Vol. 5(2)
July 2001

ISSN : 1026-6690

Bangladesh Journal of Fisheries Research

Bangladesh Fisheries Research Institute

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Publication information: The *Bangladesh Journal of Fisheries Research* is published half-yearly in two issues (January and July). The subscription rate for each annual volume is: (a) individual- BDT 500 (overseas US$ 30), (b) institution- BDT 1000 (US$ 60). The Journal is also available in exchange for publications of learned societies, research institutes and universities. All payments should be made in favour of the *Bangladesh Journal of Fisheries Research*, and all correspondence addressed to the **Director General, Bangladesh Fisheries Research Institute, Mymensingh-2201, Bangladesh. Fax : (+880-91-55259). E-mail: dgbfri@bdonline.com**

Bangladesh J. Fish. Res., 5(2), 2001: 105-114

Size related feeding patterns and electivity indices of silver barb (*Barbodes gonionotus* Bleeker) from a pond, Bangladesh

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Abstract

The feeding patterns with respect to quality and quantity of food of silver barb, *Barbodes gonionotus* varied with their size and development. The results indicated that the fish in the size group I (7-25 mm TL) were fairly omnivore with particular liking for rotifera, green and blue-green algae while the size group II (25.1-44 mm TL) and III (44.1-55 mm TL) were omnivore with higher tendency of feeding on debris, aquatic plants, green algae, blue-green algae and rotifera. However, the fish of the size group IV (55.1-80 mm TL) were found to be herbivore with feeding preference for aquatic plants, green and blue-green algae. In all the size groups, debris was the most dominant food item. Feeding preference of the fish showed clear ontogenetic shift. The electivity indices revealed that the fish were selective feeder.

Key words: Food, Feeding, Electivity index, *Barbodes gonionotus*

Introduction

There exists enormous aquaculture potential of silver barb, *B. gonionotus* as an appropriate species for the seasonal as well as perennial fish ponds. It was introduce to Bangladesh from Thailand in 1977 and by now it has become a popular fish in our country (FRI 1992). But the performance of this species in our closed water condition have not yet been evaluated. The most important aspects of biology of any fish is the study of its food and feeding habits which is a prerequisite for its culture operation. A knowledge of food and feeding habits would thus help in the species selection for polyculture by ensuring maximum survival through utilization of all available potential food in the water bodies with minimum competition.

Dietary overlap is affected by food availability, competition, and the size of the fish, among other factors. Though fish may broaden their dietary breadth when food resources are scarce, food items may remain sufficiently partitioned for competition to be avoided (Keast 1977, Keast and Fox 1990). Intrspecific niche overlap decreases with ontogenetic shifts in diet, i.e. differences in habitat utilization by young and adults and increasing disparity in size (Pen *et al.* 1993, Esteves and Galetti 1995). The present experiment was carried out to know the feeding habit and the variations in quality and quantity of food taken by different sizes of *B. gonionotus*.

Materials and methods

The *B. gonionotus* for the present study was collected from April to June '96 by a small seine net from a rainfed artificial pond. Samplings were done fortnightly at 9.00 to 10.00 am and a total of 60 fish measuring 7-80 mm in total length (TL) were collected. Immediately after collection, the fish were killed by suffocation and preserved in 10% buffered formalin to prevent further digestion of food and brought to the laboratory and dissected out the gut and put on a labeled vial for further studies. For the study, the total length of fish in millimeter were measured and grouped into four groups according to their size. All fishes were divided into four size groups and was designated as - group I (7-25 mm TL), young; group II (25.1-44 mm TL), juvenile; group III (44.1-55 mm TL), pre-adult and group IV (55.1-80 mm TL), adult.

Gut content analysis

The stomach of individual fish was dissected out immediately after sampling and the index of fullness of the stomach was visually recorded irrespective of the size of the stomach or the fish and assigned a score of; 0 for empty, 1.0 for one-fourth, 2.0 for half, 3.0 for three-fourth and 4.0 for full. Then the volume of stomach contents was also assessed visually on an obsolete scale and points were allotted to each stomach according to the volume of its contents (Hynes 1950). The stomach with largest volume was allotted 100 points, and each of the stomach as examined was then rated in one of the following point categories 0, 3, 6, 12, 25, 50 and 100 points according to volume of the food present. The categories were based on inspection and estimation, but a set of stomachs of all categories were made from extra stomach and was used in relating absolute volumes to assign point values. Stomach with intermediate quantities of food were allotted to the point categories which they closely approach. Then it was diluted with distilled water to 4 ml. One ml sub-sample from 4 ml sample was transferred by a pipette to a Sedgwick-Rafter cell. By using a binocular microscope (Swift, M-4000D), all organisms were counted and each food item was identified to the nearest taxonomic group. Organisms of each taxonomic group were then summed together and points were assigned to the different categories of food according to their respective volume partitioning the total points allotted to the fish. Bellinger (1992), Rosalind (1978) and Needham and Needham (1962) were consulted for identification of the different food items.

Plankton collection, preservation and enumeration

Water samples were also taken from different areas and depth of the pond to make representative sample of the sampling days and filtered through a fine mesh sealed plankton net. Filtered sample was taken into a plastic bottle and preserved in 5% formalin for further studies. By using a Sedgwick-Rafter cell and a binocular microscope, 1 ml sub-sample was examined for each sample and identification of different food items were done according to Bellinger (1992), Rosalind (1978) and Needham and Needham (1962).

Electivity index (E) was calculated by Ivlev's (1961) classical electivity index (E):

$E = r_{gi} - P_{wi} / r_{gi} + P_{wi}$

where, r_{gi} is the relative content of any food ingredient in the ration expressed as percentage of total ratio, and P_{wi} is the relative proportion of the same item in the environment. The calculated value of E ranged from +1 to -1, where positive values indicate selection and negative values indicate avoidance for certain food items.

Results and discussion

Relationship of size and patterns of feeding based on average index of fullness and average points per fish

The values of average index of fullness (Table 1) showed little variations in different size groups. Yet comparatively higher value of average index of fullness were recorded in the size group IV, III and II with maximum value (3.9) in the size group IV. The lowest value (2.8) of average index of fullness was recorded in the size group I and this value was closely followed by the value of 3.1 recorded in the size group II. The results clearly indicated that the fish of the larger size groups fed more actively than the smaller ones.

Table 1. Relationship of fish size and patterns of feeding of *B. gonionotus* based on average index of fullness and average points per fish

Items	Group I (7-25 mm)	Group II (25.1-44 mm)	Group III (44.1-55 mm)	Group IV (55.1-80 mm)
Number of fish examined (n)	15	15	15	15
Average length in mm	16.4	30.6	47.6	62.5
Average index of fullness	2.8	3.1	3.7	3.9
Number of total points	262	425	500	612
Average points per fish	17	28	34	40

Total length in mm in parenthesis

The values of average points per fish showed clear variations with the increase in size of fish (Table 1). The highest value (40) of average points per fish was recorded in the size group IV and the lowest value (17) of the same was recorded in the size group I. Values of average points per fish were found to decrease with the decrease in size of fish. From the values of average points per fish, it can be concluded that the amount of food in stomachs increased with the increase in size of fish. This might be due to larger size of stomachs as the fish increased in size. Dewan *et al.* (1977) observed similar size related feeding pattern in *Labeo rohita*.

Relationship of size and patterns of feeding based on food categories

Size group I: The fish of this size group fed mostly on rotifera, green and blue-green algae, debris, bacillariophyceae and euglenophyceae. In this size group, by percentage of occurrence rotifera (100%), green algae (86.66%), blue-green algae (80%), debris (66.66%), bacillariophyceae (66.66%) and euglenophyceae (60%) were the most dominant food items in this size group (Fig. 1). These were followed by higher aquatic plant (33.33%), cladocera (33.33%) and copepoda (26.66%). By percentage of total points, green algae (24.72%), rotifera (20.78%) and blue-green algae (17.25%) were found to be the most dominant food items and were followed by bacillariophyce (10.50%), debris (10.00%) and higher aquatic plants (4.39%). Next to higher aquatic plants were cladocera (4.00%), euglenophyceae (3.44%), copepoda (1.02%) and others (included dried grass leaves, stem of plants, seeds and unidentified hardy mass, these food items seemed to be of incidental comprising of only, 1%) (Fig. 2).

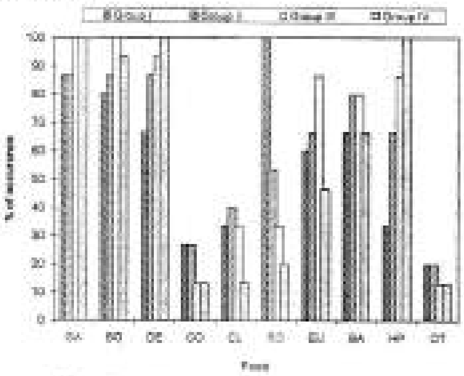

Fig. 1. Size related patterns of feeding based on percentage of occurrence with respect to food categories (GA= Green algae, BG= Blue-green algae, DE= Debris, CO= Copepoda, CL= Cladocera, RO= Rotifera, EU= Euglenophyceae, HP= Higher aquatic plants and OT= Others).

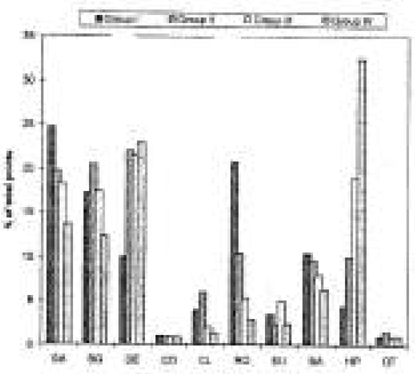

Fig. 2. Size related patterns of feeding based on percentage of total points with respect to food categories (GA= Green algae, BG= Blue-green algae, DE= Debris, CO= Copepoda, CL= Cladocera, RO= Rotifera, EU= Euglenophyceae, HP= Higher aquatic plants and OT= Others).

From the above observation, it can be concluded that the fish of this size group fed almost equally on both plant and animal foods and can be considered as fairly omnivore. However, higher aquatic plant was taken by the fish of this size group in a small amount. This was probably due to the fact that the fish of this size group were too small to eat higher aquatic plant. Kamal (1971) observed that rotifera, cladocera, copepoda and insects larvae were the food items of rohu (*L. rohita*) fry.

Size group II: In this group debris was the most dominant and preferred food item both by the percentage of occurrence and percentage of total points (Figs. 1 and 2). By percentage of occurrence, debris (86.66%), green algae (86.66%) and blue-green algae (86.66%) were the dominant food items. They were followed by bacillariophyceae (80%), euglenophyceae (66.66%) and higher aquatic plant (66.66%). Next to higher aquatic plants, rotifera (53.33%), cladocera (40%), copepoda (26.66%) and others were found to occupy the successive positions.

By percentage of total points, debris (22%) was followed by blue-green (20.51%) and green algae (19.73%). Rotifera (10.44%), higher aquatic plants (10%), bacillariophyceae (9.70%) and cladocera (6.04%) were found to occupy the successive positions after the green algae. These were followed by euglenophyceae and copepoda. From the above observation it may be concluded that debris, blue-green and green algae, higher aquatic plants and rotifera were the most preferred food of this size group. This indicated that the fish of this size group were though omnivore yet started to show feeding preferences for plant foods.

Size group III: This group showed a similar feeding pattern as that of the size group II, debris and plant food were the most dominant and preferred food items. Whereas, animal foods were taken in a small amount by this group. By percentage of occurrence, green algae (100%), blue-green algae (100%) and debris (93.33%) were the most dominant food items while by percentage of total points, debris (21.42%), higher aquatic plants (19%), green algae (18.23%) and blue-green algae (17.46%) were the most dominant food items. However, respectively by percentage of occurrence and percentage of total points bacillariophyceae (80%, 8%), rotifera (33.33%, 5.32%) cladocera (33.33%, 2.02%) and euglenophyceae (86.66%, 5%) were important food items (Figs. 1 and 2). Copepoda was taken by this fish incidentally.

A remarkable increase in the proportion of plant foods and decrease in the presence of animal foods in the stomach contents of this size group indicated that the fish of this size group are showing an ontogenetic dietary shift. Kumar *et al.* (1986) noted that *Puntius filamentosus* and *P. amphibius* were omnivore with preferences for filamentous algae and higher aquatic plants.

Size group IV: This group also showed a similar feeding pattern as that of the size group III, and were found to be feeding mostly on higher aquatic plants, debris, green and blue-green algae. By percentage of occurrence, higher aquatic plants (100%), debris (100%) and green algae (100%) occupied the highest position which were followed by blue-green algae (93.33%). Next to blue-green algae were bacillariophyceae (66.66%), euglenophyceae (46.66%) and rotifera (20%). Next to these food groups, copepoda (13.33%), cladocera (13.33%) and others (13.33%) occupied the same position in respect to percentage of occurrence (Fig. 1). However, amongst all food items, higher aquatic plants (32.47%) and debris (22.98%) were the most dominant food by percentage of total points (Fig. 2). Next to debris were green algae (13.77%), blue-green algae (12.37%), bacillariophyceae (6.35%) rotifera (2.95%) euglenophyceae (2.47%), cladocera (1.40%), others (1.03%) and copepoda (0.90%). It appeared that euglenophyceae among the plant foods and copepoda among the animal foods were by far the less important food groups.

In this size group proportion of higher aquatic plants was found to increase to a considerable extent, both by the percentage of occurrence and percentage of total points than the other size groups. From the above findings it can be concluded that the fish of this size group were herbivore with likings for higher aquatic plants, green and blue-green algae. Javid (1971) recorded that *P. sophore* was herbivore feeding mostly on algae (chlorophyceae, bacillariophyceae and xanthophyceae).

Although, the fish were found to be omnivore in most of the size groups yet the proportion of plant foods and debris were found to increase significantly in the stomach contents of the size groups II and III. Plant foods were found to be most preferred by the size group IV. This might be due to the change of food and feeding habits of fish with its increasing size. However, in all the size groups, debris was the most important food item of this fish. Rotifera and cladocera were found to be important food items in smaller size groups and less important food items in larger size groups. The amount of different food items, except higher aquatic plant was found to increase with the increase in size of the fish. This might be associated with increased size of the stomach as the fish increased in size. Whereas, the proportion of animal foods decreased with the increase in size of the fish. This fish showed less feeding performance for animal foods as it increased in size. The small size group of *B. gonionotus* had a wider dietary breadth than the large individuals. Large fish increased their specialization on certain food items (on aquatic macrophytes) and narrowed down their niche width with increasing size and competitive ability (Haroon and Pittman 1997, 1998 and 2000).

Electivity indices

Electivity indices of different size groups of fish are shown in Table 2. The present investigation showed that *B. gonionotus* appeared to be a selective feeder. For all planktonic crustaceans (copepoda, cladocera), nauplii and *Daphnia* were positively selected which decrease with the increment of fish sizes. In case of *Cyclops*, *Diaptomus*, *Diaphanosoma*, negative selection was observed in the smallest size group. Although in the later size groups those had been positively selected, except *Diaphanosoma* in size group IV which was negatively selected.

Table 2. Electivity indices (E) of four size groups of *Barbodes gonionotus*

Plankton	Electivity indices of four size groups			
	Size group I (7 - 25 mm)	Size group II (25.1 - 44 mm)	Size group III (44.1 - 55 mm)	Size group IV (55.1 - 80 mm)
Green algae				
Ankistrodesmus	-0.82	-0.50	-0.70	+0.20
Botryococcus	-	-0.31	-0.51	-0.80
Chlorella	+0.91	+1.00	+1.00	+1.00
Crucigenia	-	-	+0.20	+0.50
Gonatozygon	-0.50	-0.40	+0.20	+0.81
Gleocystis	-0.50	+0.18	+0.40	+0.53
Oocystis	-	-	-	+0.50
Pediastrum	-	-0.50	+0.29	+0.49
Scenedesmus	-	-	-	-0.47
Spirogyra	-	-	-	-0.10
Tetraedron	-	-0.50	-0.21	+0.21
Ulothrix	-0.33	+0.10	+0.59	+0.61
Volvox	-	-	-	-0.21
Blue-green algae				
Anabaena	-	-	-	+0.41
Aphanocapsa	-	-	-	+0.79
Chrococcus	-	-0.50	+0.43	+0.87
Microcystis	-0.33	-1.00	+0.19	+0.25
Merismopedia	-	-	-	-
Oscillatoria	+0.03	+0.07	+0.33	+1.00
Basillariophyceae				
Fragelaria	-	-	+0.39	+0.67
Navicula	+0.09	+0.57	+1.00	+1.00
Euglenophyceae				
Euglena	-	-	-0.50	-0.69
Phacus	-	-	-	+0.50
Copepoda				
Cyclops	-0.80	+0.20	+0.43	+0.01
Diaptomus	-0.42	+0.12	+0.29	+0.01
Nauplii	+1.00	+0.84	+0.46	+0.18
Cladocera				
Daphnia	+0.61	+0.56	+0.40	+0.08
Diaphanosoma	-0.76	+0.52	+0.43	-0.21
Rotifera				
Brachionus	+0.14	-0.50	-0.97	-1.00
Filinia	-	-0.45	-0.29	-0.10
Keratella	+0.40	+0.20	-0.70	-0.98
Lecane	-0.60	-0.40	-0.20	-0.39
Polyarthra	-	-	-1.00	-
Trichocera	-0.17	-0.29	-0.46	-0.78

Among the rotifera, *Lecane, Filinia* and *Trichocera* were avoided and *Polyarthra* was completely avoided. *Brachionus, Keratella* were positively selected in smaller size groups, although with the increment of fish size they were avoided. Among the green algae, all groups selected *Chlorella* and an increasing positive selection was observed for *Ankistrodesmus, Gonatozygon, Gleocystis, Oocystis, Pediastrum* and *Ulothrix* by the larger size groups. In this planktonic group some genera were eluded by the smaller size groups but they were positively selected by the larger sizes. *Spirogyra, Scenedesmus* and *Volvox* were avoided by all sizes. Among the blue-greens *Oscillatoria* was positively selected by all size groups. *Anabaena, Aphanocapsa, Chrococcus, Microcystis* were avoided by the smaller size groups. But they were positively selected by the larger sizes. All sizes exhibited positive selection to *Navicula*. Among the euglenophyceae, *Phacus* was selected only by at the size group IV while *Euglena* was avoided by all groups. Fish thus exhibited a ontogenic dietary shift in planktivory with the increase in their sizes from zooplankton to phytoplankton. Haroon and Pittman (1997) reported that large silver barb consumed macrophytes as well as microcystis, anabaena, spirogyra and cladocera and crustaceans (in the pond) or mollusks (in the rice field). Overall electivity was negative for microalgae. Zooplankton were avoided by large fish in the rice field. They also reported that improved fish yields may be achieved by stocking small *P. gonionotus* where available feed resources include important amounts of zooplankton, and by allowing aquatic macrophytes and weeds to grow in the rice field or pond after stocking, such that the growing fish can feed increasingly on these.

In the present study *B. gonionotus* showed pronounced elctivities for different food items and elctivity varied with the fish sizes. Selective feeding is expected when the energy gained by feeding on preferred food items exceeds the energy that has been lost during selection (Al-Akel *et al.* 1987). Wankowsky (1979) and Bartell (1982) reported that fishes expend more energy in selection of larger prey in order to gain more energy. In the present investigation *B. gonionotus* during early stage preferentially selected zooplankton (Table 2) to earn maximum energy to fulfill routine metabolic requirements and growth. The energy content of aquatic algae is very poor and carps cannot obtain sufficient energy to grow when only phytoplankton is available as food item, because phytoplankton are reported to be poorly digested and conversion efficiencies are low (Hamada *et al.* 1983, Bitterlich 1985).

A gradual increasing selection for phytoplankton and a decreasing selection for zooplankton with increment of fish size indicated changes in food habit towards herbivory. Cremer and Smitherman (1980) reported that fishes feeding on plant material generally have greater gut lengths than those feeding on animal matter. Table 3 confirms an increase in gut length relative to its standard length among the *B. gonionotus* supporting the observation that this species becomes increasingly herbivorous with the increase in size.

Table 3. Relationship between standard length and gut length of four different size groups of *B. gonionotus*

Different size groups	Average standard length (mm)	Average gut length (mm)	Gut length: Standard length
7 - 25 mm TL, I	16.4	41.00	1: 2.5
25.1 - 44 mm TL, II	30.6	85.68	1 : 2.8
44.1 - 55 mm TL, III	47.6	135.66	1 : 2.8
55.1 -80 mm TL, IV	62.5	181.25	1 : 2.9

Acknowledgments

Grateful acknowledgment is made to the IFS (International Foundation for Science) for financial assistance for the work.

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(Manuscript received 1 November 2000)

Bangladesh J. Fish. Res., 5(2), 2001: 115-122

Culture of *Amblypharyngodon mola* in rice fields alone and in combination with *Barbodes gonionotus* and *Cyprinus carpio*

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Abstract
A rice-fish culture experiment with four treatments *viz*., T_1 with *Amblypharyngodon mola* alone, T_2 with *A. mola* and *Barbodes gonionotus*, T_3 with *A. mola* and *Cyprinis carpio* and T_4 as control (without fish) was carried out in the rice fields during April through August'99. The recovery rate of *A. mola* were 42%, 37% and 42% in treatments 1, 2 and 3 respectively and the same recorded for *B. gonionotus* and *C. carpio* were 62% and 55% respectively. Among the three species of fish, *B. gonionotus* showed much higher recovery rate than both of *A. mola* and *C. carpio*. The production of *A. mola* was 12.50 kg/ha/3 months in monoculture, and 7.92 kg/ha/3 months and 8.86 kg/ha/3 months in combination with *B. gonionotus* and *C. carpio*, respectively. The production of *B. gonionotus* in T_2 was 169.29 kg/ha/3 months and *C. carpio* in T_3 was 252.92 kg/ha/3 months. The total fish production was 12.50 kg/ha/3 months, 175.21 kg/ha/3 months and 261.88 kg/ha/3 months in T_1, T_2 and T_3 respectively. The highest yields of rice grain (5.78 ton/ha) and straw (7.83 ton/ha) were recorded in T_3 and the lowest of the same was in T_4 (grain 4.96 ton/ha and straw 6.62 ton/ha). Rice yield increased by about 12.10% in T_1, 13.30% in T_2 and 16.33% in T_3 in context to T_4, rice-alone culture. The results demonstrated that the culture of fish in rice fields had profound beneficial impact on the production of rice grain and straw.

Key wards: Rice-fish culture, *A. mola*, *B. gonionotus*, *C. carpio*

Introduction

Vitamin-A deficiency is one of the major causes of wide spread child blindness in Bangladesh. Sixteen small indigenous species (SIS) of fish are prescribed for small-scale culture (Felts *et al.* 1996) in rural areas. Among these *A. mola* is of special interest to fish culturists because of its high vitamin-A and other micronutrient content. *A. mola* contains 200 IU of vitamin-A per gram of edible protein (Zafri and Ahmed 1981). A medium sized *A. mola* fish has about 2.0 g of edible protein in its body, which contains about 520 IU of vitamin-A. This means that intake of only three *A. mola* daily would contribute too more than 1,500 IU of vitamin-A, which is sufficient to save a child from blindness (BSS 1988). On the other hand, Bangladesh possess more than 2.83 million ha of seasonal paddy fields where water stands for 4-6 months, providing great scope for rice-fish culture. Fish harvested from these areas is around 37 kg/ha (MPO 1985). Fish culture in rice fields can provide adequate means of income and food for the rural people, since the production of staple grain and a high quality valuable protein can be accomplished from one system on the same piece of land (Ahmad 1956, Haroon and Alam 1992).

The potential biological advantages which *A. mola* offer is their rapid growth, several spawning in the same season and possibility to culture in the shallow stagnant water like rice fields. The present study has thus been undertaken to determine the suitability of *A. mola* culture in rice field both alone and in combination with *B. gonionotus* and *C. carpio*.

Materials and methods

The experiment was conducted in the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during April through August'99. Twelve experimental plots were randomly selected from 0.20 hectares area. Rain and deep tube-well were the sources of water supply to the experimental plots during the study period. A 0.50 meter wide embankment surrounded the experimental area and protected the plots from flooding. A 4 m^2 ditch was constructed in the middle and having a depth of about 70 cm. The plots were well ploughed, leveled and made weed free. The seedlings of rice variety BR-2 (Mala) of 45 days old were transplanted on 17th May'99 in alternative row spacing of 35 cm ± 15 cm. The plant to plant distance was 20 cm. The alternative row spacing provided enough space for easy movement of fishes. All the rice plots were identically fertilized with urea, T.S.P., MP and gypsum at the conventional rates.

After 15 days of transplanting, only *A. mola* were stocked in the T_1 at the rate of 20,000 fry/ha, *A. mola* plus *B. gonionotus* and *A. mola* plus *C. carpio* were stocked in the treatments T_2 and T_3 at the rate of 14,000 fry/ha plus 3,750 fry/ha, respectively. During the period of fish culture, water level varied between 15-30 cm. No pesticide was applied to the crop field and no supplementary feed was used for fish.

On maturity, rice was harvested on 30 August'99. The grain and straw were cleaned, sun dried to 14% moisture content and weighted plot-wise and then converted to ton/ha The fish was harvested after rice harvesting, i.e. 88 days after stocking fish fry. Number, length and weight of individual fish was counted plot-wise. All the data were analyzed statistically using Analysis of Variance (ANOVA) and the mean values were compared using Duncun's Multiple Range Test (Gomez and Gomez 1984).

Results and discussion

Growth and recovery rate of fish

During the experimental period the growth rate of *A. mola* by net (1.13 cm and 0.72 g), percentage (27.90% and 86.05%) and SGR (0.70% day) were higher in combination with *C. carpio* among the 3 treatments (Table 1). Between the rest of the two species of fish, *B. gonionotus* showed higher net increase (11.33 cm) and percentage of increase (197.85%) in length, on the contrary, *C. carpio* showed higher net increase (114.46 g), percentage of increase (1358.04%) and SGR (3.04% day) in weight might be associated with their body shape. Growth rate and specific growth rate of 3 species in length and weight are shown in Tables 2-4. The growth rate of *B. gonionotus* recorded by Hossain (1989) was 15.3 cm in length and 77.70 g in weight in his rice fish culture. Whereas, Akhteruzzaman *et al.* (1993) reported the growth rate for *B. gonionotus* and *C. carpio* were 38 g and 63 g respectively in rice fish culture. The difference between the growth rates of both the species recorded in the present study and the growth rate recorded by them might be due to stocking size, stocking density and period of culture.

The recovery rate of fish was determined from the recovery data at the end of the experiment. The recovery rate for *B. gonionotus* was almost close to the recovery rate (65% and 68%) recorded by Rahman *et al.* (1995) and Akhteruzzaman *et al.* (1993), respectively in their experiments. The recovery rate recorded for *C. carpio* in the present study is the conformity with the same (53%) recorded by Akhteruzzaman *et al.* (1993).

Production of fish

In treatment T_1, by stocking 0.90 kg of *A. mola*, only 0.6 kg of *A. mola* was produced and loss of about 0.3 kg. In treatment T_2 stocking 0.59 kg, produced only 0.38 kg of *A. mola*. While 8.03 kg of *B. gonionotus* was produced by stocking only 0.97 kg and in treatment T_3 0.43 kg of *A. mola* was produced by stocking 0.55 kg while 12.14 kg of *C. carpio* was produced by stocking 1.54 kg fry.

It was observed that production of *A. mola* was very low compared to the production, 1,750 kg/ha/year and 58.57 kg/ha/4 month recorded by Ameen *et al.* (1984) and Islam (1997), respectively. At the end of the experiment when all the fishes were harvested most of the *A. mola* were small and they could easily hide in the rice field clay. So, they were not easily harvestable. But the adult *A. mola* could be harvested easily.

The production of *B. gonionotus* in rice field recorded by Khan *et al.* (1997) was 229.22 kg/ha, which was much higher than that of the present study (169.29 kg/ha). This might be attributed to stocking size and recovery rate. The production of *B. gonionotus* obtained by MCC (1994) and Akhteruzzaman *et al.* (1993) was similar to the production recorded in the present study. Khan *et al.* (1997) obtained a production of 233.49 kg/ha of *C. carpio* in rice fish culture, which is quite close to the production recorded in the present study. So production of *B. gonionotus* and *C. carpio* is acceptable in rice fish

Table 1. Details of stocking, harvesting and production of fish under different treatments in the rice fields

Treatments	Fish species	At stocking			At harvesting			Recovery rate (%)	Production (kg/ha)	
		Average initial wt (g)	Total no. of fish	Total wt. of fish (kg)	Average final wt. (g)	Total no. of fish recaptured	Total wt. of fish (g)			Total
T_1	*Amblypharyngodon mola*	0.94±0.01	960	0.90	1.50±0.01	403	0.60	42	12.5	12.5
T_2	*Amblypharyngodon mola*	0.90±0.04	660	0.59	1.55±0.03	244	0.38	37	7.92	175.21
	Barbodes gonionotus	5.37±0.42	180	0.97	71.66±2.02	112	8.03	62	167.29	
T_3	*Amblypharyngodon mola*	0.83±0.01	660	0.55	1.55±0.03	277	0.43	42	8.96	261.88
	Cyprinus carpio	8.54±0.85	180	1.54	122.67±4.8	99	12.14	55	252.92	

culture and there was no negative impact was found on growth and production of *B. gonionotus* and *C. carpio* due to introduction of *A. mola* in rice fields. Kohinoor *et al.* (1998) found that *A. mola* exerted a negative impact on growth and production of carps in polyculture system.

Table 2. Growth rate and specific growth rate of *B. gonionotus* by average in length and weight

Parameters	Treatment	Replication	Initial	Final	Net increase	% increase	SGR (% day)
Length (cm)	T_2	R_1	6.8	17.5	10.7	157.35	
		R_2	5.6	17.0	11.8	210.71	
		R_3	5.1	16.6	11.5	225.49	
	Mean ± S.E		5.83 ±0.50	17.03 ±0.26	11.33 ±0.33	197.85 ±20.69	
Weight (g)	T_2	R_1	6.2	75	68.8	1109.67	2.83
		R_2	4.9	72	67.1	1239.38	2.83
		R_3	5.0	68	63	1260.00	2.97
	Mean ± S.E		5.37 ±0.42	71.66 ±2.03	66.3 ±1.72	1246.35 ±75.28	2.87 ±0.04

Table 3. Growth rate and specific growth rate of *C. carpio* by average in length and weight

Parameters	Treatment	Replication	Initial	Final	Net increase	% increase	SGR (% day)
Length (cm)	T_3	R_1	9.5	22	12.5	131.58	
		R_2	8.2	18	9.8	119.51	
		R_3	8.5	18	9.5	117.76	
	Mean ± S.E		8.73 ±0.39	19.33 ±1.33	10.6 ±0.95	120.95 ±5.77	
Weight (g)	T_3	R_1	10.2	132	122.8	1203.92	2.91
		R_2	7.39	120	112.6	1523.81	3.17
		R_3	8.02	116	107.98	1345.38	3.04
	Mean ± S.E		8.54 ±0.85	122.67 ±4.8	114.46 ±4.38	1358.04 ±92.53	3.04 ±0.07

Table 4. Growth rate and specific growth rate of *A. mola* by average in length and weight

Parameters	Treatment	Replication	Initial	Final	Net increase	% increase	SGR (% day)
Length (cm)	T_1	R_1	4.6	5.0	0.4	8.7	
		R_2	5.0	5.3	0.3	6	
		R_3	4.7	5.4	0.7	14.9	
	Mean ± S.E		4.77±0.01	5.23±0.12	0.5±0.12	9.87±2.65	
Weight (g)	T_1	R_1	0.94	1.49	0.55	58.81	0.52
		R_2	0.92	1.47	0.55	59.78	0.53
		R_3	0.96	1.53	0.57	59.38	0.53
	Mean ± S.E		0.94±0.01	1.50±0.01	0.56±0.01	59.32±0.28	0.53±0.003
Length (cm)	T_2	R_1	4.1	5.2	1.1	26.82	
		R_2	4.2	5.4	1.2	28.60	
		R_3	4.6	5.2	0.6	13.04	
	Mean ± S.E		4.3±0.15	5.3±0.07	0.96±0.19	22.81±4.91	
Weight (g)	T_2	R_1	0.85	1.53	0.68	80.00	0.56
		R_2	0.87	1.62	0.75	86.20	0.71
		R_3	0.97	1.49	0.52	53.60	0.49
	Mean ± S.E		0.90±0.4	1.55±0.03	0.65±0.06	73.20±9.95	0.59±0.06
Length (cm)	T_3	R_1	4.0	5.1	1.1	27.50	
		R_2	4.1	5.2	1.1	26.19	
		R_3	4.0	5.2	1.2	30.00	
	Mean ± S.E		4.03±0.03	5.2±0.03	1.13±0.03	27.90±1.12	
Weight (g)	T_3	R_1	0.83	1.50	0.67	80.72	0.67
		R_2	0.85	1.56	0.71	83.52	0.69
		R_3	0.82	1.59	0.77	93.90	0.75
	Mean ± S.E		0.83±0.01	1.55±0.03	0.72±0.03	86.05±4.00	0.70±0.02

Production of rice grain and straw

Among the four treatments, the highest production of rice grain and straw were recorded in T_3, where *A. mola* was cultured with *C. carpio*, which is closely followed by the production in T_2 and T_1. The production of grain ranged from 4.96 to 5.77 ton/ha. Khan *et al.* (1997) found that the production range of rice grain in rice fish plots was 6.03 to 6.16 ton/ha. In the present study, production of rice grain and straw obtained in the treatments with fish and without fish were found to differ significantly ($P<0.01$). On the basis of production of rice grain, no statistical significant difference ($P>0.01$) was found among the three treatments with fish. The production of grain obtained by Gupta and Mazid (1993) and Kohinoor *et al.* (1993) in their experiments on rice fish culture was almost similar to the production of grain obtained in the present study. Coche (1967) reported that the yield of grain and straw was increased by the introduction of fish into the rice fields, because they ate up harmful organisms such as insects and insect larvae and they also grazed on the weeds. In rice farming alone, weed can reduce yield upto 50%. Akhteruzzaman *et al.* (1993), Kamp and Gregory (1993) and Mazid *et al.* (1993) also stated that introduction of fish in the rice fields reduced the infestation of insects and weeds by feeding upon them and thereby improves the yield of rice.

The results of the study indicate that culture of *A. mola* in rice field alone gives a low production having positive impact on production of *B. gonionotus* and *C. carpio* in mixed culture system as well as on rice grain and straw yield.

Table 5. The production of rice grain and straw in different treatments

Treatment	Fish species	Production of rice (ton/ha)		% Increased over control	
		Grain	Straw	Grain	Straw
T_1	*A. mola*	5.56^a	7.30^b	12.10	10.27
T_2	*A. mola* *B. gonionotus*	5.62^a	7.61^{ab}	13.30	14.95
T_3	*A. mola* *C. carpio*	5.78^a	7.83^a	16.33	18.28
T_4	Without fish	4.96^b	6.62^c		

Similar superscript denotes no significant difference (P>0.01)
Dissimilar superscript denotes significant difference (P<0.01

Acknowledgements

The authors are grateful to the DANIDA for providing financial support to carry out this study through an ENRECA project.

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(Manuscript received 7 March 2000)

Bangladesh J. Fish. Res., 5(2), 2001:123-134

Culture potentials of mola (*Amblypharyngodon mola*), chela (*Chela cachius*) and punti (*Puntius sophore*) under monoculture system

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Abstract

To assess the production potentials of small indigenous fish species (SIS) in semi-intensive monoculture system, an experiment was carried out with *Amblypharyngodon mola*, *Chela cachius* and *Puntius sophore*. Three treatments each with three replications were tested with mola, chela and punti individually and the stocking density of each species was 100,000/ha. Organic fertilizer was applied to the ponds at the rate of 1,000 kg/ha at fortnightly and rice bran was supplemented daily at 3% of the total fish biomass. Partial harvesting was made after three months of stocking. Gross production of 805±52.94, 1,120±41.62 and 509±48.81 kg/ha, respectively for mola, chela and punti over a period of six months were obtained. The yield of punti was found to vary significantly ($P<0.05$) from that of mola and chela.

Key words: SIS, *A. mola*, *C. cachius*, *P. sophore*, Semi-intensive culture

Introduction

Small fishes play a vital role in the inland capture fisheries of Bangladesh. In the past, these indigenous fish species were abundantly available in rivers, streams, ponds, beels, ditches and flood plains of the country. But now a day, these species have gradually been disappearing from the systems which in turn severely affecting the biodiversity of our aquatic ecosystem. There are many small fish in our country such as *Puntius* spp., *Gudusia* spp., *Amblypharyngodon* spp., *Chanda* spp., *Ompok* spp., *Rohtee cotio*, *Colisa* spp., *Corica soborna*, *Esomus danricus* etc. which are potential to aquaculture.

Culture of small indigenous fish species needs special attention because these fish provide us plenty of vitamin, iron, calcium, and minerals. Besides it is affordable to the poor people due to its low market price compared to carps. Nutrition surveys conducted in Bangladesh revealed that there has been high prevalence of vitamin-A deficiency in rural population especially among the pre-school children. About 75% of the rural children in Bangladesh suffer from malnutrition and 25% of them below 5 years of age die due to malnutrition (Ahmed and Hassan 1983). Researches have shown that small indigenous fish species have a high nutritional value in terms of both protein content and the presence of micro-nutrients, vitamins and minerals that are not usually available in large carps (Thilsted *et al.* 1997).

In spite of great importance of small indigenous fish species, few attempts have been made to study their biological and cultural potential. Since 60s, UNICEF, Dhaka tried to attract the attention of the people to culture the small fish in small water bodies (Alam 1979, Ameen *et al.* 1982). Preliminary attempt was made to culture small indigenous fish mola, bata and kholisa in ponds (Akhteruzaman *et al.* 1997) and polyculture of carps with mola and chapila in small ponds were also tried (Kohinoor *et al.* 1997, Hossain *et al.* 1998). The present study has been devised to assess the production potentials of three important small fish, mola, chela and punti in monoculture system.

Materials and methods

Pond preparation

The study was carried out for a period of six months from May to October'98 in nine ponds of Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The ponds were with an area of 100 m^2 each and an average depth of about 1.5 m. Water of all the experimental ponds was drained out and all fish species and other animals were removed in April. The pond bottoms were treated with lime at the rate of 250 kg/ha. After 5 days of liming, the ponds were filled up with water and fertilized with organic manure (cow dung) at the rate of 1,000 kg/ha. After five days of fertilizer stocking of fish was done.

Fish stocking and management

Three treatments each with three replicates were tested. Mola, punti and chela with the average size of 1.80±0.27, 2.50±1.80 and 1.55±0.29g, respectively were stocked individually in treatments 1, 2 and 3 at the stocking density 100,000/ha. Fine rice-bran was fed to fishes at the rate of 3 % of their standing biomass. Ponds were also fertilized with cow dung at the rate of 1,000 kg/ha at fortnightly intervals.

Water quality determination

Water quality parameters such as water temperature (°C), secchi depth (cm), p^H, dissolved oxygen (mg/L), total alkalinity (mg/L), nitrate-nitrogen (mg/L), phosphate-phosphorus (mg/L), ammonia-nitrogen (mg/L) and chlorophyll-*a* (µg/L) were monitored at weekly intervals at 9.00-10.00 am.

Plankton estimation

Ten liters of pod water were taken each time from different locations and depths from each pond and were filtered through a fine mesh plankton net (25μ). Filtered sample was taken into a measuring cylinder and a standard volume of 50 ml was made carefully. Then the collected plankton samples were preserved in 5% buffered formalin in small plastic vials for subsequent studies. In the laboratory, a 1 ml sub-sample of each 50 ml sample was examined under a binocular microscope using a Sedgewick-Rafter cell. All planktonic organisms were counted from ten squares of the cell chosen at random.

Harvesting of fish

Partial harvesting of mola, chela and punti in all the treatments was done after three months of stocking. All the ponds were completely harvested after six months of rearing, first by seine netting and then by de-watering the ponds with a submersible low lift pump (Pedrollo 2 HP). The harvested fishes were counted and their lengths and weights were measured.

Data analyses

The experiment was set up following the principles of Completely Randomized Design (CRD) and the data were analysed using a statistical package, Statgraphics version 7 and Microstat.

Results

Water quality parameters

The mean values with standard deviation of the different water quality parameter as recorded from the experimental ponds under three treatments are presented in Table 1. ANOVA was performed to observe the degree of difference among the treatments.

The water temperature as recorded from ponds belonging to treatments- 1, 2 and 3 was found to vary from 27.6 to 33.0, 27.8 to 32.8 and from 27.7 to 33.0°C, respectively. However, no significant difference was observed among the treatments when DMRT was applied.

The highest values of transparency were 38.17 cm in treatment-1 in June, 32.25 cm in treatment-2 in July and 39 cm in treatment-3 in September. Again the lowest values were 27.18 cm in October in treatment-1, 21.88 cm in October in treatment-2 and 31.67 cm in October in treatmnet-3. The mean values did not show any significant difference when analysed statistically.

Table 1. Mean value ±SD and range (in parenthesis) of water quality parameters of experimental ponds under three treatments

Parameter	Treatment-1	Treatment-2	Treatment-3
Temperature (°C)	29.62 ± 0.47^a (27.6-33.0)	29.66 ± 1.28^a (27.8-32.8)	29.64 ± 1.33^a (27.7-33.0)
Transparency (cm)	34.28 ± 8.70^b (27.18-38.17)	27.67 ± 4.81^a (21.88-32.25)	33.92 ± 10.28^b (31.67-39.0)
p^H	7.54 ± 0.34^a (7.10-8.41)	7.65 ± 0.31^a (7.03-8.53)	7.62 ± 0.13^a (7.08-8.59)
Dissolved oxygen (mg/L)	3.83 ± 1.07^a (1.9-7.0)	3.92 ± 1.02^a (2.1-6.7)	4.30 ± 1.20^b (2.2-6.6)
Alkalinity (mg/L)	128.56 ± 32.03^{ab} (65-220)	121.88 ± 33.17^a (50-185)	132.18 ± 26.40^b 80-168)
Ammonia-nitrogen (mg/L)	0.48 ± 0.33^a (0.01-1.27)	0.47 ± 0.37^a (0.0-1.45)	0.51 ± 0.30^a (0.03-1.55)
Nitrate-nitrogen (mg/L)	2.59 ± 0.78^a (1.2-5.2)	2.55 ± 0.79^a (1.4-5.8)	2.61 ± 0.84^a (1.1-4.0)
Phosphate-phosphorus (mg/L)	0.90 ± 0.77^a (0.10-2.75)	0.58 ± 0.49^b (0.10-2.28)	0.76 ± 0.59^{ab} (0.11-2.05)
Chlorophyll-*a* (μg/L)	99.04 ± 49.57^{ab} (21.42-198)	111.91 ± 41.73^b (14.28-190)	85.42 ± 46.37^a (20.23-199)

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

The observed mean values ±SD for the above treatments were 7.54±0.34, 7.65±0.31 and 7.62±0.13 respectively (Table-1).

The mean dissolved oxygen concentration ±SD values for above treatments were 3.83±1.07, 3.92±1.02 and 4.29±1.20 mg/L, respectively (Table-1). The mean values as obtained for treatments-1 and 2 were significantly higher than that of treatment-3 (P<0.05), but no significant difference was observed between the values of treatments-1 and 2 (P>0.05). The maximum concentration of dissolved oxygen was 7.0 in treatment-1 and the minimum was 1.2 in treatment-3.

Total alkalinity of water of the experimental ponds was found to range from 65 to 220 mg/L in treatment-1, from 50 to 185 mg/L in treatment-2 and from 80 to 168 in treatment-3. When the mean values of all ponds were compared, a significant difference (P<0.05) was found between treatments-1 and 3.

Total ammonia content in water of the experimental ponds under treatments-1, 2 and 3 was found to range from 0.01 to 1.27, from 0.0 to 1.45 and 0.03 to 1.55 mg/L, respectively. The difference among treatments was not statistically significant. During the experimental period, the highest value of total ammonia content was recorded to be 1.55 mg/L in treatment-3 in June while the lowest in treatment-2 in May.

During the study period, nitrate-nitrogen content in water of the experimental ponds was found to range from 1.2 to 5.2, 1.4 to 5.8 and from 1.1 to 4.0 mg/L in treatments-1, 2 and 3, respectively. It seems that there was difference among treatments but that was not statistically significant.

Phosphate-phosphorus content in water of the ponds under treatments-1, 2 and 3 was found to range from 0.10 to 2.75, from 0.10 to 2.28 and from 0.11 to 2.05 mg/L, respectively. However, significant difference ($P<0.05$) was found among the mean values of different treatments.

Chlorophyll-*a* content in water of the ponds under treatments-1, 2 and 3 was found to range from 21.42 to 198, from 14.28 to 190 and from 20.23 to 199 μg/L, respectively. When these values were analysed statistically, a significant difference was observed between treatments-2 and 3, but none with Treatment-1.

Plankton enumeration

The planktonic organisms recorded from the water of the experimental ponds have been presented in Table 2.

The recorded phytoplankton population comprised of 4 broad groups *viz*., Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. A total of 27 genera of phytoplankton were recorded from treatment-1, 28 from treatment-2 and 29 from treatment-3. Out of 27 genera of phytoplankton, 5 genera belonged to Bacillariophyceae, 12 to Chlorophyceae, 7 to Cyanophyceae and 3 to Euglenophyceae in treatment-1. In treatment-2 out of 28 genera 5 belonged to Bacillariophyceae, 14 to Chlorophyceae, 6 to Cyanophyceae and 3 to Euglenophyceae. Whereas in treatment-3 out of 29 genera, 4 belong to Bacillariophyceae, 16 to Chlorophyceae, 7 to Cyanophyceae and 3 to Euglenophyceae. However, the recorded zooplankton population comprised of 2 groups *viz*., Crustacea and Rotifera. A total of 11 genera of zooplankton were recorded in treatments-1 and 3, of which 5 genera belonged to Crustacea and 6 to Rotifera. While in treatment-2, out of 10 genera, 4 belonged to Crustacea and 6 to Rotifera.

Table 2. Mean abundance of plankton in water of the ponds under three treatment

Plankton group	Treatment-1	Treatment-2	Treatment-3
Bacillariophyceae	4.62 ± 9.39^{a}	4.51 ± 7.16^{a}	3.65 ± 7.70^{a}
Chlorophyceae	12.13 ± 16.76^{a}	16.80 ± 22.99^{b}	17.29 ± 23.07^{b}
Cyanophyceae	9.25 ± 12.62^{a}	12.57 ± 10.69^{a}	10.72 ± 12.56^{a}
Euglenophyceae	4.02 ± 10.41^{a}	7.11 ± 9.04^{b}	4.37 ± 9.39^{ab}
Total phytoplankton	30.02 ± 3.86^{a}	40.79 ± 5.48^{b}	36.08 ± 6.29^{ab}
Crustacea	2.77 ± 3.78^{a}	2.26 ± 2.95^{a}	2.34 ± 2.58^{a}
Rotifera	3.31 ± 5.13^{a}	4.50 ± 6.62^{a}	4.00 ± 5.34^{a}
Total Zooplankton	6.08 ± 0.38^{a}	6.76 ± 1.51^{a}	6.34 ± 0.96^{a}

*Figures in the same row having the same superscript are not significantly different ($P>0.05$)

No significant difference (P>0.05) was found in the abundance of Bacillariophyceae. Chlorophyceae was the most dominant group in all the Treatments. DMRT showed that the values of treatment-2 and 3 were significantly higher than that of treatment-1. The abundance of Cyanophyceae did not show any significant difference among treatments when tested statistically. The abundance of Euglenophyceae was significantly higher in treatment-2 than those of treatments-1 and 3.

The mean abundance of total phytoplankton in water of the ponds belonging to treatments-1, 2 and 3 were 30.02±3.86, 40.79±5.48 and 36.03±6.29x10^3/L, respectively. ANOVA and subsequent DMRT analyses showed that the value of treatment-2 was higher than those of treatments-1 and 3, but there was no significant difference between the values of treatment-1 and treatment-3.

Crustacea was present in relatively lower numbers in all the treatments. The maximum abundance (6.76±11.51x10^3/L) was obtained in treatmnet-2 while the minimum (6.08±0.38x10^3/L) in Treatment-1. But no significant difference was observed when tested.

Growth and production of fish

Size distributions of mola, punti and chela during the study period are shown in Figures 1, 2 and 3, respectively. The bar charts for mola showed that, the weight of mola was 2.41 and 3.28g in the month of May and June, no fry was seen in the net during sampling. But in the next successive months, mola fry were found during the sampling. The mean fry weight of mola was 0.67, 0.84, 0.71 and 0.87g in the month of July, August, September and October, respectively. But in case of adult mola, the average weight decreased in July and August, but increased in the following months (Fig. 1). In case of punti, the growth trend was not similar to that of mola as may be seen in Fig. 2. The average weight of adult punti was found to increase gradually in the first two months. However, the fry was first found during sampling in the month of July and the average weight was 1.02g. In July and August, the fry weight was more or less similar but in September and October, the mean weight were increased gradually. While the mean weight of adult punti did not increase during the months of July and August but increased gradually in the following months. The growth pattern of chela was similar to that of mola as seen in Fig. 3. The weight of adult chela was the highest in October and the lowest in May. Fry of chela was found in the month of July and the weight was found to be 0.65g. The fry weight increased gradually in the following months. Comparatively less weight of adult chela was observed in the month of July and August than in other months.

The stocking and harvesting statistics of mola, punti and chela are presented in Table 3. The numbers at harvest (partial and final harvest) of each species of mola, punti and chela were higher than their initial number. At harvest, the total number of mola was significantly higher (P<0.05) than those of punti and chela. But the total number of punti and chela did not show any significant difference (P>0.05). The number of mola, punti and chela harvested were 7,069, 2,910 and 2,550, respectively.

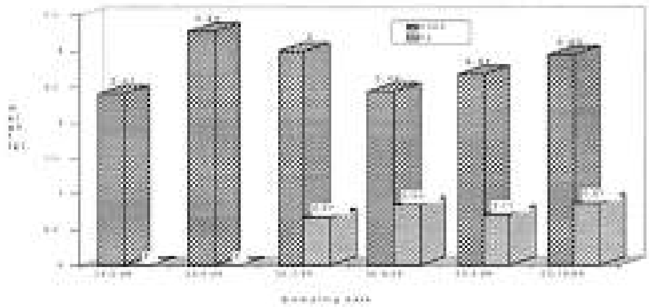

Fig. 1. Monthly average weight of fry and adult mola.

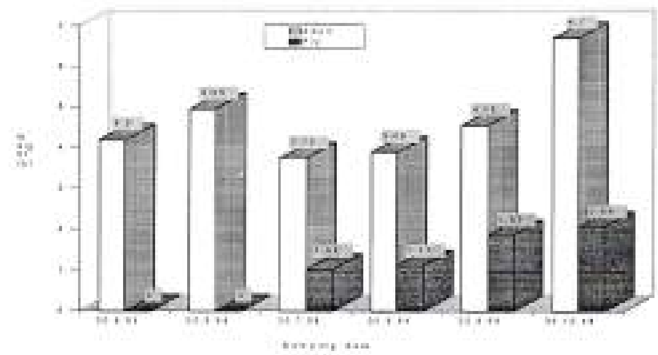

Fig. 2. Monthly average weight of fry and adult punti.

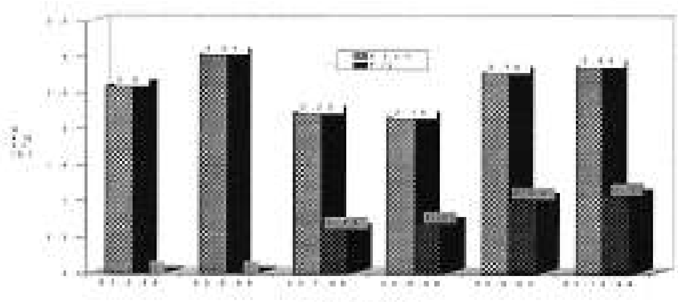

Fig. 3. Monthly average weight of fry and adult chela.

Table 3. Details of initial number and weight of fish at stocking, harvesting number and production of mola, punti and chela in monoculture system

Treat-ments	SIS	At stocking	At harvesting		
		Av. initial wt (g)	Av. Final wt.(g)	Av. total no. of fish recovered	Total wt. of fish (kg/pond)
T-1	Mola	1.80±0.27	1.14±0.49	7,069[a]	8.05
T-2	Punti	2.50±1.80	3.85±2.74	2,910[b]	11.20
T-3	Chela	1.55±0.29	2.02±0.69	2,550[b]	5.09

*Figures in the same row having the same superscript are not significantly different ($P>0.05$).

The gross yield of mola, punti and chela over a period of six months were 805±52.94, 1,120±41.62 and 509±48.81 kg/ha, respectively. The total production of punti was found to vary significantly from those of mola and chela. The production of punti was 39.13% higher than that of mola and 120% higher than that of chela. On the other hand, the second highest production was obtained from mola which was 58.15% higher than that of chela and the production of mola also showed significant difference ($P<0.05$) from that of chela (Table 3).

Discussion

Water temperature is one of the most important factors, which influence the physico-chemical and biological events of a water body. The range of water temperature (27.6 to 32.8°C) as recorded from the experimental ponds agreed well with the findings of Mollah and Haque (1978) and Wahab *et al.* (1995) from ponds of Bangladesh Agricultural University (BAU) campus. Water transparency was found to fluctuate widely (14-60 cm) in the present study. The highest transparency was recorded during June and the lowest after fertilization, which might be due to the presence of higher plankton population and suspended organic matter. Islam *et al.* (1974) recorded the minimum transparency in January and maximum in June. Dewan (1973) recorded a good correlation of transparency of water with the water depth and rainfall. Boyd (1982) recommended a transparency between 15-40 cm as appropriate for fish culture. The observed p^H range of (7.03-8.59) agreed well with the findings of Hossain *et al.* (1997) who found the p^H range of 6.7-8.3, and Kohinoor *et al.* (1998) who obtained the p^H range of 7.18-7.24 in the research ponds of Bangladesh Agricultural University campus, Mymensingh. Dissolved oxygen level in water of the experimental ponds as recorded (1.9 to 7.0 mg/L) in the present study agreed well with the findings of Wahab *et al.* (1995), who recorded a lower dissolved oxygen ranging from 2.0-7.2 mg/L during their experiment in the BAU campus. Ahmed (1993) also reported a similar trend of lower dissolved oxygen from fertilized and fed carp fingerling ponds in BAU campus.

Application of manure and supplementary feed might reduced the level of dissolved oxygen.

Natural waters, which contain 40 mg/L or more total alkalinity, are considered as hard waters for biological purposes. Hard waters are generally more productive than soft waters. Bhuiyan (1970) reported that the total alkalinity of medium productive water ranged from 25-100 mg/L. Sudipti (1998) found the average total alkalinity values were above 100 mg/L in some BAU campus ponds. The observed alkalinity level (50 to 220 mg/L) of water of the experimental ponds indicated that the productivity of the ponds was medium to high. In any culture condition, the lower concentration of ammonia-nitrogen is better for fish. The level of ammonia-nitrogen (0.01 to 1.55 mg/L) as recorded from the experimental ponds in the present study is lower than that was reported by Dewan *et al.* (1991), who recorded 0.05 to 6.20 mg/L. Kohinoor *et al.* (1998) recorded ammonia-nitrogen ranged from 0.05-0.25 mg/L. Haque *et al.* (1998) also found ammonia-nitrogen level of 0.11 to 0.13 mg/L in BAU research ponds. However, the present level of ammonia-nitrogen content in the experimental ponds was not lethal to the stocked fishes. The amount of nitrate-nitrogen (1.4 to 5.98) as recorded from water of the experimental ponds was higher than that of Mollah and Haque (1978), who recorded 0.091 to 0.77 mg/L, and Haque *et al.* (1998) recorded 0.86 to 0.90 mg/L in ponds in BAU campus. Bhuiyan (1970) reported the range of nitrate-nitrogen from 0.06 to 0.10 ppm as a suitable one for aquaculture. The possible reason for higher values of nitrate-nitrogen in the present study was fertilization, which was a routine practice in the experimental ponds. David *et al.* (1969), Munawar (1970) and Islam *et al.* (1974) recorded higher amount of nitrate-nitrogen after heavy rainfall.

Phosphorus is considered to be the most critical single element in the maintenance of aquatic productivity. The observed phosphate-phosphorus contents (0.10 to 2.75 mg/L) in water of the experimental ponds were higher than those reported by Mollah and Haque (1978), who recorded phosphate-phosphorus to be 0.55 to 0.35 mg/L. Azim *et al.* (1995) found mean phosphate-phosphorus as 0.807 mg/L in the research ponds at the of BAU campus. The probable reason behind higher phosphate-phosphorus content was heavy rainfall during this study, which might increased the amount of phosphate-phosphorus in the experimental ponds.

The probable reason behind fluctuation in chlorophyll-*a* concentration (42 to 198 μg/L) in water of the experimental ponds during the study period was the periodicity of phytoplankton, which was enhanced by manuring. Khatrai (1984) reported that phytoplankton and chlorophyll-*a* had a positive relationship with primary production. Dewan *et al.* (1991) recorded 12-30 μg/L chlorophyll-*a* in their experiment, where as Haque *et al.* (1998) found 59-159μg/L chlorophyll-*a* in their experiment.

The present recording of 34 genera of phytoplankton belonging to 4 broad groups *viz.*, Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae and 12 genera of zooplankton belonging to 2 groups *viz.*, Crustacea and Rotifera, agrees with the findings of Wahab *et al.* (1994) as reported 25 genera of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae and 5 genera of zooplankton belonging to Crustacea and Rotifera.

The higher abundance of plankton population (phytoplankton 30.02 $\times 10^3$, 4.079 $\times 10^3$ and 36.08 $\times 10^3$/L and zooplankton 6.08 $\times 10^3$, 6.76 $\times 10^3$ and 6.34 $\times 10^3$/L in treatments-1, 2 and 3, respectively) might be due to regular application of supplementary feed and fertilizers in the experimental ponds. Wahab and Ahmed (1991) reported mean phytoplankton population to be 17.72 $\times 10^4$, 9.26 $\times 10^4$ and 13.87 $\times 10^4$/L, and zooplankton to be 1.19 $\times 10^4$, 1.90 $\times 10^4$ and 1.07 $\times 10^4$/L from three sets of ponds, respectively. Wahab *et al.* (1994) recorded phytoplankton numbers ranging from 2.0-8.0 $\times 10^5$/L and zooplankton between 2.0-2.0$\times 10^5$/L. However, Kohinoor *et al.* (1998) recorded 22.50-27.83 $\times 10^3$/L phytoplankton and 5.20-6.34 $\times 10^4$/L zooplankton from polyculture ponds. Recording of the highest total plankton population in treatment-2, might be due to the fact that punti in treatment-2 consumed less amount of plankton than that of mola and chela which were stocked in the other treatments.

Culture of small fish has not yet been attempted on large scale in this country. Consequently, published information on production of small indigenous fish species in freshwater ponds are rather little. However, some of the notable works are Ameen *et al.* (1984), Hussain *et al.* (1989), Akhteruzzaman *et al.* (1990), Hossain *et al.* (1997) and Rahmatullah *et al.* (1998). In the present experiment, the mean weights of mola, punti and chela were 1.14, 3.85, 1.80g, respectively. Mustafa (1991) observed the mean weight of mola and punti were 3.03 and 7.65g, respectively in his monoculture experiment. Kohinoor *et al.* (1998) found the mean weight of mola in polyculture system was 0.74g, whereas, Hasan (1998) in his polyculture experiment with small fish observed the mean weights of mola, punti and chela as 1.10, 3.69 and 1.80g, respectively. Kamal (1996) also found the mean weight of *Puntius sophore* was 2.90g in monoculture system where the ponds were fertilized with urea and TSP. The weight of small fish in this experiment was low in comparison to the above findings

The production of mola, punti and chela as obtained in the present experiments were 505, 1,120 and 509 kg/ha/ 6 months, respectively which was more or less same as Mostafa (1991, who has reported to achieve an estimated production of 1,592, 2,373 and 1,764 kg/ha/yr from monoculture of mola, chola punti and colisha, respectively. Ameen *et al.* (1994) obtained a production of 1.75 tons/ha of mola (*A. mola*) and 8.0 tons/ha of chola punti (*P. sophore*) in monoculture and 4.49 tons/ha/8 months of mola and punti in composite culture. Akhteruzzaman *et al.* (1990) reported that in monoculture condition the production of *P. sarana* was 1,200 kg/ha/6 months, while, Kamal (1996) obtained a net production of 461 kg/ha/5 months from *P. sophore* in monoculture condition by fertilization only. Rahamatullah *et al.* (1998) reported to obtain a net yield of chapila to be 92.13 kg/ha and mola to be 57.88 kg/ha/3 months. The fish production as obtained in the present experiment was comparable to all the above mentioned findings except those of Ameen *et al.* (1994). A further trial including Ameens' technology is recommended for further study.

In view of the above, it may be concluded that the production of mola (*A. mola*), punti (*P. sophore*) and chela (*C. cachius*) was not very encouraging but small indigenous fish species (SIS) culture would add social benefit in that the fish farmer and the poor people may get a chance to consume them readily than sale them in to the market.

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(Manuscript received 12 June 2000)

Bangladesh J. Fish. Res., 5(2), 2001: 135-144

Polyculture of freshwater prawn, *Macrobrachium rosenbergii*, de Man with carps: effects of prawn stocking density

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Abstract

Effects of three stocking densities, *viz.*, 35, 50 and 65/*decimal* (1 decimal = 40.48 m^2) of juvenile freshwater prawn (*Macrobrachium rosenbergii*) on prawn and fish production were tested in a polycuture system with silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), Grass carp (*Ctenopharyngodon idella*) and silver barb (*Barbodes gonionotus*). The fish stocking density was 19/*decimal* with the species combination of silver carp-10, catla- 6, grass carp- 1 and silver barb- 2. In a 8-month culture period, the prawn yield 423 ± 144 kg/ha was significantly lower ($P< 0.5$) with the prawn stocking density of 35/decimal than that of 548 ± 178 kg/ha and 662 ± 243 kg/ha with 50 and 65/*decimal* respectively. The fish production (1844–1891 kg/ha) did not differ significantly ($p <0.05$) among the three treatments indicating that prawn stocking densities had no influence on fish yield. The lower mean harvest weight (62 g) and survival rate (67 g) and higher yield (2.67 kg/*decimal*) with the highest stocking rate of prawn reveals that as density was increased, prawn survival and individual weight at harvest decreased but total yield increased.

Keywords: *M. rosenbergii*, Polyculture, Stocking density

Introduction

Polyculture of fishes in pond is a widespread practice in many countries where stocking strategies are determined by the feeding habits of fish, taking into account natural feeds available in the various ecological niches within the pond. The freshwater prawn, *Macrobrachium rosenbergii*, has attracted an enormous interest as an aquaculture species in many of the tropical and sub-tropical countries throughout the world (Perry and Tarver 1987) and particularly its benthophagic omnivore feeding habit makes the prawn a good candidate for polyculture. Prawns are self-limiting in respect to total production due to antagonistic interactions increasing the need for polyculture to maximize total pond efficiency (New 1990).

Prawn polyculture has a potentially higher net return than prawn monoculture (Rouse and Stickney 1982). Culture of prawn with fish also improves the ecological balance of the pond water, preventing the formation of massive algal blooms (Cohen *et* *al.* 1983). Besides these cultural benefits, a major advantage of prawn polyculture for developing nations like Bangladesh is that low-cost high quality protein (fish) is produced for local consumption simultaneously with a high value luxury protein product (prawns) that may be exported to generate foreign exchange. This development model has worked remarkably well in Israel, which produces some 50% of its total fish consumed and exports prawns to the high priced European market to generate foreign income (Cohen & Ra'anan 1983).

Although the traditional Chineese aquaculture system, consisting of polyculture of planktophagic, macrophytophagic, benthophagic and omnivorous fish species has been adapted extensively to Bangladesh aquaculture conditions, polyculture of fish and prawn has not yet been widely undertaken until recently. Polyculture of *M. rosenbergii* has been investigated with Chineese and Indian carps elsewhere (Malecha *et al.* 1981, Bian and Pang, 1982, Buck *et al.* 1983, Costa-Pierce *et al.* 1984), but no scientific study has been conducted to develop an appropriate fish-prawn polyculture system in Bangladesh conditions. Though Humayun *et al.* (1986), Hoq *et al.* (1995) and NFEP (2001) reported one species and three species carp-prawn polyculture system, respectively, but in a very crude way and nothing could be concluded from their results in establishing a viable prawn-fish polyculture system in Bangladesh. The present study was, therefore, undertaken to investigate the effects of stocking rate of prawn on the production performance of fish and prawn in a polyculture system considering fish as a marginal crop with an ultimate aim of developing an appropriate grow-out of freshwater prawn under a polyculture system.

Materials & methods

Previous year's hatchery produced nursed juvenile prawns were stocked at three different densities with silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), grass carp (*Ctenopharyngodon idella*) and rajpunti (*Barbodes gonionotus*). Different prawn stocking densities of 35/*decimal*, 50/*decimal* and 65/*decimal* were considered as treatments. The stocking density of silver carp, catla, grass carp and rajpunti into each treatment pond was 10, 6, 1 and 2 per *decimal* respectively. Each of the treatments was assigned into three ponds as replication. The initial average weight of prawn was 1.8 g and that of silver carp, catla, grass carp and rajpunti was 3.6 g, 5.2 g, 50.7 g and 1.5 g, respectively.

The experiment was carried out into three earthen ponds, which were partitioned into three compartments having a water surface area of 7 *decimal* each and a mean effective water depth of about 1 m. The pond were partitioned using bamboo fetching covered with nylon mosquito net. The ponds were drained out and treated with lime and cowdung at the rate of 1 and 12 kg/*decimal*, respectively. The ponds were filled in with underground water and fertilized with 100 g urea/decimal and 50 g TSP/decimal for enhancing the natural food production prior to stocking. Fish and prawns were stocked into pond compartments in January'96 and the experiment was continued up to August'96.

The nutrient management included fortnightly manuring/fertilization and daily feeding. Dry cowdung, urea and TSP were applied fortnightly at the rate of 5 kg, 100 g and 50 g/decimal, respectively. The use and amount of fertilizer varied depending on the productivity status of ponds. Only prawns were fed with a SABINCO commercial grower pellet feed at 5% of biomass for initial 3 months and at 3% for the rest of rearing period. The feed contained 38% crude protein, 5% crude lipid, 6% crude fibre, 18% ash and 12% moisture. The pellets were applied at every evening using feeding trays hung in each pond compartment. Shelters were provided in each pond compartment with dry coconut leaves.

Gain in growth (total length and weight) of fish and prawn was recorded from seined netted samples (n=25) once in a month. At the end of the experiment, ponds were drain harvested, fish and prawns caught, total number counted for survival, measured and weighed, and gross yield computed. Among the water quality parameters, temperature was measured every day between 09.00 – 10.00 hrs using a centigrade thermometer. Dissolved oxygen, pH, ammonia and alkalinity were measured every week in between 08.00 – 09.00 hrs. Dissolve oxygen and pH were measured with a YSI model 54 oxygen analyzer and OSK-11475 pH meter respectively. Determination of ammonia and total alkalinity was performed according to the procedures outlined by AOAC (1990).

One-way analysis of variance (ANOVA) was performed on the yield data to determine treatment effects. Significant differences between treatments were isolated using Duncan's multiple range test (DMRT) at 5% level of significance. All analyses were done using on PC using Statgraphics *Version 7.0*.

Results

The final weight, survival rate, and yield of fish and prawns in each treatment are shown in Table 1. The growth of silver carp, catla, grass carp and silver barb ranged from 457-460 g, 347 – 388 g, 718 – 825 g and 185 – 202 g, respectively. The growth of each fish species was similar ($P < 0.05$) in all treatments, except catla and grass carp in T_2. The significantly higher growth of grass carp (825.28 ± 30.60 g) and lower of catla (347.09 ± 34.72 g) in T_2 might have due to some unknown reasons other than any interspecies interactions. The survival rate of each fish species was also similar ($P < 0.05$) among the all treatments. Neither the individual fish yield nor the total yield of 1891 ± 153 kg/ha in T_1, 1844 ± 162 kg/ha in T_2 and 1887 ± 186 kg/ha in T_3 were not significantly different ($P < 0.05$). Prawn with the highest stocking density of 65/decimal (T_3) showed significantly lower ($P < 0.05$) growth (61.61 ± 20.72 g) and survival rate (65.92 ± 2.27%), but higher yield of 2.67 ± 0.98 kg/decimal i.e. 662 ± 243 kg/ha than the lowest density of 35/decimal (T_1). Similarly, the weight gain and survival rate of prawns at harvest with T_2 (50/decimal) were higher but the yield was lower than that of prawns with T_3, although not significantly different (Table 1).

The monthly mean weight gain of prawn in all treatments is shown in Fig. 1. The prawns at all stocking rates gained in weight progressively with increment of rearing period. The prawns at the lowest stocking rate of 35/decimal (T_1) gained higher weight all through the study period. As the stocking rate increased, the prawns gained their weight at lower rates. The results indicate that individual weight of prawn negatively correlated with increasing stocking rate. The weight of prawns in all treatments sharply increased from April, possibly due to increase in temperature.

Table 1. Yield data of different fish species and *M. rosenbergii* in fish-prawn polyculture system (means with same superscripts letter are not significantly different at 5% level of significance)

Species combination	Stocking (no/*dec.*)	Final weight (g)	Survival rate (%)	Yield (kg/*dec.*)*	Total yield (kg/ha)
Treatment I					
H. molitrix	10	460.50 ± 29.04	96.42 ± 0.71	4.44 ± 0.31	
C. catla	6	388.50 ± 24.82^{a}	92.86 ± 2.38	2.17 ± 0.20	Fish: 1891 ± 153^{a}
C. idella	1	717.65 ± 64.32^{b}	100 ± 0.00	0.72 ± 0.07	Prawn: 423 ± 144^{b}
P. gonionotus	2	185.25 ± 26.75	82.14 ± 3.57	0.31 ± 0.05	
M. rosenbergii	35	67.85 ± 19.05^{a}	70.22 ± 4.73^{a}	1.70 ± 0.58^{b}	
Treatment II					
H. molitrix	10	457.86 ± 30.43	93.58 ± 0.72	4.29 ± 0.32	
C. catla	6	347.09 ± 34.72^{b}	95.24 ± 2.38	1.99 ± 0.25	Fish: 1844 ± 162^{a}
C. idella	1	825.28 ± 30.60^{a}	100 ± 0.00	0.83 ± 0.04	Prawn: 533 ± 178^{ab}
P. gonionotus	2	201.64 ± 23.42	83.34 ± 3.21	0.34 ± 0.06	
M. rosenbergii	50	64.04 ± 18.28^{ab}	68.86 ± 2.85^{a}	2.23 ± 0.72^{ab}	
Treatment III					
H. molitrix	10	466.50 ± 33.51	94.29 ± 1.42	4.41 ± 0.39	
C. catla	6	388.75 ± 35.09^{a}	91.67 ± 3.57	2.15 ± 0.28	Fish: 1887 ± 186^{a}
C. idella	1	739.28 ± 36.44^{b}	100 ± 0.00	0.74 ± 0.04	Prawn: 662 ± 243^{a}
P. gonionotus	2	195.50 ± 20.65	85.72 ± 7.14	0.34 ± 0.07	
M. rosenbergii	65	61.61 ± 20.72^{b}	65.92 ± 2.27^{a}	2.67 ± 0.98^{a}	

* 1 decimal = 40.48 m^2

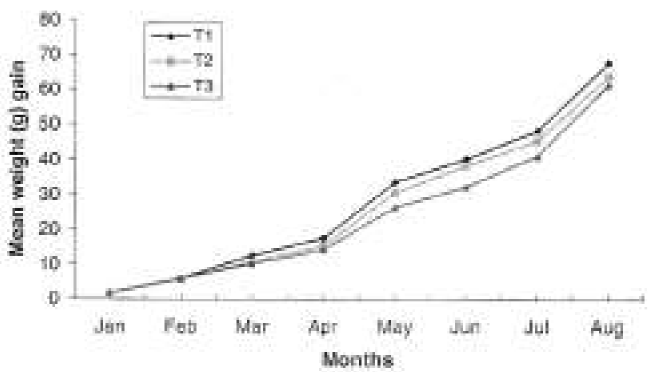

Fig. 1. Monthly mean weight gain of *M. rosenbergii* in fish-prawn polyculture ponds.

Fig. 2 shows the percent occurrence of prawn in different weight class at harvest. The occurrences of prawn in higher weight-class prawn were more than that in lower weight-class at lower stocking densities. The highest occurrence of 32.3% prawns in T_3 with 65/decimal was at 50-60 g weight class and that of 30.9% in T_1 with 35/decimal was at 60-70 g weight-class. The occurrence of prawn at 50-60 g and 60-70 g weight-class in T_2 with 50/decimal was 26.6% and 28.2%, respectively. While in T_1, 56.1% of prawns were at higher weight-class of 60-80 g, 54.8% and 55.9% of prawns were at 50-70 g in T_2 and T_3, respectively. Again, when prawns of more than 80 g of weight were 13.8% in T_1, those were 11.8% in T_2 and 5.4% in T_3. All prawns at 35 and 50/decimal were more than of 40 g. These indicate that an increase in stocking rates resulted in a decrease of occurrence of higher weight-class prawn.

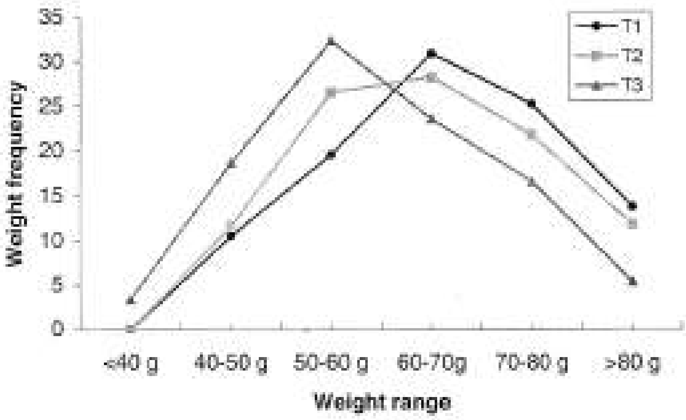

Fig. 2. Occurrence of *M. rosenbergii* at different weight-class in fish-prawn polyculture ponds.

Fig. 3 represents the sex ratio of harvested prawn at different stocking densities. The proportions of male prawns were lower than that of females in T_1 (46.2% M ; 53.8% F) and in T_2 (47.4% M ; 52.6% F). In T_3 the male population (52.3%) was higher than the female (47.7%).

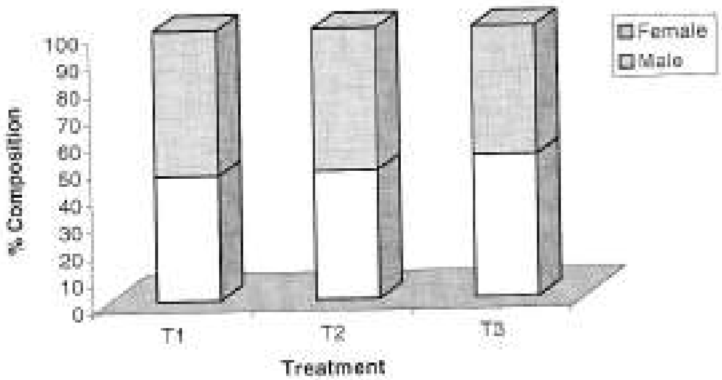

Fig. 3. Composition (%) of male and female *M. rosenbergii* in fish-prawn polyculture ponds.

The differences in sex ratio at varied stocking densities under the study were apparent, indicating that the abundance of one sex over the other one might have been occurred due to variation in stocking densities.

As the ponds were partitioned using bamboo fetch covered with nylon mesh net, water among the compartments in the same pond flowed with wind action. For this reason, water quality parameters were measured from each of three ponds, irrespective of treatment compartments. There were no significant differences in water quality parameters among three ponds. For this reason, all measured values for each parameter were averaged and are shown in the Table 2. Monthly variations in water quality values in all experimental ponds were within the acceptable limit of pond fish and prawn culture.

Table 2. Mean (range) values of water quality parameters in fish-prawn polyculture ponds

Water quality parameters	Months Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Temperature (°C)	18.5 (16-20)	19.5 (18-20)	24.4 (23-25)	25.2 (24-27)	27.5 (24-29)	26.7 (25-28)	26.4 (25-29)	27.1 (26-30)
Dissolved oxygen (mg/l)	4.5 (3.5-5.2)	4.3 (3.2-5.0)	4.9 (3.8-5.3)	5.5 (4.4-6.2)	4.8 (4.2-5.7)	4.5 (3.9-5.7)	4.2 (3.7-5.0)	4.6 (3.9-5.3)
PH	7.8 (7.5-9.0)	7.2 (7.0-8.5)	7.6 (7.4-8.8)	7.5 (6.9-8.6)	7.7 (7.5-8.9)	7.6 (7.4-9.0)	7.9 (7.5-9.0)	7.5 (6.8-8.8)
Total ammonia (mg/l)	0.25 (0.2-0.3)	0.27 (0.2-0.3)	0.25 (0.2-0.3)	0.36 (0.3-0.4)	0.33 (0.3-0.4)	0.35 (0.3-0.4)	0.26 (0.2-0.3)	0.34 (0.3-0.4)

Discussion

A similar fish yield at three different stocking densities of prawn (Table 1) indicates that the growth and yield of fish do not appear to be affected by the prawn stocking density. The significant differences ($P<0.05$) in growth and yield of prawns were also not influenced by the type and stocking rate of fish, but by the stocking rate of prawn itself. The prawn weight decreased from 68 - 62 g and the yield increased from 423 – 662 kg/ha with increasing prawn density. The weight frequency data (Fig. 2) show an increase in the proportion of larger prawns with lower stocking rate and a decrease in that with higher stocking rate. This similar inverse relation in individual weight gain and positive relation in total yield with stocking rates of prawn in polyculture with carps and tilapia has been reported by (Cohen and Ra'anan 1983, Wohlfarth *et al.* 1985). In case of a variety of prawn monoculture conditions, Smith *et al.* (1976); Brody *et al.* (1980); Perry *et al.* (1982) also observed that stocking rates of prawn had a negative with weight gain but a positive correlation with yield. Similar survival rates of prawn in the present study indicate that a stocking rate of 35-65/decimal might have no effect on survival at harvest. While Wohlfarth, *et al.* (1985) observed a slightly negative, but not significant, correlation between survival rate and stocking density of prawn in a polyculture system, no any correlation was found by Cohen and Ra'anan (1983).

A higher ($P < 0.05$) prawn yield of 2.76 kg/day/ha and a similar fish yield of 7.9 kg/day/ha (Table 1) reveals that stocking of 65 prawn/decimal (16000/ha) with 19 fish/decimal (4700/ha) may be practiced in Bangladesh aquaculture conditions for an optimum yielding crop in a fish-prawn polyculture system. When Brick and Stickney (1979) stocked juvenile prawns at 11000/ha with tilapia fry at 2000/ha, mean prawn survival, harvest weight and yield were 95%, 24.5 g and 2.1 kg/day/ha, respectively. The daily fish yield was 2.6 kg/ha. Miltner *et al.* (1983) reported mean prawn survival rate of 94%, harvest weight of 72.2 g and daily yield of 1.6 kg/ha at 2500/ha. The daily fish yield was 12.4 kg/ha at 8240 (catfish, silver carp and grass carp)/ha. High protein feed was used in both studies. The prawn yield of 1.76 – 2.76 kg/day/ha, in spite of at relatively low survival rate of 65 – 70%, in the present study is quite comparable to that of 1.6 – 2.1 kg/day/ha. However, Cohen and Ra'anan (1983) obtained an average daily yield of 3.9 kg/ha at a prawn stocking density of 15000/ha with above 85%of survival. The prawn survival rates in all treatments in the present study ranging from 66 – 70% are supposed to be of relatively low, which might be due to low temperature during the initial months of stocking (Table 2). Therefore, it leads to apprehend that the daily rate of prawn yield could have been more than that has been achieved, if the prawns are stocked at onset of summer and harvested at the onset winter months.

Although a commercial feed was used to feed the prawn only in the present study, certain amount of feed was also used by fishes and it is difficult to determine that which species actually consumed how much of feed. The fish and prawn yield was actually the result of combined effect of low rate of feeding and fertilization, as compared to high-level pond management, in terms of nutrient inputs, maintained by Cohen and Ra'anan (1983); Wohlfarth *et al.* (1985). It may, therefore, be presumed that a prawn stocking density of 16000/ha may be optimum one in polyculture system for having a good harvest at low input management. However, a higher stocking density of prawn and fish with high input management may result in high yield of both prawn and fish. A prawn yield of 3.7 – 7.2 kg/day/ha at a stocking density of 20000 - 40000/ha and fish (carps and tilapia) yield of 29.5 – 40.6 kg/day/ha at a stocking density of 13150- 13300/ha have been reported by Wohlfarth *et al.* (1985); Hulata *et al.* (1990).

Besides the relationship with growth and yield, stocking rates of prawn have also shown some effects on sex ratio. The females of harvested prawns had a higher percentage (54%) with the lowest test stocking density (35/decimal), whereas the males dominated with the highest stocking rate of 65/decimal (Fig. 3). Different authors have recorded different observations regarding the occurrence of sex ratio and stocking rate of prawn. Wang *et al.* (1975) found that the proportion of males exceeded that of females in the harvested populations from ponds stocked with relatively high densities. Smith *et al.* (1978) reported that sex ratios obtained in prawn monoculture systems were generally biased towards females (55-64%) without showing any relationship between sex ratio and stocking density. However, Cohen and Ra'anan (1983) observed, in ponds under fish-prawn polyculture system, a higher percentage (55%) of female prawns at a lower stocking density of 5000/ha and that (51%) of male at a higher stocking density of 15000/ha. However, it is beyond the capacity of the present report to explain the exact reasons of occurrence of sex ratio in harvested prawn population. It might be possible that certain environmental conditions within the pond, including stocking density, would favour the development of one sex over the other, as assumed by Cohen and Ra'anan (1983).

Finally, it can be concluded that proper stocking rates are of prime significance for aquaculture production in fish and prawn polyculture system. Though a prawn stocking rate of 16000/ha resulted in a good yield, higher stocking densities of both fish and prawn, along with better nutrient input and pond management, may tried for better yield. It, however, needs to take into account that an increase in stocking rate of prawn may increase in harvest yield, but decrease in individual weight gain. Therefore, any further study for optimizing the higher stocking rate of prawn for maximum yield should consider the rate of individual weight gain a major factor, as the market value of prawn highly depends on it.

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(Manuscript received 12 December 1999)

Bangladesh J. Fish. Res., 5(2), 2001: 145-148

Effect of carp PG doses on induced breeding of Shing, *Heteropneustes fossilis* (Bloch)

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Abstract

Five hormone doses *viz.* 25, 50, 75, 100, and 125 mg of carp PG/kg of body weight of the recipient fish were tested and they were designated as T_1, T_2, T_3, T_4, and T_5 respectively. Significantly higher fertilization (98%) and hatching rates (38%) were obtained from T_3 (75 mg of carp PG extract/kg body weight). While T_4 (100 mg of carp PG extract /kg body weight) and T_5 (125 mg of carp PG extract /kg body weight) gave the highest (90%) ovulation rate. In June and July the highest fertilization rate of 96 and 96.4% respectively and hatching rate 42.5 and 48.7% respectively were obtained. In over all consideration carp PG extract at a dose of 75 mg/kg body weight appears to be the suitable dose for induced breeding of *H. fossilis* and June and July are the suitable time for its induced breeding.

Key words: Induced breeding, PG, *H. fossilis*

Introduction

Of the endemic catfishes, shing is a popular and highly priced fish in Bangladesh. It is considered to be a highly nourishing, palatable and tasty fish. These fishes are well-adapted to adverse ecological conditions in swamps, marshes and derelict waters which are mostly shallow and characterized by heavy silt load with decaying vegetation and organic matter coupled with poor nutrient release.

During the past few years, the natural population of this catfishes has been rapidly decreasing due to various man-made and natural causes. Moreover, natural breeding grounds of this fish are also under threat due to drying up of the low lying areas and indiscriminate use of fertilizers and pesticides. If appropriate measures are not taken immediately there is every possibility the existence of this important endemic catfish species will be threatened. There is no other alternative but to develop induced breeding technique of this species to overcome the catastrophe. Pal and Khan (1969), Khan (1972a and b), Thakur *et al.* (1974 and 1977) and Saha *et al.* (1998) provided some basic information on the induced breeding of *H. fossilis.* with a view to achieve success in mass production of *H. fossilis* seeds, the present investigation was undertaken to find out appropriate dose of carp pituitary hormone (PG) for successful induced breeding of the species and to find out its peak breeding season.

Materials and methods

Male and female brood fishes were collected from the local fish market from December'96 to March'97 and were stocked in earthen ponds at a density of 20,000 fish/ha. The fishes were fed twice a day with a supplemental feed formulated from locally available ingredients containing fish meal (40%), mustard oil cake (20%), rice bran (20%), wheat bran (15%), molasses (4%) and Vit. Premix (1%) at the rate of 5-6% body weight in the morning (09:00 AM) and afternoon (16:00 PM). Only fully mature fishes were selected for induced breeding and brought to the hatchery in batches. Fishes were injected with five different doses of carp pituitary gland extract *viz.* 25, 50,75,100 and 125 mg/kg body weight and the treatments were designated as T_1, T_2, T_3, T_4 and T_5 respectively. In all the treatment groups 10 mature females were injected with a single dose of carp PG extract. After a latency period of 8-10 h, the eggs were striped out and fertilized with milt from macerated testes of a single male. In each trial the eggs stripped from a female were divided into three sub-samples of about 200 eggs per sub-sample. The eggs were then incubated in plastic sib (20 cm diameter) with nylon meshed bottom, placed in shallow cement cisterns, having continuous water flow (0.5 l/minute).

The numbers of live eggs in each batch were estimated 2-3 h after fertilization. Hatching was considered to be successful if the sac emerged from the egg envelope. Hatching, mortality and deformity were also recorded regularly. Water temperature during the breeding and incubation period was recorded by a Celsius thermometer. Data on ovulation , fertilization and hatching were also recorded to evaluate the effects of different doses of carp PG on breeding success of *H. fossilis*.

Pertinent data were subjected to necessary Arcsin and Logarithm transformation and analyses by one way analysis of variance (ANOVA). The data on fertility, hatchability, deformity were further tested to asses significant difference between treatment groups using Duncan's New Multipul Range Test (DNMRT). Necessary statistical analysis were performed after Zar (1996)

Results and discussion

Induced breeding trials of *H. fossilis* with five doses of carp pituitary gland (PG) extract showed significantly higher ($P<0.05$) ovulation at T_4 and T_5 containing carp PG extract of 100 and 125 mg/kg body weight respectively. Where as significantly lower ($P<0.05$) ovulation rate was observed at T_3 having carp PG extract of 75 mg/kg body weight, PG (Table 1). However, the fishes did not ovulation with 25 and 50 mg of carp PG extract/kg body weight (Table 1).This agree with the findings of Jhingran (1991), and Munshi and Hughes(1992) who recommended carp PG extract dose at 150-200 mg/kg body weight for economic breeding of *H. fossilis*. The effect of hormone dose on fertilization and hatching rate of eggs was significant. T_3 gave the highest ($P<0.05$) fertilization and hatching rate followed by $T_4$and T_5 (Table 1). The results agree with the findings of Pal and Khan (1969), Khan (1972a and b) and Saha (1998). However, in case of *Clarias batrachus*, the fertilization and hatching rate of eggs were reported by Naser *et al.* (1990) to be 51 to 96% and 42 to 81%, by Das *et al* (1992) to be *40 to 90* % and 25 to 75%, by Ahmed and Kabir (1985) to be 55 to 95% and 20 to 70% respectively. While Rahmatulla *et al.* (1983) reported the percentage of fertilization of eggs of the same species to vary from 50 to 90%.

Month to month variation in the rate of ovulation, fertilization, hatching deformity and mortality of eggs was significant ($P< 0.05$) of *H. fossilis* (Table 2). Ovulation rate was the highest in May (87%) which declined in June (81%) but exhibited a pronounced pick in July (84.8%) and then decreased in August (80%) (Table 2).

Table 1. Effect of different doses of carp PG extract on ovulation, fertilizstion and hatching rates

Treat ments	Dose of carp PG extract (mg/kg body weight)	No. of female induced	Ovulation response	Ovulation (%)	Fertilization (%)	Hathching (%)
T_1	25	10	Not ovulated	-	-	-
T_2	50	10	Not ovulated	-	-	-
T_3	75	10	Ovulated	80^b	98.0^a	38.0^a
T_4	100	10	Ovulated	90^a	96.5^b	37.2^b
T_5	125	10	Ovulated	90^a	92.3^c	28.1^c

Table 2. Monthly variation in the percentage of ovulation, fertilization, hatching, deformity and mortality of eggs of *H. fossilis* as recorded during the experimental months

Parameters	Month			
	May	June	July	August
Dose of carp PG extract (mg/kg body weight)	75-100	75-100	75-125	75-125
Number of fish induced	15	22	33	25
Weight (gm) of the experimental females	35-70	40-90	40-110	40-140
Ovulation(%)	86.6^a	81.0^c	84.8^b	80.0^d
Fertilization (%)	94.6^b	96.0^a	96.4^a	93.3^c
Hatching (%)	37.8^c	42.5^b	48.7^a	38.2^d
Deformity (%)	28.5^a	21.5^c	18.6^d	26.8^b
% of mortality (up to 5^{th} day)	33.3^c	42.5^a	36.8^b	31.9^d

The highest fertilization percentage (96%) was obtained in July and June while the lowest (93%) in August. The highest hatching rate (48.7%) was recorded in July while the lowest (37.8%) in May (Table 2). The results of the present experiments indicated that June and July are the peak season for induced breeding of *H. fossilis*. Similar findings on induced breeding of *H. fossilis* was obtained by Bhatt (1968), Jhingran (1991), Kuddus *et al.* (1997) and Saha(1998) and in the induced breeding of *C. batrachus* by Das *et al.* (1992). The highest (28.5%) and the lowest (18.6%) deformity was recorded in May and July respectively. However, the highest deformity as recorded in May was found to decrease gradually till July (19%) and again increasing in August (27%). Significantly higher (42.5%) mortality was found in June followed July (36.8%), May (33.3%) and August (31.9%).

Result of the present study indicate that carp pituitary gland extract (PG) at a dose of 75 mg/kg body weight gave the highest percentage of fertilization and hatching while the same hormone extract at the doses of 100 and 125 mg/kg body gave the highest percentage of ovulation. In over all consideration Carp PG extract at the rate of 75 mg/kg body weight appears to be the suitable dose for its induced breeding of *H. fossilis* and the present findings may serve as a basis for the induced breeding of similar cat fishes in Bangladesh.

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(*Manuscript received 18 October 2000*)

Bangladesh J. Fish. Res., 5(2), 2001: 149-154

Effect of feeding frequency on the growth of common carp (*Cyprinus carpio* L.) fry

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Abstract
A laboratory-feeding trail was conducted for 45 days with fry of common carp *Cyprinus carpio* L. (0.45±0.03g) in aquaria in a static indoor fish rearing system. The fry were fed on a pelleted diet containing 33% crude protein having fishmeal as major protein source. The fish fry in five treatments A, B, C, D, and E, each with two replicates were fed on 5% daily ration divided into different feeding frequencies of 2, 3, 4, 5 and 6 times a day respectively in order to observe the growth performance. Each replicate contained 15 fry having total initial weight of 6.87±0.31g. At the end of the feeding trial, significantly different and higher ($p<0.05$) growth response was observed in treatment C having a feeding frequencies of 4 times a day. Significantly the highest and the lowest percent growth of 334.30 and 218.91% were observed in fish fed on the diet (Treatment C) with 4 times and (Treatment A) 2 times feeding frequencies per day, respectively. Food conversion ratio (FCR) of 1.78 was significantly higher ($p<0.05$) in fish fed on the diet having 2 times feeding frequencies whereas, the least value of 1.22 was obtained in fish fed on the diet with 4 times daily feeding. Protein efficiency ratio (PER) ranged from 1.68 in fish in treatment A having a feeding frequencies of 2 times per day to 2.48 in fish in treatment C fed on the diet with 4 times feeding frequencies. Other growth parameters *viz*, specific growth rate (SGR), apparent protein digestibility (ADP) were also higher in treatment C than the other treatments. The results of the present study demonstrated that the growth performance of *C. carpio* was the best at 4 times feeding in a day using 33% dietary protein containing fish meal as major protein source.

Key word: Feeding frequency, *Cyprinus carpio*, Fry

Introduction

Expansion of aquacultural practice of a target species greatly depends on feeding technology and feed cost is one of the largest operational costs in aquaculture (De Silva and Davy 1992). The feed to be presented to the target species should be nutritionally balanced, easily utilizable and also digestible for the viability of the aquacultural practice. In general the feeding regime and growth of fish are very much related. It is evident from earlier studies that the rate of feeding alters nutrient intake and digestibility, as excess feeding may lead to leaching of nutrients and limited feeding may suppress growth due to starvation (Hepher 1990). Feeding frequency may provide maximum utilization of diet by providing best FCR and weight gain of cultured fish species. Therefore, an important step in the feeding strategy is to determine the optimal frequency of feeding for the target species in aquaculture to get desired growth of fish.

Multiple feeding results in a more efficient utilization of the feed than a single feeding (Murai and Andrews 1976). The number of feeding per day and the time of feeding vary with species, size of fish and environmental conditions. It is also affected by gut transit time, gastric evacuation time, exposure of feed with gastric juices, retention time, feed quality, meal size and gut length.

Among the popular exotic carps, common carp (*Cyprinus carpio*) is favourite fish to the people of Bangladesh for its palatability, hardy nature, spawning nature, high growth rate and also for its high yield. The present study was undertaken with a view to study the growth response of the fish fed on a formulated standard diet at different feeding frequencies. In these regard different aspects of growth parameters like, food conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), apparent protein digestibility (APD) were studied.

Materials and methods

The feeding trial of common carp fry (*Cyprinus carpio*, 0.45±0.03g) was carried out for a period of 45 days during the months of April to June'99 in glass aquaria of a static indoor fish rearing system in the laboratory of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh. Fry of common carp (*C. carpio*) were collected from a private farm of Digharkanda, Mymensingh. They were transferred in a plastic stocking tank of 250L capacity and were given a prophylactic treatment with 0.5% NaCl dip for 20 minutes. Then they were bathed in 0.5 ppm methylene blue solution for 24 hours followed by an acclimatization with the experimental condition for 15 days in three aquaria with adequate aeration. During acclimatization the fish were fed pelleted diet containing 33% crude protein at a ration of 5% body weight.

For the feeding trial ten rectangular glass aquaria (45cm×25cm×25cm) were used. About two-third of each of the aquarium was filled with tap water for the experiment and provided with artificial aeration using aquarium air pump (Daivo NS 4200). A natural photoperiod of day and night was maintained throughout the experiment. The ambient water temperature ranged between 27 and 32°C during the experimental period.

Before formulating the diet, the dietary ingredients were subjected to proximate analysis (Horwitz 1984). The experimental diet contained fishmeal as major source of dietary protein together with other ingredients as wheat flour, carboxy methyl cellulose (CMC), tasting salt (monosodium glutamate, MSG), vit. premix (Rhone-Poulence, Bangladesh), chromic oxide, ∝-cellulose and soybean oil. All these ingredients were mixed at required amount so that the final diet contained 33% crude protein. The formulation of the diet with different ingredients and the proximate composition are shown in Table 1.

Table 1. Formulation of the experimental diet (33% crude protein level, % dry weight basis)

Ingredients	Amount (%)	Proximate composition	% dry weight basis
Fish meal	43.00	Dry matter	92.92
Wheat flour	30.00	Crude protein	33.34
Carboxy methyl cellulose	2.00	Crude lipid	11.53
Tasting salt	0.50	Ash	9.65
Vit. Premix*	1.00	Nitrozen free extract	45.48
Chromic oxide	0.50	Gross energy (Kcal/g)	4.35
∝-cellulose	19.00		
Soybean oil	4.00		
Total	100		

* Rhone-Poulence, Bangladesh.

The feeding trial was conducted in five treatments named A, B, C, D and E each with two replicates. In each of the replicates, 15 fish were used. The fry in each replicate were fed at 5% ration level daily divided into different feeding frequencies of 2, 3, 4, 5 and 6 times respectively. Feeding was started at 9.00 am until 5.30 pm as per feeding frequencies. An adequate level of oxygen in each aquarium was ensured through artificial aeration by using aquarium air pump. Everyday in the morning before feeding started, about one-third water of aquaria was replaced by new water to keep the water quality as good as possible. Close observation was made during feeding so that no pelleted diet left uneaten in the aquaria. Siphoning method was followed to remove uneaten food (if any) and faeces from each aquarium. The total amount of feed fed was recorded for each treatment in order to subsequent calculation of SGR (Brown 1957) FCR (Castell and Tiews 1980), PER (Castell and Tiews, 1980) and APD (Maynard and Loosli 1969).

Faeces were collected during the last week of the experimental period for analysis of protein digestibility of feed. Faeces from each aquarium were removed carefully by siphoning about 30 minutes after last feeding. These were collected separately from each replicate of all treatments and pooled together according to replicate and dried in oven at 70°C and then kept in airtight vials for subsequent chemical analysis. Chromic oxide in the diet and faeces was determined by using wet digestion technique of Furukawa and Tsukahara (1996). Percent APD of the experimental diet was calculated using the formula of Maynard and Loosli (1969).

For growth data all experimental fish in each replicate of different treatments was individually weighed at every 15th days which was also used for adjusting ration. Fish were weighed up to the nearest 0.01g on a precise electronic balance. At the beginning of the experiment, 60 fish from the stocking tank was randomly collected, sacrificed, weighed and dried in oven for analyzing proximate composition as initial carcass composition of fish. At the end of the experiment, all fish of each of the replicates of treatments was weighed, sacrificed and dried in oven at 100°C for subsequent analysis for proximate composition and other growth parameters. The proximate composition of dietary ingredients, diets, faeces and fish samples were analyzed according to methods described by Horwitz (1984).

Data collected during growth trials and subsequent analysis of diets, faeces and carcass composition were used to determine growth parameters.

One factor analysis of variance (ANOVA) was performed to observe the effect of feeding frequency on the growth of fish in different treatments. For this purpose the percent data were converted to arcsine and then applied for analysis. This was followed by Tukey's multiple range test (Zar 1984) to analyze any significant difference between treatment means at 5% level of significance.

Results and discussion

It was observed that the increase of feeding frequency did not always produce increase in growth. Here, in this experiment four times feeding per day showed significantly ($P<0.05$) the best growth at the end of the experiment. The mean percent weight gain of fishes fed on diet at different feeding schedules of 2, 3, 4, 5 and 6 times a day were 218.91, 303.94, 334.30, 276.93 and 251.95% respectively. The comparison on the mean percent weight gain in fish fry fed on diet at different feeding frequencies is given in Figure 1. Significantly ($p<0.05$) higher increase of mean percent growth was observed in the fish fed four times daily than the fish fed 2, 3, 5 and 6 times daily showing an increase of feeding frequency which did not increase the growth of fish progressively. The lowest ($p<0.05$) growth was found in fish having a feeding frequency of two times per day. Similar result was observed by Chiu *et al.* (1987), Charles *et al.* (1984) for the same species of *C. carpio*. Capper *et al.* (1982) also reported different values of FCR for *C. carpio* with formulated diet at different feeding frequencies. Thus a feeding schedule of four times a day seemed to be optimum resulting a good growth.

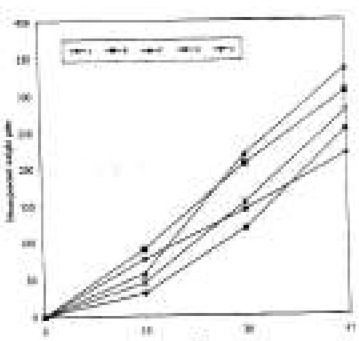

Fig. 1. Mean weight gain in C. carpio fed on the formulated diet at 5 frequencies of 2, 3, 4, 4, 5 and 6 times (A, B, C, D and E respectively) daily for 45 days feeding trial.

Specific growth rate (SGR) in treatments A, B, C, D and E were observed 2.58, 3.10, 3.24, 2.95 and 2.53 at feeding frequencies of 2, 3, 4, 5 and 6 times a day, respectively (Table 2). The SGR values in the treatment C (fish fed four times daily) was found significantly ($p<0.05$) higher than the others. The SGR increased with the increase in feeding frequency in a day reached to the peak at feeding frequency four times a day and then the value was decreased with the further increase in frequency (Chiu *et al.* 1987)

Food conversion ratio (FCR) of the diet used for feeding at different frequencies of 2, 3, 4, 5 and 6 times a day were found 1.78, 1.47, 1.22, 1.35 and 1.57 respectively. Ahsan (1995) observed FCR values of 1.79 to 2.16 for *Labeo rohita* fed on diet containing 33.92% protein. In the present study the least FCR value was observed in the treatment where the fish fed with a feeding frequency of four times in a day (Table 2). It was significantly ($p<0.05$) different from other values except from the feeding frequency of 5 times a day.

The protein efficiency ratio (PER) of the present study followed the trend opposite to FCR values and ranged from 1.68 to 2.48. Significantly ($p<0.05$) the highest PER was produced by treatment C (four times feeding per day) followed by D, B, E and A, respectively. Choudhury (1998) reported that PER value of 2.14 to 2.32 for *L. rohita.* Thus a feeding schedule of 4 times a day seemed to be optimum resulting a good growth and may be suggested as a recommended frequency for culture of *C. carpio*.

The apparent protein digestibility (APD) at different feeding schedules was found to be 71.01, 76.71, 81.76, 78.26 and 74.79 in different treatments A, B, C, D and E respectively. The highest APD value 81.76% was seen in fish fed at the frequency of four times per day and the least APD value was observed in treatment A at two times feeding per day. Carlos (1988) revealed similar result of growth response due to apparent protein digestibility in bighead carp fry. However, APD value in this study was slightly lower than that of Jayaram and Shetty (1980) who reported that protein digestibility value was 91.88% in rohu fish fed on formulated diets containing 34.33% dietary protein. In another experiment, Biswas (1997) observed the APD value of 80.50% for *Puntius gonionotous* fed on diet containing fish meal having dietary protein of 33%. Choudhury (1998) also observed a similar APD value of 81.70% when *Labeo rohita* fed formulated diets containing 33% crude protein. Therefore, the APD values of the present experiment were varied much within the range found in related species as reported by different authors. In this study, the carcass composition did not show significant variation in respect to crude protein, lipid, moisture and ash content.

Table 2. Growth parameters of *Cyprinus carpio* fed experimental diets for 45 days of feeding trial

Treat-ments	Mean Initial weight (g)	Mean Final weight (g)	Mean % weight gain	Total amount of feed fed (g)	SGR (%)	FCR	PER (%)	APD (%)
A	7.49^a	26.83^b	218.91^a	29.18	2.58^a	1.78^a	1.68^a	71.01^a
B	5.61^a	22.66^b	303.94^a	24.90	3.10^a	1.47^b	2.05^{bc}	76.71^{ab}
C	6.93^a	29.57^a	334.30^a	27.44	3.24^a	1.22^c	2.48^a	81.76^a
D	6.51^a	24.52^b	276.93^a	24.29	2.95^a	1.35^{bc}	2.23^{ab}	78.26^{ab}
E	7.81^a	24.35^b	251.95^a	25.98	2.53^a	1.57^{ab}	1.91^{bc}	74.79^{bc}

*Figures in the same column having the same superscripts are not significantly different ($p>0.05$)

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(Manuscript received 4 March 2000)

Bangladesh J. Fish. Res., 5(2), 2001: 155-162

Comparison of benthic fauna of two *beels* under different management system

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Abstract

A comparative study of benthic fauna between Rajdhala beel and Padmai beel of Netrakona District under different management system was carried out from July'99 to January'00. An average number of 1113 and 1175 organisms /m^2 were obtained from Rajdhala beel and Padmai beel respectively. A total of 22 taxa belonging to 8 diverse groups, Oligochaetes, Chironomids, Molluscs, Ceratopogonids, Diptera (other than Chironomids and Ceratopogonids), Ephemeroptera, Leeches and Crustaceans were recorded. Oligochaetes were dominated and constituted 46% and 49% of the total benthic population in Rajdhala beel and Padmai beel respectively. The next dominant group was the Chironomids, which constituted 31% and 30% of the total benthic population in Rajdhala beel and Padmai beel respectively. The highest number 1279 and 1437 individuals /m^2 of benthic fauna was recorded in December from Rajdhla beel and Padmai beel in respectively. The lowest number of benthic fauna 869 and 914 individuals /m^2 were found during September and July from Rajdhala beel and Padmai beel respectively. Monthly variation of benthic fauna among two beels were found statistically significant ($p<0.05$). The numerical distributions of benthic fauna was found to be varied with depth ranges. However, the depth wise variation of total benthic fauna between two beels was not found statistically significant. Fish yield of Rajdhala beel (488 kg/ha/yr) was appreciably higher than the Padmai beel (250 kg/ha/yr).

Key words: Benthic fauna, Beel

Introduction

Inland water areas of Bangladesh mainly included network of rivers and canals, flood plains (3-6 months inundated low lying areas), haors (large deeply flooded depression), baors (oxbow lake), beels (depressions often with permanent area of water) and ponds. Recently efforts are being given to study the inland capture fisheries resources by different GO and NGOs to increase fish production. Different approaches have taken to ensure sustainable and increased fish production from open water and to improve the socio-economic condition of the fisherman. As a part of the activities, The Community Based Fisheries Management Project (CBFM) started to work on 19 rivers and beels in late 1995. The project involves a partnership of Department of Fisheries

(DOF), five NGOs and International Center for Living Aquatic Resources Management (ICLARM). The project was designed as an action research project to test and assess alternative model of GO-NGO-fisher collaboration and thereby develop a framework for community based fishery management that might achieve grater efficiency, equity and sustainability (Thompsom *et al.* 1999). Under the CBFM project NGO Caritas is supporting fishery management in Rajdhala beel under Purbadhala thana of Netrakona district in Co-ordination with ICLARM. Another beel namely Padmai beel is also situated within the same ecological region and is under traditional management. Study programme was designed to study the comparative abundance and depth distribution of benthic fauna of Rajdhala and Padmai beels. Hopefully, the findings of this study on abundance, composition and distribution of benthic fauna of two beels can provide benchmark data for beel management in Bangladesh.

Materials and methods

Study area

The bees under study are located at Purbadhala thana of Netrakona district within 24°70′ 25°8′ N and 90°29′ 90°48′ E. Beels are in the Agro Ecological Zone (AEZ) 9 and subregion 9b of the country, which is under Old Brahmaputra flood plain (FAO 1988).

Rajdhala and Padmai beels is a semienclosed perennial round shaped waterbody. Rajdhala beel has a water depth 4.6-7.7 m and covers about 53 hectares water area. Whereas in Padmai beel water depth was recorded the maximum of 3m and the beel covers around 20 hectares. Rainfall is the main source of water in both the beel. During monsoon months the Rajdhala beel is connected by channel called Kumarkhali khal to the river Dhalai. There are two-outlet channels (khals), run away from the beel, which were fenced to prevent escape of fish, and Padmai beel is connected by a small channel to small river Kani. Watercolour appeared light green and brownish green in Rajdhala beel and Padmai beel respectively. The marginal slope and bottom of the Rajdhala beel was regular. Bottom was formed by clear clay mud. Thickness of the mud ranges from 50 to 80 cm. Physical nature of the bottom was soft and clear. The basin wall slope of the Padmai beel was lower than that of Rajdhala beel. Bottom mud was more soft and darker in colour. Unlike Rajdhala beel the bottom of Padmai beel was full of dead and decaying leaves of aquatic plants and rhizomes and tubers of emergent vegetation, which emitted a foul odour. Thickness of bottom mud ranges 70-120 cm.

Sample collection

Benthic fauna of Rajdhala and Padmai beels were studied for a period of seven months from July'99 to January'00. Benthic samples were collected monthly (15 or 16th day of the month) from each beel from 3 different depths say, shallow (0–1 m), medium deep (1-2 m) and deep (>2 m). Three replicate samples were collected from each depth. For convenience, 9 sampling spot from each beel were marked with the help of bamboo poles to establish the sampling site. An Ekman-dredge covering an area of 225 cm^2 was used for sampling of bottom sediments using an anchored country boat. Content of the dredge, along with any materials caught were transferred to a buket and taken to the shore for washing. Each sample was than washed thoroughly using a series of standard brass seives of mesh size 0.2, 0.92 and 2.0 mm. From the residue the benthic organisms were collected under contrasting background of black and white by means of fine forceps and kept into separate vial containing 5% formaldehyde for preservation (Wetzel and Lickens 1979). The vials were marked properly and taken to the laboratory of Aquaculture Department of Bangladesh Agricultural University, for analysis.

Physico-chemical data such as air temperature and water temperature, transparency (Secchidisc), pH oxygen, carbondioxide, ammonia hardness of water also collected on the sampling date by using Hach kit (DREL 2000).

Sample analysis

After 48 hours the preserved animals were transferred to a petridish and washed with tape water to remove the remainder of the washable detritus and mud. Then benthic organisms were separated and counted into different major taxonomic groups by using a magnifying glass. The sorted animals were again preserved group wise into 5% formaldehyde and labeled properly for further study.

On a later date the preserved specimens were identified into possible lower taxa under a dissecting microscope. The worms and larvae were soaked into lactophenol for a period of 24 hours for making them transparent for identification. The specimens were taken from lactophenol with the help of a fine forcep and were placed on a clean slide with a few drops of glycerine and covered with cover slip. A binocular microscope (NOVA 950 ES) with a magnification 16×4 were used to identify the specimens. Identification was done after Pennak (1953), Usinger (1963), Needham and Needham (1966) and Brinkhurst (1971).

The data obtained from the samples were tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT, following Randomized Block Design. The mean values was compared by Least Significant Difference Test (Zar 1996) at 5% level of significance.

Results and discussion

Abundance of benthic fauna depends on physico-chemical factors. In this study the measured factors were found within the acceptable ranges. There has been no remarkable difference in the value of physico-chemical factors in two beels (Table 1).

A total of 1577 and 1665 benthic organisms were collected from Rajdhala Beel and Padmai Beel respectively, this amounted to an average number of 1113 and 1175 organisms/m^2 (Table 2).

In Bangladesh no attempts have been made to classify the beels on the basis the availability of benthic organisms. Thienemann (1925) classified a lakebed producing between 1000-2000 animals/m^2 as mesotrophic. On the basis of his classification it can be concluded that both the beels are mesotrophic *i.e.*, medium productive. A total of 22 taxa belonging to 8 diverse groups were recorded from two beels.

Table 1. Physico-chemical parameter of Rajdhala beel and Padmai beel

Factor/ Beel	Air tem. (°C)	Water tem. (°C)	Trans-parancy (cm)	pH	DO (*mg/L*)	Free carbon dioxide (*mg/L*)	Amonia (*mg/L*)	Hardness (*mg/L*)
Rajdhala	27.00 ±4.65	26.13 ± 4.13	76.40 ±3.86	7.73 ±0.35	7.30 ±0.21	5.14 ±0.61	0.22 ±0.01	87.10 ±1.42
Padmai	27.00 ±4.65	25.57 ±5.20	104.39 ±5.63	7.65 ±0.28	5.93 ±0.52	5.18 ±0.19	0.20 ±0.05	102.84 ±2.62

Table 2. Total number, percentage composition and average number/m^2 of different groups of benthic fauna recorded from different months in Rajdhala beel and Padmai beel

Groups of benthic fauna	Beels	Monthly value							Total	% of total nos.	Av. no./ m^2
		July	Aug	Sep	Oct	Nov	Dec	Jan			
Oligochaeta	Rajdhala	115	150	92	116	80	88	88	729	46.23	514
	Padmai	134	166	141	122	99	74	77	813	48.83	574
Chironomidae	Rajdhala	26	36	47	69	79	124	108	489	31.00	345
	Padmai	40	39	53	60	71	144	119	496	29.79	350
Mollusca	Rajdhala	45	42	23	24	23	20	12	189	11.99	133
	Padmai	0	3	6	18	44	71	50	192	11.53	135
Ceratopogonidae	Rajdhala	18	5	0	12	21	22	30	108	6.85	77
	Padmai	6	10	6	21	19	14	14	90	5.41	63
Other Diptera (except chrinomidae & ceratopogonidae)	Rajdhala	2	2	1	1	1	1	4	12	0.76	8
	Padmai	1	1	4	3	2	4	0	15	0.90	11
Ephemeroptera	Rajdhala	0	1	3	2	2	3	4	15	0.95	11
	Padmai	0	2	2	4	1	5	4	18	1.08	13
Hirudinea	Rajdhala	2	4	5	3	4	0	3	21	1.33	15
	Padmai	2	3	2	5	3	5	2	22	1.32	16
Crustacea	Rajdhala	2	1	5	1	2	1	2	14	0.89	10
	Padmai	2	3	1	2	5	4	2	19	1.14	13
Total number	Rajdhala	210	241	176	228	212	259	251	1577	100	1113
	Padmai	185	227	215	235	244	291	268	1665	100	1175
Average number /m^2	Rajdhala	1037	1190	869	1126	1047	1279	1240	-	-	-
	Padmai	914	1121	1062	1160	1205	1437	1323	-	-	-

The major groups of benthic fauna recorded from two beels during the present study were Oligochaetes, Chironomids and Molluscs. The dominance of these groups of macrobenthos has been reported earlier by Das and Islam (1983) from tropical freshwater pond, and Kumar and Mitra (1986) from Ox-bow Lake. The probable cause of the occurrence of these dominant groups of bottom fauna may be due to the favourable ecological condition for their growth. Bottom type and amount of bottom deposits exert a significant influence upon the occurrence of bottom organisms and their kinds. The character of bottom deposits affects the nature and distribution of bottom fauna has been demonstrated by many authors (*e.g.* Reid 1964).

Monthly fluctuation of major groups of benthic fauna was observed during the study period and shown in Fig. 1. The highest number, 1279 organisms/m^2 and 1437 organisms /m^2 was found in December from Rajdhala beel and Padmai beel respectively. A lowest number 869 organisms/m^2 was found during September in Rajdhala beel and 914 organisms/m^2 during July in Padmai beel. Monthly variation in abundance of benthic fauna between two beels were found statistically significantly different ($P<0.05$).

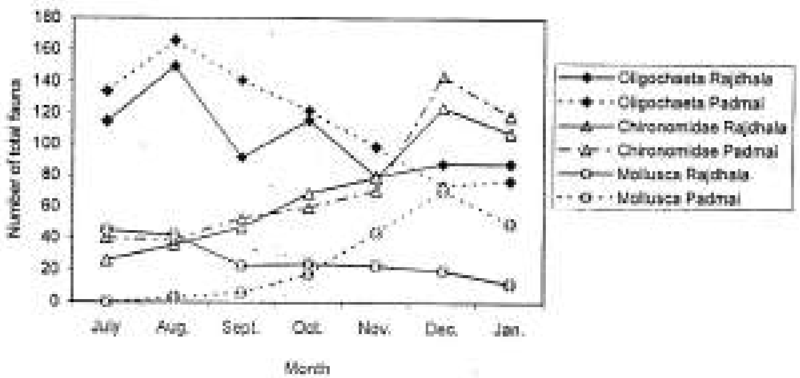

Fig. 1. Monthly fluctuation in abundance of major groups of benthic fauna in two beels .

The climatological factors revealed a close relationship with the qualities of soil and water. Moore (1980) pointed out that the diversified physico-chemical conditions of the littoral zone should result in quantitatively diversified littoral fauna. The seasonal abundance of benthic fauna may be due to changes in temperature, periodical changes of water level by the rain and flood water incursion. Sutcliffe *et al.* (1981) stated that the reproductive biology and growth rate of benthic organisms increased with increased temperature. Here in this study higher number of benthos was found in December and similar results was also reported by Dewan (1973), Das and Islam (1983). Perhaps the greater number of benthic fauna in winter months might be due to the less predation by bottom dwelling fish at low temperature or might be due to the complex community interaction.

The numerical distribution of different groups of benthic organisms varies with three depth ranges during the study period. The greater density of benthic population was found to occur in shallow (42%) and medium deep (32%) region of Rajdhala beel, while in Padmai beel greater number of organisms recorded in deep region (43%).

The benthic species are greatly distributed in these habitats according to their suitability, availability of food etc. Ball (1948) concluded that food play an important role in the distribution of benthic organisms. The higher number of benthic population in deep region of Padmai beel may be due to the flatness of the bottom and comparatively less area of deep region beel bed than the shallow and medium deep region bottom, beel bed perhaps provided suitable substratum for growing benthic fauna. Abundant macrovegetation might support more food and shelter for macrobenthos. The important vegetation being responsible for increasing the number of benthic communities has been stressed by various authors such as Dimitrov (1977). ANOVA indicated that there was no statistically significant difference of depth distribution of total fauna between two beels (Table 3). But major groups of fauna *viz*, Oligochaetes, Chironomids, Molluscs varied significantly ($P < 0.05$) between two beels at different depth.

Table 3. Summary of ANOVA analysis for depth distribution of total benthic fauna, Oligochaetes, Chironomids and Molluscs of Rajdhala and Padmai beels

Source of variance	F value			
	Total fauna	Oligochaetes	Chironomids	Molluscs
Replication	7.33 (20,100+)*	8.94 (20,100+)*	27.16 (20,100+)*	1.18 (20,100+)
Factor A (Beel)	3.74 (1,100+)	7.38 (1,100+)*	0.13 (1,100+)	0.01 (1,100+)
Factor B (Depth)	1.58 (2,100+)	32.17 (2,100+)*	13.52 (2,100+)*	15.28 (2,100+)*
AB	158.08 (2,100+)*	147.59 (2,100+)*	49.12 (2,100+)*	4.26 (2,100+)*

+ The figures within parenthesis indicate the degrees of freedom
* The figures followed by the mark indicate the significant value

Maximum dominance of Oligochaetes was observed in both the beels and constituted 46% and 49% of the total fauna in Rajdhala beel and Padmai beel respectively. This group represented by 6 species, *Branchiura sowerbyi*, *Limnodrilus hoffmeisteri*, *Aleosima* sp., *Chaetogaster* sp., *Dero digitata*, *Tubifex* sp. *Branchiura sowerbyi* was the most dominant species and account 35% and 41% of the Oligochaetes in Rajdhala beel and Padmai beel respectively. Possibly more ecological suitability, food availability and breeding facilities for Oligochaetesls had prevailed then the other groups. Das and Islam (1983) found more Oligochaetes having more organic matters in the pond mud. The maximum abundance of Oligochaetes was found in August from both beels and minimum in November from Rajdhala beel and in December from Padmai beel. This trend might be due to variation in water temperature. But monthly variation of Oligochaetes fauna between beels were found no statistically significant. The more occurrence of *Branchiura sowerbyi* is probably due to utilization of organic matter in bottom sediments by this species. High occurrence of Oligochaetes in the rainy season is also supported by Dewan (1973), Das and Islam (1983).

Chironomids ranked the second dominant group of benthic fauna recorded during the study period and constitute 31% and 30% of total benthic fauna in Rajdhala beel and Padmai beel respectively. Most dominant species was *Chironomus* sp. and accounted 61% and 57% of the groups in Rajdhala beel and Padmai beel respectively. Other species were

Procladius, *Pentaneura*, *Tenypus*. Monthly variation of total fauna of Chironomids between two beels shows statistically significant difference ($p<0.05$) (Table 4). A distinct seasonal variation in the population of Chironomids was observed in the study with the highest number in December form both the beels and lowest in July in Rajdhala beel and in August in Padmai beel. The observed lowest number in July and August might be due to heavy grazing by fish. Which agree with the observation of Brown and Oldham (1984) and Wahab (1988).

Table 4. Mean of monthly variation of total benthic fauna, Oligochaetes, Chironomids and Molluscs of Rajdhala Beel (B_1) and Padmai Beel (B_2)

Depth	Total fauna		Oligochaetes		Chironomids		Molluscs	
	B_1	B_2	B_1	B_2	B_1	B_2	B_1	B_2
July	23.33^{bcd}	20.56^{cd}	12.78^{bc}	14.89^{ab}	2.89^{f}	4.44^{ef}	5.00^{b}	0.00^{e}
August	26.78^{abcd}	25.22^{abcd}	16.67^{a}	18.44^{a}	4.00^{ef}	4.33^{ef}	4.67^{b}	0.33^{e}
September	19.56^{d}	23.89^{bcd}	10.22^{cd}	15.67^{ab}	5.22^{de}	5.89^{cde}	2.56^{c}	0.67^{de}
October	25.33^{abcd}	26.11^{abcd}	12.89^{bc}	13.56^{bc}	7.56^{bc}	6.67^{bcd}	2.67^{c}	2.00^{cd}
November	23.56^{bcd}	27.11^{abc}	8.89^{d}	11.00^{bcd}	8.78^{b}	7.89^{bc}	2.56^{c}	4.89b
December	28.78^{ab}	32.33^{a}	9.78^{cd}	8.22^{d}	13.78^{a}	12.67^{a}	2.22^{c}	7.89^{a}
January	27.89^{abc}	29.78^{ab}	9.78^{cd}	8.56^{d}	12.00^{a}	13.22^{a}	1.33^{cde}	5.56^{b}

*The figures within a group of benthic fauna (Total fauna, Oligochaetes, Chironomids and Molluscs) bearing same letter(s) indicate no differences.

Molluscs were the third dominant groups and contribute 11.93% and 11.53% of the total fauna in Rajdhala beel and Padmai beel respectively. Molluscs were represented by *Viviparus bengalensis*, *Lymnaea* sp., *Planorbis* sp., *Melanoides* sp. The occurrence of *Viviparus bengalensis* was the most dominant and constitute 45% and 56% of the Molluscs in Rajdhala beel and Padmai beel respectively. Variation of Molluscs between two beels during different months of study showed statistically significant difference ($p<0.05$). Monthly abundances of Molluscs in two beels show a diverse pattern. Molluscs were totally absent in July in Padmai beel, possibly due to greater movement of the species to the surrounding inundated agricultural lands. This can be attributed to presence of weeds and suitable water level for their food and shelter. On the contrary, maximum number of Molluscs in July in shallow region of Rajdhala beel might be due to presence of vegetation for shelter in the marginal area of the beel.

Minor groups of benthic fauna Ceratopogonidie, other Diptera (except Chironomidae and Ceratopogonidae), Ephemeroptra, Hirudinea and Crustacea were negligible in number and irregular in occurrence in both beels. Biwas (1977), Das and Islam (1983) have reported similar observation.

Post monsoon luxurious growth of aquatic weed was noticed in Padmai beel. Benthic fauna were more abundant in weed infested bottom substrate than clear open bed (Schramm and Jirka 1989). Padmai beel received agricultural discharge from the surrounding encatchment areas. Nutrient rich discharge and heavy light penetration in shallow depth might have been highly encouraging for prolific growth of weed. Shaha *et* *al.* (1990) observed that removal of macrovegetation from Kulia beel, West Bengl, India, make the ecosystem highly productive and fish yield increased from 320 kg/ha to 1077 kg/ha.

Acknowledgements

The author acknowledge with sincere appreciation Dr. Paul M. Thompson, Technical Co-ordinator, ICLARM, Dhaka for providing financial support.

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(Manuscript received 9 August 2000)

Bangladesh J. fish. Res., 5(2), 2001: 163-168

Incidence of ulcer type of disease in wild fishes of Bangladesh

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Abstract
Disease occurred in wild fish species investigated in different water bodies like canals, ditches, beel, haor, flood plain etc. in 17 districts of Dhaka division. Haemorrhagic lesions were observed on the body surface of affected fishes. Incidence of the disease in the investigated water bodies ranged from 0 to 100%. In total 19 fish species were found to be affected and prevalence of infection ranged from 0.0 to 100.0%. *Channa punctatus* and *Puntius ticto* were severely affected in all locations. Percentage of infection in these fishes ranged from 0.0 to 100.0. The highest infection was observed in Netrokona, Kishoreganj, and Mymensingh districts. Bacterial genera isolated from the lesions of these affected fishes were *Aeromonas*, *Pseudomonas*, *Flavobacterium*, *Micrococcus*, and *Staphylococcus*. Among these isolates *Aeromonas* was the dominant. Abundance of *Aeromonas* in the lesions among the investigated bacteria ranged from 75 to 90%. Five identified *Aeromonas hydrophila* were examined for their pathogenicity and were able to infect the experimental fish, silver barb (*Puntius gonionotus*). The pathogen *Aeromonas hydrophila* was thus considered to have an association with the outbreak of ulcer type of disease in the investigated fish species.

Key words: EUS, *Aeromonas hydrophila*

Introduction

Bangladesh is uniquely endowed with the diverse of very rich and extensive inland and marine fishery resources which mainly include rivers, flood plains, estuaries coastal belt and vast sea waters. Disease has become a major problem in fish production both in culture system and wild condition in Bangladesh (Rahman and Chowdhury 1996). In Bangladesh the fish has been suffering from ulcer type of diseases of different expressions including epizootic ulcerative syndrome (EUS), bacterial haemorrhagic septicaemia, tail and fin rot, bacterial gill rot, dropsy, columnaris disease, fungal disease and parasitic disease (Chowdhury 1997). In an investigation of the fish farms by spot observation many farmed fish species were found to suffer from diseases caused by bacterial pathogens (Chowdhury 1993).

Considering the importance and immediate need for the country research works, the present study was planned to achieve the prevalence of the gross fish disease occurred in wild fish species in Dhaka division, to determine the percentage composition of bacteria in the lesions of the affected fishes and to perform pathogenicity test of some recovered aeromonad isolates suspected as pathogen.

Materials and methods

Investigation of the occurrence of fish disease

Investigation of the occurrence of disease in fishes were carried out on the basis of observation and sampling of fish from different waterbodies in 17 districts of Dhaka division of Bangladesh starting from November'98 and continued up to March'99. Fish were sampled randomly from three wild waterbodies (canal, beel, haor, ditches and flood plain) of one randomly selected thana of each district. Gross diagnosis of ulcer type of disease in the investigated fish was based on eye observation on the spot having haemorrhagic lesions on the fish body. A total of 100 fish samples were grossly examined from each waterbody. Total fish species and the infected fishes were counted and percentage of infection was calculated.

Collection of fish

Mymensingh, Netrokona, Kishoreganj, Tangail and Jamalpur among 17 districts were selected for collection of severely affected fish for isolation of bacteria. Bacterial isolates were collected from the lesions of body surface of the farmed fish *viz., Channa punctatus, C. striatus, Mastacembelus armatus, M. pancalus* and *Puntius ticto*. The samples were brought to the laboratory immediately after collection for bacteriological study.

Bacteriological Investigation

Tryptone Soya Agar (TSA) was used for culture and swabs were aseptically taken on the culture plate with a sterile inoculating loop and spreaded. The plates were incubated at 25°C for 36-48 hours. Twenty colonies were randomly separated from this initial culture and individual culture was maintained on TSA slants at 4°C for characterization. Morphological and biochemical characters were studied following the methods described in the Cowan and Steel's Manual for the identification of Medical Bacteria edited by Barrow and Felthem (1993) and confirmed with the help of Bergey's Manual for Systematic Bacteriology (Volumes 1 and 2) edited by Krieg and Holt (1984). Percentage composition of the identified bacteria isolated from the lesions was based on the 20 colonies initially separated.

Artificial infection in fish

For pathogenicity test five identified *A. hydrophila* isolates were tested on silver barb (*Puntius gonionotus*) of about 15 g in weight. The experimental fish were acclimatized for 3 days in the laboratory condition and checked their health before use in the experiment. Stock suspension of individual bacteria was prepared in sterile tap water taking 18-24 h culture. In a 40*l* capacity aquarium, 15*l* of bacterial suspension was prepared in the tap water with the stock suspension in such way that the bacterial dose become 3-5x10^{5} CFU/ml. The exposure dose of bacteria was followed after Chowdhury (1997). Ten fish were exposed to bacterial suspension in the aquarium under aerated condition at room temperature ranged 27-28°C. After 24 h of exposure 80% of bacterial suspension was exchanged with tap water and from the following day 60% of water was exchanged at every 24 h. Two replications were set up for the same isolate and thus in total 20 fish were used for each bacterial isolate. Experimental period was 2 weeks. For each set of experiment control fish were maintained in the same way without exposure to bacteria. No food was applied during the experimental period. Infection was recorded by observation of lesions, mortality and continued by re-isolation of bacteria from the experimental fish.

Results and discussion

Incidence of ulcer disease in the investigated natural waterbodies were recorded from 0.0 to 100.0% in different districts (Fig. 1). The result was correlated with the reports of Chowdhury (1998) where he observed 40 to 50% of the non-farmed waterbodies were affected by ulcer disease at Mymensingh in Bangladesh.

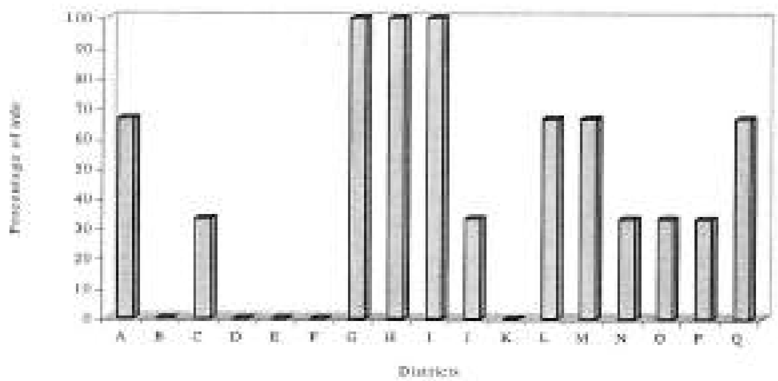

Fig. 1. Prevalence of EUS disease in natural waterbodies in different districts of Dhaka.

A: Dhaka B: Narayanganj C: Munshiganj D: Narshingdi E: Manikganj F: Gazipur G: Mymensing H: Kishoreganj I: Netrokona J: Jamalpur K: Sherpur L: Tangail M: Faridpur N: Madaripur O: Shariatpur P: Rajbari Q: Gopalganj

Nineteen different types of wild fishes *viz.*, *Amblypharyngodon mola, Anabas testudineus, Channa orientalis, C. punctatus, C. striatus, Clarias batrachus, Colisa fasciatus, Glossogobius giuris, Heteropneustes fossilis, Macrognathus aculeatus, Mastacembelus armatus, M. pancalus, Mystus aor, M. vittatus, M. tengara, Nandus nandus, Notopterus notopterus, Puntius ticto* and *Wallago attu* were found to be affected by the ulcer disease. Percentage of infection in wild fish species by ulcer disease ranged from 0.0 to 100.0%. The disease was most prevalent in Netrokona, Kishoreganj and Mymensingh districts and *Channa punctatus* and *Puntius ticto* were found to be severely affected in case of wild fish species (Table 1). Barua *et al.* (1990) observed 22 different species affected by ulcer disease and percentage of fish infection ranged from 0.0 to 100.0 and the disease was most prevalent in Bogra, Netrokona and Chandpur.

Bacterial genera recovered from the lesions of affected wild fishes were identified as *Aeromonas, Pseudomonas, Flavobacterium, Micrococcus* and *Staphylococcus.* The results were correlated with the findings of Chowdhury and Baqui (1997) where they isolated the bacterial flora from fish organs were *Aeromonas*, Coryneformes, *Flavobacterium*, Enterobacteria, *Maraxella*, *Acinetobacter* and *Bacillus*. *Aeromonas* was detected as the dominant bacteria in the lesion of affected farmed fish species and varied from 75 to 90% of the total bacterial count which are shown in Fig. 2. *Pseudomonas* was the second dominant genus followed by *staphylococcus*. However *Micrococcus* and *Flavobacterium* were less dominant bacteria found in the lesion of affected fish species. According to Chowdhury *et al.* (1995), *Aeromonas* sp. as the dominant bacteria with high percentage in the kidney of EUS affected fishes in Bangladesh. Rahman *et al.* (1998) also reported that *Aeromonas* sp. in the kidney of different affected fishes were found to be 80-90% of the total bacterial content.

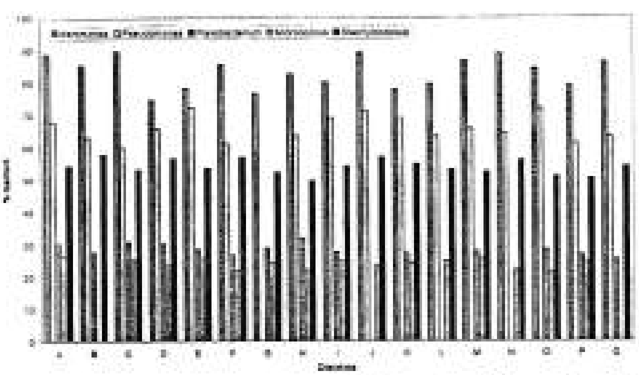

Fig. 2. Comparative percentage composition of bacterial genera in the investigated farmed fish species.

In the pathogenicity test, all the *A. hydrophila* isolates causing an ulcer type disease and mortality. In this study all of the selected isolates were able to cause lesions and mortality in the experimental fish. Appearance of lesion and mortality of fishes varied from one isolate to another. The isolate AA2 showed highest infection (100%) with 90% mortality (Fig. 3).

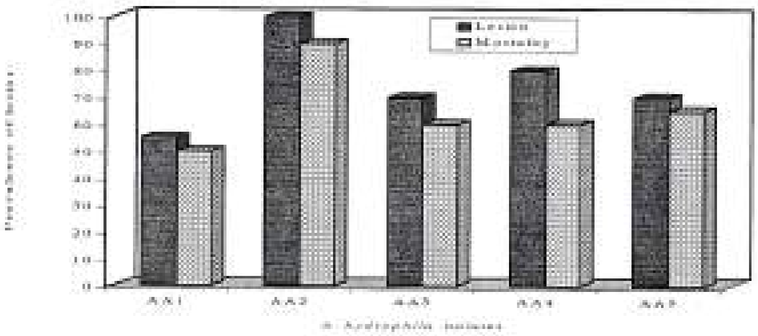

Fig. 3. Patterns of the appearance of lesions and mortality caused by different *A. hydrophila* isolates in experimental infection.

Chowdhury (1998) found 75-80% mortality in carp and catfish with exposure dose 3-5x10^5 CFU/ml of *Aeromonas hydrophila* isolates experimentally and the present study support the previous work.

The present study provides information about the occurrence of ulcer disease in farmed fishes of Dhaka division. It also provides association of the bacterial pathogen *A. hydrophila* with the disease. Knowledge of this study will be helpful to fish pathologist, fish culturists and researchers to detect ulcer disease and to take necessary measures against the bacterial pathogen.

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(Manuscript received 9 March 2000)

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Larval development of a semiterrestrial mangrove sesarmine crab *Chasmagnathus convexus* (Crustacea: Decapoda: Brachyura: Grapsidae) reared in laboratory

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Abstract

Four zoeal stages and one megalopal stage were identified in laboratory reared semiterrestrial mangrove sesarmine crab *Chasmagnathus convexus*. At an average salinity and temperature of 20±1% and 19.2±0.2°C, the megalopa was attained 24 days after hatching. Morphologically, the first zoae of *C. convexus* is very similar to those of other species of the genus *Chasmagnathus* as well as species of the genus *Helice*, in that view all share the following characteristics: lateral spine on the carapace, three pair of setae on the posterior margin of the telson furca, one plus five setae on the endopod of the maxillule, and two plus two setae on the endopod of the maxilla. The differences between the first zoea and megalopa of and those of its congeners are discussed.

Key words: Mangrove crab, *Chasmagnathus convexus*, Larval development

Introduction

Chasmagnathus convexus (De Haan) is an estuarine, semiterrestrial sesarmine crab that lives generally in burrows constructed on the river bank or in the reed marshes above the high water mark (Nakasone *et al.* 1982, Islam *et al.* 2000). Like many freshwater or terrestrial taxa that have colonized in land from the marine environment, their larval development is either abbreviated or hatching directly from the eggs (Rabalais and Gore 1985). Baba and Fukuda (1972) described the complete larval development of this species, but the illustrations and descriptions are inadequate for comparison with other species of the genus *Chasmagnathus* as well as species of sesarmine crabs. Boschi *et al.* (1967) and Green and Anderson (1973) described only the first zoea of *C. granulata* and *C. laevis*, respectively. Considering the ecological importance of this species in the estuarine environments as well as mangrove ecosystems, the present study was conducted to illustrate and describe all the larval stages of *C. convexus* in detail, and to compare them with previously studied characters of the larvae of other species of *Chasmagnathus* and other sesarmine crabs.

Materials and methods

An ovigerous *Chasmagnathus convexus* female measuring 36.7 mm carapace length and 42.3 mm carapace width, was captured from the salty spring of Waku River (bank of this river sparsely covered by mangroves), the northern part of Okinawa Island, Japan, on 25 December'98. The female was brought to the Laboratory and maintained in a plastic trough containing seawater of 20±1 ppt salinity, with moderate aeration to supply air and to circulate the seawater. Seawater temperature ranged from 17.3 to 22.9°C during the experimental period. Water was changed daily until the eggs hatched into the zoeae. The female was fed with the meat of tiger shrimp and short-necked clam.

Hatching occurred within nine days after collection. Among the newly hatched larvae, the 200 most photopositive and active zoeae were transferred into 10-liter capacity plastic bowls covered with black paper on the outside, and then reared under the same conditions as the ovigerous female. The water was aerated and half-renewed daily. Temperature was not controlled, ranged from 16.6 to 21.8°C. Zoeae were fed daily with newly hatched nauplii of *Artemia*. In addition, finely chopped meat of the short-necked clam was fed to the megalopa.

Specimens used for dissection and identification of stages were preserved in 50% ethylene glycol solution. Larvae were dissected under a binocular stereomicroscope (Nikon SMZ-10). Drawings and measurements were make with a profile projector (Nikon Profile projector V-12) and an optical microscope (Nikon FDX-35). At least 10 specimens of each stage were examined. The chromatophore pattern was determined by the observation of living larvae.

Methods for measurements of larval stages and descriptions of setal arrangements were adapted from Konishi and Shiktani (1998), Clark *et al.* (1998), Ingle (1992), Lago (1989), Hong (1988), Pohle and Telford (1981) and Rice (1979). Measurements taken were: (a) the distance between the tips of the dorsal and the rostral spines for total length (TL) of zoeae, (b) the carapace length (CL) from the base of the rostral spine to the posterior margin of the carapace of zoeae and the distance between the tip of the rostral spine and the posterior margin of the carapace of megalopa, (c) the carapace width (CW) at the widest point of the carapace of megalopa, (d) the dorsal spine length (DL) of zoeae, (e) the rostral spine length (RL) of zoeae, (f) the lateral spine length (LL) of zoeae.Setae of appendages were counted from proximal to distal segments. All features illustrated belong to the same specimen. The illustrations of appendages correspond to the true side from which the appendage was viewed under the microscope. Specimens of all larval stages and the female *C. convexus* have been deposited in the Laboratory of Marine Fisheries, University of the Ryukyus, Okinawa, Japan.

Results

Hatching of *C. convexus* larvae occurred on the morning of 3 January'99, and the larvae attained the megalopal stage at 24 days (ranged, 22-28 days) after passing through four zoeal stages. Many larvae died during metamorphosis. Measurements of typical zoeal features and larval duration are summarized in Table 1. The morphology of the first zoea is described in detail, but only morphological changes are given for subsequent larval stages.

Table 1. Measurement (mm) of various meristic characters with duration (day) of larval stages of *Chasmagnathus convexus*

Characters	1st zoea	2nd zoea	3rd zoea	4th zoea	5th zoea
Carapace length	0.52±0.01	0.61±0.02	0.83±0.03	0.97±0.01	1.73±0.02
Carapace width	-	-	-	-	1.27±0.03
Total length	1.26±0.02	1.32±0.01	1.58±0.02	1.83±0.03	-
Dorsal spine length	0.35±0.01	0.44±0.02	0.63±0.01	0.78±0.02	-
Rostral spine length	0.22±0.03	0.25±0.01	0.38±0.02	0.51±0.01	-
Lateral spine length	0.09±0.02	0.11±0.01	0.15±0.02	0.19±0.01	-
Larval duration	7.42±0.05	6.6±0.05	6.2±0.03	6.09±0.05	6.28±0.01

First Zoea (Fig. 1)

Color: Brownish or pinkish gray chromatophores on posterior base of dorsal carapace spine, posterolateral surface of carapace, base of antennule, basally on maxillipeds, mandible, base of lateral and dorsal spines, each abdominal segment and telson. This chromatophore pattern applies to all zoeal stages.

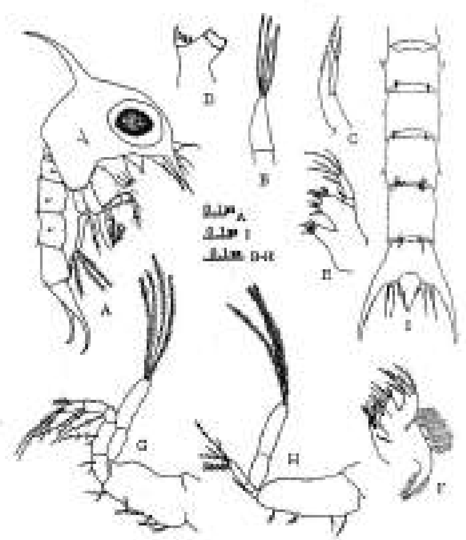

Fig. 1. First zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1st maxilliped, H. 2nd maxilliped, I. abdomen and telson (dorsal view).

Carapace (Fig. 1A): Subtriangular, smooth. Dorsal spine stout, smooth, tapering uniformly to a point, extending posteriorly. Rostral spine straight, smooth, tapered, directed downwards. Dorsal and rostral spines shorter than carapace length. Lateral spines present, shorter and more slender than preceding two spines. Posterolateral margin with 7 pairs of minute denticles. Eyes sessile.

Antennule (Fig. 1B): Exopod unsegmented and conical, with 4 terminal aesthetascs. Endopod absent.

Antenna (Fig. 1C): Protopod cylindrical with prolonged spinous process, spinous process terminates at middle of rostrum, 2 rows of denticles internally and externally. Exopod measuring 2/3 of spinous process, with 2 short setae placed at distal third. Endopod absent.

Mandible (Fig. 1D): Incisor and molar processes differentiated; incisor process with 3 large teeth; molar process cylindrical; its masticatory surface slightly hollowed. Mandibular palp absent.

Maxillule (Fig. 1E): Coxal endite with 5 plumodenticulate setae. Basial endite with 6 plumodenticulate setae. Endopod 2-segmented : proximal segment with 1 plumodenticulate seta; distal segment with 1 subterminal and 4 terminal sparsely plumose setae. Coxopod naked.

Maxilla (Fig. 1F): Coxal endite bilobed, with 4+3 plummodenticulate setae. Basial endite bilobed, with 5+5 plumodenticulate setae. Endopod bilobed, with 2+2 sparsely plumose setae. Scaphognathite with 4 highly plumose setae and elongate distal process.

First maxilliped (Fig. 1G): Coxopod naked. Basipod with 8 medial plummodenticulate setae; arranged 2, 2, 2 and 2. Endopod 5-segmented: proximal segment with 2 simple setae; segment II with 1 simple seta and 1sparsely plumose seta; segment III with 1 sparsely plumose seta; segment IV with pair of sparsely plumose setae; distal segment with 1 subterminal simple and 4 terminal sparsely plumose setae. Exopod 2 segmented : proximal segment naked; distal segment with 4 terminal natatory plumose setae. Third maxilliped and pereiopod buds: poorly developed beneath the carapace.

Abdomen and telson (Figs. 1A, I): Abdomen consists of 5 somites: somite I almost covered by carapace and naked; somite II with a pair of lateral spine directed antriorly; somite III with a pair of small lateral spine directed posteriorly; somite IV with a pair of lateral spine directed posteriorly, which is larger than that of somite III; posterolateral margin of somite V with feeblypointed minute spine. Segments II-V each with a pair of minute simple setae. Pleopod and uropod buds absent. Telson bifurcated; forks curved dorsally, cornua slightly curved dorsallyon distal section. Posteromedial margin with medial notch and 3 pairs of plumose setae. Inner margin of fork fringed with fine setae.

Second Zoea (Fig. 2)

Carapace (Fig. 2A): Same as first zoea, but eyes stalked and mobile.

Antennule (Fig. 2B): Exopod with one additional aesthetasc.

Antenna (Fig. 2C) and Mandible (Fig. 2D): Same as first zoea, but different in size.

Maxillule (Fig. 2E): Coxal endite with 6 plumodenticulate setae. Basial endite with 8 plumodenticulate setae. One highly plumose seta added on dorsal margin of coxopod.

Maxilla (Fig. 2F): Coxal endite bilobed, with 5+3 plumodenticulate setae. Basial endite bilobed, with 6+4 plumodenticulate setae. Scaphognathite with 8 highly plumose setae separated into anterior (5 setae) and posterior (3 setae) groups.

First maxilliped (Fig. 2G): Distal segment of exopod with 6 terminal natatory plumose setae.

Second maxilliped (Fig. 2H): Distal segment of exopod with 6 terminal natatory plumose setae.

Abdomen and telson (Figs. 2A, I): One plumose seta added on somite I medially. One pair of plumose setae added on posteromedial margin of telson.

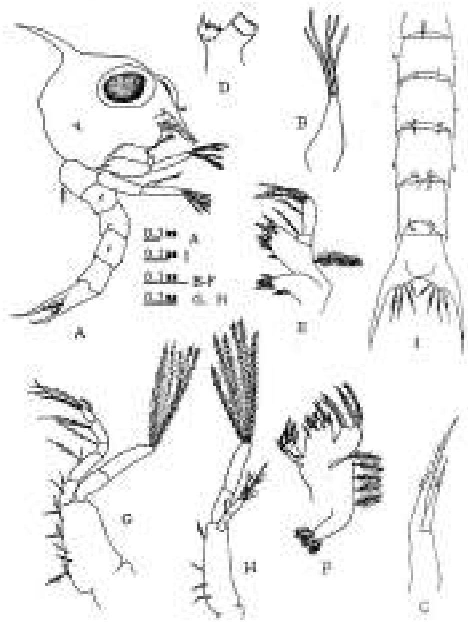

Fig. 2. Second zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1st maxilliped, H. 2nd maxilliped, I. abdomen and telson (dorsal view).

Third Zoea (Fig. 3)

Carapace (Fig. 3A): Eyes fully stalked. Other characters same as second zoea.

Antennule (Fig. 3B): Exopod with one additional aesthetasc.

Antenna (Fig. 3C): Endopod buds 2/3 as long as the protopod.

Mandible (Fig. 3D): Same as second zoea.

Maxillule (Fig. 3E): Coxal endite with 7 plumodenticulate setae. Basial endite with 9 plumodenticulate setae.

Maxilla (Fig. 3F): Coxal endite bilobed, with 6+4 plumodenticulate setae. Basial endite bilobed, with 7+4 plumodenticulate setae. Scaphognathite with 19 highly plumose setae.

First maxilliped (Fig. 3G): Setation patte on endopod changed: segment I with 1 simple seta and 1 sparsely plumose seta; segment II with 1 simple and 2 sparsely plumose setae; 1 plumose seta added on distal segment subterminally. Distal segment of exopod with 8 terminal natatory plumose setae.

Second maxilliped (Fig. 3H): Distal segment of exopod with 8 terminal natatory plumose setae.

Third maxilliped and pereiopods (Fig. 3I): Buds of third maxilliped and first-fifth pereiopods present underneath the carapace.

Abdomen and Telson (Figs. 3A, J): Consists of 6 somites. Sixth somite shorter than broad with smooth posterolateral margin, and naked. Small pleopod buds present on somites II-V. Apparent length of telson reduced by formation of somite VI.

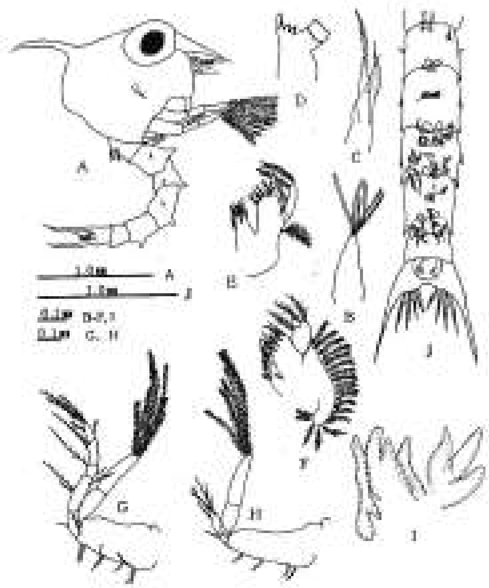

Fig. 3. Third zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1st maxilliped, H. 2nd maxilliped, I. abdomen and telson (ventral view).

Fourth Zoea (Fig. 4)

Carapace (Fig. 4A): Same as third zoea, but different in size, Dorsal spine relatively more short than the previous stage.

Antennule (Fig. 4B): Endopod present as small bud. Exopod with 6 aesthetascs.

Antenna (Fig. 4C): Endopod elongate 4/5 as long as the protopod.

Mandible (Fig. 4D): Mandibular palp present as small bud.

Maxillule (Fig. 4E): Coxal endite with 9 plumodenticulate setae. Basial endite with 11 plumodenticulate setae.

Maxilla (Fig. 4F): Coxal endite bilobed, with 6+4 plumodenticulate setae. Basial endite bilobed, with 7+5 plumodenticulate setae. Scaphognathite with 32 highly plumose setae.

First maxilliped (Fig. 4G): Distal segment of exopod with 10 terminal natatory plumose setae.

Second maxilliped (Fig. 4H): Distal segment of exopod with 10 terminal natatory plumose setae.

Third maxilliped and pereiopods (Fig. 4I): Third maxilliped bud further developed beneath the carapace. Pereiopods buds (first-fifth) more elongate, segmented incompletely. Gill buds of first-third pereiopods appearing beneath the carapace.

Abdomen and Telson (Figs. 4A, J): Pleopod buds on abdominal somites II-V further developed and partially segmented laterally. Uropod present as small buds on somite VI. One pair of plumose setae added on posteromedial margin of telson.

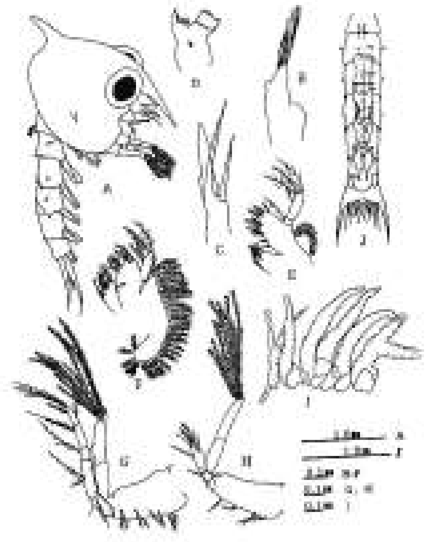

Fig. 4. Fourth zoea of *Chasmagnathus convexus*. A. lateral view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1st maxilliped, H. 2nd maxilliped, I. abdomen and telson (ventral view).

Megalopa (Fig. 5, 6)

Carapace (Fig. 5A): Subrectangular and smooth, longer than broad, narrowing anteriorly, ending in a small rostrum, slightly extended forwards and bent downwards, ordinary sites of lateral and dorsal spines slightly elevated and each with a minute spine. Orbicular edge wide and smooth. A number of small simple setae scattered on dorsal surface and on posterior margin. Eyes larger than the last zoeal stage and stalked.

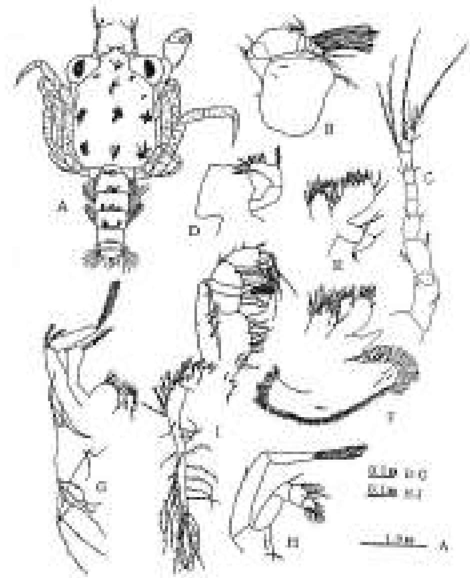

Fig. 5. Megalopa of of *Chasmagnathus convexus*. A. dorsal view view, B. antennule, C. antenna, D. mandible, E. maxillule, F. maxilla, G. 1st maxilliped, H. 2nd maxilliped, I. 3rd maxilliped.

Antennule (Fig. 5B): Peduncle 3-segmented: enlarged basal segment with 4 simple and 3 basal sparsely plumose setae; segment II with 4 simple setae; distal segment with 4 sparsely plumose setae. Flagellum 4-segmented: proximal segment naked, segment II with 2 aesthetascs; segment III with 6 aesthetascs and 1 plumose seta; distal segment with 6 aesthetascs

Antenna (Fig. 5C): Consists of 10 segments, with a setation of 2, 2, 2, 0, 0, 4, 2, 3, 3, 3; distal four segments with long setae.

Mandible (Fig. 5D): Molar process with sharp cutting edge. Palp 2-segmented: proximal segment naked; distal segment with 9 short plumose setae.

Maxillule (Fig. 5E): Coxal endite with 20 plumodenticulate, short plumose setae. Basial endite with 22 plumodenticulate, short plumose setae. Endopod unsegmented, with 3 simple and 2 sparsely plumose setae. Basipod naked.

Maxilla (Fig. 5F): Coxal endite bilobed, with 10+4 plumodenticulate, short plumose setae. Basial endite bilobed, with 8+9 plumodenticulate, short plumose setae. Endopod unsegmented, with 3 short plumose setae basally. Scaphognathite with 55 highly plumose setae on marginal and 5 simple setae on external surface.

First maxlliped (Fig. 5G): Coxal endite with 13 plumodenticulate, short plumose setae. Basial endite with 10 plumodenticulate, short plumose setae. Endopod unsegmented, with2 simple setae subterminally and 3 sparsely plumose setae distally. Exopod 2-segmented: proximal segment with 2 highlyplumose setae distolaterally; distal segment with 4 long plumose setae terminally. Epipod triangular, withy12 sparselyplumose setae.

Second maxilliped (Fig. 5H): Basally with 2 plumose setae. Endopod 4-segmented: proximal segment with 8 plumose setae. Exopod 2-segmented : proximal segment with 1 simple seta; distal segment with 5 long plumose setae terminally. Epipod absent.

Third maxilliped (Fig. 5I): Endopod 5-segmented: proximal segment with 13 short plumose setae; segment II with 2 simple and 7 short plumose setae; segment III with 3 simple and 3 plumose setae; segment IV with 4 simple and 8 plumose setae; distal segment with 4 plumose setae terminally. Exopod 2-segmented: proximal segment with2 simple and 3 plumose setae; distal segment with 4 highlyplumose setae terminally. Coxa and basis fused. Basipod with 19 plumodenticulate setae. Epipod elongate, with 28+13 sparsely plumose setae. Podobranchwell developed, with gill filaments.

Pereiopods (Figs. 6A-E): Chelipeds (pereiopod I) subequal, with spine directed ventrally on ischium, chela with frontal tooth and irregular cutting edge. Pereiopods II-IV similar in structure, dactylis tapering distally, slightly curved ventrally, with several scattered plumose, plumodenticulate, denticulate and simple setae on surfaces. Dactylis of pereiopod V with 3 long terminal serrate setae, surface with several scattered plumose, plumodenticulate, denticulate and simple setae.

Abdomen (Figs. 6K): Consists of 6 somites: somites III-V each with posterior sharp pointed ventrolateral projections, in somite V its reaching 2/3 length of somite VI. Posterior margin of somite VI smooth. Somites I-VI with 3, 4, 6, 6, 6 and 3 pairs of simple setae on dorsal surface, respectively.

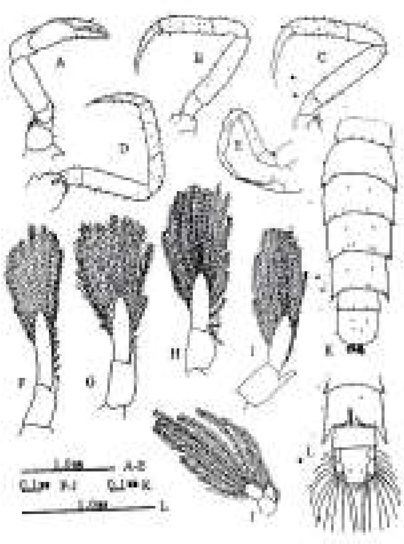

Fig. 6. Megalopa of *Chasmagnathus convexus*. A-E. pereiopods, F-I. 1st-4th pleopods, J. uropod, K-L. abdomen and telson (dorsal view).

Pleopods (Figs. 6F): Two-segmented, developed to main natatorial appendages. Endopod of pleopods I-IV each with 3 cincinnuli distolaterally. Exopod of pleopods I-IV, with 20, 19, 19 and 18 plumose setae, respectively.

Uropod (Figs. 6J, L): Uropods 2segmented : proximal segment with one external plumose seta laterally; distal segment with 11 plumose setae.

Telson (Figs. 6K, L): Posterior margin oval shaped and smooth, distinctly longer than somite VI, with 6 simple and 4 plumose setae medially on posterior margin.

Discussion

The overall morphology of the first zoea of *C. convexus* agrees very closely with the other species of the genus *Chasmagnathus* as well as the genus *Helice* having lateral spine on the carapace (Boschi *et al.* 1967, Green and Anderson 1973, Mia and Shokita 1996, 1997). In comparison with larvae of two subspecies of *Helice*, which are the most related, the fourth abdominal somite has a lateral spine in *C. convexus* and in *H. tridens*, but it is lacking in *H. wuana* (Baba and Moriyama 1972). Only a distinct character between zoeae of this species and the two subspecies of *Helice* is the presence of a paired or single setae near the distal portion of the exopod of the antenna; the setae are single in the two subspecies but paired in *C. convexus*. In the setation on the telson, the first and final zoeae of both *C. convexus* and the subspecies of *Helice* show the same formulae, 3+3 and 5+5 respectively; but in the second zoea the setation remains as 3+3 in *Helice* subspecies whereas it advances to be 4+4 in *C. convexus* (Baba and Moriyama 1972). The zoeae of *Chasmagnathus* species are readily distinguished from those of other species of the genus *Perisesarma, Neosarmatium* and *Sesarma* by having lateral spines on the carapace (Islam and Shokita 2001, Lago 1987, 1989).

The zoea larvae of the family Grapsidae have been divided into four groups on the basis of their morphological characters (Wear and Fielder 1985, Rice 1980). The first two groups are relatively homogeneous and well defined, and correspond roughly to the subfamilies Grapsinae and Plagusiinae (Lago 1993a, b). The other two groups comprise a rather heterogeneous array of morphological characteristics (Wilson 1980), and include genera from the subfamilies Sesrminae and Varuninae(Wear and Fielder 1985). From the study of New Zealand larval grapsid representatives, Wear and Fielder (1985) concluded that separation of the latter two larval groups could not be justified, and lumped all larval sesarmine and varunine together into a single subfamilial division. Lago (1993a) arrived at the same conclusion from the analysis of mouth parts setation patterns in 37 sesarmine and varunine species.

Lago (1993a,b) classified the genera *Sesarma, Aratus, Metasesarma,* (including here within *Sesarma* Serene and Soh's, 1970 genera *Perisesarma, Sesarmops* and *Bresedium*), and possible *Neosarmatium* (revised by Davie 1994) into a distinct larval subgroup within the sesarmine-varunin group. A second larval subgroup identified by Rice (1980) within the sesarmine-varunine group includes the genera *Chasmagnathus, Helice, Cyclograpsus,* *Hemigrapsus, Helograpsus, Heterograpsus* and *Eriocheir*. This indicates the same degree of homogeneity as that observed in *Helice, Sesarma* and allied genera (Lago 1993a, b).

The detailed megalopal descriptions of species within the sesarmine-varunine group have been described poorly, and intergenric comparisons are premature. However, given the known characteristics of megalopa of the genera *Sesarma, Perisesarma, Neosarmatium* and *Helice*, a tentative definition of the megalopa of *C. convexus* may be based on the following characters: antennule lacking inner flagellum; antennal seventh segment always with two, stout denticulate terminal setae; distal segment of the mandibular palp with more than eight setae; scaphognathite of the maxilla with about 55 highly plumose and 2-4 simple setae; second maxilliped lacking epipod, and endopod almost always with 3,1,6,8 setae; and distal segment of uropods with ten or eleven setae.

In the megalopa stage no distinct differences are noted in the member of *Chasmagnathus, Helice, Sesarma, Perisesarma* and *Neosarmatium* of the sesarmine-varunine group (Mia and Shokita 1996, 1997, Islam and Shokita 2000, 2001). The setation of pleopods of *Chasmanathus* is near to that of *Helice* species. The megalopa of *C. convexus* of be readily distinguished from other sesarmine crabs by the setal formula of the following structures: endopod of the first maxilliped; exopod of the first and third maxillipeds. The present results do not support the use of larval description of the subfamilies Sesarminae and Varunine, at least with their present generec composition.

Acknowledgements

We express our sincere thanks to Dr. M. Tarik (France) and Dr. N. Shikatani, University of the Ryukyus (UR) for their valuable suggestions and critically editing this manuscript. Thanks are also extended to Mr. Y. Fujita and Mr. T. Nagai of the Laboratory of Marine Fisheries, UR for their kind assistant to collect the crab sample and performing the laboratory maintenance.

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(Manuscript received 2 May 2001)

Bangladesh J. Fish. Res., 5(2), 2001:181-188

Effect of delayed icing on quality changes and shelf-life of some freshwater fish from Bangladesh

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Abstract
The quality and shelf-life of three freshwater fish species of Bangladesh, catla (*Catla catla*), magur (*Clarias batrachus*) and tilapia (*Oreochromis niloticus*) stored at room temperature and ice were evaluated. Live fishes were killed by cranial spiking and stored at room temperature (27-30 °C), ice stored immediately after death, 5 hr after death and 10 hr after death. The shelf-life and quality of the fishes were evaluated by organoleptic method, rigor-mortis studies and bacteriological assessment.

Fishes kept at room temperature became organoleptically unacceptable within 16-20 hr duration. Ice stored fishes showed considerable differences in their shelf-life when icing was delayed for different duration. Shelf-life of catla ice stored immediately after death was 20 days but shelf-life reduced to 12 days when icing delayed for 10 hr after death. Similar trend was observed for two other fish species magur and tilapia. Rigor-index of the fishes stored under different conditions also considerably varied among the three fish species, particularly effect of delayed icing was very much evident. Bacteriological study showed patterns of Aerobic Plate Count (APC) at the end of shelf-life study when fishes became organoleptically unacceptable were more or less similar for all the three fish species stored under different conditions. No definite pattern was observed in the generic distribution of bacteria in different fish species under different storage conditions. *Micrococcus*, Coryneforms, *Pseudomonas* and *Achromobacter* were the dominant groups of bacteria isolated from the fishes spoiled at room temperature and ice stored condition.

Key words: Icing, Shelf-life, Freshwater fish

Introduction

Fish is a very perishable food item. Icing has been considered immemorial days to delay the post-mortem changes in fish and keep the quality better. Since most of the people involved with fish harvesting and trading in this country are ignorant of the concept of quality during handling of fish, the longer shelf-life of these ice stored fish is not achieved as would have been expected.

The shelf-life of ice stored fishes are dependent on proper handling like icing method, adequate and optimum ratio of fish to ice, insulating material of the container and most importantly prompt icing after harvest. Delayed icing is an important factor which is responsible for shorter shelf-life of fishes. But unfortunately very little research has been carried out on this particular topic in this country. Not only that, few published reports are available on the shelf-life of ice-stored tropical freshwater fish. Bhattacharya (1990) and Bandyopadhay (1986) reported the shelf-life of *Clarias batrachus* and *Catla catla* respectively under various storage conditions. Rubbi *et al.* (1985) also studied the shelf-life of six freshwater fish species in different storage temperatures and container used. Ramachandran *et al.* (1990) reported that delay of few hours in icing of hilsa after catch considerably reduces the shelf-life.

This paper reports the effect of delayed icing on rigor-mortis, shelf-life and bacteriological changes in three commercially important freshwater fish species.

Materials and methods

Fish samples

Three freshwater fish species catla (*Catla catla*)), magur (*Clarias batrachus*) and tilapia (*Oreochromis niloticus)* were obtained either from local fish farm or from local fish market and put in an insulated box with chilled fresh water to transfer to the laboratory. On arrival to the laboratory fishes were killed by cranial spiking and kept either at room temperature or in ice in an insulated box in the ratio of 1:1 (fish: ice) immediately or after 5 and 10 hr exposure to the environmental temperature. The samples were taken out from ice at different time intervals to determine the quality of fish by organoleptic evaluation, assessing the progress of rigor-mortis and by bacteriological evaluation.

Quality assessment

The guidelines and methods used here are based on the scores on the organoleptic characteristics of fish as described by European Commission (EC) freshness grade for fishery products (Howgate *et al.* 1992) with some modification.

Rigor-index of the fishes were measured according to Baito *et al.* (1983) and used as parameter of rigor tension. At selected time intervals, rigor-index was calculated by the following equation:

$$\text{Rigor index (\%)} = \frac{Do-D}{Do} \times 100$$

Where Do and D are the distances of the base of caudal fin from horizontal line of the table at the start and at subsequent periods, respectively.

The muscle of the fish was collected aseptically at the end of shelf-life study, weighed and blended in a sterile blender. The stock suspension of the muscle was prepared by homogenizing 10 g of sample with 90 ml of physiological saline (0.85% NaCl). Aerobic plate count (APC) expressed as colony forming units per gram of fish muscle (CFU/g) of the representative samples were determined by consecutive decimal dilution method using plate count agar (Hi media).

For qualitative study, bacteria obtained during APC were isolated from the agar plates. All the colonies from a plate having discrete colonies were removed and obtained pure cultured by streaking and restreaking on to fresh agar plates and finally transferred to agar slants. The bacterial isolates were classified up to genus level according to an outline of the sequence of tests used in the screening of culture as described by Shewan *et al.* (1960).

Results and discussion

Organoleptic studies

The effects of delayed icing on the shelf-life of three different species of ice stored fish as determined by organoleptic evaluation is shown in Table 1. Fishes kept in ice immediately after catch showed longer shelf-life than those stored in delayed icing irrespective of species. Tilapia and magur were found in acceptable condition for 18, 12 and 10 days for immediate icing, 5 h and 10 h delayed icing respectively before they become organoleptically unacceptable. Catla showed similar trends of shelf-life and was found in acceptable condition for 20, 14 and 12 days for immediate, 5 h and 10 h delayed icing respectively.

Table 1. Effect of delayed icing on the shelf life of catla, magur and tilapia fish

Species	Ice stored immediately after catch	Ice stored 5 hr after death	Ice stored 10 hr after death
Catla	20 days	14 days	12 days
Magur	18 days	12 days	10 days
Tilapia	18 days	12 days	10 days

The patterns of organoleptic quality changes observed here with all the three fish species in all storage conditions were quite similar. The pattern can be divided in to 4 phases corresponding to period of 0 to 4, 4 to 12, 12 to 16, 16 to 20 and 0 to 3, 3 to 6, 6 to 10, 10 to 14 and 0 to 3, 3 to 6, 6 to 10, 10 to 12 days in ice in case of immediate icing, 5 h and 10 h delayed icing respectively. In phase 1, the fishes except 10 hr delayed icing were fresh and in excellent quality with a specific taste and natural flavour and odour. In phase 2 there was a little deterioration apart from slight loss of natural flavour. In phase 3 signs of early spoilage were evident with sour off-flavour but the fishes were judged as acceptable quality. In phase 4, the fish begin to taste stale, its appearance and texture begins to show obvious signs of spoilage, and the abdominal cavity had unpleasant smell.

The shelf-life of fish varies from species to species, size, their chemical composition and ambient temperature in which the fish are kept. In the present study, catla had longer shelf-life than tipalia and magur. This result is in agreement with Bandopadhyay *et al.* (1985), who reported that bigger sized fish have better ice storage life compared to smaller size one. The effect of delayed icing on the loss of shelf-life in all fish species was very obvious here. It was found in the present study that for every hour delay in icing shelf-life reduced by almost one day. This is due to initial quality loss during exposure of fishes at ambient temperature between 27 and 30°C. Thomas and Methen (1995) demonstrated that the shelf-life of Indian Scad (*Decapterus russelli*) were for 2, 1 and less than 1 day for 3, 6 and 8 h delayed icing respectively.

The pattern of quality changes observed in the present study is almost similar to that reported for the ice stored Codfish (FAO 1975). Faruk *et al.* (1998) reported that rohu fish (*Labeo rohita*) stored in ice in an insulated box immediately after catch had a shelf-life for 20 days. Hilsa fish (*Hilsa ilisha*) remained in acceptable condition up to 18 days when stored in ice in an insulated box immediately after catch while they were found acceptable up to 8 days when obtained from local market and stored in ice in wooden box (Kamal *et al.* 1994). Bandyopadhyay (1986) suggested that *Catla catla* and *Labeo fimbriatus* could be kept in ice for 18 days before it becomes unacceptable.

Rigor-mortis progress in fishes

Rigor-index of catla, magur and tilapia stored at room temperature (27 to 30°C), ice stored immediately after death, 5 hr after death and 10 hr after death are shown in Fig. 1, 2, 3 and 4 respectively. Rigor started within 15 min after death in fish stored both in room temperature and in ice. However, the progress of rigor-mortis was more rapid at room temperature than in ice. Rigor mortis of catla, , magur and tilapia kept at room temperature attained full rigor (100%) after 8, 4 and 5 hr respectively (Fig. 1). The state of rigor at this level continued for 2, 4 and 1 hr respectively and then started to relax from rigor. Complete relaxation occurred after 20, 20 and 16 hr of storage for catla, magur and tilapia, respectively. At this stage the fish emitted an offensive odour.

The fishes kept in ice immediately after death attained full rigor after 4, 2 and 2 h respectively (Fig 2). The state of rigor at this stage continued for 8, 16 and 12 hr for catla, magur and tilapia, respectively and then started to relax from rigor. Complete relaxation occurred after 120, 112 and 104 hr of ice storage respectively without showing any perceptible sign of spoilage. Under this condition the shelf-life of these fishes were 20, 18 and 18 days for catla, magur and tilapia, respectively according to organoleptic evaluation. In case of delayed icing when catla, magur and tilapia were stored in ice 5 hr after death, the progress rate of rigor-mortis was faster (Fig. 3) than that of fish stored in ice immediately after death. The fishes attained full rigor within 6, 6 and 4 hr and this stage continued for 8, 14 and 10 hr respectively, and complete relaxation occurred at 102, 92 and 88 hr respectively for catla, magur and tilapia. Under this storage condition the shelf-life of these fishes were found in acceptable condition for 14, 12 and 12 days respectively. Again, when the fishes stored in ice at 10 hr delay after death, attained full rigor after 10, 6 and 4 hr (Fig. 4). The state of rigor at this stage continued for 6, 10 and 8 hr respectively and then started to relax from rigor. Complete relaxation occurred after 90, 84 and 76 hr respectively without showing any perceptible sign of spoilage. The shelf-life of these fishes was 12, 10 and 10 days respectively according to organoleptic evaluation.

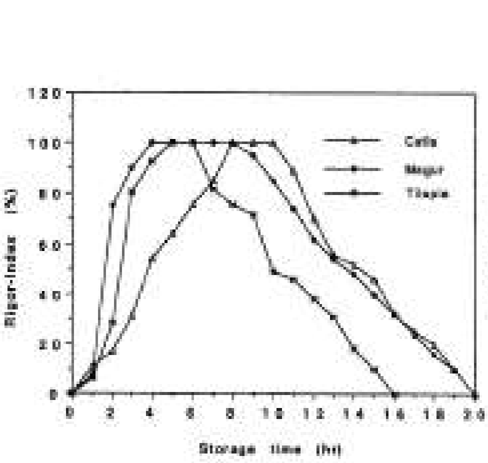

Fig. 1. Rigor-mortis process in catla, magur and tilapia fish stored at room temp. (27-30°C).

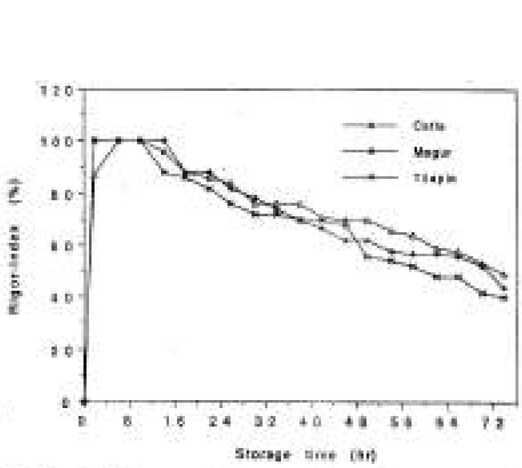

Fig. 2. Rigor-mortis process in catla, magur and tilapia fish during ice storage immediately afte death.

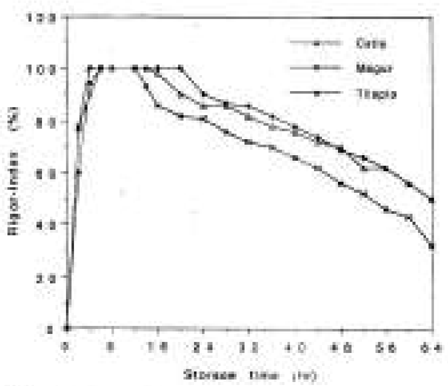

Fig. 3. Rigor-mortis process in catla, magur and tilapia fish ice stored 5 hr after death.

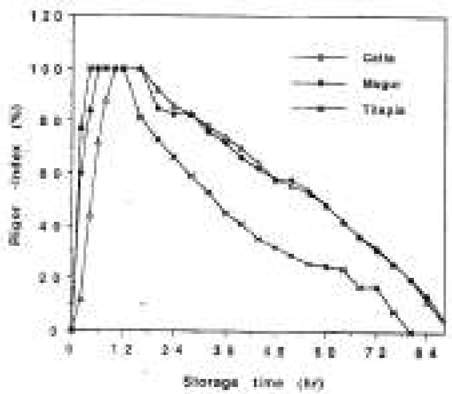

Fig. 4. Rigor-mortis process in catla, magur and tilapia fish ice stored 10 hr aftr death.

The above results showing a general trend that delay in icing makes full rigor period shorter and time required for complete relaxation from rigor also become shorter. A study showed that *Selas leptolepsis*, whether iced 9 hr or 12 hr after landing resulted in a shelf-life of eight days (FAO 1985). There are many factors that are responsible for the progress of rigor-mortis such as species, size, and catching method, handling of the fish, temperature and the physical condition of the fish. Among them rigor-mortis is known to be dependent mostly on temperature that influences the onset and the rate of progress of rigor-mortis. Although it is generally acceptable that the onset and duration of rigor-mortis is more rapid at high temperature and on the other hand lower temperature delays the rigor-mortis progress. Several fish species such as tilapia, red sea bream and plaice have recently been reported to shorten their pre-rigor periods when stored in ice (Poulter *et al.* 1981, Iwamoto and Yamanaka 1986). In the present study, rigor-mortis progress rate was found much faster in fish held at ice (0°C) than that of fish held at room temperature and for that the shelf life of fish was short at room temperature. Comparatively full rigor period lasts longer in magur than tilapia and catla. It is clear that immediate icing of fish shortened the pre-rigor but slows down the rate of progress of rigor-mortis.

Bacteriological study

The result of the aerobic plate count (APC) in muscle after shelf-life study of catla, magur and tilapia, kept at room temperature, in ice immediately after death, 5 hr and 10 hr delay after death are shown in Table 2. Fishes kept at room temperature were organoleptically unacceptable after 20, 20 and 16 hr after death. At this time, the APC per gram fish muscle was 1.54 $x10^8$, 2.28 $x10^9$, and 0.65 $x10^9$ CFU/g respectively. The fish kept in ice immediately after death were had shelf-life of 20, 18, and 18 days respectively and the APC per gram of fish muscle at that point were 0.98 $x10^7$, 0.27 $x10^8$ and 0.53 $x10^8$ CFU/g respectively. Fishes iced after 5 hr of death and stored in an insulated box were organoleptically unacceptable after 14, 12 and 12 days respectively. At this time, the APC per gram of fish muscle was 0.82x 10^8, 1.92 $x10^8$ and 1.20 $x10^8$ CFU/g respectively. Fishes iced after 10 hr of death and stored in an insulated box were organoleptically unacceptable after 12, 10 and 10 days respectively. At this time, APC per gram of fish muscle were 0.48 $x10^8$, 0.41 $x10^7$ and 0.98 $x10^8$ CFU/g respectively.

No definite trend could be observed when compared the spoilage pattern of these fishes under different storage conditions. The highest bacterial load was found in magur spoiled at room temperature, on the other hand lowest bacterial load was found in magur spoiled ice during storage when icing was done after 10 hr of death of the fish. Generally, bacterial load was lowest in the fishes spoiled during ice stored condition when iced 10 hr after death of the fish and highest load was found in fishes spoiled at room temperature. The results of this study indicate that mesophilic spoilage bacteria involved in higher numbers during spoilage at low temperature. This may be due to the fact that mesophilic spoilage grows faster than the psychrophilic one.

Table 2. Aerobic plate count (APC) of ice stored catla, magur and tilapia muscles at the end of shelf life study

Fish sample	Stored at room temp. APC/g	Ice stored immediately after catch APC/g	Ice stored 5 hr after death APC/g	Ice stored 10 hr after death APC/g
Catla	$1.54x10^8$	$0.98x10^7$	$0.82x10^8$	$0.48x10^8$
Magur	$2.28x10^9$	$0.27x10^8$	$1.92x10^8$	$0.41x10^7$
Tilapia	$0.65x10^9$	$0.53x10^8$	$1.20x10^8$	$0.98x10^8$

The generic distribution of bacteria (%) in the muscle of fishes spoiled at room temperature and in ice is shown in Table 3. A total of 98 bacterial isolates were obtained from the spoiled fish at room temperature among them 19 isolates from tilapia, 56 isolates from magur and 23 isolates from catla. Generally, a total of six different bacterial genera were identified and *Micrococcus* was found to be the most dominant group followed by Coryneforms and *Psedomonas*. The other genera found were *Achromobacter*, *Enterobacteriaceae* and *Flavobacterium* but no *Bacillus* was found. In case of fish stored in ice immediately after death, a total of 100 bacterial isolates were recovered from the spoiled fishes. Among them 50 isolates were obtained from tilapia, 32 isolates from magur and 28 isolates from catla. The bacterial genera recovered form the fish kept at room temperature were also found the ice-stored fish. Isolates from ice stored tilapia and magur indicated an overall dominance of Coryneforms and in catla *Achromobacter* was found to be the most dominant group.

Table 3. Generic distribution of bacteria (%) isolated from catla, magur and tilapia spoiled at room temp. and ice storage

Fish sample	Micrococcus	Coryne form	Entero-bacteriaceae	Pseudo monas	Achromo bacter	Flavobac terium	No. of isolets
Spoled at room temp.							
Catla	43.47	30.43	0	8.69	17.39	0	23
Magur	73.21	14.28	1.78	7.14	0	3.57	56
Tilapia	57.87	5.78	0	10.52	15.78	0	19
Spoled at ice storage							
Catla	37.5	12.5	0	0	50	0	28
Magur	34.37	40.62	6.25	6.25	12.5	0	32
Tilapia	20	70	0	0	5	5	50

There are only few reports available on the bacterial composition of tropical freshwater fish. Liston (1980) reported that warm water fish carry mostly *Micrococcus*, Coryneforms and *Bacillus*. Faruk *et al.* (1998) identified *Micrococcus*, Coryneform, *Pseudiomonas*, *Flavobacterium*/*Cytophaga* and *Achromobacter* in *Labeo rohita* ice-stored in an insulated box. Besides *Micrococcus* and Coryneform, other genera of bacteria found in this study were *Pseudomonas*, *Flavobacterium* and *Achromobacter*, which are commonly found in fishes of freshwater and marine origin. These bacteria are recognised as fish spoilage bacteria and grow well at low temperature (Frazier and Westhoff 1990).

In is known that autolytic spoilage process is more active in the early period and bacterial spoilage during later storage period and this is the predominant factor influencing organoleptic assessment. It is documented that the bacterial spoilage of fish does not begin until after rigor-mortis, where juices are released from flesh-fibers (Frazier and Westhoff 1990). Therefore, the more rigor-mortis is delayed or protracted, the longer the keeping quality or shelf-life of the fish.

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(Manuscript received 30 November 1999)

Bangladesh J. Fish. Res., 5(2), 2001:189-196

Economics of pond fish culture under BRAC supervision in Mymensingh, Bangladesh

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Abstract
This study examines the relative profitability of pond aquaculture (polyculture and monoculture of silver barb) under BRAC supervision in Trishal Upazila, Mymensingh district in Bangladesh. The results of the study showed that polyculture was economically more rewarding than monoculture, though both the farming activities were profitable. Production function analysis proved that inputs such as fingerlings, fertilizer, feed and manure had positive impact on output. Human labor and insecticides were over used. The coefficients had expected signs and were found to be very significant.

Key words: Economics, Polyculture, Silver barb, NGO

Introduction

Fishery as one of the major sub-sectors of Bangladesh agriculture has been playing a significant role in nutrition, employment, foreign exchange earning, food supply and more importantly socioeconomic stability in the rural areas.

Bangladesh Rural Advancement Committee (BRAC), a reputed non-government organization (NGO) working in Bangladesh conducts a number of income generating programs. Fish culture, among these programs, is very important one where many marginal and/or landless people are involved. The main goal of BRAC fish culture program is poverty alleviation through improved nutrition availability and income generating activity. BRAC undertook fish culture program in Bangladesh in 1984 and selected Trishal Upazila of Mymensingh district in 1989 for launching fish culture program. Fish culture under BRAC supervision evolves formation of small groups and developing an appropriate credit system. BRAC's field workers list the landless/ marginal farmers of the village having land of 0.50 acre or less. After listing, the workers start motivation program for the targeted families. Then they prepare a program of intensive motivation by forming small groups of 5 members. Usually 40 persons form a 'samitee' or association.

This paper addresses the following aspects of BRAC fish culture program: i. estimates the profitability of polyculture and monoculture of silver barb and ii. estimates the contribution of key variables to pond fish culture.

Methods

Data source

Four unions of Trishal Upazila namely: Boilor, Dhanikhola, Dharikhantal, and Kanihari of Mymensingh district, located around 15 kilometer south of Mymensingh district headquarters, were purposively selected for this study. The main reasons of selecting this area were:

- There were some successful private fish seed farmers in the area for supplying fry to the fish farmers.
- This was one of the areas where there was a heavy concentration of commercial pond fish culture.
- BRAC has been conducting a poverty alleviation program in this area by extending credit and technological support to the pond fish farmers.

Data were collected from primary sources. Before collecting data a list of the farmers of pond fish culture was collected from BRAC office. Twenty-six stocking ponds, thirteen from each of the technologies (polyculture and monoculture), from each union were selected using a stratified random sampling technique and thus, total number of participating farmers became 104. A sample survey was conducted by using a set of pre-designed questionnaire to collect necessary primary data. The study covered the whole fishing activities period of one year from January to December'97.

Analytical technique

The collected data were analyzed by using enterprise-costing technique and the results were presented in the tabular form with the help of simple statistical measures like arithmetic mean, percentage and ratio. Cobb-Douglas production function model was also employed to estimate the contribution of key factors.

The general Cobb-Douglas production function model takes the following form:

$$Y = AX_1^{b1}X_2^{b2}---X_6^{b6} \text{ or } \log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + --- + b_6 \log X_6$$

Where,

Y = Gross value of output (Tk/ha)
X_1 = Cost of fingerlings (Tk/ha)
X_2 = Cost of fertilizer (Tk/ha)
X_3 = Cost of feed (Tk/ha)
X_4 = Cost of human labor (Tk/ha)
X_5 = Cost of insecticides (Tk/ha)
X_6 = Cost of manure (Tk/ha)
A = Constant or intercept value
b_i = Production coefficients to be estimated
$i = 1,2, ---, 6$.

Results and discussion

The profitability analyses of poly and monoculture were done on the basis of full cost. All input items both family supplied and purchased were valued at the current market prices of the inputs.

Production cost in polyculture

Cost of production per hectare per year for polyculture by locations is shown in Table 1. The table reveals that the per hectare cost of pond fish production for polyculture stood at Tk 82,516 for all locations. The analysis showed that per hectare costs were Tk 82,182, Tk 81,239, Tk 82,404 and Tk 84,239 in Boilor, Dhanikhola, Dharikhantal and Kanihari locations, respectively. It is evident from the analysis that operating cost represented the lion share of the total cost i.e., 75.78 percent (Tk 62,531/ha) and the remaining 24.22 percent (Tk 19,985/ha) was interest on land value and interest on operating capital in which interest on land value alone accounted for 18.54 percent (Tk 15,296/ha). The major part of the operating cost was shared by feed and human labor representing 23.98 (Tk 19,794/ha) and 20.56 percent (Tk 16,965/ha) of total cost, respectively. The other important operating cost items were feed, manure, fertilizer, chemicals, etc.

Production cost in monoculture of silver barb

Per hectare cost of producing silver barb is given in Table 2. Per hectare cost of producing sharpunti was estimated at Tk 71,808 of which Tk 54,096 (75.33%) and Tk 17,712 (24.67) were, respectively operational and interest costs. As a single cost item, feed cost represented the lion's share (25.19%) of total cost.

Among the cost items, human labor cost appeared to be the second largest one (19.54%) and interest on land value, fertilizer, manure, interest on operating capital accounted for 18.99, 7.81, 7.03 and 5.68 percent, respectively of total cost of producing silver barb.

Profitability of poly and monoculture

Profitability of poly and monoculture is presented in this section. To obtain gross return, total produce was multiplied by its prevailing farmgate price. Gross cost was then deducted from gross return to arrive at net return. It is evident from Tables 3 and 4 that the farmers are making profits from poly and monoculture. It can be seen from the results that the farmers of polyculture are making higher profit (Tk 114,714) than that of silver barb culture (Tk 98,192).

Table 1. Item-wise cost (Tk/ha/yr) of pond fish production for polyculture

Items of cost	Locations								All locations	
	Boilor		Dhanikhola		Dharikhantal		Kanihari			
	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Average cost (Tk)	Percent
Fingerlings (No.)	6,740	4,070	6,401	3,822	6,113	3,623	6,753	3,949	3,866	4.69
Manure (kg)	11,500	5,750	11,124	5,562	10,122	5,061	12,000	6,000	5,593	6.78
Fertilizer (kg)	825	7,000	798	6,824	787	6,734	767	6,630	6,797	8.24
Feed (kg)	12,481	18,361	12,757	20,094	13,017	19,798	13,362	20,923	19,794	23.98
Other chemicals (kg)	257	3,557	226	3,047	246	3,773	251	3,515	3,473	4.24
Human labor (Manday)	337.96	16,898	332.34	16,614	341.20	17,060	345.76	17,288	16,965	20.56
Miscellaneous	-	6,160	-	5,850	-	6,352	-	5,810	6,043	7.32
Interest on land value	-	15,750	-	14,792	-	15,322	-	15,320	15,296	18.54
Int. on operating capital	-	4,636	-	4,636	-	4,680	-	4,804	4,689	5.68
Total cost	-	82,182	-	81,239	-	82,404	-	84,239	82,516	100.00

Table 2. Item-wise cost (Tk/ha/yr) of pond fish production for silver barb culture

Items of cost	Locations								All locations	
	Boilor		Dhanikhola		Dharikhantal		Kanihari			
	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Average cost (Tk)	Percent
Fingerling (No.)	3,622	3,622	3,002	3,002	3,334	3,334	3,302	3,302	3,315	4.62
Manure (kg)	10,602	5,301	10,128	5,064	9,520	4,760	10,150	5,075	5,050	7.03
Fertilizer (kg)	660	5,740	665	5,478	665	5,694	635	5,520	5,608	7.81
Feed (kg)	12,039	16,260	12,270	18,640	12,400	18,185	12,790	19,275	18,090	25.19
Other chemicals (kg)	215	2,970	198	3,144	209	3,220	215	2,970	3,076	4.28
Human labor (Man day)	267	13,350	275.64	13,782	285.76	14,288	294.32	14,716	14,034	19.54
Miscellaneous	-	5,150	-	4,910	-	4,423	-	5,209	4,923	6.86
Interest on land value	-	13,252	-	13,220	-	14,320	-	13,752	13,636	18.99
Int. on operating capital	-	3,929	-	4,052	-	4,118	-	4,205	4,076	5.68
Total cost	-	69,574	-	71,292	-	72,342	-	74,024	71,808	100

Table 3. Profitability of pond fish production for polyculture (Tk/ha/yr)

Particulars	Locations				All locations
	Boilor	Dhanikhola	Dharikhantal	Kanihari	
Yield (kg)	4,850	4,710	4,953	5,210	4,931
Gross return (Tk)	194,000	188,400	198,120	208,400	197,230
Gross cost (Tk)	82,182	81,239	82,404	84,239	82,516
Net return (Tk)	111,818	107,161	115,716	124,161	114,714
BCR (undiscounted)	2.36	2.31	2.40	2.48	2.39
Net return per Taka invested	1.36	1.32	1.40	1.48	1.39

Tables 3 and 4 reveal that both BCR (undiscounted) and net return per taka invested in polyculture appeared to be relatively higher (2.39 and 1.39 respectively) than in culture of silver barb (2.36 and 1.36 respectively). Although there is some variations in per hectare yield, but poly and silver barb culture under BRAC supervision is highly profitable.

Table 4. Profitability of pond fish production for silver barb culture (Tk/ha/yr)

Particulars	Locations				All locations
	Boilor	Dhanikhola	Dharikhantal	Kanihari	
Yield (kg)	4,000	4,200	4,300	4,500	4,250
Gross return (Tk)	160,000	168,000	172,000	180,000	170,000
Gross cost (Tk)	69,574	71,292	72,342	74,024	71,808
Net return (Tk)	90,426	96,708	99,658	105,976	98,192
BCR (undiscounted)	2.30	2.36	2.35	2.43	2.36
Net return per Taka invested	1.30	1.36	1.35	1.43	1.36

Contribution of key variables in the production process

Pond fish culture is the outcome of using various combinations of the required inputs. In pond fish culture there are some inherent characteristics of pond and factors that affect its environment and production such as, age of pond, depth of pond, size of pond, pond ownership, and these factors can be employed to explain the variation of pond fish output (Islam and Dewan 1987). Six explanatory variables were taken into account to explain the variation in production as well as gross returns of pond fish farming. Regression analysis (Ordinary least square method) was used to determine the effect of these inputs.

A short discussion is presented here about the explanatory variables included in the model.

Cost of fingerlings (X_1): Money value of fingerlings was included as an important explanatory variable to explain the variation in gross returns.

Cost of fertilizer (X_2): Fertilizers (Urea, TSP and MP) were lumped as important input in the production process. An optimum use of this input increases yield of fish in the pond.

Cost of feed (X_3): Value of feed was expected to have a direct relation with the value of fish output.

Cost of human labor (X_4): Money value of human labor used in pond fish culture should have a direct relation with the value of output.

Cost of insecticides (X_5): Money value of insecticides was taken as an important explanatory variable to explain the variation in gross return. The farmers used insecticides like rotenon, phosphotixin and quickphos.

Cost of manure (X_6): Manure (mainly cowdung) was equally an important input having direct relation with the value of output.

Estimated values of the coefficients and related statistics of Cobb-Douglas production function for the sample farmers producing fish is presented in Table 5. Cobb-Douglas production function fitted well for different categories in the study area. The aggregate function performed better as well. Islam (1987) also estimated a Cobb-Douglas production function to explain the productivity of fish ponds. The performance was measured by estimated F and R^2 values.

The coefficient of multiple determination (R^2) ranges from 0.819 in polyculture and 0.915 in sharpunti culture. R^2 value 0.915 indicates that about 92.0 percent of the total variation of output of fish farming is explained by independent variables included in the model. It also indicated that the excluded variables accounted for only 8.0 percent of the variation in pond fish production. R^2 0.819 is also high indicating 82.0 percent variation of output is explained by the independent variables, which were included in the model.

Table 5. Estimated values of coefficients and relative statistics of Cobb-Douglas production function model

Explanatory variables	Polyculture	Culture of silver barb
Intercept	2.528	1.976
Fingerlings (X_1)	0.5184**	0.6201*
	(0.0457)	(0.0754)
Fertilizer (X_2)	0.1549*	0.1027
	(0.0594)	(0.1269)
Feed (X_3)	0.0996*	0.0926*
	(0.033)	(0.0379)
Human labor (X_4)	-0.0947	-0.1907
	(0.0477)	(0.0644)
Insecticides (X_5)	-0.0185	0.0315
	(0.0226)	(0.1329)
Manure (X_6)	0.0722*	0.2727*
	(0.0314)	(0.0637)
R^2	0.819	0.915
F	33.94*	80.25*
Returns to scale (Σb_i)	0.7319	0.9289

No. of observation = 104 *Significant at 1 percent level **Significant at 5 percent level
Figures in the parentheses indicate standard error.

The F values of two categories are 33.94 and 80.25, which are highly significant implying all the included explanatory variables are important for explaining the variation of pond fish production. Therefore, F values of the individual coefficient of the relevant inputs should be expected to become significant. The nature of input output relationship is expected to be determined by the magnitude of the estimated production coefficient of individual equation. Degrees of freedom for statistical significance of the selected production function were significant. The results were tested at 1 percent and 5 percent level of significance. The summation of the production coefficients of the selected pond fish farmers indicated returns to scale. It is evident from Table 5 that 9 coefficients out of 12 show positive sign indicating positive contribution of the inputs to the return from pond fish production. Table 5 also shows that 4 coefficients in polyculture (fingerlings, fertilizer, feed and manure) and 5 coefficients in silver barb culture (fingerlings, fertilizer, feed, insecticides and manure) showed positive sign indicating positive contribution of the inputs to the return.

The summation of the production coefficients of selected variables i.e., the returns to scale (Σb_i) is 0.7319 in polyculture. It means that the production function exhibits diminishing returns to scale. If all the inputs specified in the model are increased by 1 percent, gross return will increase by 0.7319 percent (Table 5).

It is also seen from Table 5 that returns to scale is 0.9289 in case of culture of silver barb indicating diminishing returns to scale. If the inputs specified in the function are increased by 1 percent, gross return will increase by 0.93 percent. It is, however, evident from the above discussion that all the included explanatory variables have significant role in poly and monoculture production process.

Conclusions

The results of the present study clearly indicate that farmers can make profit from both poly and monoculture. The farmers, however, can make more profit from polyculture than the farmers practicing monoculture of silver barb. The results also indicate that pond fish production can be increased by improving the production technology in existing ponds. The conclusion based on the findings of the present study is that fish culture can be practiced successfully in small seasonal ponds.

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(Manuscript received 8 April 1999)

Bangladesh J. Fish. Res., 5(2), 2001:197-200

Short Note

Predatory behaviour of a perch, *Nandus nandus* (Ham.)

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Abstract

Predatory behaviour of *Nandus nandus* was studied by offering *Cyprinus carpio* as prey. The study was conducted with six *N. nandus* (8.2 ±0.2 cm and 7.60 ±0.3 g) represented as P_1, P_2, P_3, P_4, P_5 and P_6. Three size categories of prey (*C. carpio*) such as small (2.0 ±0.1 cm and 0.23 ±0.01 g), large (3.6 ±0.1 cm and 0.57 ±0.0.1g) and mixed group consisting of both small and large prey were used for 14 days of trial. Predatory behavior was classified as targeting, driving, catching, handling, resting and next attempt of catching prey. After introduction of prey into the aquarium predators followed the movement of preys by eye movements and tried to target smaller one first. The predator grasped the head of the prey by its jaws by a drive and engulfed it wholly into the mouth. The average handling time (time taken to manipulate and swallow prey from capture to ceasation of pharyngeal movement) was 42±2 sec and 47±2 sec for small and large prey respectively. *N. nandus* were ingested more small prey than large prey though the size classes were equally available in case of mixed prey used. Although the prey consumption was higher in number when small prey were ingested but in weight the consumption was higher when ingested large size of prey. The study indicated that *N. nandus*, ingested more small prey and grasped the headfirst.

Key words: Predatory behaviour, *Nandus nandus*

Despite their high market preference and wide acceptability as food fish, predatory fishes have been neglected and discouraged in the aquaculture system of Bangladesh due to their food habit. Fast growing population growth of an undesirable fish can be effectively controlled with the help of predatory fishes. Thus, the predatory fishes can play a vital role to bring back the water body in a balanced condition (Sih 1987). *Nandus nandus* is locally known as "meni" or "veda" is widely distributed throughout the Indian subcontinent and are often the most common small predator in freshwater bodies (Mustafa *et al.* 1980). Now it is rarely found in the market and unfortunately it is one of the fish going to be extinct and now a days is considered to be an endangered species. Successful breeding and rearing of "meni" in farm conditions would be tremendously helpful in preventing the fish from being extinct and to culture this fish in rice field. For successful rearing the knowledge of food and feeding habit of the species are prerequisite. Predatory fish are less well studied experimentally (Paszkowski and Tonn 1994, Das *et al.* 1998a,b). The present work was designed to study the predatory behaviour of *N. nandus* with the following objectives: (i) to determine the size specificity of the prey (*C. carpio* fry) taken by the *N. nandus* (ii) to study the predatory behaviour (movements and activities) during feeding and just after feeding of *N. nandus.*

Investigation on predatory behaviour of *N. nandus* was carried out for a period of two weeks in July'99 where *Cyprinus carpio* fry were offered as prey in six glass aquaria (60x35x30 cm) marked as aquarium No.1, 2, 3, 4, 5 and 6. *N. nandus* having total length of 8.2 ± 0.2 cm and weighing of 7.60 ± 0.3 g were used as predator. Six predators were selected from the laboratory stock placed into six aquaria in the laboratory and water was aerated continuously to maintain dissolved oxygen level at high. Predators were treated with salt (1% dip for 1hr) as a prophylactic treatment. The Predators were recognized as P_1, P_2, P_3, P_4, P_5 and P_6 following the corresponding number of the aquarium for the convenience of the study. Immediately after collection, the prey species were transferred into the laboratory and placed into a large stocking-tank. Fishes were kept into the tank without supplying any food for first two days. After that supplementary feed at the rate of maintenance ration (1% body weight) was supplied to the fish fry. Fish fry were then classified into two main size categories where small fry (total length of 2.0 ±0.01cm and weight 0.23 ±0.01g) and large fry (total length 3.6 ±0.1 cm and weight 0.57 ±0.01g). Another group consisting of both small and large fry (50%+50%) was referred to as mixed size group. All three-size categories were offered as prey to *N. nandus* for the experiment in duplicate aquaria.

Six preys were released into the aquarium containing a predator at 9 am everyday, after an hour the remaining prey(s) was removed by hand scoop net from each of the aquaria. Then fresh preys were offered to each predator as earlier at the same time of the following day. The number of prey eaten by each predator was recorded everyday This process was continued for 14 days to study the predatory behaviour of *N. nandus.*

Targeting and catching of prey

When the prey (fry of *C. carpio*) were supplied, the predator (*N. nandus*) became active. Then they followed the movement of preys by their eye movements. With in a few moments, the predator targeted/selected a prey to be attacked and immediately tried to catch it (the prey) by a drive.

Handling and resting period

Prey handling time was recorded as the time from initial capture to the time the prey was swallowed *i.e.* the ceasation of gulping movements and pharyngeal constrictions were recorded. Resting period, the duration between the completion of one meal and the start of taking of the second meal by the predator was recorded. If the predator intended to catch their prey for the second time, they moved in that direction in respect of the position of the prey as like as previous attempt starting from targeting prey to the completion of the handling and goes to resting again.

It was found that the prey species (*C. carpio*) after introduction in the aquarium took their place just opposite to the position of the predator. During the experimental period when prey were given into the aquarium the predator stopped their all activities and followed the movement of prey only by eye movements keeping itself in a resting position preferably at a corner of the aquarium. Among the prey, the predator tried to target a prey preferably the smaller one first. When the predator came forward to the prey, the prey tried to escape from the attack. Thus the prey came downwards and again started to move for upper region in the anti-clock wise direction and moved toward another corner of the aquarium.

Many predators catch their prey either head region or tail region first. Catching of prey also depends on the size and shape of the prey, nature of the prey, abundance of prey and predators also. In the present study, when *N. nandus* catch prey on the head first, the predator firstly grasped the head of the prey by its jaw and finally engulfed the prey by taking it wholly in to the mouth. Das *et al.*(1998a) stated that *C. striatus* grasped the prey by its jaw at the head region first.

Time taken to manipulate and swallow prey from capture to ceasation of pharyngeal movements was counted as handling time. In the experiment average handling time was 42±2 seconds and 47±2 seconds for small and large prey respectively. Hoyle and Keast (1987) stated the handling time of around 50 seconds for large mouthbass, *Micropterus salmonides*, Das *et al.* (1998b) also found the average handling time of *C. striatus* around 48 seconds for the prey of *Labeo rohita* fingerlings that closely resemble this study. Resting period in between prey capture were observed. During that time the predators keeps itself quiet at a corner of the bottom of the aquarium. Resting period of *N. nandus* was continued for about two minutes. In some cases, the predator failed to capture the prey in first attempt and then took second attempt to capture it after a short rest in between. If the first attempt was successful the resting period maintained was found to be a little more than the unsuccessful attempt.

Three sizes of categories of prey such as small, large and mixed were supplied to the predators in this experiment to observe the preference of prey size by the predator. It was observed that 24 and 23 large preys were captured and ingested by the predators P_1 and P_2 respectively, 46 and 40 small preys were captured and ingested by the predator, P_3 and P_4 respectively. On the other hand predators P_5 and P_6 captured and ingested 40 (28 small, 12 large) and 31 (31small) mixed preys. It was observed that predators preferred the smaller size category prey over the large preys. Predator (*N. nandus*) ingested significantly more small preys than large prey though the both size class were equally available for P_5 and P_6. Although the upper limit in prey size is constrained by the relationship between piscivore mouth size and prey body depth, piscivore tend to consume prey sizes that are much smaller than the maximum possible (Hoyle and Keast, 1987). The choice of small prey by predator might also be related to the fact that the predator preferred to spend minimum energy to capture, ingest and digest the prey. In this experipent, *N, nandus* also consumed more small *C. carpio.* as a preference. This result is in agreement with that of Paszkowski and Tonn (1994), Das *et al.* (1998b).

Total biomass of prey captured and consumed by predatory fishes differed with prey size. It was observed that the predators consumed 0.064 to 0.121 g of prey per gram of predator per day. It was found that when the prey size was small the number of prey engulfed by the predator was greater but the consumption of prey in total biomass was higher when they consumed large prey.

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(Manuscript received 8 June 2000)

Bangladesh J. Fish. Res., 5(2), 2001: 201-204

Short Note

Population structure of the grapsid crab, *Helice tridens latimera* (PARISI) in the Taiho mangrove, Okinawa, Japan

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Abstract

Grapsid crab *Helice tridens latimera* inhabiting mangroves, seashores as well as muddy and rocky areas. Ovigerous females were observed from December to May. Juveniles appeared in July and from December to April. In the laboratory they reached 9.50 mm in carapace width 4 months after hatching. It is likely that spawning of this crab occurs throughout the year.

Key words: *Helice tridens latimera*, Spawning, Juvenile

Helice tridens latimera PARISI, 1918 has so far been found in eastern Asia along the coasts of Japan, Taiwan and China (Miyake 1983, Dai and Yang 1991). This crab is common and dominant in Okinawan mangals. So far, no study has been carried out on this crab's population structure and reproductive cycle, but information exists on its larval development (Mia and Shokita 1997). The present study is a part of experiment aimed to assess the population structure of *H. t. latimera* including its breeding season, natural growth rates, abundance, and functional role in the shallow water community of the estuary of the Taiho River on Okinawa Island.

A population census of *Helice tridens latimera* was carried out monthly from May 1995 to April 1996 in the estuary of the Taiho River. Samples were collected by hand and using a scoop net in the mangrove stands, in areas surrounding gravel, and among the roots of trees. Collected specimens were sexed into three categories such as male, female and juvenile on the basis of their morphological differences of abdomen. Each individual was measured for carapace width (CW) using a vernier callipers to the nearest 0.1 mm. Females were inspected for the presence of eggs beneath their abdomen. After measurement each individual was released in the same area.

Helice tridens latimera were found running on the mangrove forest floor, in the shallow water, in gaps between the roots of trees, and inside holes, and they rarely appeared to settle down on mud. The monthly population census and structure of this species are shown in Figures 1 & 2. In all 343 males, 288 females including 8 ovigerous females, and 22 juveniles were caught during one-year experimental period. The pooled male-female ratio was 1:0.84. The peak of males occurred in July, and that of females in October. CW varies from 13.20–35.50 mm in males, 14.30–34.00 mm in female, and 5.60–11.85 mm in juveniles. Ovigerous females with carapace widths of 15.00–24.55 mm appeared from December to May. Juveniles appeared in July and from December to April, and their peak was in February. The highest catch was in July, and the lowest in December. During December to April total catch per month was lower than in other months. Among all females ovigerous ones comprised 5% in May, 40% in December, 12.5% in January, 20% in February, and 14.25% in both March and April.

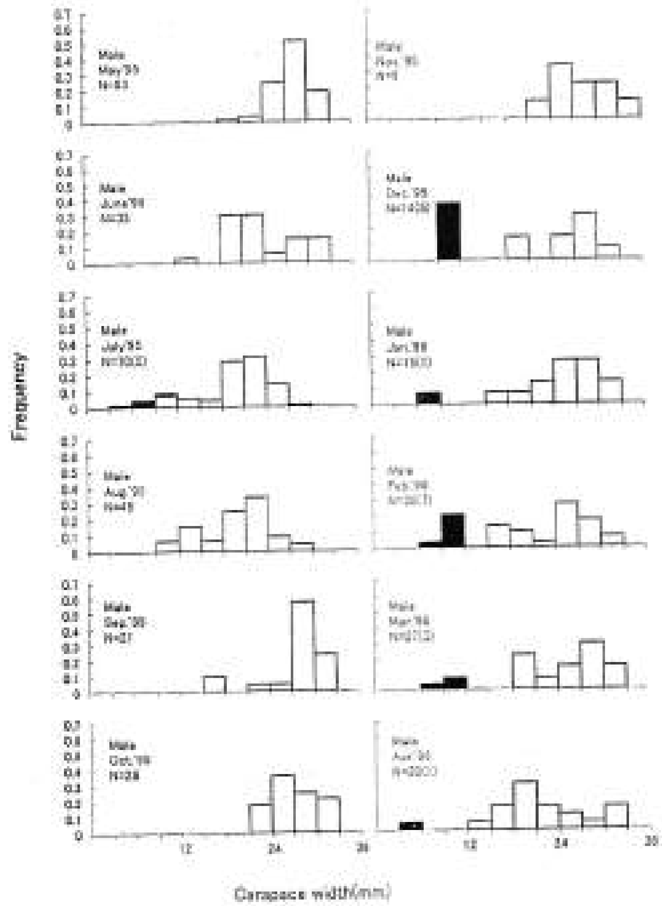

Fig. 1. Seasonal changes of the size distribution of *Helice tridens latimera* from May'95 to April'96. Figures in brackets and shaded bars indicate juveniles.

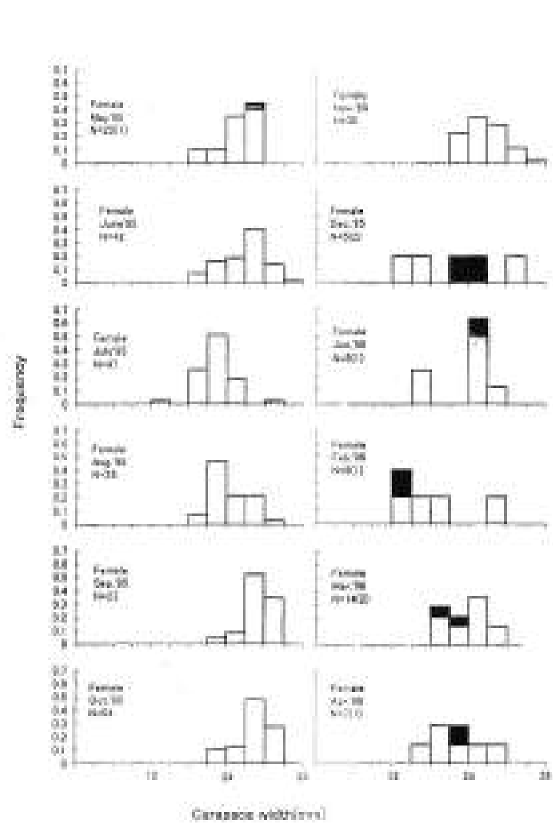

Fig. 2. Seasonal changes of the size distribution of *Helice tridens latimera* from May'95 to April'96. Figures in brackets and shaded bars indicate ovigerous females.

From the monthly population census data, it is clear that total catch was lower at low temperatures during the winter. Specimens of the sesarmid crab *Chasmagnathus convexus* stopped their activity when the air temperature fall below 13°C and became active at 16.2°C (Nakasone *et al.* 1982). The soldier crab *Mictyris longicarpus* rarely emerged when the sand temperatures were below 17°C (Kelemec 1979). Similar results for other crabs have been also reported by many authors (Hughes 1966, Sumpton and Smith 1990). It was reported that the body temperature of aquatic crustaceans must be close to that of the surrounding water (Edney 1960). Poikilothermal animals survive only within definite temperature ranges, and a change of external temperature results in a change of O_2 consumption. Similarly, the range of temperatures compatible with life is known to vary greatly between different species of poikilotherms (Florkin 1960). It was reported that the total catches of *Perisesarma bidens*, *Metopograpsus latifrons*, and *M. messor* were lower in winter than other seasons (Watanabe 1993, Windarti 1995). The results of the present study are consistent with their findings and suggest that during low temperature

H. t. latimera keep themselves hidden inside their burrows or migrate to warmer places that are suitable for their physiology.

Spawning of *Helice tridens latimera* perhaps occurs throughout the year. Although ovigerous females were caught from December to May, but this does not mean that spawning occurs only during these months. Juveniles were caught in July and from December to April, which suggests a longer spawning season. The average size of juveniles caught in July was 6.94 mm in CW. In laboratory experiments, larvae metamorphosed to juveniles (1.77 mm CW) 48 days and reached 9.50 mm in CW 4 months, respectively after hatching (Mia and Shokita 1997). Juveniles of 10.79 mm in CW were caught in December. No ovigerous females were caught from June to November, yet it is clear from the laboratory experiment that juveniles caught in December were about 4-5 months old. In conclusion, the present investigation revealed that spawning of *Helice tridens latimera* occurs throughout the year.

Acknowledgements

The authors express their gratitude to Dr. Mark J. Grygier, Lake Biwa Museum, Japan for his critical reading of the manuscript.

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(Manuscript received 4 July 2000)

Bangladesh J. Fish. Res., 5(1), 2001: 205-208

Short Note

Size frequency distribution and carapace length-total length relationship of *Acetes chinensis* in the Kutubdia channel of Bangladesh coast

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Abstract

The seasonal mean size distribution of *A. chinensis* were estimated as 29.229mm±4.77, 25.125mm±2.55, 25.165mm ±2.29 and 32.44mm ±3.63 for annual, monsoon, post-monsoon and pre-monsoon period, respectively. Seasonal mean carapace length distribution were estimated as 9.37mm±1.457, 8.063mm±0.63, 8.258mm±0.59 and 10.37mm±1.113 for annual, monsoon, post-monsoon and the pre-monsoon season. The carapace length and total length relationships was found to be TL= - 1.39±3.23 CL. Linear relation was found in arithmetic and as well as logarithmic scale.

Key words: *Acetes chinensis*, Size frequency, TL-CL relationship

Acetes is a minor planktonic crustacean group and represented by a few number of species in Bangladesh coastal waters. *Acetes* is assumed to play a significant role in the food web and dynamics of coastal water, lagoons, sea grass beds and mangrove swamps which extends over vast area in tropical and sub-tropical region (Omori 1975 and Achuthankuthy *et al.* 1973). They form conspicuous aggregation near the shore and are fished mainly with push net and fixed bag nets set near the shore against the flow of the tide. The fishing is generally done during day times (Omori 1974). In the Bangladesh coastal waters information on Sergestid shrimp of *Acetes* is scarce. But this shrimps are commonly distributed in estuarine and coastal waters of Bangladesh (Mahmood and Zafar 1989, Zafar 1992).

The present work shows size frequency distribution, relationship between carapace length-total length and length-weight relationship of *Acetes chinensis* in the Kutubdia channel for the first time from the Bangladesh coastal waters.

Samples of *Acetes* shrimp were collected for one year between September'95 and August'96 from the Kutubdia channel (Lat.21^0.53' 36" N and 91^0 54' 54" S). Samples were collected fortnightly from the catches of Behundi net (set bag net). Collected samples were kept into the plastic container and preserved in 5% neutralised formalin.

In the laboratory *Acetes chinensis* were identified and sorted out on the basis of morphometric characteristics such as the number of red spot in the endopod of the uropod, number of denticles in the rostrum, shape of the telson, presence or absence of procured tooth between the basis of first pair of pleopod and other characteristics mentioned by Omori (1975) and Xiao (1990). To confirm the taxonomic status of the species monthly different sizes of *Acetes chinensis* were also examined under a binocular stereoscopic microscope.

For the study of carapace length and total length relationship all specimen of the identified shrimp species were measured (Table1). The total length (from the tip of the rostrum to the tip of telson) and the carapace length (from the 1st denticle of the rostrum to starting point of the 1st abdominal segment) were measured with the help of millimetre scale. For establishing the total length and carapace length relationship the least square method was followed.

Table 1. Carapace length and total length relationship in different groups of *Acetes chinensis*

Class limit (mm)	Frequency	Mid points of CL (mm)	Log CL (X)	Observed mean TL (mm)	Log TL (Y)	Calculated LogTL= a+blogCL	Calculated TL=a+bCL
6.5-7.0	3	6.75	0.83	20	1.301	1.3077	20.411
7.0-7.5	5	7.25	0.86	22.7	1.356	1.3404	22.024
7.5-8.0	19	7.75	0.89	23.42	1.369	1.3737	23.638
8.0-8.5	28	8.25	0.92	24.63	1.391	1.4053	25.251
8.5-9.0	27	8.75	0.94	26.7	1.426	1.4264	26.864
9.0-9.5	23	9.25	0.97	28.04	1.447	1.4685	28.477
9.5-10	9	9.75	0.99	29.83	1.474	1.4896	30.091
10-10.5	10	10.25	1.01	31.85	1.503	12.5002	31.704
10.5-11	19	10.75	1.03	33.47	1.520	1.5212	33.317
11-11.5	35	11.25	1.05	37.87	1.540	1.5423	34.931
11.5-12	10	11.75	1.07	36.00	1.560	1.5634	36.544
12-12.5	7	12.25	1.09	38.29	1.580	1.5845	38.157

The sizes of *Acetes chinensis* varied seasonally. During the one year study, the highest size (39.5 mm) was recorded in the pre-monsoon period and the smallest (19.5 mm) was obtained in monsoon and mean length was recorded 29.23±4.77mm. In the monsoon months (May-Sept.) the size varied 23.5-29.5 mm and mean length was recorded 25.13 ±2.25mm. In post-monsoon period (Oct.-Dec.) the total length of this species was obtained between 20.5 mm and 29.5 mm with mean length of 25.17±2.29 mm and during the pre-monsoon period (Jan.-April) size range varied between 23.5 mm and 39.5 mm with mean size 32.44±3.63 mm

Highest carapace length (12 mm) was recorded in the pre-monsoon period and lowest carapace length (6.5 mm) was obtained in monsoon period and the mean carapace length was recorded 9.37±1.46mm. In the monsoon period, the carapace length varied between 6.5 mm and 9.5 mm, and mean was recorded 8.063±0.69 mm. In post-monsoon period, carapace length of this species was obtained between 7.0 mm and 9.5 mm with mean length of 8.258±0.59 mm. During the pre-monsoon period size range varied between 7.0 mm to 12.0 mm with mean length 10.37±1.11 mm.

The carapace lengths were arranged in 0.5 mm interval and their average was plotted against the average total length. Scatter diagram of total length versus body weight are presented in Fig. 1. The relationship was found to be a straight line by the method of least square. The relationship of total length and CL is the carapace length was as follows: TL = - 1.39+3.23CL, where TL is the total length and CL is the carapace length.

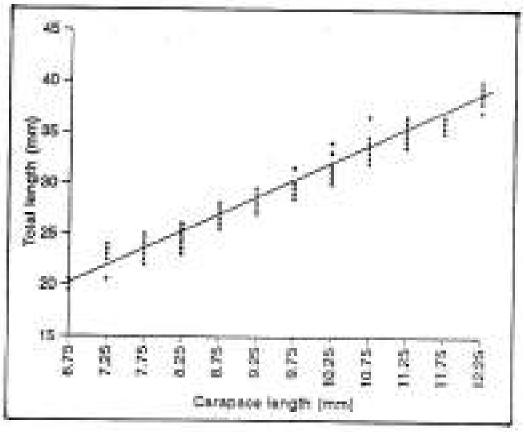

Fig. 1. Scatter diagram of carapace length and total length.

The relationship between carapace and total length of this shrimp shows a positive correlation (r = 0.9907, n = 12 groups). A linear relation was found in logarithmic scale (Fig. 1) between the total length and carapace length of *Acetes chinensis*. (Log TL = 0.44 +1.05 CL).

The relationship between carapace length and body length determined by Yasuda *et al.* (1953) for *Acetes japonicus* was CL = 2.04 + 0.18, BL for males and CL=1.13±0.18. BL for females valid for a body length range of 10-20 mm. Ikeda and Raymont (1989) determined a regression equation for *Acetes sibogae* as $\log_{10}$ (WW) = - 2.069 + 2.985. $\log_{10}$ (BL) (n=40, r=0.99) where WW is body wet weight (mg) and BL, body length (mm).

Ikematsu (1953) estimated from field samples that the life span of *A. japonicus* is 9-10 months for the winter generation and 2.5 -3.0 months for the summer generation. In the present investigation largest sizes of *A. chinensis* were found just after winter.

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(Manuscript received 6 December 1998)

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