caudal fin squeezed together.

Catch per unit effort data

The catch per unit effort (CPUE) data of six species were collected during fishing time from November and December'95. The data recorded for the calculation of CPUE were type of fishing gear, number of gear used during each fishing, number and weight of total fish harvested in each fishing, number and weight of individual fish species harvested in each fishing, number of fishermen attended in each fishing, time interval between shooting and hauling of each gear, number of shooting in each fishing and number of hours of fishing. Gear inventory for kotchal (purse seine) fishing was carried out by collecting information on no. of gear, manpower, length and width of the gear, stretched mesh size of the gear, diameter of upper and lower rope, number of float used, boat particulars (such as, size, number etc.) Kothcal jal (a seine net), the length of which varied from 64.4-331.2 m, width from 4.6-165.5 m and mesh size varied from 30-120 mm, were used for fishing.

Data analysis

The length and weight data were used to determine the length-weight relationship, regression coefficient (slope), correlation coefficient (r) and intercept. All data were converted to log_{10} value to have straight line length-weight relationship. The length-weight relationship was determined by using formula given by LeCren (1957).

The condition factor was calculated by the Fulton's condition factor formula : (Balan 1967)

$K = 100W/L^b$

Where, K = condition factor, W = observed body weight (g) of a fish, L = observed total length (cm) of a fish, b = slope or regression coefficient.

The relative condition factor was calculated by the following formula:

$Kn = W/W'$

Where, Kn = relative condition factor, W = observed body weight (g) of a fish, W' = calculated body weight (g) of a fish.

Length frequency distribution analysis were done according to size group for individual fish species for two month period (November-December'95). Percentage frequencies of different species were also determined at the same period.

Age groups were determined from length-frequency data and figure by the estimation of connecting peaks from modal class (Goeden 1978). Different peaks indicate different age groups on the basis of length and weight.

Efficiency of gear and fishermen were estimated from the catch data for two months (November-December'95). Catch per unit effort (kg/da/fm and kg/day/gear) and catch / 100 sqm/hr., catch/ha/kotchal/hr were estimated from catch data. Percentage of total carp harvested were calculated for each month from total catch data.

The recovery percentages of different species and age groups were calculated by using number of fish stocked and number of fish harvested. Production (kg/ha) of individual species for 12 months period (from December'94 to November'95) was calculated from the catch data. Recovery rate was estimated by the following formula:

$$\text{Recovery rate} = \frac{\text{Total no. of fish harvested}}{\text{Total no. of fish stocked}} \times 100$$

All calculation and analysis were done in Compaq Prolinea 4/25 microcomputer using MS Excel 5.0 software. All graphs were drawn by suing Harvard Graphics 3.0.

Results

Water qualities (temperature, Secchi depth, water depth, p^H, conductivity, TDS, water colour) were within the productive range for baor. Temperature ranged from 29 to 17.8 ^{0}C, Secchi depth from 42.7 to 58.3 cm, water depth from 260 to 284 cm, p^H from 6.92 to 7.06, TDS from 134.8 to 143.1 mg/1, and conductivity ranged from 270 to

296.3 µs during September to December'95. The water colour was light green to green.

Density (kg/sqm) of *Hydrilla*, *Urticularia*, *Ceratophyllum*, *Vallisnaria* during September to November'95 were 0.24-0.67, 0.34-1.29, 0.18-1.43, and 0.67-1.00, respectively (Fig. 1). The density (kg/sqm) of submerged macrophytes were high in November (4.29) and low in September (0.75).

Length-weight relationship of three Indian major carps (rohu, catla and mrigal) and three exotic carp species (silver carp, grass carp and common carp) were determined from length-weight data for November and December'95 (Table 1). Regression coefficient "b" of six carp species vgaried between 1.97 and 3.06. The growth of rohu and catla was found isometric, but was allometric in other four species in November. In December, the values of "b" varied from 1.97 to 3.0. The highest value was found in catla and lowest in grass carp. Isometric growth was observed in catla and the growth of other five species was allometric (Table 1).

During these two months period the values of r, K, Kn of different fish were found to range between 0.85-0.95 and 0.83-0.96, 1.20-16.67 and .47-59.3, and 1-1.03 and 1-1.1 respectively (Table 1).

Age groups of different fish species were determined from the length frequency distribution (Fig. 2ab). The estimated age group of catla were I and II, rohu were I, II & III, mrigal I, II & III, silver carp I & II, grass carp I & II, common carp I & II (Fig. 2ab). The total catch (kg) and catch per unit effort (CPUE) (catch/day/fishermen and catch/day/gear, catch/100 sqm/hour and catch/ha/hour/kochal) were calculated.

Length frequency distribution shows that catla attained 36 cm (707.8 g) and 62.5 cm (4433.3 g) during first and third year respectively. Rohu attained 30 cm (308.5 g), 49 cm (1373 g) and 63 cm (1800 g) during first, second and third year respectively. Mrigal attained 31 cm (416.15 g), 51 cm (1307.18 g) and 63.5 cm (1925 g) during first, second and third year respectively. Silver carp attained 36.67 cm (568.7 g) and 58.5 cm (2611.4 g) during first and second year respectively. Grass carp attained 47.5 cm (1255.2 g) and 61 cm (3000 g) during first and second year respectively. But in case of common carp the length and weight recorded were of 34.5 cm and 90.94 g, and 56 cm and 2750 g during first and second year respectively (Fig. 3). The highest production was achieved for common carp (162.6 kg/ha) and lowest was for mrigal (71.7 kg/ha). The highest individual weight was achieved by grass carp (1.49 kg) and lowest by mrigal (0.53 kg). The total production for the 12 months period (December'94-November'95) was 720 kg/ha. The recovery rate of these species were 33.04% for catla, 63.57% for mrigal, 16.81% for silver carp, 40.23% for grass carp and 60.34% for common carp (Fig. 3). But rohu gave an abnormal recovery rate due to unavailability of proper stocking data. The average recovery rate for all species was 39.24%.

Recovery percentage of 0 age group of individual species were calculated during the fishing period of November and December'95. Highest percentage were shown by catla (5.3), followed by common carp 4.7, silver carp 4.5, grass carp 3.4, mrigal 1.8 and rohu 0.24 respectively. Recovery percentage of mixed year class between I and II fish were also calculated. Mrigal showed the highest recovery percentage (49%).

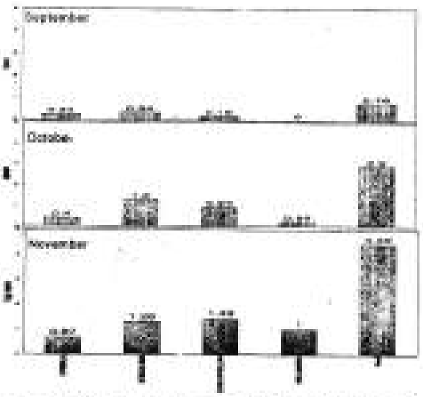

Fig. 1. Density (kg/sqm) of submerged macrophyte in the Nasti baor during September-November'95.

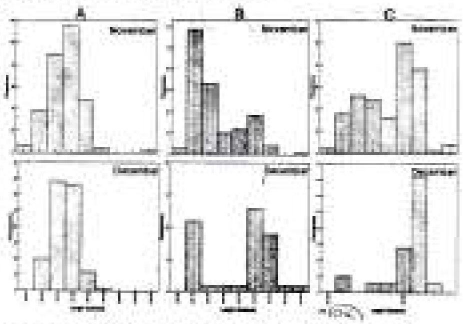

Fig. 2a. Length-frequency distribution of Indian major carps: (A) catla, (B) rohu, (C) mrigal in the catch during November-December'95.

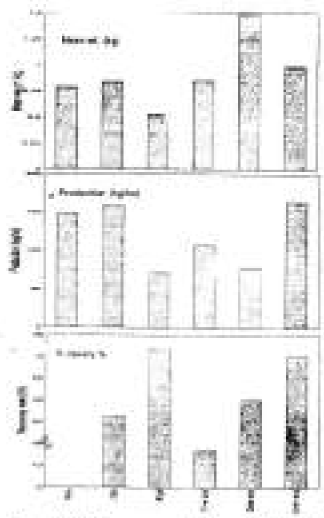

Fig. 3. Mean weight, production and recovery (%) of different carps in Nasti baor.

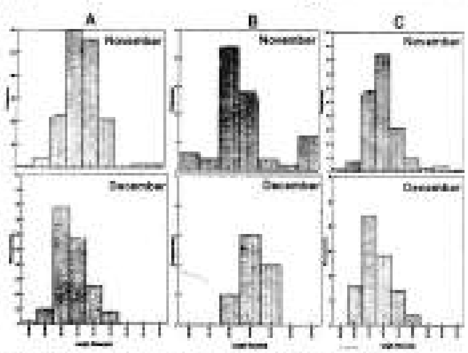

Fig. 2b. Length-frequency distribution of exotic carps: (A) silver carp, (B) grass carp, (C) common carp in the catch during November-December'95.

Table 1. Length-Weight relationship of carps harvested from Nasti baor during the month of November-December'95

Name of the species	Number of samples	Modal length (cm)	Mean total length (cm)	Mean body weight (g)	L-W relationship (LogW = a+b LogTL)	Correlation coefficient (r)	Fulton's condition factor (K)	Relative condition factor (Kn)	Comments on growth
Rohu	210 (38)*	30 (29)	41 (46.22)	629.3 (1082.90)	Log W=1.809+2.95 Log TL (Log W=-1.232+2.575 Log TL)	0.952 (0.957)	1.6 (5.999)	1 (1.106)	isometric (allometric)
Catla	302 (84)	37 (34)	39.04 (37.50)	774.98 (658.93)	Log W=-1.927+3.099 LogTL (Log W=-1.836+2.997 Log TL)	0.925 (0.926)	1.198 (1.471)	1.013 (1.008)	isometric (isometric)
Mrigal	176 (64)	50 (52)	43.10 (44.49)	959.89 (1237.19)	LogW=-1.715+2.841 LogTL (Log W=-1.827+2.902 LogTL)	0.946 (0.981)	1.979 (1.497)	1.013 (1.005)	allometric (isometric)
Silver carp	833 (180)	39 (33)	42.89 (31.71)	746.20 (591.67)	LogW=-1.56+2.745 LogTL (LogW=-1.311+2.603 LogTL)	0.88 (0.848)	2.805 (4.995)	1.018 (1.022)	allometric (allometric)
Grass carp	50 (6)	45 (50)	47.89 (47.80)	1573.60 (1283.30)	Log W=-1.031+2.508 LogTL (Log W=-0.228+1.969 LogTL)	0.845 (0.937)	9.6 (59.3)	1.031 (1.00)	allometric (allometric)
Common carp	199 (53)	36 (33)	42.35 (38.70)	981.66 (818.87)	LogW=-0.788+2.381 LogTL (LogW=-1.006+2.504 LogTL)	0.859 (0.834)	16.669 (10.04)	1.023 (1.018)	allometric (allometric)

L= Length; W= Weight; TL= Total length; a = Intercept; b= Slope
**Figures within parenthesis indicate the values for the month of December.*

Discussion

In length-weight relationship analysis, the regression coefficient "b" of different carp species in two months (November and December'95) were found to be different to some extent. These values stayed within the values of 2 to 4 reported for different carp species in different baors previously studied (Oxbow lakes project II 1994). Iqbal (1995) reported "b" values between 2.55 and 3.35 of these six carp species in Nasti baor during February to April'95. Generally length-weight relationship follows the cube law relationship (Hardjaumula *et al.* 1988), i.e. the value of "b" is equal to 3, it means that the growth of that carp species is isometric and if it is not equal to 3, the growth is assumed to be allometric. It indicates the different growth status of different species in different months. In this respect isometric growth was found in catla in both the months. It may be attributed that in November and December the baor productivity was high, Secchi depth was low and water level was ideal for growth of catla. Isometric growth was found also in rohu in November. It is noticeable that in November isometric growth was found in two species and in December isometric growth was found in only one species. The gradual fall of temperature might have decreased the productivity of baor to some extent. However, growth of fish in baor depends on several factors like stocking ratio, stocking density, ecological conditions of baor and on the quality of fingerlings stocked.

The Fulton's condition factor (K) in case of grass carp and common carp in November and December was abnormal. However, in case of large length range, Fulton, s condition factor can give misleading results (Bagenal 1978). The relative condition factors (Kn) of all species in both the months were more or less same (1.000).

It is generally assumed that modal length represent the probable age group (Goeden 1978, Balan 1967, Burhanuddin *et al.* 1974). In this studies 3 empirical year class was found in rohu and mrigal, 2 in catla, grass carp and common carp. Rohu increased 19.0 cm in the II age and 14 cm III age and mrigal increased 20 cm in II age and 12.5 cm in the III age which showed that growth of fish decreases with the increase in age (Fig. 2ab).

In case of catch per unit of effort, 0.575 kg fish were caught per ha per hour and 0.082 kg fish were per ha per hour per kochal during November which showed a poor catch. This might be due to the increased water depth of baor, which affected the gear efficiency. The poor catch in per unit of effort indicates that kochal is not the only efficient gear for the majority of the species that are stocked. However, in view of the equity and employment issues associated with the fishery, discontinuation of the use of this gear is not suggested.

Recovery percentage of silver carp was comparatively less than those of other species. It can be explained that the stocking was very high resulting high mortality and also resulting an adverse effect on growth. High recovery percentage of mrigal might be due to the combination of several factors such as ecological suitability for the species, suitable stocking rate, relative hardness of the species etc.

There was a mass mortality of carps, specially silver carp, in the Nasti baor during the last half of October'95 which might have happened due to (i) high density of fingerling stocking, (ii) water pollution due to dense jute rotteuing, (iii) wonding of fingerling due to stress during stocking, (iv) depletion of oxygen and increase of TDS and conductivity.

Density (kg/sqm) of submersed macrophyte was high in November, possibly due to decrease in number of grass carp by continuous fishing. Fishing started from this month.

Conclusions

This study highlighted stocking and harvesting status, length-weight relationship, catch assessment of six important carp species (rohu, catla, mrigal, grass carp, common carp and silver carp) in this baor. The study also highlighted the estimation of macrophytes-the major source of food for harvivorous fish species in baors. The result of this type of study will be very much useful to get a sustainable yield from the haor by utilizing the potential food resources.

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Predation by *Channa striatus* (Bloch) on *Rana tigrina* (Daudin), *Puntius gonionotus* (Bleekeer) and *Labeo rohita* (Hamilton) in the laboratory

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Abstract

The growth performance of a predatory snakehead, *Channa striatus* was tested by supplying tadpoles of *Rana tigrina* and fingerlings of *Puntius gonionotus* and *Labeo rohita* as prey for a period of 21 days in aquaria. Prey consumption by *C. striatus* was significantly different ($P<0.05$) for different prey used (T_1- *R. tigrina*, T_2- *P. gonionotus*, T_3- *L. rohita*). Tadpoles of *R. tigrina* was prefered by the predator (*C. striatus*) over *P. gonionotus* and *L. rohita* although tadpole is nutritionally inferior to each of *P. gonionotus* and *L. rohita*. Each predator preyed on 50-330 mg per day per g of their body weight. Fish preyed on tadpoles also showed the highest growth. Significant difference in weight gain was found between T_1 and T_2 and also between T_1 and T_3 but no difference was found between T_2 and T_3. Food conversion ratio (FCR) was found to be lowest in treatment T_1 followed by the treatments T_2 and T_3 respectively.

Key words : Predation, *Channa striatus, Rana tigrina, Puntius gonionotus, Labeo rohita*

Introduction

Every organism including fish requires energy for maintenance and growth which the fish must obtain from food. Predation is one of the important type of feeding to acquire energy for maintenance and growth of some fresh water fishes of Bangladesh. Among those the important groups are catfish and snake-heads. Normally predatory fishes are recognized as a devastating species in freshwater aquaculture because they consume cultured species and reduce production. In the contrary, the predatory species are known to us as a delicious food item due to their compact muscle and have got a high market value. Despite of their high market preference and wide acceptability as food fish predatory fishes have been neglected and discouraged in the aquaculture system of Bangladesh.

Predatory fish has both positive and negative effects on the community structure of an ecosystem depending on their specific role in the ecosystem (Sih 1987, Ton and Paszkowski 1986). The presence of predatory fish may be accepted for a limited period to shape the population of the desired species when a water body becomes over populated with small fishes. Fast growing undesirable fish can be controlled with the help of predatory fishes, such as *Notopterus chitala*, *N. notopterus*, *Wallago* *attu, Channa marulius, C. punctatus, C. striatus, C. orientalis, C. leucopunctatus.* Predatory fish maintain the balance of the number of fish in the natural habitat and in controlled population of prolific breeder aquaculture system, thus improve the habitat of cultured fish species and often increase the production of fish.

A snake-head (*C. striatus*) is a member of the fresh water fish family Channidae. They have a cylindrical body and large scales on the top of the cranium in a pattern similar to that of the head of a snake. They have a suprabranchial organ in the gill cavity for air breathing and can survive nearly anoxic water. Snakeheads are good jumpers. They can jump out of water and stay on land in a moist environment for an extended length of time. Snakeheads can be used in polyculture ponds for trash fish removal or for the control of juvenile fish resulting from excessive reproduction (Chen 1990). There have also been attempts to monoculture snakehead (Chen 1990). Selectivity is common in predation either in terms of size of prey or in terms of prey species. Author's argument in favour of specific selective predation of *C. striatus* do not exclude the possibility that predatory species can be cultured with the prey species. It is important to know the selectivity of prey by a predator from the purely academic and management point of view. Information regarding the prey selectivity of *C. striatus* is almost absent. Although much works have been done on the feeding of predatory fishes, eg. William 1969, Savino and Stein 1982, Tonn and Paszkowski 1986, Hoyle and Keast 1987, Tonn *et al.* 1989, Hambright 1991 and Paszkowski and Tonn 1994. The literature does not reveal any work that has been done on the predation of *C. striatus*. The present work was thus designed to ascertain the preference of prey species by *C. striatus* by supplying different body shaped prey eg. spindle shaped, *R. tigrina*, laterally flattened, *P. gonionotus*, streamlined, *L. rohita*.

Materials and methods

Experimental species and acclimatization

The disease free predator fish shol, *Chana striatus* were collected from a fish retailer which were caught by using a cast net from a beel near Kawatkhali. The prey species, the fingerlings of rui, Thai sharpunti and tadpoles of tiger frog were collected weekly form the Bangladesh Fisheries Research Institute, Mymensingh, caught with the help of seine net (Ber jal).

Acclimatization of predator

The collected predators were placed immediately into three acclimatization aquarium (60 cm x 35 cm x 30 cm) in the laboratory. The aerators (Davio 8400) were fitted to supply air in the tank. Predators were treated with salt dip (1%) and malachite green (1 ppm) as a prophylactic treatment. The predators were kept into the aquaria for 15 days, first day without any feed, prey (about 1% of body weight of predator) offered into each of the aquarium on the second day and then increased the number of prey up to the satiation of predators on the following days.

Acclimatization of prey

On the other hand, immediately after collection, three prey species (*R. tigrina, P. gonionotus* and *L rohita*) were transferred into the laboratory and placed into aquaria respectively. Then the fishes had a dip bath into a dilute salt solution (1%) as a prophylactic treatment. Water in those aquaria was aerated by using aerator (Davio 8400) continuously to maintain dissolved oxygen level at high. Species were kept into the tank without supplying any food for first two day. After that supplementary diet containing fish meal, rice bran and wheat flour (40%+10%+50%) was supplied into the aquaria at the rate of maintenance ration (1% body weight).

Experimental design

For the present study, nine aquaria were selected. Nine predators (*C. striatus*) from the acclimation aquaria were transferred into nine aquaria. The predators were then classified into three random groups. The members of three groups were numbered as P_1, P_2 and P_3 for treatment-1 (feeding with tadpoles), P_4, P_5 and P_6 for treatment-2 (feeding with Thai sharpunti) and P_7, P_8 and P_9 for treatment-3 (feeding with *L. rohita*).

Predator P_1 (21.4 cm, 66.79 g), P_2 (24.3 cm, 90.3 g) and P_3 (26.5 cm, 135.0 g) preyed on tadpole, P_4 (24.6 cm, 96.7 g), P_5 (28.8 cm, 158.7 g), and P_6 (29.2 cm, 151.6 g) preyed on *P. gonionotus* and P_7 (23.7 cm 114.0 g) P_8 (22.0 cm, 72.0 g) and P_9 (23.7 cm, 114.0 g) preyed on *L. rohita*.

During 21 days experiment, the tap water was aerated continuously to maintain dissolved oxygen concentration at saturation. The temperature of the water was always in between 28° and 30°C. Predatory behaviour was observed every 6 hours regularly during the study period. The date, time and method of prey-capture were observed and recorded.

Twenty rui (3.2-4.3 cm; 0.2 -1.0 gm) twenty *Thai shorputi* (2.8-4.7 cm; 0.2-1.3 gm) fingerling, and twenty tadpoles of *R. tigrina* (2.5-5.5 cm; 0.5-1.1 gm) were offered to each predator for 24 hours time during first week and then it was increased to 30 during the 3rd week of the experiment. The prey were released into aquarium at 8:00 hr for every day and at the same time on the following day remaining prey (if any) were caught by hand scoop net. Then fresh preys were offered to each predator.

Data collection and analysis

Total length (cm), body weight (g) as well as jaw length (cm) and mouth gap (cm) were measured and recorded at the start of the experiment. Similarly, the average length (cm) and weight (g) of prey were recorded. Prey capture techniques of predator were observed and handling time was recorded. At the end of the experiment increment in total length (cm) and body weight (g) as well as jaw length (cm) and mouth gape (cm) were measured and recorded. Data on prey eaten by predators were recorded qualitatively and quantitatively. The data on the amount of prey consumed by predator was analysed (ANOVA) after Zar (1984). Proximate analysis of prey were done according to AOAC (1980) and the FCR (Food Conversion

Ratio) was calculated by using the following formula.

$$FCR = \frac{\text{Amount of dry food (g)}}{\text{Live weight gain (g)}}$$

Results and discussion

Acclimatization took two weeks. Whereas Basak (1997) and Ahmed (1997) reported an acclimation period of one week. This basic difference may be due to the inherent differences of the stock used.

The proximate composition of three prey species is presented in Table 1, where it was found that moisture content of *R. tigrina, P. gonionotus* and *L. rohita* was 85.72, 80.45 and 83.00% respectively. Whereas the protein content of three species used as prey was 53.71%, 65.39% and 74.18% for *R. tigrina, P. gonionotus* and *L. rohita* respectively when calculated on dry matter basis. Although tadpole contained low percentage of protein but contain comparatively much higher content of lipid then the other two types of prey used *viz.* fingerlings of *P. gonionotus* and *L. rohita*.

The prey taken weekly by different predators indicate that the tadpoles of *R. tigrina* was preferred by the *C. striatus* as prey over *P. gonionotus* and *L. rohita*. Each predator preyed on 50-330 mg per day per g of their body weight (Table 2). Significant variation ($P<0.05$) in total prey consumption (on dry matter basis) was observed in the experiment. Significantly different effect ($P = <0.05$) of prey on the body weight gain of predator was also found in the experiment. Significant variation in weight gain was found between treatment, T_1 and T_2 and also T_1 and T_3 but no significant difference was found in between T_2 and T_3. Total number and biomass of different prey captured and consumed by predatory fishes differed significantly also.

Table 1. Proximate composition of tadpoles of *Rana tigrina* and fingerlings of *Puntius gonionotus* and *Labeo rohita* used as prey in the experiment

Samples	Protein	Lipid	Ash
R. tigrina	53.71	9.29	28.26
	(7.67)	(1.33)	(4.03)
P. gonionotus	65.39	5.59	21.52
	(12.78)	(1.09)	(4.20)
L. rohita	74.18	5.21	20.62
	(12.55)	(0.88)	(3.48)

Figures within parenthesis indicate the proximate composition on the biomass basis.

Time taken to manipulate and swallow prey from capture to cessation of pharyngeal movement was counted as handling time. The average handling time was 30 ± 3 sec for tadpoles of *R. tigrina;* and 48 ± 3 and 48 ± 4 sec for *P. gonionotus* and *L. rohita* respectively. Tadpoles were sluggish in movement and were less responsive to

Table 2. Prey capture in number and weight by the predator, *C. striatus* during the experimental period of 21 days (where P. stands for predator)

{PRIVATE }	Treatment 1						Treatment 2						Treatment 3					
	Prey: *R. tigrina*						Prey: *P. gonionotus*						Prey: *L. rohita*					
Day	P_1		P_2		P_3		P_4		P_5		P_6		P_7		P_8		P_9	
	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken	Number of prey	% body wt. food taken
Total prey capture in 21 days	303.0	354.42	281.00	235.79	271.00	157.54	206.00	128.48	224.00	75.48	213.00	75.73	249.00	73.09	241.0	154.67	230.0	91.65
Prey capture/day ± standard deviation	14.42 ± 3.94	16.87 ± 4.67	13.38 ± 4.74	11.23 ± 3.88	12.90 ± 4.05	7.50 ± 2.36	9.81 ± 3.59	6.12 ± 2.79	10.67 ± 2.44	3.59 ± 0.83	10.14 ± 1.69	3.60 ± 0.50	11.85 ± 2.44	3.48 ± 0.77	11.47 ± 2.66	7.36 ± 1.69	10.95 ± 2.75	4.36 ± 1.11
Prey wt./day/g of body weight of the predator	-	0.25	-	0.12	-	0.05	-	0.25	-	0.12	-	0.12	-	0.12	-	0.33	-	0.18

Table 3. Some characteristic features of predator (*C. striatus*) used in the experiment and growth performance given with calculated mean, standard deviation and the FCR of prey dry mass. T_1 = fed on live *R. tigrina*; T_2 = fed on live *P. gonionotus* and T_3 = fed on live *L. rohita*

{PRIVATE }Treatments	Total length (cm)		Body weight (g)		Jaw length				Mouth gape				Wt. gain	Wt. of prey consumed by predator (g)		FCR
					Upper jaw (cm)		Lower jaw (cm)		Vertical (cm)		Horizontal (cm)					
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final		Live biomass (g)	Dry mass (g)	
T_1	24.07 ±2.08	25.70 ±1.88	97.30 ±28.32	117.23 ±27.30	2.90 ±0.16	3.10 ±0.16	2.53 ±0.16	2.70 ±0.17	3.60 ±0.78	3.90 ±0.78	2.90 ±0.75	3.37 ±0.66	19.90 ±1.07	221.20 ±10.56	37.39 ±1.79	1.87 ±0.02
T_2	27.50 ±2.08	28.50 ±1.99	235.67 ±27.70	143.67 ±25.90	3.03 ±0.05	3.30 ±0.08	2.63 ±0.17	2.70 ±0.16	3.33 ±3.78	3.63 ±0.38	2.90 ±0.14	2.90 ±0.14	13.00 ±1.20	114.66 ±3.25	22.36 ±0.63	1.73 ±0.17
T_3	24.70 ±2.70	26.10 ±2.60	114.1 ±34.41	126.83 ±33.39	3.00 ±0.14	3.27 ±0.09	2.86 ±0.12	3.0 ±0.08	3.67 ±0.09	3.96 ±0.09	3.50 ±0.05	3.60 ±0.06	12.06 ±0.26	108.87 ±3.28	15.46 ±0.46	1.27 ±0.09

Table 3. Some characteristic features of predator (*C. striatus*) used in the experiment and growth performance given with calculated mean, standard deviation and the FCR of prey dry mass. T_1 = fed on live *R. tigrina*; T_2 = fed on live *P. gonionotus* and T_3 = fed on live *L. rohita*

{PRIVATE }Treatments	Total length (cm)		Body weight (g)		Jaw length				Mouth gape				Wt. gain	Wt. of prey consumed by predator (g)		FCR
					Upper jaw (cm)		Lower jaw (cm)		Vertical (cm)		Horizontal (cm)					
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final		Live biomass (g)	Dry mass (g)	
T_1	24.07 ±2.08	25.70 ±1.88	97.30 ±28.32	117.23 ±27.30	2.90 ±0.16	3.10 ±0.16	2.53 ±0.16	2.70 ±0.17	3.60 ±0.78	3.90 ±0.78	2.90 ±0.75	3.37 ±0.66	19.90 ±1.07	221.20 ±10.56	37.39 ±1.79	1.87 ±0.02
T_2	27.50 ±2.08	28.50 ±1.99	235.67 ±27.70	143.67 ±25.90	3.03 ±0.05	3.30 ±0.08	2.63 ±0.17	2.70 ±0.16	3.33 ±3.78	3.63 ±0.38	2.90 ±0.14	2.90 ±0.14	13.00 ±1.20	114.66 ±3.25	22.36 ±0.63	1.73 ±0.17
T_3	24.70 ±2.70	26.10 ±2.60	114.1 ±34.41	126.83 ±33.39	3.00 ±0.14	3.27 ±0.09	2.86 ±0.12	3.0 ±0.08	3.67 ±0.09	3.96 ±0.09	3.50 ±0.05	3.60 ±0.06	12.06 ±0.26	108.87 ±3.28	15.46 ±0.46	1.27 ±0.09

avoid the attack of the predator. Whereas *P. gonionotus* and *L. rohita* exhibit swift movement to avoid the attack of the predator, although the initial response i.e. staying at the far from the predator was similar for all three species used in the experiment. This susceptibility reelects in the total intake of prey by the predator. Hoyle and Keast (1987) stated the similar handling time (around 50 s) for large mouth bass, *Micropterus salmoides*.

The FCR value is lowest for *L. rohita* and the highest for *R. tigrina* and FCR for *P. gonionotus* was in the intermediate (Table 3).

Conclusions

Protein content indicates that the rui fingerling was better food for *C. striatus*. But the total tadpoles taken was much higher then the other prey and also the growth of predator was highest when tadpoles were used as prey. Here it can be concluded that *C. striatus* preferred *R. tigrina* as prey because of the easiness to catch and engulf the tadpoles. Susceptibility of tadpoles as prey might be on account of their (tadpole) sluggish movement and also on account of their round shaped body. Thus from the result it can be said that not only the nutritive value of prey but also the suitability of prey in terms of body shape and also the anti-predatory behaviour determine the selectivity of prey in the process of energy acquisition through predation.

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Food preference and intake pattern of *Penaeus monodon* (Fab.) in semi-intensive culture system

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Abstract
P. monodon juveniles prefer natural food than artificial feed in their initial stage of rearing. However, the percentage preference towards artificial feed increases as the days of culture/ average body weight increases. Consumption of artificial feed was high during evening meal (1700h) and low during night meal (2200h). The index of intestine fullness was high (8.4±0.7) during initial stage of rearing, compared to that of final stage of rearing (4.9±0.4), probably due to low nutritional value of intake material and low water depth at initial stage. At all stage of rearing omnivorous feeding habit was established and no evidence of diet periodicity in feeding activity was observed.

Key words : *Penaeus monodon*, Gut analysis, Semi-intensive

Introduction

Black tiger shrimp, *Penaeus monodon* is a nocturnal continuos intermittent feeder and its appetite vary with the environmental conditions, physiological conditions and gut evacuation rates (Mohanty 1996) and food and feeding habit of shrimp varies significantly at various stages of growth in natural environment (Tham Ah Kow 1967, Tiews *et al.* 1972, Mohanty 1975). However, not much work has been carried out in this aspect, especially, in semi-intensive culture system, where aquatic environment is artificially controlled and high-energy supplemental feed is used as a major input. Therefore, in view of feeding management, it is importance to know the food preference and intake pattern of shrimp.

Material and methods

The present study was carried out at "Shrimp Culture Pilot Project", Chandipur coast, Orissa, India, during 1996-97 culture season. A total of four crop was used for the experiment. Three ponds of 7500m^2 each (P_1, P_2 and P_3) and three ponds of 6000m^2 each (P_4, P_5 and P_6) were stocked with *Penaeus monodon* post larvae (PL_{20} stage). A stocking density (PLs/m^2) of 35, 25, 15, 30, 20 and 10 for pond no. P_1, P_2, P_3, P_4, P_5 and P_6 respectively was maintained through out the experimental period. Artificial high energy supplemental feed (NOVO feed, C.P. Group, Thailand) was used for the semi-intensive culture system, while periodic water exchange (2-30%), liming, fertilization and pond aeration using paddle wheel aerator was a regular practice.

Feeding management using check trays and standardized feeding programme were carried out as per suggested guide lines of Anon (1990) and Akiyama and Chwang (1995), and using following formulas :

(a) Total feed (Kg/day) = Average body weight (g) x % feed x nos. of survived shrimp in pond

(b) Feed to be given per lift net or check tray = $\frac{\text{Feed / meal (Kg) x LN\% x 1650}}{\text{pond area}}$

Where, LN = lift net; 1650 = one check tray is used for every 1650 m^2 pond area.

(c) Feed increment per day = Average daily growth (g) x (Biomass / Average body weight) x % feed

(d) Weekly feed conversion ratio (FCR) =

$$\frac{\text{Cumulative total feed used till date - Cumulative total feed used till previous week}}{\text{Biomass (Kg) at present - Biomass (Kg) of previous week}}$$

Monthly gut content of shrimps were analyzed monthly following "Point Volumetric" method (Sorojini 1954). A total of 652 shrimps (1.1±0.42 to 25.8±1.28g) were sacrificed for quantitative assessment of different food components during the experimental period. The degree of satiation (Fi= index of fullness) were estimated using the following formula :

Fi = w x 100/W; where, w = weight of gut content, W = weight of shrimp.

Results and discussion

On the basis of undigested food particles in the gut, the food of *Penaeus monodon* at different growth stage was composed of ten items and their preference for various food items at different stage of growth were recorded (Table 1). The total animal matter, total plant matter, total debris/mud and total pellet feed (artificial feed) in the gut of *P. monodon* showed variation from juvenile stage to sub-adult stage. Plant matter and debris/mud decreased sharply while, artificial feed/animal matter increased considerably as the days of culture (DOC) increased, thereby, a clear change in feeding habit was established. It was clear from the gut content analysis (Table 1), that shrimp juveniles prefer natural food than artificial feed in the initial stage of rearing (first month). Shrimp juveniles did not take any food during moulting period. However, the percentage preference towards artificial feed increases as DOC/ABW increases. Among the different food items, the least preferred items was diatoms at all stage of rearing. The present study also reveals that diet composition is related to the availability of food items and there is no particular selectivity towards any food items, which established omnivorous feeding habit (Mohanty 1975). Than Ah Kow (1967) reported that, all species of penaeids are herbivorous in their younger stages but are definitely carnivorous in their latter stages. However, the present study disagrees to this finding, as omnivorous feeding habit was established at the initial stage.

Table 1. Average % preference of food items (gut analysis) of *P. monodon* during different growth stages

	First Crop-96					Second Crop-96			
	Feb-96	March-96	April-96	May-96	June-96	Aug-96	Sept-96	Oct-96	Nov-96
Total no of shrimp sacrifice	34	38	41	34	30	36	37	28	22
MBW (g)	1.1(±0.42)	4.93(±0.88)	12.7(±1.63)	17.21(±1.9)	25(±1.58)	1.28(±0.38)	3.8(±0.51)	11.33(±1.34)	19.27(±1.44)
No of empty stomach	4	2	-	6	1	8	3	-	-
No of half filled stomach	11	8	17	13	4	13	8	3	1
No of full stomach	19	28	24	15	25	15	26	25	21
Food items									
Crumble/ Pelletized feed (%)	55.8	63.1	95.1	82.3	96.6	50	70.2	100	100
Copepods (%)	82.3	73.6	41.4	29.4	X	58	35.1	46.4	27.2
Worm (%)	32.3	21	7.3	17.6	X	19.4	13.5	21.4	13.6
Molluscan tissue (%)	14.7	28.9	26.8	20.5	36.6	5.5	13.5	39.2	13.6
Cladocerans (%)	32.3	21	X	5.8	X	33.3	29.7	7.1	18.1
Bottom algae / F. Algae (%)	70.5	47.3	39	38.2	43.3	58	48.6	14.2	50
Sand particle (%)	23.5	28.9	17	20.5	26.6	16.6	24.3	14.2	31.8
Mud/debris (%)	38.2	36.8	4.8	14.7	30	30.5	40.5	28.5	31.8
Diatom (%)	11.7	X	X	X	X	X	X	X	X
Crustacea (%)	X	36.8	26.8	32.3	43.3	8.3	18.9	39.2	36.3
	First Crop-97					Second Crop-97			
	Feb-97	March-97	April-97	May-97	June-97	Aug-97	Sept-97	Oct-97	Nov-97
Total no of shrimp sacrificed	43	35	37	28	24	34	48	53	50
MBW (g)	1.43(±0.38)	5.1(±1.11)	13.47(±1.49)	17.93(±1.6)	23.8(±1.78)	1.3(±0.37)	3.58(±0.71)	12.87(±1.33)	21.18(±1.51)
No of empty stomach	11	6	-	-	3	4	13	-	2
No of half filled stomach	8	11	11	6	2	13	9	14	7
No of full stomach	24	18	26	22	19	17	26	39	41
Food items									
Crumble/ Pelletized feed (%)	55.8	62.8	100	96.4	87.5	43	68.6	93	94.8
Copepods (%)	67.4	60	35.1	X	X	41	36.9	35.1	39
Worm (%)	11.6	20	X	7.1	X	19.8	13.5	X	14.4
Molluscan tissue (%)	13.9	17.1	8.1	28.5	33.3	6.3	13.5	32.2	13.6
Cladocerans (%)	39.5	37.1	24.3	X	X	28.6	31.7	6.6	16.1
Bottom algae/ F. Algae (%)	62.7	34.2	45.9	28.5	41.6	47	41.2	14.2	43
Sand particle (%)	9.3	X	5.4	X	8.3	17	23	14.2	17.2
Mud/debris (%)	25.5	25.7	18.9	X	16.6	23.6	34.8	26.5	17.2
Diatom (%)	4.6	X	2.7	X	X	3.2	X	X	X
Crustacea (%)	16.2	20	35.1	28.5	33.3	X	6.2	34.8	28.4

Marked change in food preference of *P. monodon* was recorded during last phase of culture. When preference for pellet feed, molluscan tissue and crustacean had increased significantly (>50%), preference for copepods, worm, cladocerans and diatom was down by more than 50% (Table 2), showed a clear change in intake pattern as the DOC/ABW increases, which agrees to the findings of Tiews *et al.* (1972). The diurnal feeding habit may change in relation to the age of shrimp (Reymond and Lagardere 1988), whereas no such changes was observed during the experimental period, probably due to the reason that in semi-intensive farming system, aquatic environment is artificially controlled. Mc Tigue and Feller (1989) also find no evidence of diet periodicity in feeding activity of juvenile shrimp.

Table 2. Percentage change in average percentage preference of food items (average of four corps) of *Penaeus monodon* in semi-intensive culture system during 1996 & 1997

Food items	Initial percentage preference of food item (DOC : 1-30)	Final percentage preference of food item (DOC : 90-120)	Percentage change in food preference
Pelletized feed	51.15	94.7	85.14
Copepods	67.17	14.05	79.08
Worm	20.77	7.0	66.29
Molluscan tissue	10.1	24.27	140.3
Cladocerans	33.42	8.55	74.41
Bottom algae	59.55	44.47	25.32
Sand particle	16.6	20.97	26.32
Mud/debris	29.45	23.9	18.84
Diatom	4.87	0	100.0
Crustacea	6.12	35.32	477.1

DOC : Days of culture
Total number of shrimp sacrificed = 652
Total number of full stomach = 430
Total number of half filled stomach = 159
Total number of empty stomach = 63

Meal-wise as well as month-wise artificial (pellet) feed consumption rate in percentage of total feed consumed per crop was evaluated on the basis of check tray assessment and daily feed consumption. Meal-wise average feed consumption rate was 25.9%, 24.7%, 28.0% and 21.4% for 1st, 2nd, 3rd and 4th meal respectively, while month-wise average feed consumption rate was 3.5%, 11.7%, 34.2% and 50.6% for 1st, 2nd, 3rd and 4th month respectively (Fig. 1). It is also revealed that consumption of artificial feed was high during evening hours (3rd meal) and poor during night meal (last meal) probably due to low dissolved oxygen, pH and temperature in the night times. However, feed intake pattern of *P. monodon* is also affected by several other factors such as feed attractant quality, feeding practice, moulting stage, water quality, bottom condition and availability of natural food (Mohanty 1996). Food intake and consumption rate is related to the rate of gastric clearance and volume of stomach which is directly related to ingestion, digestion and food progression, which in turn related to water temperature and pH. When gut fullness decreases, appetite increases and probability of eating rises (Mohanty 1996). The index of intestine fullness in the initial stage of rearing was high up to (8.4±0.7), compared to that of final stage of rearing up to (4.9±0.4), probably due to low nutritional value of intake material (sand, mud/debris) and low water depth (90-110cm) at the initial stage. During initial stage of rearing when low water depth was maintained, the sediment strip became a suitable substrate for benthic and detrital food particle which are less nutritive and count a major share in the gut content.

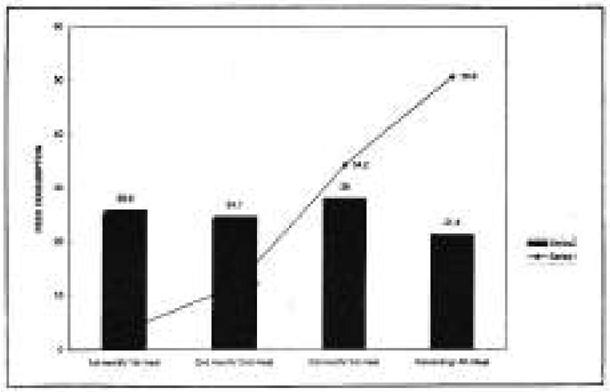

Fig. 1. Monthwise (-) and (|) feed consumption rate in percentages of total feed consumed per crop.

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Optimization of stocking density for environmental-friendly improved extensive shrimp farming system in south-west part of Bangladesh

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Abstract
An experimental culture practice of *P. monodon* on extension approach was conducted in two brackishwater earthen ponds of Demonstration Farm and Training Center (DFTC), Kaliganj, Satkhira. The experiment was aimed to provide farmers with appropriate technology that can immediately improve pond yield with keeping the environment in friendly condition. For optimization of stocking density of a cost effective environmental friendly improved extensive shrimp farming, the ponds were stocked with coastal river post larvae of *P. monodon* at the stocking rates of 2 pls/m^2 and 2.5 pls/m^2 without supplementary feeding. To control experimental error another five farmer's gher were used as replicates of each demo-pond. Considering the farmers buying ability, Cost of inputs and other facilities kept minimal. The impact of stocking density was evaluated on the basis of growth, survival rate, production and economic return. Better production (average 299.01 kg/ha) with same survival rate (39.33%) were found with a stocking density of 2.5 pls/m^2 without causing any deterioration in the culture environment.

Key words : *P. monodon*, Shrimp farming, Stocking density

Introduction

Shrimp farming are still major growth industries in many parts of Asia, Africa and Latin America (Rackowe *et al.* 1983) and represents an extremely valuable element in the economy of many developing countries as a major source of foreign exchange. In Bangladesh about 80% of total exportable shrimp produces from the districts of Satkhira, Khulna & Bagerhat (BBS 1996). Considering the enormous potentiality for export promotion from this sector, the government of Bangladesh merged the business into industrial sector. It is worthwhile to mention that average production of shrimp in this region is about 150 kg/ha/year through traditional and extensive method of cultivation with little exception. But there is still enough scope to increase the present production level through environmental friendly improved extensive shrimp farming. Therefore, Considering the prevailing fact, an experiment was undertaken to develop an optimum stocking rate with environmentally friendly improved extensive shrimp farming (in South-west part of Bangladesh) techniques.

Materials and methods

Experimental site

Two ponds each of 1.25 ha was selected for this experiment in the demonstration shrimp farm and training center complex of the DOF at Kaligonj, Satkhira. Ten local farmer's gher more or less similar nature also selected for farmers contact as well as replicates of demo-pond.

Experimental procedure

The experiment was conducted during the month of April to August'96. There were two treatments with six replicates each. In T_1, pond was stocked with a rate of 2pls/m^2 and for T_2 it was 2.5pls/m^2.Five farmer's gher were used as replicates for each treatment. No feed were supplemented during the culture operation.

Pond preparation

The ponds bottom were dried and tilt by tractor. Soil pH were tested and lime were added depending on the soil pH. Flushing gates were fenced using bamboo slits and nylon mesh screen. Water was introduced gradually at a minimum depth to facilitate the soil and lime interaction. Cowdung at the rate of 500kg/ha, mustard oil cake 100 kg/ha and phosphate + urea 35 kg/ha (P:U = 3:1) were applied followed by addition of water up to a depth of 30-40 cm and wait for natural feed development.

Stocking

Two ponds were stocked with locally available seed at the density of 2 pl/m^2 and 2.5 pls/m^2 respectively.

Water exchange and fertilization

In all the ponds water exchanged fortnightly during new moon and full moon. Inorganic fertilizer (urea and phosphate) were applied during the experimental period, depending on the availability of natural feed. To avoid sudden changes of temperature, salinity, pH, dissolved oxygen etc. due to heat and rainfall, effort were made to maintain an ideal water depth of 1.0m in grow-out ponds and in the ghers.

Data collection

Water quality parameters were measured every day using appropriate methods. Sampling for growth study were done fortnightly basis.

Harvesting and data analysis

After attaining marketable size shrimp were harvested by total weight were recorded. Comparison of treatment mean were carried out using one-way analysis of variance followed by testing pair-wise difference using Duncan's Multiple Range Test (Gomez and Gomez 1984) to determine differences in means ($P<0.05$).

Economic evaluation

An economic analysis was performed Production cost and gross benefit were estimated on the basis of whole sale market price of shrimp and inputs during the experimental period.

Results

The post larvae stocked at two different stocking densities in demo-pond were acclimated mostly within 2 hours but depending upon the salinity variation the time varied accordingly in farmers gher. The fortnightly growth performance by length and weight of two stocking densities of T_1 and T_2 are presented in Tables 1 and 2 respectively. During the experimental period growth trend of shrimp under both the treatments in the demo-pond were similar. But sluggish growth were noted during the whole experimental period. The final growth of T_1 and T_2 in demo-pond were recorded 25.21g and 42.79g, respectively. The weight gain, survival rate and production performance are shown in table 3 and 4 respectively. The mean value of survival rate, production, weight gain and culture period of demo-pond and local farmer's gher in T_1 and T_2 are presented in Table 3. The culture period of T_1 required 143 days whereas in T_2 took 149 days. The production of T_2 was (299.01 kg/ha) higher than T_1 (231.24 kg/ha). The mean weight gain and survival rate of both treatment were found almost similar.

Table 1. Fortnightly growth performance of *P. monodon* of T_1 during the experimental period

	Fortnight									
Pond /Gher	1	2	3	4	5	6	7	8	9	10
Demo pond	1.1	4.3	8.1	16.1	17.3	18.5	19.4	20.1	21.5	25.2
Farmers gher										
Gher 1	1.2	4.2	7.4	9.5	12.4	15.5	16.7	19.8	22.6	23.4
Gher 2	1.3	4.5	7.5	9.4	12.8	17.6	20.6	23.5	25.3	26.5
Gher 3	1.3	4.3	8.2	16.5	22.4	25.3	29.5	33.6	39.5	42.0
Gher 4	1.2	4.5	8.1	12.2	14.1	16.3	17.4	19.4	21.5	22.2
Gher 5	1.4	4.3	8.5	12.5	17.5	22.5	26.1	29.5	32.5	34.0
Mean weight	1.28	4.36	7.94	12.02	15.72	19.44	22.06	25.16	28.28	29.63

Table 2. Fortnightly growth performance of *P. monodon* of T_2

	Fortnight									
Pond /Gher	1	2	3	4	5	6	7	8	9	10
Demo pond	1.2	4.1	8.3	14.3	20.1	26.0	35.7	37.2	38.3	42.8
Farmers gher										
Gher 1	1.3	4.0	8.2	12.1	14.3	16.2	17.5	19.4	21.6	22.0
Gher 2	1.2	3.9	7.5	11.3	14.5	17.5	18.2	19.3	20.5	21.0
Gher 3	1.3	4.2	8.1	11.5	16.3	22.5	27.1	29.5	31.3	32.0
Gher 4	1.4	9.3	8.3	12.4	16.5	22.1	26.5	30.5	33.2	35.0
Gher 5	1.2	4.3	8.0	12.2	13.8	16.5	17.2	19.3	25.1	26.0
Mean weight	1.2	5.1	8.0	11.9	15.0	18.9	21.3	23.6	26.3	27.2

Table 3. Growth, survival rate and production performance of shrimp in two treatments

Treatments	Weight gain (g)	Survival rate (%)	Production (kg/ha)	Culture period (days)
T_1	28.89	40.67	231.24	143
T_2	29.88	39.33	299.01	149
±SE*	3.23	2.95	38.45	2.11

SE= Standard error of treatment mean, calculated from residual mean square in the analysis of variance.*

Water quality parameters like salinity, water depth, temperature, pH, oxygen and transparency were monitored fortnightly from each experimental pond. The recorded values of each parameters throughout the experimental period are presented in Table 4.

Table 4. Physico-chemical parameters of the water of the cultured ponds during the experimental period

Treatments	Parameters						
	Salinity (ppt.)	Depth of water (m)	Temperature (°C)		pH	O_2	Transparency (cm)
			Water	Air			
Pond / Gher	1	2	3	4	5	6	7
T_1 (Demo pond)	18-7	0.7-1.0	25-34	26-33	8.8-9.2	3.8-7.1	25-40
Farmers gher							
Gher no. 1	17-5	0.4-0.8	25-33	26-32	8.5-9.1	4.2-7.2	31-42
Gher no. 2	17-4	0.5-0.7	25-32	25-33	8.4-8.9	4.1-7.3	33-45
Gher no. 3	16-6	0.6-0.9	26-32	25-32	8.2-9.2	3.5-67	32-44
Gher no. 4	18-7	0.5-0.8	26-32	26-33	8.7-9.4	3.5-7.2	34-43
Gher no. 5	17-3	0.6-0.9	26-32	25-32	8.1-8.9	3.6-7.4	36-44
T_2 (Demo pond)	18-6	0.7-1.0	25-33	25-32	8.8-9.3	4.7-8.1	28-36
Farmers gher							

Gher no. 1	17-5	0.3-0.8	25-33	25-33	8.6-9.2	4.2-8.1	35-42
Gher no. 2	16-5	0.4-0.8	26-34	26-33	8.1-9.0	4.6-8.4	33-45
Gher no. 3	18-4	0.3-0.7	25-33	26-32	8.1-92	4.4-8.2	33-43
Gher no. 4	17-5	0.4-0.9	26-33	25-33	8.0-9.3	4.1-8.3	34-44
Gher no. 5	19-6	0.5-0.8	26-33	25-33	8.1-9.0	4.5-8.3	35-39

The comparative gross margin analysis of shrimp production between two stocking densities are presented in Table 5. The production cost of T_1 was comparatively lower (27442.00 Tk/ha) than T_2 (30442.00 Tk/ha). The major cost item during the experiment were seed and land. The seed cost in T_1 covered 43.73% of the total cost which was comparatively lower than T_2 (49.27%). The gross margin of T_1 and T_2 were 41360.20 Tk/ha and 56845.80 Tk/ha. The benefit cost ratio of T_1 and T_2 were 2.57 and 2.87, respectively.

Table 5. Gross margin analysis of shrimp production of two stocking densities at Kaligonj

Items		T_1		T_2
No. of ghers		6		6
Average gher size (ha)		2.75		2.35
Post larvae stocked/ha		20000		25000
Production (kg/ha)		231.24		299.01
Gross Benefit (Tk/ha)		**68802.20**		**87287.80**
Shrimp		64747.20		83722.80
Others weed fish		4055.00		3565.00
Input cost (Tk/ha)	Taka	%	Taka	%
Land	7500.00	27.33	7500.00	24.64
Seed (Pls)	12000.00	43.73	15000.00	49.27
Ploughing	250.00	0.91	250.00	0.82
Lime	1235.00	4.50	1235.00	4.06
Gate repair	800.00	2.92	800.00	2.63
Inorganic Fertilizer (urea and TSP)	907.00	3.31	907.00	2.98
Organic manure (cowdung)	250.00	0.91	250.00	0.82
Labour cost	4000.00	14.58	4000.00	13.14

Others	500.00	1.82	500.00	1.64
Production cost (Tk.)		**27442.00**		**30442.00**
Gross margin (Tk/ha)		41360.20		56845.80
Gross margin as % of production cost		150.72		186.74
Benefit cost ratio		2.57		2.87

Discussion

Data revealed that higher production (299.01 kg/ha) was obtained from the pond stocked with 2.5 pls/m^2 without significant variation in average survival rate, weight gain and production between two stocking densities whereas the variation were found significant for demo-pond. Similar observation also reported by Tiro *et al.* (1986) whereas the production rate obtained was 317 kg/ha/crop. The higher production with low stocking rate, support the findings of Kungvankij *et al.* (1986). The production obtained through improved traditional shrimp farming, as reported by the authors are almost similar to the present findings and which is more than two times than the traditional shrimp production rate (80-130 kg/ha/crop). For both the treatments a direct relationship between stocking density and mortality rate were observed that confirmed the findings of Chien and Ray (1990). Lower average production obtained from the ponds of T_1 is in disagreement with the findings of Chien and Ray (1990) which might be due to low water depth in that ponds resulting an eutrophication thus pave the way of huge algal bloom. And on the other hand fish excretions and other organic metabolites in bottom sediment can also resulted in the degradation of the water qualities and retarded the normal shrimp growth (Shilo and Rimon 1982).

The wide range of fluctuation of temperature from 25-34°C and transparency level from 25-44cm were affected the growth of *P. monodon* mostly in farmer's gher. The result showed that the growth rate of the shrimp was very low or stunted after 90 days of culture period. This might because of the sudden decline in salinity level up to 4 ppt.

The study demonstrates that in improved extensive method growth of *P. monodon* does not effect even in comparatively slight high stocking density if the management system is efficient. The growth performance of shrimp in this experiment was 40.67g in 143 days is comparable to that obtained from the grow-out pond which was 33-36g in 130 days (Kunguan *et al.* 1990).

The present study revealed that environmentally friendly management practice may affect profitability of the farms. In south-west part of Bangladesh the most important consequences observed for deteriorated environment are presence of opportunistic pathogens in the pond water those become active in a favorable environmental condition because of poor management during culture operation and introduction of other harmful pathogens due to intensification of culture. Low production in traditional system also involves low survival of seed because of unavailability of food materials and improper acclimatization during release to culture pond and entrance of predators with unscreened tidal water those fed in the gher. To keep at friendly environment for shrimp culture, maintenance of proper culture time is of paramount importance, because culture period of shrimp has specific nature that supports optimum production, which is a function of the prevailing physico-chemical and biological factors. Timely culture and interaction of water quality parameters that attributed to positive impact and efficient management of farming aspects were found to play a vital role in keeping the culture environment suitable. The study also indicate that greatest economic impact would be achieved by improving revenue-determining factors (shrimp density, growth rate, survival and market value) rather than intensification.

Conclusions

Considering the technical, economical and environmental aspects, the improved extension method may be considered for viable for increasing the present average production rate of Bangladesh by more than 100 percent. Study also suggest that higher rate of production through improved method of shrimp farming with low stocking rate can be achieved by efficient management of the farm.

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Effect of submerged aquatic vegetation on growth and survival of *Penaeus monodon* (Fab.)

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Abstract
An experiment was conducted in brackishwater ponds with transplanted aquatic weed (*Najas* sp.) to study the effect of submerged aquatic vegetation on culture of *Penaeus monodon*. Out of six ponds three were without any aquatic vegetation (T_1) while in other three ponds weeds were planted covering 40% of the pond bottom (T_2). Hatchery produced post larva of *P. monodon* (0.006 g) were stocked in all ponds at a density of 40,000/ha. Shrimps were fed twice daily with commercial and formulated feed prepared from locally available ingredients. After 105 days of rearing shrimp of highest average weight (63.18g) was obtained from T_2 with a survival rate of 25.90% and the total production was obtained at 654.54kg/ha. The average weight, survival and total production of shrimp in T_1 were 35.0 g, 28.76% and 405.63 kg/ha, respectively.

Key words : *P. monodon*, Aquatic weed

Introduction

The shrimp usually graze on soft parts of plants associated with small organisms such as copepods, ostracods, insects larvae, nematods and snails (Thomas 1972) and more particularly on the decaying remains of the plants on the pond bottom, however, excessive growth ruins the aquatic environment. In Asian countries, the aquatic *plants Najas gramina* and *Ruppia maritima* normally occur abundantly in lower salinities at 10 to 0 ppt (Krishna 1988). There is still a contradictory opinion among shrimp farmers in Bangladesh about the role of aquatic weeds in shrimp production. Shrimps generally favor clean soft bottom due to its burrowing habits but the presence of excessive aquatic weeds at the bottom might have a negative impact on the growth and production of shrimp. Studies on such aspect is still lacking in this country. Considering the lack of information, in the same line, the present study was undertaken to observe the effect of growth of the submerged aquatic rooted vegetation *Najas* sp. on survival and growth of *Penaeus monodon*.

Materials and methods

Six ponds, each of 0.25 ha area were selected for two treatments with three replications in the Brackishwater Station, Bangladesh Fisheries Research Institute, Khulna. After completion of pond preparation, the ponds were first flashed with 20-30cm tidal water to reduced the soil acidity. Then agricultural lime was applied at a rate of 100 kg/ha followed by the application of cow dung (500 kg/ha) and mustard oil cake (100 kg/ha). Inorganic fertilizers like Triple Super phosphate (TSP) and Urea were also applied at a rate of 35 kg/ha in 3:1 proportion. Tidal water was then added to obtain required water level at the ponds (40-60cm) and waited for natural feed development. Out of six ponds, three were without any aquatic vegetation (T_1) and other three were with wild aquatic weed- *Najas* sp. covering about 40% of the pond bottom area (T_2). After 7 days of fertilization the ponds were stocked with hatchery bred post larvae of *Penaeus monodon* (0.006 g each) with a density of 40,000/ha (Table 1). After stocking, shrimps were fed with commercially supplemented Starter-1 feed (Saudi-Bangla shrimp feed) for 30 days, twice a day at 7: 00 and 18: 00 hours at a rate of 100% body weight during first week of stocking, then reduced to 60% and 40% for the 2nd and 3rd week, respectively. In addition, boiled trash fish flesh was supplemented at the rate of 20% of body weight for 1st and 2nd week and then 10% for the next 15 days. During rest of the period, feeding was done by formulated feed prepared from local ingredients (30-32% protein content) in the second month at 5% of body weight and 3% in the rest of the days, till harvest. Water exchange of the ponds (preferably 30%) was done fortnightly during new and full moons. To maintain water productivity, ponds were treated with Urea and TSP (3 : 1) at a rate of 30 kg/ha after every exchange of water. Water quality parameters such as dissolved oxygen, pH, salinity, temperature and transparency were monitored fortnightly. Growth performance of shrimp were recorded by weekly sampling. After 105 days of rearing shrimps were harvested in mid July.

Results and discussion

Detail of the records of stocking and harvesting are shown in the Table 1. The data revealed that, survivals of shrimp were 25.90% and 28.76% in T_1 and T_2, respectively. Badapanda *et al*. (1985) obtained 30-35% of survival of *Penaeus monodon* in pond culture. A general survival rate of penaeid shrimp at 36% was mentioned by Lee and Wickins (1992) which is not in agreement with the present finding, the rates obtained in both the treatments were low. However, irrespective of survival rate, a great deal of variation in total shrimp production between the treatments were obtained, where production rate of T_1 and T_2 were recorded as 654.54 and 405.63 kg/ha, respectively, for 105 days of culture.

Table 1. Details of stocking and harvesting of *P. monodond* culture experiment

Treatments	Pond area (ha)	Stocking density (nos./ha)	Culture period (days)	Initial weight (g)	Final weight (g)	Survivl %	Production (kg/ha)
T_1	0.25	40,000	105	0.006	63.18	25.90	654.54
T_2	0.25	40,000	105	0.006	35.26	28.76	405.63

Fortnightly average values of physico-chemical parameters of pond water are presented in Table 2. During the experimental period, least variation in water temperature was recorded from both the treatments. For T_1, temperature was ranging between 29.68°C (1st April) and 32.38°C (30th April), while for T_2, these values were 29.33°C (1st April) and 32.78°C (15th May) respectively.

Table 2. Physico-chemical parameters of cultured ponds

Air temp.	T_1	30.00	31.50	33.25	32.75	31.75	31.25	31.33	31.25
(°C)	T_2	30.00	31.50	33.25	32.75	31.75	31.25	31.33	31.25
Water temp.	T_1	29.68	31.00	32.38	31.75	31.10	30.33	30.50	30.90
(°C)	T_2	29.33	31.50	32.00	32.78	30.78	30.68	30.68	31.20
Salinity	T_1	17.00	21.00	22.50	20.75	20.50	16.25	13.33	10.20
(ppt)	T_2	17.00	20.75	22.50	21.00	20.50	16.00	13.33	9.00
pH	T_1	8.22	8.28	8.08	7.50	8.08	7.93	8.40	8.00
	T_2	8.27	8.55	8.48	8.60	8.78	9.68	9.00	9.05
Transparency	T_1	34.68	31.50	36.00	26.50	30.75	32.00	29.00	28.00
(cm)	T_2	29.67	43.25	46.25	36.25	36.25	44.00	43.17	49.25
Dissolved	T_1	7.77	7.48	6.18	6.30	5.48	5.35	5.53	5.20
Oxygen (ppm)	T_2	6.98	6.20	5.43	4.98	5.45	4.90	4.82	4.90

No sudden change in salinity levels of pond water was noticed during the experimental period and the salinity prevailed mostly within 9 to 22 ppt. Highest salinity (22.5 ppt) was recorded in between May-April for the pond water of both the treatments with gradual decrease in salinity level in all the ponds due to the addition of occasional rain water, in the subsequent days.

Water pH was recorded during the period, however, the range was obtained between 7.5 to 8.4 in T_1 and between 8.2 to 9.4 in T_2 the mean values during experiment were 8.8 in T_2 and 8.06 in T_1, with a deviation between 7.5 to 9.05 which shows a slight higher in treatment T_2 with an increasing trends form mid to end of the experiment.

The average transparency for T_1 and T_2 were found at 31.05 and 41.01cm, respectively. From the values it is apparent that, transparency during experimental period was higher in T_2 than T_1 which was presumably due to the presence of *Najas* sp. that covered 40% of the pond area. In case of dissolved oxygen content the average value for T_1 and T_2 were found at 6.16 and 5.45 mg/1, respectively.

Growth performance was recorded fortnightly and shown as cumulative average values in Table 3. Growth was observed less in T_2 than T_1 from the mid of April up to the period of harvest and gained approximately 50% less body weight then treatment T_1. Comparative growth attainment due to difference in treatment showed a distinct variation between the treatments.

Table 3. Average cumulative growth of *P. monodon*

Sampling	Treatment T_1		Treatment T_2	
Period	Length (cm)	Weight (g)	Length (cm)	Weight (g)
April 1st*	1.45±0.06	0.006±0.0005	1.45±0.06	0.006±0.0005
April 15th	2.30±0.11	0.20±0.02	2.11±0.09	0.10±0.01
April 30th	6.05±0.28	4.23±0.95	4.78±0.24	2.17±0.15
May 15th	14.03±0.44	19.80±1.30	12.18±0.53	15.00±1.14
May 30th	14.74±0.29	27.52±1.36	13.21±0.28	18.93±1.43
June 15th	18.38±0.50	39.20±2.17	14.08±0.34	25.15±1.86
June 30th	19.99±0.35	51.50±1.83	15.78±0.47	32.00±2.10
July 15th	20.77±0.28	63.18±2.39	17.16±0.25	35.26±1.01

* = *Initial*

In aquatic environment plants together with the prawn and other aquatic organisms respire and consume oxygen in absence of sunlight, thereby lowering the dissolved oxygen content in the pond (Chen and Ramos 1989), on the other hand, growth of vegetation within pond reduced the efficiency of pond productivity (Lee and Wickins 1992). Generally, a clear and soft bottom is preferred by shrimp which support to produce a good crop both in terms of yield and quality (Shigeno 1969, Chen and Ramos 1989, Lee and Wickins 1992). In the present study, a clear difference in production between the treatments and the effect of physico-chemical parameters of pond water on production was observed. Some effects of aquatic weed in controlling water color (Chen 1976) was also observed. Moreover there were other problems as noted and these were interference in management of aquatic animals and polluting the pond bottoms due to accumulation of dead weeds, which greatly play a vital role in production function.

Survival data revealed that aquatic vegetation had reduced the rate of mortality in T_2 than in T_1. The rate of production in T_2 was 405.63 kg/ha with an average individual weight and survival at 35.26 g and 28.76%, respectively (Table 1). The higher average production (654.54 kg/ha) obtained from T_1 with an individual average weight at 63.18 g showed a better culture performance in T_1 than T_2. This findings proved that efficiency of pond productivity was reduced due to the presence of aquatic vegetation in T_2 which was in general agreement with the finding of Lee and Wickins (1992). Day-night maximum biological oxygen demand in the ponds of T_2 produced stressed conditions due to the presence of aquatic weeds causing hindrance in growth performance of the shrimp and showed a significant reduction in growth ($P < 0.001$) and total production of shrimp in treatment T_2.

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Effects of supplementary feeds on growth and survival of freshwater giant prawn (*Macrobrachium resenbergii* deMan)

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Abstract

Highest growth of prawn was obtained with Feed B (743kg/ha) with highest survival rate (60.88%) followed by Feed A where production and survival rate was 659 kg/ha and 53.50%, respectively. Feed A contained 30% dry ground cow viscera, 40% oil cake, 20% rice-bran and 10% wheat bran. Feed conversion ratios were found to be 7.60:1 for Feed A and 6.46:1 for Feed B, which indicated that Feed B was more efficiently utilized by the prawn than Feed A. Statistical analysis revealed that the differences in production of prawns among the treatments were highly significant ($P < 0.01$).

Key words : *Macrobrachium resenbergii*, Feed, Survival

Introduction

Macrobrachium rosenbergii, locally known as "Golda chingri" has great potential for culture in freshwater ponds, but in practice, culture of this species in the country is still in the primitive stage and the production rate is also very low. Simultaneously the natural stock of prawn is declined day by day due various environmental and man-made factors. Absence of improved culture and management practices are also responsible for such adverse situation. As little work have been done on mono-culture of "gold" in Bangladesh so more investigations are needed to develop the culture techniques of the species to increase the production. Considering the above facts the study was undertaken to find out the effects of different feeding treatments on the growth, survival and production of *M.* rosenbergii pond culture system.

Materials and methods

Nine earthen ponds each of 0.16 ha were selected for this study and marked as P-1, P-2, P-3. All the ponds were dried-up to eradicate insects, poisonous gases and undesirable fishes. Lime ($CaCO_3$) was applied at the rate of 200kg/ha and then fertilized with both organic and inorganic fertilizers. Each pond was divided into three equal compartments (area of each compartment was 0.053 ha) by bamboo fencing. Physico-chemical factors of pond water *viz.* water depth, temperature, transparency and pH were determined at fortnightly intervals, and free carbondioxide, dissolved oxygen and water hardness were recorded at bimonthly intervals.

Juveniles of *M. rosenbergii* which are available from local rivers (Dakatia and Meghna) were collected and then kept for nine days in cement cisterns, filled with pond water for acclimatization. They were finally stocked on August'95 at the rate of 15000 juveniles/ha (800 juveniles in each compartment) in all the ponds. Initial mean weight of the juveniles were 4.85g in P-1, 4.20g in P-2 and 4.00g in P-3. All the ponds were fertilized monthly with cow dung at the rate of 750 kg/ha (40 kg in each compartment), and urea at the rate of 40 kg/ha (2.1 kg in each compartment). After two months, compost fertilizer of cow dung, water hyacinth and lime at the ratio of 10:20:1 were used instead of cow-dung.

Ponds of P-1 were considered as controlled (without any supplementary feed). Feed was supplied at the rate of 5% of the body weight of prawn every day in the evening in the ponds of P-2 and P-3. Feed-A was used in P-2 and Feed-B in P-3.

Sampling of prawn was conducted once in a month the final harvest was done after 180 days of culture on February'96 by dewatering the ponds.

Results and discussion

Physico-chemical parameters

Initially same water depth was tried to maintain in all the ponds. However, the depth increased gradually and reached its peak during the month of October (261.34cm to 300.17cm) and then gradually fall down up to the minimum level (131.67cm to 167.67cm) in the month of January (Table 1). Hanson and Goodwin (1977) observed that the water depth ranging from 91 cm to 122cm is known to be beneficial for growth and survival of prawns. Transparency and pH generally increased with the increase of water level with an exception of minimum pH recorded in November. Minimum water temperature (22.37^0 to 22.94^0) was recorded in all the ponds during January and the maximum was recorded during August in the ponds of P-1 and P-2, and in October in P-3. The water transparency become higher in P-1 ponds probably due to low plankton growth and suspended particles in the pond water.

Table 1. Physico-chemical parameters of the ponds under different treatments

Months	Water depth (cm)	Temp. (^{0}C)	Trans-perancy (cm)	pH	DO (mg/l)	CO_2 (mg/l)	Hardness (mg/l)
Aug.	176.5-195.8	33.97-35.20	31.10-35.20	8.12-8.59	-	-	-
Sep.	244.7-276.8	30.88-32.00	34.10-46.34	8.00-8.38	3.47-4.42	3.88-5.42	64.46-92.58
Oct.	261.3-300.2	33.14-33.79	38.05-49.17	7.67-7.90	-	-	-
Nov.	214.3-250.3	30.32-31.82	36.20-42.17	8.88-9.37	5.56-6.78	3.05-5.21	61.71-86.23
Dec	168.7-218.8	24.22-27.05	35.20-39.43	8.54-9.10	-	-	-
Jan.	131.7-167.7	22.72-22.94	29.84-33.54	8.72-9.22	4.65-6.27	4.32-5.93	64.98-87.88

Minimum values of dissolved oxygen (3.47 to 4.42mg/1) in all the ponds were found in September, whereas maximum values for P-2 and P-3 ponds were recorded in November and for P-1 ponds in January. Water hardness showed maximum values (64.46 to 92.58 mg/1) in September for P-1 and P-2 ponds and in January for P-3 ponds. Maximum free CO_2 was recorded (4.32mg/1 and 5.93mg/l) for P-2 and P-3 ponds in January and for P-1 ponds in November and the minimum (3.05mg/1 and 3.34mg/l) for P-2 and P-3 pond during November and for P-1 ponde in September (Table 1). According to Hanson and Goodwin (1977), this species can tolerate a wide and fluctuating rang of temperature and dissolved oxygen. Swingle (1971) described pH values ranging from 7.21 to 8.84 as the desired level for pond fish culture.

Survival and mortality rate of juveniles

A total of 8,427 galda juveniles were collected of which 9.21% and 4.15% died during the period of transportation and acclimatization, respectively. The rate of survival was 87.17%.

The causes of the mortality of juveniles might be due to shortage of oxygen, physical injury caused by friction with raugh surface of the container during transportation period, higher water temperature in the cistern and secondary infection as a result of physical injury of the juveniles during the period of acclimatization.

Production and growth

The highest average weight (36. 16g) increment were found in P-3 ponds and lowest value in P-1 ponds (22.38g). Similar results were found in their daily average individual growth increment (Table 2). The daily increment of weight ranging from 0.12g to 0.20g, although these were close to observation of Arieli *et al.* (1981) and Ling (1967a) but seems secured quite low when compared with that of Arieli and Rappaport (1982) who recorded 0.29g/ day individual increment over a growing period of 120 days.

Table 2. Growth and production of *M. rosenbergii* in monoculture experiment

Ponds	Final wt. (g)	Individual increment /day (g)	Total % increment (g)	Survival (%)	FCR	Total wt. at harvest (kg)	Production (kg/ha)
P-1	27.73	0.12	463.80	53.50	-	11.70	441
P-2	37.00	0.18	781.09	58.50	7.6	17.64	659
P-3	40.25	0.20	892.64	60.88	6.7	19.69	743

During the grow out period, the survival rates of prawn in P-2 and P-3 ponds were almost similar (53.5% and 60.8%) and lowest in P-1 ponds (53.5%), but as a whole it reflected high mortality rate ranging from 39.12 to 46.50%. High mortality rate and consequent low production may be due to cannibalism, predation by birds and animals and pouching . Takata (1974) observed 18% survival rate over a culture period of 300 days with the stocking density of 18 individuals of *M .rosenbergii* per square meter. Maximum increase in weight (40.25g) was also recorded for P-3 ponds followed by P-2 (37g) and P-1 ponds (27.73g) where the rate of increment is in agreement with the findings of Khan *et al.* (1980).

Prawns of P-3 ponds showed higher feed conversion ratio (6.5:1) with the supplementary feed "B" than those of the prawns of P-2 ponds where the average feed conversion ratio was 7.6:1 with the supplementary feed "A". The results indicate that, the feed "B" is more acceptable for consumption and growth of these prawns.

In the ponds of P-3, highest rate of production (743kg/ha) was recorded, followed by a gradual decrease in P-2 (659kg/ha) and P-1 ponds (441kg/ha) which might occur due to the differences in feeding treatments of the ponds. Results also indicate that the feed type "B" enhanced the production in comparison to feed type "A" and controlled treatment.

From Table 3 it is apparent that among the total catch 27.10% 30.70% and 63.16% of prawn harvested from the ponds of P-3, P-2 and P-1, respectively. Brody *et.al.* (1980) stated that the size of prawn above 30g in weight is regarded as marketable size in many parts of the world. The results show that highest average weight gain was in the ponds of P-3 with the supplementary feed type "B". In all the ponds, a smaller no. of prawns were found within the range of 8.0 to 12.0g, most of them were infected by parasitic isopodes. However, the growth in weight per month in all the ponds increased almost in a similar fashion during the fist two months of this experiment (4.73g to 5.55g) and reached its peak ranging from 27.39g to 38.58g in the month of November. Monthly increment in growth of weight was also highest (8.78g to 7.65g) in November. The increment in growth during the month of December and January were lowest ranging from 0.36g to 1.5g, which might due to the unavailability of moulted prawn at sampling, low water temperature, variation in the physico chemical condition of water, use of insufficient feed and other environmental factors. Menon *et al.* (1972) and Islam *et al.* (1984) also observed similar trends of growth variation in *M. rosenbergii*. During the harvesting period (February) growth of prawns in all the ponds decreased because of the inclusion of all sizes of specimen together which was mostly due to the variation in individual growth rate(Ling 1967b).

However, from the above results, it is clear that in prawn monoculture system, sub optimal environmental conditions and management procedures are the main limiting factors. Although the feed type B gave the best result but the maximum yield was only 743kg/ha/yr. Whereas in Hawii 1360kg of prawns/acre/year are produced by adopting the intensive culture system. However the production level of 743kg /ha/yr in this experiment is quite satisfactory compared to our national production level of 75-100kg/ha/yr.

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Production of Thai sharpunti (*Puntius gonionotus* Bleeker) in polyculture with carps using low-cost feed

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Abstract
The effectiveness of duckweed and rice bran as a low cost supplementary feed was compared through a six months production trial of rajpunti (*Barbodes gonionotus*) with carps. Six earthen ponds of 360 m^2 each were used for the trial. Three ponds received duckweed, while the other three received rice bran as supplementary feed. Fish biomass after six months of rearing increased to an average of 2,056 kg/ha in ponds which received duck weed and 2,056 kg/ha in rice bran treated ponds. The net profit with duckweed and rice bran worked out to Tk. 69,752 and Tk. 73,480 kg/ha, respectively. This study revealed that duckweed is a low cost supplementary feed, particularly for farmers with limited income.

Key words : *P. gonionotus*, Silver carp, Common carp, Polyculture, Duck weed

Introduction

Rajpunti, *Puntius gonionotus*, was introduced into Bangladesh from Thailand in 1977. The species has high potentiality for culture in seasonal ponds, ditches and road-side canals where the major carps do not perform well. It is a herbivore, feeding mainly on aquatic plants, grasses and algae (Phaohorm 1970 and Srisuwantach 1981). Hussain *et al.* (1989) studied the production potential of this species in earthen ponds, while Kohinoor *et al.* (1993) reported on optimizing its production by using a mixture of rice bran (60%) and mustard oil cake (40%) as supplementary feed. The species is suitable for low input culture system in small seasonal ponds and ditches because of its quick growth. This investigation was undertaken to evaluate the efficacy of duck-weeds (*Lemna* spp.) as a low cost supplementary feed.

Materials and methods

The experiment was carried out from October'93 through March'94 in six ponds of 360 m^2 each, with an average water depth of 90 cm. Fingerlings of rajpunti (*Barbodes gonionotus*), silver carp (*Hypophthalmichthys molitrix*) and mirror carp (*Cyprinus carpio* var *specularis*) were uniformly stocked in ponds at a stocking density of 20,000, 1,000 and 1,000/ha, respectively. Duckweed was given as supplementary feed in three ponds (T-1) while rice bran was used in the second treatment (T-II). In both the treatments, fertilization was done with cow dung at fortnightly intervals at a rate of 1,000 kg/ha.

The ponds were prepared by draining and application of lime to the pond bottom at the rate of 250 kg/ha. Three days after the application of lime, ponds were filled with ground water and fertilized with cattle manure at the rate of 750 kg/ha. Five days after the application of cattle manure, inorganic fertilizers- urea and TSP were applied 8 and 17 kg/ha, respectively. Five days after the application of fertilizers, fish were stocked in all the ponds. Feeding began immediately after stocking. Rice bran and duckweed were fed at 4-6 and 8-10 % of body weight of fish biomass, respectively. Ten percent of the stock was sampled fortnightly, to estimate the growth and standing crop, based on which feeding was adjusted.

The important physico-chemical parameters of water *viz.*, temperature (°C), secchi disc transparency (cm), pH and dissolved oxygen (mg/L) were analyzed every seven days, following standard methods (APHA 1989). The samples of water were collected between 09.00 to 10.00 AM. Plankton samples were collected fortnightly from each of the experimental ponds. Ten liters of water, collected from different locations and depths of each pond, were passed through a plankton net of 25μm mesh size. Filtered samples were transferred into a measuring cylinder and carefully made up to a standard volume of 50 ml. Plankton samples were then preserved in 5% formalin in small plastic vials for subsequent studies. One ml sub-sample was examined under a binocular microscope using a Sedgewick-rafter cell (S-R cell). Plankton cells in 10 randomly chosen squares were counted and used for quantitative estimation using the following formula (Stirling 1985):

$$N = \frac{A \times 100 \times C}{V \times F \times L}$$

Where, N= No. of plankton cells, A = Total no. of plankton counted, C = Volume of final concentrate of the sample in ml, V = Volume of a field in cubic mm, F = Number of fields counted and L = Volume of original water in litre

After six months of rearing, the fish were harvested by dewatering the ponds. During harvest, they were counted and individually weighed to assess survival, growth and production. Statistical analysis of all the data was performed using the Student's t-test (Zaman1982). One way analysis of variance (ANOVA) was applied whenever necessary, following Sokal and Rohlf (1991).

Results and discussion

The physico-chemical properties of water in the experimental ponds were: water temperature 17-32°C, Secchi disc transparency 16-50 cm, pH 7.1-8.9 and dissolved oxygen 2.0-7.4 mg/L (Table 1). ANOVA of the mean values of each water quality parameter did not show any significant difference between the two treatments.

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

Parameter	October	November	December	January	February	March
Water temperature(°C) 0	23-32	25-27	17-23	15-23	15.5-27.0	20.5-28.0
Secchi disc transparency (cm)	24-40	22-32	18-50	16-24	20-30	18-30
Dissolved oxygen (mg/L)	2.5-5.9	2.7-5.0	2.0-6.0	2.0-6.3	2.0-5.6	2.4-7.4
pH	7.31-8.4	7.6-8.5	7.4-8.9	7.1-8.0	7.5-8.7	7.46-8.71

The temperature recorded in this experiment was found to be comparatively low for the optimum growth of carp as the experiment was conducted during the winter months. Dewan *et al.*(1991) reported a temperature range from 30.2 to 34.0°C (June-August) while Wahab *et al.* (1996) recorded a temperature range 28.5 to 31.3°C (August-November) in their experiment with carps. pH is one of the most important factors in pond fish culture system. Swingle (1967) considered a pH of 6.5 to 9.0 as satisfactory for fish culture. Ali *et al.* (1982) observed a pH range of 7.5 to 9.5 in a freshwater pond at the BAU campus. In this experiment, pH ranged from 7.1 to 8.9 which indicates that the ponds were conducive for fish culture. Transparency of ponds was high in January and low in December. The higher values of transperancy were probably due to decreased concentration of plankton. Mollah and Haque (1978) recorded a transparency of 91.5- 127cm in ponds of Bangladesh Agricultural university Campus. Boyd (1982) suggested a transparency between 15 to 45 cm to be good for fish culture. Kohinoor *et al.* (1998) recorded higher values in August-September due to higher rainfall. The level of dissolved oxygen (DO) was within the acceptable range in all the experimental ponds. Generally oxygen content was higher in winter and lower in summer, probably because of the inverse relationship between dissolved oxygen content and temperature. Boyd (1982) stated that dissolved oxygen content of 5 to 7 ppm is good for pond fish culture.

The group-wise mean abundance of plankton observed in two treatments is shown in Table 2. Phytoplanktonic population mainly comprised of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. In T-I, the mean value of phytoplankton was 24.46±5.79 cells/L, while in T-II, the abundance was marginally higher at 26.29±7.64 cells/L. Chlorophyceae was the dominant phytoplanktonic group in terms of number in both treatments throughout the experiment. Euglenophyceae abundance was the lowest in the two treatments. There was no significant variation between treatments with regard to phytoplankton population.

Table 2. Mean (±sd) plankton numbers ($x10^3/L_{water}$) recorded in the two treatments

Treatment	T-I	T-II	Significance level
Phytoplankton			
• Bacillariophyceae	4.71±2.02	4.20±2.76	NS
• Chlorophyceae	10.11±4.61	11.91±6.24	NS
• Cyanophyceae	6.64±3.12	6.39±2.98	NS
• Euglenophyceae	3.0±1.96	3.79±1.59	NS
Total	24.46±5.79	26.29±7.64	NS

Zooplankton	2.10±1.19	2.0±1.09	NS
• Crustacea			
• Rotifera	3.41±2.20	3.05±1.95	NS
Total	5.51±1.67	5.05±1.99	NS

• *NS= Not Significant at 5% level*

The zooplankton population was represented by only two groups *viz.*, Crustacea and Rotifera. The mean values of zooplankton in T-I and II were 5.51±1.67 and 5.05±1.91 unit/L, respectively and the difference was not significant (P>0.05). Rotifera was the dominant group in terms of abundance in both the treatments.

Phytoplankton population showed an inverse relationship with zooplankton population. Similar results were also recorded by Islam and Saha (1975). Wahab and Ahmed (1991) estimated mean phytoplankton population of 17.72 x 10^4 /L, 9.36x 10^4/L and 13.87 x 10^4 /L from three sets of ponds, respectively. In another study, Wahab *et al.* (1994) recorded phytoplankton numbers ranging from 2.0 x 10^5 to 8x 10^5 cell/L and zooplankton between 2.0x 10^4/L to 2x 10^5 unit/L in three ponds. Haque *et al.*(1998) observed phytoplankton and zooplankton abundance of 3.78±0.15 to 50.64±1.29 cells/L and 4.91±0.8 to 6.16±0.8, respectively in their study. Compared to these observations, the plankton abundance was lower in the present study and this might be due to the lower quantity (about 50%) of fertilizers used.

The month-wise growth performance of rajpunti, silver carp and mirror carp is shown in Figure 1. Throughout the study period, fish fed with rice bran showed higher growth than those receiving duck weed.

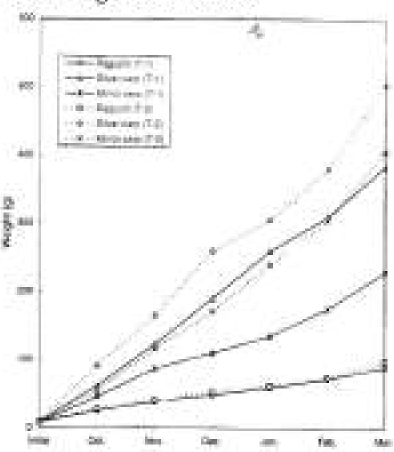

Fig.1. Monthly growth (g) of fishes under two treatments.

Details of stocking density, initial weight (g), harvesting weight, specific growth rate (SGR), survival rate and total production are shown in Table 3. Rajpunti reached an average final weight 89.0±12.25 and 98.0±14.63 in T-I and II, respectively. There was no significant difference (P>0.05) between the two treatments.

Table 3. Stocking density, gross production, specific growth rate (SGR), survival and FCR of rajpunti and other carps using duckweed and rice bran

Treat-ments	Species	Stocking density (k/ha)	Av. initial Wt.(g)	Av. Final Wt. (g)	SGR (%)	Production (kg/ha) Species wise	Total	Survival (%) Species wise	Total	AFCR
T-I	Rajpunti	20,000	8.03±3.45	89.0±12.25	1.33	1,575.89		88.53	80.94	10.09
(Duck- weed)	Silver carp	1000	8.54±2.46	384±18.67	2.11	3,14.26	2,056.08	81.83		
	Mirror carp	1000	7.07±3.42	229±24.69	1.93	165.93		72.46		
T-II	Rajpunti	20,000	8.5±3.69	98.0±14.63	1.35	1,807.69		92.23	86.22	5.2
(Rice bran)	Silver carp	1000	8.21±2.15	503±20.95*	2.34	427.55	2,565.87	85.00		
	Mirror carp	1000	6.83±3.65	406±30.25*	2.27	330.63		81.44		

Significant at 5% level

On harvest silver carp weighed 384.00±18.67 in T-I and 503.00±20.95g in T-II. The specific growth rate was higher in T-II (2.34%). Significant difference ($P<0.05$) in its harvesting weight between the two treatments was observed. Mirror carp grew to an average weight of 229.00±24.69 and 406.00±30.25g in T-I and II, respectively. The specific growth rate was also higher in T-II (2.27%). The harvesting weight of mirror carp also showed significant difference ($P<0.05$).

The mean survival rate of the different species in the two treatments varied between 82-86% in the present study which was higher than the survival rate reported by Wahab *et al.* (1991) for Indian major carps in polyculture, where supplementary feed was given. Lakshmanan *et al.*(1971) observed a carp survival rate of 80% in polyculture, where ponds were fertilized with both organic and inorganic fertilizers and fishes were fed with a mixture of rice bran and mustard oil cake. In another study, Kohinoor *et al.*(1993) obtained a survival rate of 86 to 94% in the monoculture of Thai sharpunti. Wahab *et al.*(1995) found that the survival of fish including sharpunti was higher than 80% in polyculture of native carps. Haque *et al.* (1998) recorded 88.89 to 93.93% survival of rohu, catla and mirror carp in their experiment.

The gross production from ponds provided with duckweed (T-I) was 1,923 to 2,128 kg/ha, with an average of 2,056 kg/ha/6 months. In the case of ponds fed with rice bran (T-II), gross production ranged from 2,407 to 2,655 kg/ha with an average of 2,565 kg/ha/6 months. Gross production from rice bran fed ponds was significantly higher ($P<0.05$) than those provided with duckweed.

The cost of production and return from culture of rajpunti with silver carp and mirror carp are presented in Table 4. While estimating the cost of production, variable costs of only lime, feed, fertilizer and fingerlings were taken into consideration. Cost of production amounted to Tk.16,397.60/ha and Tk. 32,263.79/ha in T-I and T-II, respectively, it being higher in T-II due to the higher cost of rice bran. The gross revenue in T-I amounted to Tk. 86,150.40/ha, leaving a net benefit of Tk. 69,752.80, while gross revenue from T-II, amounted to Tk. 1,05,744.60, with a net benefit of Tk. 73,480.81/ha, showing a higher profit per hectare from ponds fed with rice bran. Economic analysis indicates that an additional cost of Tk.15,866.19 is required for getting the additional net benefit of Tk. 3,728.01 using rice bran which works out to a return of 23.6% on investment, but would be difficult for a small farmer.

Table 4. Cost and benefits per hectare from culture of rajpunti with carps using duckweed (T-I) and rice bran (T-II) as supplementary feed

Inputs	T-I		T-II	
	Quantity (kg)	Cost (Tk.)	Quantity (kg)	Cost (Tk.)
A. Cost				
- Lime	250	750.00	250	750.00
- Cattle manure	11,000	4400.00	11,000	4,400.00
- Fingerlings	22000 nos.	7100.00	22,000 nos.	7,100.00
- Rice bran	-	-	13,342.52	20,013.79
- Duckweed	20,738	4147.60	-	-
		16,397.60		32,263.79
B. Benefits				
- Rajpunti (Tk.45.00/kg)	1,575.89	70,915.05	1,807.69	81,346.05
- Silver carp (Tk.30.00/kg)	314.26	9,427.80	427.55	12,826.50
- Mirror carp (Tk.35.00/kg)	165.93	5807.55	380.63	11,572.05
Gross benefit		86,150.40		1,05744.60
Net benefit (B-A)		69,752.80		73,480.81

Baily and Bhuiyan (1982) obtained high production of fish using supplementary feed along with inorganic and organic fertilization. Davis *et al.* (1983) harvested yields of carps ranging from 1,890 to 3,820 kg/ha/yr., while Ameen *et al.*(1983) obtained 3,100 kg/ha/yr from carps ponds. Hussain *et al.* (1989) reported a rajpunti production of 1,952 kg/ha/5 months in monoculture with rice bran feeding. Kohinoor *et al.* (1993) obtained an yield of 2,384 kg/ha/6 months when rajpunti was fed on rice bran and mustard oil cake and the ponds were also fertilized with organic and inorganic fertilizers. In trials with farmers' participation, Gupta (1991) reported an yield of 1.6 tons/ha/6 months when rajpunti was fed on rice bran.

The present study indicates that the use of duckweed in lieu of rice bran as a supplementary feed can give economically satisfactory results, though the net benefit and production per hectare are lower with duckweed. However, it appears to be a viable alternative to rice bran as a supplementary feed for polyculture of rajpunti and carps particularly for farmers who do not have easy access to rice bran.

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Effects of artificial feeds on production of fishes in polyculture

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Abstract

A study on the effects of artificial feeds on the growth and production of fishes in polyculture in 6 ponds along with some limnological conditions was conducted. Species of Indian and Chinese major carps (*Labeo rohita, Catla catla, Cirrhinus mrigala, Hypophthalmicthys molitrix*) and catfishes (*Clarias batrachus, Clarias gariepinus*) were stocked in 6 ponds. Stocking rate in both cases were 32044 fingerlings per hectare. Ratio of species of Rui : Catla : Mrigal : Silver carp : African Magur : Local Magur = 25% : 25% : 5% : 25% : 14% : 6%. Fertilization and artificial feeds were given in 3 ponds (treatment I) and only fertilization was done in other 3 ponds (treatment II). Average yield/ha/yr was 7.903 m.ton in case of fertilization and artificial feeding application and 3.374 m.ton in case of only fertilization application.

Urea, TSP and cowdung were applied fortnightly at the rates of 400 kg/ha/yr, 2000 kg/ha/yr and 4000 kg/ha/yr respectively. Wheat bran, rice bran and mustard oil cake were given daily as an artificial feed in treatment I. Whereas treatment II was conducted without any artificial feed. Ratio of artificial feed was wheat bran : rice bran : oil cake = 2 : 2 : 1 (by wt). Absence of artificial feed in 3 ponds under treatment II seriously affected the growth and production of fish.

Key words : Artificial feeds, Fertilization, Water quality, Polyculture

Introduction

Fertilization is one of the most important techniques to increase the fish production. Through fertilization natural food of fish i.e. plankton is increased. On the otherhand artificial feed application is the another most important technique to increase the fish production. Plankton constitutes the foundation of food chain in aquatic ecosystem. Inorganic fertilizers increase mainly the phytoplanktonic population of pond water. Organic fertilizers increase mainly zooplankton. The greater is the plankton biomass, the larger is the standing crop.

The composition of supplementary diets should be simpler and less expensive. In order to be economically beneficial the efficiency of supplementary diets must be as high as possible. This depends to a large extent on the level of feeding and the composition of the diet (Hepher and Pruginin 1981).

In view of the above facts the author felt necessary to study the effects of fertilization and feeds on composite fish culture and fish production along with limnological conditions in 6 experimental ponds with the following objectives: (i) To study the effects of artificial feeds on the growth and production of fishes in polyculture system. (ii) To study the limnological conditions of the experimental ponds under two treatments.

Materials and methods

The study was conducted for a period of 3.5 months from August to November'92 in six ponds at the campus of Bangladesh Agricultural University, Mymensingh. All the ponds were rectangular in size having an area of 0.004 hectare. All the ponds were situated side by side in the same area.

Study of limnological conditions

Water quality parameters were determined following standard methods (APHA 1971) and data of rainfall and sunshine were collected from Bangladesh Agricultural University Weather Yard. Plankton was studied according to Rahman (1992), Prescott (1962), Needham and Needham (1962) and Pennak (1953).

Supplementary feeds

Three ingredients such as wheat bran, rice bran and mustard oil cake were applied as supplementary fish feed once daily in the morning between 0800 and 0900 h. The required amount of feed was mixed with a little amount of water to make it into a thick `dough' rolled into balls. The balls were then thrown into the ponds.

Feed was supplied everyday at the rate of 5% of the total fish biomass. Fish sampling was carried out at an interval of 15 days in order to calculate the increase in total wt. and to adjust the amount of feed.

Experimental design

The experiment was done according to the following experimental design.

Treatments	Description of the treatment	Ponds
Treatment I	Aritificial feeding (wheat bran: rice bran: mustard oil cake = 2:2:1 by wt.) and fertilization (cowdung, 4000 kg/ha/yr; urea, 400 kg/ha/yr; and T.S.P., 2000 kg/ha/yr.	1, 2, & 3
Treatment II (control)	Only fertilization (cowdung, 4000 kg/ha/yr; urea, 400 kg/ha/ T.S.P., 2000 kg/ha/yr.	4, 5, & 6

Results and discussion

The results of the experiment regarding the physico-chemical and biological parameters such as water temperature, air temperature, transparency, rainfall, sunshine, dissolved oxygen, free CO_2, pH, total alkalinity, PO_4-P, NO_3-N, plankton, and productions of fishes have been presented in Tables 1 and 2 and have been discussed below.

Table 1. Fortnightly limnological conditions of the ponds under two treatments

Factors	Treatment I (± s.d.)	Treatment II (± s.d.)
Air temperature (^{o}C)	29.96	29.96
Water temperature (^{o}C)	28.93 ± 2.53	29.06 ± 2.64
Transparency (cm)	24.53 ± 6.93	33.25 ± 5.98
Rainfall (mm)	0.86 ± 0.50	0.86 ± 0.50
Sunshine period (hrs)	6.74 ± 2.13	6.74 ± 2.13
Dissolved O_2 (mg/L)	4.14 ± 1.58	4.10 ± 1.36
Free CO_2 (mg/L)	6.13 ± 0.89	5.88 ± 0.55
PH	6.95 ± 0.23	6.71 ± 0.18
Total alkalinity (mg/L)	139.88 ± 30.80	97.88 ± 13.09
PO_4-P (mg/L)	0.48 ± 0.68	0.63 ± 0.96
NO_3-N (mg/L)	2.11 ± 0.39	2.03 ± 0.57
Phytoplankton density ($X10^3$ cells/L)	18620.71±3416.99	13931.00±2135.43
Zooplankton density ($X10^3$ cells/L)	2672.14±491.29	2157.86 ± 804.73

Table 2. Estimated yield of fish of the ponds under different treatments

Treatments	Pond no.	Yield of fish ton/ha/yr	Average yield ton/ha/yr	Percent increment of yield of treatment I over treatment II
Treatment I (Fertilization + artificial feeding)	1	8.997	7.903	234.23%
	2	7.593		
	3	7.120		
Treatment II (Only fertilization)	4	3.274	3.374	
	5	3.387		
	6	3.460		

Limnological conditions

Temperature(^{o}C) **:** During the period of investigation fortnightly average air and water temperature ranged from 24.7 to 32.2^{o}C and 23.2 to 31.3^{o}C and the mean values were 29.94 ± 2.34^{o}C and 28.93 ± 2.53^{o}C respectively.

Transparency (cm) : Fortnightly average transparency ranged from lowest 13.1 cm in the month of November to highest 40 cm in the month of September. The high values of water transparency in September were probably due to increased volume of water and decreased concentration of plankton. Saha and Sinha (1969) recorded the highest values of transparency in August and September during increased rainfall.

Rainfall (mm) : During the period of investigation rainfall ranged from 0 to 1.32 cm. The highest rainfall was recorded in the month of September which was 1.32 cm and the lowest rainfall was recorded in the months of October, November which was 0.00 cm.

Sunshine period (hrs) : During the period of investigation sunshine period varied from 3.25 to 9.0 hrs. Period of sunshine was highest (9.0 hrs) in the month of October and it was lowest (3.25 hrs) in the month of August.

Dissolved oxygen (mg/L): The dissolved oxygen showed fortnightly variations in all the ponds during the study period. Its concentrations varied from 1.9 to 6.8 mg/L in the ponds under treatment-I & 2.4 to 6.5 mg/L in the ponds under treatment II.

The high values of dissolved oxygen content were found in November and low in August. The highest value of dissolved oxygen was probably due to low temperature. The low values of dissolved oxygen was due to greater consumption of oxygen by organic matter and suspended substances and also due to reduced photosynthetic activity of phytoplankton as the weather was cloudy.

Free carbondioxide (mg/L) : The free carbondioxide content of the ponds under different treatments were not hazardous to fishes. Mean values under treatments I & II were 6.13 ± 0.89 and 5.88 ± 0.55 respectively. At very lower values or even at 0 mg/L of free CO_2 the photosynthetic activities of phytoplankton occur normally. High concentrations of free CO_2 toxic to fish are usually accompanied by low values of dissolved oxygen. In general, free CO_2 in excess of 20 mg/L may be regarded as harmful to fishes, although lower values may be equally harmful in waters of low oxygen content (less than 3 to 5 mg/L) (Lagler 1972).

pH : Fortnightly average pH values as recorded were in alkaline range in all the ponds which indicate suitability for fish culture.

Total alkalinity (mg/L): The average mean values were 139.88 ± 30.80 mg/L under treatment I and 97.88 ± 13.09 mg/L under treatment II. According to Mairs (1966) water bodies having total alkalinity 40 mg/L or more are considered more productive than waterbodies of lower alkalinity. According to Boyd (1982) total alkalinity should be more than 20 mg/L in fertilized ponds.

Phosphate-phosphorus (mg/L): The ranges of phosphate-phosphorus were 0.13 to 2.12 mg/L under treatment I and 0.11 to 2.93 mg/L under treatment II. The values of phosphate-phosphorus were more of less same in the months of August, October and November but were higher in all the ponds during the month of September. Rain might had increased the amount of PO_4-P in September. High values of PO_4-P in September were due to low concentration of phytoplankton as maximum of the days were cloudy, so consumption rate of PO_4-P was also low. Moyle (1946) from a study of a large number of lakes and ponds, gave the phosphorus fertility scale as 0.00-0.02 mg/L (low), 0.02-0.05 mg/L (fair), 0.05-0.10 mg/L (good), 0.10-0.20 mg/L (very good), and above 0.20 mg/L (excessive).

Nitrate-nitrogen (mg/L): The ranges of NO_3-N were 1.63 to 2.61 mg/L under treatment I and 1.23 to 3.13 mg/L under treatment II. The cause of the higher values of phosphate-phosphorus and nitrate-nitrogen might be due to regular fertilization done in the ponds.

Plankton

Plankton is the basic food of all the organisms living in the water. Directly or indirectly fishes and other aquatic organisms depend on plankton. Fertilization is the cheapest and simplest means for increasing aquatic productivity. Fortnightly variations of phytoplankton and zooplankton have been shown in Fig. 1. The plankton population showed an increase with the fertilizer application in all the ponds. The fluctuations in abundance of both phytoplankton and zooplankton were not similar in the ponds under treatments I and II.

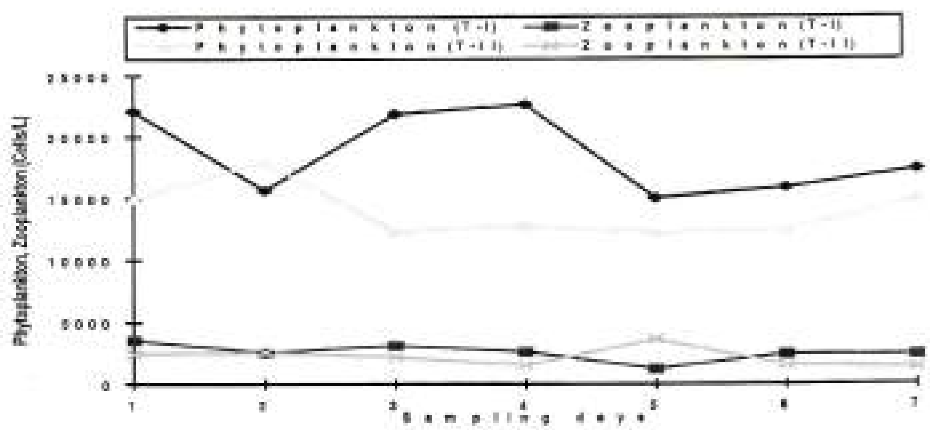

Fig. 1. Fortnightly variations of density of phytoplankton and zooplankton of the ponds under treatments I & II.

Fish production

Production of fishes has been shown in Fig. 2 where all the species showed the higher yields in treatment-I which was probably due to supplementary feed application. Similar results were found by Lakshmanan *et al.* (1971) and Murty *et al.* (1978). Partially similar results were found by Hossain *et al.* (1997) who got best growth performance of mirror carp, tilapia and Thai sharpunti in treatment III which received both fertilization and artificial feeding. The production of fish of different ponds under two treatments have been presented in Table 2. It is seen from the table that average yield of all species of fish was 7.903 ton/ha/yr under treatment I when the average yield of fish was 3.374 ton/ha/yr under treatment II. The percent increment of fish yield under treatment I over treatment II was 234.23%, that is artificial feeding increased fish yield more than double. In pond nos. 4, 5 & 6, (treatment II) total yields were not satisfactory due to the absence of artificial feed. Kuronuma (1968) conducted an experiment for 5 months by stocking 1.41 metric tons of carp fingerlings in 6 net cages of which 3 were 181 m^2 and the rest 29 m^2 and 9.4 tons of fish were harvested by supplying 13.1 tons of feed and the net production was 29 kg/m^2.

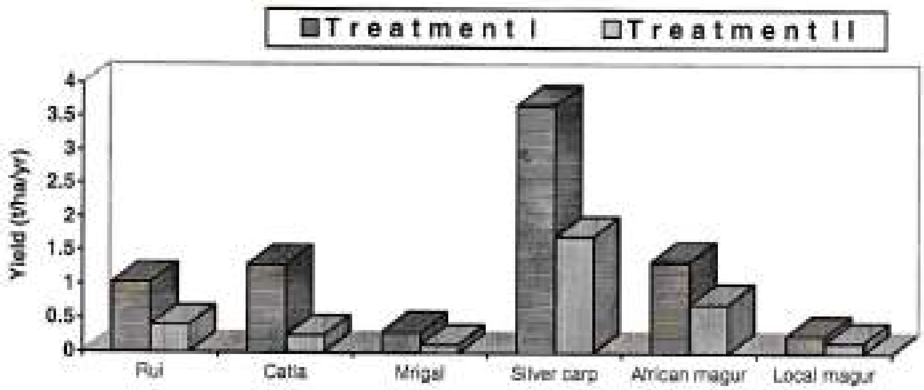

Fig. 2. Species-wise estimated yield (t/ha/yr) under treatments I and II.

Faluroti and Omorinkoba (1987) found maximum estimated yield of fish about 1.5 ton/ha/75 days in a pond, which is similar to that of the present experiment; in an experiment entitled 'Performance of fertilization and supplementary feeding on fish production under a polyculture system in warm water fish ponds' in Nigeria.

Ahmed and Sheri (1994) found in an experiment of culture of *Channa marulius* that best growth was in the group where organic and inorganic fertilizers, artificial feed and Tilapia as forage fish were supplied followed by next best growth in the group where fertilizers and artificial feed were added.

Ghosh *et al.* (1984) conducted an experiment entitled 'Effects of feeding rates on production of common carp and water quality in paddy-cum-fish culture' in which the fish were fed on a mixture of rice bran and mustard oilmeal (1:1) at the rates of 2, 4, and 6% of total body weight and found that the growth of individual fish and fish yield increased with the increasing feeding rates.

Conclusions

Average yield was 7.903 M.ton/ha/yr in case of fertilization and artificial feeds application and 3.374 M.ton/ha/yr in case of only fertilization. Absence of artificial feed in 3 ponds under treatment II seriously affected the growth and production of fish. The fish yield under treatment I (fertilization + artificial feeding) was 234.23% higher than that under treatment II. Finally it can be concluded that in fish culture artificial feeding should be done along with fertilization because artificial feeding increases fish production very significantly.

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Effect of stockig density on the growth of Thai pangas, *Pangasius sutchi* (Fowler) in net cage fed on formulated diet

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Abstract
A three month long experiment was conducted to observe the effect of stocking density on the growth of *Pangasius sutchi* in net cages. The size of each cage was 1m^3. The three stocking density used were 40, 50 and 60 fishes/m^3 and designated as treatment T_1, T_2 and T_3 respectively. Each treatment had three replicates. All the fishes were of same age group having mean length and weight of 7.13 ± 1.37 cm and 2.46 ± 0.12 g. respectively. The fish in all the net cages were fed a diet containing 34% protein The result of the study showed that fish in the treatment T_1 stocked at the rate of 40 fish / m^3 resulted the best individual weight gain followed by T_2 and T_3 respectively. The specific growth rate (SGR) ranged between 3.51 and 3.09, the food conversion ratio (FCR) values ranged between 1.73 and 2.04 with treatment T_1resulting the lowest FCR. The protein efficiency ratio (PER) values were 1.69, 1.16 and 1.43 for treatment T_1, T_2, and T_3 respectively. There was no significant ($P> 0.05$) variation among the survival rates of fish which ranged between 92 and 95%. The net production in different treatments were 2189, 2343, and 2283g for treatment T_1, $T_2$and T_3 respectively. The result of the present study indicated that the best individual growth of *P. sutchi* was obtained at a density of 40 fish/ m^3 but the highest total production was obtained at a stocking density of 50 fish / m^3 in net cages.

Key words : *P. sutchi*, Cage, Stocking density, Formulated diet

Introduction

Culture of fish in cages is a comparatively new method of aquaculture which has gained much popularity throughout the world due to a number of advantages over the conventional methods of fish farming. Fish cage culture has been defined as the rearing of fish stocks, generally from juvenile to marketable size, in a totally enclosed aquatic environment. In this system of culture fishes are confined in wire meshes, net cage or bamboo splits-made cage which are supported or suspended in open and closed water bodies. Fish in cage are easy to manage, advantageous to rear quality and selective fishes, easy to harvest (Dham 1975). It is easy to eliminate predation and competition, and easier to treat diseases and parasites. It also provides for closer observation of feeding and other behavior of fishes. Fishes could be stocked at a much higher density in cages when compared to other forms of fish culture (Coche

1976). For cage culture or any other intensive culture system, selection of species is also important since all species are not suitable for all culture system. *Pangasius. sutchi* is a suitable fish for cage culture or any other intensive culture system. (Tavarutmanegul *et al.* 1979). Stocking density is an important factor for the production of all fishes as well as *P. sutchi* in cages. There are a number of literature on the culture of fish in cages with different commercial fish species conducted in different parts of the world. Even in Bangladesh some information is available on the culture of carps and other catfishes, but no information is available on the optimum stocking density on the culture of *P. sutchi* in cages. Therefore the present study was undertaken to determine the optimum stocking density of *P. sutchi* in cages fed on formulated diet.

Materials and methods

The experimental cages were set in a brood stock pond of size 0.4 acre at the northern side of the Fisheries Faculty Building, Bangladesh Agricultural University, Mymensingh. The experiment was conducted for three months from 24th August to 24th November'97.

The cages were square shaped made of iron framework and were covered by high density polyethylene (HDPE) net. The size of each cage was 1m x 1m x 1m. The mesh size of the net was 1cm, so that the experimental fish fry could not escape. Iron rods were welded to construct a square shape frame and nets were attached to the rod with the help of nylon twine. One edge of upper side of each cage was kept open which was tied with nylon threads in such a way that it could be opened to deliver feed in the feeding plate.

The cages were installed from several bamboo bars. The frame was fixed with bamboo poles inserted into the pond bottom. The cages were tied fixed with the frame by nylon ropes at the time of suspension, about 1 feet of the upper portion of the cages were always kept above the water level. Care was taken so that the cages did not touch the bottom of the pond. The cages were placed about 10 feet away from the pond bank. A flat form made of bamboo stick/plates installed along side the cages were used for easy feed supply and observation of the cages. For easy management and identification, the cages were numbered as 1 to 9 and were divided into three treatment e.g. T_1, T_2 and T_3 each having three cages.

In each cage, a feeding plate was hung from the four upper corners of the cage with the help of nylon rope. It was placed in such a way that it could be taken out easily for giving food and cleaning regularly. The feeding plates were of earthen plate. They were of about 23 cm in diameter and 6 cm in depth.

The fingerlings of *P. sutchi* locally called "Thai pangas" were collected from local fish traders. All the fish were of same age group having mean length and weight of 7.13 ± 1.37 cm and 2.46 ± 0.12g respectively. The fish were stout and naturally moving . Before the start of the experiment the fingerlings were acclimatized to the new environment in floating cages for seven days . Then the fish were stocked in experimental cages at a density of 40, 50, 60. fish/cage for treatment T_1, T_2 and T_3 respectively.

To prepare the feed for feeding the experimental fish, sesame meal, fish meal, mustard oil cake, rice bran, wheat bran, wheat flour and were ground thoroughly and sieved to pass through 0.5 mm mesh size. Before formulation of diets, all ingredients were analyzed for their proximate composition. The result of proximate composition analysis is shown in (Table. 1). An experimental diet was formulated to contain 35% protein. All the ingredients well mixed together according to the formula (Table 2) and then put in to the pellet machine for the preparation of pelleted feed of size 1mm. The feeds were supplied twice daily once in the morning (at 9: 00 am) and in the evening (at 4: PM) at a rate of 10% of the body weight during the 1st month and then the feeding rate was reduced 8 and 6% for the 2nd and 3rd month respectively. For the 1st 15 days the feeds were supplied in dough form and rest of the study period pelleted feeds were used. Fortnightly sampling was done to adjust the feeding rate by measuring the weight of fish and observed the health condition of fish.

Table1. Proximate composition (% dry matter basis) of different feed ingredient

Ingredients	Dry matter	Protein	Lipid	Ash	Fibre	NFE[1]
Fish meal	90.30	59.07	17.98	15.70	1.17	6.08
Sesame meal	91.35	33.29	8.35	14.87	24.02	19.47
Mustard oil cake	92.97	36.51	11.29	9.19	11.63	31.46
Rice bran	89.97	12.62	16.52	13.62	16.34	40.91
Wheat bran	88.50	18.21	4.40	4.77	14.01	58.61
wheat flour	87.12	15.12	7.20	5.77	15.31	56.60

[1]*Nitrogen free extract calculated as 100-% (moister + protein + lipid + crude fibre + ash)*

Table 2. Formulation and price of experimental diet

Ingredients	% Inclusion	Quantity (g/kg)	Price of ingredients (Tk/kg)	Price of feed (Tk)
Fish meal	30	300	29.00	8.70
Sesame meal	18	180	7.00	1.26
Mustard oil cake	2	20	6.00	0.72
Rice bran	25	250	4.50	1.125
Wheat bran	10	100	6.00	0.60
Wheat flour	5	50	10.00	0.50
Total	100	1000		12.90/kg

Proximate composition of the dietary ingredients, feed and fish were determined in triplicate according to (AOAC 1980). and the results are shown in Table 3.

Table 3. Analyzed proximate composition of the experimental diet (% dry matter basis)

Composition	Percentage (%)
Dry matter	92.18
Protein	34.11
Lipid	8.74
Ash	18.74
Crude fibre	14.03
NFE[1]	24.35

[1]*Nitrogen free extract calculated as 100-% (moister + protein + lipid + crude fibre + ash)*

One way analysis of variance (ANOVA) followed by Duncan;s multiple range test (DMRT) was done to determine the significance of variation among the treatment means. Standard error (SE) of treatment means were calculated from the residual mean square in the analysis of variance.

Results

Growth performance of *P. sutchi* in terms of initial weight, final weight, weight gain, %weight gain, specific growth rate (%day), food conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein utilization (ANPU), survival rate, production(g/m^2), cost of production and net production are shown in (Table 4). The initial average weight 2.46 g reached a final weight of 58.09, 52.04 and 40.04g in treatment T_1, T_2 and T_3 respectively. The maximum weight gain was in treatment T_1 (55.63g) and the minimum gain in weight in treatment T_3 (37.58g) (Table 4). The significantly (P<0.05) highest weight gain of fish was obtained with treatment T_1 followed by T_2 and T_3. The specific growth rate (SGR) of fish in different treatment groups ranged between 3.51 and 3.09. Treatment T_1 produced significantly (P<0.05). The highest SGR (3.51), while the treatment T_3 produced the lowest SGR (3.09).

Table 4. Growth and feed utilization of *Pangasius sutchi* during the experimental period

Parameters	Treatments			
	T_1	T_2	T_3	± S.E[2]
Initial weight (g)	2.462^a	2.462^a	2.462^a	0.948
Final weight (g)	58.096^a	51.043^b	40.046^c	0.531
Weight gain (g)	55.634^a	48.581^b	37.584^c	0.546
% weight gain	2259.7^a	1970.67^b	1526.56^c	51.942
Specific growth (SGR %day)	3.51^a	3.37^b	3.09^c	0.026
Food conversion ratio (FCR)	1.73^c	1.81^b	2.04^a	0.012

Protein efficiency ratio (PER)	1.69^a	1.61^b	1.43^c	0.033
Apparent net protein utilization. (ANPU %)	41.82^a	32.06 b	24.28 c	0.487
Survival rate (%)	94.16^a	92.00^b	94.97^a	0.052
Production (g/m^3)	2189.01	2343.00^b	2282.85^c	1.575

[1]*Figures in the same row with the same superscripts are not statistically different P>0.05).*
[2]*Sndard error of treatment means calculated from the residual mean square in the analysis of variance.*

The mean Food Conversion Ratio (FCR) values in different treatments varied between 1.7 and 2.04. The highest FCR values (2.04) was recorded in treatment T_3 and the lowest (1.73) in treatment T_1. The values of FCR in three different treatment are significantly (P>0.05) different from each other. The PER values ranged between1.43 to 1.69. Treatment T_1 had the highest PER (1.69) and treatment T_3 had the lowest PER (1.43). The values of PER in three different treatments are significantly (P>0.05) different from each other.

The ANPU % values for all treatments ranged between 24.28 and 41.82 (Table 4) The highest ANPU % value was obtained in treatment T_1 and the lowest value was obtained in treatment T_3. The value of ANPU% in three different treatments are significantly (P<0.05) different from each other.

The survival of fish in different treatment ranged between 92.00 and 94.79 %. There was no significant (P<0.05) difference between the survival rates of fish in treatment $T_1$and T_3. The highest fish production was recorded in treatment T_2 and the lowest was recorded in treatment T_1. Fish production in three treatments were significantly (P<0.05) different from each other.

Discussion

In the present study the effect of stocking densities on the growth of *P. sutchi* in cages was observed. The results indicated that the growth rate of *P. sutchi* (Flower) varied in different stocking densities. Treatment T_1 (40 fishes/m^3) showed the best result in terms of growth and feed utilization. Ahmed (1982) reported that the stocking rate of *Labeo rohita*,10 fishes/m^3 in floating ponds gave the best result in terms of individual growth followed by 20 and 30 fishes/m^3 respectively. The highest growth in terms of net yield/m^3 was obtained with the stocking rate of 30 fishes/m^{3}and the lowest relative growth 385.18% was obtain at the high stocking density 500fish/m^3. Haque *et al.* (1994) found that in case of *Cyprinus carpio* cultured in floating ponds the best growth was recorded at lowest density (5fishes/m^3) and least growth was recorded at highest density (20 fishes/m^3) . But the stocking densities of 15 fishes/m^3 gave the highest net yield/m^3. Dimitrov (1976) observed that low stocking densities 20 fishes/m^3 gave the highest production of carps in net cages compared to the high densities 80 and 150 fishes/m^3. Chaitiamvong (1977) found a production of 65 kg/m^3 of *P.Sutchi* with a stocking density of 25-40 fish / m^3 in floating cage in Thailand. Haque *et al.* (1984) observed lower production in java tilapia when stocked at higher densities in cages. Thiemmedh (1961) obtained a production of 180 to 240 kg/m^3 from Pangas in a year when stocked at a rate of 113 fishes/m^3

In the present study although the best individual growth of fish was observed at stocking densities of 40 fishes/m^3, the over all highest production was observed in treatment T_2 with a stocking density 0f 50 fish/m^3.

Level of crude protein and other necessary elements in the diets and the mode of feed presentation influenced the growth rate of the fish (Khan 1997). In the present study, optimum level of dietary protein (34.11%) enhanced the growth of *P. sutchi*. The present findings are in agreement with those reported by Islam *et al.* (1983) who recorded highest growth rate of *Catla catla* fingerling in cages by feeding with the diet containing 32.59% protein. Deyoe and Tiemeier (1968) observed that a diet containing 25% crude protein and animal sources with a minimum amino acid level gave the best growth in channel catfish fingerlings. It has been demonstrated that supplemental feeds containing 20 to 50% crude protein in different combination gave significant growth of different fishes cultured in cages. (Hasan *et al.* 1985)

The SGR values in the present study is more or less similar to the values of (3.3) reported for common carp when fed a prepared diet using rice bran, groundnut, oil cake and fish meal 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*. Wee and Ngamsnae (1987) reported a much lower SGR values of 1.27 to 1.85 in *P. gonionotus* feed varying protein levels (15 to 55 %) under laboratory condition.

The FCR values obtained in this study were satisfactory. The FCR values obtained in the present study were lower than the values(4.45) Reported by Rashid (1997) for *P. Sutchi* in cage feed diet containing 29.98% protein.

The temperature ranged between 22.4 and 29.7°C in the experimental cages. *P. sutchi* is an endemic fish of south east Asia where the temperature varies from 28 to 32°C all the year round. Thus the low temperature during the last month of the experiment probably slowed down the growth. Brown (1957) reported that temperature altered the rates of metabolic process and could be expected to have a considerable effect on the growth of poikilothermous animals. The percentage of mortality of the stocked fish in different treatments were not significant, which indicated that mortality of fishes in cages were not influenced by the stocking density (Pennington and Strawn 1977).

The result of the study indicated that the best individual growth of *P. sutchi* was obtained at a density of 40 fishes/m^3 but the highest total production was obtained at stocking density of 50 fish/m^3 in net cages. Thus, for better production a stocking density of 50 fish/m^3 could be used for *P. Sutchi* cage culture in Bangladesh.

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Minimization of cannibalism of African catfish (*Clarias gariepinus* Burchell) larvae in indoor culture system

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Abstract
For minimizing cannibalism of African catfish (*Clarias gariepinus*) larvae two trials for a period of 14 and 15 days respectively in four aquaria of size 120 x 49 x 32 cm^3 were conducted. Seven days old African catfish larvae with an initial total length and weight of 7.84 (±0.40) mm and 4.40 (±1.18) mg respectively in the first trial and similarly 7.52(±0.61) mm and 3.98 (±0.56) mg in the second trial at the rate of same stocking densities of 2500 larvae in each aquarium were stocked in both trials. Cannibalistic larvae were separated by using grader frame from each treatment at 7 days and 5 days interval during first and second trial respectively. Two mesh sizes i.e., 5 mm and 7 mm were used in the grader frame in both trials. Survival rate was significantly higher in T_1 than that of T_2 in each trial. Grading of larvae with 5 days interval resulted higher survival rate than that of 7 days interval.

Key words : *Clarias gariepinus*, Cannibalism

Introduction

African catfish has been well adopted to the environment of Bangladesh and its growth rate is highly encouraging. There is an increasing demand of its larvae. Though different techniques of larvae rearing of the species have been established through research, cannibalism is considered as one of the serious impediments for large scale larvae and fry rearing of the catfish.

Cannibalism is the process of both killing and eating an individual of the same species. As a biological phenomenon, sibling cannibalism can possibly be regarded as a specialized predation strategy developed as a mechanism to ensure survival of 'fit individuals', in the Darwinian sense, under 'harsh' or unstable environmental conditions reproductively to contribute successfully to future generation (Fox 1975). Cannibal phenotypes are morphologically similar to, but much larger than normal phenotypes.

Though in nature cannibalistic populations are self-regulated below the capacity of the environment and more resilient, cannibalism is considered as the only problem under high density fish culture since the mid 1970s. Larval and juvenile sibling cannibalism occurs in important culture species such as yellowtail (*Seriola quinqueradiata*), turbot (*Scophthalmus maximus*), eels (*Anguilla anguilla*), koi-carp (*Cyprinus carpio*), sea-bass (*Dicentrarchus labrax*) and gilthead bream (*Sparus aurata*)

(Chaudhuri & Tripathi 1979, Smith 1979, Kentouri 1980, Degani & Levanon 1983). Cannibalism has been recorded in wild populations of *Clarias gariepinus* (Corbet 1961 and Bruton 1979). Aboul-Ela *et al.* (1973) reported that heavy losses (up to 65%) have been attributed to larval and juvenile sibling cohort cannibalism of *Clarias gariepinus*. So, the present study was designed to establish a technique of minimizing cannibalism of its larvae.

Materials and methods

The experiments were conducted at the Department of Fisheries Biology and Genetics under the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh during July to September'97. Two trials were conducted during the period. Larvae of *Clarias gariepinus* for each trial were obtained by induced spawning of broods collected from the culture ponds of the department by using carp pituitary gland and 'Sumaach (HCG, India)'. The larvae were first fed after two days of hatching. They were provided with Tubificid worms in a paste form. Food particle size was gradually increased corresponding with the average mouth size of the larvae. The experiment was conducted in four aquaria of size 120 x 49 x 32 cm^3 which were marked as treatment-1 (T_1) and treatment-2 (T_2) each having two replications. Grading was done in the two aquaria under T_1 (experimental) while the aquaria under T_2 were considered as control and no grading was done. 2500 larvae of 7 days old were stocked in each aquarium containing 156 litres of water i.e., 16 larvae per litre of water in both trials. In the aquaria the larvae were fed with Tubificid worms twice a day to their satiation level. Continuous water flow was maintained in each aquarium. About two-third of water of each aquarium was changed everyday. The aquaria were cleaned by siphoning after half an hour of feeding.

For grading, a grader was developed which was a net tied to a rectangular frame of PVC (Polyvinyl Chloride) pipe. The first trial continued for 14 days while the second trial continued for 15 days. In the first trial grading was done two times - at the 7th and 14th day of starting the trial with the grader box of 5 mm and 7 mm mesh size respectively. In the second trial grading was done three times - at the 5th, 10th and 15th day of starting the trial with the grader box of 5 mm, 7 mm and 7 mm mesh size respectively. During grading, the grader was placed at one end of the aquarium carefully removing the larvae from that end. The grader was then drawn slowly from one end to the other. Feed was not provided to the larvae in the morning on the day of grading. After grading, the separated larvae from two aquaria under T_1 (in which grading was done) were counted and total length and weight of each was recorded. The separated larvae were replaced in another aquarium. After grading total length and weight of twenty larvae from each aquarium (both experimental and control) were recorded on the day of grading and released in the respective aquarium. Dead bodies of larvae were collected daily from each aquarium every six hourly interval during each trial. Usually whole dead bodies and in some instances only the head portion of larvae were collected from the bottom of the aquaria. The whole dead bodies of larvae were considered as the natural mortality while the availability of heads and the complete disappearance of the larvae were considered as the mortality due to cannibalism. After final grading total number of remaining larvae in each aquarium was counted.

Results

Growth (total length and weight) of *Clarias gariepinus* larvae under different treatments (i.e., T_1 and T_2) as recorded during the two trials (i.e., first and second trial) are presented in Table 1 and Table 2. The initial average total length and weight of the larvae stocked in the first trial were (7.84 ± 0.40) mm and (4.4 ± 1.18) mg. The final average length and weight of the larvae were 14.33 (± 0.13) mm and 25.26 (± 1.60) mg; 31.01 (± 4.15) mm and 509.90 (± 24.84) mg in T_1 and T_2 respectively. At the end of the first trial the average number of larvae survived in T_1 and T_2 were 715 and 26 respectively. The maximum and minimum length and weight of the cannibalistic larvae at that time in T_2 were 66 mm and 2574 mg and 14mm and 23 mg respectively.

Table 1. Growth (length and weight) of both cannibalistic and non-cannibalistic *C. gariepinus* larvae in the first trial

Treatments	Stocking density (per aquarium)	Average length (mm)			Average weight (mg)		
		Initial	1st grading	2nd grading	Initial	1st grading	2nd grading
T_1*	2500	7.84 (±0.40)	11.66 (±1.35)	14.33 (±0.13)	4.40 (±1.18)	13.96 (±0.30)	25.26 (±1.60)
T_2©	2500	7.84 (±0.40)	13.66 (±0.46)	31.01 (±4.15)	4.40 (±1.10)	35.23 (±1.50)	509.90 (±24.84)

* *Average growth of non-cannibalistic larvae after grading.*
© *Average growth of both cannibalistic and non-cannibalistic larvae.*

Table 2. Growth (length and weight) of both cannibalistic and non-cannibalistic *C.gariepinus* larvae in the second trial

Treatments	Stocking density	Average length (mm)				Average weight (mg)			
		Initial	1st grading	2nd grading	3rd grading	Initial	1st grading	2nd grading	3rd grading
T_1*	2500	7.52 (±0.61)	9.46 (±0.46)	11.30 (±0.20)	14.90 (±0.20)	3.98 (±0.56)	11.10 (±0.30)	14.35 (±0.75)	27.20 (±1.10)
T_2©	2500	7.52 (±0.61)	10.69 (±0.03)	15.81 (±0.48)	32.41 (±1.50)	3.98 (±56)	16.36 (±0.43)	62.91 (±1.33)	540.10 (±7.19)

* *Average growth of non-cannibalistic larvae after grading.*
© *Average growth of both cannibalistic and non-cannibalistic larvae.*

In the second trial, the initial average length and weight of the larvae were 7.52 (± 0.61) mm and 3.98 (± 0.56) mg. The final average length and weight of the larvae in T_1 and T_2 were 14.90 (± 0.20) mm and 27.20 (± 1.10) mg and 32.41 (± 1.50) mm and 540.10 (± 7.19) mg respectively. At the end of the second trial the average number of larvae survived in T_1 and T_2 were 1258 and 21 respectively. The maximum and minimum length and weight of the cannibalistic larvae at that time in T_2 were 61 mm and 2456 mg and 17 mm and 56 mg respectively.

Table 3 presents the mean (± SE) of final number, total survival (%), natural mortality (%) and cannibalism-induced mortality (%) during the first and second trial. The average (± SE) of final number and total survival of *C. gariepinus* larvae were significantly higher ($P < 0.01$) in T_1 than T_2 in both trials, but the final number and total survival were higher in T_1 of second trial than that of first trial. There was no significant difference between the natural mortality of T_1 and T_2 in any of the trials. The average (± SE) cannibalism-induced mortality was significantly higher ($P < 0.01$) in T_2 than T_1 in both trials.

Table 3. Survival rate, natural mortality and cannibalism-induced mortality of *C. gariepinus* larvae during first and second trial after 14 days and 15 days respectively of rearing at the same stocking densities

Group	First trial Mean ± SE		t-values and significance level	Second trial Mean ± SE		t-values and significance level
	T_1	T_2		T_1	T_2	
Final number	715.00±33.00	25.50±4.50	20.70*	1258.00±69.00	20.50±3.50	17.91*
Total survival (%)	28.60±1.32	1.02±0.18	20.70*	1258.00±69.00	20.50±3.50	17.91*
Natural mortality (%)	10.80±0.68	9.80±2.60	0.37 IS	7.64±0.72	7.98±2.62	-0.13 IS
Cannibalism-induced mortality (%)	60.60±0.64	89.60±2.00	-13.81*	42.04±2.04	91.68±2.28	-16.23*

* *$P < 0.01$*
IS, Insignificant ($P < 0.05$)

Discussion

In the present experiment it was observed that the larger larvae of *Clarias gariepinus* first turned into cannibals. Giles *et al.* (1986) working on pike larvae also observed that the largest fish in each tank first turned cannibalistic. Both types of cannibalism i.e., 'tail-first' and 'head-first' as described by Hecht and Appelbaum (1988) in case of *Clarias gariepinus* larvae occurred in the present experiment. Growth and cannibalism of African catfish (*Clarias gariepinus*) larvae in all the treatments were investigated during the experiment. The results indicated that the growth rate of larvae varied among two treatments of both trials. Growth rate was higher in T_2 than that of T_1 in both trials. As grading was not done in treatment T_2 in both trials, there occurred a great size variation among the survivors due to cannibalism. As cannibalistic larvae were separated periodically from each aquarium under T_1 in both trials, the remaining larvae were more or less of same size. Because of the same grader used in both trials there was no remarkable difference in growth rate in T_1 in each trial.

Survival rate was significantly higher in T_1 than that of T_2 where a severe loss occurred during the rearing period of *Clarias gariepinus* larvae into culture system because of cannibalism. Van Dame *et al.* (1989) reported severe losses (upto 40%) of Koi-carp (*Cyprinus carpio*) larvae and juveniles during the rearing with artificial diets at high densities. As grading was not done in T_2 cannibalism-induced mortality was the highest in this case in both trials. So, it can be said that cannibalism of *Clarias gariepinus* larvae can be reduced by regular grading in larval rearing system.

Final number of larvae survived, at the end of the trials, was higher in second trial compared to the first. In the first trial, grading was done at 7 days interval while in the second trial, grading was done at 5 days interval with same grader box. Cannibalism-induced mortality was apparently lower in T_1 of second trial than that in T_1 of first trial due to grading variation. So, it can be concluded that regular grading of fish by size with short intervals during culture period can minimize cannibalism of *Clarias gariepinus* larvae.

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Pathogenicity of *Aeromonas hydrophila* artificially infected to Indian major carp (*Cirrhinus mrigala* Ham.)

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Abstract

Abrasion, feeding, injection and immersion methods were used to evaluate the pathogenecity of five different strains of *Aeromonas hydrophila viz.* RG(rui gill), ML (mrigal lesion), SG (sharpunti gill), F_1K (mrigal kidney), GFL (gold fish lesion) and Ah-19 (*Aeromonas hydrophila*- 19, Ref. Strain) against *C. mrigala* H. Bacterial suspension containing viable cells of 7.5x 10[illegible] per ml was found to be very effective in intra-muscular injection and feeding resulting 100% mortality after 96 hr of inoculation. The strain RG, ML and F_1K produced scale loss with erosion of the skin surface with/without haemorrhagic lesion after 48 hr of inoculation following abrasion method. The strains SG and Ah-19 resulting scale loss with erosion of the skin surface with/ without haemorrhagic lesion after 72 hr of inoculation following abrasion and injection methods. SG and F_1K caused reddening in mouth region after 72 hr of feeding inoculation, whereas RG resulted frank ulcers from eroded dermal layer exposing underlying musculature which was haemorrhagic after 96 hr of inoculation by abrasion method.

Key words : *C. mrigala*, *Aeromonas hydrophila*, Pathogenecity

Introduction

Bacterial diseases are reported to be a potential threat to our fish culture systems. Pathogenic bacteria affects fish either as primary pathogens or as opportunistic invaders and are responsible for considerable losses in fish populations. The progressive development of the disease from initiating events to some subsequent stage in the host-pathogen relation is dependent on the ability of the disease causing agent to produce toxins and on the humoral and cellular defense mechanisms of the host besides environmental conditions (Munro 1982). Information on the pathogenecity of bacteria in Indian major carps is scarce in the country. The present study was, therefore, undertaken to develop a practical method for consistent establishment of disease in *C. mrigala*.

Materials and methods

Apparently healthy fingerlings of mrigal, *C. mrigala* (Length 10-11.5cm, wt 10-20g) were collected from a local private nursery and were acclimated for 72 hr at the Disease Laboratory of Fresh water Station, Fisheries Research Institute, Mymensingh.

Collection of various strains of Aeromonas hydrophila

Six strains of *Aeromonas hydrophila* viz. F_1K, RG, ML, SG, GFL and Ah-19 were collected and used for inoculation experiments. F_1K was isolated from the kidney of *Cirrhinus mrigala* without any external clinical symptoms of disease. RG was isolated from the gill of *Labeo rohita* showing fin rot and gill necrosis signs. ML has been isolated from the body lesion of *C. mrigala* and SG was isolated from the gill of *Puntius gonionotus* having sign of gill necrosis, fin rot and distinct body lesion. GFL was isolated from the body lesion of *Carassius auretus* showing severe disease symptom of fin rots, scale protrusion, severe deep ulcerative lesions all over the body and decayed caudal fin together with swollen kidney and liver. Moreover, one strain, Ah-19 was collected from Japan and was used as a reference type strain.

Preparation of bacterial suspension

The collected bacterial strains were grown on TSA agar plates for 24 at 30°C and suspensions were prepared with 0.85% NaCl (physiological saline) that resulted in a concentration of 5 to 7.5 x 10^8 viable cells/ml.

Inoculation & Injection

Artificial inoculations were carried out following four different methods *viz.* injection, feeding, abrasion and immersion. The collected fish fingerlings, after acclimated, were inoculated with 0.1ml of the bacterial suspension (5 to 7.5 x 10^5 cells/ ml) intra-muscularly (Supriayadi 1986). Three fishes per replication and three replications for each treatment (strain) were used. The fingerlings of the control treatment received only 0.85% physiological saline solution. After inoculation, each three fingerlings were allowed to stay in 10 l of sterilized water in a bucket with continuous mild aeration throughout the 96 h of study period.

Feeding

This study was carried out by using the same number and size of fingerlings as used in case of injections. Each fingerling was fed with 0.1ml of bacterial suspension (5 to 7.5x10^8 cells/ml). The bacterial suspension was fed to fingerlings by pipetting with Pasteur pipette and 0.1ml of physiological saline was fed to each fingerling of control group. After being fed, the fingerlings were allowed to stay in 10 l of sterilized water in a bucket with continuous mild aeration and the fingerlings were observed up to 96 h for mortality and development of clinical signs.

Abrasion

This study was carried out following the method of Cipriano (1982). Fingerlings were placed on a damped cloth; 1ml of 2.0x10^9 cells/ml of bacterial suspension was then pipetted out onto a Pasteur pipette and scales along the left lateral line area were then abraded with the culture. The fish were held a few seconds before being returned to the bucket as done in case of injection method and feeding method. In case of control treatment the fingerlings were not abraded with the bacterial suspension.

Immersion

The method of Cipriano (1982), Ramaiah and Monohor (1980) was followed for water- borne infection of the bacterium through immersion method. In this experiment, fish fingerlings were exposed to bacterial suspension of 10^6 cells/ml of water in the challenge vessel contained 10 l of water. Mortality and development of disease symptoms in each group were recorded. Under control treatment the fingerlings were exposed only in sterilized water.

Observation and collection of data

The inoculated fingerlings were observed periodically and data regarding mortality and development of disease symptoms of the fingerlings were recorded after every 24 hr for four days. Experimentally induced lesions were classified using the modified classification of Lio-Po *et al*. (1992).

Reisolation and identification of the inoculated strains

This test was carried out following the method of Inglis *et al*. (1993). Surfaces of the diseased lesions of the inoculated fish fingerlings were disinfected with 70% ethanol and were streaked onto TSA agar plate. The bacterial colonies were reisolated for the preparation of the pure culture and were identified following the manual for identification of Medical bacteria (Cowan 1974, Holt 1977).

Results

Pathogenecity study of Aeromonas hydrophila (challenge test)

Result of experimental infection of *Cirrhinus mrigala* H. by four different inoculation techniques *viz*. abrasion, feeding, injection and immersion with six different strains of *Aeromonas hydrophila viz*. RG, ML, SG, F_1K, GFL and Ah-19 are shown in Table 1. In case of abrasion, 100% mortality was found in the strains RG and SG, whereas 66% was recorded with F_1K and Ah-19. No mortality was observed with GFL and control (untreated). The mortality of fish started after 48 hr. of inoculation with strains RG, ML and F_1K though 33% mortality was recorded in case of ML. In case of feeding 100% mortality was recorded in the strains RG, SG and GFL. Under this inoculation method Ah-19 and F_1K resulted 66% and 33% mortality, respectively. The strain ML and control (untreated) did not show any mortality even after 96 hr of inoculation. In the present challenge experiments, it was observed that injection method was found to be the most effective method in resulting 100% infection after 96 hr of inoculation. In this method the strains RG, F_1K and Ah-19 showed mortality of the inoculated fish after 48 hr of inoculation. Under immersion method only two strains RG and F_1K resulted 33% and 66% mortality, respectively. The other strains were found to be ineffective to cause mortality of the inoculated fish fingerlings.

Table 1. Results of experimental infection of *Cirrhinus mrigala* with six different strains of *Aeromonas hydrophila* expressed as mortality

Treatment (methods)	Isolates	Post inoculation hours of mortality				Mortality (%)
		24 hr	48 hr	72 hr	96 hr	
Abrasion	RG	-	1	-	2	100

	ML	-	1	-	-	33
	SG	-	-	1	2	100
	F,K	-	1	-	1	66
	GFL	-	-	-	-	0
	Ah-19	-	-	2	-	66
	Control	-	-	-	-	0
Feeding	RG	-	1	-	2	100
	ML	-	-	-	-	0
	SG	-	-	1	2	100
	F,K	-	-	1	-	33
	GFL	-	-	-	3	100
	Ah-19	-	-	2	-	66
	Control	-	-	-	-	0
Injection	RG	-	1	-	2	100
	ML	-	-	2	1	100
	SG	-	-	1	2	100
	F,K	-	1	1	1	100
	GFL	-	-	2	1	100
	Ah-19	-	1	1	1	100
	Control	-	-	-	-	0
Immersion	RG	-	-	-	1	33
	ML	-	-	-	-	0
	SG	-	-	-	-	0
	F,K	-	1	-	1	66
	GFL	-	-	-	-	0
	Ah-19	-	-	-	-	0
	Control	-	-	-	-	0

RG= Rui gill, ML= Mrigal lesion, SG= Sarputi gill, F,K= Kidney of Mrigal, GFL = Goldfish lesion, Ah-19= Reference strain from Japan. Mean of three replications (3 fish/replication)

Symptom development study

The results of the inoculation tests revealed that development of symptoms in each of the four inoculation methods started after 48 hr of inoculation (Table 2). The strains RG, ML and F,K produced scale loss with erosion of the skin surface with/without hemorrhagic lesions after 48 hr of inoculation following abrasion method. The other strains tested did not produce any sign at this time in any of the inoculation methods. The strain SG and Ah-19 resulted scale loss with erosion of the skin surface with/without hemorrhagic lesions after 72 hr of inoculation following abrasion and injection methods, while the strain GFL showed the same symptom after 72 hr of inoculation only in case of injection method. The strains SG and F,K developed reddening in mouth region after 72 hr of feeding inoculation. The strain RG resulted frank ulcers on eroded dermal layer and underlying musculature which became hemorrhagic after 96 hr of abrasion.

Table 2. Effect of different strains of *Aeromonas hydroplila* on development of disease symptoms in *C. mrigala* experimentally infected by four different methods

Treatment (methods)	Isolates	Post inoculation hours of Symptom development			
		24 hr	48 hr	72 hr	96 hr
Abrasion	RG	-	-	++	++
	ML	-	-	-	-
	SG	-	+	+	+
	F,K	-	-	+	+
	GFL	-	-	-	-
	Ah-19	-	+	-	-

	Control	-	-	-	-
Feeding	RG	-	-	+	-
	ML	-	-	-	-
	SG	-	(+)	++	+
	F_1K	-	-	-	++
	GFL	-	-	-	-
	Ah-19	-	+	-	-
	Control	-	-	-	-
Injection	RG	-	-	+	-
	ML	-	+	+	+
	SG	-	+	+	+
	F_1K	-	-	+	+
	GFL	-	+	+	+
	Ah-19	-	+	+	+
	Control	-	-	-	-
Immersion	RG	-	-	-	-
	ML	-	-	-	-
	SG	-	-	-	-
	F_1K	-	-	-	-
	GFL	-	-	-	-
	Ah-19	-	-	-	-
	Control	-	-	-	-

RG= Rui gill, ML= Mrigal lesion, SG= Sarputi gill, F_1K= Kidney of Mrigal, GFL = Goldfish lesion, Ah-19= Reference strain from Japan. - = No external signs of disease or lesion
+ = Scale loss with erosion of the skin surface with/without hemorrhagic lesion. + = Reddening in mouth region
++ = Frank ulcers from eroded dermal layer, exposing underlying musculature which may be hemorrhagic.

Discussion

The maximum percentage of mortality was obtained by the injection method, while the minimum by the immersion method. The other two inoculation methods (abrasion and feeding) showed moderate type of mortality. However, all the tested strains of *Aeromonas hydrophila* caused death in *C. mrigala*. The findings of the present study agree with the results of other researchers. Heuschmann- Brunner (1978) reported that fish pathogenic strains of *Aeromonas hydrophila* were found associated with diseased and healthy fish in surface water and in sewage. Kuo *et al.* (1980) reported that the infection of virulent strains of gliding bacteria by contact method was more effective than by intraperitoneal inoculation. They also reported that the incidence of pathogenic strains were higher in standing water than in flowing water. Muroya and Nakajima (1981) reported that the three methods tested viz. injection, oral administration and immersion methods were found to cause mortal infection in the experimental fish. Bang (1983) studied bacterial infection with the disease of colour carp and reported severe inflammation followed by death. He reported 50% mortality within 96 hr of inoculation in case of sand gobies injected with *Aeromonas hydrophila* showing disease symptom and most moribund fish were lethargic. Wang and Xu (1985) reported that artificial infection with pure culture of *Aeromonas hydrophila* resulted disease in fish and the infection rate reached 80%. Cartright *et al.* (1994) observed the association of virulent strains of *A. hydrophila* with Epizootic Ulcerative Syndrome in various species of fish in South East Asia. Pathiratne *et al.* (1994) observed *A. hydrophila* as a predominant bacterium associated with epizootic ulcerative syndrome (EUS) of fresh water fish in Sri Lanka. They reported that *A.. hydrophila* may play an important role in the pathogenesis of the disease. Fotis *et al.*

(1994) pointed out that *A. hydrophila* could be the important cause of erythrodermatitis in carp. The challenge test has confirmed the pathogenicity of *A. hydrophila* to *C. mrigala* H. and developed distinct signs and symptoms of the disease. Considering the basis of pathogenesis study, future plan of research work need to be promulgated in a befitting manner in order to represent the situation of the bacterial diseases of the country.

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Incidence of ulcer disease in African catfish (*Clarias gariepinus* Burchell) and trial for its chemotherapy

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Abstract

Young *Clarias gariepinus* cultured in an artificial tank were severely affected by an ulcer type of disease where 77% fish died within 5 weeks. From the lesions and kidney of affected fish *Aeromonas, Pseudomonas, Flavobacterium, Micrococcus* and *Staphylococcus* were isolated where *Aeromonas* was observed as the dominant bacteria. Among them, an *A. hydrophila* isolate AGK 34 was detected as a pathogen by the experimental challenge test. In order to find out a suitable remedial measure of the disease, four different chemotherapeutants were applied to the affected fish in 6 different ways under laboratory condition. Affected fish were recovered from the disease in different treatments. But the best result was obtained by a successive bath in 1-2% NaCl and subsequent oral treatment with commercial oxytetracycline at a dose of 75 mg/kg body weight of fish.

Key words : Ulcer disease, *Aeromonas hydrophila*, Chemotherapy

Introduction

African magur, *Clarias gariepinus* is one of the fast growing exotic fish in Bangladesh. It has been widely cultured both in ponds and artificial tanks in this country since 1989. Like all other fishes, they are not free from the threatening of various types of diseases in Bangladesh.

Chowdhury (1993) reported that farmed carps and catfishes including African magur have been suffering from diseases like ulcer type of disease including EUS, various types of lesions, tail and fin rot, bacterial gill rot, fungal and parasitic diseases in a number of fish farms of Bangladesh. Among these, ulcer type of disease is the most important one where bacteria were found to be involved with the disease (Rahman and Chowdhury 1996). No systematic works on the diseases of *Clarias gariepinus* were reported. Proper diagnosis of any disease is very important to the context of Bangladesh. Moreover, our fish farmers have no proper knowledge of fish health management, use different chemicals as an irregular practice of chemotherapy. In most cases farmers fail to control the incidence of disease, which need research based information and its extension.

Considering the importance, present research works were planned to find out the mortality patterns of fish suffering from ulcer type of disease under a case study, to isolate and identify bacteria from the affected fish, to perform the challenge test with some suspected bacterial isolates, and to perform trials of chemotherapy to control the disease.

Materials and methods

Outbreak of ulcer disease in an artificial tank

A total of 500 African magur, *Clarias gariepinus* (43 ± 7 g) was stocked to grow up in an artificial tank (11.7 m x 6.65 m x 1.1 m) situated at the site of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Under ground water was used in that tank and changed in every 3 or 4 weeks. The fish were fed prepared food using rice bran (45 %), fish meal (15 %), mastard oil cake (30%) and flower (10%) in irregular basis.

An ulcer type of disease was observed in that fish from the second week of November to the middle of December, 1996. The disease was grossly detected by the appearance of lesions on the body surface of fish. Investigation of the incidence of lesions and mortality of fish was considered as a case study. It was performed on the basis of observation and sampling of fish 2-3 times in a week from different parts of the tank. Some physico-chemical parameters viz., P^H , temperature and dissolved oxygen of tank water was also recorded during the study period.

Bacteriological examination

Moribund and freshly dead fishes were collected randomly from different parts of the tank with a scoop net in a plastic container with the same water and brought immediately to the Fish Disease Laboratory for bacteriological examination.

Tryptone Soya Agar (TSA. Oxoid), Cytophaga agar (Anacker and Ordal, 1959) and Aeromonas Agar Base (Oxoid) supplemented with ampicillin SR 136 E were used for culture and isolation of bacteria in the present study.

Swabs from external lesions and kidney of the affected fishes were taken aseptically and inoculated into different bacterial culture media according to the standard decimal dilution method. The culture plates were incubated aerobically at 25° C for 48 h. Then some representative colonies were further cultured on fresh agar plates to obtain pure cultures.

Characterization of the bacterial isolates

The bacterial isolates were characterized and identified following the standard morphological and biochemical tests stated in the Cowan and Steel's Manual for Identification of Medical Bacteria edited by Barrow and Feltham (1993). However the aeromonad isolates were further identified up to species level according to the methods described in the Bergey's Manual of Systematic Bacteriology (vol. 1) edited by Krieg and Holt (1984). The results of the tests were also confirmed with a known strain of *Aeromonas hydrophila* (Thai Strain).

Bacterial challenge test

For bacterial challenge test, 4 identified aeromonad isolates were selected which were recovered form the kidney of infected fish. Healthy young *C. gariepinus* (20g) and an exotic carp, *Puntius gonionotus* (15g) were used as experimental fish. The fish were acclimatized in the laboratory earlier. The test was performed following a water-borne infection method (contact by immersion) described by Rahman and Chowdhury (1996).

Drug Sensitivity test

Sensitivity test was performed to know the sensitivity of the selected aeromonad isolates to different drugs. The test was conducted according to the method described by Chowdhury *et al.* (1997).

Trials for Chemotherapy

In order to find out suitable remedial measures of the disease 4 different chemotherapeutants were applied in 6 different ways on the affected fish in laboratory condition. The application methods and doses of the chemotherapeutants were used according to the standard methods and doses described by Herwig *et al.* (1979) and Roberts *et al.* (1989) for the treatment of fish suffering from various diseases. The chemotherapeutants were commercial oxytetracycline, commercial cotrim, table salt (NaCl) and quick lime [$Ca(OH)_2$].

At a time, 28 affected fish were collected randomly from the tank and kept in 7 different aquarium (60 cm x 15 cm x 15 cm) containing preserved tap water where, the stocking load was maintained 10 g/l. Then different treatments of drugs were applied on these fish. The trial was continued for 20 days and artificial aeration was maintained in that time. The aquarium water was changed every after two days. All the treatments were repeated 4 times. After the treatment the recovered fish were observed in the laboratory with normal peleted feed prepared with rice bran, fish protein concentrate and flower at a rate of 3% of the body weight.

Drug application

Treatment I

The affected fish were successively bathed in 1%, 1.5% and 2% NaCl solution for 1 hour for each step and transferred to an aquarium containing tap water. The treatment was repeated for 5 days.

Treatment II

Commercial oxytetracycline capsule (Phermadesh Lab. Ltd.) containing 250 mg oxytetracycline were used in this treatment. Everyday small pellets were prepared using rice bran, fish protein concentrate and flour and required amount of OTC was mixed with the feed. The rate of OTC applied to the affected fish was 75 mg/kg body weight /day for 5 days. The feeding rate was 3% of the body weight.

Treatment III

Commercial cotrim tablets (Square Pharmaceuticals Ltd.) were crushed into powder form and mixed with the pellets. The dose of cotrim supplied to the affected fish was 100 mg/kg body weight/day for 5 days.

Treatment IV

At first the fish were successively bathed in 1%, 1.5% and 2% NaCl solution for 1 hour each and kept in an aquarium containing tap water. The fish were fed feed with OTC at 75 mg/kg body weight /day for 5 days.

Treatment V

In this treatment the fish were simultaneously bathed in 1%, 1.5% and 2% NaCl for 1 hour at each step and maintained in an aquarium with normal tap water. Then the fish were fed cotrim at 100 mg/kg body weight/day using the pellet feed for 5 days.

Treatment VI

The fish were successively dipped in NaCl (1%) plus $Ca(OH)_2$ (0.1%), NaCl (1.5%) plus $Ca(OH)_2$ (0.15%) and NaCl (2%) plus $Ca(OH)_2$(0.25%) for 5 minutes at each step. The fish were then maintained in an aquarium containing tap water and observed for recovery.

Treatment VII (control)

No drugs were applied on the affected fish. Only pelleted feed was supplied to the fish and water was changed in every 2 days.

Results and discussion

A severe ulcer type of disease in young *Clarias gariepinus* occurred in an artificial tank with the expression of irregular lesions on the body surface of fish which gradually turned into ulcers. The affected fish started to die within 3-4 days after appearance of the disease. In the first week, out of 500 stocked fish 15.0% showed lesion on the body surface and 13.6% died (Fig. 1). However, the disease became severe in the 3rd week when mortality recorded 26.0%. In the 5th week of the experiment the affected fish were found to recover, when mortality became 5.0%. During this period cumulative mortality was 77.0%. The results were correlated with the reports of Rickards (1978) where he observed 80% mortality of Japanese eel fingerlings caused by an ulcer type of disease in Japan. Fotis *et al.* (1994) also observed 80% mortality of common carp (*Cyprinus carpio* L.) in an ulcer type of disease in Greece. However, during the study period P^H of the tank water was recorded as 7.78. Average temperature and dissolved oxygen was recorded 21.5°C and 7.6mg /l respectively.

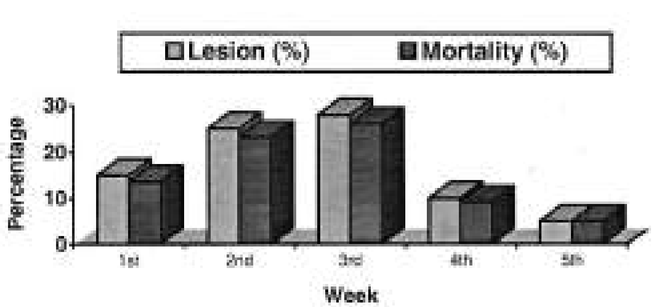

Fig. 1. Prevalence of the occurrence of lesion and mortality in *C. gariepinus* in the artificial tank.
T-1 : Bath in NaCl, T-2 : Oral treatment with commercial oxytetracycline, T-3 : Oral treatment with commercial cotrim, T-4 : Bath in NaCl and subsequent oral treatment with commercial oxytetracycline, T-5 : Bath in NaCl and subsequent oral treatment with commercial cotrim,
T-6 : Dip in NaCl mixed with $Ca(OH)_2$, T-7 : Control

From the lesions and kidney of affected fishes, *Aeromonas, Pseudomonas, Flavobacterium, Micrococcus* and *Staphylococcus* were isolated. Moreover, *Cytophaga* were also isolated from the lesions of affected fishes. However, the percentage composition of bacteria in kidney of both healthy and diseased fishes are shown in Table 1. In the present study, *Aeromonas* was detected as the dominant bacteria in the kidney of disease affected fishes which was 80% of the total bacterial content. In contrast, 35% *Aeromonas* was found in that of the healthy fishes. Abdullah (1989) isolated *Aeromonas hydrophila, Pseudomonas aeroginosa, Pseudomonas* spp., *Edwardsiella* spp., *Moraxella* spp., *Flavobacterium* spp., *pasteurella* spp., *Bacillus* sp. and *Enterobacter* sp. from diseased catfish (*Clarias macrocephalus*) in Malaysia. Pal and Pradhan (1990) also isolated pseudomonads, aeromonads (*A. hydrophila*) and coccus (*Micrococcus varians*) from the lesions of ulcerative condition of air-breathing fish in India. However, Chowdhury *et al.* (1997) observed that the aeromonad content in the kidney of healthy *Puntius gonionotus* varied from 20-50% in different months but, Rahman and Chowdhury (1996) observed 72-82% aeromonad content in the kidney of farmed carp fishes suffering from an ulcer type of disease.

Table 1. Percentage composition of bacteria in the kidney of both healthy and diseased fish

Fish	Aero	Pseudo	Flavo	Micro	Staph
Healthy fish	35	15	7	31	12
Diseased fish	80	7	2	8	3

Aero : Aeromonas, Pseudo : Pseudomonas, Flavo : Flavobacterium, Micro : Micrococcus, Staph : Staphylococcus

As aeromonad was the dominant bacterial group recovered from the lesion and kidney of affected fish, they were further identified as *A. hydrophila*, *A. sobria* and *Aeromonas* spp. Rahman and Chowdhury (1996) also classified some aeromonad isolates as *A. hydrophila*, *A. sobria* and *Aeromonas* spp. recovered from some ulcer disease affected carp fishes. Species level identification of bacteria isolated from an exotic catfish, *C. gariepinus* is the first time report in Bangladesh.

The results of the bacterial challenge test are shown in Table 2. In the present study only the *A. hydrophila* isolate AGK 34 successfully produce disease both in *C. gariepinus* and in *P. gonionotus* with mortality. But, no pathogenic response were observed either in *A. hydrophila* isolate AGK 94 and or in *A. sobria* isolate AGK 25 and AGK 98. Esteve *et al.* (1993) observed that *A. hydrophila* causes ulcer disease in European ell, *Anguilla anguilla*. Rahman and Chowdhury (1996) also reported *A. hydrophila* as a pathogen causing ulcer disease in some carp fishes which supported the present study. However, in the present study two species of experimental fish were used. High mortality was observed in both of the fish species when they were challenged to the *A. hydrophila* isolate AGK 34. Thus it is suspected that the isolate might be highly virulent one. Moreover, among the two species of fish tested, *P. gonionotus* showed higher mortality. The reasons of such findings were not studied. But, it is suspected that *P. gonionotus* might be more susceptable to the pathogen.

Table 2. Experimental infection with the selected aeromonad isolates

Aeromonad isolates	Experimental fish	Nos. of fish Tested	Nos. of fish Died	Mortality (%)
AGK 25	*Clarias gariepinus*	20	0	0
AGK 34	"	20	16	80
AGK 94	"	20	0	0
AGK 98	"	20	0	0
Control (no bacterium)	"	20	0	0
AGK 25	*Puntius gonionotus*	20	0	0
AGK 34	"	20	18	90
AGK 94	"	20	0	0
AGK 98	"	20	0	0
Control (no bacterium)	"	20	0	0

Data summarizes two repeated trials

In the drug sensitivity test, all of the selected aeromonads including the pathogenic isolate were found to be sensitive to oxytetracycline (OT), oxolinic acid (OA) and chloramphenicol (C). Most of these isolates were found to be resistant to erythromycin (E), streptomycin (S) and sulphamethoxazole (SXT) (Table 3). The results were correlated with the findings of Sunthonnan *et al.* (1981). However, Banu (1996) observed that 26% aeromonad isolates recovered from different fish farms of Mymensingh were resistant to oxytetracycline. But in the present study, all of the isolates were found to be sensitive to the antibacterial agent. The reasons of such findings were not studied. It is believed that such findings were due to the serological difference of these isolate from other isolates.

Table 3. Sensitivity patterns of the selected Aeromonad isolates recovered from diseased fishes

Aeromonad Isolate	Response to different antibiotic agents with their zone of inhibition (mm)					
	OT	OA	C	SXT	S	E
AGK 34	+27	+23	+28	±15	R	R
AGK 94	+30	+30	+36	+20	R	R
AGK 98	+27	+21	+25	R	±20	R
AGK 25	+23	+17	+18	± 18	R	15

OT : Oxytetracycline (30 µg/disc), OA: Oxolinic acid (2 µg/disc), C: Chloramphenicol (30 µg/disc), S XT : Sulphamethoxazole (25 µg/disc), S: Streptomycin (10 µg/disc), E: Erythromycin (10 µg/disc)

In the chemotherapy trials, the best result was observed in T-IV, successive bath in NaCl and subsequent oral treatment with commercial oxytetracycline. In this treatment, the percentage of recovery was 43.75% (Fig. 2). In the oral treatment with commercial oxytetracycline (T-II) 31.25% fish were recovered. No fish were recovered from the disease in T-VI, dip in NaCl mixed with $Ca(OH)_2$. The prevalence of recovery of diseased catfish (*C. gariepinus*) in T- I, T-III and T-V were recorded 25%, 12.5% and 25% respectively. Roberts *et al.* (1989) found tetracycline to be effective in oral treatment of *Puntius gonionotus* at 500 mg/500 g feed in an ulcer type of disease. Jhingran (1990) also found oxytetracycline to be effective for the treatment of EUS affected fishes. In the present study all the treated fish were not cured in none of the treatment. It was suspected that unrecovered fish were severely infected before the treatment started. However, the results of the chemotherapy trials might be applicable to other ulcer disease affected farmed fish. The present study will help fish farmers in choosing suitable treatments in order to save there fish from ulcer disease.

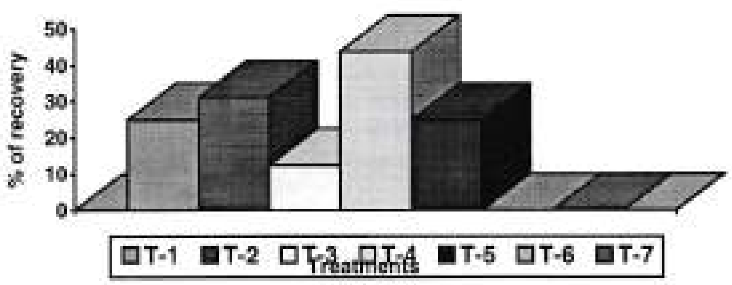

Fig. 2. The revocery patterns of diseased catfish (*C. gariepinus*) with different treatments.

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Development of a new model of feeding strategy analysis of fish incorporating resource availability and use data

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Abstract

A feeding strategy model is proposed using stomach content and resource availability data as a modification to Costello (1990) and Amundsen *et al.* (1996). Incorporation of feeding electivity index (*E*) instead of the prey-specific abundance signifies the importance of resource availability in prey selection as well as the predator's ability to specialize, generalize or avoid particular prey items at the individual and population level.

Key words : Feeding strategy, Prey importance (electivity), Tilapia

Introduction

Niche breadth in animal are often measured without regard to the relative frequencies of the various resources available to the organisms. Thus these indices lack wide acceptability and objective interpretations, simply because resources thus used by the predators are not simultaneously incorporated in those indices. Feinsinger *et al.* (1981) defined niche width as the degree of similarity between the frequency distribution of resources used by a predator and the frequency distribution of resources available to it. Niche width can appropriately be quantified now with Czekanowski's proportional similarity (PS) index which takes into account the resource available or accessible to the predators and the resource used by the predators as well (Feinsinger *et al.* op. cit.).

Prey abundance and selection are of paramount importance in feeding strategy of any fish. Feeding strategy changes with ontogenetic dietary shifts, variations in morphological adaptations and development of feeding apparatus such as, protrusible jaw mechanisms, pharyngeal teeth's (Wootton 1990), encounter and capture varying with visibility, encounter probability, escape speed, ingestion and retention (Pearre 1986).

In this paper it has been shown that, feeding strategy analysis incorporating Ivlev's (1961) feeding electivity index (*E*) signifies the importance of resource availability in prey selection as well as the predator's ability to specialize, generalize or avoid particular prey item both at individual and population level.

Materials and methods

The data used in this paper was part of a work carried out at the Riverine Station, Chandpur, of the Bangladesh Fisheries Research Institute during 13-15 July'95 in a nursery pond using two size (small and large) categories of *Oreochromis* spp. [*Oreochromis niloticus* (L.) x *O. mossambicus* (Peters) natural hybrid]. The fish and sub-surface plankton were sampled every 3 h from the nursery pond for 48 h to analyze their gut contents, food consumption, feeding electivity and available food.

Pond preparation and fish stocking

The pond was a nursery type, about 1,620 m^2 in size (water area 990 m^2), 1.85 m in maximum depth and was kept weed-free for easy netting. The pond was prepared in June 1995 by completely drying, liming (250.0 kg. ha^{-1}) and manuring once (cow-dung 10.0 t. ha^{-1}, urea 16.0 kg. ha^{-1} and triple super phosphate 32.0 kg. ha^{-1}). Two sizes of *Oreochromis* spp. juveniles, collected from the Riverine Station's other nursery ponds, were stocked at a density of 7.0 juveniles. m^{-2} (3,465 individuals of each size). Before stocking in the pond, fishes were kept in a flow-through system for 48 h to completely empty their gut contents. The small fishes were 4.3-9.3 cm in total length (TL) and 1.6-15.5 g in weight and the large fishes were 9.5-13.5 cm in TL and 14.4-46.4 g in weight. Prior to stocking in the pond the fish had been fed a supplemental feed composed of 40% rice bran, 40% wheat bran and 20% fish meal at 2-5% of body weight (bw), once daily but not during our experiment. Two days after stocking, 10 fishes of each size were sampled every 3 h for 48 h with a cast net (3x6 m, mesh 0.5 cm). In total, 320 fishes (160 of each size) were collected.

Stomach content analysis

Fishes were checked immediately after capture for regurgitation (if seen, the fish was replaced), and preserved in 10% buffered formalin until examined. Each fish was measured for TL (mm), and weighed ($\pm$ 1 mg) using a Sartorius electronic balance within two weeks after collection and no correction factor for fixation was used. Only the anterior portion of the digestive tract lying between the esophagus and the first major bend of the small intestine, just after the stomach, was dissected out as digestion is less advanced in this portion and food items remain mostly identifiable. Tilapias are reported to have a relatively long and coiled intestine up to 14 times the body length (Edwards 1987), and food digestion and assimilation is completed in the first half of the intestine (Bowen 1981). Similar methods have also been adopted by McComish (1967) and Minckley *et al.* (1970) for buffalo fish; Dewan *et al.* (1977, 1985 and 1991) for carps and Dewan and Saha (1979) for tilapia.

Each stomach was blotted uniformly with tissue paper and weighed once along with the gut contents, then opened longitudinally and gut fullness assessed on a visual scale of 0 (empty), 0.25 ($1/4^{th}$ full), 0.5 (1/2 full), 0.75 ($3/4^{th}$ full) and 1.0 (completely full). The entire gut contents were then carefully transferred to a petri dish or a vial with a standard 10 ml of distilled water. Cleared guts were weighed again to calculate the weight of the gut contents (Dettmers and Stein 1992). Stomach contents were expressed as mg. g^{-1} of bw of the fish (wet weight of both). Larger food items of animal origin were usually counted under a dissecting stereo microscope (Wild Herbrugg), but in the case of tiny items (such items of plant origin, rotifers) the gut contents were well mixed, and 1 ml was sub-sampled by a digital Finn pipette to a Sedgwick-Rafter counting cell (1,000 mm^3, 50x20x1 mm) and 100 randomly chosen grids out of 1,000 were examined and counted under an inverted microscope (Olympus CK2). Three such sub-samples were enumerated per fish. All organisms were identified to genus level (Prescott 1962; Ward and Whipple 1978) and the percentage of each category determined. Percentage composition by number (the percentage abundance) was used for calculating the relative abundance (%) of food item in the stomach (Windell and Bowen 1978, Bowen 1983).

Selection of available plankton by fish was calculated using Ivlev's (1961) electivity index (E).

$$E = St_i - P_i / St_i + P_i$$

where St_i and P_i are the relative proportion of the prey category i in the fish gut (ration) and in the environment, respectively. The resultant index reflects random ingestion (around 0), weak to strong selection (up to +1.0) and weak to strong avoidance (down to -1.0) of a particular food item.

Plankton

Five one litre samples of surface to sub-surface water (within 0.02 m depth) were taken from three places of the pond (near the bank, middle and other side) every three hours prior to fish sampling, filtered through a 15 µm plankton net, carefully washed into plastic jars and made up to a standard 200 ml volume with 5% buffered formalin. Once well settled, plankton were concentrated in a standard 50 ml volume and preserved until examination. Three such 1 ml sub-samples were taken from each plankton sample and the mean numbers. l^{-1}, relative abundance (%) and identification of each food item were done in the same way as for stomach content.

Costello (1990) and Amundsen et al. (1996) approach

Costello's method incorporates frequency of occurrence (FO) of a given prey type (expressed as a frequency of the total number of stomachs in which prey are present) in the x-axis and percentage abundance of a given prey type (defined as the percentage of total stomach contents in volume, weight or numbers in all predators comprised by that given prey) ingested by fish in the y-axis (Fig. 1a). In the Costello plot, generalized feeding strategy (a high within-phenotype contribution to the niche width) is indicated by data points distributed along the entire x-axis, rather than just to the lower right quadrant. In practice, specialized feeding strategy (a high between-phenotype contributions to the niche width) will rarely be determined, as the data points of prey abundance and FO rarely fall into the upper left quadrant (Amundsen *et al.* 1996).

An amendment to the Costello (1990) method was developed by Amundsen *et al.* (1996) by only substituting prey-specific abundance (defined as the percentage in volume, weight or number a given prey taxon comprises out of all prey items in only those predators in which that given prey occurred) for percentage abundance on the y-axis (Fig. 1b) and keeping the FO in the x-axis as such.

In Costello (1990) and Amundsen *et al.* (1996) methods nothing is told about the affect of resources available, accessible or selectivity to a fish's feeding strategy. Presumably it should be considered as, equal availability and electivity of all resources. In nature and field level studies, this assumption is unwarranted and thus describes inappropriately the feeding strategy in respect to both components of the total niche width.

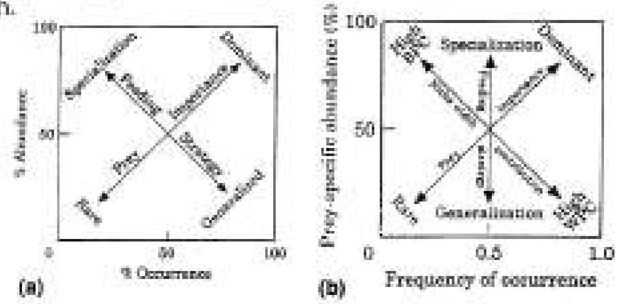


Fig. 1. Explanatory diagram for the (a) Costello (1990) and (b) Amundsen *et al.* (1996) methods (BPC= between-phenotype component, WPC= within-phenotype component).

Results and discussion

New approach

We suggest the use of electivity index, *E* (Ivlev 1961) on the *y*-axis, and maintaining the FO on the *x*-axis (Fig. 2) of the Amundsen *et al.* (1996) plot. We have followed a similar principle (as indicative of biologically significant dietary overlap, coined by Zaret and Rand (1971) in considering the electivity index beyond the arbitrary level of +0.4 and -0.4, respectively representing a biologically significant selection and avoidance, and between -0.4 and +0.4 as generalization. The FO of a particular prey item in the fish's stomach will direct the trends of either individual (low FO) or population (high FO) strategies.

This approach has been applied to the resultant Ivlev's electivity index derived from feeding data (Tables 1 and 2) of two sizes of tilapia, *Oreochromis* spp. and plankton availability data from a nursery pond (Haroon and Pittman 1998). The graphical feeding strategy thus obtained with this new model are shown in Figures 3a and 3b.

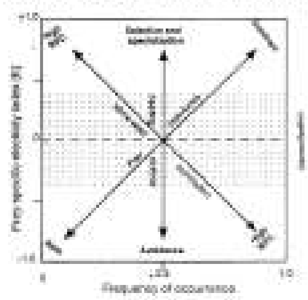


Fig. 2. Explanatory diagram of feeding strategy, niche width contribution and prey electivity for the proposed new method.

Table 1. Diel mean plankton composition (P_i%), stomach composition (St_i%) and resultant electivity indices (E) of two sizes (6 and 12 cm) of *Oreochromis* spp. from a nursery pond (13-15 July 1995), Bangladesh

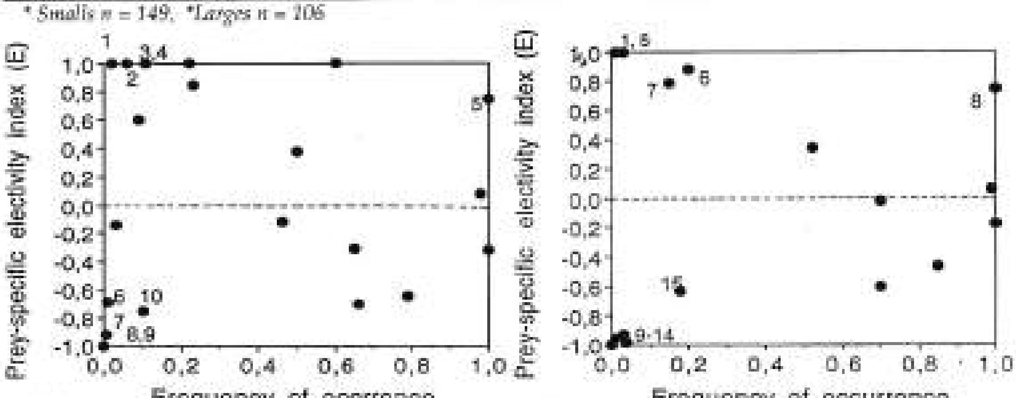
Species	Pond					
	6 cm			12 cm		
	Pi%	Sti%	E	Pi%	Sti%	E
Chlorophyceae						
Ankistrodesmus	6.90	3.67	-0.31	6.90	2.58	-0.46
Scenedesmus	7.02	1.47	-0.65	7.02	1.53	-0.64
Dictyospharium	0.0	0.58	+1.0			
Selenestrum	0.0	0.03	+1.0			
Pediastrum	6.71	7.88	+0.08	6.71	7.64	+0.06
Pleurotaenium						
Closterium	0.0	0.06	+1.0	0.0	0.006	+1.0
Spirogyra	0.05	0.0	-1.0	0.05	0.0	-1.0
Cosmarium				0.0	0.06	+1.0
Cyanophyceae						
Merismopedia	14.41	2.55	-0.70	14.41	0.16	-0.98
Anabeana	6.61	51.23	+0.74	6.61	44.54	+0.74
Oscillatoria				0.0	0.006	+1.0
Bacillariophyceae						
Melosira	55.42	28.42	-0.32	55.42	39.40	-0.17
Asterionella	0.0	0.21	+1.0			
Euglenoid						
Euglenophyceae						
Euglena	0.0	0.25	+1.0	0.0	0.008	+1.0
Phacus	0.02	0.08	+0.60	0.02	0.33	+0.88
Total Phytoplankton	97.14	96.43	-0.003	97.14	96.26	-0.004
Unidentified macrophyt remain				0.0	0.09	+1.0
Rhizopoda						
Diffulgia	0.0	1.20	+1.0			
Rotifera						
Polyarthra	0.11	0.02	-0.69	0.11	0.004	-0.93
Brachionus	1.13	0.88	-0.12	1.13	1.08	-0.02
Keratella	0.43	0.93	+0.37	0.43	0.87	+0.34
Filinia	0.03	0.38	+0.85	0.03	0.24	+0.78
Trichocerca	0.04	0.03	-0.14	0.04	0.0	-1.0
Crustacea						
Moina				0.0	0.01	+1.0
Diaptomus	0.06	0.0	-1.0	0.06	0.0	-1.0
Cyclops	0.23	0.01	-0.92	0.23	0.006	-0.95
Unidentified nauplii	0.83	0.12	-0.75	0.83	0.19	-0.63
Total Zooplankton	2.86	3.57	+0.11	2.86	2.40	-0.09
Digested food					1.25	

Table 2. Frequency of occurrence (Freq. Occurr.) and prey-specific Ivlev's (1961) electivity indices data of two sizes (4.3-9.3 cm TL and 9.5-13.5 cm TL) of tilapia, *Oreochromis* spp. from a nursery pond (13-15 July 1995), Bangladesh

Food items	Small size*		Large size*	
	Freq. Occurr.	Electivity	Freq. Occurr.	Electivity
Chlorophyceae				
Ankistrodesmus	0.15	-0.31	0.85	-0.46

Scenedesmus	0.79	-0.65	0.70	-0.64
Dictyosphaerium	0.22	+1.0		
Selenestrum	0.02	+1.0		
Pediastrum	0.98	+0.08	0.99	+0.06
Closterium	0.06	+1.0	0.01	+1.0
Cosmarium			0.03	+1.0
Spirogyra	0	-1.0	0	-1.0
Cyanophyceae				
Merismopedia	0.66	-0.70	0.04	-0.98
Anabaena	1.0	+0.74	1.0	+0.74
Oscillatoria			0.01	+1.0
Euglenophyceae				
Euglena	0.11	+1.0	0.01	+1.0
Phacus	0.09	+0.60	0.20	+0.88
Unidentified macrophytes			0.01	+1.0
Rhizopoda				
Diffulgia	0.60	+1.0		
Rotifera				
Polyarthra	0.01	-0.69	0.03	-0.93
Brachionus	0.46	-0.12	0.70	-0.02
Keratella	0.50	+0.37	0.52	+0.34
Filinia	0.23	+0.85	0.15	+0.78
Trichocerca	0.03	-0.14	0	-1.0
Crustacea				
Moina			0.01	+1.0
Diaptomus	0	-1.0	0	-1.0
Cyclops	0.006	-0.92	0.01	-0.95
Crustaceans nauplii	0.10	-0.75	0.18	-0.63

* *Smalls n = 149,* **Larges n = 106*



(a) (b)

Fig. 3. Application of new feeding strategy analysis method to stomach content data of *Oreochromis* spp. [*O. mossambicus* (Peters) x *O. niloticus* (Linnaeus) natural hybrid] and resource data from a shallow nursery pond (13-15 July 1995), Bangladesh (refer to Tables I and II). The black dots represent different food items (only the important ones are labeled). **(a)** 4.3-9.3 cm TL, *n*= 149 (1= *Selenestrum* sp., 2= *Closterium* sp., 3= *Euglena* sp., 4= *Asterionella* sp., 5= *Anabaena* sp., 6= *Polyarthra* sp., 7= Crustaceans egg, 8= *Diaptomus* sp., 9= *Spirogyra* sp., 10= Crustaceans nauplii); **(b)** 9.5-13.5 cm TL, *n*= 106 (1= Aquatic macrophytes, 2= *Closterium* sp., 3= *Euglena* sp., 4= *Cosmarium* sp., 5= *Moina* sp., 6= *Phacus* sp., 7= *Filinia* sp., 8= *Anabaena* sp., 9= *Trichocera* sp., 10= *Spirogyra* sp., 11= *Diaptomus* sp., 12= Crustaceans egg, 13= *Polyarthra* sp., 14= *Merismopedia* sp., 15= Crustaceans nauplii).

Interpretations

The fish show selection of prey items when the data points are located on the upper part of the plot (+0.4 to +1.0). Data points positioned in the lower part (-0.4 to -1.0) represent food items that are avoided and food items that have been eaten inadvertently or randomly (between the ranges of +0.4 and -0.4) are positioned in the mid part of the plot. Data points located in the upper left quadrant indicate selection and specialization of prey at individual level (though of low occurrence in the gut but those prey have been strongly preferred by few fish), indicating a high between-phenotype component. Data points generally a single point or a few, in the upper right quadrant represent prey selection and specialization by the fish population (high occurrence of the prey in the gut and that food item has been strongly selected), also indicating a high between-phenotype component. Data points in the mid part of the plot (between +0.4 and -0.4) indicate a generalized feeding strategy, similar to Amundsen *et al.* (1996) within-phenotype component.

Data points in the lower left quadrant indicate avoidance of that food type at the population level. An electivity index of -1.0 for any food item would mean that this particular food item was available in the environment (plankton in this experiment) but never in the fish's ration, and thus the frequency of occurrence of that food item is 0. This applies to all the items found in the environment but avoided by the fish population, and correctly leads to a clustering of data points on the lower left corner. Data points closer to the lower right corner would indicate that most fishes are ingesting that food item but in much lower proportions (indicating avoidance) than found in the environment.

Similarly, there will be an electivity index value of +1.0, indicating strong selection for certain prey items, when they are absent in the resource availability spectrum (plankton in this experiment) sometimes because of their rare occurrence and at other times due to biased sampling and enumeration procedure, but present in the fish's gut. Because, there is no single unbiased sampling procedure for quantifying entire resource spectrum (plankton, benthos, detritus, aquatic vegetation, etc.) available or accessible to fish.

Conclusions

Feeding strategy analysis by Amundsen *et al.* (1996) method seems inappropriate because resource availability data are not taken into account, rather considered as irrelevant. The present proposed method would facilitate understanding of the feeding strategies and total niche width components of predators with reference to the resource availability in the environment. Moreover, information about selection and the predator's ability or limitation to specialize, generalize or avoid prey items both at the individual and population level can be obtained and interpreted objectively. This method seemed to meet the necessity of both resource use and selectivity, concurrently. If the problem inherent to sampling procedure and quantification of entire resources available/accessible to the predators could be overcome in future, the feeding strategy analysis with the proposed method would be more robust and accurate than as reported here. It may be opined that Amundsen *et al.* (1996) method can only be used when resource availability data are lacking.

Since niche width can be described in relation to resource availability and use concurrently (Feinsinger *et al.* 1981), why not feeding strategy analysis using resource use and availability data be in accordance with the theoretical concept of total niche width as coined by Hurlbert (1978) and Petraitis (1979).

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