



TRADITIONAL PRACTICE OF MUD CRAB (*Scylla olivacea*) FATTENING IN THE SOUTH WEST REGION OF BANGLADESH

Dipak Kamal, Momotaz Khanom* and Shafiq Rheman

Fisheries & Marine Resource Technology Discipline, Khulna University, Khulna 9208, Bangladesh

KUS 07/18-250607

Manuscript received: June 25, 2007; Accepted: December 10, 2007

Abstract: The state of art of traditional practice of mud crab fattening was evaluated in terms of technical and economic aspects from 30 randomly selected fattening farms at Paikgacha, Khulna during April to December 2001. Farmers fattened only lean (empty egg and/or hepatopancreas) females, of 170-200 g individual biomass that were rejected during grading at local crab landing centers, for 1-3 weeks using low cost tilapia and/or trash fish at a rate of 5-8% day⁻¹ of stock biomass. Continuous stocking and harvesting of lean and ripe females respectively was a function of availability and prices of lean individuals. Thus, maintaining a fixed stocking density was not observed. The survival and production rates were recorded at 80±14% (range: 60-100%) and 1.46±0.48 Kg m⁻² (range: 0.71-2.10) respectively. The net income of a farm with an average size of 122±22 (range 90-150) m² was recorded at Tk. 23,221±8,490 yr⁻¹.

Key words: Mud crab, *Scylla olivacea*, fattening, survival, production, cost-benefit

Introduction

Mud crab is one of the most potential exportable aqua-resources of Bangladesh (Ahmed, 1992; Khan and Alam, 1992). Continued increase in export of live mud crab plays an important role to the foreign exchange earnings of Bangladesh (Azam *et al.*, 1998). Fattening of mud crab has become a new agro-business across the coastal zone of Bangladesh (Kamal, 2002, Kamal *et al.*, 2003; Zafar, 2003, 2004) in recent years like other Southeast Asian countries (Patterson and Samuel, 2005; Anon, 2003; Williams and Primavera, 2001; Triño and Rodriguez, 2001; Agbayani, 2001; Kuntiyo, 1992; Ladra, 1992; Kristensen, 1992; Thongkum, 1988; Kathirvel, 1983). Fattening of mud crab is a holding operation of lean female or soft male crabs for a short period of time to harvest fully ripe females or hard shelled males using low cost feeds in small enclosures (Triño and Rodriguez, 2001). A number of crab fattening methods have so far been developed in the Indo-Pacific region namely, pond culture, cage culture, pen culture, polyculture with fish, shrimp and algae, etc. (Patterson and Samuel, 2005; Triño and Rodriguez, 2001;

* Corresponding author. E-mail: <momotaz_khanom@yahoo.com>, Mobile: 0119-9674361
DOI: <https://doi.org/10.53808/KUS.2007.8.2.0718-L>

Marichamy and Rajapackiam, 2001; Marichamy 1996; Babu and Monjulatha, 1995; Chong, 1995; Felix *et al.*, 1995; Kathirvel 1993; Liong, 1992).

The fattening of mud crab is growing rapidly as a new economic activity in the coastal region of Bangladesh due to high demand of large egg bearing females (body weight ≥ 180 g) and hard shelled males (body weight ≥ 400 g) and particularly due to comparatively good returns on investment in a short time period. However, the present practice of mud crab fattening is said to be traditional in nature and is mainly carried out by poor coastal communities without financial assistance from formal agencies (personal communication).

In Bangladesh, crab fattening in ponds was started in the early 1990's (Kamal, 2002), while fattening and culture of mud crab in bamboo cages, pens and pots only at experimental level were started in the early 2000's (Obayed, 1998; Kamal, 2002, 2004; Kamal and Uddin, 2004; Zafar, 2003, 2004; Khatun, 2007). Salam *et al.* (2003), using GIS tools, identified the lower South-western region as the most suitable for developing mud crab culture in Bangladesh.

Mud crab fattening and culture have been reported as sustainable and promising for the poor coastal communities from many other countries (Patterson and Samuel, 2005; Anon, 2003; Mwaluma, 2002; Trino and Rodriguez, 2002; Williams and Primavera, 2001; Ikhwanuddin and Oakley, 1999; Liong, 1993; Kuntiyo, 1992; Ladra, 1992; Liong, 1992). Unfortunately, about 30-45% (Kamal *et al.*, 2003; Khan and Alam, 1992) of the harvested crabs do not reach to the consumers table due to transport mortality and rejection at various stages of handling prior to export (Kamal *et al.*, 2003; Ladra and Lin, 1992). Sustainable development of mud crab fattening could reduce the current loss of rejected but valuable crab resource and could provide alternate livelihood to the millions of coastal poor especially shrimp fry collectors or forest byproduct harvesters.

In view of the above, the present study was made to assess the distribution of crab fattening farms and the state of art of traditional mud crab fattening practiced by local farmers in terms of technical and economic aspects from the South-western Paikgacha *Upazila* under Khulna district of Bangladesh.

Materials and Methods

Study area: Several field visits were made in three coastal districts, namely Bagerhat, Khulna and Satkhira (Fig. 1) to assess the distribution of mud crab fattening farms. The technical (farm size and design, pond management, species, stocking, fattening period, food and feeding, method of harvesting, survival rate, production rate) and economic (various costs and benefits) aspects of mud crab fattening by the local farmers were evaluated. For this data were collected through a prescribed questionnaire from randomly selected 30 fattening farmers from three different locations of Paikgacha *Upazila*, namely- Shibsha River Ghat, Kapilmuni and Shamukpota, between April and December, 2001. The species used in fattening in the area was identified as *Scylla olivacea* following Kennan *et al.* (1998) and Keenan (1999).

The survival and production rate of fattened crabs were calculated following Rattanachote and Dangwatanakul (1991):

Survival rate (%) = (No. of crab caught/No. of crab stocked) X 100).

Production rate (Kg m^{-2}) = Weight harvested / Pond size (m^2);

Production rate (%) = (Weight harvested / Weight stocked) x 100.

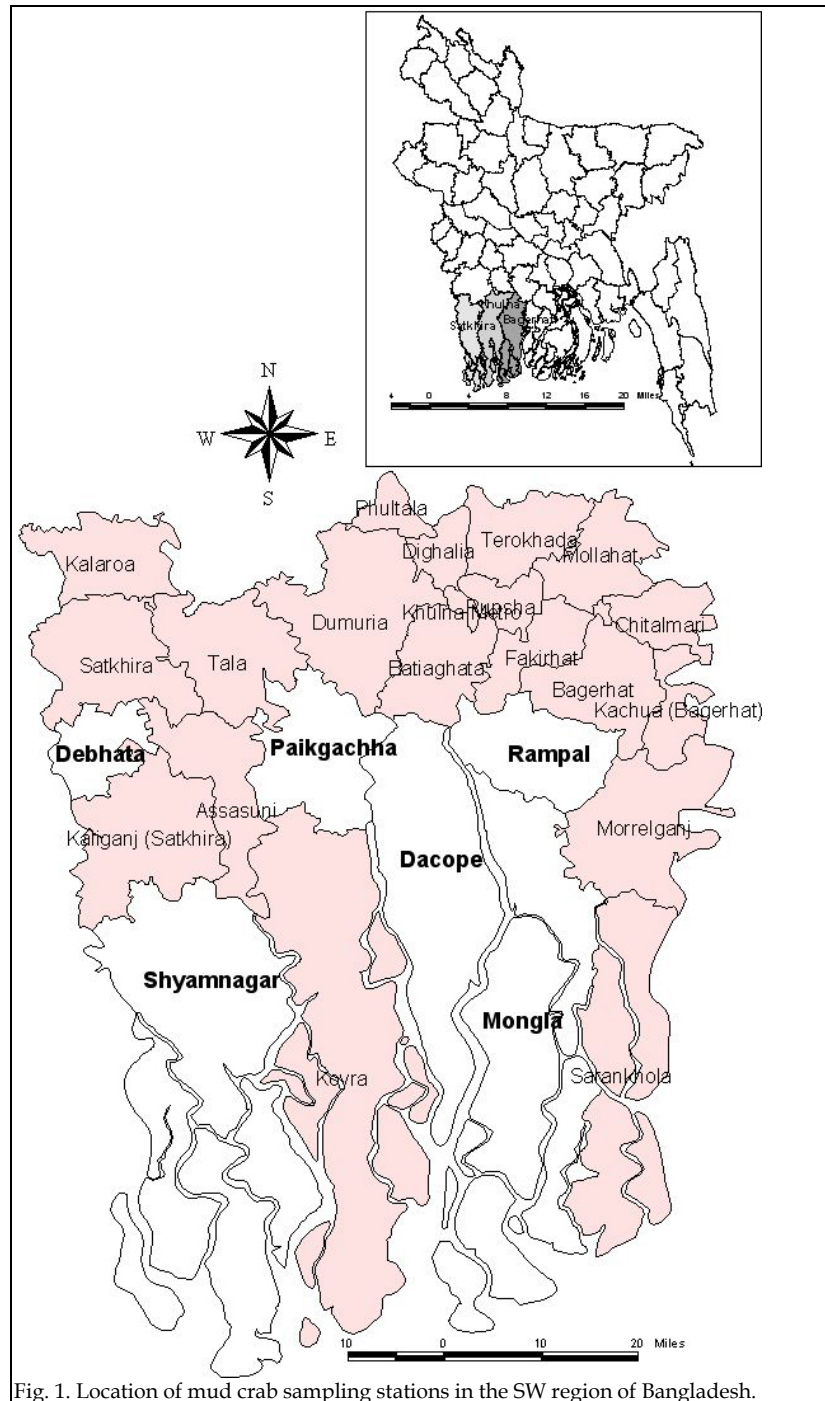


Fig. 1. Location of mud crab sampling stations in the SW region of Bangladesh.

Economic analyses: Different types of costs and returns were analysed through standard production economics on mean values of 30 crab fattening farms following Shang (1990).

Statistical analysis: All the statistics (mean, SD, correlation coefficients, and regression) among different variables were analysed and graphically presented by using the Microsoft Excel Software.

Results

Distribution of crab fattening farms: The location, number of mud crab fattening farms and manpower involved are shown in Fig. 1 and 2. The maximum and the minimum fattening farms and manpower involved were found in Khulna and Satkhira district respectively (Fig. 2). Again in Khulna district, the maximum number of farms (614 no) and manpower (1597 person) were recorded in the Paikgacha Upazila and the minimum number of farms (125 no) and manpower (325 person) were found in the Dacop Upazila (Fig. 3). Most of the fattening farms are established near the bank of a river or a canal where brackishwater was available throughout the year (Photo 1). Most of the family members work in their farms beside their regular economic activities.

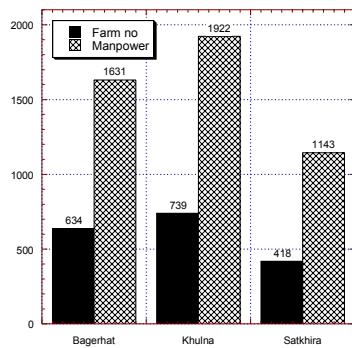


Fig. 2. Distribution of mud crab fattening farms and manpower in three South-western districts of Bangladesh.

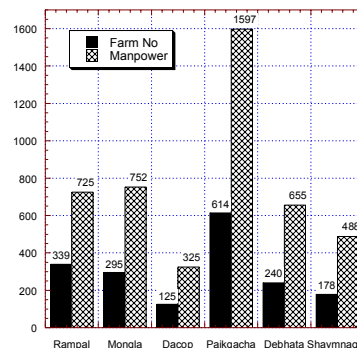


Fig. 3. Distribution of mud crab fattening farms and manpower in six South-western Upazilas of Bangladesh.

Farm size and design: The size of mud crab fattening ponds varied between 90 and 150 m² with a mean size of 122.22±21.81 m². Almost all the ponds were found rectangular in shape with a common inlet and outlet made of PVC pipes. In most of the farms (>95%) water was exchanged twice a month, during the new and full moon spring tides. Usually a single pond was divided into 3-4 components (Photo 1) or more (Photo 2) by using bamboo fences (*bana*) of 1-2 m high (Photo 3). The pond depth varied from 1 to 1.5 m with the depth of water in the pond between 0.5 and 1.0 m. Some fatteners used fine nylon mosquito net (locally called '*Moshari jal*') or medium mesh nylon nets (Photo 1, 2) around the bamboo fencing in order to prevent escaping stocked crabs from the pond. Each fattening farm has small hut (Photo 4) made of dried *Nypa* leaf and bamboo used to stay night guard and to keep relevant materials (bamboo pens, bamboo baskets, ladder, scoop net and feed, etc.).

Farm management: Most of the fattening farms (90%) did not follow any post-stocking management except the water exchange through natural tidal flow twice a month and daily application of fresh trash or Tilapia fish as feeds. Some fatteners (20%) did exchange old water only before stocking new batch of crabs or when water quality

became severely polluted due to uneaten food materials. Farmers did not use any kind of fertilizer or lime in their ponds before or after stocking.

Species and sex: Almost all the farmers fatten only a single species available in the region, i.e. red mud crab (*Scylla olivacea*). All the farmers were found to fatten only female mud crab.



Photo 1. A mud crab fattening farm at Paikgacha, Khulna.



Photo 2. A series of bamboo pens constructed in an earthen pond.



Photo 3. Bamboo fence used in making pens in earthen ponds.



Photo 4. A guard room beside the fattening farm.



Photo 5. Selling fattened crabs at local landing center.

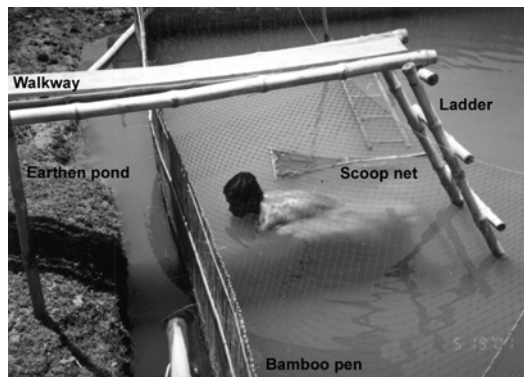


Photo 6. Partial harvesting by hand picking.



Photo 7. Selective harvesting with scoop net



Photo 8. Fatteners packing basket full with harvested crabs.

Stocking: Most of the farmers stocked their ponds with rejected grade (lean or empty, body weight 170-200 g) female crabs, locally called '*khosha*'. Farmers mainly collected these rejected crabs from crab trading depots and from nearby shrimp ponds (*gher*). Stocking was done during early morning or late evening. However, there was peak and lean season in mud crab fattening-the peak season was winter and the lean was summer. However, a few (20%) farmers continued crab fattening throughout the year. Most of the farmers stocked and harvested their ponds simultaneously.

Stocking density: Fatteners did not maintain any stocking density during stocking seed crabs. However, stocking density varied from <1 to > 3 (0.72-3.50) individual m^{-2} with a mean density of 1.97 ± 0.96 individual m^{-2} (Table 1).

Fattening period: The period of fattening varied from one to three weeks depending on the stage of maturity of the gonad and/or hepatopancreas and prices of fattened crabs in the depots. Some farmers (~15%), however, kept fattened animals in their ponds for extended period of time, usually additional 1-2 weeks, in order to get good prices.

Harvesting method: Only fattened individuals, i.e. carapace is full with hepatopancreas and/or gonad, were harvested regularly. Harvestable crabs were checked by light

Table 1. Production parameters for traditional mud crab fattening practice in Paikgacha, Khulna Bangladesh (n = 30).

Parameters	Mean \pm SD	Range	
		Mini.	Max.
Pond size (m^2)	122 \pm 22	90	150
Fattening period (days)	12 \pm 5	7	21
Crab stocked (no)	241 \pm 119	65	450
Crab stocked (Kg)	45 \pm 20	15	80
Stock size (g)	192 \pm 11	170	200
Stocking density (indv. m^{-2})	1.97 \pm 0.96	0.72	3.5
Crab harvested (no)	180 \pm 67	65	293
Crab harvested (kg)	37 \pm 12	15	56
Survival rate (%)	80 \pm 14	60	100
Production rate (%)	87 \pm 15	63.64	100
Production rate (kg m^{-2})	1.46 \pm 0.48	0.72	2.10

Table 2. The regression equation parameters (a, b) and correlation coefficients among stocking density, survival rate and production rate in mud crab fattening practice.

Relationships	Regression parameters		r^2	n
	a	b		
Production rate vs. stocking density	-13.802	110.64	0.8608	30
Survival rate vs. stocking density	60.08158	7.341411	-0.7	30
Survival rate and production rate	-0.54757	0.011354	0.619	30

a= intercept ; b= slope; r= correlation coefficient; n= sample size.

examination at the anterolateral sides of carapace of the animals (Photo 5). Fattened crabs showed no light penetration through the carapace. Unfattened individuals were returned to the pond. Farmers usually check their stock daily and fattened ones are harvested. A continuous selective harvesting regime with baited traps and/or small scoop net was common practice (Photo 6-7). The fattened crabs were taken out from the pond by using a small push net. A few fatteners, however, found to use bare hands for harvesting fattened individuals. Total harvesting was done at the end of fattening season by hand after dewatering the pond. Each harvested crab was tied with nylon threads, kept in bamboo basket (Photo 8) and transported immediately to the nearby crab landing center by tricycle van.

Survival rate: The mean survival rate of fattened crab in traditional method was estimated at $80 \pm 14\%$ with a range from 60 to 100%. The survival rate showed a significant negative correlation with the stocking density ($r^2=0.7$, $p<0.05$).

Production: The estimated production parameters are shown in Table 2. The production rate was found to vary from 0.72 to 2.1 Kg m⁻² with a mean production rate of 1.46 ± 0.48 Kg m⁻² (Table 2). The relationship among the production rate,

Table 3. Cost-benefit analyses of traditional mud crab fattening in a cycle (7-21 days) for an average 121.5 ± 20.69 m² farm area in Paikgacha, Khulna (n = 30).

Variables	Average \pm SD	Range	
		Minimum	Maximum
1. Farm area (m ²)	122.22 \pm 21.81	90	150
2. Fattening period (days)	11.89 \pm 5.44	7	21
3. Stocking (kg)	45 \pm 19.84	15	80
4. Price of crab seed (Tk. kg ⁻¹)	81.67 \pm 6.61	75	90
5. Selling price (Tk. kg ⁻¹)	197.22 \pm 12.53	185	220
6. Production (kg crop ⁻¹)	36.78 \pm 12.01	15	56
7. Feed used (kg)	29.61 \pm 22.76	5.25	72
8. Price of feed (Tk. kg ⁻¹)	22.78 \pm 4.41	20	30
9. Number of crop year ⁻¹	10.78 \pm 2.05	8	14
Total Costs per Crop (Tk.) (A+B):	4957.70 \pm 1979.65	1912.98	8504.41
A. Variable Costs per Crop (ΣA1-A5):	4620.961 \pm 1890.73	1691.25	7800
A1. Seed (Tk. crop ⁻¹)	3569.444 \pm 1369.864	1350	6000
A2. Feed (Tk. crop ⁻¹)	669.5833 \pm 497.5157	131.25	1440
A3. Labour (Tk. crop ⁻¹)	284.4444 \pm 78.12028	180	420
A4. Transport (Tk. crop ⁻¹)	73.5555 \pm 24.0162	30	112
A5. Nylon threads (Tk. crop ⁻¹)	35.91111 \pm 13.37577	13	58
B. Fixed costs per Crop (ΣB1-B5):	336.7394 \pm 117.7288	178.73	533.81
B1. Lease (Tk. yr ⁻¹)	179.347 \pm 60.99832	96.23	280.68
B2. Bamboo pen*	83.51167 \pm 31.79718	42.86	137.5
B3. Netting *	47.92267 \pm 16.29915	25.71	75
B4. Hut*	13.97745 \pm 4.753918	7.5	21.88
B5. Scoop net, basket, ladder etc.*	11.98067 \pm 4.074787	6.43	18.75
C. Profitability			
Total investment (Tk.)	4921.79 \pm 2769.85	6546.52	16291.05
Revenue per crop (Tk.)	7149.444 \pm 2055.776	3150	10360
Production cost/Kg (Tk.)	132.499 \pm 15.65477	122	160.24
Return on Investment (%)	151.4077 \pm 25.47932	115.41	193.33
Pay back period (Days)	8.596665 \pm 5.400551	4.03	17.32
Braek-even quantity (Kg)	25.70107 \pm 11.40399	9.11	45.97
Break-even price (Tk.)	132.499 \pm 15.65477	113.79	160.24
Gross profit/crop (Tk.)	2528.483 \pm 802.6987	1070	3280.4
Net profit/crop (Tk.)	2191.744 \pm 744.8517	1237.02	2867.59
Gross profit/crop (Tk./m ²)	259.2708 \pm 136.091	113.78	451.02
Net profit/crop (Tk./m ²)	227.6988 \pm 126.1495	43.32	409.66
Gross profit/yr (Tk)	26652.1 \pm 8734.961	12840	37886.4
Net profit/yr (Tk.)	23220.62 \pm 8490.175	10397.73	34411.02
BCR	1.514077 \pm 0.254793	1.15	1.93

* 3 yr lifetime; ** based on 10 crops/yr

survival rate and stocking density in the investigated farms are given in Table 3. The relationship between production rate and stocking density was found to be positive and significant ($r^2=0.86$, $p<0.05$). Similar relationship was noticed between production rate and survival rate ($r^2=0.619$, $p<0.05$). However, a significant inverse relationship was found between survival rate and stocking density ($r^2=0.7$, $p<0.05$).

Cost benefit analysis: The cost-benefit analyses of 30 traditional mud crab fattening farm was performed on the mean values on a single cycle and are shown in Table 3. The mean net income from a farm with an average size of 122 ± 22 m² was Tk. 23,221 \pm 8,490 from 10 crops in a year on average. The mean benefit cost ratio per farm was estimated for a cycle at 1.514077 ± 0.254793 (range 1.15-1.93).

Among variable costs, the major cost involvement was the price for seed crab, which varied from Tk. 1,350 to 6,000 with a mean value of Tk. 3,569 \pm 1,370 crop⁻¹. The minimum variable costs involved was the cost for tying harvested crab using nylon threads (Tk. 36 \pm 13 crop⁻¹). Among different fixed costs (lease, labor and construction materials), the land lease cost was found to be the highest (Tk. 179 \pm 61 crop⁻¹) followed by bamboo pen (Tk. 84 \pm 32 crop⁻¹), nylon netting (Tk. 48 \pm 16 crop⁻¹), guard room (Tk. 14 \pm 5 crop⁻¹) and scoop net, ladder, basket etc. (Tk. 12 \pm 4 crop⁻¹). The average gross and net profit per crop from a traditional mud crab farm with an average size of 122 ± 22 m² was estimated at Tk. 2,528 \pm 800 and 2,190 \pm 744 respectively (Table 3).

Discussion

Distribution of crab fattening farms: Most of the crab fattening farms are around the crab landing centers, within the impact zone of the Sundarbans (20 km around the reserved forest), mainly due to the availability of seed crabs, low cost trash fish, and ready market to sell out fattened crabs. Large number of fattening farms in Paikgacha and Rampal Upazila could be due to the presence good communication facilities to both the Sundarbans and traditional shrimp *ghers*, the major sources of wild crab harvesting, by water ways and to the export point in the capital city, Dhaka by road. Sometimes, a considerable volume of (5-20% of harvested crabs) rejected crabs are returned from Dhaka during export grading to these landing centers to sell out to the fatteners at lower prices. However, the quality of these rejected crabs become poor due to double transport stress.

Species and sex: Of the four mud crab species available in the Indo-Pacific region (Kennan *et al.*, 1998) only the red mud crab (*Scylla olivacea*) is being fattened in the SE region of Bangladesh (Ahmed *et al.*, 2005). What Zafar (2003, 2004) reported from the east coast of Bangladesh as *S. serrata* would be *S. olivacea* (Ahmed *et al.*, 2005). The other three species, namely, *S. serrata*, *S. tranquibarica* and *S. paramamosain* are being fattened in other Asian countries (Patterson and Samuel, 2005; Triño and Rodriguez, 2001; Kenan, 1997; Rattanachote and Dangwatanakul, 1992; Ladra, 1992; Liong, 1992). Only female crabs were found to fatten in the study region because its price was 2-3 times higher than that of male crabs against the same fattening period and feed costs. By 2004, however, local fatteners became familiar with the fattening of soft-shelled male mud crabs mainly due growing demand and corresponding price hike for male crabs in the international

markets. Zafar (2004) and Khatun (2007) studied on both male and female crabs in their experimental studies.

Pond size and design: Small bamboo pens installed in earthen ponds was found as the single means of crab fattening in this study. Single celled cage, net cage, floating net cages, popular in many SE Asian countries (Rattanachote and Dangwatanakul, 1992; Liong, 1992; Kennan, 1997) were not found in the study area. The cemented tank has reported not to be suitable at all for fattening mud crab (Bede and de Silva, 1992). Salam and Hasan (2004) and Kamal (2002) have reported fattening practice of mud crab in small bamboo pens installed in earthen ponds. The average size of mud crab fattening ponds in Surat Thani province of Thailand was around 270 m² (Rattanachote and Dangwatanakul, 1992). The pens observed in the present investigation were comparatively smaller in size than that of other SE Asian countries (Table 4). The reason for the smaller pen size is they are mostly managed by the family members. However, in an experiment, Obyed (1998) used 600 m² pens in earthen pond for fattening mud crab at Mongla, Bagerhat, Bangladesh. In another experiment, Zafar (2004) conducted comparative fattening study of *S. serrata* in single-celled bamboo cage (30 cells cage⁻¹, 1.5 ft long and 8 inch wide) and bamboo pens (30x30 m) installed in earthen ponds in the Chakaria Sundarbans of Bangladesh.

Food and feeding: Low cost trash fish was found as the main food used in mud crab fattening both in home (Obyed, 1998; Kamal, 2002; Salam and Hasan, 2004) and abroad (Rattanachote and Dangwatanakul, 1992; Nazar, 2003). However, coastal crab fatteners in Bangladesh were found to use shrimp head, mussel meat and tilapia (Salam and Hasan, 2004), low cost fresh and salted eels (*Anguilla* sp.; Zafar, 2004), mixture of different locally available ingredients e.g., trash fish, soft-shelled snails, bivalve meat, mussel or clam meat, crustaceans, animal entrails etc. (Nazar, 2003). The traditional mud crab fatteners used trash fish and horse mussel to feed their stock (Hanvivatanaki, 1990). Most of the research workers used 5% feed to biomass of the stocked animals applied once or twice a day (Zafar, 2004; Obyed, 1998; Nazar, 2003). The crabs were fed with fresh trash fish at the rate of 10-15% of body weight per day and mortality during fattening varied from 10-15% (Cholic and Hanafi, 1992). In Taiwan fatteners fed larger size stock (8-12 cm carapace width with stocking density of 2-4 m⁻²) once a day at rate of 200 g trash fish per crab and live snail at 100 m⁻² (Sivasubramaniam and Angel, 1992). Obyed (1998) found FRC at 1.8 with trashfish.

Stocking and stocking density: The stocking practice was found to be fully dependent on the supply of rejected grade crabs from local crab landing centers (depot) and the price. The variation in stocking density among the farms was mainly due to availability of lean crabs from various sources. Obyed (1998) used a stocking density of 0.8 crab m⁻² for fattening. Zafar (2004) stocked 120 crabs (60 male and 60 female) in open cage (without chamber) system and 60 crabs in 60 celled cage, one male (160-180 g) or female (140-160 g) in every compartment (1x60). Keenan (1997) practiced crab fattening in pond at a stocking rate of 10 individual m⁻² for 30 days. A stocking density of 2 individual m⁻² in pen system was used in Indonesia (Cholik and Hanafi, 1992). The Taiwanese traditional mud crab fatteners used a stocking density 2-4 individual m⁻² (females of 8-12 cm

carapace width) which was reduced to 1 individual m^{-2} during the summer (Sivasubramaniam and Angel, 1992).

Fattening period: Fatteners usually identify a fully ripe female by examining the anterolateral sides of the carapace using torch-light or against sunlight. No light passes through carapace in females with fully mature ovary and/or hepatopancreas. In Bangladesh, Salam and Hasan (2004) reported 12-15 days fattening period for female crabs in bamboo pens. Zafar (2004) harvested berried females from pot culture after 14 days of stocking. Zafar (2004) fattened *S. serrata* in 14-15 days in bamboo cell cage (30 cells cage^{-1}) and earthen ponds. The fattening period in the present investigation was 7-21 days, which is comparatively shorter than that in SE Asian countries (15-35 days) (Triño and Rodriguez, 2001; Keenan, 1997; Liong 1993; Macintosh *et al.*, 1993; Chollik and Hanafi 1992; Ladra 1992; Rattanachote and Dangwatanakul, 1992; Sivasubramian and Angell 1992).

Survival rate: The survival rate ($80 \pm 14\%$, range 60-100%) found in the present study is closer to that (85.20%) reported for *S. serrata* from traditional fattening farms in Surat Thani, Thailand (Rattanachote and Dangwatanakul, 1992); 80-100% for *S. serrata* fattening in earthen pond in the Philippines (Kuntiyo, 1992); 80-85% for *S. serrata* with a stocking density of 10 individuals m^{-2} from Australia (Keenan, 1997). Obayed (1998) reported a poor survival rate (55%) in a mixed sex (male and female) fattening experiment at Mongla, Khulna due to aggressive behaviour of males over females. The lower survival rate ($80 \pm 14\%$) observed in the present study in comparison with 88-100% of Zafar (2004), 88.33% of Kamal (2004) and 90% of Saha and Ahmed (1999) from Bangladesh could be due to higher stocking densities used by the traditional farmers. Therefore, an inverse relationship was found between the stocking density and survival rate. Gunarto and Chollik (1990) reported the survival rate of 77.05%, 49.17% and 32.06% at stocking density of 1, 3 and 5 crab m^{-2} respectively. Zafar (2004) also observed 91.90%, 64.13% and 42.16% survival with stocking densities 1, 2 and 4 crabs m^{-2} respectively from SE coast of Bangladesh.

Mortality of crab due to cannibalism has widely been documented as a serious problem in crab fattening (Triño and Rodriguez, 2001; Bede and De Silva, 1992). Kuntiyo (1992) suggested to use several small compartments or cubicles to accommodate a single crab per compartment or a net cage battery to overcome this problem. Zafar (2004) achieved 100% survival when used single celled bamboo cage in mud crab fattening. Higher survival rate has been reported as the function of lower stocking density in mud crab fattening and culture by many workers (Trino *et al.*, 1999; Gunarto and Chollik, 1990; Baliao *et al.*, 1981).

However, Triño and Rodriguez (2001) attributed sex (male) as the factor for lower rate of survival (86.9 ± 1.88) in mixed sex fattening than in monosex fattening due to aggressive behaviour of male crabs over the females. Chollik and Hanafi (1992) suggested that mixed sex culture enhances cannibalism. Zafar (2004) observed culture system as a factor affecting mortality, being no mortality of females and only 3.33% mortality of males in cage system and 3-12% mortality in pond system. Zafar (2004) reported seasonal variation (salinity and temperature) as the key factors for the variation in growth and mortality in both the fattening systems (cage and pond). A higher mortality has been

attributed to transportation stress as Liong (1991) observed that the survival rate of local crabs was higher (>90%) than that of imported crabs (60-80%).

Growth and production: Zafar (2004) observed comparatively higher growth rate in male crabs than that of females. Zafar (2004) obtained mean growth of female crabs at 16.00 ± 4.68 g in 15 days in bamboo pots and 0.34 g crab⁻¹ day⁻¹ in earthen ponds. Zafar (2004) observed comparatively higher average daily growth in cage system (1.12 g indiv.⁻¹ day⁻¹) than the earthen pond (0.51 g indiv.⁻¹ day⁻¹). In general, the juvenile crabs showed an increase of 60-120% of its body weight at each moult (Nazar, 2003). Obyed (1998) found the specific growth rate (SGR) of mud crab in fattening pond at 2% day⁻¹. Rattanachote and Dangwatanakul (1992) reported a weight increase of 40.92-69.58 g and 118.36-144.27 g for female and male crabs respectively in 30 days with 500 m² pond with a stocking density of 3-5 crabs m⁻². Triño and Rodriguez (2001) observed a production rate of fattened mud crab in 20-30 days for monosex male, female and mixed sex at 17.9 ± 44.3 , 15.9 ± 39.3 and 14.2 ± 30.4 Kg per 150 m² pond respectively. A comparison of pond size, stocking density, survival rate and production rate in traditional fattening practice of mud crab from different sources is given in Table 4.

Cost benefit analysis: Liong (1992) attributed mud crab fattening as lucrative and it possess large turnover rate. Similar trend was seen in the present investigation in Bangladesh as the net profit margin of Tk. 228±126 (range 43-410) per crop per square meter pen area is quite satisfactory for poor landless coastal people of Bangladesh in comparison with any other available businesses in the region. Zafar (2004) attributed that mud crab fattening in bamboo cell-cage was sustainable and economically viable as higher gross profit (Tk. 350 cage⁻¹ in 15 days) was obtained with bamboo cell-cage than the earthen pond (Tk. 224 pond⁻¹ in 15 days). Liong (1992) reported that the purchase of stockable crab and trash fish constitutes the major operating expense. Liong (1992) mentioned the high profit rate in pond system mainly due to low operating cost. However, the scale of operation is much smaller, and, hence, total returns or net income, may not be too impressive (Liong, 1992). The similar trend was also noticed in the SW region of Bangladesh.

Mud crab in live condition is being exported mainly to SE Asian countries (Azam et al, 1998) and the price of mud crab is usually higher than that of fish and mollusks in those countries (Agbayani, 2001) which is expected to increase in the world market in future. However, the increasing prices for large sized seed crabs set the main constraints in mud crab fattening by the resource-poor fatteners in the study area. Agbayani *et al.* (1997) reported that the demand for mud crab is price-elastic in Bangladesh, India, Sri Lanka, Indonesia, and the Philippines. Demand increases as the price decreases.

Problems: The key problems in mud crab fattening in the study area include- i) insufficient supply of the post-moult lean crab for fattening; ii) high investment cost for making bamboo pen; iii) inconsistent supply and higher price of trash fish; iv) inconsistent prices of seed and fattened crabs at local markets; and, v) poor credit facilities to the poorest group.

Kamal, D.; Khanom, M. and Rheman, S. 2007. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*, 8(2): 269-285.

Table 4. A comparison of production parameters for different types of crab fattening methods in South and SE Asia.

Source	Triño and Rodriguez, 2001	Keenan, 1997	Keenan, 1997	Keenan, 1997	Ladra, 1992	Rattanaachote and Dangwatanakul, 1992.	Liong, 1992	Bede and Silva, 1992	Zafar, 2004	Kamal, 2004	This study
Method	Pond	Pond	Cage	Mangrove enclosure	Fish pond	Pond	Floating net-cage	Shrimp pond	Cage	Pen	Pond
Location	Tigbauan, Iloilo Philippines	Sarawak	Semarang	Sarawak	Aklan, Philippines	Surat-thani, Thailand	West coast of Malaysia	NE coast, Lanka	Sri SE coast, Bangladesh	SW Bangladesh	SW Bangladesh
Species	<i>S. serrata</i>	<i>S. olivacea</i> <i>S. tranquebarica</i>	<i>S. paramamosai</i>	<i>S. olivacea</i> <i>S. tranquebarica</i>	<i>Scylla</i> sp.	<i>S. serrata</i>	<i>S. serrata</i>	<i>S. serrata</i>	<i>S. serrata</i>	<i>S. olivacea</i>	<i>S. olivacea</i>
Sex	M, F (M+F)	(M+F)	(M+F)	(M+F)	(M+F)	M, F	(M+F)	--	F (M+F)	F	F
Fattening period (days)	20-30	30	20	120	10-15	20-30	2-14	35	21	30	7-21
Pond/Enclosure size (m ²)	150	8000	9	200	500	500-800	3m x 3m x 2m; 3-5 cm mesh; 40-200 cages	0.4 ha, 3 compartments with wire mesh	483.92	100	122±22 (7-21)
Stocking density	0.25-0.5 indv. m ⁻²	10 indv. m ⁻²	10 indv. m ⁻²	3 indv. m ⁻²	2-3 indv. m ⁻²	3-5 indv. m ⁻²	30-60 kg cage ⁻¹		0.5, 0.33, 0.5	0.25-1	2.12±0.903
Seed size (g):	M: 286±1.2-338-3.1 F: 267±0.9-338-2.8 Mixed: 338±3.4	250	350	85	150-200	200-400	Minimum 150		F: 140-160 M: 160-180	100-130	170-200
Harvesting method	Partial with baited liftnet & drained with scoopnet	--	--	--	--	1. Partial with scoop net 2. Full with rack 3. Iron hook	Selective, daily	Partial	Complete hand picking	Complete, hand picking	Partial, hand picking
Harvesting size (g):	M: 496-520 F: 432-484 Mixed: 517	--	--	--	--	--	--	--	M: >400 F: >180	163-204	≥180
Feeding rate (% stock biomass)	10	2.5%	5%	5%	5-8	7-10		8 kg 100 ⁻¹ animals day ⁻¹	5-10	5	5-8
Food items	75% Mussel+25% 25% fish bycatch	Trash & offal	Dried fish & crabs	Trash fish	kitchen leftovers, fish & animal entrails, swine manure, snail	Trash fish	Trash fish, fish offal	Trash fish, fish offals, clam	Fresh eel+ salted eel	Trash fish+ Tilapia	Trash fish+ Tilapia
FCR	--	--	--	--	--	--	1	--	--	1.95	--
Cover/Encloser	--	Vegetated centre mound	Small branches	Mangroves	Bamboo or plastic polyethelene netting	1 m high bamboo pens	Vegetation	Rocks, deadwood, old tyres.	Bamboo cage		Bamboo pens
Survival rate (%)	51-55	70-90	85	85	--	85.2	60-90	--	85-91.5	88.33	80±14%
Production rate (%): Wt. harvested /Wt. stocked (kg) x 100		1.5	1.07	2.5	1.55	93.77		20.21 ha ^{-0.4}			87±15
Production rate (kg/100m ²)	M-17.9 F-15.9 Mix.-14.2				33	14.03-22.45			14.2-17.9		146±48

Conclusion

Mud crab fattening in bamboo pens in earthen ponds has been found economically viable for the resource-poor coastal people. Future expansion of crab fattening would reduce considerable loss (>30%) of harvested crabs during grading for export. Considering the constraints mentioned above, measures are to be taken to enhance supply of seed crabs, to develop low cost supplementary feeds and to provide micro-credit to the poorest part of the coastal population in order to ensure continued growth in mud crab fattening business across the coastline of Bangladesh.

References

- Agbayani, R.F. 2001. Production economics and marketing of mud crabs in the Philippines. *Asian Fisheries Science*, 14: 201-210.
- Agbayani, R.F.; Belleza, E.T. and Agbayani, E.C. 1997. Aquaculture Economics in Asia and the Pacific: A Regional Assessment. Food and Agriculture Organization of the United Nations. Rome. p 35-80.
- Ahmed, A.T.A.; Hossain, M.N. and Iqbal, M. 2005. Taxonomic status of the mud crab, *Scylla olivacea* (Herbst, 1796) in Bangladesh. *Bangladesh Journal of Zoology*, 33(2): 125-135.
- Ahmed, K. 1992. Mud crab: a potential aqua-resource of Bangladesh. pp. 95-102. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Anil, M.K. and Suseelan, C. 2001. Experimental fattening of the green mud crab *Scylla oceanica* (Dana). pp. 95-110. In: Menon, N.G. and Pillai, P.P. (eds.), *Perspective in Mariculture*. The Marine Biological Association of India, Kochi.
- Anon. 2003. Myanmar aquaculture and inland fisheries. RAP Publication 2003/18, FAO Regional Office For Asia and the Pacific, Bangkok, 62 pp.
- Azam, K.; Kamal, D. and Mostafa, M. 1998. Status and potential of mud crab (*Scylla serrata*) in Bangladesh. pp. 150-160. In: Rahman, M.A.; Shah, M.S.; Murtaza, M.G. and Matin, M.A. (eds.), *Proceedings of the National Seminar on Integrated Management of the Ganges Floodplains and Sundarbans Ecosystem*. Organized jointly by Khulna University, Bangladesh Agricultural Research Council and Department of Agricultural Extension, Khulna University, Bangladesh.
- Babu, D.E. and Manjulatha, C. 1995. Methods in crab culture –a need in Indian coastal aquaculture. *Fish Chemistry*, 15(7): 41-43.
- Baliao, D.D.; Rodriguez, E.M. and Gerochi, D.D. 1981. Culture of mud crab *Scylla serrata* (Forsk.) at different stocking densities in brackishwater ponds. Quarterly Research Report, SEAFDEC Aquaculture Department, Manila, 5(1): 10-114.
- Bede, D. and de Silva, D. 1992. Results of trails of mud crab (*Scylla serrata*) fattening. pp. 155-159. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Cholik, F. and Hanafi, A. 1992. A review of the status of the mud crab (*Scylla serrata*) fishery and culture in Indonesia. pp. 13-25. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Chong, L.P. 1995. Crab culture present status and future prospects. *Fish Chemistry*, 15(4): 39-43.

- Kamal, D.; Khanom, M. and Rheman, S. 2007. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*, 8(2): 269-285.
- Felix, S.; Gazendran, M. and Subramaniam, S. 1995. Aquaculture of mud crab. *Seafood Export Journal*, 26(6): 5-6.
- Gunarto and Cholik, F. 1990. Effects of stocking densities on mangrove crab (*Scylla serrata*) in ponds. *Coastal Aquaculture Research Journal*, Manors, Indonesia, 12(2): 55-61.
- Hanvivatanaki, P. 1990. Cost and returns of crab fattening in Surat Thani provinces. Bay of Bengal Programme, Madras, India.
- Hossain, M.N. and Ahmed, A.T.A. 2006. Crafts and gears used in catching mud crab, *Scylla olivacea* (Herbst) in Bangladesh. *Journal of the Asiatic Society of Bangladesh*, 32(1): 1-10.
- Ikhwanuddin, A.M. and Oakley, S. 1999. Culture of mud crabs in mangrove areas: the Sarawak experience. pp. 1-7. In: Mackintosh, D. (ed.), *Proceedings of the Regional Workshop on Integrated Management of Mangrove/Coastal Ecosystems for Sustainable Aquaculture Development*. March 23-25, 1999, Inland Fisheries Division, Department of Agriculture, Kuching, Sarawak, Malaysia.
- Kamal, D. 2002. Development of fattening technology for the mud crab (*Scylla serrata*) in small ponds with special reference to biology, nutrition, microbial quality, marketing and transportation from the South-Western region of Bangladesh. Final Report, Action Research for Poverty Alleviation Project, Grameen Trust, Grameen Bank Bhaban, Dhaka, Bangladesh, 91 pp.
- Kamal, D. 2004. Action research on the development of appropriate technology for mud crab (*Scylla olivacea*) culture through active participation of poor women in the impact zone of the Sundarban mangrove forest, Bangladesh. Final report, Research Initiatives, Bangladesh (RIB), Dhaka, Bangladesh.
- Kamal, D. and Uddin, M.F. 2004. Performance of mud crab (*scylla olivacea*) culture in bamboo pens at different stocking densities from Southwest Bangladesh. Paper presented at the 7th Fisheries Forum held at Hotel Equatorial, Penang, Malaysia, 30 November- 4 December, 2004. The Book of Abstract, p. 83, 7th Asian Fisheries Forum 2004, Forwarded by Gupta, M.V., Chair of the Science Committee, 420 pp.
- Kamal, D.; Tapadar, M.S. and Uddin, M.F. 2003. Production, marketing and transportation of mud crab (*Scylla olivacea*) from the southwestern region of Bangladesh. pp. 123-143. In: Murtaza, M.G. (ed.), *Proceedings of the Seminar on The Sundarbans, the Largest Mangrove Forest on the Earth: A World Heritage Site*. June 25-26, 2003, Khulna University, Bangladesh.
- Kathirvel, M. 1983. Crab resources and prospects for crab culture. *CMFRI Bulletin*, 34: 66-68.
- Kathirvel, M. 1993. Mud crab. pp.72. In: Handbook on Aqua farming of Shrimps, Lobsters and Mud crabs. MPEDA Publication, Cochin.
- Keenan, C.P. 1999. The fourth species of *Scylla*. pp. 48-58. In: Keenan, C.P. and Blackshaw, A. (eds.), *Mud Crab Aquaculture and Biology*. ACIAR Proceedings No. 78. Canberra, Watson Ferguson, Brisbane, Australia.
- Keenan, C.P.; Davie, P.F. and Mann, D.L. 1998. A revision of the genus *Scylla* de Haan, 1833. *The Raffles Bulletin of Zoology*, 46: 217-245.
- Keenan, K.C. 1997. Aquaculture of the mud crab, genus *Scylla*: past, present and future. In: *Mud Crab: Aquaculture and Biology*. Proceedings of International Scientific Forum held in Darwin, Australia, ACIAR Proceedings, 78: 9-13.
- Khan, M.G. and Alam, M.F. 1992. The mud crab (*Scylla serrata*) fishery and its bio-economics in Bangladesh. pp. 29-40. In: Angell, C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Khatun, M.M. 2007. Comparisons of growth and economic performance among monosex and mixed-sex culture of mud crab (*Scylla olivacea*) using locally available feeds in pens in the tidal flats of mangrove forests, Bangladesh. M.Sc. Thesis, Faculty of Aquaculture and Aquatic Resource Management, Asian Institute of Technology, Thailand.

- Kamal, D.; Khanom, M. and Rheman, S. 2007. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*, 8(2): 269-285.
- Kristensen, H. 1992. Mud crab fattening technology transfer to the small-scale fisherfolk of Ranong province, Thailand. pp. 235-239. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Kuntiyo. 1992. Fattening of mud crab, *Scylla serrata* Forskal, in net cages installed in the drain canal of intensive prawn ponds fed with trash fish and prawn pellet. MS Thesis. University of the Philippines in the Visayas, 60 pp.
- Ladra, D.F. and Lin, J.C. 1992. Trade and marketing practices of mud crab in the Philippines. pp. 211-221. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Ladra, F.D. 1992. Mud crab fattening practices in the Philippine. pp. 151-155. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Liong, P.C. 1992. The fattening and culture of mud crab (*Scylla serrata*) in Malaysia. pp.185-190. In: Angell C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Liong, P.C. 1993. The culture and fattening of mud crabs. *INFOFISH International*, 3: 46-49.
- Marichamy, R. 1996. Mud crab culture and hatchery. Bulletin of Central Marine Fisheries Research Institute, 48: 103-107.
- Marichamy, R. and Rajapackiam, S. 2001. The Aquaculture of *Scylla* Species in India. *Asian Fisheries Science*, 14: 231-238.
- Nazar, A.K.A. 2003. Prospects of fattening mud crabs using cages in Andaman and Nicobar Islands. *OSTI Newsletter*, 1(2): 2-3.
- Patterson, J. and Samuel, V.D. 2005. Participatory approach of fisherwomen in crab fattening for alternate income generation in Tuticorin, southeast coast of India. *Asian Fisheries Science*, 18: 153-159.
- Rattanachote, A. and Dangwatanakul, R. 1992. Mud crab (*Scylla serrata* Forskal) fattening in Surat Thani Province. pp. 171-177. In: Angell, C.A. (ed.), *Mud Crab: Report of the Seminar on the Mud Crab Culture and Trade*. Surat Thani, Thailand, November 5-8, 1991, The Bay of Bengal Programme Report no: BOBP/REP/51, Madras, India.
- Saha, M.R. and Ahmed, S.U. 1999. Technique of crab fattening. Bangladesh Fisheries Research Institute, Brackish water station, Paikgacha, Khulna, Bangladesh, 8 pp.
- Salam, M.A. and Hasan, S.R. 2004. Identify the potential access rights and governance of the poor and landless in the coastal communities who are engaged in the culture and harvesting of mollusks, shrimp PL nursing and mud crab fattening activities, DFID-UGC SUFER Project Report, Dhaka, 33 pp.
- Shang, YC. 1990. *Aquaculture Economics: Basic Concepts and Methods of Analysis*. West-View Press, USA, 153 pp.
- Thongkum, C. 1988. An assessment of mangrove crab (*Scylla serrata*) culture in ponds in Surat Thani. M.Sc. Thesis, Asian Institute of Technology, Bangkok, Thailand, 111 pp.
- Triño, A.T. and Rodriguez, E.M. 2001. Mud crab fattening in ponds. *Asian Fisheries Science*, 14: 211-216.
- Triño, A.T.; Millamena, O.M. and Keenan, C. 1999. Commercial evaluation of monosex pond culture of the mud crab *Scylla* species at three stocking densities in the Philippines. *Aquaculture*, 174: 109-118.
- Williams, M.J. and Primavera, J.H. 2001. Choosing tropical portunid species for culture, domestication and stock enhancement in the Indo-pacific. *Asian Fisheries Science*, 14: 121-142.

Kamal, D.; Khanom, M. and Rheman, S. 2007. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*, 8(2): 269-285.

Zafar, M. 2003. Culture of mud crab (*Scylla serrata*) through participation of the poor coastal people, Bangladesh. DFID-UGC SUFER Project Report, University of Chittagong, Bangladesh, 11 pp.

Zafar, M. 2004. Culture of mud crab *Scylla serrata* in the coastal area of Bangladesh. DFID-UGC SUFER Project Report, Institute of Marine Science, University of Chittagong, Chittagong, Bangladesh, pp. 6-16.