Incorporation of golda (*M. rosenbergii*) in the carp polyculture system

Fisheries and Marine Resource Technology Discipline

Khulna University, Khulna

Bangladesh

April 2004

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Examination Roll No. MS 990622

Session: 1998 – 99

This thesis is submitted to the Fisheries and Marine Resource Technology Discipline in partial fulfilment of the requirements for the degree of

Master of Science

In

Fisheries and Marine Resource Technology

April 2004

Incorporation of golda (*M. rosenbergii*) in the carp polyculture system

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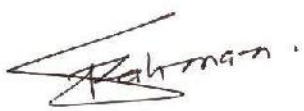
DECLARATION

These results submitted in this thesis are entirely the candidate's own investigations and no part of the results have been accepted for any degree, nor it is being concurrently submitted for any degree

Supervisor



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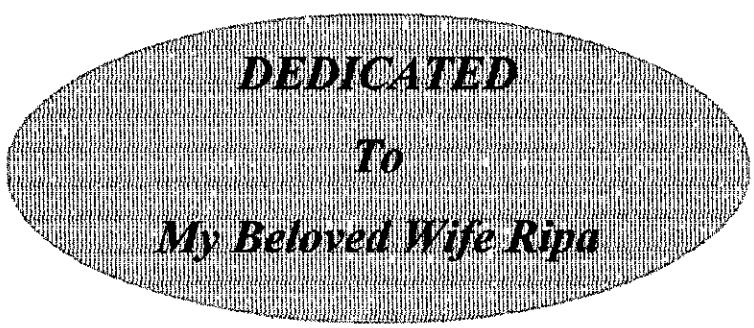
DEDICATED
To
My Beloved Wife Ripa

ACKNOWLEDGEMENT

It is my great pleasure for being able to complete this thesis, first my appreciation and indebtedness go for the Creator of this Universe, the Almighty Allah.

There were many people who helped me in various ways to complete successfully this course. I wish to express my thanks and appreciation to them all, specially.

The author express his deepest sense of gratitude and sincere application to his Supervisor Sk. Mustafuzur Rahman, Assistant Professor, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna for his constant vigilance, invaluable, erudite, scholastic, constructive guidance, advice, patience and encouragement to complete this paper

The author would like to express his deep appreciation to his respective and honorable teacher Professor Dr. Khairul Azam, Head, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna, whose kind and continuous inspiration, scholastic guidance, constructive criticism and constant encouragement to complete this thesis paper successfully.

The author likes to extend thanks to the Fish Farmer at Kharshanga village, Dumuria, Khulna for their support to complete this experiment.

The author likes to bestow appreciation to his younger brother Tuhin, Bijon, Mamun and Monir Ms in Fisheries, Khulna University, Khulna, for his cooperation and assistance in analyzing the data.

The author likes to extend thanks to younger brother and younger brother Lokman for their providing all sorts computer facilities for the work.

The author wishes to offer sincere gratitude and indebtedness to his parents for their kin interest, generous support and encouragement to carry out the work successfully.

The Author

ABSTRACT

The investigation was conducted to evaluate the economic performance of polyculture of prawn (*M. rosenbergii*) with carps in the three ponds at the village named Kharshanga under Dumuria upazila in Khulna over a period of 12 months (June, 2002 to May, 2003). The experiments were designed as T_1 and T_2 and each treatment was conducted with three replication. The treatment T_1 was stocked with *M. rosenbergii* juveniles at stocking density of 10,000/ha along with silver carp (*Hypophthalmichthys molitrix)*, rohu (*Labeo rohita)*, catla (*Catla catla)*, mrigal (*Cirrhinus cirrhosus)* and grass carp (*Ctenopharryngodon idella)* at 5060 fingerling/ha at the ratio of 29.17: 25.0: 12.5: 16.67: 1.0 (silver carp: rohu : catla: mrigal: grass carp). On the other hand, the treatment T_2 comprised of only the above carps having the same stocking density and species ratio. Supplementary feed consisting of mustard oil cake and rice bran (1:3) was applied in ponds once daily in the morning at 4% of the body weight. Water quality parameters of ponds such as temperature, dissolved oxygen and pH were inspected and monitored monthly. After twelve months of rearing, the gross productions of 358.13 kg/ha and 2592.91 kg/ha of golda and fish respectively were obtained from the T_1. The gross production (2400.18 kg/ha) of fish was achieved from the T_2. The initial weight was positively correlated with the final weight in the treatments and there is significant variation between initial weight and final weight. The variation between survival rate and net production was significant. Among the treatments, T_1 shows better performance in terms of survivability (90.61%) and benefit cost ratio (1.24). The results of T_1 indicate that the polyculture of prawn with carps is more economic than only carp culture.

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Chapter-One

INTRODUCTION

1.0 INTRODUCTION

1.1 Background

Bangladesh has extensive areas of water bodies including ponds, lakes, canals, haors, baors, rivers floodplains and marine waters that cover an area of 2,091,494 ha. The fisheries resources of these areas represent one of the most valuable assets of our country. Total freshwater bodies of our country are 5.28 square million ha where as rivers and estuaries are 1.03 million ha, haors and beels 0.14 million ha, ponds and ditches 0.22 million ha, baors 0.0006 million ha, floodplains 2.83 million ha and coastal shrimp farm area 0.14 million ha. Moreover, Bangladesh was 16.61 million sq. km of marine water bodies (DoF, 2001).The inland waters of Bangladesh are one of the most productive resources in the world.

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 and earning foreign currency. Fisheries sector contributes 63% of the national animal protein supply. About 12 million people are directly and/ or indirectly involved in fisheries sector. About 1.2 million and 10.8 million people are engaged in full-time and part time fishing activities, respectively. In the fiscal year 2001-2002, the total fish and fishery production of Bangladesh was about 18.90 lakh metric tons of which about 41,482 metric ton worth Tk. 16,371 million was exported. The contribution of fish and fishery products was 4.76% to foreign exchange earning (DoF, 2003).

In the fishery sector, prawn and shrimp occupy a remarkable stratum. 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 contributed about 90% of total income from frozen products (Biswas, 1996). During the fiscal year 2001-2002, about 30,209 mt of frozen prawn and shrimp products worth Tk.14,478 million were exported (DoF, 2003). Among shrimp and prawn products, prawn has very high demand in domestic and international market, especially in USA (Paul, 2002).

The water resources of Bangladesh were very rich in past but the production of fish and prawn has failed to keep pace with the population size that is increasing at

geometric rate. Per capita annual fish intake of Bangladesh is 13.5 kg whereas the annual fish needed per capita is 18.0 kg. The annual total fish demand is 2.4 million metric ton (DoF, 2003). The demand can be fulfilled through proper utilization of the vast water and human resources with the application of modern aquaculture technology. Various culture systems are being practiced in our country. These are mainly monoculture, polyculture, cage culture, pen culture etc. Among them, poly culture is one of the most popular systems in our country.

Polyculture of fishes in pond is a wide spread 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 fresh water prawn (*M. 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 the potentially to give 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 formulation 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 along with a high value luxury protein product (prawns) that may be exported to generate foreign exchange (Cohen *et al.* 1983).

Selections of fish species play an important role to make culture viable for any cultural practices. For better utilization of different strata and zones of a pond, three or more species should be socked. In our country suitable or common combinations of fish for poly culture is rohu (*Labeo rohita*), catla *(Catla catla*) and mrigal (*Cirrhina cirrhosus*). Some times calbasu (*Labeo calbasu*) has also been included in the polyculture. In recent, polyculture of prawn with carps have drawn an attention to the farmers for their better growth performance with profit. Carps polyculture technology

is well established but this new technology is not well adopted by the fish farmers especially species combination and low-cost supplementary feed. The main principle of polyculture is to gain the maximum output with the minimum cost utilizing all the tropic levels of ponds properly. Farmers of this country do not maintain the species combination and feeding regime during polyculture. Development of production technologies can not be taken as a determinant for acceptance of the same by the fish and prawn farmers. Some other factors might be considered of which the economic profitability and relative advantages of the production technologies are the most important ones (Khaleque *et al.* 1998). Shang and Costa-price (1983) emphasized the importance of economic analysis of any culture practices. It provides a basis not only in the decision making of the individual farmer but also in formulation of aquaculture policies.

Thus, the present study was conducted to explore a suitable stocking model or option that could be adopted by the fish farmers in order to drive maximum benefit from the ponds.

Chapter-Two

OBJECTIVES

2.0 OBJECTIVES

Gher farming system in the southwestern region of Bangladesh is taken as a traditional custom or alternative income source but due to tremendous population pressure and shortage of alternative employment opportunities in this area motivate people to fish culture as their prime livelihood. CARE (2000) reported that opportunity 10-20% of this has expanded gher farming at the rate of 10-20% each year. Almost one million people in the southwestern part of Bangladesh are engaged in fisheries sector and treated it as one of the most prime livelihood strategy.

Dumuria under Khulna district has a vast scope to expand aquaculture. Once, farmers usually stocked *M. rosenbergii* with other native species ignoring basic principle of polyculture. Even though they did not apply adequate feed

Considering the farmers interest, highly productive water resource and the socio-economic condition of the people; the study area was rationally selected to introduce the polyculture of prawn with carps and thus the study was designed to achieve the following objectives:

- ⇒ To determine the suitable physico-chemical parameters of the study farms.
- ⇒ To determine the suitable species combination in polyculture of prawn with carps.
- ⇒ To observe the growth performance under various combination used.
- ⇒ To analyze the economic performance of the new species combinations in some selected farms.

Chapter-Three

REVIEW OF LITERATURE

reducing the availability of nutrients (Alabaster and Lioyd, 1980) including Phosphorous, eg. Bicarbonates and hence alkalinity. If the pH is reduced, problems may encounter with soft Prawn. Nagarajiaah and Gupta (1983) reported that lower and higher pH values occurred due to high rainfall and high abundance of algae respectively. Higher pH (pH>9) has harmful effect on prawn and carp culture. Martyshev (1983) described that pH value of 7.0 is optimum for carp culture. Chiu (1987) noted that optimum range of pH is 6.9-8.8 for prawn culture.

Bhuyan (1970) is of opinion that pH above 7.0 is suitable for fish production and dissolved oxygen from 5.0 to 7.0 mg/L is required for high production.

3.2 Growth, survival, production and economic effect

Siddique *et al.* (1999) conducted an experiment to observe a suitable supplementary feed for polyculture of *M. rosenbergii* with Indian major carps in ponds at Bangladesh Agricultural University, Mymensingh. Feed was prepared by different combination of fishmeal, mustard oil cake, sesame meal, rice bran and wheat bran. They found that supplemental feed containing 30% fish meal, 12.5% mustard oil cake, 12.5% sesame meal, 25% rice bran and 25% wheat bran was the best for polyculture of *M rosenbergii* with Indian major carps.

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 8,000/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 found that the average weight of catla, rohu and prawns were 926, 785 and 58 g, respectively. Survival rates of the fishes were between 65 and 66% while 49% for the prawns. The production rate obtained from the experiment was 1,243 kg/ha for the fishes and 229 kg/ha for the prawns.

Malecha *et al.* (1981) tested the feasibility of raising the freshwater prawn, *Macrobrachium resenbergii* 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 5,500/ha. The production was averaged

2,516 kg/ha (14.38 kg/ha/day) in the manure 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 8,000/ha, yielding a record production of 10,183 kg/ha after rearing over a period of one year due to polyculture with *M. rosenbergii.*

Ariza and Romero (1993) stated that silver carp has higher growth rate than other species. In four months of culture, weights of 683g for silver carp were obtained.

Cohen *et al.* (1983) recorded 0.20 to 0.39 gram /day growth of prawn in polyculture system. The low growth might be explicable by the observed lower water temperature. Ling suggested (1969) that the optimum temperature for growth of post juvenile prawn was in the range of 28-31^0 C. Use of less protein diet might have also contributed to poor growth rate.

Chaudhuri *et al.* (1978) reported fish production by application of composite fish culture technology in ponds, with a high stocking density of 13,320 fingerlings per ha. The ponds recorded average gross and net productions of 7,633.5 and 7,444.8 kg/ha/yr which was about 7 times the normal production of around 1,000 kg/ha/yr. reported by the ordinary fish farmers.

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.

Gupta *et al.* (1990) showed that the total production of Indian and exotic carps were 4,917 kg/ha/yr. with supplementary feed. The ponds with supplementary feed i.e. rice bran and mustard oil cake (1:1) was provided at the rate of 3 % of body weight.

Halver (1984) stated that polyculture may produce an expected result if the fish with different feeding habits are stocked in proper ratios and combinations.

Janeeck *et al.* (1984) studied the "Experimental rearing of stock carp in polyculture with silver carp and grass crap" and reported that the yield of silver carp was dominant among the total production.

Jhingran (1976) reported that culture of silver carps along with Indian major carps has recently been developed in India as composite fish culture and a production of 3,000-5,800 kg/ha per 6 months and 7,000-9,000 kg/ha per year in different parts of the country has been achieved.

Kader *et al.* (1989) conducted a polyculture experiment with exotic silver carp in different stocking combinations. Silver carp and catla when stocked in 2:1 ratio gave higher yield. A severe food competition between these two species was clearly noticed.

Lakshamanan *et al.* (1971) reported results of 8 field experiments on composite culture of fish using seven important cultivated species, Viz. *Catla catla, Labeo rohita, Cirrhinus cirrhosus, Hypophthalmichthys molitrix, Ctenopharyngodon idella, Cyptinus carpio var. communis* and *Labeo* calbasu. Fingerlings were stocked at densities of 4,450, 5,000 and 6,250/ha. The ponds were fertilized with organic and inorganic manures fortnightly and fishes were fed daily with a mixture of mustard oil cake and rice bran and grass carp with suitable aquatic weeds. Survival was generally high, averaging more than 80 percent, which resulted in high rate of production ranging from 2,230 to 4,209 kg/ha/yr.

Ling (1969) reported that through polyculture a yield of 7,287 kg/ha could be obtained from heavily fertilized ponds as against 424 kg/ha obtained from the ponds without fertilizer. In his experiment the ponds were stocked with the species of silver carp, bighead carp, grass carp, grey mullet, common carp and sea perch.

Milstein (1990) stated that the growth and yield of some fish species might be higher in polyculture than in monoculture due to positive interactions between species. When the concentrations of the different fish species are adequate in the polyculture pond, the growth rate of plankton, macrophytes, benthos and nekton keep pace with the rate of consumption by the cultured fishes. In unbalanced conditions, the system is affected in different ways according to the food chain level where the imbalance occurs.

Murty *et al.* (1978) conducted an experiment on composite fish culture through nitrogenous fertilization with and without supplemental feed. In their experiment three Indian carps and three exotic major carps were used at a stocking density of

5,000 fingerling/ha. The yields of fish obtained though fertilization alone was 2,275.37 kg/ha/yr., as against 3,858.58 kg/ha/yr obtained by using feed and fertilizers which indicated that combined use of feed and fertilizer have a significant effect on fish production.

Opuszynski (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.

Uddin *et al.* (1987) studied the effect of stocking ratios on the growth of fishes under carps polyculture system at a stocking density of 6,500 fingerlings/ha. After 10 months of rearing, the maximum gross production was obtained at 3,389 kg/ha with species ratio of catla. 30: silver carp 10: rohu 30: mrigal 20: grass carp 10. In their treatment the fishes were fed daily with a mixture of mustard oil cake and rice bran (3:2 ratio) at the rate of 3% fertilizers (10 kg/ha/month) during the study.

Wahab *et al.* (1994) reported the composite culture of Indian major carps viz., catla, rohu, mrigal, silver carp and common carp stocked at the rate of 15,000/ha. The ponds were fertilized with cow-dung 366 kg/ha + Urea 9 kg/ha + TSP 7 kg/ha daily, cow-dung 2,566 kg/ha + Urea 64 kg/ha + TSP 51 kg/ha weekly and cow-dung 5,500 kg/ha + Urea 137 kg/ha + TSP 110 kg/ha fortnightly. The yield of different species of fish in different treatments was 1,870.12 kg/ha, 1,699.23 kg/ha and 1,622.33 kg/ha respectively.

Alam *et al.* (1995) evaluated the economics of different types of polyculture system involving exotic and native major carps. Fish yield of 1,640-2,995 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 1,196, 1,617 and 982 kg/ha/6 months, respectively.

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 10,000 and 15,000/ha stocking densities along with *Hupophthalmichthys molitrix*, *Catla catla*, *Labeo rohita* and *Cirrhinus cirrhosus* in the ratio of 1.75: 0.75: 1.50: 1.0 where total number of carps were 5,000/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 272 kg/ha/yr. of *M. rosenbergii* and 2,423-2,875 kg/ha/yr. fish were obtained from polycultrue ponds and 2,305.45 kg/ha/yr of fish was obtained from the pond where only carps were cultured. They concluded that the production of fish in the pond would not be affected due to polyculture with *M. rosenbergii.*

Hunter *et al.* (1983) demonstrated that juvenile prawn introduced into large pond with a multiple of fish species resulted in a commercial crop of both prawn and fish without any negative effective on prawn and fish production. Due to introduction of prawn in the period when prawn was stock at a density of 25,000/ha along with channel cat fish at 15,000/ha production of 90-270 kg/ha of prawn and 670-770 kg/ha of fish were obtain after 140 days rearing.

Chapter-Four

MATERIALS AND METHODS

4.0 MATERIALS AND METHODS

4.1 Study area and Duration

The experiment was carried out at Kharshanga village under Dumuria upazila in Khulna district, Bangladesh during the period of 1 June 2002 to 31 May, 2003.

4.2 Pond Preparation

All the ponds were rectangular in shape and similar size, depth and basin confirmation. This surface area of each pond was 0.1 ha with good dikes. The embankments were covered with grasses and shrubs. A total of 6 ponds were selected of which three ponds were stocked carps with prawn (T_1) while other three ponds were stocked with only carp species (T_2).

Before stocking the fish fingerlings and juveniles of prawn all the ponds were properly prepared for the experiment. All kinds of aquatic vegetation like floating, emergent, submerged and spreading were removed manually. Broken dikes and holes were repaired for protecting flood. The predators and undesirable species were removed by netting and repeated by rotenone at a rate of 5 ppm. A bamboo-framed feeding device measuring 5-ft length × 5-ft width was installed in each pond to supply grasses or soft vegetation for grass carp. This frame prevented the grass leaves from spreading out over the pond.

Liming was done to neutralize soil, kill pathogenic bacteria, promote biological productivity etc. The requirement and dose of liming depend on soil condition (Paul, 2002).The applied rates of liming was 250 kg/ha. Ponds were fertilized with urea and triple super phosphate and manured with decomposed cow dung (1,200 kg/ha) before stocking with the preferred type of fish and prawn fingerlings.

4.3 Stocking

Good quality fish fingerlings and prawn juveniles were collected from local nursery and transported to the pond site. All ponds were stocked with silver carp, catla, rohu, mrigal and grass carp at a density of 1750, 750, 1500, 1,000, 60 fingerlings/ha, respectively (Table1). With carps, *M. rosenbergii* juveniles were stocked at a density of 10,000/ha into the three ponds belonging to the treatment (T_1). The fingerlings were acclimatized before being released into the experimental ponds. The initial

average weights and sizes of each species of fishes and prawns were recorded. Species combinations, weight, sizes and stocking densities are presented in (Table1).

Table1. Stocking densities and species combination of two treatments followed this experiment. Each treatment was conducted with the replication of three.

Treatments	Local name	Scientific name	No. of fish /prawn per pond	No. of fish/ prawn /ha	Size (cm)	Weight (g)
T_1	Silvercarp	*Hypophthalmichthys molitrix*	175	1750	12	6.23
	Catla	*Catla catla*	75	750	14	9.28
	Rohu	*Labeo rohita*	150	1500	12	4.13
	Mrigal	*Cirrhinus cirrhosus*	100	1000	12	4.56
	Grass carp	*Ctenopharyngodon idella*	06	60	24	25.23
	Prawn	*Macrobrachium rosenbergii*	1000	10000	2.7	1.23
T_2	Silver carp	*Hypophthalmichthys molitrix*	175	1750	12	6.23
	Catla	*Catla catla*	75	750	14	9.28
	Rohu	*Labeo rohita*	150	1500	12	4.13
	Mrigal	*Cirrhinus cirrhosus*	100	1000	12	4.56
	Grass carp	*Ctenopharyngodon idella*	06	60	24	25.23

4.4 Fertilization

The ponds were fertilized fortnightly with urea and TSP at the rate of 24.7 kg/ha and 18.5 kg/ha, respectively. The TSP was dissolved in water and then mixed with urea and spreaded over the pond surface in the morning. Besides this, all the ponds were manured daily with liquid cow-dung at the rate of 300 g/decimal except the cloudy or rainy day. The measured quality of fresh cow-dung was kept in the earthen container (Chary) for overnight before spraying on the pond water. The fertilizers were used to enhance the production of plankton that served as natural food for fish and prawn.

4.5 Supplementary Feeding

The supplementary feeds were applied daily to fish and prawn. Locally available medium-grade rice bran (75%) and mustard oil cake (25%) were given at the rate of 4% of their body weight. Mustard oil cake was soaked overnight and then mixed with

rice bran thoroughly and was given to the fish and prawn in the form of small ball. The daily ration (feed) was adjusted based on the determination of total biomass through monthly sampling. Special care was taken for grass carp as they prefer higher aquatic plants. Duck weeds and or soft grasses were also supplied to the grass carp at the rate of 20% of their body weight.

4.6. Water Quality Parameters

Water quality parameters of ponds such as temperature, dissolved oxygen and pH were inspected and monitored monthly. Water temperature was recorded with Thermometer (YSI, model 58, USA). DO meter (YSI, model 58, USA) was used to observe the dissolved oxygen level and pH was recorded by pH meter. Secchi disc reading was taken to ensure the plankton production

4.7. Growth Measurement

The growth of fishes and prawn were monitored monthly from each pond through random sampling. At least 15 fishes and prawn of each species were sampled with the help of a cast net for the determination of their total body weight.

The following parameters were used to evaluate the growth:

Weight gained (g) = Mean final growth (g) - Mean initial weight (g)

$$\text{Percentage of weight gained} = \frac{Weight\ gained\ (g)}{Initial\ weight\ (g)} \times 100$$

Net increase = Final weight (g) - Initial weight (g)

$$\text{Survival rate (\%)} = \frac{No.\ of\ harvested\ fish}{Initial\ No.\ of\ fishes} \times 100$$

4.8 Harvesting

At the end of the experiment, all fishes and prawn were harvested by netting repeatedly with a fine meshed seine net from each pond.

4.9 Production (kg/ha)

The gross and net production (kg/ha) of fish and prawn were calculated by the following formula:

$$\text{Gross production (kg/ha)} = \frac{Survival\ rate \times Stocking\ density \times Final\ weight\ (g)}{100 \times 1000}$$

$$\text{Net production (kg/ha)} = \frac{Survival\ rate \times Stocking\ density \times Net\ increase\ (g)}{100 \times 1000}$$

4.10 Data Analysis

Statistical analysis for correlation coefficient, standard deviation and graphical representation were conducted on PC using Microsoft Excel (Version 5) program.

4.11 Benefit Cost Analysis

Cost-benefit ratio was calculated by the following formula given by (Loudon and Loudon, 2000).

Total cost (Tk.) = Fertilizer + Lime (Tk.) + Feed (Tk.) + Fry (Tk.) + Miscellaneous (Tk.)

Miscellaneous (Tk.) = Labor + Maintenance cost

Total yield (kg/ha) =Gross production

Total income (Tk.) = Commodity selling price per unit × Total yield

Total net income (Tk.) = Total income (Tk.) -Total expenditure (Tk.)

Rate of return % = (Total income / Total expenditure) × 100

Cost benefit ratio = Total income / Total expenditure.

Chapter-Five

RESULTS

5.0 RESULTS

5.1 Physico-chemical Parameters.

5.1.1 Water temperature

The average water temperature was recorded as 24.09 ± 4.09 ^{0}C and 23.87 ± 3.99, respectively in T_1 and T_2 during the study period. Water temperature was the maximum (29.40 ± 0.70^{0}C) in August and the minimum (18.00 ± 0.84^{0}C) in February in T_1 while in case T_2 the maximum was recorded (29.30 ± 0.70^{0}C) in August and the minimum was (17.81 ± 0.45^{0}C) in February 2003 (Annex1a and Fig.1).

5.1.2 Dissolved oxygen

The maximum dissolved oxygen content was found to be 7.69 ± 0.14 mg/L and 7.55 ± 0.08 mg/L and the lowest as 6.34 ± 0.15 mg/L and 5.40 ± 0.26 mg/L in T_1 and T_2, respectively during the study period (Annex 1b and Fig.2). Monthly variations of dissolved oxygen content was recorded to be the highest in April, and January under treatment T_1 and T_2, respectively. The lowest was recorded 6.34 ± 0.15 mg/L in Octover and November and 5.40 ± 0.26 mg/L in August under T_1 and T_2, respectively (Annex 1b and Fig. 2).

5.1.3 pH

The average values of pH was found to be 6.69 ± 0.41 and 6.59 ± 0.47 in T_1 and T_2, respectively (Annex 1c). Monthly variation of pH values ranged between 6.15 ± 0.05 (September) to 7.50 ± 0.22 (August) in T_1 while from 5.60 ± 0.11 (April) to 7.50 ± 0.13 (August) in T_2 (Annex 1c and Fig.3).

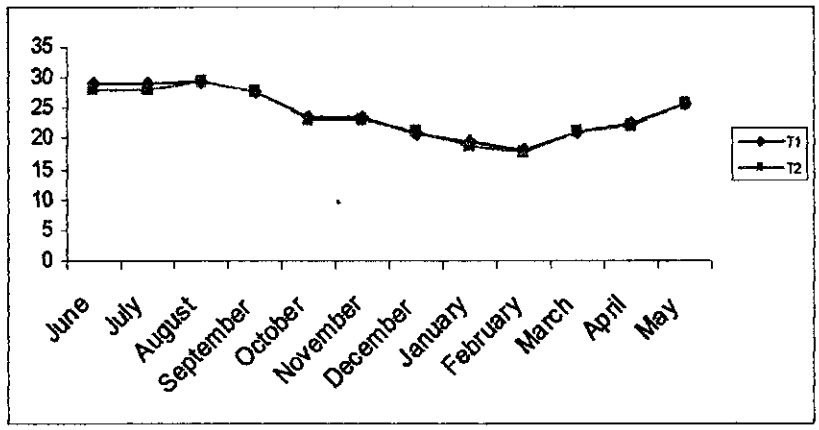

Fig.1. Monthly variation of water temperature (°C) in different treatments during the study period.

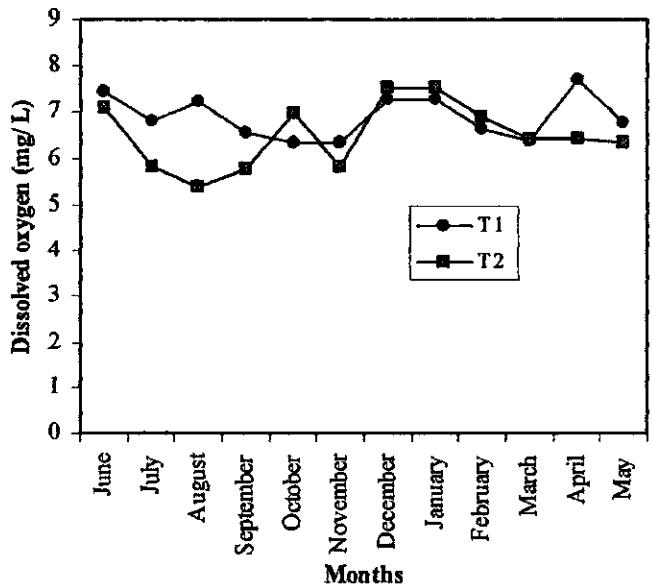

Fig.2. Monthly variation of dissolved oxygen (mg/L) in different treatments during the study period.

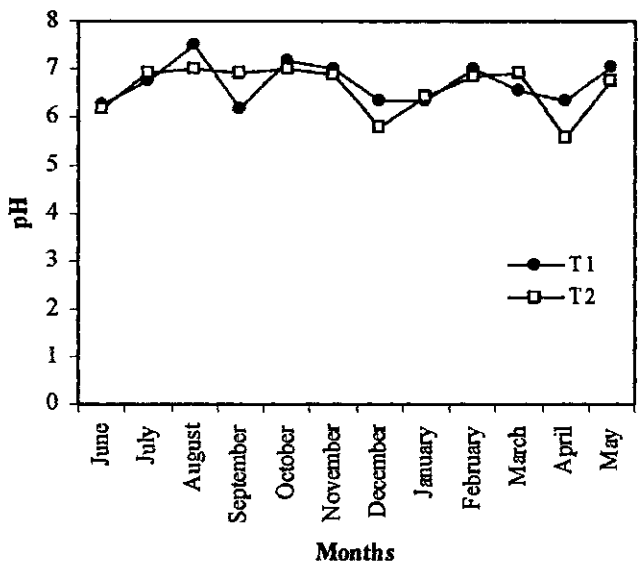

Fig.3. Monthly variation of pH of water in different treatments during the study period.

5.2 Growth performance

Weight of all the stocked species was found to increase gradually in experimental period. Silver carp was found to grow from an average initial weight of 6.23 ± 0.12g to average final weight of 661.33 ± 0.24g and 648.20 ± 3.07g in T_1 and T_2. Net increment of 655.10 ± 0.27g and 641.97 ± 1.04g was obtained for T_1 and T_2, respectively (Annex III and Fig. 4 and 5).

Catla was found to increase from an average initial weight of 9.28 ± 0.17g to 625.52 ± 0.09g and 532.48 ± 0.08g in T_1 and T_2 respectively. The net increment under T_1 and T_2 was 616.24 ± 1.4g and 523.20 ± 0.03g, respectively (Annex III and Fig. 4 and 5).

Rohu was found to increase from an average initial weight of 4.13 ± 0.20g to438.57 ± 2.07g and 495.21 ± 2.04g. The net increment under T_1 and T_2 was 434.44 ± 1.2 g and 491.08 ± 1.28g, respectively (Annex III and Fig. 4 and 5).

Mrigal was found to increase from an average initial weight of 4.56 ± 0.07g to 496.35 ± 1.35g and 480.20 ± 3.12g in T_1 and T_2 respectively. The net increment under T_1 and T_2 was 491.79 ± 0.18g, 475.64 ± 2.07g respectively (Annex III and Fig. 4 and 5).

Grass carp was found to increase from an average initial weight of 25.23 ± 0.15g to 1458.58 ± 1.62 and1442.35 ± 2.86g in T_1 and T_2 respectively. The net increment under T_1 and T_2 was 1437.35 ± 0.23g, 1417.12 ± 2.14g respectively (Annex III and Fig. 4 and 5).

Golda was found to grow from an average initial weight of 1.23 ± 0.32g to 57.30 ± 0.54g. The net increment was 56.07 ± 1.6g (Annex III and Fig. 4 and 5).

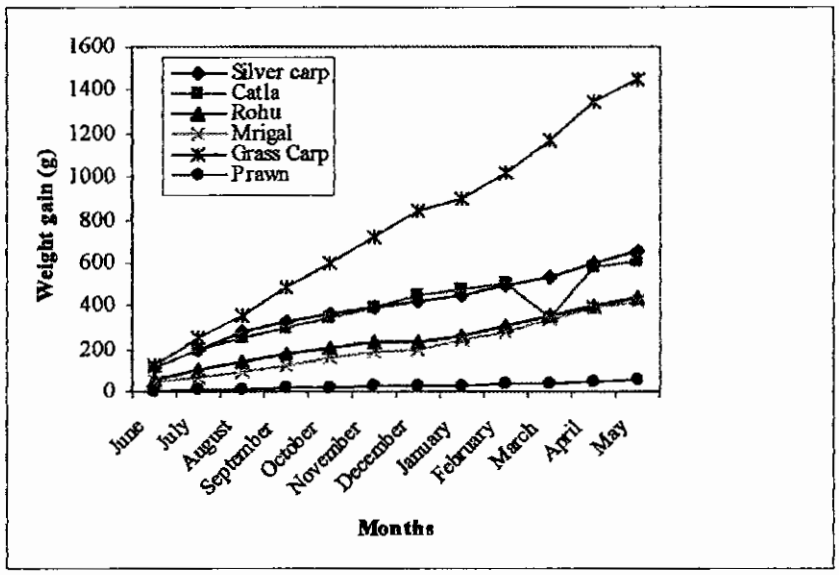

Fig.4. Monthly variation of weight during the study period in T_1.

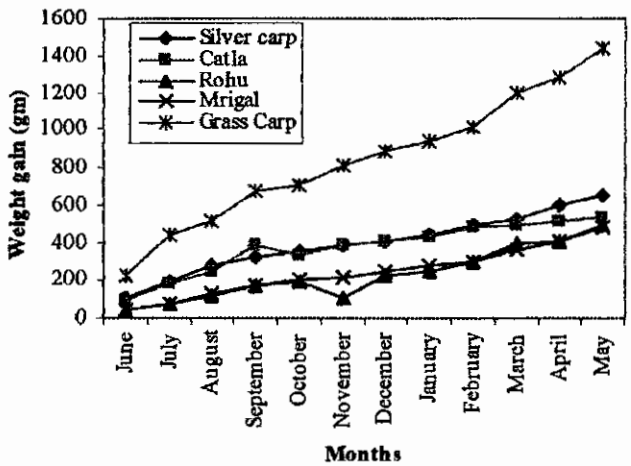

Fig.5. Monthly variation of weight during the study period in T_2.

5.3 Survival rate

At the end of the experiment, the survival rate of fishes and prawn were estimated separately and the values so far recorded have been summarized in Annex III. The average survivability was recorded as 90.61% and 84% in T_1 and T_2, respectively (Fig. 6 and 7).

Grass carp showed the average survival rate of 100% in T_1 whereas 90% was observed in T2.

Silver carp showed the average survival rate of 94% and 88% in T_1 and T_2, respectively.

Catla showed the average survival rate of 92% in both T_1 and T_2.

Rohu showed the average survival rate of 97.05% in T_1 where as 90% in T_2.

Mrigal showed the average survival rate of 70% in T_1 where as 60% in T_2.

The average survival rate of prawn was observed to be 62.50% in T_1.

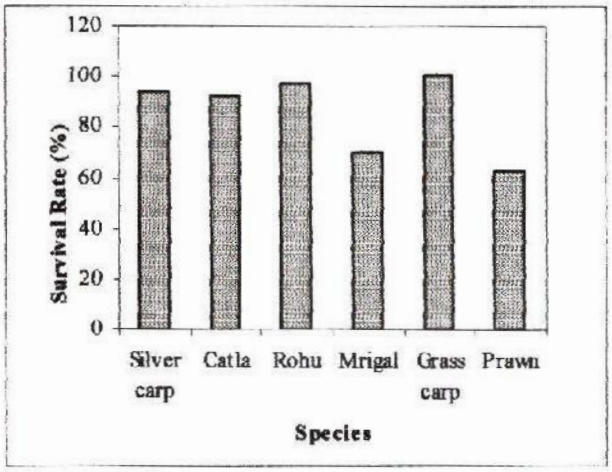

Fig. 6. Average survival rate of different species in T_1.

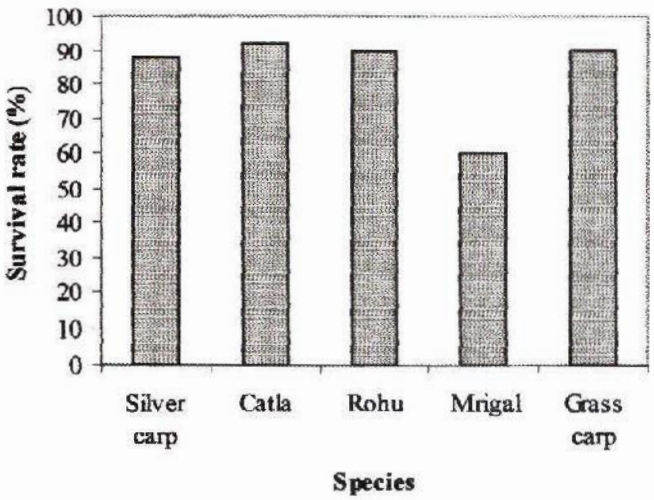

Figure.7. Average survival rate of different species in treatment T_2.

5.4 Production

The gross and net production of fishes and prawn in different treatments during the study period are shown in Annex III and Fig. 8. Among the treatments, the average gross and net production of fin fish was recorded as 2,592.91 kg/ha and 2,565.66 kg/ha in T_1 whereas 2,400.18 kg/ha. and 2,394.50 kg/ha, respectively in T_2. In case of prawn, the gross and net production was recorded to be 358.13 kg/ha and 350.43 kg/ha in T_1.

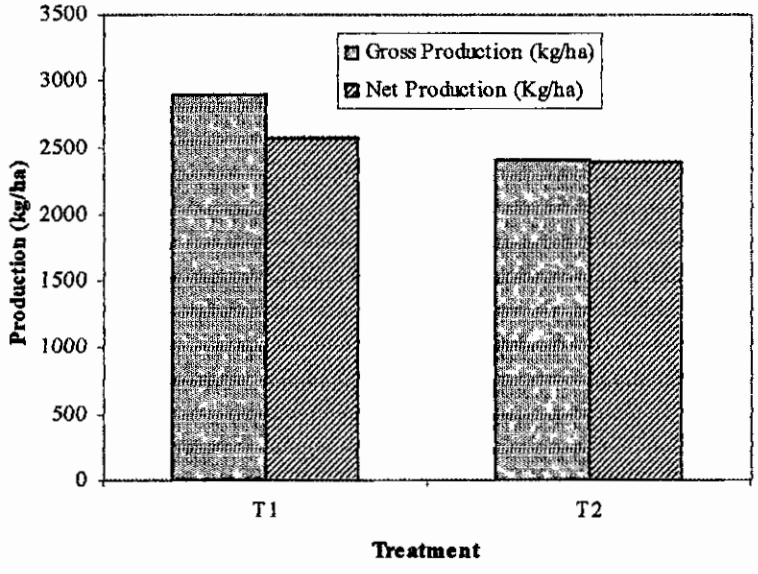

Fig. 8.Gross and net production in different treatments in the study period.

4.5 Cost- benefit Analysis

The total costs were estimated as Tk. 83,183.00 for T_1 and Tk. 53,183.00 for T_2. The gross income was estimated as Tk.18,6562.48 and Tk. 95,409.85 for T_1 and T_2, respectively (Annex 1Va and Fig. 9). Therefore, the cost benefit ratio in the experimental ponds was estimated as 1.24 and 0.79 in T_1 and T_2, respectively (Annex IVb).

It could be concluded through analysis of marginal rate of return and benefit-cost ratio that T_1 is more profitable in context of lucrative economic return (Fig. 10).

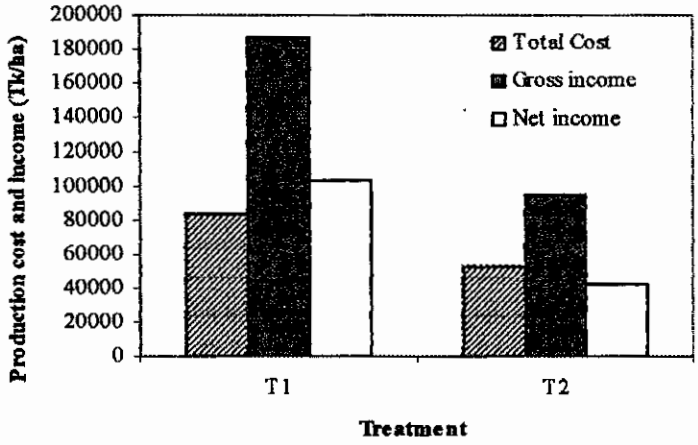

Fig. 9. Total cost, gross and net income (Tk/ha) in different treatments.

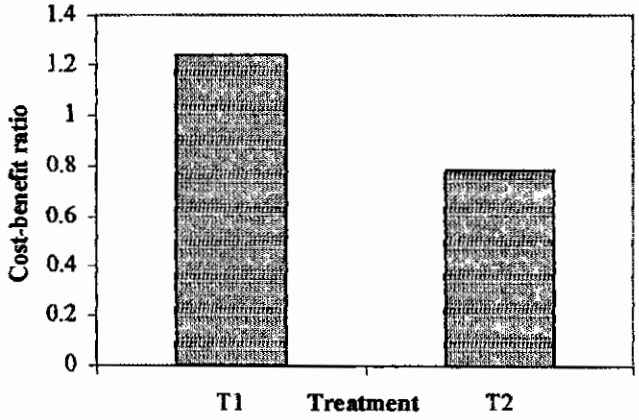

Fig.10. Cost benefit-ratio in different treatments.

5.6 Interpretation of results

5.6.1 Relation between initial weight and final weight (g)

There is a positive relationship between initial average weight and final average weight of fish and prawn in different treatments (Fig.11and 12). The relationship is moderately significant at 5% level of probability (Table 2).

Table. 2. Relationship between initial average weight and final average weight (g).

Treatments	Regression equation (y on x)	correlation coefficient 'r'	Value of 't'	't' table value at 5% level
T_1	y =51.759+185.	0.967	3.313972*	
T_2	y = 45.164x + 273.2	0.972	3.960520*	2.015049

*Significant at 5% level

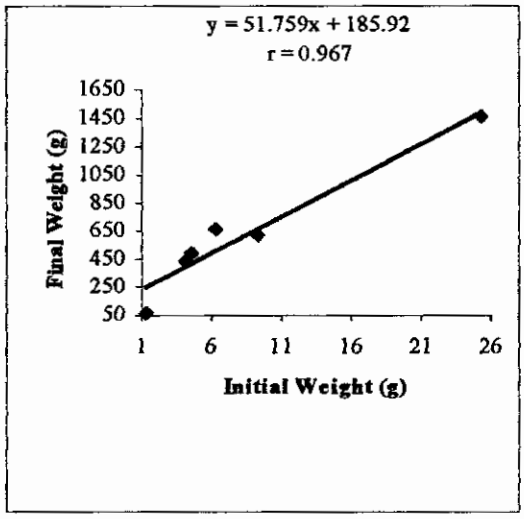

Fig.11. Regression of y between average initial weight (g) and average final weight (g) in T_1.

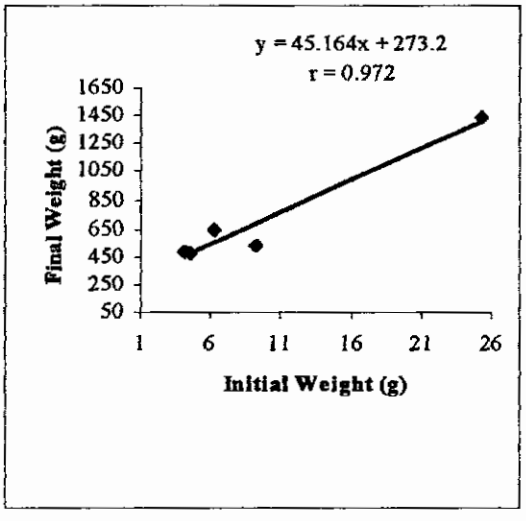

Fig. 12. Regression of y between average initial weight (g) and average final weight (g) in T_2.

5.6.2 Relation between survival rate (%) and net production (kg/ha)

The net production was found to be positively correlated with survival rate in all the treatments (Fig.13 and 14). But relationship between survival rate and net production was less significant in all treatments (Table 3).

Table 3. Relation between survival rate (%) and net production (kg/ha).

Treatments	Regression equation (y on x)	correlation coefficient 'r'	Value of 't'	't' table value at 5% level
T_1	y =4.764x + 76.672.	0.220	2.920297*	
T_2	y = 6.2505x - 46.142	0.241	2.541423*	2.015049

*Significant at 5% level

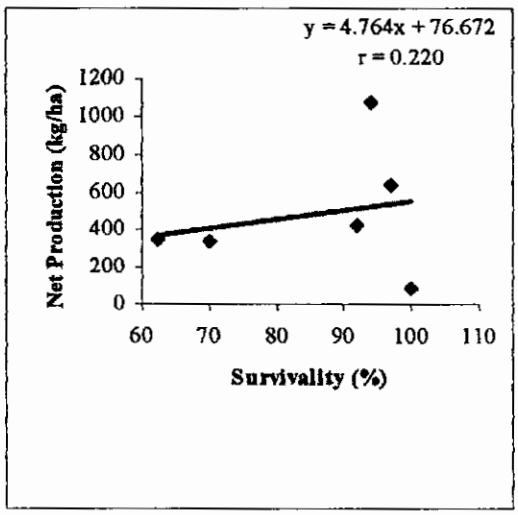

Fig. 13. Regression of y between average survival rate and production in T_1.

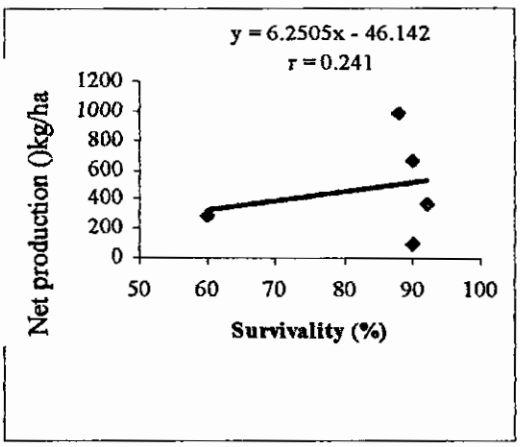

Fig. 14. Regression of y between average survival rate and production in T_3.

Chapter-Six

DISCUSSION

6.0 DISCUSSION

6.1 Phsico -chemical Parameters

6.1.1 Water Temperature (^{0}C)

The water temperature (17.8-29.4^{0}c) as recorded from the experimental ponds during the study period was found to be suitable for rearing of the stocked species. Temperature is one of the important physico- chemical parameters, which influences the physical, chemical and biological nature of water body (Mirza *et al.*, 1978). Rahman *et al.* (1982) stated that the favorable temperature for carp species was 26.06-31.97 ^{0}C. Ali *et al.* (1982) stated that 20.5-36.5 ^{0}C was favorable for fish culture. Alam *et al.* (2001), reported that the mean value of water temperature for fish-prawn polyculture systems ranged between 18.5–27.1^{0}C.

Recording of the highest temperature in August and the lowest in February agree with the findings of Durve and Bal (1961) who reported the lowest temperature of water during winter and the highest during summer in Kelwa water body. Lakshmanan *et al.* (1967) observed that the highest temperature of all the ponds in Asam during the months from July to August and the lowest during the months from December to January. The variation in water temperature of the studied ponds is near about similar to the results of Lakshmanan *et al.* (1967) and Durve and Bal (1961). Macan and Maudsley (1966) concluded that the temperature of water varied depending on season and size of species stocked.

6.1.2 Dissolved Oxygen (mg/L)

Dissolved oxygen content of the experimental ponds indicates that they were productive. Bhuyan (1970) reported that dissolved oxygen in the range of 5.0 to 7.0 mg/L was suitable for high production. Ali *et al.* (1982) stated that the favorable range of dissolved oxygen was 7.2-10.5 mg/L for high production. Michael (1969) stated that the dissolved gases were found to be associated with biological activities in water. He further observed variations in total quantity of plankton affected the fish growth and production.

Recording of the maximum dissolved oxygen in February (winter) and the minimum in August (monsoon) agrees with findings of Pahwa and Mehrotra (1966) who stated the dissolved oxygen values were the maximum during winter and the minimum during July and August. Dewan (1973) observed higher oxygen concentration during winter and lower during monsoon. Lakshminarayana (1965) also observed the higher values of dissolved oxygen throughout most of winter season.

6.1.3 pH

Recording of the highest pH value in August and the lowest in December agrees with the findings of Verma (1969) who observed the highest values of pH during summer and the lowest of the same during winter. Michael (1969) reported that the pH ranging between 7.3 and 8.4 were most suitable for prawn and fish culture.

6.2 Growth performance

Slowing down of growth of fishes and prawn in February in all treatments due to lowering of the water temperature. Similar observation was made by Sutton (1974).

Of all the experimental species, grass carp and silver carp showed better growth performance. Ariza and Romero (1993) recorded the highest growth of silver carp than the other species. Vesudevappa *et al.* (1989) stated that silver carp showed the best growth followed by catla, rohu and mrigal. Islam *et al.* (1999) reported that the growth of fish in the pond is not affected due to polyculture with *M. rosenbergii*. They further reported that the growth of prawn would be better if mrigal is not cultured. The obtaining of lower production of prawn in the present study might be due to stocking of mrigal whose habitat and feeding zone is the same as that of the prawn. However, Engle (1987) reported that polyculture of prawn with rui, catla, mrigal, silver carp, and grass carp were shown to be periodically more profitable than prawn monoculture.

6.3 Survival Rate

Recording of the higher survival rate of grass carp closely followed by silver carp and catla agrees with findings of Alam *et al.* (2001) who observed that grass carp showed the highest survival rate (100%) followed by silver carp (96.42%) and catla (92.86).

The recording of 62.50% survival rate of *M. rosenbergii* is lower than that reported by in Islam *et al.* (1999). Lower survival rate of *M. rosenbergii* in the present study would be due to the stocking of mrigal.

6.4 Production

Higher production was obtained from T_1 through polyculture of carp and galda than T_2 where only carp were cultured. Similar result was obtained by Alam *et al.* (2001). However, the production obtained from the present experiment is higher than those obtained by Islam *et al.* (1999).

Higher production in T_1 might be attributed to better combination of polyculture system of prawn with craps and proper utilization of topic level and feeding habits. Islam *et al.* (1999) reported that the application of feed, type of feed, water quality and soil productivity affect the yield.

6.5 Economic return on fish and prawn production

Higher profit from treatment T_1 than T_2 was probably higher production in T_2 and production of high priced golda with carps. Islam and Dewan (1986) noted that higher yield was the factor for higher net return and price of the fish and economic use of both material inputs and labor influenced net return.

It could be concluded that in terms of net and gross profit (Tk/ha), return on investment, cost- benefit ratio and production rate. Polyculture of carps with prawn is a profitable aquaculture system in Bangladesh.

Chapter-Seven

CONCLUSION

7.0 CONCLUSION

Bangladesh is trying hard to increase the annual prawn and fish production to fight against serious protein deficiency of her people. But the production of prawn and fish per unit area are still very low in comparison to other countries, mainly due to the lack of appropriate technical knowledge. Moreover, they don't have enough capital to invest in this sector. In this situation, we have needed to recommend the applicable, economically effective technology to the prawn and fish farmer by which they are encouraged on pond prawn and fish culture. Therefore, an experiment was conducted to explore the production potential in polyculture of prawn with carps.

The findings of the present trial have revealed that the overall fish production and net profit could be increased through pond polyculture of carps with prawns. So the foregoing results showed that there is a great potential for increasing fish production from farmers' ponds, which are commonly used for mixed carp species in the rural areas of Bangladesh. The present study recommended that the incorporation of prawn in the carp polyculture system would be profitable in Bangladesh. However, higher stocking densities with other commercial fast growing species and better management using cheap locally available feed ingredients are needed future investigation.

Chapter-Eight

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Chapter-Nine

APPENDICES

APPENDICES

Annex 1a. Monthly variation of water temperature (Mean ± SD) in different treatments during the study period.

Months	Temperature (°C)	
	T_1	T_2
June	29.09 ± 0.30	28.07 ± 0.79
July	28.91 ± 0.31	28.16 ± 0.60
August	29.4 ± 0.70	29.3 ± 0.60
September	27.6 ± 0.70	27.79 ± 0.70
October	23.54 ± 0.28	23.13 ± 0.46
November	23.54 ± 0.35	23.13 ± 0.94
December	20.89 ± 0.31	21.07 ± 0.94
January	19.63 ± 0.25	18.93 ± 0.15
February	18.0 ± 0.84	17.81 ± 0.86
March	21.0 ± 0.64	21.26 ± 0.50
April	22.47 ± 0.98	22.19 ± 0.66
May	25.64 ± 0.45	25.64 ± 0.86
Average	24.09 ± 0.60	23.87 ± 0.43

Annex 1b. Monthly variation of dissolved oxygen (Mean ± SD) in different treatments during the study period.

Months	Dissolved oxygen (mg / L)	
	T_1	T_2
June	7.46 ± 0.15	7.09 ± 0. 13
July	6.81 ± 0.09	5.83 ± 0.06
August	7.25 ± 0.13	5.4 ± 0.26
September	6.53 ± 0.11	5.78 ± 0.07
October	6.34 ± 0.12	6.99 ± 0.17
November	6.34 ± 0.15	5.8 ± 0.05
December	7.26 ± 0.13	7.52 ± 0.08
January	7.27 ± 0.14	7.55 ± 0.08
February	6.62 ± 0.16	6.88 ± 0.07
March	6.39 ± 0.15	6.43 ± 0.10
April	7.69 ± 0.14	6.4 ± 0.14
May	6.76 ± 0.13	6.34 ± 0.05
Average	6.87 ± 0.46	6.45 ± 0.71

Annex 1c. Monthly variation of pH of water (Mean ± SD) in different treatments during the study period.

Months	T_1	T_2
June	6.27± 0.11	6.16± 0.11
July	6.73± 0.06	6.92± 0.23
August	7.5 ± 0.13	7.5± 0.22
September	6.15 ±0.05	6.93± 0.24
October	7.18 ±0.13	6.99± 0.18
November	6.98 ±0.20	6.88± 0.11
December	6.34 ±0.15	5.78± 0.16
January	6.35 ±0.18	6.43± 0.16
February	6.99 ±0.28	6.83± 0.07
March	6.53 ±0.16	6.92± 0.16
April	6.32 ±0.09	5.6± 0.11
May	7.03 ± 0.12	6.73± 0.03
Average	6.69 ±0.41	6.59± 0.47

Annex II. Monthly variation of average weight (g) of fish and prawn in different treatments during the study period.

Species	Initial	June	July	August	September	October	November	December	January	February	March	April	May
T_1													
Silver carp	6.23 ± 0.12	109.99 ± 0.12	197.79±2.1	270.70±0.03	328.28±1.4	360.32±2.01	388.38±1.07	413.32±2.03	447.70±1.07	496.60±2.14	546.36±1.34	595.50±1.35	661.33±2.14
Catla	9.28 ± 0.17	109.10±0.27	189.30±1.6	254.70±1.14	290.90±0.07	340.38±0.03	432.33±2.04	446.32±3.4	472.66±2.04	500.50±1.27	547.47±0.65	600.30±0.09	625.52±1.38
Rohu	4.13 ± 0.20	39.39±0.14	78.72±0.07	112.20±2.3	165.30±1.08	195.32±2.07	224.55±1.8	233.31±1.7	249.49±1.24	280.00±0.54	303.33±2.14	406.34±1.52	438.57±2.07
Mrigal	4.56 ± 0.07	43.88±0.37	81.25±0.06	126.30±0.08	172.57±2.4	209.90±1.04	249.50±0.61	289.75±3.1	320.05±0.08	368.80±3.1	406.60±1.32	456.79±2.13	496.35±1.35
Grass Carp	25.23 ± 0.15	117.44±1.3	240.00±1.3	347.64±2.13	399.96±1.57	550.38±1.41	633.32±1.24	712.20±1.25	824.90±1.34	937.50±1.24	1150.30±0.71	1290.54±2.04	1458.58±1 .62
Prawn	1.23 ± 0.32	6.60±1.7	8.99±2.1	14.80±0.34	9.90±2.03	25.50±1.13	28.80±2.04	29.30±0.08	33.60±2.04	39.50±3.4	45.36±1.34	51.80±0.58	57.30±0.54
T_2													
Silver carp	6.23 ± 0.12	110.55±3.12	192.25±4.1	275.50±2.73	323.60±1.78	350.61±1.64	384.43±2.41	402.50±1.62	438.80±1.64	490.39±0.82	524.74±2.61	599.98±4.12	648.20±3.07
Catla	9.28 ± 0.17	100.80±2.61	181.12±3.37	244.40±2.08	380.50±2.61	330.30±2.51	382.20±3.10	400.50±2.31	426.61±2.45	477.10±1.34	493.36±3.14	510.15±3.61	532.48±1.84
Rohu	4.13 ± 0.20	39.90±2.14	79.79±2.81	115.50±3.41	166.40±2.67	190.80±4.36	101.50±1.67	220.50±3.53	244.70±3.34	293.50±1.56	393.91±1.97	408.80±2.81	495.21±2.04
Mrigal	4.56 ± 0.07	38.52±3.34	77.94±2.37	125.50±2.74	166.60±1.76	199.90±4.51	215.50±2.51	242.80±3.08	276.76±1.27	300.80±2.62	367.70±2.31	402.10±2.42	480.20±3.12
Grass Carp	25.23 ± 0.15	221.12± 2.42	440.68±3.25	506.92±2.09	671.71±2.61	701.75±3.10	805.72±3.4	888.11±2.61	936.61±1.63	1010.10±4.23	1195.35±2.71	1280.00±1.63	1442.35±2.86

Annex III. Survival rate (%), gross and net production (kg/ha) as obtained from different treatments during the study period.

Treatments	Species	Stocking no./ ha	Weight (g)			Survival rate (%)	Production (kg/ha)		Average (kg/ha/yr)
			Initial	Final	Increment		Gross	Net	
T_1	Silver carp	1750	6.23 ± 0.12	661.33 ± 2.14	655.10 ± 0.27	94	1087.89	1077.64	2951.04 ± 1.37
	Catla	750	9.28 ± 0.17	625.52 ± 1.98	616.24± 1.4	92	431.61	425.21	
	Rohu	1500	4.13 ± 0.20	438.57 ± 2.07	434.44 ± 1.2	97.05	638.45	632.44	
	Mrigal	1000	4.56 ± 0.07	496.35 ± 1.35	491.79 ± 0.18	70	347.45	344.25	
	Grass carp	60	25.23 ± 0. 15	1458.58 ± 1.62	1437.35 ± 0.23	100	87.51	86.12	
	Prawn	10000	1.23 ± 0.32	57.30 ± 0.54	56.07 ± 1.6	62.50	358.13	350.43	358.13 ±1.18
Total						**90.61**	**2951.04**	**2565.66**	
T_2	Silver carp	1750	6.23 ± 0.12	648.20 ± 3.07	641.97 ± 1.04	88	998.23	988.63	2400.18 ± 2.4
	Catla	750	9.28 ± 0.17	532.48 ± 1.84	523.20 ± 0.03	92	367.41	361.01	
	Rohu	1500	4.13 ± 0.20	495.21 ± 2.04	491.08 ± 1.28	90	668.53	662.96	
	Mrigal	1000	4.56 ± 0.07	480.20 ± 3.12	475.64 ± 2.07	60	288.12	285.38	
	Grass carp	60	25.23 ± 0. 15	1442.35 ± 2.86	1417.12 ± 2.14	90	77.89	96.52	
Total						**84**	**2400.18**	**2394.50**	

Annex IVa. Cost benefits analysis for different treatments.

T_1

Species	Stocking density (No. /ha)	Fry cost (Tk./ piece)	Total fry cost (Tk./ha)	Gross production (Tk. kg/ha)	Selling Price (Tk./kg)	Gross income (Tk./kg)
Silver carp	1750	1.00	1750	1087.89	32.00	34812.48
Catla	750	1.50	1125	431.61	38.00	16401.18
Rohu	1500	1.50	2250	638.45	40.00	25538.00
Mrigal	1000	1.50	1500	347.45	40.00	13898.00
Grass carp	60	1.00	60	87.51	32.00	2800.32
Prawn	10000	3.00	30000	358.13	260.00	93112.50
Total						**186562.48**

T_2

Species	Stocking density (No. /ha)	Fry cost (Tk./ piece)	Total Fry cost (Tk./ha)	Gross production (Tk. kg/ha)	Selling price (Tk./kg)	Gross income (Tk./kg)
Silver carp	1750	1.00	1750	998.23	35.00	34938.05
Catla	750	1.50	1125	367.41	40.00	14696.40
Rohu	1500	1.50	2250	668.53	45.00	30083.85
Mrigal	1000	1.50	1500	288.12	45.00	12965.40
Grass carp	60	1.00	60	77.89	35.00	2726.15
Total						**95409.85**

Annex IVb. Cost benefits analysis for different treatments.

Characters	T_1	T_2
Fertilizer + Line (Tk./ha)	12998	12998
Feed (Tk./ha)	28500	28500
Fry Tk.	36685	6685
Miscellaneous (Tk.)	5000	5000
Total cost (Tk./ha)	83183	53183
Total yield (kg/ha)	2951.04	2400.18
Gross income (Tk./ha)	186562.48	95409.85
Net income (Tk./ha)	103379.48	42226
Rate of return %	124.28	79.40
Cost benefit ratio	1.24	0.79