Tuning Different Input Costs of Mud Crab Fattening And Analysis of Its Profitability

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DECLARATION

Tuning Different Input Costs of Mud Crab Fattening And analysis of its profitability

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.

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July, 2015 **Md. Wasiul Islam**

Abstract

The present study was conducted in Kalapara and Galachipa upazilla under Patuakhali district, from February to April 2015 during dry season by using a structured and pre-tested interview schedule in order to assess their current input practices with its profitability analysis. A total of 50 households from Kalapara and Galachipa (25 from each) were randomly selected. Comparatively higher stocking density 4879.01 (kg/ha) was found in Kalapara upazilla than Galachipa (4063.2 kg/ha). The cost and return analysis revealed that average gross revenue was11.29 lac BDT/ha/crop in two areas. Higher revenue was recorded in Kalapara upazilla (13.19 lacBDT/ha/crop) followed by Galachipa (9.37 lac BDT/ha/crop). The net margin of crab fattening were 6.42 lac (BDT/ha/crop) in Kalapara and 4.48 lac (BDT/ha/crop) in Galachipa with average production cost ratio of 1.95 and 1.93 respectively. Treatment-1 and Treatment-2 with three replications in each area to compare the fattening system were done by 30 cages, partitioned into 16 compartments. Single adult non-gravid female crab (204.42 ± 2.58g) was stocked into each compartment of the cages and 80 crabs (204.42± 2.58g) were also stocked into earthen pond at 2 individual/ m^2. Survival rate of crab was found 93.75 ± 6.25% and 86.12 ± 2.16% respectively in cages and encircled earthen area. Significantly higher production of crab from cages (3.30±0.08 kg/m^2) was recorded than the encircled earthen area (0.37±0.01 kg/m^2). Comparative benefit-cost analysis showed that bamboo cage fattening attained higher net profit (Tk 91,630.00) than in encircled earthen area (Tk 9,345.00) from 12 crops (12-16 days per crop) fattening period. The present study revealed that mud crab fattening using bamboo cage might be better than encircled earthen area with fencing in Bangladesh.

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CHAPTER 1

INTRODUCTION

Mud crabs namely (*Scylla serrata, Scylla. tranquebarica, Scylla olivacea, Scylla paramamosain*) which are distinguished by external morphology (such as- shell color, carapace spine number, carapace width, anterolateral teeth of carapace, and outer spines of cheliped carpus etc). *Scylla serrata* is an economically important species found in Australia and Asia. *Scylla tranquebarica* is found in mangrove areas from Pakistan and Taiwan to the Malay Archipelago and other Indo-Pacific regions. *Scylla paramamosain* is found in Japan, Taiwan, China (including Hong Kong), Vietnam, Cambodia, Singapore and Indonesia. In their most common form, the shell color varies from a deep, mottled green to very dark brown. *Scylla olivacea,* is the most valuable local crab sold in markets. These crabs are caught in traps or hooked out of their burrows during low tide. These crabs can survive out of water for extended periods as long as they are kept cool. Mud crabs are widely distributed in the tidal waters of Cox's Bazar, Noakhali, Barisal, Potuakhali, Satkhira, Khulna and around the offshore islands particularly Moheshkhali, Kutubdia, Sandwip and Hatia in Bangladesh (Khan and Alam, 1992).

Mud crab mainly grown up in the coastal waters of 15-30 ppt salinity and particularly dominates in the mangrove fauna (Khan and Alam, 1992). It is also available in the coastal shrimp ponds and ghers. The mud crab has emerged as one of the most potential export-earning aqua-resources in Bangladesh since 1977 when export of live crab had started (Ahmed, 1992). The species has been being overfished due to high demand and good price (Azam*et al.*, 1998). At present, mud crab is largely exported to Singapore, Hong Kong and Malaysia. Exporting rate of mud crab from Bangladesh is increasing very rapidly. However, the major part of the export is based on the harvest from the wild resources. As a result the continued pressure on the species could lead to ultimate extinction.

The production of crab was 4485 MT (Metric Ton) in the production year of 2010-11 and value was 540.11 million (BDT). In the previous year, the production was 692 MT. In 2011-2012 fiscal years, Bangladesh has earned 7.23 million US dollars indicating its importance in the foreign exchange earnings.

Mud crab aquaculture has been practiced for many years in Southeast Asia, based primarily on capture and fattening of juvenile crabs from the wild. There is an unmet demand for mud crabs and this has led to over-exploitation in many areas. The mud crab, *Scylla serrata* is widely distributed in the Pacific and Indian oceans. It is available in brackish coastal waters and estuaries and has a great potential for aquaculture. Crab culture and fattening are however, still in the experimental stage in South Asia (Samarasinghe *et al.* 1992). Mud crab of genus *Scylla*, also known as green crab or mangrove crab constitute an important secondary crop in the traditional shrimp or fish culture systems in the Asian countries including Bangladesh. The importance of live mud crab as an export commodity has opened up great opportunities for crab farming. Considering the increasing demand of mud crab in the local and international markets, it has been gaining popularity among the coastal communities in greater Khulna and Chittagong regions (Azam *et al.* 1998).

The annual production of crab is estimated to be more than 10,000 tons (Zafar and Ahsan 2006). Crab fattening is widely practiced in Thailand, Taiwan, Malaysia, Singapore, India, Indonesia and Bangladesh. Gravid female with full orange-red egg masses are in great demand in seafood restaurants of the South-east Asian countries. Due to its high price, people started to hold immature female crabs in some kind of enclosures and fed them until the gonads developed and filled the mantle cavity.

It had been assumed that culture as well as fattening would be possible in the coastal area of Bangladesh. Special attention had been paid to promoting the rearing of small crab to marketable size, considering the low prices paid by dealers for small size wild crab and the potential danger to the resource as a consequence of more intensive catching of female crab. In Bangladesh, coastal farmers have been practicing mud crab fattening mainly in encircled earthen ponds. In earthen ponds, some crabs manage to escape and cannot be caught in time due to burrowing inside the mud. High mortality and poor survival are the main constraints of crab fattening in existing systems. The introduction of mud crab fattening in cages is new in our country though it has been practiced in the Philippines, Indonesia, Malaysia and other South-east Asian countries. In the Philippines, only documented studies on fattening crabs were in bamboo (DA, Region VI 1988) and net cages (Kuntiyo 1992). Pens and floating cages made of bamboo, polyethylene netting and galvanized wire netting are used in coastal waters, shallow lagoons and ponds for mud crab fattening (Cholik and Hanafi

1992, Liong 1993). In Myanmar, the traditional mud crab fattening practice is done in ponds, bamboo enclosure and cage in river and canal system. Felix *et al.* (1995) reported mud crab fattening practice in cage in Vietnam. In Malaysia, floating cages ($6m^3$ with a depth of 1m) are used to fatten mud crab (Sivasubramain and Angel 1992). It is very much needed to improve fattening techniques of mud crab to get higher production in Bangladesh. No reliable information is available regarding the comparative study between fattening of mud crab using different input cost. Therefore, the present study was undertaken with different input costs of mud crab fattening and analysis of its profitability.

Objective:

- To determine economic feasibility and analyses profitability of mud crab (*Scylla serrata*) fattening by tuning different input cost.

CHAPTER 2

REVIEW OF LITERATURE

Review of related literature is necessary in the sense that, it provides scope for reviewing the stock of knowledge and information relevant to the proposed research. Despite the fact that a few numbers of works have been done in Bangladesh related to this research, there are some published reports of related activities. However, the limited numbers of works so far published are mentioned here along with other related works.

Mahmood (1977) reported 16 crab species at the coast of Bangladesh. Bhuyan and Das (1976) made a taxonomic investigation and reported 15 species of crab from the intertidal zone. They reported that the mud crabs are a significant component of the Sundarban ecosystem in terms of energy transfer, nutrient trapping, substrate modification and a food item. Live export of the species contributes significantly to the national economy.

Levitt (1990) described about the trading of mud crab. He mentioned that the mud crab trading made a part of interference between the supplier, exporter and consumer as a business pattern.

Khan and Alam (1991) mentioned that in recent years, live mud crab has become one of the most important exported commodities due to high price and demand in the international market. The mud crab leading the supreme position among the various crab species in Bangladesh in the view of market demand, economic profit, and excellent food quality, large size than the other countries and as profession of the minority group. The export of the live *Scylla serrata* from Bangladesh has increased significantly in the past few years. Shrimp and crab live in similar environmental conditions.

Ahmed (1992) mentioned about the seasonal abundance of the mud crab. He mentioned that the peak abundance of adult crab occurs during mid and late monsoon (June- August). The early monsoon (April- May) and post monsoon (September-October) are the seasons of fairly good abundance. Less abundance appears during the winter months from November to February.

Liong (1992) found that fattening of crab is profitable because of the fast turnover, low operating cost, high survival rate and good market demand for the end products.

Bhaumik and Saha (1994) stated that crab already has got position and reared with shrimp. Crabs are commercially important, commending high prices in local and international market and used as a source of income for coastal fisher folk and also for domestic consumption. In past it was a virgin stock and marketed only locally and in negligible quantities. Non-Muslims like Hindu, Buddhists etc. were traditionally consumed as food item but the Muslim population was not involved because of their religious barrier. With the mixing of the modern culture their attitude are gradually starting to change.

Azam *et al.* (1998) reported that from mid ninety decade, the crab marketing system expanded with foreign markets opening up. Mud crab first appears as an export item in 1977-78 and settled from 1982 (SEAFDEC, 1998). In recent years it is exported to international market, particularly Singapore, Hong Kong and Taiwan (Azam *et al.* 1998). It is now being harvested on an increasing scale. In recent years, the mud crab has emerged as one of the potential export oriented trades in Bangladesh.

Suseelan and Anil (1998) conducted a study on prospects of crab culture for rural development. They showed that the importance of live crabs as an export commodity has opened up great opportunities for crab farming in India. Mud crab farming is practiced in commercial scale in countries like Thailand, Malaysia, Indonesia, Philippines, Singapore and Taiwan mainly by the artisanal sector. In India mud crab farming is picking up in many maritime states as an important source of income generation in the coastal rural sector. The present paper reviewed the mud crab farming methods, rates of production and economics, and pointed out the problems and measures for sustained development of crab farming in the country.

Saha *et al.* (2000) conducted a study on effects of cow dung application on the production of mud crab(*Scylla serrata* Forskal) in brackish water pond. They revealed that a culture experiment of mud crab (*Scylla serrata*) for 84 days was conducted in earthen pond at Brackish water Station, Bangladesh Fisheries Research Institute, Paikgachha, Khulna. The aim of the experiment was to study the effects of cow dung application on crab production and water quality. There were three treatments as without cow dung (T sub (1)), 500kg cow dung/ha/fortnight (T sub (2)) and 750 kg

cow dung/ha/fortnight (T sub (3)) with three replicates for each. The result was evaluated on the basis of growth, production, survival rate etc. The range of salinity during the experiment was 8-19 ppt. Trash fish and fresh shrimp had were used as feed on row basis in every alternate week at a rate of 8% body weight of crab at the same time rice bran and wheat flour were used at rate of 2% body weight as a source of carbohydrate. The production of T sub(1), T sub(2) and T sub(3) were 720.35kg, 862.16kg and 669.19kg/ha respectively. Though the effects of cow dung on production of crab in insignificant but in terms of production, survival rate and growth, the study suggests that the application of cow dung in addition to feed can be recommended for mud crab culture at a rate of 500 kg/ha/fortnight.

Agbayani (2001) examined production economics and marketing of mud crabs in the Philippines. It was found that the current price of mud crabs in the local market is relatively higher than fish and mollusks and is projected to increase in the world market. This increasing trend in domestic and export markets are expected to step-up the demand for crab seeds. In the Philippines, the technology of mud crab grow-out culture is already being transferred to resource-poor fisher folks for adoption as an alternative livelihood. However, buying competition among big and small crab farmers is foreseen to be disadvantageous to small farmers. There is a need to hasten the development and transfer of technology on mud crab breeding and hatchery to stabilize the supply and price of crab seeds. This paper discusses the economic viability of four grow-out culture methods for mud crabs, namely: pond monoculture, poly-culture with milkfish, culture in mangroves, and fattening in ponds. The marketing system of mud crabs covers product development, pricing, distribution channels, and promotion activities.

J. Mwaluma (2002) found that lower stocking densities ensure higher survival rates. He also recommended that fattening should be done on floating cages rather than submersion into the pond bottom.

Uddin (2002) conducted a study on marketing and transportation system of the mud crab (*Scylla serrata*).He showed that the present state of marketing and transportation system of the mud crab has been evaluated though field survey for upazilas of Khulna district at monthly interval for one year from January to December 2001. Mud crab

business was found in 5 upazilas namely Paikgachha, Koyra, Dumuria, Batiaghata and Decope. The annual production of mud crab in each upazila of Paikgachha, Koyra, Dumuria, Batiaghata and Decope was estimated to be 20,27,140 kg, 1,62,300 kg, 72,920 kg,1,00,400 kg and 1,49,800 kg respectively. The maximum 57,300kg was produced in July and the minimum 51,640 kg in February. The total of 25,12,560-kg mud crab was produced in Khulna district in 2001. The maximum average price was 153.58 Tk./kg for f1(female) grade crabs and 147.33 Tk./kg for XL(male) grade crabs in the district. The domestic market of mud crab has yet not developed in this region because of high price and religious prohibition among the Muslims. All the harvested crabs were marketed in the foreign country through air freight in live condition. Major export markets of crab were Singapore, Hong Kong and Malaysia.

Salam *et al.* (2003) conducted a comparison of development opportunities for crab and shrimp aquaculture in southwestern Bangladesh, using GIS modeling. The study identifier and quantified appropriate sites for brackish water aquaculture development in southwest Bangladesh using remote sensing, GPS and geographical information systems(GIS).A series of GIS models were developed in order to priorities the most suitable areas for brackish water shrimp and crab farming. Using qualitative and quantitative output from the models, the benefits of shrimp and crab farming and alternative land uses in the Khulna region were compared, based on gross production, economic output and employment potential. Comparisons were made of brackish water shrimp and crab culture with moderately saline-tolerant tilapia and prawn culture, freshwater carp culture and traditional rice production systems. Shrimp was identified as the most capital intensive and risky production system. Earnings per hectare were a little higher for shrimp culture than that of crab culture.

Ghosh *et al.* (2004) conducted a study on economics of mud crab fattening in West Bengal. The study showed that the mud crab, *Scylla serrata*, also known as mangrove crab is a portunid crab, that is, it is a member of a group of swimming crabs which has the last pair of legs flattened for swimming. S. serrate is the largest portunid crabs. Mud crabs are large crabs with a smooth, broad carapace. They have nine even sized teeth on each side of their eyes. In the most common form, the color varies from very dark brown to mottled green. The other, generally smaller form has a deeper body and is reddish brown. In India the mud crabs have come into prominence since early

eighties with the commencement of live crab export to the South East Asian counties which have created a renewed interest in the exploitation as well as in the production of mud crabs as an export commodity have opened up great opportunities for crab farming. It has high demand and price in the export market.

Sathia dhas and Najmudeen (2004) reviewed the economic efficiency of mud crab farming/fattening under different production systems and evaluated its techno-economic performance by comparing them with semi-intensive shrimp farming. Net annual profit from the fattening system is Rs.14.99 lakh/ha and that of culture is only Rs.11.15 lakh/ha(Table 3). Annual profit from crab fattening with composite culture with fish and shrimps approximately Rs.8.17 lakh/ha. Fattening system provides the highest rate of return of 244% followed by culture system (189%), which is much higher than that obtained for all types of shrimp farming. Crab fattening with composite culture provides a rate of return of 145%.

Zafa and Ahsan (2006) conducted a study on Marketing and Value Chain Analysis of Mud Crab (*Scylla sp.*) in the Coastal Communities of Bangladesh. In this study the researcher identified a number of potential alternative livelihood options for the disadvantaged groups, one of the options is mud crab *Scylla sp.* trading that has been gaining popularity among the coastal community of greater Khulna and Chittagong regions. However, as with other aquatic products the main problem of pro-poor entrepreneurship development in the country is that vertical integration between the primary producers and the consumers in the marketing system is yet to be developed. In absence of proper policy orientation, the activities of a number of intermediaries having no stakes in the production and processing of the products often make such integration really difficult.

Himu Bain (2006) conducted a study on mud crab (*Scylla serrata*) in Bangladesh. Mud crab business plays a vital role to earn foreign currency in Bangladesh. Thestudy identified the socio economics characteristics of mud crab collectors, to examine the supply chain of mud crab and to determine value addition at different levels. Primary data were collected from August to September, 2006. The price and demand of crab was higher in winter season when the catch was scanty in supply. Price of female crab

was higher than that of the male. It was found that 90% of exportable crab came from natural sources with rest being from the fattening center. The value addition of the fattener step was the greatest among all other intermediaries suggesting that further technological advancement in fattening of eggless or soft shell crab could bring a momentum in a crab business.

Ferdoushi and Xiang Guo (2009) conducted a study in two different locations; Paikgachha and Koyra two upazilas under the Khulna district, from February to April 2009 during dry season by using a structured and pre-tested interview schedule in order to assess their current practice with its profitability analysis.

Begum *et al.* (2009) conducted a Comparative study of mud crab (*Scylla serrata*) fattening practices between two different systems in Bangladesh. This study was conducted to compare the survival, production and economics of mud crab fattening in cage with fattening in encircled earthen brackish water pond.

Shah *et al.* (2009) found that mud crab fattening using bamboo cage might be better than encircled earthen area with fencing.

Ferdoushi and Xiang-Guo (2010) found from their study that, there isa great potentiality in the south west part of Bangladesh for mud crab fattening. However, the highest seed cost (which constituted about 74.18% of the total cost) and lack of proper knowledge about mud crab fattening werealso reported in those studied areas.

Shelley *et al.* (2011) Mud crab aquaculture – A practical manual.FAO Fisheries and Aquaculture Technical Paper. There are four species of mud crab, *Scylla serrata, Scylla tranquebarica, Scylla paramamosain* and *Scylla olivacea*that are the focus of both commercialfisheries and aquaculture production throughout their distribution. They areamong the most valuable crab species in the world, with the bulk of theircommercial production sent live to market. This is the first FAO aquaculturemanual on this genus, covering everything from its basic biology and aquacultureproduction, through to stock packaging and being ready to go to market.Information on mud crab biology, hatchery and nursery technology, grow-

outsystems, disease control, processing and packaging has been collated in thismanual to provide a holistic approach to mud crab aquaculture production.

Chandra *et al.* (2012) conducted a survey on the production and marketing of mud crab, *Scylla serrata* (Forskal, 1755) in the south-western part of Bangladesh. An investigation was conducted to estimate approximate production and assess the marketing of mud crab in the south-western region of Bangladesh.

Mahmud *et al.* (2013) conducted a study on Marketing of Mud Crab *Scylla serrata*(Forksal) from Khulna District to International Markets. This study evaluated the marketing channel of mud crab (*Scylla serrata*) from Khulna region (Paikgachha, Koyra, Rupsa) to international markets and the livelihoods of the involved people were also being studied for a period of six months from January to June 2011.

The above mentioned discussion and review indicate that different studies conducted on mud crab production and marketing. The present study has, therefore, been designed to determine the tuning different input costs of mud crab fattening and analysis of its profitability.

CHAPTER 3

MATERIALS AND METHOD

3.1.1

The study was conducted in two different locations; Kalapara and Galachipa two sub-district of Patuakhali district in Bangladesh from February to April 2015 in order to assess the current farming practice of crab fattening with its cost and return analysis. A total of 50 crab fatteners (25 for each area) were randomly selected for better understanding of mud crab fattening.

3.1.2 Data collection

The field survey was done by the researcher herself through structure questionnaire interviews from randomly selected 50 crab fatteners from those two locations. The questionnaire was designed so as to capture such variable like size of the pond area, stocking density, production (in kilograms), different cost involved and benefit earned during the fattening period in dry season.

3.1.3 Analytical frame work

The analytical tools used in achieving the research objectives in this study are; simple descriptive statistics, cost and return analysis.

3.1.4 Cost return analysis

Several variable cost like seed cost, fertilizers and chemical cost, laborer cost, harvesting and marketing cost were estimated during the period of fattening. There were some fixed cost such as land rent, depreciation cost for bamboo pens, and guard room. Also salary cost for guard (most of the farmers tend to recruit guard to protect against stealing) and interest of Operating Capital (IOC). Interest on operating cost was calculated by taking into account the variable cost in this study. Interest on operating capital was charged at the rate of 13% per year and was estimated for the period during the fattening, which was on average 21 days in the study area. The standard formula for calculation of interest on operating capital is as follows:

Interest in Operating Capital = Al.i.t

Where, Al = Total investment/2

i = interest which is 13 per year

t = time duration of the culture period

Gross margin analysis and profitability ratio were used to examine the cost and returns of crab fattening in the study area by the following profitability equations:

GM = TR-TVC..... (1)

NR = TR- TC..... (2)

Production Cost Ratio = TR/TC..... (3)

Here, GM= Gross Margin, TR=Total Revenue, TC= Total Cost, TVC= Total Variable Cost and NR= Net Revenue.

3.2.1

Another experiment was conducted in brackish water pond of Kalapara upazilla in Patuakhali district from 1 to 16 May, 2015. The ponds were connected with tidal canal through inlet and outlet for tidal flush. Mud crab fattening in cage and encircled earthen ponds were considered as Treatment-1 and Treatment-2, respectively to compare the fattening system.

3.2.2 Pond preparation

After repairing of dyke and gates, the ponds were allowed to sun and dried up to the bottom soil cracks. As per the experimental design for Treatment-2 ponds were encircled with bamboo slits made fence with an area of 40 m2 each. The bamboo slits was pushed into the mud up to 50 cm depth to prevent escape burrowing of crabs. Lime was applied @ 250 kg/ha in the pond after drying. After seven days of liming, the pond was filled up (about one meter) with tidal water of the nearby river and after seven days cow dung was applied @ 750 kg/ha. After four days, inorganic fertilizers (TSP 25 kg/ha and urea 20 kg/h) were applied.

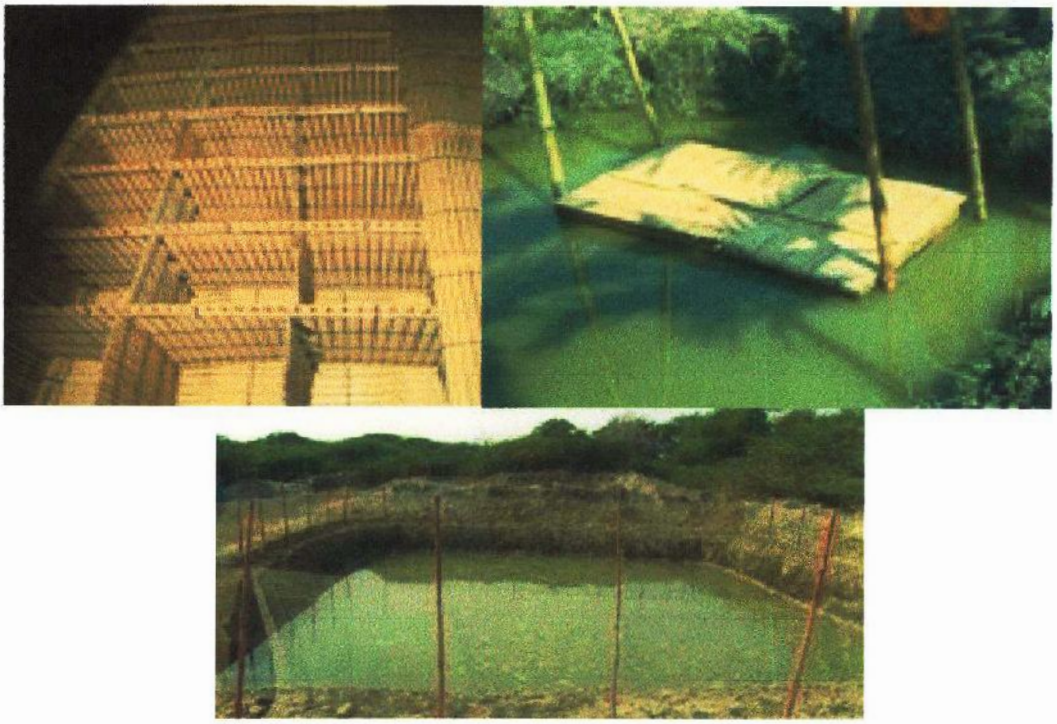

Figure: Crab fattening in cages and earthen encircled pond.

3.2.3 Cage preparation and setting in the pond

For Treatment-1, ponds with the same area were prepared following the pond preparation procedure of mud crab fattening in encircled earthen area except the bamboo fencing. Thirty cages of 1m (L) x 1m (W) x 0.3m (H) partitioned into 16 compartments (each 25 × 25 × 30 cm) were made with bamboo slits. Each cage was provided with a lid to prevent the escape of crabs. A gap of 0.5 to 1.0 cm was provided between the slits at the top and sides of the cages to enable free movement of water and air through the cages but no gap was provided at the bottom to enable easy movement of the crabs. The cages were suspended in the pond with sealed plastic drums in such a way so that the cages can move up and down with the fluctuation of tide.

3.2.4 Stocking

Adult non gravid female crabs without broken legs or chelate were procured in good health conditions. After 3-4 days of applying inorganic fertilizers, stocking was done in early morning. In case of Treatment-2, the stocking density was maintained @ 20,000 crabs/ha whereas in Treatment-1, one crab was stocked in each compartment

of the cages. The weight of crabs (204.42±2.58g) was maintained same within the treatments.

3.2.5 Feeding and management

The crabs were fed twice a day with chopped tilapia @ 8% of body weight of the stocked crab. A periodic check was made during the fattening period. Drifting seaweeds and other debris was removed to facilitate easy circulation of water and prevent damage to the cages. About 50% of water was exchanged with tidal water at every new and full moon throughout the experimental period. The pond water level was maintained within 80-100 cm throughout the experiment.

3.2.6 Sampling

In situ measurement of temperature, salinity, dissolved oxygen concentration and pH were carried out daily at 07:30 h using a thermometer, ATAGO refract meter (ATAGO Co., Ltd, Tokyo, Japan), DO meter, and a pH meter, respectively. After seven days onwards, checking for the development of gonad of the stocked crab was started. Gonad checking was done by placing the crabs in front of electric light or strong sun light.

3.2.7 Harvesting

After the fattening period (12-16 days), all the crabs were harvested by draining out the pond water or individually caught by hand. The pincers of the crab were bound with straw or string
(nylon thread) to enable easy handling.

3.2.8 Data Analysis

ANOVA was done to observe any differences in growth parameters of crabs and Duncan's New Multiple Range Test (DNMRT) also employed for further analysis of the results.

CHAPTER 4
RESULT AND DISCUSSION

4.1.1 Pond size and design

The average sizes of the ponds by location are showing in Table 1. Usually all Ponds were in rectangular shaped and surrounded by bamboo fence which prevent the crab to escape. Some fatteners also used to set mosquito nets over the bamboo fence for the same purpose. Ponds were divided into several parts to keep the male and female crabs separately because of the aggressive behavior of male over female which reduce the survival rate. Similar finding is also reported by Kamal *et al.* (2007). All ponds had common inlet and outlet for water exchange.

The average size was about 0.07±0.04 hectare with a range of 0.01 to 0.2 hectare.

Table 1. Average pond size (in hectare) in two study area

Pond Size	Kalapara (n= 25)	Galachipa (n= 25)	Total (n= 50)
Average size	0.08±0.04	0.06±0.04	0.07±0.04
Maximum	0.16	0.2	0.2
Minimum	0.02	0.01	0.01

Data is presented as mean ± standard deviation

4.1.2 Pre stocking management

Table 2 showing the pre-stocking management of crab fattening in their ponds by area. Almost all farmers (90%) prepared their pond before stocking. However, only 73.3% farmers in Patuakhali region dried their pond before stocking (Table 2). Most of them (91.1%) in those study areas applied lime before and after the stocking at the rate of 0.5 to 1 kg decimal-1. Farmers were found to use urea and crystalline potash (K2O) to keep the water parasite free and to maintain the good shell color for getting the higher market value.

Table 2. Distribution of farmers according to the pre stocking management for mud crab fattening by two study areas in Patuakhali region

Pond management	**Kalapara Total (n=25)**	**Galachipa Total (n=25)**	**Total (n=50)**
Pond preparation			
No Pond preparation	0 (0)	5 (20)	5 (10)
Pond preparation	25 (100)	20 (80)	45 (90)
Drying	**Total (n=25)**	**Total (n=20)**	**Total (n=45)**
No	10 (40)	2 (10)	12 (26.7)
Yes	15 (60)	18 (90)	33 (73.3)
Total	25 (100)	20 (100)	45 (100)
Tilling			
No	8 (32)	15 (75)	23 (51.1)
Yes	17 (68)	5 (25)	22 (48.9)
Total	25 (100)	20 (100)	45 (100)
Liming			
No	2 (8)	2 (10)	4 (8.9)
Yes	23 (92)	18 (90)	41 (91.1)
Total	25 (100)	20 (100)	45 (100)
n = sample size. Figures in brackets indicate percentages			

4.1.3 Stocking Density

Among four available mud crab species in the Indo-pacific region mainly the *Scylla serrata* is being fattened in the south part of Bangladesh. Two crab fattening season so far have been identified in Bangladesh, one is the dry or peak season (November to April) and another one is lean season or wet season (May to October). However, some fatteners continue the crab fattening throughout the year. Usually the crab Fatteners in Bangladesh stocked the lean female and soft male crabs (locally called PD and KHOSA) collected from the crab trading depots and from shrimp farms. Its fully depends on the supply and price of crabs in the international and local market. In fact the farmers did not maintain any standard stocking density. The stocking density was varied from 2020.91 to 4879.01 (kg ha-1) and 2544.85 to 4063.2 (kg ha-1) in

Kalapara and Galachipa respectively. Average stocking density in Kalapara was found comparatively higher (3451.64±662.61 kg ha-1) than Galachipa (3440.76±361 kg ha-1) (Table 3). Table 4 showing different grade of stocked male and female crab used as seed for fattening.

Table 3. A comparison of Stocking density (kg ha-1) and Production (kg ha-1) in two study area

Stocking density (kg ha-1)	**Kalapara (n= 25)**	**Galachipa(n=25)**	**Total (n= 50)**
Average	3451.64±662.61	3440.76±361	3446.20±528.12
Maximum	4879.01	4063.2	4879.01
Minimum	2020.91	2544.85	2020.91
Production (kg ha-1)			
Average	3020.63±625.22	3047.58±327.03	3034.11±493.99
Maximum	4391.11	3614.11	4391.11
Minimum	1706.55	2275.39	1706.55

Table 4. Grade of Mud crab used for fattening in the study area

	Grade	**Weight (gm)**	**Carapace**
Male	PD-XXL	>500	Soft
	PD-XL	>400	Soft
	PD-L	>300	Soft
	PD-M	>250	Soft
	PD-SM	<200	Soft
	Grade	**Weight**	**Hepatopancrease**
Female	KS1	>180	Partially developed
	KS2	>150	Poor
	KS3	<120	Poor

4.1.4 Feeding

Commonly available low cost trash fishes are the main food used in crab fattening (Rattanachote and Dangwatanakul, 1992). Most of the farmers in the present study applied small trash fishes, tilapia, shrimp and prawn heads and the eels as foods for

crabs for fattening. Farmers usually applied the food at the rate of 5 to 8% of the body weight. According to Cholic and Hanafi (1992), 10 -15% of body weight feed rate in every day can reduce the mortality and increased the survival rate up to 85 to 90%. Farmers in the three study regions applied feed in every alternative day and some of them in daily at the rate of 5 to 10%. The Distribution of farmers according to the feeding frequency is showed in Table 5.

Table 5. Distribution of farmers according to the feeding frequency by two study area

Feed Application	**Kalapara**	**Galachipa**	**Total (n=50)**
	Total (n=25)	**Total (n=25)**	
Daily	6 (24)	10 (40)	16 (32)
Alternative	19 (76)	15 (60)	34 (68)
n = sample size. Figures in parenthesis indicating percentages			

4.1.5 Water Exchange

The crab fattening in Bangladesh is mostly traditional and farmers do not maintain any water management practice like shrimp and prawn culture, when the water deteriorates severely they change the water. A total of 58% fatteners in those study area exchanged water during fattening period. About 60% farmers in Galachipa and 56% in Kalapara had the facility for exchanging the water during fattening period (Table 6).

Table 6. Distribution of farmers according to whether or not they change water during mud crab fattening period by area

Water Exchange	**Kalapara**	**Galachipa**	**Total (n=50)**
	Total (n=25)	**Total (n=25)**	
Yes	14 (56)	15 (60)	29 (58)
No	11 (44)	10 (40)	21 (42)
n = sample size. Figures in parenthesis indicating percentages			

4.1.6 Harvesting

Mainly the fattening period depends on the market price and on the stage of maturity of the gonad and meat content of the fattened crabs. Farmers usually monitored and cheeked their stocked crabs and only fattened ones were harvested. A continuous

selective harvesting were done by bare hands, sometime they also used small scoop net for harvesting. The matured fattened crabs at first checked through light examination and the un fattened individual were returned again to the pond. Total harvesting is usually done at the end of fattening season after dewatering the pond. Harvested fattened crabs were tied with nylon threads and kept into the bamboo basket and immediately transported to the nearby landing center.

4.1.7 Survival rate and Production

The average survival rate in two areas was about 88±2%. The highest survival rate (93%) was found in Kalapara. Rattanachote and Dangwatanakul, (1992) reported 80±14% survival rate of *Scylla serrata* from traditional fattening farms in Surat Thani, Thailand, 80-100% survival rate reported by Kuntiyo (1992) in Philippines. However, found low survival rate in mixed sex fattening due to aggressive behavior of male crab over female. About 88% survival rate is reported by Zafar (2004) which is similar to the present study. A comparative higher growth with significant higher survival rate was observed in male than female with at lower stocking densities (0.5 m2-1) but total production was lower (Zafar, 2004). Around 98% of survival rate was recorded by Trino *et al.* (1999) at low density of 0.5/m2. In another experiment by Trino *et al.* (2001) found 87% survival rate at 0.5/m2 at undersized stocked male or female whereas 87 to 100% survival rate achieved at 0.25/m2 at lean market sized.

Trino and Rodriguez (2001) reported a production rate of 17.9±44.3, 15.9±39.3 and 14.2±30.4 kg per 150 m2 for monosex male, female and mixed sex crab farming during 20 to 30 days. In the present study the mean average production of two areas was 2947.04 ±593.43 (kg ha-1crop-1) with a range of 1526.79 to 4391.11(kg ha-1crop-1).

4.1.8 Cost and return of investment.

Table 7. Cost and return of investment (BDT ha-1crop-1) of mud crab fattening in the study areas

Cost Type	Cost item	Patuakhali		Mean total (BDT)
		Kalapara(BDT)	Galachipa(BDT)	
1.Variable cost (VC)	a) Seed	515352.5	350282.6	432817.50
	b) Feed	90560.67	61980.02	76270.34
	c) Labourer	47060.19	5229.4.57	49677.38
	d) Liming	851.53	936.39	893.96
	e) Fertilizers and chemical application	677.08	663.16	670.12
	f) Marketing and others	4332.70	4044.46	4188.58
	Total Variable cost (VC)	658834.71	470201.15	564517.93
2. Fixed cost (FC)	a) Land rent	3246.99	3229.76	3238.38
	b) Depreciation cost for Bamboo pen	9387.47	9686.34	9536.90
	c) Depreciation cost of Guard room	1706.33	2504.73	2105.53
	d) Salary	1976	1920	1948
	Interest in Operating cost	2440.98	1742.10	2091.54
	Total Fixed cost (FC)	18757.78	19082.93	18920.35
	Total Cost (VC+FC)	677592.48	489284.08	583438.28
	Survival rate (%)	87±3	84±1	88±2
	Production (kg ha-1crop-1)	3020.63±625.22	3047.58±327.03	3034.11
	Total Revenue	1319712.08	937493.38	1128602.73

	(BDT ha-1crop-1)			
	Gross Margin (BDT ha-1crop-1)	660877.37	467292.23	564084.80
	Net Margin (BDT ha-1crop-1)	642119.60	448209.30	545164.45
	Production cost ratio	1.95	1.93	1.94
	Break even price	228.38	161.88	195.13
(Values in parentheses indicate the percent of total costs) (1$ = 79 BDT during the study period of 2014)				

Seed cost is one of the highest input costs among all cost which contributed about 74.18% of the total cost in the present survey (Figure 3). Linog (1992) also reported the seed and feed cost constitutes the major operating cost in mud crab farming. A mean total production cost per hectare per crop for crab fattening in two areas is about 583438.28 (BDT ha-1crop-1). Total variable cost in Kalapara and Galachipa is about 658834.71 (BDT ha-1crop-1) and 470201.15 (BDT ha-1crop-1) respectively. Higher fixed cost found in Galachipa region 19082.93 BDT ha-1crop-1) compare to Kalapara(18757.78 BDT ha-1crop-1). However, cost for feed was found lower in Galachipa(61980.02 BDT ha-1crop-1). Average gross revenue from two areas was about 1128602.73 (BDT ha-1crop-1). From the study the net margin in crab fattening were about 642119.60 (BDT ha-1crop-1) in Kalapara and 448209.30 (BDT ha-1crop-1) in Galachipa with production cost ratio of 1.95 and 1.93 respectively (Table 7). From the cost and return analysis the average production cost ratio (1.94) from two areas indicating that farmers are able to make profit of 0.94 BDT per 1 BDT investment. Mud crab fattening in bamboo cell-cage would be sustainable and economically viable with a gross profit of 350 BDT cage-1 in 15 days (Zafar 2004). The average net profit 227.69 (BDT per crop per meter square) is also reported by Kamal *et al.* (2007) in the southern part of Bangladesh. Figure 2 showing percent of different cost (average) for mud crab fattening.

4.2.1 Comparing of mud crab (Scylla serrata) fattening practices between two different systems in Bangladesh: bamboo cages and encircled earthen area

The ranges of water quality parameters recorded in the experimental ponds for the duration of the experiment were: salinity: 10-18 ppt; temperature: 26-31° C; pH: 7.5-8.7 and dissolved oxygen: 4.0 -7.9 mg/l. These ranges were generally within acceptable levels for mud crab fattening (Cholik and Hanafi 1992).

In encircled earthen area, crabs started to be fattened after 14 days of stocking and at 16 days all the fattened crabs were harvested from the pond but in case of cage crabs started to be fattened from 10 days and finished at 12 days of stocking. So the fattening duration was shorter in cages than the encircled earthen area. In the present research, F1 category of fattened crabs was found 87.5% in cage followed by 73.75% in encircled earthen area (Table 8). At the end of the experiment, survival rate of crab was found 93.75 ± 6.25% in cages, whereas in earthen pond it was 86.12 ± 2.16% (Table 8). The difference of survival rate was not statistically significant. Rattanachote and Dangwatanakul (1992) observed the mud crab fattening practice in earthen pond in Surat Thani province of Thailand and reported 85.20 % of survival rate and 93.77% production rate. The lower survival rate in encircled earthen pond could be due to the cannibalistic nature of mud crab. Mortality due to cannibalism has been widely documented (Iversen 1986). DA, Region VI (1988) used bamboo cage battery (with several small compartments or cubicles to accommodate a single crab per compartment) for mud crab fattening and recorded a survival of 87% which was lower than the present study. Kuntiyo (1992) showed a weight increment of 23 to 37 g and survival of 80-100%, 35 days after stocking in net cage battery. In Vietnamese intensive farming of mud crab, the stocking density was 1-1.5/m^2, achieving 1.5t/ha for each crop. After 4-6 months, the crabs achieved an average weight of 300-450g and fed with trash fish and molluscs. (Thach, 2004).Escritor (1972) concluded that cannibalism and the burrowing habitat of *SCYLLA serrata*should be controlled to minimize losses and to make the crab culture profitable. Survival in pond culture is generally lower as a result of cannibalism and escape (Liong 1992).

Table 8. Survival and harvest of different category crabs from fattening in cages and encircled earthen area (Values are means ± SD of three replicates)

Treatments	No of crab	No of crab harve	Survival (%)	Category of harvested crabs					
				F1		F2		F3	
				Nos.	%	Nos.	%	Nos.	%

	stocked	sted							
T1	16/cage (1m 2)	15±1.00	93.75± 6.25	14.33± 0.57	87.5±0.5	1.33± 0.57	6.25± 0.34	0	0
T2	80 Nos. / 40 m2 area	69±1.73	86.25± 2.16	59±1.73	73.75± 3.30	6.33± 0.57	7.5±0.42	4.33± 0.57	5± 0.5

F1: Weight of individual crab >180g with all the appendages unbroken.

F2: Weight of individual crab between 150g to 179g.

F3: Weight of individual crab between 100g to 149g.

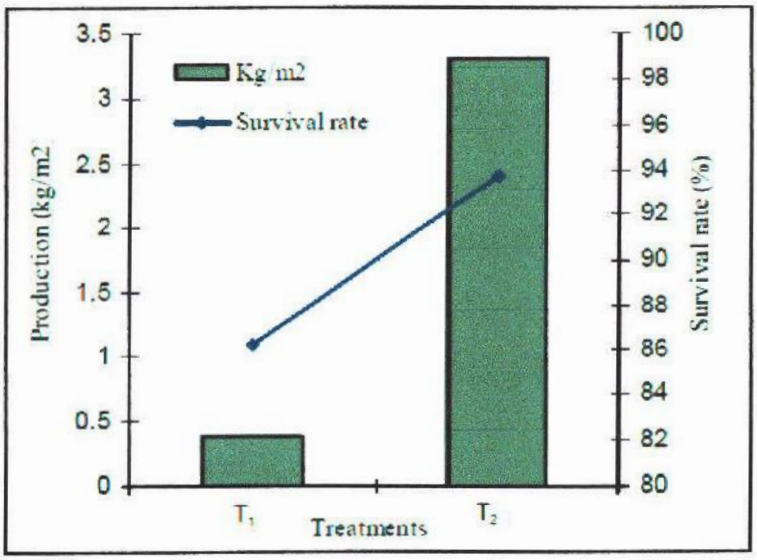

Fig.1. Production and survival rate of fattened mud crab in different treatments

Fattening of mud crab in cage shows that average weight gain was higher (16.24± 0.85 g) than the average weight gain in earthen pond (10.81±0.74 g) during the fattening period (Table 9). The difference of weight gain was not statistically ($P>0.05$) significant. Total production (F1 + F2 + F3 grade crabs) of crab from cages was found 3.30±0.08 kg/m^2, which was significantly ($P<0.05$) higher than the production of encircled earthen area (0.37±0.01 kg/m^2) (Table 9). This study revealed that better

survival and production can be attained in fattening by stocking the crabs individually which agrees with the result of Marichamy and Rajapaciam (2001).

Table 9. Production of fattened crabs in cages and encircled earthen area (Values are means± SD of three replicates)

Treatments	Initial body wt. (gm)	Final body wt. (gm)	Wt. gain (gm)	Production (kg/m2)			Total Production (kg/m2)
				F1	F2	F3	
T1	204.42±2.58	220.66±2.08a	16.24±0.85a	3.08±.07a	0.22±.01a	0	3.30a ±0.08
T2	204.42±2.58	215.43±1.91b	10.81±0.74b	0.32±.01b	0.03±.01b	0.02±.01	0.37b ±0.01
Figures in the same column with dissimilar superscripts are significantly different (P<0.05)							

Fattening of crab is profitable because of the fast turnover, low operating cost, high survival rate and good market demand for the end products (Liong 1992).The comparative benefit-cost analysis on 12 crops basis is shown in Table 3. In case of mud crab fattening using bamboo cage, the total production cost, total income and net profit were Tk 2,64,770.00, Tk 3,56,400.00 and Tk 91,630.00, respectively from 30 cage (40m2 area) within twelve crops (12 days per crop) fattening period. In case of crab fattening in encircled earthen area, the total production cost, total income and net profit were Tk 43,645.00, Tk 53,280.00 and Tk 9,3 45.00, respectively from 40m2 pond area within twelve crops (16 days per crop) fattening period. The benefit-cost ratio (BCR) of mud crab fattening were 1:1.35 and 1:1.21 in case of cage and earthen pond, respectively. Suceelan *et al.* (1995) estimated an annual net profit of Rs. 111,550 for six crops of fattening in a 0.1 ha farm (earthen pond) in Kerala backwaters. The present economic analysis revealed that mud crab fattening in cage is economically feasible and more profitable than the encircled earthen area. DA, Region VI (1988) also reported crab fattening in cages as economically viable though it requires high maintenance requirements in terms of labor (Bensam 1986).

Table 10.Comparative benefit-cost analysis of different crab fattening methods.

Treatments	Area (m2)	Produce	Income		Expenditure (Tk.)				Net profit 12 crops -1
		Quantity (kg)	Unit price (Tk.)	Total income (Quantity × unit price)	Item	Quantity	Unit cost	Total cost	
Cage (T1)	40	1188	300	3,56,400.00	Bamboo cage	30 nos.	1,000.00	30,000.00	91,630.00
					Plastic drum	20 nos.	100.00	2,000.00	
					Bamboo (cage setting)	10 nos.	120.00	1,200.00	
					Guard shade, gate	-	-	2,000.00	
					Lime & Fertilizers (organic+ inorganic)	-	-	200.00	
					Non gravid crabs (avg. 200g)	1152 kg.	150.00	1,72,800.00	
					Feed (trash fish @8%BW)	1383kg.	40.00	55,320.00	
					Wages	10 days	75.00	750.00	
					Miscellaneous	-		500.00	
					Total cost (Tk.)			2,64,770.00	
					Benefit-Cost ratio (BCR)	1:1.35			
Encircled earthen area (T2)	40	177.6	300.00	53,280.00	Bamboo fence	26 m	70.00	1,820.00	9,345.00
					Bamboo (fence setting)	05	120.00	600.00	
					Guard shade, gate	-	-	2,000.00	
					Lime & Fertilizers (organic+	-	-	2,00.00	

					inorganic)				
					Non gravid crabs (avg. 200g)	192kg	150.00	28,800.00	
					Feed (trash fish @8%BW)	230 kg	40.00	9,200.00	
					Wages	7 days	75.00	525.00	
					Miscellaneous	-		500.00	
					Total cost (Tk.)			43,645.00	
					Benefit-Cost ratio (BCR)	1:1.21			

4.2.1 Comparing cage culture and pen culture in Bangladesh

There is some confusion concerning the terms 'cage culture' and 'pen culture' in fish farming. Both terms are often used interchangeably. Both the culture types are more precisely can be termed as enclosure culture and involve holding organisms captive within an enclosed space whilst maintaining a free exchange of water. The two methods, however, are distinct from one another. A cage is totally enclosed on all sides, or all sides but the top, sides by mesh or netting. Whereas in pen culture the bottom of the enclosure is formed by the lake or sea bottom. Nylon, plastic, polyethylene and steel mesh which although much more expensive have a much longer life span and permit better water exchange. Most designs currently in use are of the floating type, and rely on a buoyant constructed either from locally available materials (e.g. wood, bamboo), or from steel or plastic pipe, and from which is suspended by a synthetic fiber net. Styrofoam or oil drums are frequently used for supplementary floatation.

Cages are usually floated in rafts, and either anchored to the pond bottom or alternatively connected to shore by a wooden walkway. Pens are still constructed in much the same way as they always were, except that nylon or polyethylene mesh nets have replaced the traditional split bamboo fences. The nets are attached to posts set every few meters, and the bottom of the net is pinned to the substrate with long wooden pegs. Buttressing may be used to strengthen the structures in exposed areas. Pens are usually built in shallow (<10m) waters, are 3-5 m deep, and 1-50 ha in size. Soft substrates are preferable.

Cages and pens have several advantages over the methods of culture. Because they use existing water bodies, require comparatively low capital outlay and use simple technology. They are popular with farmers, extension workers and development programs.

CHAPTER 5
CONCLUSION

From the result 4.1, it is revealed that there is a great potentiality in the south part of Bangladesh for mud crab fattening by the average production cost ratio (1.94) from two areas. However, the highest seed cost (which constituted about 74.18% of the total cost) and lack of proper knowledge about mud crab fattening were also reported in those studied areas.

From the results of the study 4.2, it may be concluded that fattening of mud crab in floating cage might be better than that of encircled earthen area. This result might be helpful in reducing the traditional fattening method and motivating the people to adopt the scientific method using bamboo made floating cages. Proper food management can minimize the predatory behavior of mud crab. It may help the people of the coastal region to poverty alleviation through using their water bodies by practicing this technique. Cages and pens have several advantages over the method of traditional culture. Because they use existing water bodies, require comparatively low capital outlay and use simple technology. They are popular with farmers, extension workers and development programs. The present economic analysis revealed that mud crab fattening in cage is economically feasible and more profitable than the encircled earthen area.

CHAPTER 6

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