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Development of Carp and Prawn (*Machrobranchium rosenbergi*) Polyculture System in Kishoreganj District of Bangladesh

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Abstract: A study was undertaken to develop the economic status of rural women of Kishoregonj district in Bangladesh through fish farming. In total, 200 beneficiaries of Nari Uddug Kendra (NUK) having various sizes of pond were selected by baseline survey at Pakundia, Hossainpur and Tarail Upazillas (sub-districts) of Kishoreganj district and made a two-day training on carp-prawn polyculture and provided counseling on the pond sites in a small group routinely from pond preparation to marketing of their products. Five fish species viz., silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*) rohu (*Labeo rohita*), grass carp (*Ctenopharingodon idela)* and Thai sharpunti (*Barbodes gonionotus)* and one prawn species, golda (*Machrobranchium rosenbergi*) were used in the present investigation. Pond preparation and management were depended upon the use of lime, cow dung, urea and Triple Super Phosphate (TSP). The average stocking densities of fish fingerlings and shrimp post-larvae (PL) were 17,290 ha^{-1} with the species compositions of silver carp (20%), catla (10%), rohu (20%), grass carp (1.43%), Thai sharputi (14.3%) and golda (34.3%). Supplementary feed comprising of rice/wheat bran and mustard oilcake (2:3) was applied at the rate of 8-12% of the total live fish weight twice daily. Duckweed either produced in pond or collected from the external sources was also used as additional supplementary feed. Physico-chemical parameters of pond water were within the normal range for fish culture. Mean production of fish and shrimp was obtained to be 1,980 kg ha^{-1} over an average culture period of 240 days. Pond management input and cost-benefit data were recorded by the farmers and were then analyzed by fish experts. The mean production cost was estimated to be Tk. 18,772 ha^{-1} with a benefit of Tk. 47,041 ha^{-1}.

Key words: Carp, prawn, polyculture, development, benefit

INTRODUCTION

Fish and Fisheries play an important role in supplying food as quality protein, providing employment opportunities and earning foreign exchange. In our national economy, it contributes 5.3% to the GDP, 5.79% to the export earnings and about 63% of animal protein to our daily diet (DoF, 2002). Presently, 1.40 million people are engaged full time and 12 million as per time in fisheries sector in the country for livelihood and trade. Another 3.08 million fish and shrimp farmers are cultivating fish both at subsistence and commercial level (Mazid, 2002).

Bangladesh is fortunate enough having a vast water resources in the form of small ponds, lakes, canals, rivers, floodplains and estuaries covering an area of 4.34 million hectare (Mazid, 2002; Rahman and Rahman, 2003). Once various species of fish and shrimp was available in these natural water bodies but has sharply declined in recent years due to natural and men-made interventions in the aquatic ecosystems (IUCN, 1998; Hussain and Hossain, 1999; Hussain and Mazid, 2001). The above water bodies were very rich in the past, but the production of fish failed to keep pace with the population size, which is increasing in geometric rate. As a result, fish has become rare in the market in recent years. For this reason, people can not consume the fish easily, which causes about 70% of people to suffer from malnutrition (DoF, 1999). Therefore, there is a chronic deficiency of essential nutrients in the diets of the people of Bangladesh (Ahmed *et al*., 1977). To overcome this severe problem, it is urgently needed to

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supply protein-rich diet to the people. This can only be achieved through culture of fishes in our utilized and derelict inland water bodies scattered throughout the country. Due to the lack of proper planning for the fisheries sector in the past, we have reached now a day to the critical point. There is no alternative way to overcome this problem without developing culture-based fisheries.

In Bangladesh, many development agencies have recently been promoted aquaculture as a key component to increase fish production. Although shrimp/prawn culture is going to be the most popular and commercially profitable business in many areas of Bangladesh, especially at the southern and north-west regions (Rangpur, Dinajpur, Rajshahi and Bogra) and little practiced in Mymensingh but not so well practiced in Kishoregonj area. Nari Uddug Kendra (NUK), a center for women initiatives, works all over Bangladesh to human resource development by providing training and creating productive employments. NUK initially started a pen-based aquaculture and became ATDP-II client and further expanded their aquaculture activities by working with 200 grass root level beneficiaries, especially women at three Upazillas (Pakundia, Hossainpur and Tarail) of Kishoregonj district. The specific objectives of the present study are to create self-employment and to improve the economic and social status of the poor women-headed families and their counterparts through production of fish in their ponds. An additional aim is to create awareness and to motivate house-keeping women through mass contact for taking part in aquaculture activities, which has been neglected for decades.

MATERIALS AND METHODS

Survey, site selection and training activities: Two hundred beneficiaries having nearly 600 acres of freshwater bodies where carp polyculture system is being practiced. A large number of fish farmers were involved in pangas culture in their ponds. But recently, pangas culture is drastically decreased due to high price of feeds and low profitability. Some group-members practiced carp-shrimp polyculture and got a tremendous profit in contrast to carp alone, because market price of shrimp is very high and is considered to be a high-priced exportable item. Considering the higher benefits, farmers become interested to make groups to boost up production through carp-shrimp polyculture systems in Kishoregonj district. However, the group does not have sufficient technical manpower to support the polyculture effectively. For this purpose, the groups seek a fisheries expert from ATDP. The fisheries expert signs an agreement with ATDP to provide technical support for 200 beneficiaries of NUK in different Upazillas of Kishoregonj district. Pond visits, group discussion and training were made to some most potential fish farmers. Counseling was also provided during the pond visits.

In order to serve the activities effectively, the region was divided into 6 units for quick survey. The survey was conducted to know the water resources of the farmers, their pond condition, ownership patterns, culture system, stocking density and protocol, culture period for each crop, input (fry, feed etc.) status, socioeconomic condition of the fisherman (income and living standard, housing condition, literacy and education, infrastructure facility, constraints etc.). The survey results helped to know the present situations of aquaculture (shrimp-fish culture) system of that area.

A Two-day training on carp-shrimp polyculture system was organized for NUK members among the eight groups at 5 venues. The venues were in different unit offices of NUK at three Upazillas (Pakundia, Hossainpur and Tarail) of Kishoregonj. The major training topics covered were pond preparation, eradication of aquatic weeds, unwanted fish and other animals, selection of suitable fish species, collection and transportation of fish and shrimp seeds, nursery pond management, grow-out management, selection of feed ingredients and feed preparation, feed implementation method, water quality management, fish health management, harvesting and marketing of cultivated fish species etc.

Pond preparation and management: All aquatic weeds, which directly decrease fish/shrimp production were eradicated/removed by the farmers using the following methods:

- Physical method.
- Biological method through herbivorous fish, like grass carp.
- Fertilization with inorganic fertilizers to remove submerged weeds.
- Application of chemicals (e.g., Simazin, Endothelia etc.) to destroy weeds.

Unwanted fishes, which are not normally, reared in pond such as carnivorous fishes (shoal, boal, gajar, taki, baila, chitol, foli etc.) and weed fish (puti, mola, dhela chela, etc.) were eradicated by the following ways:

- Sun drying,
- Application of fish toxin

Among them, sun drying was considered to be the best method to eradicate unwanted fishes. After the removal of aquatic weeds and unwanted fishes, quick lime ($CaCO_3$, 250 kg ha^{-1}) was applied during pond preparation or culture, whenever necessary. Liming increase Ca^{++} in water, remove the acidity of soil and water, increase decomposition of organic materials, decrease turbidity of water, eradicate parasites and increase appetite of fish. After 5-7 days of liming, the ponds were fertilized with cowdung (1000 kg ha^{-1}), urea (50 kg ha^{-1}) and triple super phosphate (25 kg ha^{-1}) to increase the productivity in terms of phyto- and zooplankton, the primary food for fish fingerling/shrimp PL.

Transportation of fish fingerling/PL and stocking management: After fertilization, when sufficient natural foods were available, all ponds were then stocked with strong and healthy fish and shrimp seeds. Transportation of PL depends on the distance to be transported. About 30,000 PL was transported in 40 liters of aerated water if the distance was less than 1 h. When 18-24 h required, PL was transported in a 45×80 cm polyethylene bag with 8 Litre of water and oxygen. All fry/PL were properly acclimatized with pond water before stocking so that they were not been exhausted due to the sudden change of environmental conditions. Cool weather and evening hours were selected for stocking. The research was conducted for 240 days from August, 2004 to March, 2005 in 200 ponds. The average stocking densities of fish fingerlings and shrimp PL in all the experimental ponds were maintained at 17,290 ha^{-1} with the species compositions of silver carp (20%), catla (10%), rohu (20%), grass carp (1.43%), Thai sharputi (14.3%) and golda shrimp (34.3%). The details of stocking densities, ratios and sizes by species of fish and shrimp are shown in Table 1.

Water quality and feed management: Sufficient plankton in pond water was ensured by the application of organic (cowdung, 750 kg ha^{-1}) and inorganic (urea, 25 kg ha^{-1} and TSP, 25 kg ha^{-1}) fertilizers at fortnightly intervals. Water quality parameters (such as temperature, dissolved oxygen, pH, transparency, total alkalinity and ammonia-nitrogen) were analyzed fortnightly between 09.00 and 10.00 h, following the standard method (APHA, 1992) and maintained at optimum level for the production of natural food and normal growth of fish and shrimp.

Supplementary feed mostly depends on the natural food (plankton) present in the pond. High amount of supplementary feed were used when there was a scarcity of natural foods in water. Supplementary feed usually comprising of rice/wheat bran and mustard oilcake (2:3) was applied at the rate of 8-12% of the total fish weight twice daily. In addition, duckweed either produced in pond or collected from the external sources was used as supplementary feed.

Table 1: Details of stocking densities, ratios and sizes by species of fish and shrimp

Species	Stocking density (No. ha^{-1})	Stocking ratio (%)	Stocking size (cm)
Silver carp (*Hypophthalmichthys molitrix*)	3,458	20	7-10
Catla (*Catla catla*)	1,729	10	7-10
Rohu (*Labeo rohita*),	3,458	20	7-10
Grass carp (*Ctenopharingodon idela*),	247	1.43	7-10
Thai sharpunti (*Barbodes gonionotus*)	2,470	14.3	6-8
Golda (*Machrobranchium rosenbergi*)	5,928	34.3	3-5
Total	17,290	100	

Health management: Sampling was done regularly to monitor growth and health condition of fish and prawn. The following steps were undertaken for maintaining good health of fish and prawn:

- Eradication of the tree-branches from the pond embankment to ensure adequate sunlight.
- Control of aquatic weeds.
- Regular observation on the movement of fish and shrimp.
- Netting in pond at fortnightly interval for exercise of fish.
- Control of dissolved oxygen and pH of the pond water.
- Application of supplementary feed and fertilizer stopped when the transparency level of water was below 8 cm.

Harvesting, transportation, quality control and marketing: Two methods were used to harvest the cultured fish, one was netting and another was complete drying the pond. All fishes were not captured by netting, only marketable fish were harvested.

After harvesting, fishes were thoroughly washed with clean water and then kept in baskets. Ice was used, when transportation takes for a long time. Farmers usually harvest fish/shrimp early in the morning as temperature remains at low level during this time. As the market price of fish is generally high in dry season, the farmers usually sold their cultured fish and prawn during this time in order to get higher benefits.

RESULTS

During the study, ponds were selected by baseline survey at three Upazillas of Kishoregonj district owned by group members of NUK having ponds of ten to several hundred acres. Nearly 50% pond was 0.10-0.20 acres in size. In some cases, rice field was converted to pond by constructing dikes around the field, where rice and fish were being cultured alternately, i.e. rice in dry season and fish in wet season.

The water temperature was found to vary from 20.40 to 33.80°C with a mean level of 28.25°C. The temperature was highest in the month of August (33.80°C) and lowest in January (20.40°C) (Table 2). This trend might be due to cooler weather in winter season. The mean dissolved oxygen (DO) concentration in morning hours obtained to be 4.80±1.02 mg L^{-1} with a range from 3.20 to 5.30 mg L^{-1} throughout the experiment. The pH varied from 7.10 to 8.45 with a mean of 7.68±0.48. Water transparency ranged between 27.26 and 61.56 cm with a mean value of 34.42±8.85 cm. The highest transparency level was observed in September and the lowest in January. Mean total alkalinity of water of the experimental ponds was found to be 132.26±26.55 mg L^{-1} and ranged from 79.0 to 170.0 mg L^{-1}. Total ammonia content of pond water was found to be ranged between 0.02 and 1.30 mg L^{-1} with a mean of 0.49±0.34 mg L^{-1}. The highest amount of ammonia content (1.30 mg L^{-1}) was recorded in August while the lowest (0.02 mg L^{-1}) in December. Color of pond water was greenish to brownish, indicates the existence of adequate natural foods for culture of both fish and shrimp.

The final harvesting month of fish and shrimp was in March 2005. Golda was usually harvested in December due to high market price. The mean production of carps and prawn was estimated to be 1,980 kg ha^{-1} over an average culture period of 240 days. Average investment cost, income and cost-benefit data are also shown in Table 3. Some farmers consumed a proportion of their fish and such quantities were also priced for assessing the value of the total crops. Items such as cow dung and duckweed were usually collected and no financial cost

Table 2: Mean values (±SD) and ranges of water quality parameters in ponds over the 240-day experiment

Parameters	Mean values	Ranges	Standard Deviation (SD)
Temperature (°C)	28.25	20.40-33.80	±3.12
Dissolved oxygen (DO, mg L^{-1})	4.80	3.20-5.30	±1.02
Hydrogen-ion concentration (pH)	7.68	7.10-8.45	±0.48
Transparency (cm)	34.42	27.26-61.56	±8.85
Total alkalinity (mg L^{-1})	132.26	79.00-170.00	±26.55
Ammonia-nitrogen (mg L^{-1})	0.49	0.02-1.30	±0.34

Table 3: Research site/area, number of beneficiaries, pond size, average production, expenditure and benefit

Research site/area	No. of beneficiaries	Pond size (dec.)*	Average production (kg/dec.)	Expenditure (Tk/dec.)	Income (Tk kg^{-1}/dec.)	Benefit (Tk kg^{-1}/dec.)
Kutragar	7	125	8.8	80	285	205
Pumdi	15	280	8	70	265	195
Payerabanga	10	155	7.9	74	280	206
Rahimpur	7	315	8.1	75	290	215
Awoliapara	7	75	8.4	74	285	211
Gredan	5	85	7.88	75	270	195
Dnail	4	75	7.9	76	275	199
Latifpur	5	40	8	80	280	200
Shahedal	4	55	7.5	75	275	200
Burirchar	6	190	7.6	76	272	196
Jathashera	4	80	7.65	75	275	200
Padurgati	8	200	7.85	74	270	196
Pitolgonj	13	290	8.1	80	280	200
Barua	5	120	8.5	75	275	200
Bishanathpur	8	205	7.5	74	265	191
Horshi	7	185	7.8	75	260	185
Tarakandi	5	225	7.7	76	285	209
Chartaki	4	190	7.65	78	270	192
Jangalia	4	90	7.9	82	20	-62
Seramde	8	357	8	78	255	177
Hosende	6	125	7.8	75	280	205
Shanmania	4	120	7.7	82	270	188
Hapainna	4	175	7.5	80	275	195
Banduldia	6	150	8	75	265	190
Bashati	10	260	8.5	75	260	185
Gopinathpur	3	135	8.4	78	265	187
Taljanga	6	210	8.5	74	282	208
Aryura	7	270	8.2	72	275	203
Tamnikonapara	7	180	8.4	75	274	199
Nandipur	5	180	8.6	75	273	198
Bandagumra	3	60	8.5	74	290	216
Shahabag	3	85	7.9	73	285	212
Average			8.02 (1,980)	76 (18,772)	266.45 (65,813)	190.45 (47,041)

Figures in parentheses are total of average production, expenditure, income and benefits per hectare over a culture period of 240 days *247 decimal = 1 hectare was assigned to the farmers. However cow dung does have a market value, principally as a fuel and was priced at Tk. 0.5 kg^{-1}. Despite duckweed had no financial cost, it was estimated at Tk. 0.5 kg^{-1} as labor costs. Average expenditure of production was Tk. 18,772 ha^{-1} with a benefit of Tk. 47,041 ha^{-1}.

In the study area, a number of constraints for fish farming were reported, including dike overflow, water pollution, harvesting and marketing problems, natural disasters (excessive rainfall, over flood, droughts etc.), poisoning, multiple ownership, lack of money, higher production costs, lack of proper technical knowledge and good quality fish seeds.

DISCUSSION

Physico-chemical parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organisms. Growth, feed efficiency and feed consumption of fish are normally governed by environmental factors (Fry, 1971; Brett, 1979).Water temperature is one of the most important factors, which influence the physico-chemical and biological events of a water body. The range of temperature recorded from the experimental ponds agrees well with the findings of Mollah and Haque (1978) and Wahab *et al.* (1995) from the ponds of Bangladesh Agricultural University (BAU) campus. Water transparency was found to fluctuate widely in the present study. The highest transparency was recorded in September and the lowest after fertilization, might be due to the presence of higher plankton population and suspended organic matter in water column. Islam *et al.* (1974) recorded the minimum transparency in January and maximum in June. Dewan (1973) observed a good correlation of transparency with the water depth and rainfall. Boyd (1982) recommended a transparency between 15 and 40 cm as appropriate for fish culture. Wahab *et al.* (1994) recorded transparency depth ranging from 15.0 to 74.0 cm in polyculture ponds. Rahman (1992) concluded that the transparency of productive water bodies should be 40.0 cm or less. The observed pH values agree well with the findings of Hossain *et al.* (1997) and Kohinoor *et al.* (1998) who found the pH ranges of 6.70-8.30 and 7.18-7.24, respectively in the research ponds of Bangladesh Agricultural University (BAU), Mymensingh. Dissolved oxygen (DO) levels in the water of experimental ponds agree with the findings of Wahab *et al.* (1995), who recorded the DO concentrations ranging from 2.7 to 7.2 mg L^{-1} during their experiment in the BAU campus. Ahmed (1993) also reported a similar trend of lower DO levels from fertilized and fed carp fingerling ponds. Fluctuations of DO concentrations might be due to application of organic manure and supplementary feeds as well as consumption of oxygen by fish and other aquatic organisms (Boyd, 1982). However, the DO level was within the acceptable range for fish culture.

Natural waters containing 40 mg L^{-1} 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 total alkalinity of medium productive water ranged from 25 to 100 mg L^{-1}. Paul (1998) found the average total alkalinity values were above 100 mg L^{-1} in some BAU campus ponds. The observed alkalinity levels of waters of the experimental ponds indicated that the productivity of the ponds was medium to high. The findings of the present study are in close agreement with those of Rahman and Rahman (2003) and Rahman *et al.* (2005). Higher alkalinity levels might be due to application of higher doses of lime during pond preparation and frequent liming throughout the experiment (Boyd, 1982; Jhingran, 1991). The level of ammonia-nitrogen recorded from the experimental ponds in the present study is lower than that was reported by Dewan *et al.* (1991) who recorded 0.05-6.20 mg L^{-1}. Haque *et al.* (1998) found ammonia-nitrogen level of 0.11-0.13 mg L^{-1} in BAU research ponds. Kohinoor *et al.* (2001) recorded ammonia-nitrogen ranged from 0.01 to 1.55 mg L^{-1} in monoculture ponds. However, the present level of ammonia-nitrogen content in the experimental ponds was not lethal to the stocked fishes (Kohinoor *et al.*, 1998, 2001).

Different species in polyculture pond occupy different niches with their complementary feeding habits, fully utilizing all the natural feeds in the pond, thus increasing the total fish production (Tang, 1970; Sinha and Gupta, 1974). Lakshmanan *et al.* (1971) recorded the fish productions, which were varied from 2230 to 4209 kg ha^{-1} yr^{-1} in polyculture with Chinese carp and Indian major carps by stocking in varying proportions at different densities. Good results were also obtained by Singh *et al.* (1972) from polyculture ponds using silver carp, grass carp, common carp together with Indian major carps and the production recorded by them was 6,196 kg ha^{-1} yr^{-1}. However, the production recorded in the present study was 1,980 kg ha^{-1} over an average culture period of 240 days with the above recommended species. Mazid *et al.* (1997) found a gross production of 3,600 kg ha^{-1} yr^{-1} from composite culture of Indian major carps and Chinese carps in Bangladesh. Gupta and Rab (1994) recorded the production of 1480 kg ha^{-1} fish over an average culture period of 215 days from 181 ponds in central and western Bangladesh at an average stocking rate of silver carp, 26%, catla, 19%, rohu, 20% and silver barb, 17% along with other species at 18%. The total production of carp and golda obtained from the present study were within the range of good production level compared to the above findings.

Although shrimp/prawn culture is going to be the most popular and commercially profitable business in many areas of Bangladesh, especially southern region, north-west region (Rangpur, Dinajpur, Rajshahi and Bogra) and little practiced in Mymensingh region but prawn culture are not well practiced in this region (Kishoregonj). Therefore, prawn (*Machrobranchium rosenbergi*) was experimentally introduced in the present study to evaluate the growth and production. Although the gross production in the present study was high compared to the other findings, the production of prawn in some ponds were not good might be due to the lack of proper management and technical knowledge. Therefore, the production could be increased if the PL or juvenile is stocked at proper time with quality supplementary feed at recommended doses. This study is the first demonstration of carp-prawn polyculture system in women-headed farmers' pond in Bangladesh, which might immensely be helpful towards the development and dissemination of this technology in the rural farmers to a greater extent. Such techniques might eventually be useful for the improvement of socio-economic conditions and livelihood of the rural households. Further studies are also needed to find out more appropriate stocking densities, species combinations and ratios of carps and shrimp to boost up production of carp and prawn in polyculture system.

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