Journal of Fisheries
Volume 2 Issue 3 Pages: 187-194 December 2014
Peer Reviewed | Open Access | Online First

eISSN 2311-3111
pISSN 2311-729X

Original article
DOI: dx.doi.org/10.17017/jfish.v2i3.2014.38

Farming of giant freshwater prawn (*Macrobrachium rosenbergii*) in Bagerhat, Bangladesh

Shirin Akter • Md. Mer Mosharraf Hossain • Sanjoy Banerjee Bappa • Bipul Kumar Dey • Md. Farid Uz Zaman

Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology, Jessore-7408, Bangladesh

Correspondence: Bipul Kumar Dey, Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology; Email: bipulkumar.jstu@gmail.com

Received: 11 Jul 2014, Received in revised form: 16 Oct 2014, Accepted: 14 Nov 2014, Published online: 29 Nov 2014

Citation: Akter S, Hossain MMM, Bappa SB, Dey BK and Zaman MFU (2014) Farming of giant freshwater prawn (*Macrobrachium rosenbergii*) in Bagerhat, Bangladesh. Journal of Fisheries 2(3): 187-194. DOI: dx.doi.org/10.17017/jfish.v2i3.2014.38

Abstract

The study was carried out to know the present status of *Macrobrachium rosenbergii* culture in Bagerhat district, Bangladesh from March 2012 to January 2013. Education levels of farmers were found as illiterate (12.3%), primary (36.19%), secondary (20%), SSC (13.33%), HSC (12.38%) and graduate (5.71%). *M. rosenbergii* culture was the primary and secondary occupation of 80% and 20% farmers respectively. Average stocking density and production in extensive, improved extensive and semi-intensive culture were 9609, 11502 and 22847 per ha and 193, 284 and 488 kg/ha/year respectively; rearing period ranges from 6-10 months and survival rate varied from 55 to 60%. In improved extensive and semi-intensive culture 82.86% and 71.43% farmers applied farm-made feed instead of company feeds respectively and 11.43% and 37.14% farmers used both feeds. 91.43%, 80% and 68.57% respondents responded on normal to high mortality in extensive, improved extensive and semi-intensive culture respectively. Lack of finance and appropriate technology, scarcity of quality PL, diseases and inadequate extension work were major problems of prawn culture.

Keywords: Bagerhat, *Macrobrachium rosenbergii*, culture, extensive, improved extensive, semi-intensive

INTRODUCTION

The giant freshwater prawn (*Macrobrachium rosenbergii*) is an importance aquatic crustacean species (Akand and Hasan 1992), mostly distributed in the tropical and subtropical regions (Abramo and Brunson 1996), abundant in the south-southeast Asia and Asia-pacific region (Akand and Hasan 1992). After its domestication in 60s, it has been gradually appeared as a major aquaculture species in many countries including Australia, Brazil, Honduras, Indonesia, Israel, Malaysia, Mauritius, Mexico, the Philippines, Viet Nam, United States of America (New 2002), China, India, Thailand, Vietnam and Ecuador and also in Bangladesh (Akand and Hasan 1992). Bangladesh has entered into the commercial prawn farming in early 90s and has become a world player as one of the seven export countries (Ahmed 2001). Three Asian countries (Bangladesh, Taiwan and Thailand), together with China, contributed 97% of world production of this species (FAO 2001).

Bangladesh is considered one of the most suitable countries in the world for giant freshwater prawn farming because of its favorable soil condition, weather and temperature (Paul 1997). Water pH mostly ranges from 7 to 8 and the water temperature often remains 28-32 °C during most times of the year, which are ideal for prawn culture (Asaduzzaman 2005). Culture practice of this species is increasing day by day (Shafi 2003) and culture area has been expanding on an average of 10-20% per annum (Williams and Khan 2001, DoF 2002, Khondaker 2007). For example, the prawn culture area extended from 6,000 ha in 1994 (Chanda and Khondaker 1994) to an estimated 50,000 ha (Khondaker 2007) and 56248 ha in 2010 (BFFEA 2010). Because of

high growth rate (reach marketable size within a span of 3-4 months only), omnivorous feeding habits, accept variety of feeds, rich favorable flavor and taste, high nutritive value (Shafi 2003), high market value and increasing demand in abroad (DoF 2013) such as US and European market; especially Belgium, United Kingdom, Germany, Netherlands and Denmark (DoF 2012). During 2009-2010, Bangladesh exported 18% shrimp and prawn in USA, 17% in Belgium, 14% in UK, 10% in Netherland, 8% in Germany, 3% in Russia, 3% in Saudi Arabia, 3% in Japan and rest 24% in other countries. The EU countries import nearly 70% of the countries giant freshwater prawn, worth about 12000 million BDT (BFFEA 2010). Thus Bangladesh was the third largest global producer, producing 30636 T equating to 14% of global production of giant freshwater prawn in 2010 (FAO 2012). In Bangladesh, *M. rosenbergii* is cultured mainly in Bagerhat, Khulna, Jessore, Narail, Pirojpur and Gopalgonj district; some another considered districts are Barishal, Borguna, Potuakhali, Banalkati, Satkhira and Madaripur (Karim 1997).

In Bangladesh, giant freshwater prawn farming first started in the southwest region in the early 1970s (Mazid 1994) at Fakirhat sub-district in Bagerhat district (Abedin *et al.* 2001). In the late 1980s, prawn farming practise began to be adopted widely in the Fakirhat area, where prawns were grown along with fish including Indian major carps (*Labeo rohita, Catla catla* and *Cirrhina mrigala*) and exotic carps (*Hypophthalmichthys molitrix* and *Cyprinus carpio*) with rice (Kamp and Brand 1994). More than 70% (Muir 2003) or 75% (Ahmed *et al.* 2013) of prawn farms are located in the south-western part of Bangladesh. In 2008–2009, Bangladesh produced 26138 MT of prawns from different water bodies, while 90% of this production (23597 MT) was by aquaculture from south-western region (DoF 2010, Rahman 2010) but its global production in was 215029 MT in 2010 (FAO 2012). In recent years 95% shrimp and prawn farms are registered by the DoF (Department of Fisheries) with the help of BQSP- UNIDO. Now the number of registered prawn farms is 97845 with an area of 56248 ha (BFFEA 2010). In Bangladesh approximately 2000 million shrimp fry is collected annually from wild sources. With respect to fresh water shrimp (*M. rosenbergii*) more than 90% of the total for the PL is derived from natural sources (Banks 2003). Although there are 81 freshwater prawn hatcheries in Bangladesh, only 38 (47%) are operational. These hatcheries produce around 100 million PL per annum, equating to 20% of the total demand (Ahmed and Troell 2010).

Fisheries is an important subsector of agriculture as contributing 4.39% to national GDP and 22.76% to the agricultural GDP and 2.46% to foreign exchange earnings came from this sub sector in 2011-12 (DoF 2013). Giant freshwater prawn is an important product of this sub-sector as the highly valued product for international market and almost all Bangladeshi prawns are therefore exported (BFFEA 2010). As a result about 70% of the total production is exported to foreign markets and the rest (30%) is consumed locally (Paul 2008). During the fiscal year 2009-10, Bangladesh exported 80% shrimp and prawn products which accounts for 20% of fish (BFFEA 2010). Most of world production of *M. rosenbergii* is from aquaculture and world fisheries production of this species was 5500 MT in 1999, 5% of world fisheries production (FAO 2001). During the fiscal year 2010-11, Bangladesh exported 54891 MT of frozen and processed prawn and another shrimp species which price was 356.82 million BDT (DoF 2012) and commonly this species covers 25-30% of total exported prawn and shrimp species (DoF 2013). *P. monodon* comprises 60% of the firmed shrimp production, followed by the *M. rosenbergii* which accounts for 25% (Ahmed 1996).

During the economic year, 2011-12, total production of giant freshwater prawn and another shrimp species was 239460 MT where 137175 MT came from farms (DoF 2013). But the production rate (300-500 kg/ha) of *M. rosenbergii* in Bangladesh is very low comparing with the production of various countries of the world namely Japan, Thailand, Taiwan, Malaysia, produce giant freshwater prawn at 4000-8000 kg/ha, but different prawn and/or shrimp experts stated that the soil quality, climatic condition and temperature of Bangladesh is very suitable for the culture of this species (Ali *et al.* 2009). However, the progress of prawn farming is slow in the northern and north-central regions because of inadequate extension services, lack of technical knowledge of farmers on prawn farming and poor supply of PL (Ahmed 2011) but Bangladesh plans to produce 60000 MT of prawns from 80000 ha of farms by 2015 (Karim 2011), when the production was 30636 MT in 2010 (FAO 2012) and 23240 MT from around 50000 ha farm area (Wahab *et al*. 2012).

The production rate of giant freshwater prawn in Bangladesh is very low, indicating that there are some problems and/or limitations in culture. So this case study was conducted in Bagerhat district as a valuable region of *M. rosenbergii* culture, to know about the present status of culture practice and to identify the problems and limitations.

METHODOLOGY

Study area and duration: The coastal area lies in the alluvial plains of Bangladesh between 89.00° E and 92.20° E in the northern and north-eastern part of the Bay of Bengal (Brown 1997). The study area, Bagerhat district is lies between 89'30" and 90'00" E. The case study was carried out in Bagerhat Sadar, a sub-district of Bagerhat district, a well-known shrimp and prawn production zone in the south-western part of Bangladesh (Figure 1). The total area of this district is 3959.11 km^2 and Bagerhat Sadar retains 272.73 km^2 and thus the study area covered 6.89% area of Bagerhat district and the duration of the study was March, 2012 to January, 2013.

Figure 1: Map of Bagerhat district, Bangladesh, indicating the case study area by red circle (source: Banglapedia)

Sampling framework: Sample farms were selected randomly emphasizing on various culture strategies (extensive, improved extensive, semi-intensive). These culture strategies were categorized by following the categorizing keys (Table 1), emphasizing the stocking density. Stocking density were categorized as <12000 PL/ha, +12000-<18000 PL/ha and +18000-<25000 PL/ha respectively in extensive, improved extensive and semi-intensive culture strategies. In every culture strategy 35 farmers were included that means 105 farmers totally. Primary data were composed employing effective techniques such as personal interview (home visit), focus group discussion (FGD), and telephonic interview and farmers were interviewed to collect the present culture techniques, production rate, diseases and other constraints in culture of giant freshwater prawn. The present diseases were identified by applying disease identifying keys (Table 2). Secondary data were collected from various government and fisheries correlated institutions and also collected from websites and published literatures.

Table 1: Identifying keys for culture methods

Culture strategies	*Categorizing keys*
Extensive	Very little cost, only a few shrimp PL are released in the farm, no fertilizer or supplementary feed are used, stocked species are fully depend on natural food, any initiatives are not taken, any technological aspects of farming are not considered.
Improved extensive	Species are stocked at relatively low density after removing aquatic weed and weed fish / predatory fish, irregular fertilizing and feeding, other activities of planned culture are performed irregularly.
Semi-intensive	Maintenance of necessary renovation of the water body, complete control of predatory and weed fish, medium stocking density, regular fertilizer and hand made feed (sometimes commercial feed) application, partial harvesting and restocking after 3-4 months of fry stocking, water exchange when need, supply of oxygen (aeration) are performed.

Source: USAID (2011)

Table 2: Disease identifying keys

Diseases	*Syndrome*
WSSV	Feed fobicity, weakness, slow movement, come to the surface water, gathering near to the dyke at day time, white spot on the tail and/or whole body surface, gill damage
Black gill	Feed fobicity
Black spot	Black spots on shell, tail and gills, cleft on shell
Soft shell	Softening of shell, low growth rate, weakness and slow movement
Bacterial	Blackish spot on the shell, breakage of shell, changing of general colour, breakage of tail and other appendages
Fungal	Drop spots on gills, gill damage
Protozoan	Harm to shells and gills

WSSV = White spot syndrome virus
Source: USAID (2012)

The equations were used for inference of percentage of various factors are as follows:

Percentage (%) of specifically educated farmer=

$$\frac{No.\ of\ specifically\ educated\ farmers}{No.\ of\ total\ interviewed\ farmers} \times 100$$

Percentage (%) of occupation of farmers=

$$\frac{No.\ of\ farmers\ of\ specific\ occupation}{No.\ of\ total\ farmers} \times 100$$

Percentage (%) of specifically involvedness of farmer=

$$\frac{Specifically\ involved\ farmers}{total\ farmers} \times 100$$

Data analysis: The collected data were subjected to descriptive analysis by means of the computer software, Microsoft Excel 2007.

RESULTS

Farmers' contour: The education levels of farmers were categorized into six types such as illiterate, primary, secondary, SSC (Secondary School Certificate), HSC (Higher Secondary Certificate), and graduate. Among these education levels, primary school level education was found at highest portion (36.19%) and lowest portion (5.71%) in graduate (Figure 2). Among the interviewed farmers, 80% were involved in prawn culture as their primary occupation and 20% as their secondary occupation and the farmers which were educated under SSC level, doses of various chemicals and feed were not properly measured by considering the water volume and/or other considering measures. The maximum, minimum and average farming experience of farmers were 25, 3 and 13 years respectively.

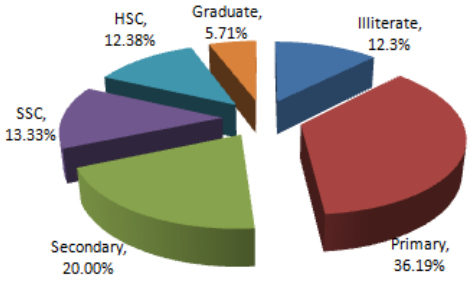

Figure 2: Education level at different farmers

Pre-stocking management: Most of the farmers performed partial pre-stocking management measures and in some cases it was absent (Table 3). Farmers applied organic and/or inorganic fertilizers and lime from pond preparation to final harvest in farms although the application rate differed from farmer to farmer in various culture systems (Table 4). Monoculture was not practiced in extensive culture and in semi-intensive culture, no integrated (rice-fish-prawn/rice-prawn) culture was recorded.

Table 3: Pre-stocking management status in different culture strategies

Culture strategy	*Culture system*	*Pond preparation measure (% of farmer)*					
		PP	*BD*	*BT*	*Lm*	*Ft*	*WS*
Extensive	MC	-	-	-	-	-	-
	MxC	-	-	-	28.57	8.57	-
	IC	-	85.71	91.43	-	100	-
Improved extensive	MC	57.14	42.86	31.43	97.14	97.14	28.57
	MxC	77.14	62.86	28.57	94.29	100	20.00
	IC	5.71	80.00	94.29	97.14	100	5.71
Semi-intensive	MC	100	91.43	88.57	100	100	71.43
	MxC	91.43	85.71	45.71	88.57	88.57	22.87
	IC	-	-	-	-	-	-

MC=Monoculture; MxC=Mixed culture; IC=Integrated culture; PP=Predator purge; BD= Bottom drying; BT= Bottom tilling; Lm= Liming; Ft= Fertilizing; WS= Water swap

Table 4: Liming and fertilization rate in surveyed farms

Culture strategy	*Culture system*	*Average liming rate (kg/ha/year)*	*Average fertilizing rate (kg/ha/year)*	
			Organic	*Inorganic*
Extensive	MxC	24.67	22.43	-
	IC	-	71.60	208.07
Improved extensive	MC	66.41	29.02	83.54
	MxC	74.08	32.35	97.86
	IC	13.53	27.91	269.71
Semi-intensive	MC	143.33	-	104.19
	MxC	107.29	18.82	113.28

MC=Monoculture; MxC=Mixed culture; IC=Integrated culture

Stocking management: Most of the farmers especially in extensive and improved extensive culture strategies did not perform the acclimatization process before releasing the PL. According to their statement, 55-60% survivility was gained in different culture system and stocking rate also differs (Table 5).

Table 5: Stocking management status of surveyed farms

Culture strategy	*Acclimatization (% of farmers)*	*Mean stocking rate (No./ha)*	*Survival*	*Stocking period (Month)*	*Production (kg/ha/year)*
Extensive	5.71	9502	<55%	6-10	HP: 230 LP: 23 AP: 193
Improved extensive	48.57	11609	<60%	6-8	HP: 377 LP: 90 AP: 284
Semi-intensive	71.43	22847	<60%	6-8	HP: 508 LP: 370 AP: 488

HP=Highest production; LP=Lowest production; AP=Average production

Post-stocking management: Mostly the farm-made feed was used in maximum farms instead of commercial feeds (Table 6). Water quality parameters were not checked in maximum farms and a great portion of farms was susceptible to various diseases those caused death of cultured species (Table 7) but did not take any strong protective measure without some exception in semi-intensive strategy.

Table 6: Responding rate of farmers based on feed types and present diseases

Culture strategy	*Feed type*	*User farmer (%)*	*Responded farmers on disease (%)*
Extensive	Farm-made	-	91.43
	Commercial	-	
Improved extensive	Farm-made	82.86	80.00
	Commercial	17.14	
	Both	11.43	
Semi-intensive	Farm-made	71.43	68.57
	Commercial	28.57	
	Both	37.14	

Table 7: Disease prominence in surveyed area

Disease	*Responded farmer (%)*	*Time of outbreak (month)*	*Death intensity*
WSSV	100	Nov-Jan	Very high
BG	50.48	Nov-Feb	High
SS	84.76	Jun-Sep	Normal
BA	94.29	Jun-Oct	Normal
BS	95.24	Jun-Sep	High
Bacterial	55.24	Any time	Normal
Fungal	72.38	Jun-Sep	Normal
Protozoan	65.71	Any time	Normal
NDD	53.33	Any time	Normal

WSSV=White Spot Syndrome Virus; BG=Black gill; SS=Soft Shell; BA=Broken Antenna; BS=Black/brown Spot; NDD=Nutritional Deficiency Disease

DISCUSSION

Education is a vital factor in every sphere of life also in aquaculture. In the present study, the farmers which acquired below SSC level education are error performers in calculation of doses and rates respectively of chemicals and feeds but they occupy the major portion (total 68.49%) of the farmers. Because of high market value and increasing demand in abroad (DoF 2013), 80% farmers commercially culture *M. rosenbergii* as primary occupation and the rest 20% farmers considers as secondary occupation. According to Samad *et al*. (2014), 95% was found practicing prawn farming on commercial basis, where as 5% was found as non-commercial in Avaynagar Upazilla of Jessore district, Bangladesh.

In pre-stocking management in study area, a great portion of farmers mainly in extensive and improved extensive farming strategies not perform all of the pond preparation measures although major portion of farmers use lime but the lowest liming was at 24.67 kg/ha/year in extensive and at 143.33 kg/ha/year in semi-intensive culture strategy but according to Hasanuzzaman *et al.* (2011), sometimes farmers were reported to use lime at the rate of 105.68 kg/ha/year and in Avoynagar upazilla, Bangladesh, it was at 232.18 kg/ha/year (Samad *et al*. 2014). In the study it was found that, 94% (highest) of farmers practiced bottom tilling for paddy cultivation in integrated culture (rice-prawn and/or rice-fish-prawn) and 28.57% (lowest) in mixed culture (fish-prawn) belonging to improved extensive culture strategy, although tilling helps to mix the lime and fertilizer with the soil during pond preparation and thus increases the productivity of land by increasing the natural food (FAO 2002).

Among the responded farmers, fear of disease was existed associated with the use of organic fertilizers. As a result they limited the use of organic fertilizers; it was the similar finding to Wahab *et al*. (2011). This was found that, in case of mixed culture belonging to semi-intensive culture, average application of organic fertilizer at the rate of 18.82 kg/ha/year (lowest) and in integrated culture belonging to the extensive culture strategy it was at 71.60 kg/ha/year (highest); here is a dissimilarity with the findings of Ahmed (2001) and Hasanuzzaman *et al.* (2011) when the application of organic fertilizers were respectively at the rate of 1500 kg/ha/year and 410.22 kg/ha/year but according to Ahmed (2013) it was at 100-150 kg/ha/year. In case of inorganic fertilization, in the present study, average use of inorganic fertilizers was at 208.07 kg/ha/year (highest; emphasizing the paddy culture) in integrated culture occupying the extensive culture strategy and at 83.54 kg/ha/year (lowest) in case of monoculture occupying the improved extensive culture strategy. That is around the rate, stated by Ahmed (2013) and Hasanuzzaman *et al.* (2011) respectively at 45-85 kg/ha/year and 180.34 kg/ha/year.

Average stocking density of PL (post larvae) varies in extensive, improved extensive and semi-intensive culture strategies respectively at 9609 PL/ha, 11502 PL/ha and 22847 PL/ha in the study area, which is also in line with a density of 1500-15000 PL/ha reported by Alam *et al.* (2007), and a density of 7411-39520 PL/ha reported by Barmon and Karim (2007). According to Ahmed *et al.* (2008a), prawn farmers practiced a stocking density of 19830-21155 PL/ha. The average stocking densities were found to be 30000/ha (2.5 PL/m^2) in semi-intensive farming, 20000 (2.0 PL/m^2) in improved extensive and 15000 (1.5 PL/m^2) in extensive systems (Ahmed 2013) that is higher than the stocking

density recorded in the present study.

In the three culture strategies, 5.71%, 48.57% and 71.43% farmers perform the acclimatization consciously, correspondingly in extensive, improved extensive and semi-intensive culture strategies, where the assumed survival rate was correspondingly <55%, <60% and <60%, it is closely similar to the survival rate 50 to 60% that was found by Ahmed *et al.* (2008a,b).

Stocking period of PL ranges from 6-10 months in study area and the average production was lowest in extensive culture, that was 193 kg/ha/year and in that order 284 kg and 488 kg/ha/year in improved extensive and semi-intensive culture strategies but according to (DoF 2010), the yield ranges from 400-500 kg/ha/year. These production rates are lower than other prawn producing countries, such as China, India, Taiwan, Thailand and Vietnam (Weimin and Xianping 2002; Raizada *et al.* 2005; Vicki 2007). It has reported that the present level of annual prawn production can be increased to 1500-2500 kg/ha/year through the application of advanced technologies (Katalyst 2009).

It was estimated that, greater part (82.86%) of farmers apply farm-made feed in improved extensive and 71.43% in semi-intensive, similar findings was stated by Ahmed (2001), who said that farmers use home-made feed like cooked rice, fried rice, rice bran, boiled wheat, wheat bran, maize, boiled papaya and roots of arum, chick peas and fish meal. This statement is also similar to the report of Barmon *et al.* (2006) and Ahmed *et al*. (2008b), who reported snail-meat used commonly in prawn farming system. Responded farmers in this study usually do not supply the feeds in extensive culture strategies but 11.43% farmer use both of the feed types in improved extensive culture and in semi-intensive culture that was estimated as 37.14%. Ahmed (2001) stated that farmers also often use commercial pelleted feed for better prawn growth. Farm-made aqua feeds and industrially manufactured pelleted feeds are used by improved extensive and semi-intensive farmers respectively (Ahmed 2013); in this study it was found that, in both culture strategies a small amount of farmers use both feed types. Generally a great portion of farmers do not use the commercial feeds because of its high price but low quality. There is a similarity that, the majority of the respondents (53%) reported that high feed price was the single most important constraint regarding their use of commercially manufactured pelleted feeds (Ahmed 2013).

Among the responded farmers, 91.43%, 80.00% and 68.57% are respond to various present diseases correspondingly in extensive, improved extensive and semi-intensive culture strategies. Mac Rae *et al.* (2002) stated that disease is a common and major problem of prawn farming in Bangladesh, and a wide variety of diseases are found including shell diseases or black spot, white spot and gill disease. White spot syndrome virus, black gill, soft shell, broken antenna, black/brown spot and nutritional deficiency disease are noticed by the great portion of interviewed farmers those are occurred more or less throughout the year and cause normal to very high intensity of death of *M*. *rosenbergii* in farms. Cai *et al*. (1997) also said that, black spot, the most widespread disease of prawn from post larvae to harvest size, causing mass mortalities and losses in the aquaculture industry. Bacterial necrosis, a common disease observed in adult prawns, was recorded from rice-prawn farming systems during August to December, 2002 that was reported by Te and Tam (1994).

Bagerhat district is famous for shrimp and prawn culture in Bangladesh but there are many existing problems in farming due to absence of remarkable extension work. On the other hand lack of finance, lack of technology supply and PL scarcity during proper stocking period are other important problems. So these problems should be mitigated to increase the production rate.

REFERENCES

Abedin J, Islam S, Chandra G and Kabir Q (2001) Freshwater Prawn Subsector Study in Bangladesh. CAREGOLDA project, Bangladesh.

Abramo DLR and Brunson MW (1996) Biology and Life History of Freshwater Prawns. Mississipi State University, USA, pp. 23-28.

Ahmed ATA (1996) Policy guidelines for management of coastal shrimp culture development. A paper presented at the World Aquaculture ’96 Conference, Bangkok. January, 1996.

Ahmed N (2001) Socio-economic aspects of freshwater prawn culture development in Bangladesh [dissertation]. Scotland, UK: Institute of Aquaculture, University of Stirling.

Ahmed N (2011) The farming of white gold in Mymensingh, Bangladesh: mission impossible? World Aquaculture. pp. 42-64.

Ahmed N (2013) Linking prawn and shrimp farming towards a green economy in Bangladesh: confronting climate change. Ocean Coast Manage 2013, 75: 33-42.

Ahmed N and Troell M (2010) Fishing for prawn larvae in Bangladesh: an important coastal livelihood causing

negative effects on the environment. Ambio, 39: 20-29.

Ahmed N, Ambrogi AO and Muir JF (2013) The impact of climate change on prawn post larvae fishing in coastal Bangladesh: socioeconomic and ecological perspectives. Marine Policy, 2013. 39: 224-233.

Ahmed N, Brown JH and Muir JF (2008b) Freshwater prawn farming in *gher* (farm) systems in southwest Bangladesh. Journal of Aquaculture Economics and Management, 12: 207-223.

Ahmed N, Demaine H and Muir JF (2008a) Freshwater prawn farming in Bangladesh: history, present status and future prospects. Aquaculture Research, 39: 806-819.

Akand AM and Hasan MR (1992) Status of freshwater prawn (*Macrobrachium* spp.) culture in Bangladesh. In: Freshwater Prawns (edited by E.G. Silas), pp. 33–41. Kerala Agricultural University, Thrissur, India.

Alam MJ, Islam MS, Pal HK and Karim M (2007) Year-round and rotational freshwater prawn, *Macrobrachium rosenbergii* and paddy farming: size quality, production, and economics. Bangladesh Journal of Fisheries Research 11(1): 75-92.

Ali ML, Mahmud Y, Pramanik WA, Zaher M and Mazid MA (2009) Improved Nursery Management and Poly-culture Technology of Freshwater Prawn (Golda). Extension manual No. 34, Bangladesh Fisheries Research Instute, Mymensingh, Bangladesh.

Asaduzzaman M (2005) The Potentials of Organic Farming of Giant Freshwater Prawn (*Macrobrachium rosenbergii*) in Bangladesh. MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Banks R (2003) Brackish and marine water aquaculture. Report on Fisheries Sector Review and Future Development. Department of Fisheries, *Matshya Bhaban*, Ramna, Dhaka 1000, Bangladesh.

Barmon BK and Karim M (2007) Analysis of feeds and fertilizers for sustainable aquaculture development in Bangladesh. In: Hasan MR, Hecht T, De Silva SS and Tacon AGJ (Eds.) Study and analysis of feeds and fertilizers for sustainable aquaculture development, pp. 113-140. FAO Fisheries Technical Paper No. 497. Rome, FAO, 510 pp.

Barmon BK, Kondo T and Osanami F (2006) Economic evaluation of rice-prawn gher farming system on soil fertility for modern variety (MV) paddy production in Bangladesh. Paper prepared for presentation at the international association of agricultural economists conference, Gold Coast, Australia, August 12-18, 2006.

BFFEA (2010) Shrimp and Fish News, edited by Mahmudul Hasan. 43 pp.

Brown BE (1997) Integrated Coastal Management: South Asia. Department of Marine Science and Coastal Management University of Newcastle, UK.

Cai SL, Wang CM and Yang CH (1997) Studies on prevention and cure of white and black spot disease of shrimp. Marine Fisheries Research 18: 28-33.

Chanda AC and Khondaker HR (1994) *Galda chingri chash* (Farming of Freshwater Prawn). In: Fish compendium, 1994, Department of Fisheries, Dhaka, Bangladesh, pp. 24-28.

DoF (2002) Shrimp aquaculture in Bangladesh, a vision for the future. Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Dhaka, Bangladesh, 7 pp.

DoF (2010) Fishery Statistical Yearbook of Bangladesh 2008-2009. Fisheries Resources Service System, Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Dhaka, Bangladesh, 26(1), 41 pp.

DoF (2012) *Sharonika*, *Matshya Saptah*, 2012. Department of Fisheries, Ministry of Fisheries and Livestock, Government of Peoples Republic of Bangladesh, 13 pp.

DoF (2013) National Fish Week 2013Compendium (in Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, 144 pp.

FAO (2001) 1999 Fisheries statistics: Capture Production. Volume 88/1. FAO, Rome.

FAO (2002) Farming of Freshwater Prawns: A Manual For the culture of the giant river prawn (*Macrobrachium rosenbergii*). Food and Agricultural organization, Fisheries Technical Paper, 428 pp.

FAO (2012) Fishstat Plus, Version 2.32. Rome, FAO. Available at: www.fao.org/fishery/statistics/software/fishstat/en

Hasanuzzaman AF, Rahman MA and Islam SS (2011) Practice and Economics of Freshwater Prawn Farming in Seasonally Saline Rice Field in Bangladesh, Mesopotamian Journal of Marine Science, 2011, 26 (1): 69-78.

Kamp K and Brand E (1994) Greater Options for Local Development through Aquaculture. CAREGOLDA Project, Dhaka, Bangladesh.

Karim M (1997) Modern fisheries management for maximizing profit earning-Keynote paper. The workshop on Agribusiness Credit Fund (ACF) for promotion of Livestock, Poultry and Fisheries subsectors and related issues, MOA/USAID/ATDP, Dhaka, Bangladesh.

Karim M (2011) Power point presentation-*Macrobrachium* export industry in Bangladesh: addressing food safety issues along the entire value chain of the industry. In: Conference on Freshwater Prawns, Giant Prawn 2011, Kochi, India.

Katalyst (2009) Development of *Galda chingri*: endeavour of katalyst. In: National Fish Week Compilation (edited by © 2012 Blackwell Publishing Ltd., Aquaculture Research, 43: 970-983, Status and prospects of giant river prawn farming Wahab *et al.* Ed. by Khaleq MA), pp. 43-44. Department of Fisheries (DoF), Ministry of Livestock and Fisheries, Dhaka, Bangladesh.

Khondaker HR (2007) Freshwater prawn resources of Bangladesh and role of department of Fisheries for prawn farming development. In: Wahab MA and. Faruk MAR (Eds): Abstracts-national workshop on freshwater prawn farming: search for new technologies, Bangladesh Agricultural University and Bangladesh Fisheries Research Forum, Mymensingh, Bangladesh, 9 pp.

Mac Rae IH, Champman G, Nabi SMN and Dhar GC (2002) A survey of health issue in carp-*Macrobrachium* culture in rice fields in Bangladesh. In: Primary Aquatic Animal Health Care in Rural, Small Scale Aquatic Development, FAO Fisheries Technical Paper 406, pp. 95-112.

Mazid MA (1994) Evaluation of Prawn Farming on Socio-Economic Aspects. Fisheries Research Institute, Mymensingh, Bangladesh.

Muir JF (2003) The Future for Fisheries: Economic Performance. Fisheries Sector Review and Future Development Study. Commissioned with the association of the World Bank, DANIDA, USAID, FAO, DFID with the cooperation of the Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka, 172 pp.

New MB (2002) Farming freshwater prawns: a manual for the culture of the giant river prawn (*Macrobrachium rosenbergii*). FAO Fisheries Technical Paper No. 428. Rome, FAO. 212 pp.

Paul SK (1997) Chingri: Rug Babosthapona (a book of shrimp disease management), written by Dr. Susanta Kumar Paul. Published by Monika Paul, 2 Notun Poltan Lane, Dhaka-1250, Bangladesh. First Edition-November 1997, pp. 1-211.

Paul SK (2008) Shrimp: Environment-Friendly Culture Technology, Socio-Economic and Quality Control Management. Momin offset press, 9, Nilkhet, Babupura, Dhaka, 304 pp.

Rahman SMS (2010) Effects of Biotechnical Management of all-Male Freshwater Prawn on Pond Ecology and Production in Polyculture Systems. PhD Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh, 99 pp.

Raizada S, Chadha NK, Javed H, Ali M, Singh IJ, Kumar S and Kumar A (2005) Monoculture of giant freshwater prawn, *Macrobrachium rosenbergii* in inland saline ecosystem. Journal of Aquaculture 20: 45-56.

Samad MA, Hossain MM, Nima Rahman ABMS and Haidar MI (2014) Present status of freshwater prawn culture and management system in Abhaynagar Upazila in Jessore of Bangladesh. Bangladesh Research Publications Journal 9(3): 182-189.

Shafi SM (2003) Applied Fishery Science. Published by Atlantic Publishers and Distributors, New Delhi-27, Volume 1, ISBN 81-269-0277-9, pp. 238-257.

Te BQ and Tam VT (1994) Common diseases in cultured fish and shrimp at Mekong delta; Treatment and preventing methods. Agriculture Publishing House (in Vietnam). Tropical Biomedicine 28 (1): 85-89.

USAID (2011) Improved Shrimp Culture in *Gher* (farm), Written by Sattyanarayan Roy, Md. Mizanur Rahman, Sudhindra Nath Sarkar and Biswajit Mondal. Published by Director**,** WorldFish Center, Bangladesh

USAID (2012) Farmers' Guide on Environment Friendly Shrimp Culture Management. Published by Feed the Future Aquaculture, The WorldFish Center, Bangladesh and South Asia Office, Dhaka, Bangladesh.

Vicki SS (2007) Social, economic and production characteristics of freshwater prawn *Macrobrachium rosenbergii* culture in Thailand. Master Thesis, Michigan, United States of America, School of Natural Resources and Environment, University of Michigan, 47 pp.

Wahab MA, Nahid SA, Ahmed N, Haque MM and Karim M (2012) Current status and prospects of farming the giant river prawn Macrobrachium rosenbergii (De Man) in Bangladesh, Journal of Aquaculture Research 43: 970-983, Blackwell Publishing Ltd.

Wahab MA, Nahid SAA and Haque MM (2011) Power point presentation on Freshwater prawn farming in Bangladesh: development trends, challenges and sustainability issues. In: Conference on freshwater prawns, GIANT PRAWN 2011, Kochi, India.

Weimin M and Xianping G (2002) Freshwater prawn culture in China: an overview. Aquaculture Asia, 7(1): 7-12.

Williams D and Khan N (2001) Freshwater prawn *gher* farming Systems: indigenous technology developed in southwest Bangladesh. CARE GOLDA Project, CARE Bangladesh, Dhaka.