

**DEVELOPMENT OF NURSERY TECHNOLOGY OF
FRESHWATER PRAWN (*MACROBRACHIUM ROSENBERGII*) PL**

A Thesis

By

Md. Moksedur Rahman

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**DEVELOPMENT OF NURSERY TECHNOLOGY OF
FRESHWATER PRAWN (*MACROBRACHIUM ROSENBERGII*) PL**

Approved as to style and content by



Dr. Khandaker Anisul Huq

Professor and Head

Fisheries and Marine Resource Technology Discipline
Khulna University, Khulna
Bangladesh



August, 2007

Declaration

Development of nursery technology of Freshwater prawn

(Macrobrachium rosenbergii) PL

The results presented in the thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it being concurrently submitted for any degree.

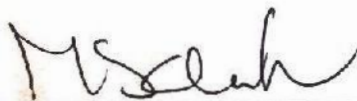


Signature of the candidate

Md. Moksedur Rahman

Examination Roll No: MS-050603

Session: 2004-2005



Signature of the supervisor

Dr. Md. Saifuddin Shah

Professor

Fisheries and Marine Resource Technology Discipline
Khulna University, Khulna, Bangladesh

August, 2007

Dedicated

**To my
Late Father**

Acknowledgement

All praises are to the almighty, the merciful and the ruler of the universe, whose mercy keeps me alive and enables me to pursue my activities; the same enabled me to complete the present thesis for the degree of MS in Fisheries and Marine Resource Technology.

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Md. Moksedur Rahman
Khulna University
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Abstract

Reports on nursery technology of freshwater prawn are scanty. Prawn culture is an important production venture in the southwest of the country. The rate of prawn production is low and the causes of which is mainly attributed to the lack of timely available good quality seed. There are reports on drastic reduction of natural sources of seed supply and now hatchery-produced PL are meeting the greater part of the demand. The hatchery produced seed are not as strong as the natural ones and suffer from heavy mortality in the stocking ponds. There is no proven nursery technology in Bangladesh. The present study was conducted during June to December, 2006 with a view to developing a nursery technology with respect to optimization of stocking density and survivability of prawn PL in earthen ponds. Hatchery obtained PL were reared with commercial nursery feed and monitoring of water quality for 14 weeks in 12 ponds (1.25dec each) at Khulna University. Four densities viz., 500, 800, 1000 and 958 PL/dec were used with three replicates in each. The range of temperature, DO, pH, alkalinity, hardness, ammonia and phosphate during the study were within the acceptable limit. The mean initial weight of prawn PL was 0.005g. Net gains in weight were 2.069, 4.042, 2.680, and 1.707g from the four treatments, respectively. The mean values of specific growth rate of the PL were 3.192, 3.550, 3.332 and 3.090% per day from the four densities, respectively. Highest values of growth rate and survival rate were found in 500PL/dec density. Second highest values of growth rate and survivability were found in 800PL/dec. However, a density of 500-800 PL/dec may be used for better growth and survivability in the prawn nurseries, though there are scopes for further improvement of the process through feeding trial and/or other aspects.

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List of abbreviations and non-English words

AFGRP	Aquaculture and Fish Genetics Research Program
ANOVA	Analysis of Variance
BER	Bangladesh Economical Review
BFRF	Bangladesh Fisheries Research Forum
DFID	Department For International Development
DoF	Department of Fisheries
dec	Decimal
<i>et al.</i>	Et alia (L) and others
g	Gram
Galda	Local name of Fresh water prawn, <i>Macrobrachium rosenbergii</i> (De Man, 1879)
GDP	Gross Domestic Product
<i>Gher</i>	Enclosure made by building higher dikes around the rice fields
ha	Hectare
kg	Kilogram
l	Liter
mg	Milligram
NGO	Non-government Organization
ppm	Parts per million
PL	Post-larvae
%	Percent
Tk.	Taka, Bangladeshi unit of currency

CHAPTER 1
INTRODUCTION



Chapter 1

Introduction

1.1. Background of the study

Bangladesh is a country of deltaic plains dominated by the three major river systems; the Ganges, the Brahmaputra and the Meghna, covering an area of 14.30 million hectares. The vast inland open water resources comprise in the form of rivers, canals, beels, floodplains etc.; the total area of the resources stand at 4.93 million ha of which rivers and estuaries include 1.031 million ha, beels 0.0142 million ha, floodplains 2.824 million ha, Kaptai Lake 0.0688 million ha and polder/enclosure 0.873 million ha. Moreover, there are 0.412341 million ha of waters of which ponds and ditches include 0.2655 million ha, oxbow lakes 0.005488 million ha, and shrimp farms 0.141353 million ha. The country has a 710 km long coastline and approximately 16.6 million hectares of marine area. The Exclusive Economic Zone (EEZ) extends up to 200 nautical miles from the coastline (DoF, 2006). All these physical resources indicate that the country has a vast aquacultural production potential.

The importance of fisheries sector has also been reckoned high in last two decades as this sector has become a great source of generation of employment opportunities, foreign exchange earning and animal protein supplier in the daily diets of the people. Conspicuously, while the chance of supply of animal protein from fish, in general, is far less than livestock in global nutrition, the percentage of animal protein from fish in Bangladesh is about 0.63 (DoF, 2006). In Bangladesh, 12 million people depend directly or indirectly on the fisheries sector for their livelihoods, of which 1.2 million are engaged as full time and 10.8 million as part time in the

sector (DoF, 2006). Fish production of the country for the year 2006-2007 was 2.44 million metric tons, in which 78.94% came from inland waters and 21.06% from marine water (BER, 2007). In 2006-2007 fisheries contributed 4.73% to the GDP and about 5.71% to the foreign exchange earnings. The country has earned Tk. 25720 million by exporting 0.063337 million metric tons of fish and fishery products to foreign countries (BER, 2007). If these waters are taken under scientific culture (intensive or semi-intensive), the total production can be increased by many folds of the current production.

As the largest species of the genus, *M. rosenbergii* has been widely used in aquaculture and has thus been introduced throughout most of the tropical and temperate regions of the world. It is now cultured in at least 43 countries across five continents, with Asia contributing more than 98% of global production (Mather and de Bruyn, 2003). The major producers are China, Bangladesh and Thailand. A significant capture fishery also exists in several countries of South and Southeast Asia (Aurher *et al.* 2004). The freshwater prawn is highly valued in the international market and therefore, almost all Bangladeshi prawn are exported to USA, Japan, Europe, especially, Belgium, UK, Italy and Germany where the price of head-less prawn ranged from US \$ 6.75 to 21.25/kg (DoF, 2001).

The world farmed shrimp/ prawn market, mostly headless is roughly 1.6-1.7 million ton/year. The market is dominated with 8 brackish/ salt water species which accounts for 1.4 million tons and 7 freshwater species combined produce roughly 0.2 - 0.3 million tons. Bangladesh produces about 3.0% overall cultured shrimp/prawn in the world, and her share is roughly 5-6%

of the freshwater farmed production. Bangladesh farmed freshwater prawn industry depends on a single species - the freshwater giant prawn, galda (*M. rosenbergii*) (Hossain, 2007)

The history of galda culture in Bangladesh is not very old. Its culture in the coastal freshwater ponds was started at about the same time of start of bagda culture in the coastal Bheries during 1960s. However, its culture has got more attention in recent years especially since its production from capture fisheries has leveled off (Chou *et. al.* 1994). Bangladesh has a unique and favorable environment for prawn culture. Since the freshwater prawn (*M. rosenbergii*) has become one of the most important export products in Bangladesh, the government has declared a program named "Vision-2008" to increase the export earnings to Tk. 1000 million by 2008 and designed specific support programs to boost the production (Khan, 2005). Department of Fisheries (DoF) and non-governmental organizations (NGOs) provide training, extension services and other facilities for the development for prawn production. In spite of a vast potential of this sector in this country, there has been unregulated, uncontrolled and uncoordinated horizontal expansion of prawn farming rather than increasing the efficiency of the production system (Deb, 1978).

Among the freshwater prawns the species *M. rosenbergii* has been introduced in the aquaculture system of the country during 1970's. At present, the galda culture is being done in around 0.05 million ha area and is being practiced in different culture methods. Every year the area is being expanded at the rate of 10%. At present average production of galda is about 459 kg/ha. Besides, galda farm is producing other agriculture and aquaculture products (Khondaker, 2007). Prawn aquaculture has experienced a boom in the recent times. According to the projection of the ministry of Fisheries and Livestock, galda farming will expand from the

current level to 0.08 ha. Export from galda will expectedly rise to over US\$ 300 million by 2015 (Karim, 2007). The species has a number of advantages if compared with other crustaceans. It can easily adapt with a range of temperatures (15°C to 35°C). Fast growing individuals of the species can reach the marketable size in about six to seven months. It's nutritional value and omnivorous habit has made the species an excellent candidate species of aquaculture (Chen and Chen, 2003).

Although it is a freshwater species, however, it requires the brackish water habitats for spawning. Thus the river/beel dwelling populations migrate to the estuaries for spawning. After spawning is completed, the parents return back to the riverine/lacustrine habitats. The larvae remain in the estuarine conditions; complete their larval development and start to migrate to the freshwater habitats. As the post-larvae are available in the coastal rivers/creeks, the adult galda used to be naturally available in the freshwaters and semi saline waters in the coastal areas. Galda is also available from the bagda farming *ghers* during winter harvest of white fishes from the *ghers*. Freshwater prawns, like all crustaceans, have a hard outer skeleton or shell that must be shed regularly for growth to occur. The process of shedding the shell is called molting and increases in weight and length of the prawn principally occur soon after each molting. Growth is therefore incremental rather than continuous. (Arthur *et al.* 2004)



Although the species can be cultured in the freshwater ponds throughout the country, easy availability of seed and the involvement of comparatively less cost of construction of ponds in the coastal low lying lands/beels have positively contributed to the flourishing of galda culture in the south-west coastal region of the country. The ponds/*ghers* in the areas can be dug on the

surface of the ground with moderate high dykes and with periphery canal inside the ponds/*ghers*, to be used as refuge for the prawn during winter dry months, if over wintering is required. They can be cultured both singly and in polyculture with Indian major carps and Chinese carps being integrated with paddy in the pond bottom and vegetables on the pond dykes. Because the technology of culture could not keep pace with the demand in the international market, it led to the horizontal expansion of the farms. Galda is farmed in the districts of Khulna, Bagerhat, Jessore, Narail, Gopalganj, Pirojpur, Noakhali, Chittagong, Cox's Bazar and day by day the acreage is increasing. The present culture practice is done at traditional level or at best at improved traditional level where some amount of feeding, fertilization and water management are done in the ponds. The farmers are mainly the marginal ones unlike the *Penaeus monodon* farmers who are mainly the rich and powerful ones. Two types of culture - monoculture and mixed culture are practiced in Bangladesh. Successful laboratory scale hatchery trials were initiated in the year 1975 and during that period two small scale freshwater prawn hatcheries were developed and operated in Cox's Bazar (Zafar, 2007).

In the face of increasing demand of galda fry and the possibility of over exploitation of the natural seed stock, the Directorate of Fisheries, Government of Bangladesh established shrimp hatchery during 1986 at Cox's Bazar and finally the most commercial production of galda fry was run in April 1992. At present, about 60 galda hatcheries are available across the country producing 100-150 million PL. With the increase in the farm areas, there has been a concomitant increase in demand of seed of galda in the coastal areas. Availability of seeds poses to be an obstacle in the development of commercial culture of this species in the country. So long the demand of seed was used to be met from the natural collection, but of late, the

natural sources are drastically reduced and now hatchery-produced seed is meeting a significant part of the demand. The farmers have claims against the quality of hatchery produced PL. Farmers usually have a strong interest in wild PL rather than hatchery reared PL due to good adaptability in nature, good growth performance and better survival rate. The prawn nursery technology has not been optimized. In any culture venture, be it aquaculture, agriculture, horticulture, and poultry farming, nursery management is the most critical stage for successful culture operation. In prawn farming sector there has not been establish a separate group of nursery operators, nor is the farmers themselves trained enough to carryout nursery operation of the PL, thus, production of quality PL, high survival rate, more fry production and eco-friendly culture of galda are the vital researchable issues in Bangladesh (Shah, 2006 and Zafar, 2007).

Constant diminishing of agricultural lands, increasing family sizes, new needs of the added population, escalated cost of living, etc all urgently warranted enhanced income from the limited farm lands to meet the farmers' minimum necessities of life. Of late, many farmers are profitably growing high priced and exportable freshwater prawn in association with selected species of fin fish, but generally alternating with paddy in low-lying mono-crop lands. These lands used to remain fallow under deep monsoon water during the second half of the year. Income from such farms could be further increased if it were possible to raise an early crop of galda in the first half of the year also. This is, however, not easy because of non- availability of fry either from the wild or from the hatcheries since the winter low temperature is not suitable for prawn maturation and breeding (Karim, 2007).

Khandaker (2007) reported that insufficient quality seed and feed supply, lack of hatchery and farming technicians, lack of operational skillness of farmers and extension workers are the prevalent problems of freshwater prawn cultivation.

Nursing of newly hatched prawn PL for 1-3 months, prior to stocking in the grow-out pond, is an important step in freshwater prawn aquaculture (Alam, *et al.* 1997). In Bangladesh, prawn nursing is important because climatic conditions and intermittent water availability restricts the length of growing season and hinders continuous culture up to marketable size (New, 1990). Lack of technical knowledge and inadequate research on prawn nursing system leads to higher mortality, therefore, reducing benefit of the farming system (Asaduzzaman *et al.* 2005).

Effective extension of the farming technology may create good demands for over-wintered juveniles, thereby greatly triggering hatchery, nursery and farm operation periods and their productivity and profitability. The technology may thus be very conducive to supporting various types of shrimp-based business, all leading to poverty reduction in rural areas (Karim, 2007). An appropriate nursery technology can facilitate the early farming technology through making the galda juvenile available during the on set of the culture period when the scarcity of galda seed is at the peak. There are very limited published reports on prawn nursery system in Bangladesh. Some authors such as Angell (1994), Alam *et al.* (1997), Barman *et al.* (2003) and Asaduzzaman *et al.* (2005) reported about prawn nursery system in Bangladesh.

The PL obtained from a commercial prawn hatchery was reared in 12 ponds, each measuring 1.25dec. at the Khulna University campus for 14 weeks. Four densities, 500, 800, 1000,

958PL/dec. each with three replications were tried. The physical and chemical parameters of the water of the ponds were monitored once in a week and their ranges were within the acceptable limit. The mean initial weight was 0.005g. Net gains in weight were 2.069, 4.042, 2.680, and 1.707g from the four treatments respectively. The mean values of specific growth rate of the PL were 3.192, 3.550, 3.332 and 3.090% per day from four densities tried. Highest values of the growth parameters were found in 500PL/dec density. The survival rates ranged from 34.11% to 79.39% and the highest one was also found in 500PL/dec. However, farmers and fingerling traders may be suggested to use the density of 500- 800 PL/dec in order to get rid of higher mortality problem, although there are still scopes for improvement of this process through feeding trial, duration of nursing and other aspects concerning better management.

1.2. Problem Statement

The PL produced from the hatchery is not as strong as the PL collected from the natural sources. The natural PL is caught at comparatively older stages of development. The hatchery owners try to sell out the PL just after the completion of hatching to start their next cycle of production; they do it for their business gains. Because the farmers do not have the proper knowledge / facilities for carrying out the nursery operation of the hatchery-produced PL, the often poor nursed or even without nursed PL are stocked in the ponds. As a result the mortality becomes very high and since farming technology is again traditional, the production of prawn has remained ever low in Bangladesh. There is no proven technology for nursing the prawn PL; the same could be a determining factor for increasing the supply of healthier and stronger juveniles for stocking in grow out ponds. At the backdrop of the above scenarios the present

study was conducted with a view to optimizing the stocking density and obtaining higher survival rate in nursery rearing of prawn PL in earthen ponds.

1.3. Hypothesis Setting

There is no any proven nursery technology for prawn PL in Bangladesh; the system has not been formalized as yet. The hypothesis is set like that if an appropriate nursery technology is brought out in galda culture system, a major problem in galda production system would be solved. Since the technology will reduce the huge mortality of galda fry that occur in grow out ponds, stocking of nursery reared good quality seed would ultimately help increasing the total production of galda in the country. The technology may thus be very conducive to supporting various types of prawn-based activities, all leading to poverty reduction in rural areas and ultimately contributing to the economy of the country.

1.4. Objectives of the study

Aquaculture of prawn is an important production venture in the southwest of the country. The sector suffers from various problems. The principal cause of poor production has been attributed mainly to the lack of timely available good quality seed. The PL produced from the hatcheries is weak and suffer from heavy mortality in the stocking ponds. There is no proven nursery technology for prawn PL in Bangladesh; the farmers do not have the proper knowledge about the breeding and nursing of prawn. Thus the main purpose of the research was to bring out a technology for nursing prawn larvae with suitable feeding, fertilization and management of the nursery ponds, so that trained man power can be produced in the area. The ultimate

purpose was to create an impact on the increase of productivity of prawn by using good quality prawn seed.

So the main objectives of the experiment were:

- To optimize the stocking density of prawn PL in the nursery ponds
- To determine the survival rate using these densities
- Derivation / development of a technology for nursery management of prawn PL

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CHAPTER 2

LITERATURE REVIEW

Chapter 2

Literature Review

The Literature published specifically on nursery technology of fresh water prawn (*M. rosenbergii*) is not very common in Bangladesh. Some workers such as Angell (1994), Alam *et al.* (1997), Barman *et al.* (2003) and Asaduzzaman *et al.* (2005) reported about prawn nursery system in Bangladesh. Information on various aspects relating to as general biology, artificial and natural breeding, food and feeding, larval rearing and farming of galda are available on a limited scale.

Freshwater prawn farming is one of the topics reviewed in a number of books on crustaceans farming (Lee and Wickens, 1992) and on aquaculture, in general (Pillay, 1990). In addition, several proceedings of meetings devoted entirely to the topic of freshwater prawn culture have been published (Silas, 1992; Thakur *et al.* 1994). The purpose of this chapter is to review the available research results related to the present investigation.

Growth of PL of freshwater prawn in the nursery pond is highly dependent on water management and pond depth as well as on the quantity of supplementary feed used (Apud *et al.* 1981). They also mentioned that stocking densities in intensive nursing systems range from 100,000 to 400,000 PL/ha with the optimum of 150,000 to 250,000 PL/ha as practiced by most intensive growers where the survival vary from 60-80%.

Polyculture of prawn with milk fish was conducted by Pudadera and Lim (1982). They observed that prawns can grow at a significantly faster rate when stocked at low densities (2000

milk fish with 6000 prawn/ha) than if stocked at higher densities (4000 milk fish with 6000 prawn/ha)

The minimum required ambient temperature for rearing of freshwater prawn to be 22 °C was stated by Raanan *et al.* (1984)

The minimum requirement of dissolved oxygen level of prawn is reported to be 3-4 mg/L., however, at a level below 2 mg/l of oxygen prawn exhibit an initial period of hyperactivity with swimming at the surface and jumping followed by mortality (Apud, *et al.* 1985).

Sandifer and Smith (1975) reported that satisfactory temperature for prawn culture ranged from 26 °C to 31 °C and optimum temperature being 28 °C to 30 °C.

Wang (1985) studied the weight and width relationship of freshwater prawn (*Macrobrachium rosenbergii*) and found that there is no significant difference ($P < 0.05$) in the weight and width and orbit length and width relationship of male and female. This relationship allows the development of a simple mechanical prawn size sorter.

The growth of monosex population of *M. rosenbergii* under intensive grown condition in cages was studied by Sagi *et al.* (1986). They found that all male population yielded 437.8 g/m² within 150 days, whereas all female population and a mixed population produced 248 g/m² and 260 g/m². They also reported growth performance of each sex when raised alone and when

raised in mixed sex populations; the females are strongly affected by the presence of male, resulting in growth inhibition; the males are hardly influenced by the presence of females.

Chalorkpunrut (1987) observed that prawns stocked at 60/m² showed the best survival rate which was statistically different from that of prawn stocked at 40 and 30/m² but not different from that stocked at 50 and 70/m².

Heinen *et al.* (1987) studied the poly culture of *M. rosenbergii* and found that an average total prawn biomass of 160 kg/ha prawns may be attained at low stocking densities in the catfish ponds.

Estilo (1988) mentioned that mortality of shrimp would occur at low (1 ppm) dissolved oxygen levels for prolonged period. He also noted that the levels of dissolved oxygen should not be below 4 mg/l for shrimp culture.

Jia- Mo *et al.* (1988a) conducted a monoculture experiment on *M. rosenbergii* in earthen ponds and found the total yield 547.7 kg/ha, average yield 91.28 kg/ha for 142 days culture period, survival rate 57.68% and the average size of the prawn 17.58g. They also reported the food conversion rate to be 3:1 with "Camaronina" (35% protein); the water temperature during the culture fluctuated from 28.5 °C to 33 °C; the pH from 7.5 to 8.5 and the dissolved oxygen to be 4.5 ppm.

Jia- Mo *et al.* (1988b) stated about the intensive prawn (*M. rosenbergii*) culture in earthen ponds where the stocking density ranged from 6.5 to 13 prawn/m² by using pelleted feed and found that 50% of the prawns reached a medium size at the end of the culture period and only 30% reached higher size.

Shrimp post larvae could tolerate pH as low as 6.5 and the recommended pH range for the shrimp culture could be 7.5 to 8.5 (Law, 1988)

D'Abramo *et al.* (1989) studied the mono culture of prawn (*M. rosenbergii*) in earthen ponds of each 0.06 to 0.07 ha for 135 to 142 days where juvenile prawns were stocked at the densities ranging from 39,536 to 1,18,608 PL/ha. They noted survival range to be from 54.3% to 89% and the range of mean prawn weight at harvest to be from 15.0 to 44.3g that decreased with increasing stocking density.



Ang (1990) obtained 979 kg prawn/ha/158 days cycle with 32.4% survival when prawns were stocked at 10/m² and fed 30% protein ration at 20, 10 and 5% body weight for the first, second and subsequent months, respectively. A second trial was made where production of 1110 kg /ha/154 days and 2297 kg/ha/154 days were obtained from stocking densities of 10/m² and 20/m², respectively.

Thai *M. rosenbergii* hatchery management results in a stocking density of 30-50/l (New, 1990) and Hawaiian hatcheries expect 50-70 % survival to achieve at stocking density of 30/l. For *M. rosenbergii* larval rearing, a salinity range of 10-15 ppt is generally practiced. Optimum

temperature range of 26-31 °C or above 35 °C cause retarded development or mortality. Newly hatched brine shrimp nauplii (artemia), fish flesh, mussel flesh, squid flesh and egg custard are frequently used as feed in the hatcheries. Artemia nauplii are maintained at 1 nauplii/ml and increased to about 5 nauplii/ml while feeding in Thailand but Hawaiian hatcheries tend to use 5-15 nauplii/ml (New, 1990). The PL production rate has been reported to be 10-20/l in Thailand, and 30/l in Hawaii, (New, 1990).

Using an arrangement of carbohydrate sources at 40% inclusion level in isonitrogenous semi-purified diets for post larvae of *M. rosenbergii*, Briggs (1991) obtained the best growth rate with wheat flour, followed by polysaccharide dextrin and alpha starch at 94% and the disaccharide source at 90% of that achieved by wheat flour, alpha cellulose and chitin were less effective. The results confirmed that complex carbohydrates were utilized more effectively than simpler di or mono saccharides. An important finding was that cellulose often used as “non nutrient” bulking ingredient in diets used for nutritional studies, may contribute significantly to the nutrition of prawn.

Sheen and D'Abramo (1991) found that 2-10% range of dietary lipid levels of a 2:1 cod liver oil mixture had no significant effect on survival or molt interval. All produced better results than no lipid mixture. The authors concluded that freshwater prawns do not have a specific level of dietary lipid and that optimal level depends on the amount and quality of dietary protein, the level of available dietary energy and the fulfillment of specific fatty acid requirement.

Thangadurai (1991) evaluated the economic viability of farming freshwater prawn, *M. rosenbergii* in ponds by rearing them at densities of 20,000/ha and 30,000/ha in monoculture systems and observed that the high production of 630 kg/ha has been obtained with a feed combination of groundnut oil cake, rice bran and fish flesh which indicated that a stocking density of 30,000/ha is optimum for a production of 600 kg/ha /6-7 months.

Freshwater prawn (*M. rosenbergii*) has been grown to market size in a variety of conditions, both by scientists and farmers in up to 25 ppt salinity in pens and cages and in ponds. Ang *et al.* (1992) concluded that when PL₃₂ of *M. rosenbergii* were reared in cages for 24 weeks, a stocking density of 10/m² gave better growth and survival than 2/m² although the final biomass was the highest at the highest stocking density.

Nuruzzaman (1992) reported that the shrimp PL (14.0 to 17.0 mm) usually should be stocked in the nursery ponds at the rate of 50,000–100,000 PL/ha. After passing 30-40 days the PL retained from 50-55 mm in size. He also stated that after liming, 1000-1200 kg/ha chicken droppings and 500-600 kg/ha cow dung should be applied depending on the fertility of the pond soil. Besides, 50 kg/ha urea and 4 Kg/ha TSP should also be applied.

Durairaj *et al* (1992) noted that an improved growth rate was found when prawns in manured ponds were fed with pellet containing shrimp head meal (20%) and fishmeal (10%) rather than a conventional feed of 1:2:1 groundnut oilcake, rice bran and trash fish but the trial was unreplicated.

Jose *et al.* (1992) worked on the polyculture of *M. rosenbergii* stocked at 10,000/ha with catla, rohu and mrigal (2:2:1). Three months later further trials were made at the densities at the range of 100–200/m² in manured and fed homestead ponds in India with a gross production of 106–254 kg/ha of prawn and 279–408 kg/ha of carp in a 106 day period.

Kanit *et al.* (1992) conducted research work on variation of physico-chemical properties of water and phytoplankton in intensive shrimp ponds in Thailand and reported that the major genus of phytoplankton *Trichodesmium* is prevalent in the shrimp pond; its density increased from 5,665 cells/l to 1,28,541 cells/l and 11.94 million cells/l from the 6th and 12th week, respectively. After the 12th week, it was decreased to 2,03,262 cells/l. They also stated that the second most abundant species was *Spirogyra* and its number increased from 38 cells/l in the second week to 2.19 million cells/l in the 18th week.

Koshio *et al.* (1992) found that there was a general tendency for the FCR and PER of prawn groups fed diets containing soybean protein (SBP) though SBP had lower lysine and methionine levels than either CPC or whole prawn.

Law *et al.* (1992) found that a 40% protein diet supported optimum growth compared with 25, 30 and 50 %.

Rao *et al.* (1992) observed that the differential growth rates between males and females appeared to be more pronounced in case of *M. malcolmsonii* than *M. rosenbergii*.

Tidwell *et al.* (1992) studied distillers dried grains with solubles (DDGS) as a protein source in practical diets for freshwater prawn raised in ponds where juvenile prawn averaging 0.66g were randomly stocked into nine 0.02 ha ponds at 19760/ha by using three isonitrogenous diets (35% crude protein) containing 0.20 or 40% DDGS and observed that average yield, survival, individual weight and feed conversion did not differ significantly among the treatments. They reported that the yield, survival, individual weight and feed conversion were 833 kg/ha, 75%, 57g and 3:1 from which it appeared that DDGS is a suitable ingredients for use in practical diets for fresh water prawn at inclusion rates of up to at least 40% of the total formulation,

Environmental stresses including a variety of factors such as the presence of a large number of bacteria associated with larvae, temperature, pH, DO, salinity, over crowding, physical handling etc were considered important in shrimp farming by different workers (Nash *et al.* 1987 and Hameed, 1993).

Many farms make their own feed in the developing countries, where most of the prawn is cultured (New *et al.* 1993). For example, 90% of Brazilian prawn farms are less than 3 ha and prefer to make their own feed. Grow out feeds for *M. rosenbergii* in Thailand are commonly farm-made. Typical formulations containing fresh fish, soybean meal, corn meal, broken rice, vitamins, minerals and chicken feeds, sometimes with shrimp shell meal, are described by Boonyaratpalm and New (1993).

Sadek and El-Gayar (1993) evaluated the effect of used agricultural drainage water with salinity from 4-6 ppt, total hardness from 900-1500 ppm and total alkalinity from 170-180 ppm on the growth rate of *M. rosenbergii* in earthen ponds at different stocking densities (1 or 2

prawns/m²) and observed an average weight of 52.8±0.7g and 50.8±2g for the two densities 1 and 2 prawns/m², respectively with individual daily increments of 318±0.5 and 319±5.5mg/day after 155 days culture period. They also reported that the survival rates varied from 62 to 80% at stocking densities between 1 or 2 prawns/m² and no difference was observed in feed conversion rate, calculated as 4.1±0.2 and 4.6±0.3 for the two densities of 1 and 2 prawns/m², respectively.

Siddiqui and Al-Hinty (1993) studied the feasibility of freshwater prawn monoculture in the central region of Saudi Arabia where juveniles with an average weight of 2.98±0.2g were stocked in 12.10m² concrete tanks at 2, 4, 8 and 16/m² and reared for 175 days by feeding twice daily a combination of fresh fish meat (25%) and dry fish feed (75%). They reported that the survival rate varied from 71-93% which was influenced by the stocking density and the growth rate was negatively related to stocking density with mean weights of 25.4g, 19.5g, 17.6g, 13.38g at stocking densities 2, 4, 8 and 16/m², respectively where the corresponding yield at those densities were 46.3g, 61.9g, 96.1g and 172g/m².

Daniels and D'Abramo (1994) and Rao *et al.* (1992) observed that differential growth rate between males and females is more pronounced in the case of *M. malcolmsonii* than *M. rosenbergii* and suggested that if the juveniles used are size-graded before stocking, it can significantly improve the yield.

MacLean *et al.* (1994) studied effect of organic fertilizer and formulated feed in pond culture of the freshwater prawn and observed added organic matter being rapidly decomposed and mineralized. The sediments appeared to act alternately as sources and sinks of nutrients although there was least variation in sediment nutrients levels in the treatment done with manure only. Applied pelleted feed was directly consumed by the prawns. In absence of pelleted feed macro benthos appeared to limit prawn growth after one month's culture.

Daniels *et al.* (1995) found that density had a significant effect on average whole body weight of *M. rosenbergii* at harvest but no significant effect on either total yield, survival or feed conversion where juveniles of 0.11 ± 0.085 g were stocked into triplicate earthen ponds, of each 0.04-0.07ha at densities of 39540, 59300 and 79100/ha, grown for 131-134 days by feeding a specially formulated diet and additionally three ponds were also stocked at 39540/ha by using a commercial sinking catfish feed. They reported that the mean weight was significantly higher for prawns stocked at 39540/ha (34.3g) than that for those stocked at either 59300/ha (26.7g) or 79100/ha (26.3g) and average total yield ranged from 1041-1662kg/ha for stocking densities from 39540-79100/ha.

Hoq *et al.* (1996) measured a few water quality parameters in five prawn farmers' ponds in Kolaroa thana under Satkhira district. They recorded that the temperature ranged from 27.5-30.5 °C, pH from 7.5-8.0 and DO from 4.0-5.9mg/l.

Alam *et al.* (1997) stated the development of method of nursery rearing of prawn PL to juvenile in hapa-net and cement cistern. According to them in nylon hapa-net nursery for 45 days, juvenile prawn of 47-48 mm could be produced with a survival rate of 84-88% at the stocking density of 100-300 PL/m². Result of a 42 day nursery rearing of *M. rosenbergii* PL in 2m³ cement cisterns have shown that a stocking density of as high as 1000-1200/m² could be practiced indoor for juvenile prawn production with an expected average body weight and survival rate of 786-907mg and 66-75%, respectively. They also added that research attempts were also been made in developing feed for nursery.

Tidwell *et al.* (1998) conducted an experiment to evaluate the effect of added substrate on the growth and population structure of freshwater prawns raised in ponds. Juvenile prawns (0.3±0.2g) were stocked at 59280/ha into six 0.04ha ponds. Three ponds received added structure in the form of four multi level habitat PVC structures. The three control ponds received no added structure. Prawns were fed a commercial diet (32% protein) twice daily according to a computer generated feeding schedule. Average individual weight, daily yield and total yield were significantly higher ($P < 0.05$) and orange claw males (OC) were significantly lower than in ponds with added structure. Also average individual weight of orange claw males, reproductive females and virgin females were significantly higher ($p < 0.05$) in ponds with added structure characteristics of prawns at lower stocking densities. Optimum relationships between stocking rates and amounts and types of habitats should be evaluated as methods to increase production levels.

Chiranjib *et al.* (1999) observed that the survival rate of *M. rosenbergii* larvae was 42.91% after 28 days of culture. They found that mortality rate was higher in green water than in clean water. They concluded that a closed water system is suitable for *M. rosenbergii* larvae rearing.

Marques *et al.* (1999) observed the effect of two feeding management regimes on the growth of *M. rosenbergii* cultured under experimental conditions. They stated that feeding of prawns twice a day could increase growth.

Chand *et al.* (2000) conducted an experiment on standardization of feeding strategies for monoculture of *Macrobrachium rosenbergii*. They found that tray feeding was superior to traditional broadcasting method of feeding in achieving better growth, survival and production of prawns.

Chen and Chen (2003) investigated the effects of pH on survival, growth, molting and feeding of giant freshwater prawn and found that 24, 48, 72, and 96hour LC 50s median Lethal Concentrations) of pH of juveniles (0.13 ± 0.01 g) were 4.00, 4.05, 4.07 and 4.08, respectively. Survival rates of juveniles (2.65 ± 0.06 g) following 56 days exposure to pH 8.2, 7.4, 6.8, 6.2 and 5.6 were 100%, 88.9%, 94.4%, 94.4% and 94.4%, respectively. The body weight, total length, feeding rate and molting frequency of prawns were significantly lower ($P < 0.05$) in acidic pH. Finally they concluded that the minimum acceptable pH levels were 6.2 and 7.4 based on growth and feeding, respectively.

The effect of multiple stocking for enhancing survival, production and marketable yield structure of *Macrobrachium rosenbergii* resulted with a range of survival rate from 38.92% (without nursery phase) to 63.31% (with two separate nursery phases) and the mean net production was found to be varied from 169.4 to 744.5 kg/ha/8 months (Kurup and Ranjit, 2005).

Through a survey in order to assess the nursing systems of Giant freshwater prawn in Bangladesh it was found that farmers of Bagerhat sadar, Fakirhat, Noakhali and Phulpur of Mymensingh reared the PL in the small ponds or trench of the ghers and they generally stocked 400-900 PL per 40 m² resulting with a high mortality rate (40-60%) (Asaduzzaman *et al.* 2005)

Another experiment was conducted by Asaduzzaman *et al.* in 2006 in order to evaluate the effect of control of Carbon/Nitrogen ratio by addition of low cost carbohydrate to the water column on water quality and pond ecology in fresh water prawn *M. rosenbergii* post-larvae nursing system. Control of C/N ratio by the addition of low cost carbohydrate to the pond water column benefited the freshwater prawn nursing practices in three ways; increased heterotrophic bacterial growth supply bacterial protein augmenting the prawn post-larvae growth performances, reduced demand for supplemental feed protein and subsequent reduction in feed cost and reduced toxic NH₃-N and NO₂-N levels in pond nursing system.

Income from low-lying mono-crop farms, previously which were remained fallow under deep monsoon could be farther increased if it were possible to raise an early crop of galda in the first half of the year which is however not easy because of non-availability of fry either in the wild

or at the hatcheries since the winter low temperature is not suitable for prawn maturation and breeding (Karim, 2007).

Khondaker (2007) worked on “Fresh water prawn resources of Bangladesh and role of Department of Fisheries for prawn farming development” in which he stated the major problems of DoF concerning galda farming and suggested the galda farmers to stock hatchery produced good quality PL or juvenile in nurseries instead of stocking directly into the *ghers* and to provide appropriate shelters in the nursery and culture ponds.

Demaine (2007) reported on an integrated approach for prawn farming development in Noakhali and stated about the scarcity of the hatchery produced galda PL.

The effect of stocking density of prawn in surface feeding carps cum prawn polyculture for 6 months from September 2006 to February 2007 in northern part of Bangladesh was studied by Hossain (2007) and he reported about the necessity for studying the growth of prawn in warmer season as well as to explore the feasibility of prawn nursery.

The potential of freshwater prawn and self-recruiting small fish species mola (*Amblypharyngodon mola*) in rotational rice-fish/prawn culture systems were investigated in farmers rice fields in Mymensingh, Bangladesh by Kunda *et al.* (2007). In the experiment the highest revenue of Tk.364,971.30/ha per 122 day and net income of Tk. 215,144.30/ha per 122 days was obtained in a treatment of ‘all male prawn with carps and mola’ and the highest benefit-cost ratio 2.49:1 was observed in the same treatment and the other two treatments were of ‘mixed sex of prawn with said species’ and ‘all female prawn with the said species’.

CHAPTER 3

MATERIALS AND METHODS

Chapter 3

Materials and methods

3.1 Site selection

The experiment was conducted in the pond complex located at the Khulna University premise from June to December of 2006. Twelve ponds, measuring 1.25 decimal (0.50 square meter) each, were selected. The selected ponds were with adequate aquaculture facilities, such as necessary water depth (1.25-1.5m), well constructed dikes, free from flood or water logging, sunny, available sources of water supplies, easy to access etc. The ponds were more or less equal in depth, basin configuration and pattern.

3.2 Experimental protocol

With a view to develop a nursery technology of *M rosenbergii* with respect to optimization of stocking density and survivability of PL in the nursery ponds the experiment was conducted. A total of twelve ponds were used to carry out the research work. The ponds were divided into three groups in accordance with the three treatments on density of stocking of the PL, each with three replications. Three densities were 500 PL/ decimal, 800/ dec. and 1000/dec. There was a control group of ponds with 958/dec density having the same number of replications. For convenience, the treatments were denoted as T_1 , T_2 , T_3 and T_c .

3.3 Sample and sampling

3.3.1 Preparation of Nursery ponds

A) Purchase of inputs - feed, fertilizer, chemicals etc

Prior to getting started, various types of inputs such as feed, fertilizer, chemicals etc required for the experiment were purchased from the local market. Nylon nets for fencing, bamboo, plastic bucket, especially hand-made feeding tray (Fig 15), nylon rope, knife, bamboo branches were bought from local market. Two types of feed were bought; Yeon Starter feed and Quality Grower feed and cow dung was bought from the nearby village of the nursery pond site. Other fertilizers such as Urea and TSP and chemicals such as Rotenone, Ethyl-4 amino benzoate (Benzocain), and alcohol were bought from the local market.

B) Removal of weed

All kinds of aquatic weeds and grasses including algae and other plants submerged in or floating on to the water surface were removed carefully. Method for removing these weeds was manual and no chemical was applied for this purpose. Due to inconvenience, full drying of the ponds was not done.

C) Dyke repair

Dykes of the twelve ponds were checked whether there were leakages or damages that might result either entering unwanted lives into the ponds or escape of the prawn larvae. If there was any, was repaired very carefully.

D) Fencing

All the twelve ponds were enclosed with nylon netting of smaller mesh size (Fig 13) with 0.6 meter height from its base. The netting provided with the protection of the ponds from unwanted lives such as frog, snail, snake, duck, insects, other invertebrates, fish etc that might either be predator on the prawn PL directly or take a portion of feed applied for the PL, resulting poor growth and survival. It also provided protection against the escape of the prawn PL by walking as well as horizontal cross contamination of the ponds from the nearby water bodies through various agents.

D) Removal of predators and unwanted species

To kill the insects and unwanted lives, the ponds were treated with Rotenone in afternoon, at the dose of 30 g/decimal for every 30 cm (1 ft) water depth. One half of the total amount of rotenone powder required was applied into the pond water, dissolving in water in a plastic tub before application and the other half was applied by preparing a dough of it by mixing with water so that it could reach to the bottom of the pond.

E) Liming of ponds

After one week of application of Rotenone, lime was applied into the ponds at a dose of 2 kg/dec. as excess black soil was found to be present at the bottom level of the ponds. Lime was applied to the ponds after mixing with water in a plastic tub.

F) Fertilization

After one week of application of lime, the pond was fertilized with both organic and inorganic fertilizers. The only organic fertilizer was cow dung and it was applied at the rate of 10 kg per dec. and the inorganic fertilizers, Urea and Triple Super Phosphate (TSP) were applied at 150g and 75g per dec. respectively.

G) Substrate for the PL

Before stocking the PL, several bamboo branches were placed into the ponds with a view to facilitating shelter for the PL. A total of 20-25 pieces of dried bamboo sticks were used for each pond keeping them submerged under water.



3.3.2 Stocking of the ponds with hatchery-produced PL

After one week of fertilization when the pond water color turned to green, post larvae of 25 days' old were stocked in the ponds. The PL were not stocked directly rather they were acclimatized for 4-5 hours keeping the poly bags submerged in the nursery ponds before stocking. Then they were stocked at the densities of 500, 800, and 1000 PL/dec. in the ponds attributed as T₁, T₂ and T₃ respectively and at 958 PL/dec. in the control group ponds, having three replications in each of them.

3.3.3 Rearing of the PL and collection of data

Feeding Strategy and fertilization during rearing

The PL was fed with a commercial larval feed for up to 4 weeks of stocking named “Yeon Feed”, and in the subsequent days they were fed with a grower feed named “Quality Feed”. Composition of these two feeds are shown in the following table

Table 1: Composition of feed used in the present experiment

Ingredients	Yeon Nursery Feed	Quality Grower Feed
Energy	3200 K cal	-
Crude Protein	42%	9%
Crude fat	8%	29
Moisture	10%	11%

Source: Leaflet of the feed companies

The feeding rate in the experiment was 10% of the body weight and the feeding frequency was twice daily; in the morning (8.00 am) and in the evening (6.00 pm) for all of the ponds. Both broadcasting and tray methods were followed for feeding during the rearing period. Feed was broadcasted homogenously to the whole pond. The amount of supplemental feed was adjusted every week on the basis of body weight of the PL recorded weekly.

Cow dung was applied at 1 kg/dec in every 15 days and Urea and TSP were applied once in every week at the rate of 50g/dec and 25g/ dec respectively.

3.3.4 Data collection from the sampling of prawn PL

A push net (*thela jal*) was used to collect sample of prawn PL from each pond every week. The substrate materials were removed during sampling and the whole area was netted for sampling.

The stocking weight of the PL was recorded before releasing into the ponds. Data on growth of the PL in weight was recorded once in a week and the physico-chemical parameters of the pond water were also recorded weekly. A total of 20 PL from each pond was collected and taken to the laboratory. For easy of recording of the weight the PL were anesthetized by bathing in a solution of 1 ppt Ethyl-4-amino benzoate (Benzocain) prepared at 10% alcohol (Shah, 1984). After that the individual weight of the PL was measured in gram up to 3 digits after the decimal point by using an electric balance and then was returned to the respective ponds. The sampled PL were handled very carefully to avoid any handling stress.

3.3.5 Management of water quality parameters

Procedure of the Study

Water samples were collected from each pond. Recording of on the-spot data and collection of water samples were made between 09.00 am. to 12.00 pm. pH, Water temperature, Dissolved oxygen (DO), total ammonia, hardness total alkalinity and phosphate were recorded fortnightly

between 9.00 am to 11.30 am. The facilities at the Water Chemistry Research Laboratory of Fisheries and Marine Resources Technology Discipline were used for the analyses.

a. Temperature

Water temperature of the twelve experimental ponds was measured on the site by using a Centigrade mercury thermometer (0-50 °C) by dipping the thermometer bulb 3-4 cm in water.

b. pH

By using a pH meter (Hanna Instrument Model: ISO 9001) the pH of the experimental ponds was measured on the site. Calibration of the instrument was done immediately before measurement by using standard buffer of pH 4.0 and 7.0.

c. Dissolved Oxygen (DO)

Dissolved Oxygen was measured on the site using the Azide modification of Winkler method

d. Total alkalinity

Alkalinity of the water samples were measured in the laboratory by titration method.

e. Hardness

Hardness of the water samples was measured by complexometric titration (EDTA titration)

3.4 Data analysis

3.4.1 Analysis of Experimental Data on Growth

Experimental data collected during the growth trial were used to determine the following growth parameters.

Weight gain (g) = Mean final prawn weight - Mean initial prawn weight

(Sandifer and Smith 1975)

$$\text{Percentage weight gain (\%)} = \frac{\text{Mean final prawn weight} - \text{Mean initial prawn weight}}{\text{Mean initial weight}} \times 100$$

(Sandifer and Smith 1975)

$$\text{Average daily weight gain(g)} = \frac{\text{Mean final prawn weight} - \text{Mean initial prawn weight}}{T_2 - T_1}$$

(Willis and Berrigan, 1977)

$$\text{Specific growth rate (\% per day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

(Willis and Berrigan, 1977)

Where,

W_1 = Initial live prawn body weight (g) at time T_1 (day)

W_2 = Initial live prawn body weight (g) at time T_2 (day)

3.4.2 Estimation of survival rate

The survival rate of the PL for each pond was estimated on the basis of number of PL harvested at the end of the experiment. The survival rate was calculated by counting the actual number of PL survived, divided by the initial number stocked and multiplying by 100 and thus,

$$\text{Survival rate (\%)} = \frac{\text{No. of actual PL survived}}{\text{No. of actual PL stocked}} \times 100$$

(Willis and Berrigan, 1977)

3.4.3 Statistical analysis

Data recorded from sampling of the ponds were coded and entered into a database system using Microsoft Excel program. All numerical data collected during sampling were converted into appropriate units for convenience before transferring to computer. Preliminary data sheets were compared with the original coding sheets to ensure the accuracy of the data entered. At each stage, data were checked up, edited and coded. SPSS (Statistical Package for Social Science) was used to analyze the data. Data were summarized using descriptive statistics.

CHAPTER 4

RESULTS

Chapter 4

Results

4.1 Water quality parameters

A number of water quality parameters such as water temperature, dissolved oxygen, pH, total alkalinity, total ammonia, hardness and phosphate were measured at fifteen days interval during the period of experiment.

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

The temperature of the ponds water was found to be more or less similar in different ponds. The mean values of water temperature ranged from 25.10 to 31.70 $^{\circ}\text{C}$ in different treatments (Table 2)

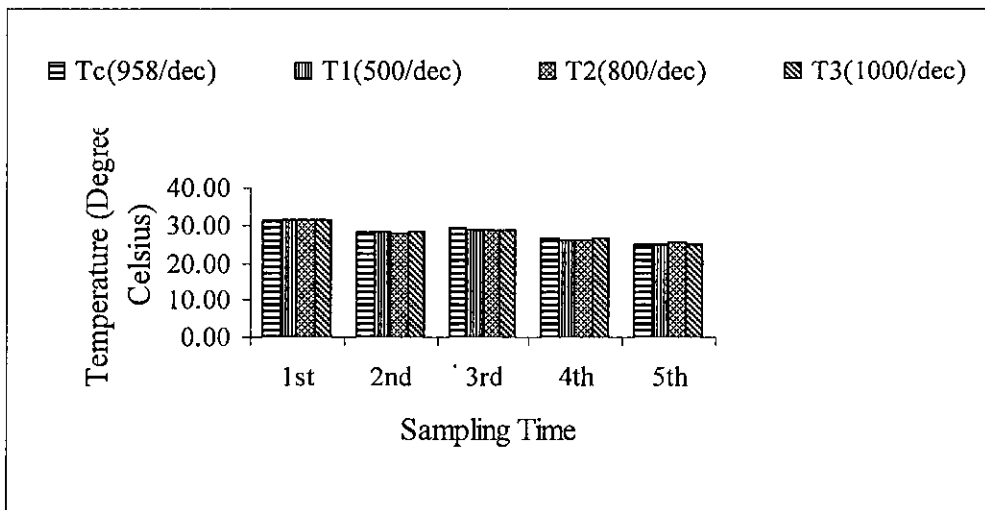


Fig1. Fortnightly temperature variations during the experiment

4.1.2 Dissolved Oxygen (mg/l)

Slight variations of dissolved oxygen concentration were found in all the ponds. The values were found to be ranged from 4.21 to 6.90mg/l. In the ponds for T_c, the average value of DO

was found to be 5.587 ± 0.058 mg/l and similarly the values for T_1 , T_2 and T_3 were found to be 6.092 ± 0.156 , 5.639 ± 0.187 and 5.513 ± 0.217 mg/l, respectively (Table 2).

There were no significant difference among the treatments and the control group except between T_c and T_1 when compared using ANOVA ($P < 0.05$). Variations of dissolved oxygen at 15 days interval in three treatments are shown in Fig 2.

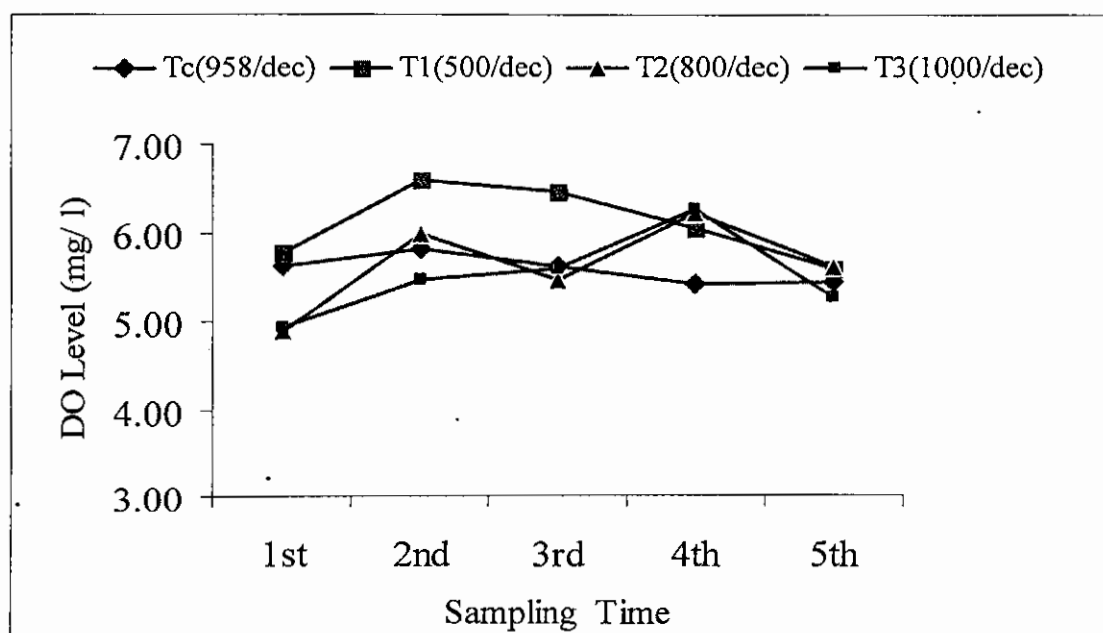


Fig 2: Fortnightly DO variations in the experimental ponds

4.1.3 pH

pH values were found to fluctuate from 6.6 to 7.70 in different treatments. The average values of pH were found to be 7.080 ± 0.112 , 7.087 ± 0.083 , 7.367 ± 0.053 and 7.380 ± 0.039 mg/l in T_c , T_1 , T_2 and T_3 , respectively (Table 2). The maximum and minimum values in the replicates were found to be 7.333 and 6.767, 7.333 and 6.900, 7.533 and 7.233 and 7.467 and 7.267 for the treatments T_c , T_1 , T_2 and T_3 , respectively (Table 2).

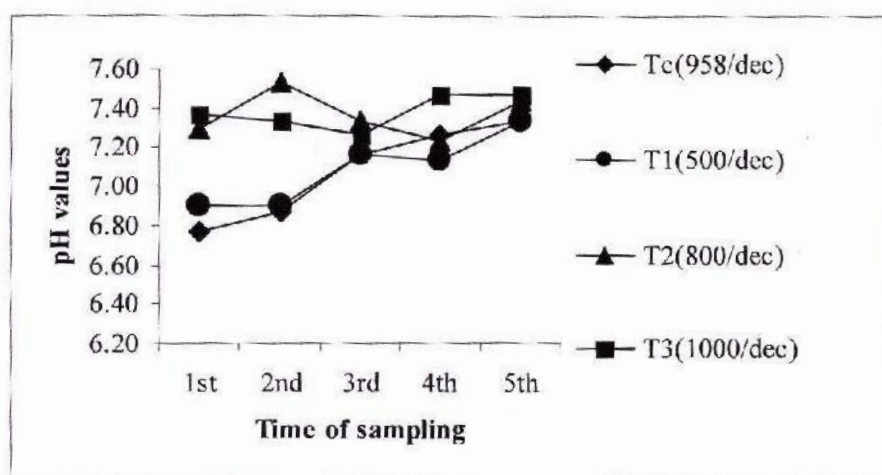


Fig. 3: Fortnightly variations of pH during the experiment

4.1.4 Total Alkalinity (mg/l)

The values of total alkalinity as recorded from the twelve ponds were found to range from 100.00 to 212.00 mg/l in all the treatments. The average values of alkalinity were found to be 163.022 ± 10.546 , 150.00 ± 8.640 , 154.722 ± 8.489 and 133.055 ± 8.055 mg/l in T_c, T₁, T₂ and T₃, respectively (Table 2). The maximum and minimum values in the replicates were found to be 183.333 and 127.777, 179.167 and 129.167, 175.000 and 127.777 and 154.167 and 116.667 mg/l for the treatments T_c, T₁, T₂ and T₃, respectively (Table 2).

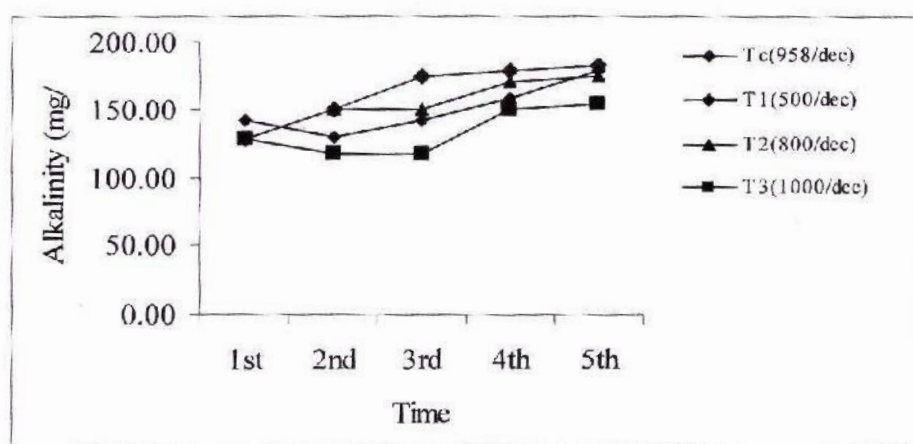


Fig.4: Fortnightly variations of alkalinity in the experiment

4.1.5 Hardness (mg/l)

The values of total hardness were found to range from 161 to 222.00 mg/l in the treatments.

The average values of hardness were found to be 182.6 ± 1.52 , 185.867 ± 1.323 , 196.733 ± 1.827

and 196.667 ± 1.597 mg/l for T_c , T_1 , T_2 and T_3 , respectively (Table 2).

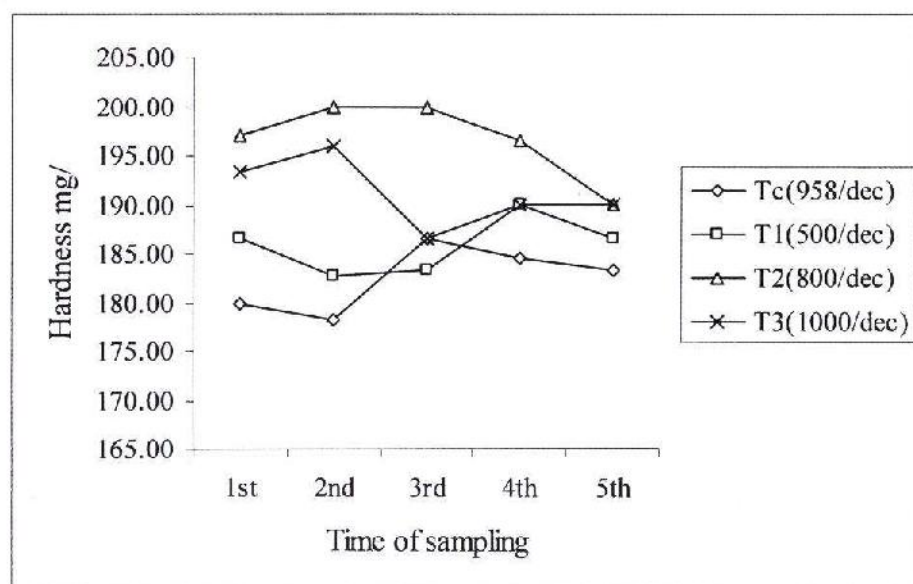


Fig 5: Fortnightly variations of hardness in the experiment

4.1.6 Total Ammonia (mg/l)

The average values of total ammonia as recorded were found to range from 0.04 to 0.10 mg/L

in the treatments. The highest values were found in the ponds for T_{2c} , T_{3b} and T_{3c} . The average

values of ammonia were found to be 0.084 ± 0.006 , 0.090 ± 0.006 , 0.073 ± 0.009 and 0.089 ± 0.004

mg/l in T_c , T_1 , T_2 and T_3 , respectively (Table 2). The maximum and minimum values in the

replicates were found to be 0.099 and 0.073, 0.099 and 0.073, 0.087 and 0.050 and 0.096 and

0.077 mg/l for the treatments T_c , T_1 , T_2 and T_3 , respectively (Table 2).

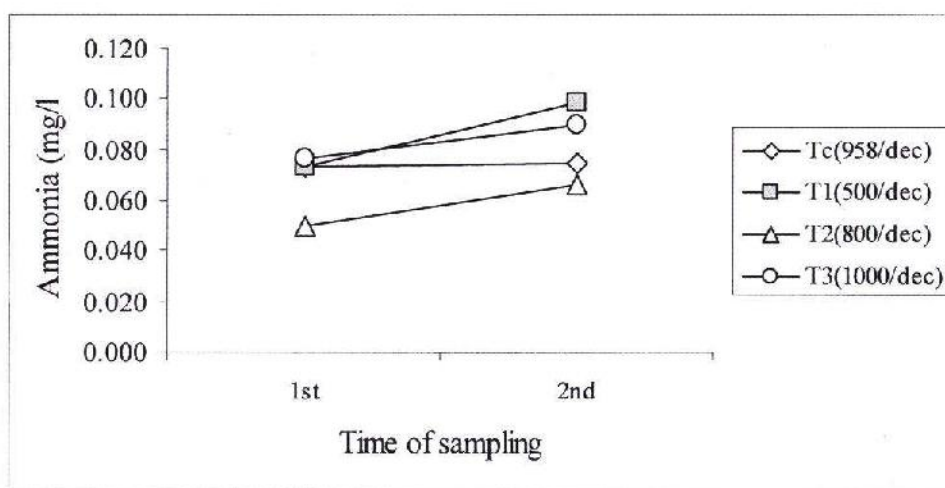


Fig 6: Fortnightly variations of ammonia in the experiment

4.1.7 Phosphate (PO_4) (mg/l)

The values of total phosphate level as recorded from the twelve ponds were found to range from 0.38 to 0.82 mg/l in the treatments. The highest value was found in the pond T_{3c} and the lowest was found in T_{1c} . The average values of phosphate were found to be 0.560 ± 0.023 , 0.665 ± 0.031 , 0.588 ± 0.018 and 0.663 ± 0.034 mg/l in T_c , T_1 , T_2 and T_3 , respectively (Table 2). The maximum and minimum values were found to be 0.620 and 0.520, 0.720 and 0.580, 0.640 and 0.560 and 0.733 and 0.570 mg/l for the treatments T_c , T_1 , T_2 and T_3 , respectively (Table 2).

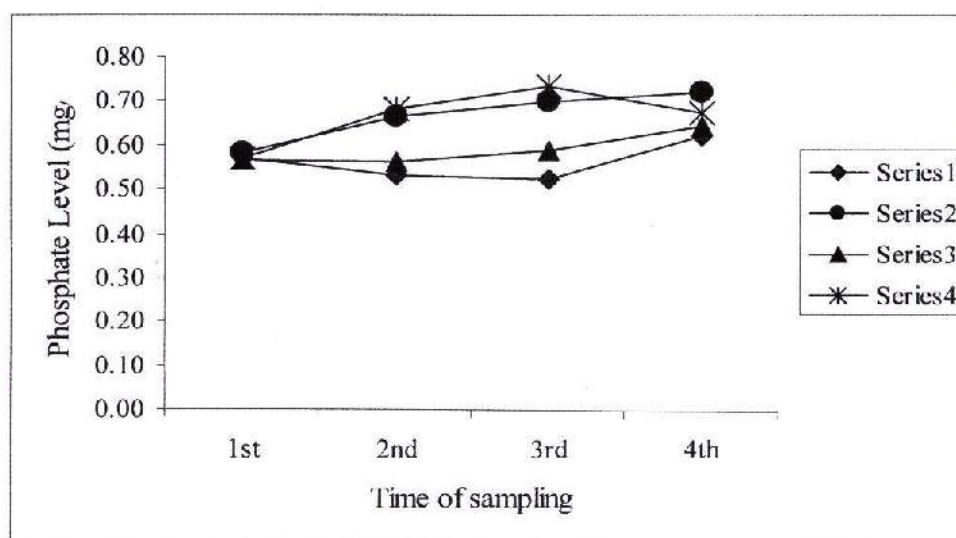


Fig 7: Fortnightly variations of phosphate level in the experiment



4.2 Growth performance

The results of the experiment on the growth performance of *M. rosenbergii* have been shown in Table 3 and Figures 8, 9 and 10.

4.2.1 Weight Gain (g)

After a rearing period of 14 weeks, the final average weights gained by the PL stocked were found to be 2.074, 2.685 and 1.712g from T_c, T₁, T₂ and T₃, respectively whereas the net gain in weights of the PL were found to be 2.069, 4.042, 2.680 and 1.707g from T_c, T₁, T₂ and T₃, respectively (Table 3, Fig 8) and the highest mean final weight and net gain in weight were 4.047g and 4.042g, respectively, in T₁ (500/ dec).

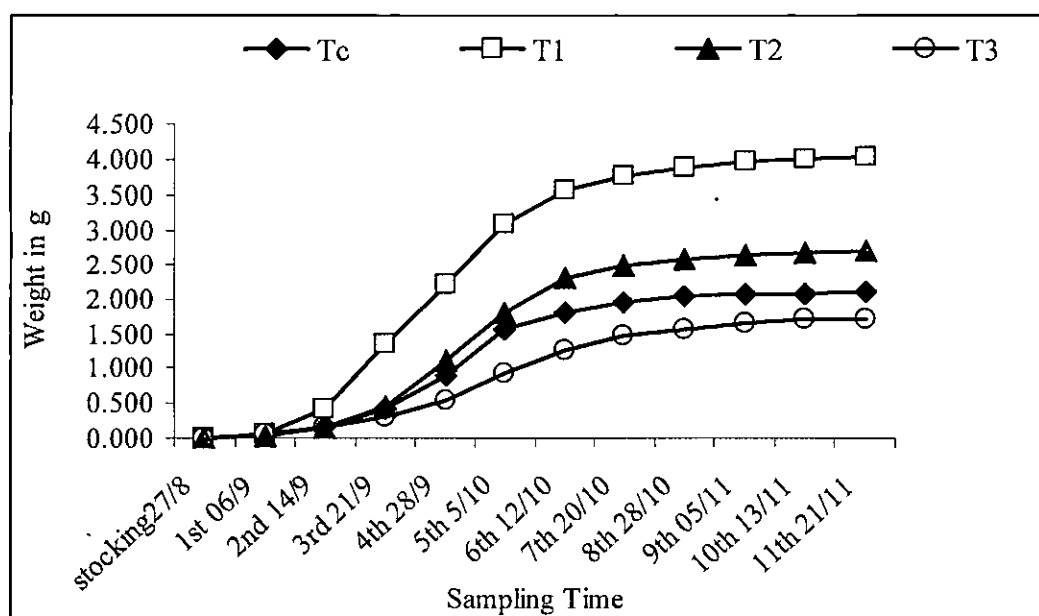


Fig 8: Growth performance of galda PL in the experiment

Table 3: Weekly growth performance of *M. rosenbergii* PL by mean weight gain, percentage of weight gain and specific growth rate

Parameters	Weekly average value											During the study period			
	Initial	1st	2nd	3rd	4th	5th	6th	7 th	8th	9th	10th	11th	Net gain	Mean net gain	Average daily gain
Treatments	T _c	0.005	0.041	0.160	0.404	0.908	1.564	1.794	1.936	2.019	2.061	2.074	2.069		0.025
	T ₁	0.005	0.071	0.416	1.332	2.194	3.082	3.562	3.782	3.914	3.981	4.027	4.042	2.625	0.049
	T ₂	0.005	0.043	0.163	0.458	1.104	1.782	2.285	2.482	2.561	2.631	2.659	2.685	2.680	0.033
	T ₃	0.005	0.061	0.142	0.291	0.536	0.921	1.243	1.470	1.557	1.635	1.689	1.712	1.707	0.021
Percentage	T _c	720	289.43	153.03	124.67	72.35	14.70	7.88	4.32	2.08	0.42	0.18	2955/week		
weight	T ₁	1322	485.09	220.19	64.69	40.50	15.59	6.17	3.49	1.72	1.16	0.50	5774/week	5069.25 (per week)	
gain	T ₂	753	281.25	181.35	141.22	61.41	28.23	8.62	3.18	2.72	1.09	0.97	3828/week		
	T ₃	1113	134.07	104.69	84.52	71.66	35.01	18.24	5.94	4.99	3.32	1.38	2439/week		
SGR (%)	T _c	9.138	7.380	5.760	5.022	3.377	0.851	0.412	0.230	0.111	0.024	0.010	3.192		
per day)	T ₁	11.53	9.590	7.220	3.095	2.109	0.899	0.325	0.186	0.093	0.062	0.027	3.550		
	T ₂	9.311	7.265	6.418	5.463	2.971	1.543	0.449	0.170	0.146	0.059	0.052	3.332		
	T ₃	10.84	4.617	4.444	3.801	3.352	1.862	0.909	0.313	0.264	0.178	0.074	3.090		

4.2.2 Average Daily Weight Gain (g)

The average values of daily weight gain found in the experiment over a period of 14 weeks were 0.025, 0.049, 0.033 and 0.021g/day from T_c , T_1 , T_2 and T_3 , respectively and the highest value (0.049 g/day) was found in T_1 (500/ dcc) (Table 3).

4.2.3 Percentage of Increase in Weight

The percentages of net increase in weight in the PL were 2955, 5774, 3828 and 2439% per week from T_c , T_1 , T_2 and T_3 , respectively and the highest percentage of net increase in weight (5774% per week) was found in T_1 (500/ dcc) (Table 3).

Weekly obtained percentages of increase in weight were found to decrease rapidly from the beginning and more or less slowly towards the end of the experiment. Weekly variations of percentage weight gain of the PL under the treatments are shown in Table 3 and Fig 9.

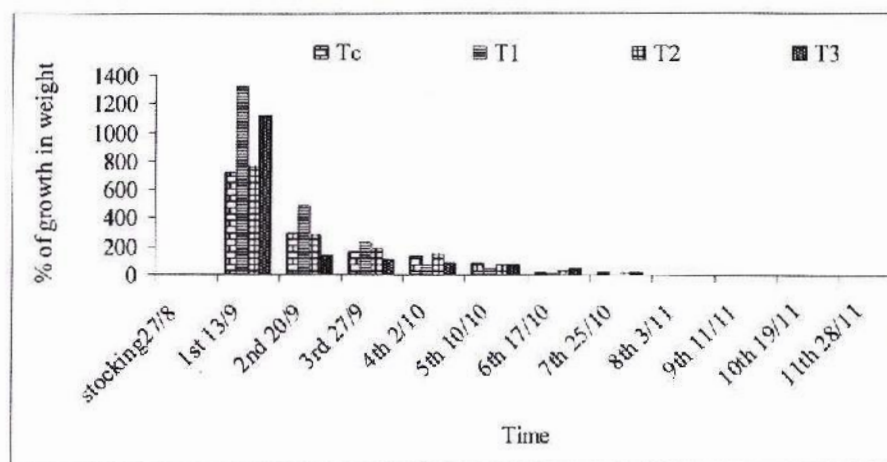


Fig 9: Percentage of weight gain in the experiment

4.2.4 Specific Growth Rate (% per day)

The mean values of specific growth rate observed in the experiment to be 3.192, 3.550, 3.332 and 3.090% per day in T_c , T_1 , T_2 and T_3 , respectively and the highest value (3.550 % per day) was found in T_1 (500/ dec) whereas the lowest (3.090 % per day) was in T_3 (1000/dec) (Table 3 and Fig 10).

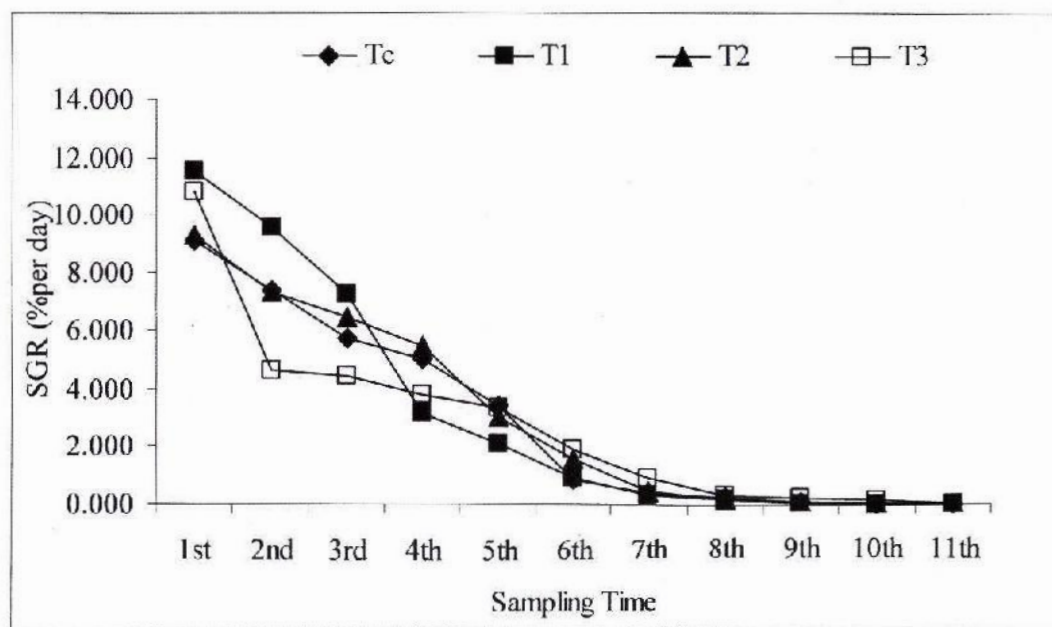


Fig 10: SGR (%) obtained from the different treatments used in the experiment

4.3 Survival rate

After a rearing period of 14 weeks, the survival rates (mean values) of the stocked PL were found to be ranged from 34.11% to 79.39% in the treatments. The mean values of survival rates were obtained to be 46.39, 79.09, 48.50 and 34.11% from T_c , T_1 , T_2 and T_3 , respectively (Table 4).

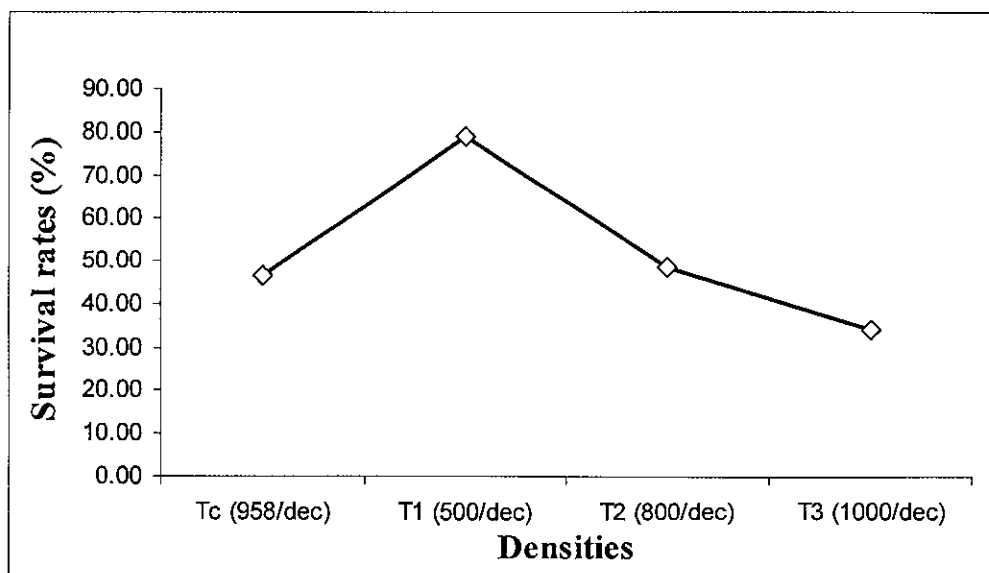


Fig 11: Survival rates at different stocking densities used in the experiment

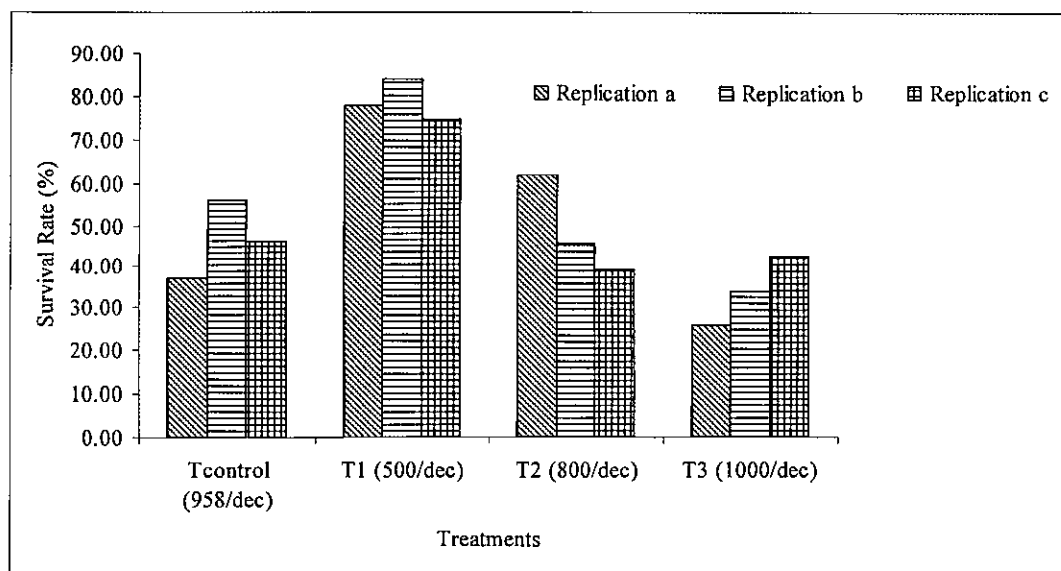


Fig 12: Survival rates at different stocking densities used in the experiment

The highest rate was found in treatment T₁ and the second highest was found in T₂. No significant difference between T_c and T₂ was found using ANOVA ($P < 0.05$) but differences were there among the other treatments

Table 4: Survival rates at different stocking densities

Treatments	Replication	No. of juveniles released	No. of juveniles Survived	Survival rate (%)	Mean survival rate
T _c	Tc1	766	284	37.08	46.39
	Tc2	766	429	56.01	
	Tc3	766	353	46.08	
T ₁	T1 a	625	488	78.08	79.09
	T1 b	625	526	84.16	
	T1 c	625	469	75.04	
T ₂	T2 a	1000	612	61.20	48.50
	T2 b	1000	451	45.10	
	T2 c	1000	392	39.20	
T ₃	T3 a	1250	326	26.08	34.11
	T3 b	1250	427	34.16	
	T3 c	1250	526	42.08	

CHAPTER 5

DISCUSSION

Chapter 5

Discussion

Lack of availability of seed appears to be an obstacle in the development of culture of *M. rosenbergii* in Bangladesh. Farmers usually have a strong interest in wild PL rather than hatchery produced PL; the hatchery produced PL have low survival rates and poor growth performance compared to wild PL. Usually the absence of a nursery rearing phase of the PL after the hatchery cycles of rearing results in low survival rates in the grow-out ponds (Bindu *et al.* 1999). Regardless of grow-out approach, the incorporation of prawn nursery system seems to offer potential for increasing the yields, value and predictability of the crop (Smith *et al.* 1978; Willis and Berrigan, 1977). However, rearing the post larvae in nurseries under high stocking densities, in turn, has resulted in higher mortality rates and also in increased size disparity among the individuals (Malecha *et al.*, 1989).

Moreover, with the adoption of a nursery phase, faster morphotypic transformation might have taken place, since the post-larvae reared in the nurseries had a better opportunity to survive, which resulted in the presence of larger prawns at the time of harvest (Kurup and Ranjit, 2005)

Kurup and Ranjit (2005) in a study unequivocally established the necessity of incorporation of a nursery phase for improving the net yield and revenue from *M. rosenbergii* farming. The utilization of nursery system to improve profitability of existing traditional and commercial farms in tropical regions appears to be most promising. Nursery rearing has been found to be beneficial for several reasons including the following; a) small nursery ponds can be more closely managed to ensure higher survival during a time when the young prawns are most susceptible to predation and harsh environmental condition, b)

juvenile prawns are larger and can be more easily enumerated for accurate stocking of production ponds, c) the expected higher survival of juvenile than PL in production ponds increases the final production and d) higher stocking densities in nursery ponds result in more efficient utilization of food and space in the pond (Mulla and Rouse, 1985). Lack of technical knowledge and inadequate research on prawn nursing system lead to higher mortality, therefore, reducing the benefit of the farming system (Asaduzzaman *et al.* 2005). Thus, nursery technology development in order to gain high survival rate and improvement of quality PL, is a vital researchable issue in Bangladesh

In the present study, an attempt has been made to optimize the stocking density and to determine the survival rate for developing an appropriate nursery technology through rearing the post-larvae of *M. rosenbergii* in earthen ponds. The findings of the present study are discussed in the light of the available references on prawn nursery system in Bangladesh and elsewhere.

5.1 Water quality parameters

Growth, feed efficiency and feed consumption of fish and prawn are normally governed by a few environmental factors (Fry, 1971). Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organism. Fujimura and Okamoto (1970) reported that density, food, temperature, shelter and insect predator are important factors affecting survival in prawn nursery ponds. The water quality parameters measured in different treatments in the present study throughout the experimental period were found to be within the acceptable range

5.1.1 Temperature

Fish and galda (*M. rosenbergii*) have the same temperature tolerance and it is supposed that galda also have similar optimum temperature requirements as fish and the recommended suitable temperature range is 21.9 - 33.5 °C for prawn culture (Fair and Foftner, 1981).

Hoq *et al.* (1996) reported that water temperature ranging from 27.5 to 30.5 °C was suitable for the growth of *M. rosenbergii*. Maclean *et al.* (1994) suggested the favorable temperature range to be 28.9 to 29.1 °C for the species. The water temperature recorded from the experimental ponds ranged from 25.10- 31.70 °C and was within the range of suitable temperature as recommended by Fair and Foftner (1981) however, the lower limit is somewhat less than that of described by Hoq *et al.* (1996) and Maclean *et al.* (1994). Since the winter season was approaching nearer during end of the experiment, it led to the lowering of the average temperature obtained in the experiment.

There were no significant difference in temperature among the treatments when compared using ANOVA ($P < .05$). Variations of water temperature among the treatments are shown in Fig 1.

5.1.2 Dissolved Oxygen

Successful fish and shrimp culture depends on the careful management of dissolved oxygen at optimum level. In the present study, dissolved oxygen levels in the pond water was varied from 4.21 to 6.90 mg/l. Hoq *et al.* (1996) recorded DO ranging from 4.0 to 5.9 mg/l in five prawn farms which were suitable for fish culture. Jia-Mo *et al.* (1988b) reported the presence of dissolved oxygen at 4.5 mg/l in *M. rosenbergii* culture ponds. Jaruvat and

Somnuk (1987) reported that shrimp would normally die if dissolved oxygen is less than 0.7 mg/l. Hossain *et al.* (2000) reported the presence of dissolved oxygen content at 3.0 to 6.1 mg/l in earthen ponds used for *M. rosenbergii* monoculture. Ali and Mazid (2005) stated that 5-7 mg/l DO as favorable for prawn PL and if the DO level falls to 2 ppm or less, galda PL stopped taking food and further, if the DO level falls below 1 ppm, the PL will die immediately. However the upper and lower limits of DO levels in the present study was within the tolerable limit for the prawn PL as reported by the above authors.

From the statistical point of view, difference in DO level between T_c and T_1 was significant and the same among the other treatments were not significant when compared using ANOVA ($P < 0.05$). The significantly higher level of DO in T_1 indicated the better quality of water i.e. little or no organic deposit might exist in the bottom level of the ponds of T_1 .

Variations in DO level in the different experimental ponds have been shown in Fig 2.

5.1.3 pH:

pH is considered as an important factor in fish culture. It indicates the acidity-alkalinity condition of a water body. It is also called the productivity index of a water body. Rapid fluctuation of pH level of a culture pond causes the hinder of growth of galda PL. The pH value 7 is of neutral condition of water and if it falls below to 7, the water will be acidic and an increase above 7 makes the water basic in properties. A drastic fall of pH value below 7 causes the extrusion of sodium chloride content of the PL body which results into death of the PL and most of the microorganisms reproducing rapidly cause diseases and consequently the disease resistance power and appetite for food is lost gradually (Ali and Mazid, 2005). The pH values ranging from 6.1 to 7.7 are considered suitable for culture of

M. rosenbergii in earthen ponds (Jia-Mo *et al.* 1988a). Hoq *et al.* (1996) reported pH values ranging from 7.5 to 8.0 in five prawn farmers ponds. Hossain *et al.* (2000) reported 6.8 to 8.4 pH value range as suitable for *M. rosenbergii*. Das (1998) recommended the pH value for prawn and shrimp as 7.5-8.7. Mean pH values recorded in different ponds in the present study were 7.080 ± 0.112 , 7.087 ± 0.083 , 7.367 ± 0.053 and 7.380 ± 0.039 which were within the suitable ranges as reported by the above authors.

Statistically the difference in the pH levels between T_c and T_2 , T_1 and T_2 , and T_1 and T_3 was significant but the same among the other treatments was insignificant. Variations of water pH in the treatments have been shown in Fig 3.

5.1.4 Total alkalinity

Total alkalinity has little direct effect on fishes but indirectly the well being of fish may be affected by total alkalinity value of water body, because ponds with low values of alkalinity are generally biologically less productive than those with high values. Total alkalinity may be several hundred ppn in natural water bodies. According to Alikunhi (1957) total alkalinity more than 100 ppn should be present in highly productive water bodies. According to Boyd

(1990) total alkalinity should be more than 20 ppm in fertilized ponds as fish production increases with the increase of total alkalinity. Total alkalinity values in the present study ranged from 100.00 to 212.00 mg/l. These values were more or less similar to the results of Dewan *et al.* (1991), Wahab *et al.* (1995), Nirod (1997) and Kohinoor *et al.* (2001). Therefore, it might be concluded that the values obtained was within the suitable range for fish and galda PL culture.

There were no significant difference among the treatments when compared with ANOVA ($P < 0.05$). Variations of total alkalinity among the treatments have been shown in Fig 4.

5.1.5 Hardness (mg/l)

In the present study the values of total hardness were found to range from 161 to 202.00 mg/l in the treatments. The average values of hardness were found to be 182.6 ± 1.52 , 185.867 ± 1.323 , 196.733 ± 1.827 and 196.667 ± 1.597 mg/l for T_c , T_1 , T_2 and T_3 , respectively (Table 2). From the statistical point of view difference among the treatments was insignificant. On average 40-200 ppm hardness in the pond water is good for prawn PL (Ali and Mazid, 2005) and the findings of the present study were found to fall within the range. Variations of total hardness among the treatments have been shown in Fig 5.

5.1.6 Total Ammonia (mg/l)

Ammonia is a toxic gas and is very much harmful for the growth and survival of the PL of *M. rosenbergii*. Waste material of the PL and excess feed etc produce this toxic gas after decomposition, if excess feed is delivered to the ponds. If the ammonia level of the pond crosses its tolerable limit, the ammonia level in the blood is increased and the PL stopped taking food and consequently dies due to malfunctioning of blood (Ali and Mazid, 2005). The average values of total ammonia as recorded from the twelve ponds were found to range from 0.04 to 0.10 mg/L. The highest value was found in the ponds T_{2c} T_{3b} . Both Das (1998) and Ali and Mozid (2005) recommended the favorable ammonia level for galda PL to be less than 1 ppm. Average ammonia level in all the treatments in the present experiment was less than 1 ppm (Table 2). Variations of total ammonias among the treatments have been shown in Fig 6.

5.1.7 Phosphate (PO_4) (mg/l)

Phosphate is an important nutrient in the aquacultural water. The values of total phosphate level as recorded from the twelve ponds were found to range from 0.38 to 0.82 mg/L. The highest value was found in the pond T_{3c} and the lowest was found in T_{1c} . The average values of phosphate were found to be 0.560 ± 0.023 , 0.665 ± 0.031 , 0.588 ± 0.018 and 0.663 ± 0.034 mg/l against T_c , T_1 , T_2 and T_3 , respectively (Table 2). The phosphate level of a prawn culture pond should be within 0.5-1.00 mg/l (Das, 1998). The phosphate level in the present experiment was found within this range. Variation in the phosphate level has been shown in the Fig 6.

Since the water quality parameters recorded in this study fell within the suitable ranges statistically, the same did not have any adverse effect on the production under the treatments. The results obtained in this study could be considered to conform to the ideal situation for prawn PL nursery.

5.2 Growth performances of the stocked galda, *M. rosenbergii* PL

During the present study, the growth performances of galda PL (*M. rosenbergii*) in different stocking densities were studied under pond nursery rearing system.

5.2.1 Weight Gain (g)

From the present study it is apparent that highest weight was gained by the prawn PL stocked at the density of 500 PL/dec in the treatment T_1 and the second highest was obtained from T_2 . T_1 showed higher growth in terms of net increase in weight than that of T_c (958/dec), T_2 (800/dec) and T_3 (1000/dec). Treatment T_3 showed the lowest growth

performance. This might be explicated to competition for food. Growth in terms of weight depends upon environmental parameters, density of stocking, food supply, shelter, insect, predation etc (Fujimura and Okamoto, 1970). The higher growth rate obtained in T_1 could be attributed to the low stocking density compared to the other treatments that might facilitated the prawn PL better opportunity to consume both natural and supplementary feed. Water temperature is one of the major factors that govern the growth of fish and other aquatic organism (Fujimura and Okamoto, 1970). If prawn PL is kept at temperature far below the suitable lower limit (25°C) normal growth is stunted and the PL become very weak (Ali and Mazid, 2005). The water temperature of the experimental ponds was found to be below the recommended temperature range during the last two weeks due to onset of winter and consequently the growth rate was found to be low during the end of the experiment.

There were highly significant differences among all the treatments in terms of weight (g) gain when compared using ANOVA ($P < 0.05$).

The growth rates and average weight gain obtained in the present experiment were found to increase more or less rapidly at the beginning of the experiment and then started decreasing towards the end of the experiment (Fig 8)

The results of the present experiment concerning the net weight gained by the prawn PL is more or less similar with that of Asaduzzaman *et al.* (2006) where they found the final weight of the stocked PL ranging from $2.51 \pm 0.08\text{g}$ to $5.95 \pm 0.10\text{g}$ with a stocking density of $20/\text{m}^2$; the study though was concerned with evaluating the effect of control of carbon/nitrogen ratio by addition of low cost carbohydrate. In their study the final mean weight gain was found to be $2.29 - 5.47\text{g}$.

5.2.2 Average Daily Weight Gain (g)

During the present study, treatment T₁ showed better performance in terms of average daily weight gain (g) than that of the other treatments. These findings were agreeable with the findings of Sadek and El-Gayar (1993) who found the daily weight gain in *M. rosenbergii* to be 0.318 and 0.319g. The lower average daily gain in T₃ might be due to competition for feed.

5.2.3 Percentage of Increase in Weight

The percentage of increase in weight 5774% per week in the treatment T₁ was significantly higher than that of in T_c, T₂ and T₃ which might be explicated to the less competition for food in low stocking density applied in the treatment.

The percentage of increase in weight was found higher during the earlier weeks of the experiment with a gradual decrease in the later weeks and the same was attributed to the natural reason that growth rate is faster at the early stages of growth.

5.2.4 Specific Growth Rate (% per day)

During the present study, the SGR of *M. rosenbergii* was significantly highest 3.550 % per day in treatment T₁. The findings were agreeable with the findings of Sharma and Reddy (1996).

SGR was found to be decreased gradually towards the end of the rearing period of the prawn PL in the experimental nursery ponds. Prawn PL was reared during early winter when the water temperature was comparatively lower. Since growth of prawn PL mostly

depends upon temperature, one of the major growth factors, the growth rate was found to be decreased with a gradual decrease of water temperature at the approach of the winter.

5.3 Survival rate

The ultimate aim of the research was to help obtaining a higher survivability rate compared to the prevailing rates in the culture farms in the areas by stocking nursery reared PL. The available information suggest that the rate of survival is very poor with the galda farmers and the same was mainly attributed to the lack of nursery technology of the hatchery produced PL of galda. The without nursed PL are stocked in the culture farms with the consequent high mortality and less production from the farms.

In the present study the highest survival rate of galda PL was obtained at 79.09% in treatments T₁, which could be explicated to the low stocking density. The results were agreeable to the findings of D'Abramo *et al.* (1989) who found that the survival rate of prawn PL in earthen ponds varied from 54.3% to 89%. Siddiqui and Al-Hinty (1993) report that the survival rate of freshwater prawn PL (*M. rosenbergii*) varies from 71 % to 93%. Ali and Mazid (2005) reported that in traditional system of PL rearing in earthen ponds, the rate of survivability generally ranged from 40-50% and sometimes 100% mortality could occur in those rearing practices due to poor management either in feeding or maintenance of appropriate stoking density and water quality.

Generally by using an arbitrarily stocking density of more than 1000 PL/dec the galda farmers face a higher mortality rate (up to 50-70%) (Asaduzzaman *et al.* 2005). The survival

rate obtained from T₁ (500 PL/dec) was much higher than that of the rates obtained by the traditional farmers.

Asaduzzaman *et al.* (2006) reported a range of survivability from 54.87% to 70.77% in a study using diets with carbohydrate and without carbohydrate which were more or less similar to the findings of the present experiment (34.11- 79.09%); their feeding system was apparently based on better understanding of the food used in the nursery systems for galda.

Survivability of prawn PL depends upon not only stocking density but also many other factors. Since the experimental ponds were small (1.25 dec) in size the PL got only a little place for freely locomotion and movement, the growth rate might be slower than that of the natural open water conditions. Since the ponds could not be dried out and ploughed; the presence of black soil at the pond bottom might have produced, to some extent, toxic gases. Moreover it was very much difficult to remove the small snails from the pond that took up some amount of feed and nutrition supplied for the prawn PL. Therefore, if the ponds were prepared well through drying and ploughing, even better results both in growth rate and survivability could be obtained from the experiment.

However, farmers and fingerling traders may be suggested to use the density of 500- 800 PL /dec in order to get rid of higher mortality problem, although there are still scopes for improvement of this process through feeding trial, duration of nursing and other aspects concerning better management.

CHAPTER 6
CONCLUSION



Chapter 6

Conclusion

The principal cause of poor production of prawn has been attributed mainly to the lack of good quality seed. There are reports on drastic reduction of natural sources of seed supply and at this juncture hatchery-produced PL are meeting the most part of the demand. The hatchery produced seed are not as strong as the natural ones and suffer from heavy mortality in the stocking ponds in the absence of nursery technology. There is no proven system of prawn nursery in the galda culture regions of Bangladesh. The present experiment was carried out with a view to optimizing stocking density and survival rates in earthen nursery ponds in order to develop a nursery technology. Four densities of hatchery produced PL, viz. 500, 800, 1000 and 958PL/dec.(control group) having three replications in each, were tried in twelve ponds (1.25dec each) for a period of 14 weeks. The ranges of different physico-chemical parameters - temperature, DO, pH, alkalinity, hardness and ammonia of the pond water recorded in the experiment were within the favorable limit. Out of the four densities tried, the density 500PL/dec provided with the highest survival and net gain in weight; the second highest survival and growth rate were achieved in the density 800PL/dec. Thus a density range of 500-800/dec may be recommended for use in the prawn nurseries for better growth and survivability. However, there are scopes for further improvement of the process through feeding trial and/or other management oriented aspects.

CHAPTER 7
REFERENCES

Chapter 7

References

- Alam, M.J. Hoq, M.E., Jahan, D.A. and Mazid, M.A., 1997. Nursery rearing of *Macrobrachum rosenbergii* (De Man) using hapa-nets: effects of stocking density. *Bangladesh Journal of Fisheries Research*, 1(1):09-16.
- Ali, M.L. and Mazid. M.A., 2005. Improved management technology of galda chingri (*Macrobrachium rosenbergii*) Extension manual No. 32. Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh, 48 pp.
- Alikunhi, K.H., 1957. Fish culture in India. Fm. Bull. *Indian Council for Agricultural Research*, 20: 144.
- Ang. K.J., 1990. Evaluation of the production potential of *Macrobrachium rosenbergii* in monoculture in Malaysia. In: Hirano, R. and Hanyu, I. (eds.). Proceedings of the Second Asian Fisheries Forum, 17-22 April, 1989, Tokyo, Japan. *Asian Fisheries Society*, Manila, Philippines, pp. 103-106.
- Ang, K.J., Komilus, C.S. and Cheah, S.H., 1992. Culture of *Macrobrachium rosenbergii* in cages. An abstract. In: Third Asian Fisheries Forum, 26-30 October, 1992, Singapore, (Abstract OSC-07). *Asian Fisheries Society*, Manila, Philippines, 127 p.
- Angell, C.L., 1994. Cage nursery rearing of shrimp and prawn fry in Bangladesh. BOBP/WP/92, Madras, India, 16p.

- Apud, F.D., Deatras, N. and Gonzales, K., 1981. Feeding behavior and food preference of *Penaeus monodon* Fab. With scrap *Tilapia mossambica*. *Fisheries Research Journal*. Phillippine, 6:27-31.
- Apud, F.D., Primavera, J.H. and Terres, J.P.L., 1985. Farming of Prawn and Shrimp. 3rd Ed. Aquaculture Extension Manual no. 5. Tigbauan, Lioilo, Philippines, SEAFDEC Aquaculture Department. 67 p.
- Arthur, J.R., Hurwood D., Lovell, E.R., Bondad-Reantaso, M.G. and Mather. P.B., 2004. *Pathogen and Ecological Risk Analysis for the Introduction of Giant River Prawn, Macrobrachium rosenbergii, from Fiji to the Cook Islands*. Queensland, Australia. 1-51 pp
- Asaduzzaman M., Fatema, M.K., Wahab, M.A., Ahmed, Z.F. and Yang Yi., 2005. Nursing systems of giant freshwater prawn *M. rosenbergii* post-larvae in Bangladesh. *Progress report of Agriculture*, 16(2):131-138.
- Asaduzzaman, M., Salam, M.A. Wahab, M.A. Kunda, M. and Rahman, M.B., 2006. Effects of control of Carbon/Nitrogen ratio by low cost carbohydrate addition on water quality and pond ecology in fresh water prawn *M. rosenbergii* post-larvae nursing system. *Bangladesh Journal of Fisheries Research*, 10(2):121-130.
- Barman, S.K., Azad, M.S., Aleem, N.A., Haque, M.M.U. and Hossain, M.A.R., 2003. Study on the shrimp and prawn post-larvae nursing in hapa. *Progress report of Agriculture*, 14(1 &2):91-94.

- BER, 2007. Bangladesh Economic Review (BER), Ministry of Finance and Planning. Dhaka, Bangladesh. 95pp.
- Bindu, R.P., Tripathy, A.P. and Rao, K.J., 1999. Observations on the growth of post larvae of *Macrobrachium rosenbergii* in polythene sheet covered earthen nursery ponds during winter. *Indian journal of Fisheries*, 46 (1):57-59.
- Boonyaratpalm, A and New, M.B., 1993. On-farm preparation and feeding strategies for marine shrimp and freshwater prawns. In: New, A.B., Tacon, A.G. and Casavas, L. (eds.). *Farm-made Aquafeeds*. Proceedings of the FAO, AADCP Regional Expert Consultation on Farm-Made Aquafeeds, 14-16 December, 1992. FAO/AADCP, Bangkok, Thailand. pp. 120-134.
- Boyd, C.E., 1990. *Water Quality in Ponds for Aquaculture*. Birmingham Publishing Co., Birmingham, Alabama, UK. 482 pp.
- Briggs, A R., 1991. The performance of juvenile prawns, *Macrobrachium rosenbergii*, feed a range of carbohydrate source in semi-purified diets. *Journal of World Aquaculture Society*, 22(3): 16A.
- Chalorkpunrut, P., 1987. Studies on growth and survival of the post larvae of freshwater prawn, *Macrobrachium rosenbergii* (De Man) stocked at different levels and fed with two types of pellet. *Fisheries Science*, 12: 6.

- Chand, B. K., Behera, S. and Panigrahi, A.K., 2000. Standardization of feeding strategies for monoculture of *Macrobrachium rosenbergii* (de Man). *Environ. Ecol.* 18(3): 732-737.
- Chen, S.M. and Chen, J.C., 2003. Effects of pH on survival, growth, molting and feeding of giant freshwater prawn, *Macrobrachium rosenbergii*. *Aquaculture*, 218 (1-4): 613-623.
- Chiranjib, C., Chatterjee, T.K., Chakraborty, S.K. and Chakraborty, C., 1999. Water quality of larvae rearing system of giant freshwater prawn, *Macrobrachium rosenbergii*. *Environ. Ecol.* 17(2): 432-435.
- Chou, L.M., Munro, A.D. Lau, T.J. Chen, T.W. and Cheong, L.K.K., 1994. The Third Asian Fisheries Forum, *Asian Fisheries Society*, Manila, Philippines. pp. 973-986.
- D'Abramo, L.R., Heinen, J.M., Robinette, H. R. and Collins, J.S., 1989. Production of the freshwater prawn *Macrobrachium rosenbergii* stocked as juveniles at different densities in temperate zone ponds. *Journal of World Aquaculture Society*, 20(2): 81-89.
- Daniels, W.H. and D'Abramo, L.R., 1994. Pond production characteristics of freshwater prawn, *Macrobrachium rosenbergii* as, influenced by the stocking size graded populations of juveniles. *Aquaculture*, 122: 33-45.

- Daniels, W.H., D'Abramo, L.R., Forideren, M.W. and Martin, D.D., 1995. Effects of stocking density and feed on pond production characteristics and revenue of harvested freshwater prawn, *Macrobrachium rosenbergii* stocked as size graded juveniles. *Journal of World Aquaculture Society*, 26(1): 38-47.
- Das, B., 1998. Chingri Chhash O Babosthapon (Prawn Culture and Management) Vol 1, Bangla Academy, Dhaka, Bangladesh. pp 128-166.
- Deb, A.K., 1978. Fake blue revolution: environmental and socio-economic impacts of shrimp culture in coastal areas of Bangladesh. *Ocean Coastal Management*, 41: 63-88.
- Demaine, H., 2007. Freshwater prawn farming development in Noakhali : An integrated approach towards sustainability. In: Wahab M.A. and Faruk, M.A.R. (eds.). 2007. Abstracts- National Workshop on "Fresh water Prawn farming: search for new Technologies". 16 May, 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.
- Dewan, S., Wahab, M.A., Beveridge, M.C.M., Rahman, M.H. and Sarker, B. K., 1991. Food selection, electivity and dietary overlap among planktivorous Chinese and Indian major carps. fry and fingerlings grown extensively, managed rain-fed ponds in Bangladesh. *Aquaculture Fisheries Management*, pp. 277-294.

- DoF, 2001. Fisheries Resource Information of Bangladesh (2001-2002). In: Sharanika of Fish Fortnight Compendium (12-16 August). Department of Fisheries Under the Ministry of Fisheries and Livestock, Bangladesh. pp 110.
- DoF, 2006. Fisheries Resource Information of Bangladesh (2005-2006). In Sharanika of Fish Fortnight Compendium (12-16 August). Department of Fisheries Under the Ministry of Fisheries and Livestock, Bangladesh. pp 110.
- Durairaj, S., Chandrasekharan, G. and Umamaheswary, R., 1992. Experimental culture of giant freshwater prawn in Tamil Nadu.. In: Silas, E.G. (ed.). *Freshwater prawns*. Kerala Agricultural University, Thrissur, India. pp 76-179.
- Estilo, V.E.J., 1988. Pond construction design and facilities. In: Chiu, Y. N., Santos L.M. and Juliano, R.O. (eds.). 1988. *Technical consideration for the management and operation of Intensive Prawn Farms*. Aquaculture Society. Lioilo, Philippines, pp 30-79.
- Fair, P.H. and Foftner, A.R., 1981. The role of fon-nulated feeds on natural productivity in culture of the prawn, *Macrobrachium rosenbergii*. *Aquaculture*, 24: 233-243.
- Fry, F.E.L., 1971. The effect of environmental factors on the physiology of fish. In: Hoar, W.S., Randall, D. R. and Brett, J.R. (eds.). *Fish Physiology*, Vol. 6. Academic press, New York. pp. 1-98.

- Fujimura, T. and Okamoto, H., 1970. Notes on progress made in developing a mass culture technique for *Macrobrachium rosenbergii* in Hawaii. Indo-Pacific fisheries council, 14th session, Bangkok, Thailand, 18-27 November, 1970: 16 pp.
- Hameed, A.S.S., 1993. Study on the aerobic heterotrophic bacterial flora of hatchery reared eggs, larvae and post-larvae of *Penaeus indicus*. *Aquaculture*, 117:195-204.
- Heinen, J.M., Rohinette, H.R., D'Abramo, L.R. and Rusch, R.L., 1987. Polyculture of freshwater prawns, *Macrobrachium rosenbergii* and Channel catfish fingerlins, *Ictalurus punctatus* in 1985 in Mississippi. *Journal of World Aquaculture Society* 18 (3): 190-195.
- Hoq, M.E., Islam, M.M. and Hossain, M.M., 1996. Polyculture of freshwater prawn (*Macrobrachium rosenbergii*) with Chinese and Indian carps in farmer's pond. *Journal of Tropical Aquaculture*, 11: 13 5-14 1.
- Hossain M.A., 2007. Fresh water Prawn farming: search for new Technology. In: Wahab M.A. and Faruk, M.A.R. (eds.). 2007. Abstracts- National Workshop on "Fresh water Prawn farming: search for new Technologies". 16 May 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.
- Hossain, M.A., Siddique, M.A.L. and Miaje, M.A.H., 2000. Development of low cost feed for culture of giant freshwater prawn, *Macrobrachium rosenbergii* (de Man) in ponds. *Bangladesh Journal of Fisheries Research*, 4(2): 127 -134.

- Jaruvat, N. and Somnuk, K., 1987. Comparison of oxygen consumption between ablated and unablated eye stalks of the tiger shrimp, *Peneaus monodon* fabricus. Brackish water Fisheries station, Rayong, Thailand. Department of Fisheries Ministry of Agricultural, *Technical paper* (13). 53 pp.
- Jia-Mo, P., Zhi-Guo, L., Zi-Hao, Y., Martimes-Silva, L.E. Osorio-Dualiby, D. and Torres-Virviescas, M., 1988a. The intensive culture of freshwater prawn *Macrobrachium rosenbergii* (De Man). In: *TRIANEA*, 1988(1): 45-55.
- Jia-Mo, P., Zhi-Guo, L., Zi-Hao, Y., Martinez-Silva, L.E., Osorio-Dualiby, D. and Toress-Virviescas, M., 1988(b). The intensive culture of freshwater prawn, *Macrobrachium rosenbergii* (De Man). In: *Memoirs of the Second Meeting National Aquaculture Network*, Neiva, September, 1988: 217-236.
- Jose, S., Nair, C.M. and Tharnpy, D.M., 1992. Culture of *Macrobrachium rosenbergii* in homestead ponds. In: Silas, E. G (ed.). *Freshwater prawns*. Kerala Agricultural University, Thrissur, India. pp. 200-205.
- Kanit, C., Puth, S. and Dusit, T., 1992. Variation physico-chemical properties of water and phytoplankton in intensive shrimp pond and Amphone Ranot, Sengkhal. National Institute for Coastal Aquaculture, Songkhala, Department of Fisheries, Ministry of Agriculture. *Technical Paper*, (4). 52 pp.
- Karim, M., 2007. Raising two Prawn crops a year to increase farm income, reduce rural poverty and increase export earning in Bangladesh. In: Wahab, M.A. and Faruk, M.A.R. (eds.). 2007. Abstracts- National Workshop on "Fresh water Prawn

farming: search for new Technologies". 16 May 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.

Khan, M.M., 2005. *Effect of stocking density on the production of M. rosenbergii culture in pond*. M.Sc. thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp 66.

Khandaker, H.R., 2007. Freshwater prawn resources of Bangladesh and role of Department of Fisheries for prawn farming development. *In*: Wahab M.A. and Faruk, M.A.R. (eds.). 2007. Abstracts- National Workshop on "Fresh water Prawn farming: search for new Technologies". 16 May 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.

Kohinoor, A. H. M., Wahab, M.A., Islam, M. L. and Thilsted, S.H., 2001. Culture potentials of mola (*Amblypharyngodon mola*), chela (*chela cachius*) and punti (*Puntius sophore*) under monoculture system. *Bangladesh Journal of Fisheries Research*, 5(2): 123-134.

Koshio, S., Kanazawa, A. and Teshima, S. I., 1992. Nutritional evaluation of dietary soybean protein for juvenile freshwater prawn, *Macrobrachium rosenbergii*. Nippon Suisan Gakkaishi. Bull. *Japan Society of Fisheries Science*, 5(5): 965-970.

- Kunda, M., Wahab, M.A., Dewan, S., Mazid, M.A., Thilsted, S.H., and Roos, N., 2007. Potential of freshwater prawn (*Macrobrachium rosenbergii*) and self-recruiting small species Mola (*Amblypharyngodon mola*) in rotational rice-fish/prawn culture systems. In: Wahab M.A. and Faruk, M.A.R. (eds.). 2007. Abstracts- National Workshop on "Fresh water Prawn farming: search for new Technologies". 16 May 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.
- Kurup, B.M. and Ranjit, K., 2005. Multiple stocking for enhancing survival, production and marketable yield structure of *Macrobrachium rosenbergii* (De Man). *Indian Journal of fisheries*, 52(1): 37-46.
- Law, A. T., 1988. Water quality requirements for *Penaeus monodon* culture. In: Proceedings of the Seminar on Marine Prawn Farming in Malaysia, Serdang, Malaysia. Fish. Soc. (3): 53-65.
- Law, A.T., Poh, Y.T and Ang, K.J., 1992. Least-cost feed formulation of juvenile *Macrobrachium rosenbergii* by using linear programming technique. An abstract. In: Third Asian Fisheries Forum, 26-30 October 1992, Singapore (Abstract PN-05). *Asian Fisheries Society*, Manila, Philippines. 188 pp.
- Lee, D.O.C. and Wickens, J.F., 1992. *Crustacean farming*, Blackwell Scientific Publications, London, England. 392 pp.

Maclean, M.H. Brown, J.H., Ang, K.J. and Jauncey, K., 1994. Effect of organic fertilizer and formulated feed in pond culture of the freshwater prawn, *Macrobrachium rosenbergii* (de Man). Institute of Aquaculture, University of Stirling, Stirling, UK. 245 pp.

Malecha S.R.; Sandifer, P.A., Cotsapas, L., Parcival, L., D'Abramo, L. MacMichael, E. R., Desmond, T. and Zacarias, D., 1989. Potential application to Brazil of recent advances in the culture of marine shrimp and freshwater prawns. In: *Proceedings of third Brazilian Symposium of Prawn Farming*, Joao Pessoa, Brazil, p 33-47.

Marques, A.J., Lombardi, V., Lobao, V.L and Roverso, E.A., 1999. Effect of two feeding management on the growth of freshwater prawn (*Macrobrachium rosenbergii* de Man) cultured in ponds. *Revista Ceres*, 16: 19-27.

Mather, P.B., and De Bruyn, M., 2003. Genetic diversity in wild stocks of the giant freshwater prawn (*Macrobrachium rosenbergii*): implications for aquaculture and conservation. *NAGA*, 26(4): 4-7.

Mulla, M.A. and Rouse, D.B., 1985. Comparison of four techniques for prawn (*M. rosenbergii*) nursery rearing. *Journal of World Mariculture Society*, 16: 227-235.

Nash, G., Chirabut, S. and Limsuan, C., 1987. Idiopathic muscle necrosis in the freshwater prawn *M. rosenbergii* De man. Cultured in Thailand. *Journal of Fisheries Diseases*. 10:109-120.

New, M.B., 1990. Freshwater prawn culture: A review. *Aquaculture*. 88:99-143.

New, M.B., Tacon, A.G. and Casavas, I. (eds.). 1993. Farm-made aquafeeds. Proceedings of
FAO/AADCP Regional Consultation on Farm-Made Aquafeeds, 14-18 December
1992. Rice-freshwater prawn (*Macrobrachium rosenbergii*) farms in the Mekong
Delta, Vietnam. NAGA. 16(4) 18-20.

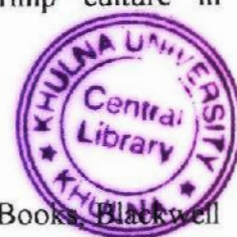
Nirod, D.B., 1997. Effect on stocking density on the growth and production of mola
(*Amblypharyngodon mola*). An M.S. thesis submitted to the Department of
Fisheries, Management, Bangladesh Agricultural University, Mymensingh. 75 pp.

Nuruzzaman, A.K.M., 1992. Chingri O Matsha Ponar Palan Paddhaty (The rearing system
of shrimp and fish fry). Bangladesh-E Chingri Chash (Shrimp culture in
Bangladesh). Dhaka, Bangladesh. pp.141-152.

Pillay, T.V.R., 1990. *Aquaculture: Principles and Practices*, Fishing News Books, Blackwell
Scientific Publications. Oxford, England, 591 pp.

Pudadera, B.J.Jr. and Lim, C., 1982. Evaluation of milk fish prawns in polyculture system.
Fisheries Research Journal of Philippines. 7(1): 51-59.

Raanan, Z., Saghi, A., Cohen, D., 1984. Production of *Macrobrachium rosenbergii* in
intensive monoculture, Kalia, *Fish Breed. ISR*, 1985, Vol-108. No. 2: 224.



Rao, P.V., Rao, K.V., Krishna, R.R. and Haribabu P., 1992. Studies on the growth of two *Macrobrachium spp.* in monoculture. In: Silas E. G. (ed.). *Freshwater prawns*, Kerala Agricultural University, Thrissur, India. pp. 183-186.

Sadek, S.S. and El-Gayar, F.M.H., 1993. Production of the giant freshwater prawn (*Macrobrachium rosenbergii*) reared in brackish water ponds (Egypt). In: Proceedings of the First International Symposium on Aquaculture Technology and Investment Opportunities. Ministry of Agriculture and Water, Riyadh, Saudi. pp. 296-303.

Sagi, A., Raanan, Z. Cohen, D. and Wax, Y., 1986. Production of *Macrobrachium rosenbergii* in monosex populations; yields characteristics under intensive monoculture condition in cages. *Aquaculture*, 51: 265-275.

Sandifer, P.A. and Smith, T.I.J., 1975. Effects of population density on growth and survival of *Macrobrachium rosenbergii* reared in recirculating water management system. *Proc. World Mericulture Society*, 6:43-53.

Shah, M.S., 1984. *Genetic Studies in Poecilia and Tilapia*. Ph.D. thesis, University of Wales, UK. pp 341

Shah, M.S., 2006. Value chain analysis of galda (*M. rosenbergii*, De Man) at different levels of production, processing and marketing in greater Khulna areas of Bangladesh, BFRF, AFGRP and DFID. pp 55.

- Sharma, M. and Reddy, A.K., 1996. Intensive culture of freshwater prawn, *Macrobrachium rosenbergii* in cemented tanks. *Fish Chimes*, 16(9): 25-26.
- Sheen, S.S. and D'Abramo, L.R., 1991. Response of Juvenile freshwater prawn, *Macrobrachium rosenbergii* to different levels of a cod liver/com oil mixture in semi-purified diet. *Aquaculture*, 93: 121-134.
- Siddiqui, A.Q. and Al-Hinty, H.M., 1993. Feasibility of freshwater prawns, *Macrobrachium rosenbergii*, culture in the central region of Saudi Arabia. Effect of density on growth, yield and population structure. *In: Proceedings of the First International Symposium on Aquaculture Technology and Investment Opportunities*. Ministry of Agriculture and Water, Riyadh, Saudi. pp 296-303.
- Silas, E. G. (ed.). 1992. Freshwater prawns. *In: Proceedings of the National Symposium on Freshwater Prawns, Macrobrachium spp.*, 12-14 December 1990, Kochi., India. Kerala Agricultural University, Thrissur, India. 272 pp.
- Smith, T.I.J., Sandifer, P.A. and Smith, M.H. 1978., Population structure of Malaysian prawn, *Macrobrachium rosenbergii* (De Man) reared in earthen ponds in South Carolina 1974-1976. *Proceedings of World Mericulture Society*, 10:369-384.
- Thangadurai, A.J., 1991. Experimental culture of freshwater prawn, *Macrobrachium rosenbergii* in ponds. *In: Proceedings of National Symposium on New Horizons in Freshwater Aquaculture*, 23-25 January, 1991, Bhubaneswar, Orissa, India. Central Institute of Freshwater Aquaculture, Bhubaneswar, India. 7 pp.

- Thakur, N.K., Tawari, R. and Joseph, M.M., 1994. Freshwater Prawn Farming in India. *In*: Thakur, N.K., Tawari, R. and Joseph, M.M (eds.).1994. Proceedings of the Workshop on Status of Freshwater Prawns Farming in India. 17-18 March, Special Publication No. 10. *Asian Fisheries Society*, Bangalore, India. 113 pp.
- Tidwell, J.H., Webster, C.D. Clark, J.A. and D'Abramo, L. R., 1992. Evaluation of distillers dried grains with soluble as a protein source in diets for the freshwater prawn, *Macrobrachium rosenbergii*. *Aquaculture: Growing towards the 21st century*. pp. 216-217.
- Tidwell, J.H., Coyle, S.D. and Schurneister, G., 1998. Effects of added substrate and increased stocking density on the production and population structure of freshwater prawns (*Macrobrachium rosenbergii*) in ponds. *Aquaculture'98*, Book of Abstracts, 541 p.
- Wahab, M.A., Ahmed, Z.F., Islam, A. and Rahmatullah S.M., 1995. Effect of Common Carp, *Cyprinus carpio* (L) on the pond ecology and growth of fish in polyculture. *Aquaculture Resesrch*, 26: 619-928.
- Wang, J.K., 1985. Weight and width relationship of freshwater prawn (*Macrobrachium rosenbergii*). *Aquacultural Engineering*, 4(1): 21-32.
- Willis S.A. and Berrigan, M.E., 1977. Effects of stocking size and density of growth and survival of *Macrobrachium rosenbergii* (De Man) in ponds. *Proceedings of World Mericulture Society*, 8:251-264.

Zafar, M., 2007. An overview of *Macrobrachium rosenbergii* farming in Bangladesh. In: Wahab M.A. and Faruk, M.A.R. (eds.). 2007 Abstracts- National Workshop on "Fresh water Prawn farming: search for new Technologies". 16 May 2007, Bangladesh Agricultural University, Mymensingh. Bangladesh Agricultural University and Bangladesh Fisheries Research Forum. 28 p.

Appendices

Appendix 1
Tables

Appendix 1: Tables

Table 5: Average growth performance of *M. rosenbergii* PL

Treatments	Stocking	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
	27/8	06/9	14/9	21/9	28/9	5/10	12/10	20/10	28/10	05/11	13/11	21/11
Tc	0.005	0.041	0.160	0.404	0.908	1.564	1.794	1.936	2.019	2.061	2.070	2.074
T1	0.005	0.071	0.416	1.332	2.194	3.082	3.562	3.782	3.914	3.981	4.027	4.047
T2	0.005	0.043	0.163	0.458	1.104	1.782	2.285	2.482	2.561	2.631	2.659	2.685
T3	0.005	0.061	0.142	0.291	0.536	0.921	1.243	1.470	1.557	1.635	1.689	1.712

Table 6: ANOVA (Single Factor) for Temperature between T_c and T₁

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.8777	1	5.877778	0.449173	0.5216	5.317645
Within Groups	104.686	8	13.08578			
Total	110.564	9				

Table 7: ANOVA (Single Factor) for Temperature between T_c and T₂

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.186778	1	0.186778	0.03289	0.860599	5.317645
Within Groups	45.43111	8	5.678889			
Total	45.61789	9				

Table 8: ANOVA (Single Factor) for Temperature between T_c and T₃

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.081	1	0.081	0.013913	0.909013	5.317645
Within Groups	46.57556	8	5.821944			
Total	46.65656	9				

Table 9: ANOVA (Single Factor) for Temperature between T1 and T2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.969	1	3.969	0.309447	0.593234	5.317645
Within Groups	102.6089	8	12.82611			
Total	106.5779	9				

Table 10: ANOVA (Single Factor) for Temperature between T1 and T3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.578778	1	4.578778	0.353051	0.568809	5.317645
Within Groups	103.7533	8	12.96917			
Total	108.3321	9				

Table 11: ANOVA (Single Factor) for Temperature between T2 and T3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.021778	1	0.021778	0.003915	0.951642	5.317645
Within Groups	44.49822	8	5.562278			
Total	44.52	9				

Table 12: ANOVA (Single Factor) for DO between Tc and T1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.6367	1	0.636721	6.145133	0.038175	5.317645
Within Groups	0.8289	8	0.103614			
Total	1.4656	9				

Table 13: ANOVA (Single Factor) for DO between Tc and T2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0066	1	0.00659	0.04599	0.8356	5.3176
Within Groups	1.1459	8	0.14323			
Total	1.1525	9				

Table 14: ANOVA (Single Factor) for DO between T_c and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01369	1	0.01369	0.104474	0.754812	5.317645
Within Groups	1.048298	8	0.131037			
Total	1.061988	9				

Table 15: ANOVA (Single Factor) for DO between T_1 and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.513778	1	0.513778	2.321338	0.166114	5.317645
Within Groups	1.770627	8	0.221328			
Total	2.284404	9				

Table 16: ANOVA (Single Factor) for DO between T_1 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.837138	1	0.837138	4.002912	0.080426	5.317645
Within Groups	1.673058	8	0.209132			
Total	2.510196	9				

Table 17: ANOVA (Single Factor) for DO between T_2 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0393	1	0.039271	0.157873	0.701513	5.317645
Within Groups	1.99	8	0.248752			
Total	2.0293	9				

Table 18: ANOVA (Single Factor) for pH between T_c and T_1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0001111	1	0.0001	0.0023	0.9631	5.31764
Within Groups	0.3893333	8	0.0487			
Total	0.3894444	9				

Table 19: ANOVA (Single Factor) for pH between T_c and T_2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.2054	1	0.20544	5.375	0.04904	5.31764
Within Groups	0.3058	8	0.03822			
Total	0.5112	9				

Table 20: ANOVA (Single Factor) for pH between T_c and T_3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.225	1	0.225	6.4184	0.035066	5.317645
Within Groups	0.2804	8	0.0351			
Total	0.5054	9				

Table 21: ANOVA (Single Factor) for pH between T_1 and T_2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.196	1	0.196	8.054795	0.021876	5.317645
Within Groups	0.194667	8	0.024333			
Total	0.390667	9				

Table 22: ANOVA (Single Factor) for pH between T_1 and T_3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.215111	1	0.215111	10.16273	0.012844	5.317645
Within Groups	0.169333	8	0.021167			
Total	0.384444	9				

Table 23: ANOVA (Single Factor) for pH between T_2 and T_3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.000444	1	0.000444	0.041451	0.843754	5.317645
Within Groups	0.085778	8	0.010722			
Total	0.086222	9				

Table24: ANOVA (Single Factor) for Alkalinity between T_c and T_1

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	423.9312	1	423.9312	0.912276	0.367478	5.317645
Within Groups	3717.57	8	464.6962			
Total	4141.501	9				

Table 25: ANOVA (Single Factor) for Alkalinity between T_c and T_2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	172.225	1	172.225	0.375839	0.556861	5.317645
Within Groups	3665.932	8	458.2415			
Total	3838.157	9				

Table26: ANOVA (Single Factor) for Alkalinity between T_c and T_3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	2245.003	1	2245.003	5.098853	0.053885	5.317645
Within Groups	3522.365	8	440.2957			
Total	5767.368	9				

Table 27: ANOVA (Single Factor) for Alkalinity between T_1 and T_2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	55.74321	1	55.74321	0.151968	0.706835	5.317645
Within Groups	2934.473	8	366.8092			
Total	2990.217	9				

Table 28: ANOVA (Single Factor) for Alkalinity between T_1 and T_3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	717.8043	1	717.8043	2.057552	0.189364	5.317645
Within Groups	2790.907	8	348.8633			
Total	3508.711	9				

Table 29: ANOVA (Single Factor) for Alkalinity between T_2 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1173.611	1	1173.611	3.427516	0.101266	5.317645
Within Groups	2739.269	8	342.4086			
Total	3912.88	9				

Table 30: ANOVA (Single Factor) for Hardness between T_c and T_1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	33.61111	1	33.61111	3.361111	0.104104	5.317645
Within Groups	80	8	10			
Total	113.6111	9				

Table 31: ANOVA (Single Factor) for Hardness between T_c and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	966.9444	1	966.9444	43.5125	0.00017	5.317645
Within Groups	177.7778	8	22.22222			
Total	1144.722	9				

Table 32: ANOVA (Single Factor) for Hardness between T_c and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	466.9444	1	466.9444	17.51042	0.003061	5.317645
Within Groups	213.3333	8	26.66667			
Total	680.2778	9				

Table 33: ANOVA (Single Factor) for Hardness between T_1 and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	640	1	640	36	0.000323	5.317645
Within Groups	142.222	8	17.77778			
Total	782.2222	9				

Table 34: ANOVA (Single Factor) for Hardness between T_1 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	250	1	250	11.25	0.010019	5.317645
Within Groups	177.7778	8	22.22222			
Total	427.7778	9				

Table 35: ANOVA (Single Factor) for Hardness between T_2 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	90	1	90	2.612903	0.14466	5.317645
Within Groups	275.5556	8	34.44444			
Total	365.5556	9				

Table 36: ANOVA (Single Factor) for Ammonia between T_c and T_1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.89E-05	1	5.89E-05	0.422525	0.539755	5.987374
Within Groups	0.000836	6	0.000139			
Total	0.000895	7				

Table 37: ANOVA (Single Factor) for Ammonia between T_c and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000273	1	0.000273	1.15076	0.324629	5.987374
Within Groups	0.001425	6	0.000238			
Total	0.001699	7				

Table 38: ANOVA (Single Factor) for Ammonia between T_c and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.92E-05	1	4.92E-05	0.427192	0.537597	5.987374
Within Groups	0.000691	6	0.000115			
Total	0.00074	7				

Table 39: ANOVA (Single Factor) for Ammonia between T_1 and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000586	1	0.000586	2.594819	0.15834	5.987374
Within Groups	0.001355	6	0.000226			
Total	0.001941	7				

Table 40: ANOVA (Single Factor) for Ammonia between T_1 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.36E-07	1	4.36E-07	0.004215	0.950347	5.987374
Within Groups	0.00062	6	0.000103			
Total	0.000621	7				

Table 41: ANOVA (Single Factor) for Ammonia between T_2 and T_3

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000554	1	0.000554	2.750064	0.148324	5.987374
Within Groups	0.00121	6	0.000202			
Total	0.001764	7				

Table 42: ANOVA (Single Factor) for Phosphate between T_0 and T_1

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02205	1	0.02205	7.579249	0.033158	5.987374
Within Groups	0.017456	6	0.002909			
Total	0.039506	7				

Table 43: ANOVA (Single Factor) for Phosphate between T_0 and T_2

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.001513	1	0.001513	0.881306	0.38408	5.987374
Within Groups	0.010297	6	0.001716			
Total	0.01181	7				

Table 44: ANOVA (Single Factor) for Phosphate between T_c and T₃

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.021356	1	0.021356	6.364238	0.04512	5.987374
Within Groups	0.020133	6	0.003356			
Total	0.041489	7				

Table 45: ANOVA (Single Factor) for Phosphate between T₁ and T₂

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.012013	1	0.012013	4.69459	0.073395	5.987374
Within Groups	0.015353	6	0.002559			
Total	0.027365	7				

Table 46: ANOVA (Single Factor) for Phosphate between T₁ and T₃

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.56E-06	1	5.56E-06	0.001323	0.972161	5.987374
Within Groups	0.025189	6	0.004198			
Total	0.025194	7				

Table 47: ANOVA (Single Factor) for Phosphate between T₂ and T₃

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.011501	1	0.011501	3.827299	0.098191	5.987374
Within Groups	0.018031	6	0.003005			
Total	0.029532	7				

Table 48: ANOVA (Single Factor) for Survival rates between T_c and T₁

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1604.556	1	1604.556	28.85603	0.0058	7.70865
Within Groups	222.4224	4	55.60559			
Total	1826.979	5				

Table 49: ANOVA (Single Factor) for Survival rates between Tc and T2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8.97682	1	8.97682	0.07727	0.794809	7.70865
Within Groups	464.7016	4	116.1754			
Total	473.6784	5				

Table 50: ANOVA (Single Factor) for Survival rates between Tc and T3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	226.2099	1	226.2099	2.9444907	0.161313	7.70865
Within Groups	307.2992	4	76.82479			
Total	533.509	5				

Table 51: ANOVA (Single Factor) for Survival rates between T1 and T2

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1373.5	1	1373.501	16.72278477	0.014983	7.70865
Within Groups	328.53	4	82.13353			
Total	1702.0	5				

Table 52: ANOVA (Single Factor) for Survival rates between T1 and T3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	3035.7	1	3035.7	70.95587	0.001087511	7.70865
Within Groups	171.1317	4	42.78293			
Total	3206.832	5				

Table 53: ANOVA (Single Factor) for Survival rates between T2 and T3

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	325.3121	1	325.3121	3.14759	0.150709375	7.70865
Within Groups	413.4109	4	103.3527			
Total	738.723	5				

Appendix-2:
Photographs





4



2

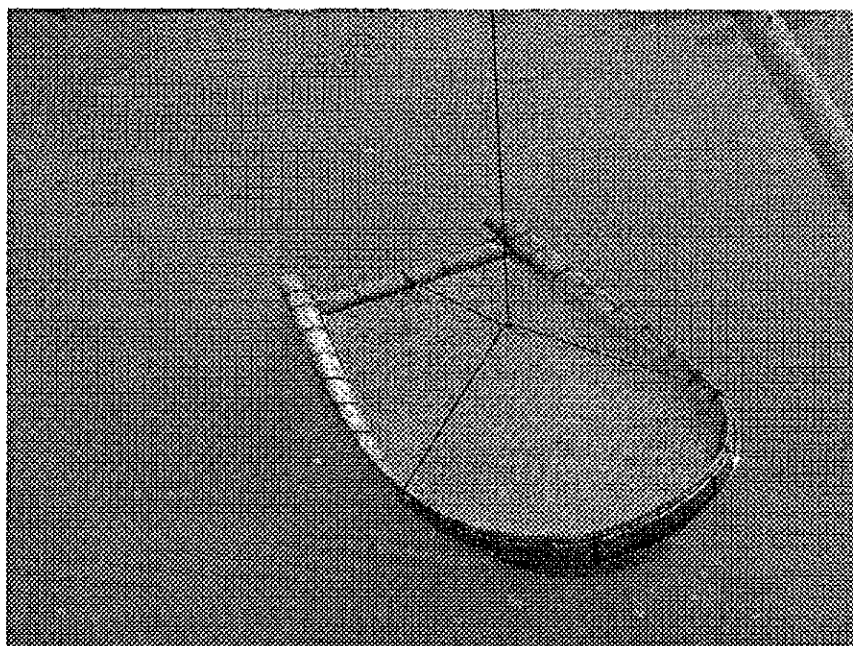


Fig 15: Hand made feeding tray

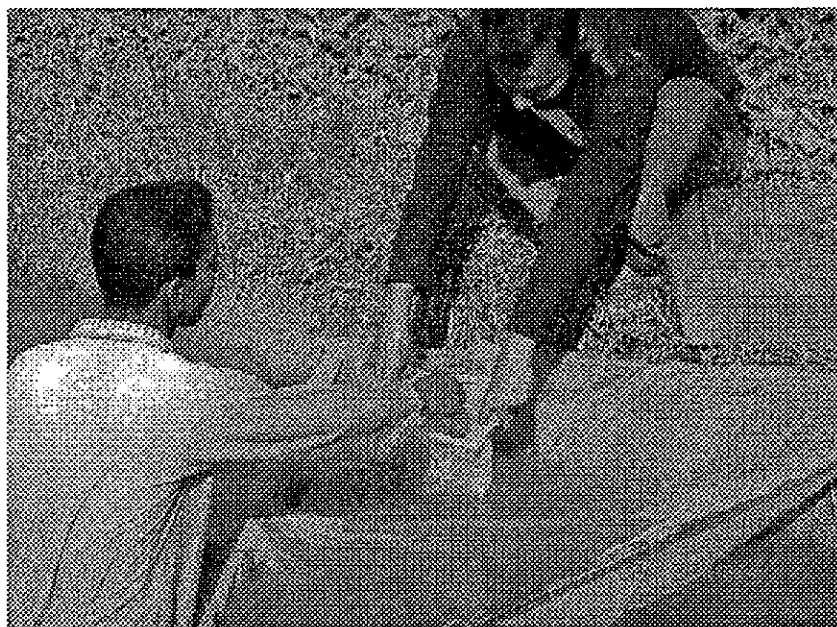


Fig 16: Sampling of the PL for growth measurement