

**A comparative study between Mono and Polyculture System of
Golda (*Macrobrachium rosenbergii*) with Carp (*Labeo rohita*
and *Catla catla*) in Bagerhat, Bangladesh.**



BY

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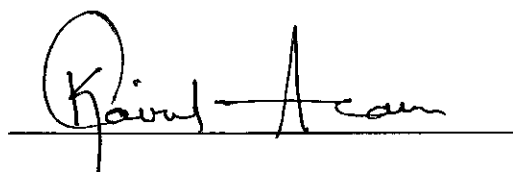
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**A comparative study between Mono and Polyculture System of
Golda (*Macrobrachium rosenbergii*) with Carp (*Labeo rohita*
and *Catla catla*) in Bagerhat, Bangladesh.**

Approved as to style and content

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DECLARATION

The results in this project thesis are entirely the candidate's own investigation and no part of the results has been accepted for any degree, nor it is being concurrently submitted for any degree.

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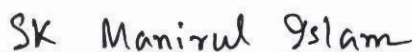
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Dedicated to

My Beloved Parents

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The Author

ABSTRACT

The study was conducted to compare the biological and economical feasibility of monoculture of *Macrobrachium rosenbergii* and its polyculture system with carps (*Labeo rohita* and *Catla catla*). The study was conducted from 1st June to 1st December 2002 at Fakirhat Thana of Bagerhat district. The study was observed the following attributes: growth, survival rate, production and income. In monoculture, the initial weight of prawn was 4.13 ± 0.15 g and in polyculture system the average initial weight of prawn, rohu and catla were 4.10 ± 0.10 , 68.0 ± 3.39 and 73.33 ± 3.05 g respectively. The final average weight of *M. rosenbergii* were 103.03 ± 6.47 and 92.83 ± 3.55 g in mono and polyculture ponds respectively. The final average weight of *L. rohita* and *C. catla* were 278.56 ± 10.37 and 262.81 ± 11.62 g respectively in polyculture system. In both culture systems, fertilizer and supplementary feed were used. In monoculture, the stocking density of *Macrobrachium rosenbergii* was 55/decimal. In polyculture, the numbers of prawn were 35/decimal where catla and rohu were 10 and 10/decimal respectively. The average growth rate of *M. rosenbergii* in mono and polyculture system was recorded 0.54 g/day and 0.49 g/day. In case of catla and rohu it was 1.05 g/day and 1.6g/day respectively. The survival rate of *M. rosenbergii* in mono and polyculture was found 65% and 75% respectively where catla and rohu was 90%. The total production of prawn in mono and polyculture system was 906.8 and 605.18 kg/ha respectively where the production of catla and rohu in polyculture was 584.2 and 619.1 kg/ha respectively. The average production cost in mono and polyculture system were 171397 Tk/ha and 167371 Tk/ha respectively. The gross income was 255650 and 295066 Tk/ha in case of mono and polyculture system whereas the net income was 84252 and 127694 Tk/ha respectively. The growth rate of *M. rosenbergii* was higher in monoculture than the polyculture system. From the above study it is understood that though Galda showed faster growth in monoculture, the polyculture of *M. rosenbergii* is said to be economically more profitable and feasible in the present culture system.

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LIST OF ABBREVIATIONS

MP	Monoculture Ponds
PP	Polyculture Ponds
MP1	Monoculture Pond One
MP2	Monoculture Pond Two
MP3	Monoculture Pond Three
PP1	Polyculture Pond One
PP2	Polyculture Pond Two
PP3	Polyculture Pond Three
AOAC	Association of Official Analytical Chemists
CARE	Co-operation of American relief everywhere
DOF	Department of Fisheries



Chapter-One

Introduction

INTRODUCTION

Bangladesh is enriched with fisheries resources. The role of fisheries in the economy of the country is highly significant in supplying nutritional benefit to the people of the country, providing employment opportunity and earning foreign currency. Unfortunately high fishing pressure due to rapid increasing population of the country, water pollution and natural hazards have become serious limiting factors in reducing the production of fishes in Bangladesh.

The gher revolution in the south-west region of Bangladesh is a remarkable example of how farming communities in the region have harnessed indigenous knowledge and used it to overcome severe food shortages arising from the degradation of their farmland caused by embankments. Gher farming has now been widespread in south-west Bangladesh, refers to the cultivation of the Giant Freshwater Prawn (*Macrobrachium rosenbergii*) in freshwater systems. These range from monoculture prawn ponds through to polyculture farms where several crops including the freshwater prawn are grown together. In polyculture *gher* farming, the freshwater prawn (*Macrobrachium rosenbergii*) culture with white (eg. Indian major carp, exotic fish or common carp) fish.

The coastal area of Bangladesh is 710 km in length, situated from Satkhira to Cox's Bazar. Greater Khulna region has the best overall conditions for prawn farming and is considered as the most suitable area for prawn cultivation as over 75% of country's prawn production comes from greater Khulna region. Shrimps and prawns play an important role in the economy of Bangladesh. Frozen fish and fisheries products have achieved the second position in foreign exchange earning and about 90% of total incomes from frozen products come from shrimps and prawns (Biswas, 1996). In 1997-98 Bangladesh earned about 1181.48 crore Taka by exporting frozen shrimp and prawn products in 1997-98 (DOF, 1999).

Prawn farmers faced many problems, such as; land used right, land use policy, legal support, shortage of prawn fry, infrastructure, industrial credit and marketing facilities. Very recently production of prawn has faced big setback worldwide including Bangladesh due to viral outbreak. It was estimated that viral infection causes a loss to world production of US Dollar 2 billion (Ahmed, 1995).

Farmers in Bagerhat district developed the gher farming technology in the 1980s. Since then gher farming was spreaded rapidly to other districts: Khulna, Jessore, Gopalganj and Satkhira, and the number of gher increases by approximately 10-20 percent every year (CARE Bangladesh, 2000). Gher farming is now the primary livelihood strategy of more than 100,000 rural households in the south-western region of Bangladesh. Gher farming has brought about dramatic changes in society as well as to the institutions that govern the local and the regional economy. It also generates substantial foreign currency for the country every year through exporting prawns – the major product of the gher.

There is no effort to compare the economic feasibilities of monoculture and polyculture systems practiced widely used in Bangladesh. The present study has been carried out to compare biological and the economic feasibility between mono and polyculture methods that are widely practiced in the greater Khulna region.

The study was carried out to compare the monoculture of *M. rosenbergii* and its polyculture with carp. By this regards, this study was undertaken to the following objectives:

1. To compare the production between monoculture of *M. rosenbergii* and its polyculture with carp.
2. To know the economic feasibility of two culture methods widely practiced in Bagerhat area.

Chapter Two

Review of Literature

REVIEW OF LITERATURE

Chand *et al.*, 2002 reported the size variation among the carp species in a given period. Giant freshwater prawn (*Macrobrachium rosenbergii*) was cultured with Indian carps (*Catla catla* and *Labeo rohita*) in a 0.42 ha pond. 10-days-old prawn seeds were stocked at 8000/ha while 12-15 cm catla and rohu fingerlings were stocked at 1200/ha each in the pond. The growth was fast in catla than rohu. They were found the average weight of catla, rohu and prawns were 926, 785 and 58 g, respectively. Survival rate of the fishes were between 65 and 66% while 49% for the prawns. The production rate obtained from the experiment was 1243 kg /ha for the fishes and 229 kg/ha for the prawns.

Islam *et al.*, 1999 conducted an experiment at Bangladesh Agricultural University, Mymensingh, on the feasibility study of polyculture of *M. rosenbergii* with carps in ponds. Juveniles of *M. rosenbergii* were stocked at 10000 and 15000/ha stocking densities along with *Hypophthalmichthys molitrix*, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* in the ratio of 1.75: 0.75: 1.50: 1.0 where total number of carps were 5000/ha. Supplementary feed consisting of sesame oil cake and rice bran (1: 1) was applied in ponds daily at 4% of the standing crop. After 12 months rearing, production level 95-172 kg/ha/yr of *M. rosenbergii* 2423-2875 kg/ha/yr fish were obtained from polyculture ponds 2305.45 kg/ha/yr of fish was obtained from the pond where only carps were cultured. It indicated that the production of fish in the pond would not be affected due to polyculture with *M. rosenbergii*.

Mirza *et al.*, 1978 studied the physico-chemical characteristics of the river Old Brahmaputra at Mymensingh for a period of one year. The physical factor, temperature was found to play important role in aquatic medium and the value of dissolved oxygen was positively correlated with photosynthetic activities of the phytoplankton population.

Dewan, 1973 investigated into the ecology in a Mymensingh lake (Bangladesh Agricultural University Campus). He observed higher oxygen concentration during winter and lower oxygen concentration during monsoon. He pointed out that the dissolved oxygen bears an

inverse relationship with temperature and free carbon-di-oxide; a direct relationship with pH and total alkalinity.

George, 1961 found that dissolved oxygen varied from 4.5 ppm to 9.9 ppm. He noted the highest value at 5.30 PM and lowest at 5.30 AM and stated that high O₂ content were associated with high rate of photosynthesis.

Azim et al., 2002 conducted an experiment at Netherlands on the production of 3 Indian major carps, catla (*Catla catla*), rohu (*Labeo rohita*), and kalbaush (*L. calbasu*), in a periphyton-based polyculture system. Four stocking combinations were applied: 60% rohu plus 40% catla with a total stocking density of 10000/ ha. (Treatment CR), CR plus 15% kalbaush (C15), CR plus 30% kalbaush (C30), and CR plus 45% kalbaush (C45). A treatment with 60% rohu plus 40% catla without bamboo substrate was used as control (CR0). Net fish yields of the 3 species were found to be higher in treatment C15. Highest total fish yield, over a 90-day culture period, was recorded in treatment C15 (2306 kg/ha), followed by treatment C45 (1914 kg/ ha), treatment CR (1652 kg/ha), treatment C30 (1507 kg/ha), and treatment CR0 (577 kg/ha). Fish production from the periphyton-based system was 2.8 times higher than that of the control. The addition of 15% Kalbaush (i.e. a stocking ratio of 12:8:3 rohu-catla-Kalbaush) at a total stocking density of 11500 juveniles ha⁻¹ resulted in a further 40% increase in production and was an appropriate combination in a periphyton-based polyculture system.

Goolish and Adelman, 1984 recorded maximum growth rate at 30 °C temperature of juvenile common carp. They also observed that the temperature of natural inland waters in the temperate regions generally varies between 0 °C and 30 °C, the maximum values occurring particularly in shallow waters in summer and the minimum exceptionally fall below zero in winter.

Islam et al., 1978 observed minimum values of dissolved oxygen during summer and maximum in winter. They observed water temperature was closely related with air temperature.

Lakshminarayana, 1965 in his study on the physico-chemical characteristics observed the higher values of dissolved oxygen throughout most of winter seasons. He stated that the low values of pH during rainy due to the changes in the levels of carbon-de-oxide and carbonates.

Lakshmanan et al., 1967 studied on survival and growth of cultivated fishes at the Government fish farms in five districts of Assam. They observed the highest temperature on all the ponds during the months July to August and the lowest during the months of December to January.

Martyshev, 1983 stated from the study of the chemical parameters characterizing the suitability of water for carp and trout farms; he observed more than 4 ppm dissolved oxygen and pH 7.0 is optimum values for carps.

Michael, 1969 reported that the pH ranging between 7.3 and 8.4 was the most suitable for fish culture. The amount of dissolved gases at any given time was found to be associated with biological activities in water. He further observed variations in total quantity of plankton affected the fish growth and production.

Oppenheimer et al., 1978 observed a declining trend of dissolved oxygen, pH, alkalinity and hardness during monsoon in three ponds in Dhaka city and pointed out that the horizontal bottoms of the ponds were richer in nutrients than the sloping sides.

Singh and Singh, 1975 concluded that in organically manure ponds dissolved oxygen, pH and total alkalinity remained in the range of 3.0-8.5 mg/l, 6.0-7.8 and 30-125 mg/l which were they considered to be favorable for the growth and survival of major carps and related species of fish.

Chiu, 1988a, 1988b gave valuable suggestions for planning of prawn farms and pointed out the criteria for intensive prawn farms.

Baticados, 1988 described typical prawn diseases, their causes, and prevention and control measures.

Rahman et al., 1982 made a study on the physico-chemical conditions of four selected ponds and the river Old Brahmaputra. The ranges of water temperature, dissolved oxygen, free carbon-de-oxide, pH, phosphate-phosphorus and nitrate nitrogen were 26.06-31.97 °C, 6-9.2 mg/l, 0-3 mg/l, 7.2-7.6, 0.028-0.173 mg/l and 0.074-0.304 mg/l respectively in the river Old Brahmaputra

Chaudhuri et al., 1978 reported fish production by application of composite fish culture technology in ponds, with a high stocking density of 13320 fingerlings per ha. The ponds recorded average gross and net productions of 7633.5 and 7444.8 kg/ha/yr., which was about 7 times, the normal production of around 1000 kg/ha/yr. reported by the ordinary fish farmers.

Davis et al. (1984) conducted fish culture trials in managed farmer's ponds with different feeding and stocking regimes. The species were employed, silver carp, catla, rohu, mrigal, common carp and grass carp while the feed were rice bran, mustard oil cake and rice bran + mustard oil cake and compost. Average fish production from 16 ponds was 2830 kg/ha with a range from 1890 to 3820 kg over the 12 months studies period.

Dewan et al., 1991 stated that least dietary overlap was observed between catla and rohu and between silver carp and bighead carp, whilst highest values (i.e. greatest overlap) were for catla-silver carp and catla-bighead carp in the pond of Bangladesh.

Dunseth and Smitlierman, 1977 conducted an experiment to find out the effectiveness of polyculture using carp and bighead carp in catfish grow-out ponds. They noted a slight reduction in catfish yield but the total fish production increased from 2371 lbs/acre/yr. in monoculture to 4118 lbs/acre/yr. in polyculture.

Hepher and Milstein, 1989 studied the interaction between bottom feeding fish (common carp and hybrid tilapia) and a filter feeder (silver carp) in polyculture in fertilized ponds with no supplementary feeding. The silver carps were stocked at two densities; 1,300 and 2,600/ha. Combined yield of all species in the polyculture was highest at the density of 1,300 silver carp/ha (2116 kg/ha in 156 days). At 2,600 silver carp/ha (1690 kg/ha in 156 days) inhibition of growth rate of silver carp itself reduced total yield as compared with the lower density.

Jhingran, 1976 reported that culture of silver carps along with Indian major carps has recently been developed in India as composite fish culture. In this method, the production as high as 3000-5800 kg/ha per 6 months and 7000-9000 kg/ha per year in different parts of the country has been achieved.

Malecha et al., 1981 tested the feasibility of raising the freshwater prawn, *Macrobrachium rosenbergii* without supplemental feeding in a polyculture system with silver carp, bighead carp and grass carp and later with common carp in a ratio of 65:1:4:12 with a combined density of about 5500/ha. The production was averaged 2516 kg/ha (14.38 kg/ha/day) in the manured ponds and 613 kg/ha (6.06 kg/ha/day) in the effluent ponds.

Mathew et al., 1988 reported the result of a study on composite culture of six species viz., catla, rohu, mrigal, common carp, silver carp and grass carp. They stocked in proportion of 10:5:10:25:30:20 respectively at a density of 8000/ha, yielding a record production of 10183 kg/ha after rearing over a period of one year.

Opuszyanski, 1986 described the increased yield of polyculture as being a function of stocking density, age of fish, fertility of ponds and environmental temperature. He suggested that maximum economic yield should be considered rather than maximum possible yield in case of polyculture practices.

Tang, 1970, Sinha, 1974 and Gupta, 1990 have been shown that different species stocked in polyculture ponds occupy different niches with their complimentary feeding habits, fully

utilizing all the natural food in the pond, thus increasing the total fish production from the pond.

Alam et al., 1995 evaluated the economics of different types of polyculture system involving exotic and native major carps. Fish yield of 1640-2995 kg/ha/7 months using the locally available inputs resulted in a net profit of Tk 52,055-87,641 /ha.

Awal et al., 1995 assessed the fish production and economic return of carp culture in six polyculture ponds. They recorded a net profit per hectare per 6 months for native, exotic and mixed polyculture system to be Tk. 30,825.00, Tk. 35,912.00 and Tk. 18,135.00, respectively through production of 1196, 1617 and 982 kg/ha/6 months, respectively.

Chapter Three

Materials and Methods

MATERIALS AND METHODS

3.1 Study Areas and Duration

The experiment was carried out at Fakirhat Upazilla under the district of Bagerhat, Bangladesh during the period of 1st June to 1st December 2002. Fortnightly visits were made to collect data regarding regular prawn farming activities, along with insite collection of physico-chemical parameters of the prawn ponds. Data on farming activities were collected both by direct physical observation and through interview with the farmers at the pond.

3.2 Experimental Ponds

The monoculture and polyculture ponds used in this study have using for a long time for the culture of *Macrobrachium rosenbergii* with carp (*Labeo rohita* and *Catla catla*). The experimental ponds were located in the village Mulghar, Fakirhat Upazilla under the district of Bagerhat (shown in the Map) about 30 km away from Khulna University. Three monoculture (MP1, MP2, MP3) and three polyculture (PP1, PP2, PP3) ponds were selected for the present study. The water surface area of the three monoculture ponds were 100, 150 and 120 decimals and the three polyculture ponds were 140, 130 and 150 decimals respectively. The shapes were varied from square to rectangular and also irregular. Bottom topography of the ponds was mostly plain and the most embankments were covered with tree.

3.3 Pond Preparation

3.3.1 Repairing:

Farmers repair their ponds after 2 or 3 years of first construction. However, farmers carried out repairment of dikes every year. They excavated a peripheral canal around the inner side of the embankment. They also, removed aquatic weeds and bushes.

3.3.2 Ploughing:

After dewatering and drying ploughing was done in all the polyculture and monoculture ponds for two times about 1 week interval. Ploughing was carried out in order to improve soil quality by exposing subsoil up.

3.3.3 Liming:

Though the requirement and dose of liming depends on soil condition, farmers are capable to follow optimum dose. Most of the farmers of surveyed ponds used calcium oxide and dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) as liming agent. During pond preparation, liming was carried out 10-15 days after ploughing. CaO was used at a rate of 200 kg/acre while dolomite at a rate of 40 kg/acre in all polyculture and monoculture ponds. In polyculture ponds, farmers used CaO and dolomite was applied at monthly interval from stocking to final harvest at a rate of 45 kg/acre and 9 kg/acre respectively.

3.3.4 Fertilization:

Urea, TSP and Cow dung were applied at a rate of 12 kg/acre, 8 kg/acre and 200 kg/acre respectively in all the surveyed ponds one week before stocking of prawn fry. After fry stocking, Urea, TSP and Cow dung were applied once a month at a rate of 6 kg/acre, 4 kg/acre and 50 kg/acre respectively in all the polyculture and monoculture ponds until harvesting.

3.3.5 Predator Control:

In order to control predator, rotenone at a rate of 0.75 kg/acre was applied after watering to get rid of undesired species of fish, mollusks, amphibians etc and other competitors from ponds. Bushes along the dike were removed manually to destroy habitats of other predators such as snakes, otters, frogs etc.

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3.4 Dike height and base width

Dike is the most important physical structures of pond particularly in country like Bangladesh where flood is recurring and devastating phenomenon. Dike height varied from 1.5 -2.0 m in both monoculture and polyculture ponds respectively. Base width varied from 1.0 -1.5 m in both monoculture and polyculture ponds respectively.

3.5 Stocking of Prawn and Carp fingerlings

Prawn (*Macrobrachium rosenbergii*) and carp (*Labeo rohita* and *Catla catla*) fingerlings were collected from local suppliers and stocked in all the surveyed ponds. No nursing practices were observed either in monoculture or in polyculture ponds. The average initial length and weight of the fingerlings in monoculture ponds were 6.62 cm and 4.13 g (Table-11) respectively. While average initial length and weight of the fingerlings of *M. rosenbergii* in polyculture ponds were 6.43 cm and 4.1g (Table-12) respectively. The average initial weight of the fingerlings of *Labeo rohita* and *Catla catla* in polyculture ponds were 73.33 g (Table-14) and 68.0 g (Table-13) respectively. All the surveyed ponds were stocked during the first week of June 2002. The average stocking density of fingerlings were 55 fingerlings/decemal in both mono and polyculture ponds. In polyculture ponds, stocking rate of catla and rohu were 10/decemal.

3.6 Acclimatization

All farmers acclimatized their fingerlings through gradual exchange of water in the container with pond water. This was done by slowly adding pond water in to the fingerlings container. The containers were placed pond on to the pond water for a certain time during early morning. The whole acclimatization process was done within two hours in all the surveyed ponds.

3.7 Grow- out Management

3.7.1 Feeding:

Feeding of fingerlings were carried from next day after stocking in both monoculture and polyculture ponds with oil cake, rice bran and snail meat until harvesting during either evening or morning. A small amount of feed was given at the inner corner of pond to check feeding appetite of the prawns. Amount of feed given in each pond was recorded everyday. Sometimes the feed supply was stopped immediately after heavy rainfall.

3.7.2 Monitoring of Water Quality Parameters:

The five major parameters of the pond water viz. temperature; pH, water transparency, dissolved oxygen (DO) and depth were recorded regularly either in the morning or evening. Temperature was recorded by using centigrade thermometer (0-100°C, China). pH were recorded by pen pH meter (Hanna) respectively. A secchi disk (30 cm dia) was used to measure water transparency and water depth was measured with a wooden meter scale.

3.7.3. Disease Control:

Regular inspection of prawn health was carried out every day to monitor any out break of disease. Any disease affected prawn, if found, was removed immediately from the pond. If any diseases occur then it may exchange the pond water or increase the water depth of the ponds. Balance diet also beneficial to prevent disease.

3. 7.4. Harvesting:

At the end of experiment, all the fishes were harvested by netting repeatedly with a fine meshed seine net from each pond. The final growth gained was recorded by measuring weight (g) of individual fish. All the fishes were sold to the fish trader.

2. 7.5. Production:

The gross and net production (kg/ha) of fishes was calculated by the following formula:

$$\text{Gross production (kg/ha)} = \frac{\text{Survival rate} \times \text{stocking density} \times \text{Final weight (g)}}{247 \times 1000}$$

$$\text{Net production (kg/ha)} = \frac{\text{Survival rate} \times \text{stocking density} \times \text{Net weight (g)}}{247 \times 1000}$$

* Where 1 ha = 247 Decimal.

3.8 Data Analysis

3.8.1 Growth Monitoring:

The growth of both prawn and carp (*Labeo rohita* and *Catla catla*) were monitored fortnightly from each pond during daytime through random sampling method. Growth of both prawn and carp (*Labeo rohita* and *Catla catla*) were recorded in weight (g) fortnightly with a triple beam simple balance. For taking weight samples of both prawn and carp (*Labeo rohita* and *Catla catla*) were collected from 4 to 5 selected spot using cast net and the both prawn and carp (*Labeo rohita* and *Catla catla*) were kept in a aluminum container covered with a lid to avoid jumping. For each pond 10-15 pieces of both prawn and carp (*Labeo rohita* and *Catla catla*) were weighted randomly. The total length of the both prawn and carp (*Labeo rohita* and *Catla catla*) were recorded by using ordinary centimeter scale. The growth (by weight) was measured from the fortnight data. The growth rate (by weight) of the both prawn and carp (*Labeo rohita* and *Catla catla*) were calculated following Mahmud *et al.*, (1993):

$$\text{Growth Rate: (g/day)} = \frac{W2 - W1}{T2 - T1}$$

Where, W2 = Weight (g) at time T2

W1 = Weight (g) at time T 1

T 2 = Date of last sampling.

T 1 = Date of previous sampling.

3.8.2 Survival Rate:

To measure the survival rate, the total stock of prawns in a pond was calculated weekly by the following formula:

$$X = \frac{\text{Mean no. of Prawn in the net.}}{\text{Dimension of cast net}} \times \text{pond size}$$

*Where, X = Stock in pond

The dimension of the selected cast net was calculated by the formula:

Dimension of net = πr^2 , where, r = radius of the net.

The survival rate was calculated by using the following formula:

$$\text{Survival rate} = \frac{\text{Stock of prawn at sampling time}}{\text{Total no. of prawn stocked}} \times 100$$

3.8.3 FCR (Food Conversion Ratio):

The food conversion ratio for the improved traditional ponds was calculated following Newton (1990) as follows:

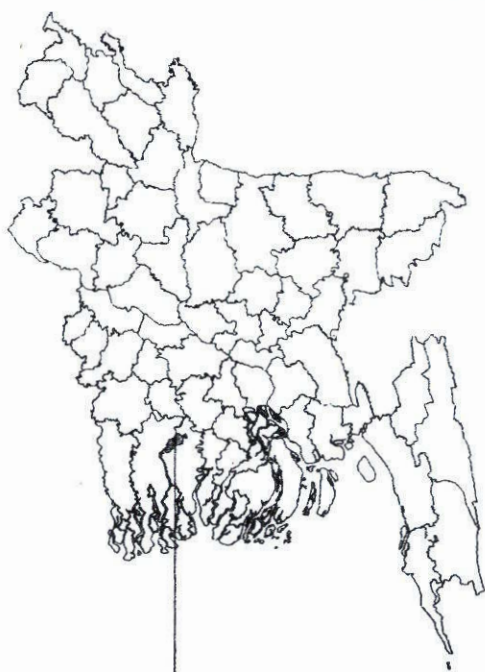
$$\text{FCR} = \frac{\text{Weight of food persented (kg)}}{\text{Weight of animal produced (kg)}}$$

DISTRICT: BAGHERHAT
UPAZILA: FAKIRHAT

STUDY AREA

FAKIRHAT

BAGERHAT



STUDY AREA



LOCATION OF THE STUDY AREA

Chapter-Four

Results

RESULTS

4.1 Physico-chemical Parameter

4.1.1 Water Temperature ($^{\circ}\text{C}$)

Monoculture (MP1, MP2 and MP3) Ponds: The average water temperature values were varied between 21.67°C and 34.67°C in all the monoculture ponds (Table-1). The highest temperature value 35°C was recorded in pond MP2 and during 1st August and September 15. The lowest temperature value 21.1°C was recorded during 1st December in pond MP2. The water temperature values were found to fluctuate in all the pond (Fig: 1)

Polyculture (PP1, PP2 and PP3) Ponds: The average water temperature values were varied between 23.67°C and 33.67°C in all the polyculture ponds (Table-2). The highest temperature value 34.2°C was recorded in ponds PP1 and PP2 during 1st August. The lowest temperature value 22.1°C was recorded during 1st December in pond PP1. The water temperature values were found to fluctuate in all the pond (Fig: 2)

4.1.2 P^{H}

Monoculture (MP1, MP2 and MP3) Ponds: The average P^{H} values were varied between 7.57 and 8.03 in all the monoculture ponds (Table-3). The highest value of P^{H} (8.5) was recorded in pond MP1 during September 15 and November 15, 2002 respectively. The lowest value of P^{H} (7.5) was recorded in pond MP1 and MP2 during 1st September 2002 respectively. However, the fluctuation of P^{H} values showed different patterns in all the ponds (Fig: 4)

Polyculture (PP1, PP2 and PP3) Ponds: The average P^{H} values were varied between 7.7 and 8.37 in all the polyculture ponds (Table-4). The highest value of P^{H} (8.5) was recorded in pond PP1 during October 15, 2002 respectively. The lowest value of P^{H} (7.1) was recorded in pond PP1 during 1st August 2002 respectively. However, the fluctuation of P^{H} values showed different patterns in all the ponds (Fig: 5)

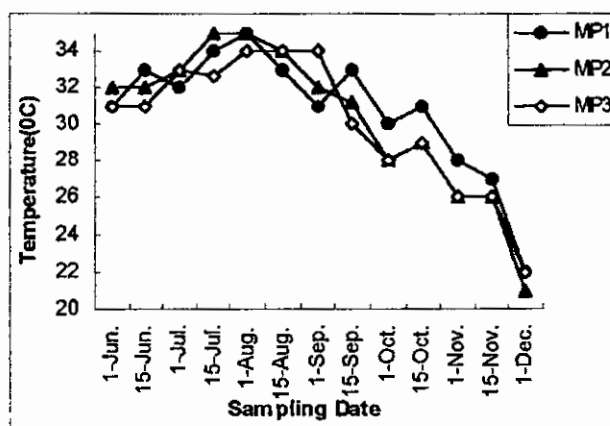


Fig.1 Fortnightly variation of water temperature (°C) in three different monoculture ponds during the study period.

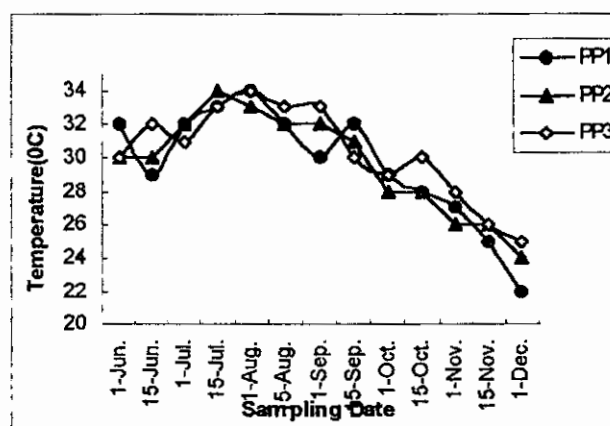


Fig.2 Fortnightly variation of water temperature (°C) in three different polyculture ponds during the study period.

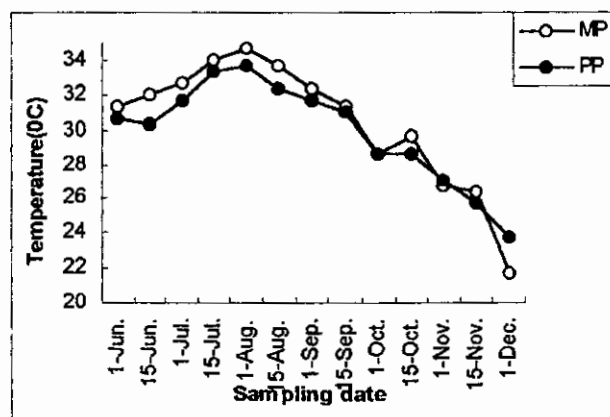


Fig.3 Fortnightly variations of water temperature (°C) in different culture system during the study period.

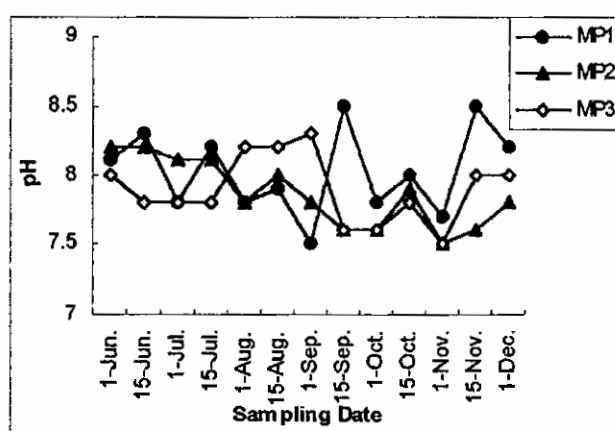


Fig.4 Fortnightly variations of water pH in three different monoculture ponds during the study period.

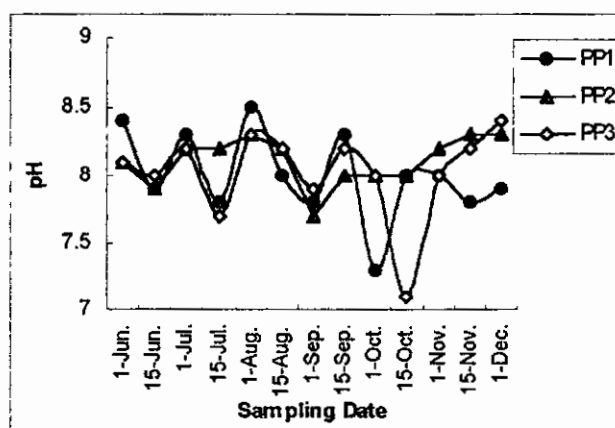


Fig.5 Fortnightly variations of water pH in three different polyculture ponds during the study period.

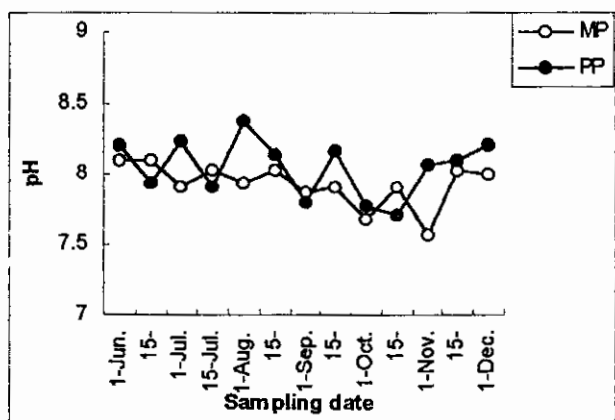


Fig.6 Fortnightly variations of water pH in different culture system during the study period.

4.1.3 Water Transparency (cm)

Monoculture (MP1, MP2 and MP3) Ponds: The average water transparency values were varied between 35.67 and 41.0 cm in all the monoculture ponds (Table-5). The secchi disk readings showed higher value (43 cm) was recorded in the pond MP1 during July 15, 2002. The lowest secchi disk reading (32 cm) was recorded MP2 during 1st July 2002. The fluctuation of water transparency values showed different patterns in all the ponds. (Fig: 7)

Polyculture (PP1, PP2 and PP3) Ponds: The average water transparency were varied between 30.0 cm and 38.66 cm in all the polyculture ponds (Table-6). The secchi disk readings showed higher value (42 cm) was recorded in the pond PP1 during 1st October 2002. The lowest secchi disk reading (28 cm) was recorded PP2 during August 2002. The fluctuation of water transparency values showed different patterns in all the ponds. (Fig: 8)

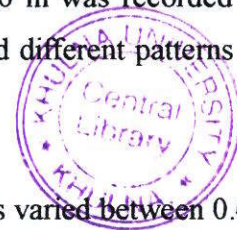
4.1.4 Water Depth (m)

Monoculture (MP1, MP2 and MP3) Ponds: Water depth was varied between 0.68 and 1.38 m in all the monoculture ponds (Table-7). The highest water depth 1.4 m was recorded in pond MP1 during September 15, 2002. The lowest water depth 0.6 m was recorded in pond MP1 during 1st June 2002. The fluctuation of water depth showed different patterns in all the ponds. (Fig: 10)

Polyculture (PP1, PP2 and PP3) Ponds: The average water depth was varied between 0.69 and 1.38 m in all the ponds (Table-8). The highest water depth 1.4 m was recorded in pond PP2 during September 15, 2002. The lowest water depth 0.62 m was recorded in pond PP1 during 1st December 2002. The fluctuation of water depth showed different patterns in all the ponds. (Fig: 11)

4.1.5 Dissolved Oxygen (DO)

Monoculture (MP1, MP2 and MP3) Ponds: The average Dissolved Oxygen (DO) values were varied between 6.33 and 7.67 mg/l in all the monoculture ponds (Table-9). The highest Dissolved Oxygen (DO) value 8 mg/l was recorded in pond MP1 and MP2 during September 15, 2002. The lowest Dissolved Oxygen (DO) values were recorded in pond MP2



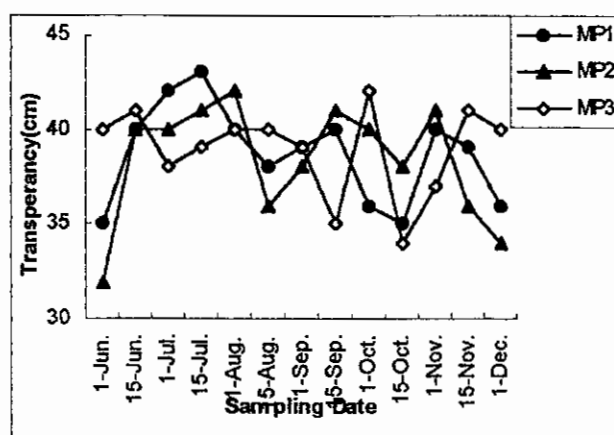


Fig.7 Fortnightly variation of water transparency (cm) in three different monoculture ponds during the study period.

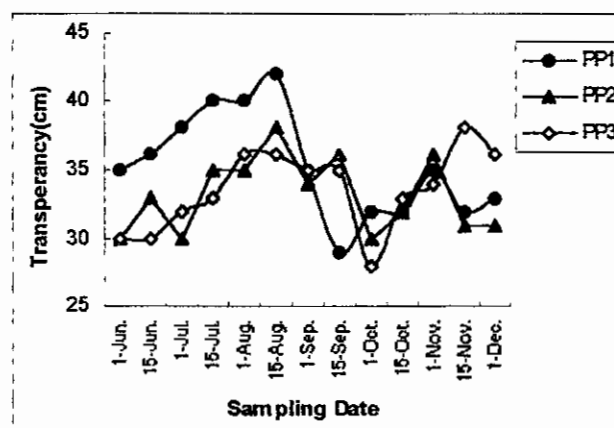


Fig.8 Fortnightly variation of water transparency (cm) in three different polyculture ponds during the study period.

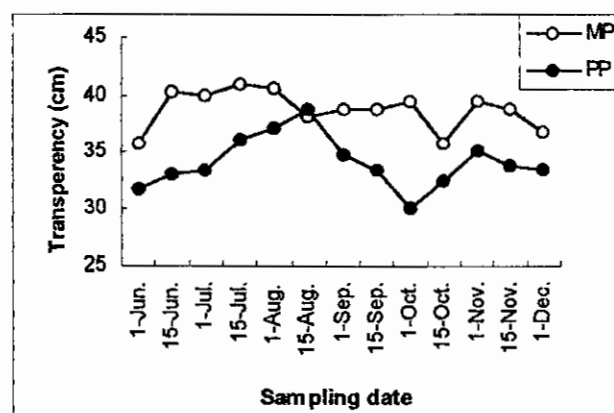


Fig.9 Fortnightly variation of water transparency (cm) in different culture system during the study period.

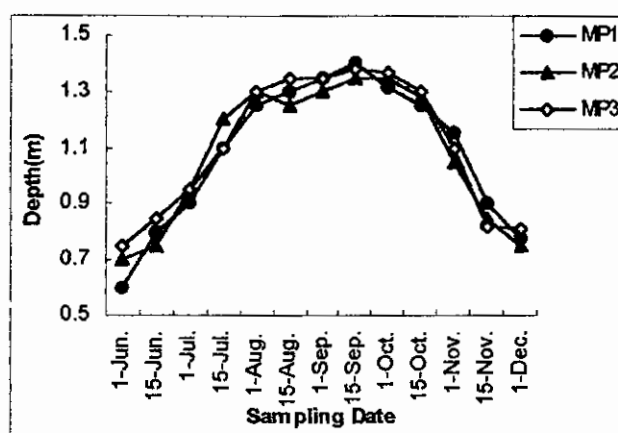


Fig.10 Fortnightly variation of water depth (m) in three different monoculture ponds during the study period.

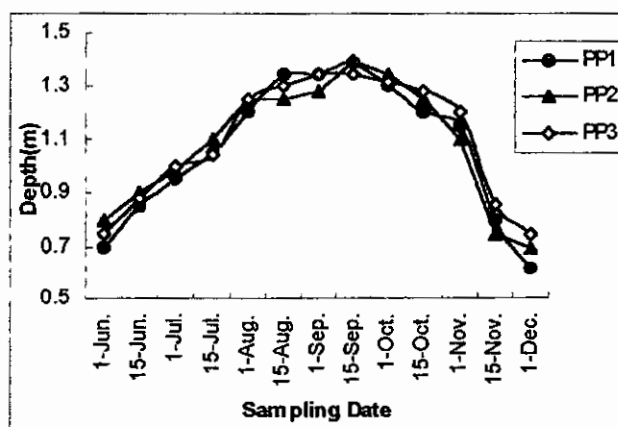


Fig.11 Fortnightly variation of water depth (m) in three different polyculture ponds during the study period.

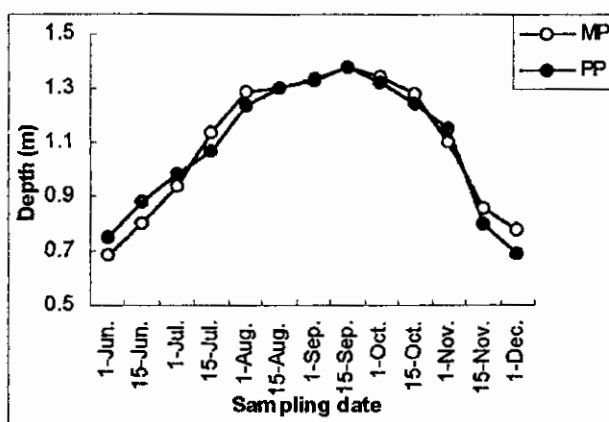


Fig.12 Fortnightly variation of water depth (m) in different culture system during the study period.

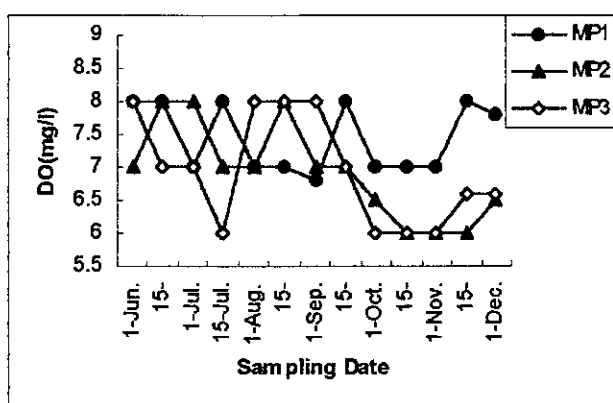


Fig.13 Fortnightly variation of Dissolved Oxygen (DO) in three different monoculture ponds during the study period.

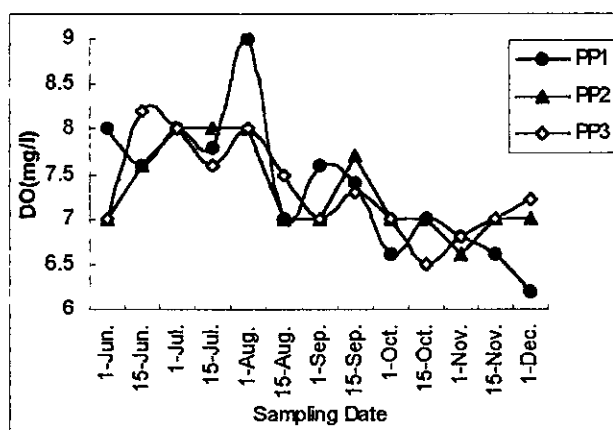


Fig.14 Fortnightly variation of Dissolved Oxygen (DO) in three different polyculture ponds during the study period.

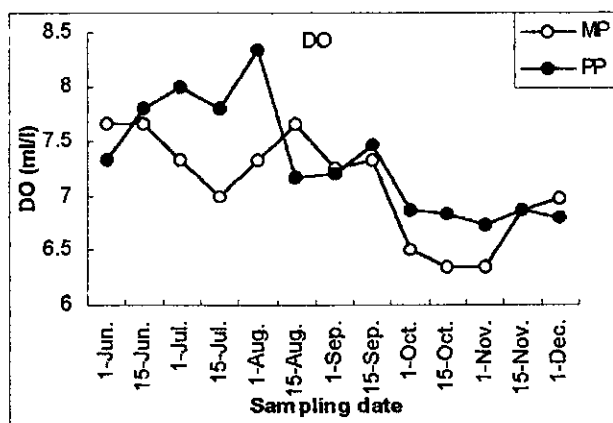


Fig.15 Fortnightly variation of Dissolved Oxygen (DO) in different culture system during the study period.

and MP3 during 1st June 2002. The fluctuation of Dissolved Oxygen (DO) values showed different patterns in all the ponds. (Fig13)

Polyculture (PP1, PP2 and PP3) Ponds: The average Dissolved Oxygen (DO) values were varied between 6.73mg/l and 8.33mg/l in all the polyculture ponds (Table-10). The highest Dissolved Oxygen (DO) value 9mg/l was recorded in pond PP1 and PP2 during October 15, 2002. The lowest Dissolved Oxygen (DO) values were recorded in pond PP2 and PP3 during 1st September 2002. The fluctuation of Dissolved Oxygen (DO) values showed different patterns in all the ponds. (Fig14)

4.2 Growth Performance

Monoculture (MP1, MP2 and MP3) Ponds: The growth of *Macrobrachium rosenbergii* by weight in all the ponds is presented in Fig16. The growth of all monoculture ponds increased throughout the culture period. The initial average body weight of *Macrobrachium rosenbergii* in the pond MP1, MP2 and MP3 were 4.3, 4.1 and 4 g respectively (Table-11). After culture period the final weight in the pond MP1, MP2 and MP3 were 110.5, 99.6 and 99 g respectively. The initial overall average body weight was measured at $4.13 \pm .15$ g and the final overall average body weight was measured at 103.7 ± 6.80 g (Table-11). Therefore, the overall average absolute growth [Final weight – Initial weight] of the prawn in monoculture pond was found to be 98.57 g.

Polyculture (PP1, PP2 and PP3) Ponds: The growth of *Macrobrachium rosenbergii* by weight in all the ponds is presented in Fig17. The growth of all polyculture ponds increased throughout the culture period. The initial average body weight of *Macrobrachium rosenbergii* in the pond PP1, PP2 and PP3 were 4, 4.2 and 4.1 g respectively (Table-12). After culture period the final weight in the pond PP1, PP2 and PP3 were 96.5, 92.6 and 89.4 g respectively (Table-12). The initial overall average body weight was measured at $4.1 \pm .1$ g and the final overall average body weight was measured at 92.83 ± 3.55 g. Therefore, the overall average absolute growth [Final weight – Initial weight] of the prawn in polyculture pond was found to be 88.73 g.

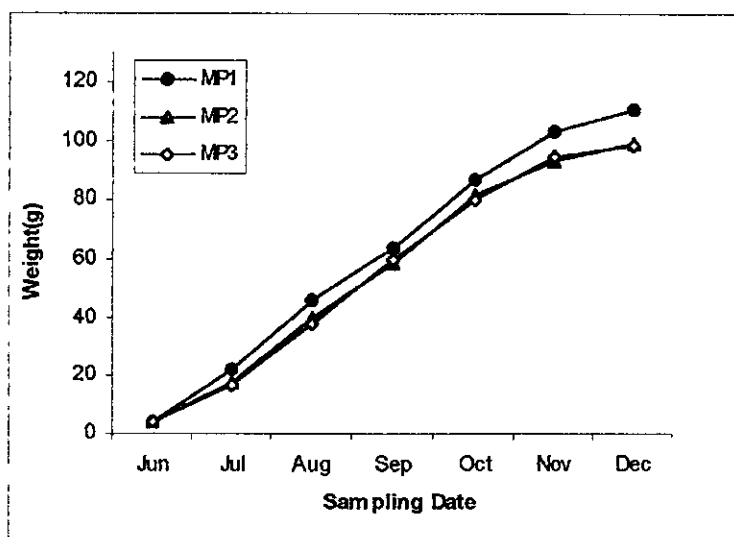


Fig.16 Monthly gains in weight (g) of *M. rosenbergii* under three different monoculture ponds during the study period.

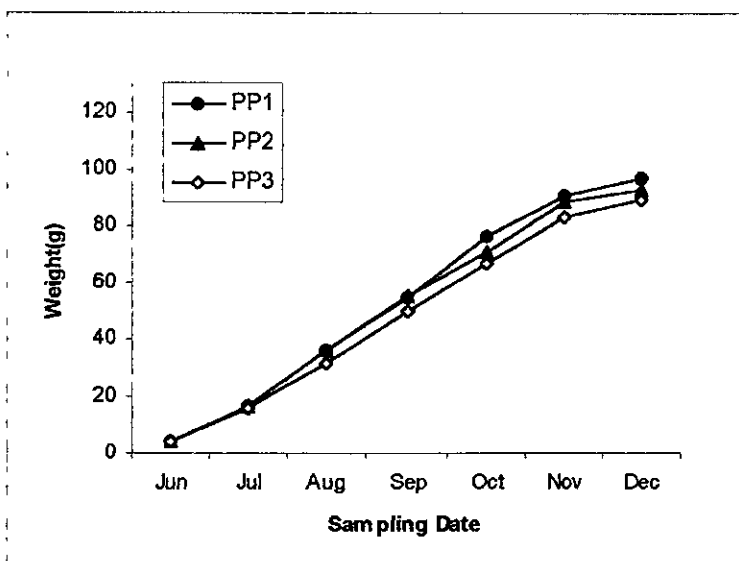


Fig.17 Monthly gains in weight (g) of *M. rosenbergii* under three different polyculture ponds during the study period.

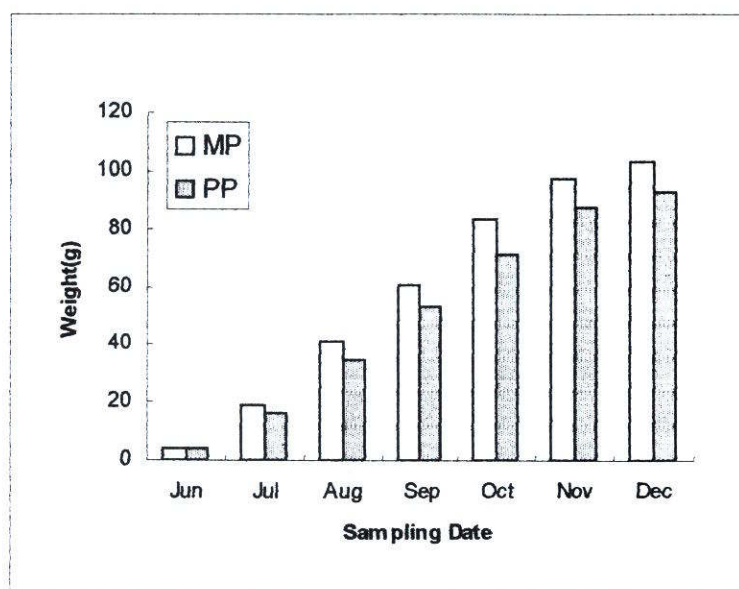


Fig.18 Monthly gains in weight (g) of *M. rosenbergii* under two different culture systems during the culture period.

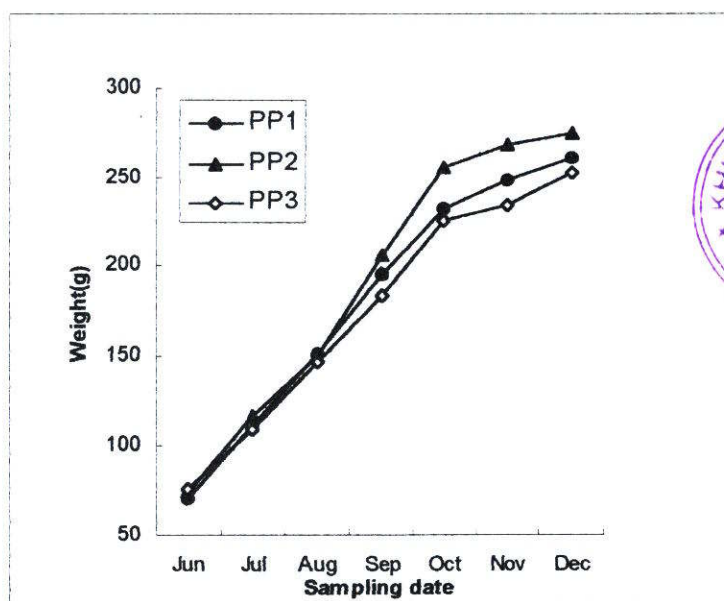


Fig.19 Monthly gains in weight (g) of *C. catla* under three different polyculture ponds during the study period.



The growths of *Labeo rohita* by weight (g) in all the polyculture ponds are presented in Fig: 20. The growth of all polyculture ponds increased throughout the culture period. The initial average body weight of *Labeo rohita* in the pond PP1, PP2 and PP3 were 72.5, 66.3 and 65.2 g respectively (Table-14). After culture period the final weight in the pond PP1, PP2 and PP3 were 275.3, 270.1 and 290.1g respectively (Table-14). The initial overall average body weight was measured at 68 ± 3.93 g and the final overall average body weight was measured at 278.5 ± 10.37 g. Therefore, the overall average absolute growth [Final weight – Initial weight] of the in polyculture pond was found to be 210.5 g.

The growths of *Catla catla* by weight in all the ponds are presented in Fig: 19. The growth of all polyculture ponds increased throughout the culture period. The initial average body weight of *Catla catla* in the pond PP1, PP2 and PP3 were 70.2, 73.5 and 76.3 g respectively (Table-13). After culture period the final weight in the pond PP1, PP2 and PP3 were 260.5, 275.4 and 252.5 g respectively (Table-13). The initial overall average body weight was measured at 73.33 ± 3.05 g and the final overall average body weight was measured at 262.8 ± 11.62 g respectively. Therefore, the overall average absolute growth [Final weight – Initial weight] of the catla in polyculture pond was found to be 189.47 g.

4.3 Growth rate

Monoculture (MP1, MP2 and MP3) Ponds: The monthly average growth rate of *M. rosenbergii* by weight in the entire ponds presented in Table-11. The maximum average growth rate (0.74 g/day) was observed in monoculture system during 1st August 2002 and the minimum growth rate (0.18 g/day) was observed in 1st December 2002 (Fig: 21). The overall average growth rate values for monoculture ponds were 0.54 g/day respectively.

Polyculture (PP1, PP2 and PP3) Ponds: The monthly average growth rate of *M. rosenbergii* by weight in the entire ponds presented in Table-12. The maximum average growth rate (0.61 g/day) was observed in polyculture system during 1st September 2002 and the minimum growth rate (0.17g/day) was observed in 1st December 2002 (Fig; 12). The overall average growth rate values for polyculture ponds were 0.49 g/day.

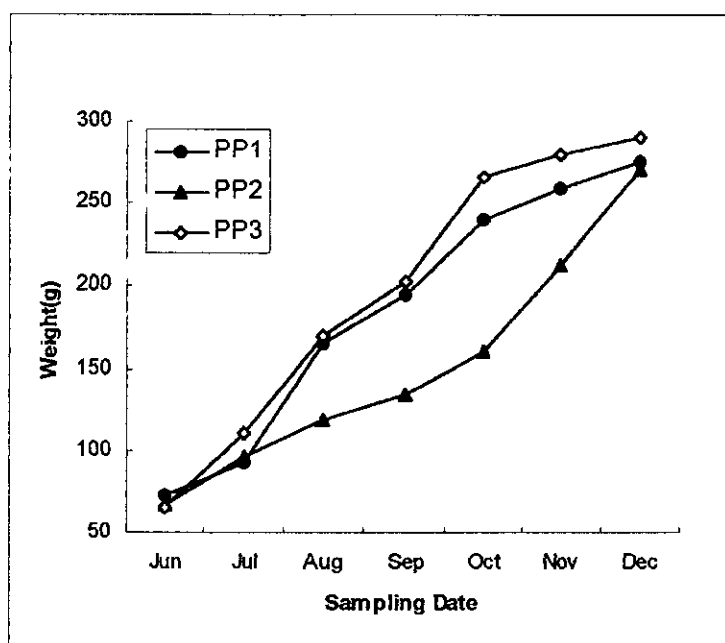


Fig.20 Monthly gains in weight (g) of *L. rohita* under three different polyculture ponds during the study period.

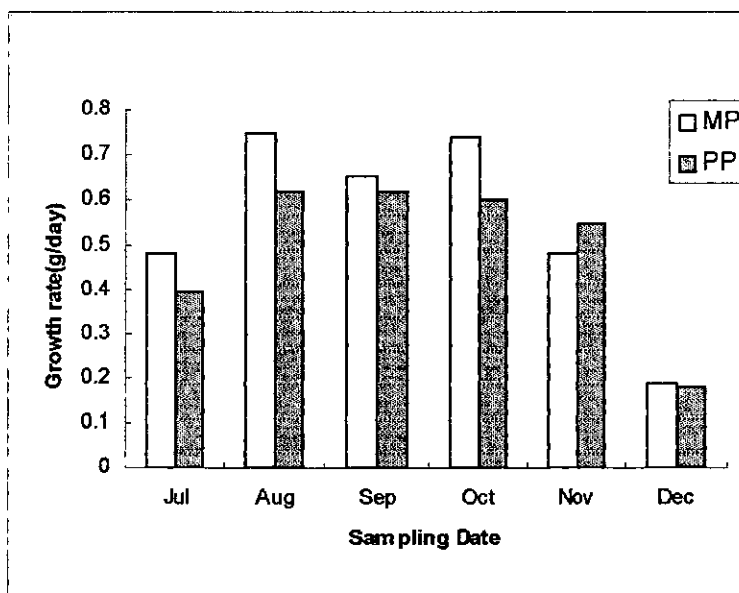


Fig.21 Monthly growth rate of *M. rosenbergii* by weight (g/day) under two different culture systems during the study period.

The monthly average growth rate of *Labeo rohita* by weight in the entire ponds presented in Table-14. The maximum average growth rate (1.72 g/day) was observed 1st August 2002 and the minimum growth rate was observed during 1st December 2002, which was 0.94 g/day. The overall average growth rate of was 1.16 g/day. The monthly average growth rate of *Catla catla* by weight in the entire ponds presented in Table-13. The maximum average growth rate (1.54 g/day) was observed during 1st October 2002 and the minimum growth rate (0.41 g/day) was observed in 1st December 2002. The overall average growth rate of catla was 1.05 g/day.

4.4 Production

Monoculture (MP1, MP2 and MP3) Ponds: The total production of MP1, MP2 and MP3 were found to be 395.03, 534.1 and 424.7 kg with production rate 975.74, 879.49 and 874 kg/ha respectively (Table-17). Pond MP1 showed better production than MP2 and MP3. The overall total average production and production rate from monoculture ponds were found to be 1353.83 kg and 909.8 kg/ha respectively (Table-18).

Polyculture (PP1, PP2 and PP3) Ponds: The total production of PP1, PP2 and PP3 were found to be 354.6, 315.99 and 352.01 kg with production rate 625.6, 600.3 and 605.18 kg/ha respectively (Table-17). Pond PP1 showed better production than PP2 and PP3 (Table-17). The overall total average production and production rate from polyculture ponds were found to be 1022.6 and 605.18 kg/ha respectively (Table-18).

The overall total average production and production rate of *Labeo rohita* from polyculture ponds were found to be 1052.73 kg and 619.1 kg/ha respectively (Table-18). The overall total average production and production rate of *Catla catla* from polyculture ponds were found to be 993.38 kg and 524.2 kg/ha respectively (Table-18).

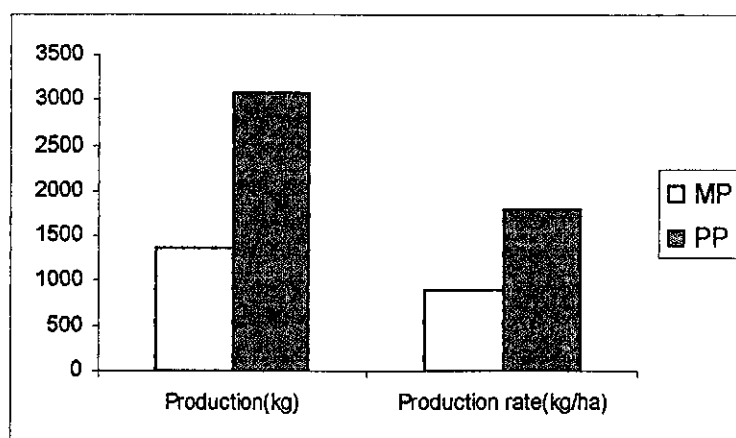


Fig.22 Gross production and production rate in different culture system.

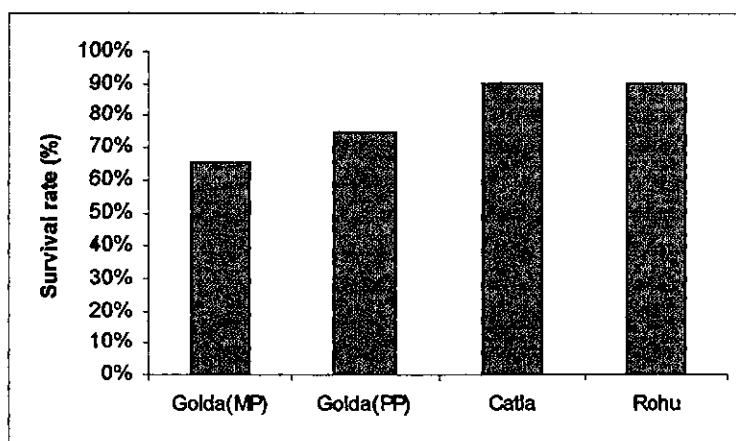


Fig.23 Average survival rate of different species in mono and polyculture System.

4.5 Survival Rate:

Monoculture (MP1, MP2 and MP3) Ponds: Average survival rate of *Macrobrachium rosenbergii* from three ponds was found to be 65% respectively (Fig: 23). After experimental period, survival rates in all the ponds MP1, MP2 and MP3 were found to be 70%, 61% and 64% respectively.

Polyculture (PP1, PP2 and PP3) Ponds: Average survival rate of *Macrobrachium rosenbergii* from three polyculture ponds was found to be 75% respectively (Fig: 23). After experimental period, survival rate of *L. rohita* and *C. catla* were 90% respectively.

4.6 FCR [Food Conversion Ratio]:

The final FCR in mono and polyculture ponds were found 1:1.25 and 1:1.09 and the overall average was 1: 1.17 respectively.

4.7 Cost Benefit Analysis:

The cost was estimated as 171397 Tk/ha and 167371 Tk/ha for monoculture and polyculture ponds respectively (Table-16 and Fig: 24). The gross incomes were estimated as 255650 Tk/ha and 295066 Tk/ha in mono and polyculture ponds respectively (Table-16). Therefore the net profit in the experimental monoculture and polyculture ponds were 84252 Tk/ha and 127694 Tk/ha respectively (Table-16).

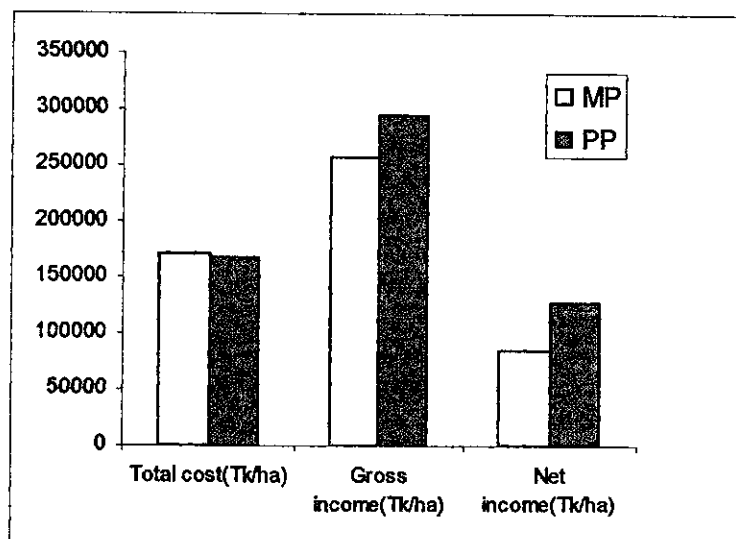


Fig.24 Total cost, gross and net income (Tk/ha) in different culture system.

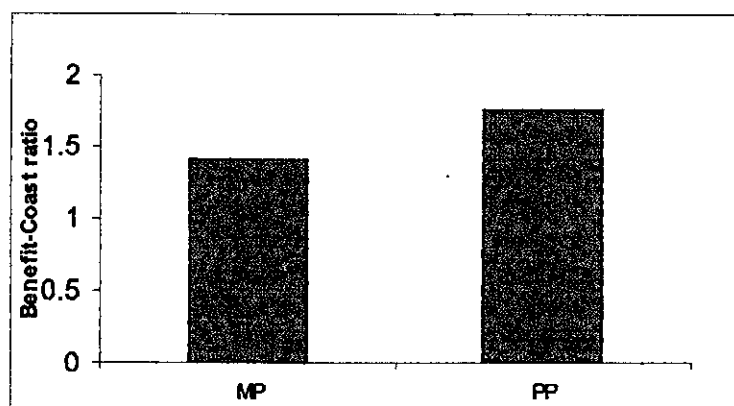


Fig.25 Benefit-Cost ratio in different culture system.

Chapter-Five

Discussion

DISCUSSION

5.1 Physico-chemical Parameter

5.1.1 Water Temperature ($^{\circ}\text{C}$):

Temperature, one of the important physico-chemical parameter, which influences the physical, chemical and biological nature of water body. The water temperature found to fluctuate between 21°C to 35°C during the study period. Chiu (1987) reported that the optimum temperature for *M. rosenbergii* is 25°C to 32°C but Hoq *et al.*, (1996) stated the favorable temperature for polyculture of fresh water prawn is 26.5°C - 31.5°C . Ali *et al.*, (1982) stated that 20.5°C - 36.5°C is favorable for fish culture. The temperature was maximum during 1st August and minimum during 1st February. Islam *et al.*, (1999) and Humayunn *et al.*, (1986) also give some important opinion.

5.1.2 pH:

The pH values in all monoculture and polyculture ponds in the present study were 7 to 9 which is the best range of pH for fish culture (Boyd and Fast, 1992). Chiu (1987) noted that optimum range of pH is 6.9-8.8 for prawn culture. The pH range in all the monoculture and polyculture ponds indicate that the water was neutral to alkaline with pH ranging from 7.1 to 8.5. Low pH reduces ammonia toxicity (Whitfield 1974) but mobilize metals, including iron and aluminum, which can reduce yields in aquaculture ponds (Simpson *et al.*, 1983). Low pH can also natural pond productivity presumably by reducing the availability of nutrients (Alabaster and Liod, 1980) including Phosphorous, eg. Bicarbonates and hence alkalinity. If the pH is reduced, problems may encounter with soft Prawn. Nagarajah and Gupta (1983) reported that lower and higher pH values occurred due to high rainfall and high abundance of algae respectively. Higher pH ($\text{pH} > 9$) has harmful effect on prawn and carp culture. Martyshev (1983) described that pH value of 7.0 is optimum for carp culture.

5.1.3 Water Transparency:

The recommended level of water transparency for prawn and carp culture is 34 to 60 cm (Humayun 1986). The water transparency in all the monoculture and polyculture ponds were varied from 28 to 45 cm during the study period. There were no effect of water transparency on the growth of prawn and carp in all the mono and polyculture ponds hence the presence of natural food was optimum.

5.1.4 Dissolved Oxygen:

Dissolved oxygen was ranged from 6 to 9 mg /l. George (1961) stated, the productive range of dissolved oxygen is 4.5-9.9 mg/l for fish culture. Ali *et al.*, (1982) stated the favorable range is 7.2-12.5 mg/l for the culture of carp. Bhyan (1970) reported dissolved oxygen content from 5.0-7.0 mg/l is required for production. However Wulff (1982) reported that juveniles in *M. rosenbergii* in freshwater prawn could tolerate minimum oxygen levels of 1.0-1.5 mg/l and suggested not to allow the prawns at such levels for long time.

5.1.5 Depth:

Hasson and Goodwin (1977) observed that the water depth ranging from 91 to 122 cm are known to be beneficial for growth and survival of prawns. The water depth ranging from 95 to 130 cm is beneficial for the growth of carps (Humayun *et al.*, 1986). The desirable depth of water could not be maintained in the both mono and poly culture ponds. Water depth in all monoculture ponds varied between 0.6 to 1.4 m while the polyculture ponds varied between 0.62 to 1.4 m during the study period and watercolor was green throughout the culture period, which indicates high primary productivity i.e., presence of enough natural food (Moniruzzaman 1996). The increase of water depth in all the mono and polyculture ponds from June to July may be due to heavy rainfall. The decrements of water level in all the mono and polyculture ponds were due to the seepage and evaporation.

5.2 Growth Performance

Among the monoculture ponds, comparatively a higher growth of *M. rosenbergii* by weight was found in pond MP1 (Table-11) while among the polyculture ponds higher growth of *M. rosenbergii* by weight was found in pond PP1 (Table-12). The final average growth by

weight of *M. rosenbergii* in present study after experimental period in monoculture pond was 102.7 ± 6.80 g and 92.83 ± 3.55 g in polyculture pond. Tidwell *et al.*, (1993) reported that the individual growth of 42 g respectively in the monoculture of *M. rosenbergii* using formulated diet containing 32% protein.

Among the polyculture ponds higher growth of *Catla catla* by weight was found in pond PP2 (Tabla-13) and the higher growth of *Labeo rohita* was found in pond PP3 (Table-14). The final overall average growth by weight of *Catla catla* in present study after experimental period was 189.47 g and the final average growth by weight of *Labeo rohita* in present study after experimental period was 210.5 g culture pond.

The stocking density of prawn fry in monoculture pond was 55/decimal and 35/decimal in polyculture ponds. The stocking density of *Labeo rohita* and *Catla catla* was 10/decimal. The growth of all species in mono and polyculture ponds is quite satisfactory in compression to the result of Mazid and Mahmood, (1994). Chand *et al.*, (2002) were found the average weight of catla, rohu and prawns were 926, 785 and 58 g in polyculture system which is lower than the present study.

5.3 Growth Rate:

The daily increment of weight ranging of *M. rosenbergii* in mono and polyculture ponds were 0.54 g/day and 0.49 g/day which is greater than Arili *et al.*, (1981) and Ling (1967) but seems secured quite low when compared with that of Arieli and Rappaport, (1982) who recorded 0.56 g/day increment over a growing period of 150 days. In another experiment in polyculture of prawn Hoq *et al.*, (1996) reported a weight gain of 80.2 g in 120 days with stocking density 60/decimal. The daily increment of weight ranging of *Catla catla* and *Labeo rohita* was 1.05 and 1.16 g/day which are greater than Hoq *et al.*, (1996) but it the growth rate of catla seems low when compared with that of Humayan *et al.*, (1986) who recorded 110.2 g/day increment.

5.4 Production

The production rate of *M. rosenbergii* in three different mono culture pond MP1, MP2 and MP3 was 973.74 kg/ha, 879.49 kg/ha and 874.17 kg/ha (Table-17). MP1 pond shows the better production than the other. This might be attribute because of less fluctuation of physico-chemical parameters and natural productivity. The production rate of *M. rosenbergii* in three different polyculture pond PP1, PP2 and PP3 was 625.6 kg/ha, 600.3 kg/ha and 605.18 kg/ha (Table-17). PP1 pond shows the higher production rate which is better than the other ponds. This might be attribute because of less fluctuation of physico-chemical parameters natural productivity and good feeding response in the pond. The production of *L. rohita* and *C. catla* was 619.1 kg/ha and 524.2 kg/ha respectively (Table-18). The net production rate of monoculture pond was 909.8 kg/ha where polyculture ponds showed 1353.83 kg/ha. The production rate of prawn in the present study is higher than that of Mazid and Mahmood, (1994) but lower than that of Ang (1990). Hoq *et al.*, (1996) and Humaun *et al.*, (1986) also reported good results from the polyculture of *M. rosenbergii*. Laksman *et al.*, (1971) obtained good result in polyculture with Chinese and Indian major carps by stocking in varying proportions in different densities. The fish production recorded by them varied from 2230-4209 kg/ha/ya. Chand *et al.*, (2002) obtained the production rate from polyculture of prawn 1243 kg /ha for the fishes and 229kg/ha for the prawns.

5.5 Survival Rate

The highest survival rate 75% was recorded in polyculture system and the lower survival rate 65% was monoculture pond in the case of *M. rosenbergii* (Table-15). Tidwell *et al.*, (1993) reported that the individual survival rate of 78 % respectively in the monoculture of *M. rosenbergii* using formulated diet containing 32% protein. Among the entire species relatively higher survival rate was recorded in *Labeo rohita* that is similar to *Catla catla*. However, survival rates were better than the result of Mazid *et al.*, (1989). Chand *et al.*, (2002) found the survival rate of catla, rohu and prawn in poly culture system was 65%, 66% and 49%, which is lower than the present study.

5.6 FCR

The overall average FCR were 1:1.4 and 1:1.2 for monoculture and polyculture ponds. It is highly satisfactory when compared with Tidwell *et al.*, (1993) who reported that the FCR was 1: 2.9 respectively in the monoculture of *M. rosenbergii* using formulated diet containing 32% protein.

5.2.6 Cost- Benefit Analysis

The average ratio of profit to total cost from the three monoculture ponds is about 149.15%, which indicate a average profitability of the culture system in fresh water prawn, while the average ratio of profit to total cost from the three polyculture ponds is about 176.29% which is indicate a good profitability of the culture system. In general prawn farming is more than 200% profitable through semi-intensive system (Islam *et al.*, 1990). The overall average production cost (per ha), gross profit (per ha) and net profit (per ha) of the monoculture ponds were Tk.171397, Tk.255650 and Tk.84252 respectively (Table-16). The overall average production cost (per ha), gross profit (per ha) and net profit (per ha) of the polyculture ponds were Tk.167371, Tk.295066 and Tk.127694 respectively (Table-16). It is clear that polyculture system is economically more feasible than that of monoculture system in terms of net and gross profit (per ha), profit (per kg), ratio of profit to total cost (%), production rate (kg/ ha) and production cost (Tk/kg).

Chapter-Six

Conclusion

CONCLUSION

Bangladesh is trying hard to increase the annual fish production to fight the serious protein deficiency of her people and increase the income from fisheries sector. For this purpose, the study was conducted to determine the best culture system from mono and polyculture of *M. rosenbergii*. In the present study it is clear that polyculture is better in all aspect of economic feasibility (survival rate, production rate, net income, gross income and ratio of profit). The study showed that the gross production of mono and polyculture was 1358.48 kg/ha and 3069.60 kg/ha. The gross income of mono and polyculture was 255650 and 295066 Tk/ha and the net income was 84252 Tk/ha and 127694 Tk/ha. Most of the fishermen believe that monoculture of *M. rosenbergii* is better than the polyculture. They think polyculture is more expensive than monoculture. This study shows that it is wrong. So it is conclude that polyculture is better than the monoculture of *M. rosenbergii*.



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Chapter-Eight

Appendix

Questionnaire

Date:

Name of the farm:

Location:

1.Area of the farm

ha/ acre/decimal	
Water area	
Total area	

2.Water depth

Highest	
Highest	

3.Water quality measurement

Do you maintain water quality measurement	What type of water quality measurement?

4.Plankton bloom

When	Color	Bad effects

5.Fry collection

Fry source	
Size (PL) and Age	
Facilities during transport	
Transport time	
Fry transport with • Earthen pot • Poly Bag • Aluminum deck	
Transport cost	

6.Sticking

Time of stocking	
Density	
Time of harvesting	

7. Fertilizing

Types	Rate
Organic - Cow dung - Poultry - Others	
Inorganic - Urea - Tsp - MP - Others	

8. Culture management

Culture system	Species with ratio
• Mono-culture • Poly-culture	
✓ Culture techniques • Traditional • Improved traditional • Semi-intensive	
Culture period	
✗ Source of water	
Eradication of weed fish	
Monitoring of • Water quality • Growth • Survival • Feeding	

9. Do they culture other crop except fish? (Yes\No)

Type of crop	
✓ Total production	

10. Food and feeding

Types of feed	Amount of feed (Kg) % of body weight	Feeding time	Feeding method

11. Formulation of hand made food

Ingredient	Ratio

12. Diseases

Frequency of diseases	Name of disease	Symptom	When (at which size/stage)	Mortality	Controlling measure with using rate
2002					
2001					
2000					
1999					

13. Coast benefit analysis

Line item	Amount	Unit price/rate	Coast (Tk.)	Total coast (Tk.)
Pond preparation				
Predator control				
Ploughing				
Fertilization before stocking				
Fertilization after stocking				
Liming before stocking				
Liming after stocking				
Seed				
Staff salary				
Feed				
Labor (temporary)				
Labor (permanent)				
Transport coast				
Others coast				
Total production (<i>M. rosenbergii</i>)				
Total production (Other species)				

Appendix

Table-1. Fortnightly variation of water temperature ($^{\circ}\text{C}$) in the three different monoculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
MP1	31	33	32	34	35	33	31	33	30	31	28	27	22
MP2	32	32	33	35	35	34	32	31	28	29	26	26	21
MP3	31	31	33	32.7	34	34	34	30	28	29	26	26	22
Average	31.33	32.00	32.67	34.00	34.67	33.67	32.33	31.33	28.67	29.67	26.67	26.33	21.67

Table-2. Fortnightly variation of water temperature ($^{\circ}\text{C}$) in the three different polyculture ponds during the study period

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
PP1	32	29	32	33	34	32	30	32	29	28	27	25	22
PP2	30	30	32	34	33	32	32	31	28	28	26	26	24
PP3	30	32	31	33	34	33	33	30	29	30	28	26	25
Average	30.67	30.33	31.67	33.33	33.67	32.33	31.67	31.00	28.67	28.67	27.00	25.67	23.67

Table-3. Fortnightly variation of water pH in the three different monoculture ponds during the study period.

Pond on.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
MP1	8.1	8.3	7.8	8.2	7.8	7.9	7.5	8.5	7.8	8	7.7	8.5	8.2
MP2	8.2	8.2	8.1	8.1	7.8	8	7.8	7.6	7.6	7.9	7.5	7.6	7.8
MP3	8	7.8	7.8	7.8	8.2	8.2	8.3	7.6	7.6	7.8	7.5	8	8
Average	8.1	8.1	7.9	8.03	7.93	8.03	7.87	7.9	7.67	7.9	7.57	8.03	8

Table-4. Fortnightly variation of water pH in the three different polyculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
PP1	8.4	7.9	8.3	7.8	8.5	8	7.8	8.3	7.3	8	8	7.8	7.9
PP2	8.1	7.9	8.2	8.2	8.3	8.2	7.7	8	8	8	8.2	8.3	8.3
PP3	8.1	8	8.2	7.7	8.3	8.2	7.9	8.2	8	7.1	8	8.2	8.4
Average	8.2	7.93	8.23	7.9	8.37	8.13	7.8	8.17	7.77	7.7	8.07	8.1	8.2

Table-5. Fortnightly variation of water transparency (cm) in the three different monoculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
MP1	35	40	42	43	40	38	39	40	36	35	40	39	36
MP2	32	40	40	41	42	36	38	41	40	38	41	36	34
MP3	40	41	38	39	40	40	39	35	42	34	37	41	40
Average	35.67	40.33	40.00	41.00	40.67	38.00	38.67	38.67	39.33	35.67	39.33	38.67	36.67

Table-6. Fortnightly variation of water transparency (cm) in the three different polyculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
PP1	35	36	38	40	40	42	35	29	32	32	35	32	33
PP2	30	33	30	35	35	38	34	36	30	32	36	31	31
PP3	30	30	32	33	36	36	35	35	28	33	34	38	36
Average	31.67	33.00	33.33	36.00	37.00	38.67	34.67	33.33	30.00	32.33	35.00	33.67	33.33

Appendix

Table-7. Fortnightly variation of average water depth (m) in the three different monoculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
MP1	0.6	0.8	0.9	1.1	1.25	1.3	1.35	1.4	1.31	1.25	1.15	0.9	0.78
MP2	0.7	0.75	0.95	1.2	1.3	1.25	1.3	1.35	1.35	1.28	1.05	0.85	0.75
MP3	0.75	0.85	0.95	1.1	1.3	1.35	1.35	1.38	1.37	1.3	1.1	0.82	0.81
Average	0.68	0.80	0.93	1.13	1.28	1.30	1.33	1.38	1.34	1.28	1.10	0.86	0.78

Table-8 Fortnightly variation of average water depth (m) in the three different polyculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
PP1	0.7	0.85	0.95	1.05	1.2	1.35	1.35	1.39	1.3	1.2	1.15	0.8	0.62
PP2	0.8	0.9	0.98	1.1	1.25	1.25	1.28	1.4	1.35	1.25	1.1	0.75	0.7
PP3	0.75	0.88	1	1.04	1.25	1.3	1.35	1.35	1.32	1.28	1.2	0.86	0.75
Average	0.75	0.88	0.98	1.06	1.23	1.3	1.33	1.38	1.32	1.24	1.15	0.80	0.69

Table-9. Fortnightly variation of average Dissolved Oxygen (mg/l) in the three different monoculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
MP1	8	8	7	8	7	7	6.8	8	7	7	7	8	7.8
MP2	7	8	8	7	7	8	7	7	6.5	6	6	6	6.5
MP3	8	7	7	6	8	8	8	7	6	6	6	6.6	6.6
Average	7.67	7.67	7.33	7.00	7.33	7.67	7.27	7.33	6.50	6.33	6.33	6.87	6.97

Table-10. Fortnightly variation of average Dissolved Oxygen (mg/l) in the three different polyculture ponds during the study period.

Pond no.	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	1-Oct	15-Oct	1-Nov	15-Nov	1-Dec
PP1	8	7.6	8	7.8	9	7	7.6	7.4	6.6	7	6.8	6.6	6.2
PP2	7	7.6	8	8	8	7	7	7.7	7	7	6.6	7	7
PP3	7	8.2	8	7.6	8	7.5	7	7.3	7	6.5	6.8	7	7.2
Average	7.33	7.80	8.00	7.80	8.33	7.17	7.20	7.47	6.87	6.83	6.73	6.87	6.8

Table-11. Monthly growth (g) variation of *M. rosenbergii* in different monoculture ponds with gross growth rate (g/day) and Net growth rate (g/day).

Pond no.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Net growth rate (g/day)
MP1	4.3	21.7	45.7	63.4	87	103.6	110.5	
MP2	4.1	17.5	39.8	58.5	81.4	93.5	99.6	
MP3	4	16.8	37.8	60	80.2	95	99	
Average	4.133	18.666	41.1	60.633	82.866	97.366	103.033	
SD	0.152	2.650	4.107	2.510	3.629	5.450	6.473	
Growth rate (g/day)		0.484	0.747	0.651	0.741	0.483	0.188	0.549

Table-12. Monthly growth (g) variation of *M. rosenbergii* in different polyculture ponds with gross growth rate (g/day) and Net growth rate (g/day).

Pond no.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Net growth rate (g/day)
PP1	4	16.4	36.1	54.7	76.2	90.8	96.5	
PP2	4.2	16.1	36.4	55.1	70.6	88.7	92.6	
PP3	4.1	15.5	31	49.4	66.43	82.9	89.4	
Average	4.1	16	34.5	53.066	71.0766	87.466	92.833	
SD	0.1	0.458	3.034	3.181	4.902	4.091	3.555	
Growth rate (g/day)		0.396	0.616	0.618	0.600	0.546	0.178	0.492

Table-13. Monthly growth (g) variation of *C. catla* in different polyculture ponds with gross growth rate (g/day) and Net growth rate (g/day).

Pond no.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Net growth rate (g/day)
PP1	70.2	110.4	150.2	195.2	232	248.5	260.5	
PP2	73.5	115.5	149.5	205.4	255.5	268.4	275.4	
PP3	76.3	108.5	145.8	183.5	225.5	234.5	252.5	
Average	73.333	111.466	148.5	194.7	237.666	250.466	262.8	
SD	3.053	3.619	2.364	10.958	15.782	17.035	11.621	
Growth rate (g/day)		1.271	1.234	1.54	1.432	0.426	0.411	1.052

Table-14. Monthly growth (g) variation of *L. rohita* in different polyculture ponds with gross growth rate (g/day) and Net growth rate (g/day).

Pond no.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Net growth rate (g/day)
PP1	72.5	92.5	165.2	194.2	239	258.3	275.3	
PP2	66.3	96.2	118.4	134.2	160.5	212.2	270.1	
PP3	65.2	110.2	170.2	203.2	265.3	280.2	290.1	
Average	68	99.633	151.266	177.2	221.6	250.233	278.5	
SD	3.935	9.336	28.572	37.51	54.523	34.710	10.376	
Growth rate (g/day)		1.054	1.721	0.864	1.48	0.954	0.942	1.169

Table-15. Cost benefit analysis in different treatments in study period.

Culture type	Species	No. Of Fishes	Survival rate (%)	Cost of fry (Tk/peace)	Selling price (Tk/kg)	Gross cost (Tk)	Gross income (Tk)
Mono Culture	Golda	20350	65%	5	320	256750	434708.6
Polyculture	Golda	14700	75%	5	320	284600	327516
	Catla	4200	90%	6	80		79470.72
	Rohu	4200	90%	6	90		94745.7

Table-16. Cost Benefit analysis in different treatments in the study period.

Characters	Monoculture	Polyculture
Seed (Tk)	101750	123900
Feed (Tk)	135000	145700
Fertilizer + Lime (Tk)	8000	5000
Miscellanies (Tk)	12000	10000
Total cost (Tk/ha)	171397.973	167371.904
Gross income (Tk/ha)	255650.034	295066.447
Net income (Tk/ha)	84252.061	127694.5422
Rate of return (%)	149.1558	176.293
Benefit Cost Ratio	1.4	1.76