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Observation on some of the environmental parameters and feed quality of selected golda (*Macrobrachium rosenbergii*) farms in Bangladesh

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Abstract
A study was conducted to ascertain the existing farm water, effluent and feed quality of selected giant freshwater prawn farms from major prawn farming areas (Bagerhat Sadar, Noakhali Sadar and Mymensingh) of Bangladesh during July to November 2005. Water quality parameters such as the mean values of dissolved O_2, alkalinity, NO_2-N, PO_4-P and NH_3-N did not show any significantly differences among the farming areas. Whereas significant differences ($p<0.05$) were observed in the mean values of temperature, secchi disc visibility, pH and chlorophyll *a*. However, all the water quality parameters in the farming areas were within the suitable range for prawn culture. There was no significant variation in nutrients concentration of discharged effluent among the prawn farming areas. All of the nutrients measured in effluent water were within the acceptable range and did not seem to pose a direct threat to the recipient environment. The analysed crude protein contents of commercial CP, Quality and Saudi-Bangla prawn feeds were 31.84%, 27.21% and 28.97%, respectively, whereas all analysed farm made feeds were less than 25%. The other nutrients of prawn feeds varied largely with the source of feeds and ingredients used to prepare feed. The annual yield of prawn varied from 320.4 to 512.6 kg ha^{-1} (mean 412.3 kg/ha) depending on the management system.

Key words : Freshwater prawn, Water quality, Effluent, Feed quality

Introduction

Freshwater prawn farming is the major aquaculture industry in Asian countries contributing over 98% of the total production. Production of freshwater prawns has increased dramatically in recent years. In the past, Bangladesh was an exporter of prawn caught by artisanal fishers in rivers, lakes and flooded depressions (Angell 1992), and now has been well placed in export market for exporting farmed output (New 1995). The prawn industry supports a thriving local economy and generates important foreign exchange earnings for the country and many people's livelihood depend on the prawn industry (Williams and Khan 2003).

The increasing demand and steadily rising price of freshwater prawn in the international market caused a silent revolution in the development of freshwater prawn farming. Water quality parameters of freshwater prawn farms are important not only for the fact that production is affected by them but also that water quality problems are now common in freshwater prawn farms in many parts of the world. Again waste generated during culture, mainly faeces and unconsumed feed, settle on the bottom. Mineralization of accumulated organic matter under anaerobic conditions leads to the formation of toxic metabolites like NH_4^+ and NO_2^- (Fast and Boyd 1992, Hopkins *et al.* 1994, Avnimelech and Ritvo 2003), spoiling the living environment of freshwater prawn.

Successful commercial farming of freshwater prawns must involve supplementary feeding (New and Singholka 1985). Many authors (Law *et al.* 1990, Durairaj *et al.* 1992 and MacLean *et al.* 1989) stated that high production and survival rate of prawns fed on low-cost feeds rely on locally available ingredients. Currently, in Bangladesh, prawn farmers use three types of supplementary feed: processed feed, homemade feed and snail meat. Many farmers use commercial feeds to feed the prawn. Fair and Fortner (1981) found that formulated feeds contributed markedly to increase in prawn growth. Growth, health and reproduction of freshwater prawn primarily dependent upon adequate supply of nutrient, both in terms of quantity and quality, in feed. Therefore, it is very important to evaluate the nutrient status of most commonly used freshwater prawn feeds.

The present investigation was conducted with the objectives of exploring the culture practices followed by the freshwater prawn farmers, the water and feed quality maintained during the farming cycle, the nutrient loading of the discharged effluent to the environment and the rate of production in relation to the inputs used.

Materials and methods

Selection of prawn farms

To determine the water quality parameters, three farms were selected from each of Mymensingh, Bagerhat Sadar and Noakhali Sadar for a period of 5 months from July to November 2005. The farms were nearly equal in size, similar in shape, depth, basin and configuration and water supply facilities.

Prawn farming techniques

Freshwater prawn farming in Bangladesh may be categorized broadly into two culture methods-Bheri (gher) culture and polyculture of prawn with carps in ponds. Pond based freshwater prawn culture was prevalent in Mymensingh and Noakhali and gher based prawn culture was prevalent in Bagerhat sadar. Before starting prawn culture, almost all farmers dried their ponds or ghers, repaired their dikes when they become narrow and fragile due to rain, floods and pedestrian effect and removed aquatic weeds in the dry season particularly after the harvesting of *boro* paddy. Ponds and ghers were applied with agricultural lime (CaO) at 0.5 to 2.0 kg/40 m^2 and fertilized at 50 to 200 g/40 m^2 of urea, 50 to 200 g/40 m^2 of triple super phosphate (TSP) and 1 to 3 kg/40 m^2 of cowdung during pond/gher preparation. Water in the farm is usually supplied 3 to

5 days after fertilization. After 7 to 10 days of fertilization, prawn fry are transferred from the nursery ponds/trench of gher to the farms. All of the farms followed polyculture of freshwater prawn and Indian major carps and species combination of carps were not similar in these locations. Farmers usually do not maintain particular stocking density, being affected by the availability of fry and financial status of the farmers. However, most farmers try to stock at a density of 15,000 to 20,000 post-larvae per hectare (1.5 to 2 PL/m^2).

Water quality parameters

Water quality parameters such as temperature (°C), transparency (cm), dissolved oxygen (mg/l), total alkalinity (mg/l), phosphate-phosphorus (mg/l), nitrate-nitrogen (mg/l), nitrite-nitrogen (mg/l), ammonia-nitrogen (mg/l) and chlorophyll a (μg/l) were measured monthly between 0090 and 1000 hrs on each sampling date. Water samples were collected using a horizontal water sampler from three location of each pond and transported to the laboratory through acid preservation. Temperature, transparency and dissolved oxygen were measured on the spot. The analyses of other water quality parameters were done in the Water Quality and Pond Dynamics Laboratory of the Faculty of Fisheries, BAU, Mymensingh.

Temperature and dissolved O_2 were measured by a digital DO meter (YSI model 58). Transparency was measured by using a secchi disc and pH with a pH electrode (Jenway, model 3020). Total alkalinity was determined titrimatrically following Stirling (1985). Chlorophyll *a* was determined spectrophotometrically after filtering samples through Whatman GF/C filters and subsequent acetone extraction of the filtrate following Boyd (1979). The filtrate was analyzed for nitrate-nitrogen (HACH Kit DR/2010, a direct reading spectrometer using Nitraver-6 and Nitriver-3 powder pillows), ammonia nitrogen (HACH Kit DR/2010, a direct reading spectrometer by using Nesslar reagent, mineral stabilizer and trimethyl alcohol) and phosphate-phosphorus (HACH Kit DR/2010 by using phosver-3 reagent powder pillows).

Farm effluent quality parameters

During water exchange and harvesting, effluent water collected from the outlet were measured for dissolved oxygen (mg/l), phosphate-phosphorus (mg/l), nitrate-nitrogen (mg/l), nitrite-nitrogen (mg/l) and ammonia-nitrogen (mg/l). Effluent samples were filtered for nutrient analysis except ammonia which was determined on unfiltered samples. Nutrients were analyzed by a spectrophotometer (HACH Kit DR/2000) following Stirling (1985).

Feed quality analysis

To evaluate the feed quality, different types of feeds (commercial and farm made) were collected from the study area. Commercial feeds were collected from the local market of the study area and homemade feeds that were commonly used by the prawn farmers were collected from the farmer's levels. The proximate compositions of all

collected feeds were analyzed according to the methods given in Association of Official Analytical Chemists (AOAC 1980).

Production and yield

Data on the total production of freshwater prawn and white finfish were obtained from the farm record book of each farmer.

Results

Prawn farming techniques

According to the information obtained from the farmers, it was found that in all the selected farms the methods used for freshwater prawn farming is extensive or improved extensive. Prawn juveniles were stocked after nursing in nursery pond or pocket ghers in May to July and were harvested primarily from November to January. All farmers followed polyculture of prawn with carps mainly for family consumption but in recent years, due to the high risks associated with growing prawn (high price of PLs, feeds), farmers were increasingly growing fish for sale alongside with prawn. A range of carp species were cultured with prawn. Farmers stocked silver carp (*Hypophthalmicthys molitrix*), catla, *Catla catla* and rohu, *Labeo rohita* with freshwater prawn. In Bagerhat Sadar, farmers also stocked black tiger shrimps (*Penaeus monodon)* with freshwater prawn in the same gher with a minimum supply of saline water for 2-3 months. Due to short supply of natural post-larvae, selected farmers are now dependent on hatchery produced post-larvae of prawn.

Water quality parameters

The result of the water quality parameters of the selected farms have been shown in Table 1. Significant difference ($p<0.05$) of temperature was observed among the prawn farming areas. The highest mean value of transparency, 28.13 cm, was recorded in Mymensingh and the lowest, 21.74 cm, was recorded in Noakhali Sadar. There was significant difference ($p<0.05$) of transparency among the study zones.

The dissolved oxygen concentrations under different study areas were found to fluctuate from 4.0 to 8.1, 4.1 to 8.2 and 3.2 to 8.7mg l^{-1} in Noakhali Sadar, Bagerhat Sadar and Mymensingh, respectively. Dissolved O_2 concentration was found to increase gradually over the culture period (Fig. 1a). However, there was no significant difference ($p>0.05$) of dissolved O_2 among the study area. The mean values of pH in Noakhali Sadar, Bagerhat Sadar and Mymensingh were 7.05 ± 0.12, 7.00 ± 0.09, and 7.72 ± 0.08, respectively. The pH value was always higher in Mymensingh compare to other farming zones (Fig. 1b). There was significant difference ($p<0.05$) of pH among the farming areas.

Table 1. Means (±SE) of monthly water quality parameters recorded from different study area. Values are means of 5 sampling dates and three ponds *(N=15)*

Parameter (Mean± S.E)	Noakhali Sadar	Bagerhat Sadar	Mymensingh	ANOVA
Temperature (°C)	29.84 (0.19)^{b}	30.23 (0.19)^{b}	30.93 (0.24)^{a}	*
Secchi depth (cm)	21.74 (1.99)^{b}	24.71 (1.99)^{ab}	28.13 (1.92)^{a}	*
DO (mg/l)	5.75 (0.30)	5.81 (0.37)	5.39 (0.34)	NS
pH	7.05 (0.12)^{b}	7.00 (0.09)^{b}	7.72 (0.08)^{a}	*
Alkalinity (mg/l)	73.47 (4.44)	79.2 (5.00)	74.33 (4.18)	NS
Chlorophyll *a* (μg/l)	81.03 (7.30)^{b}	127.86 (17.2)^{a}	102.48 (13.17)^{ab}	*
Nitrate-nitrogen (mg/l)	0.037 (0.005)^{b}	0.139 (0.035)^{a}	0.123 (0.018)^{a}	*
Nitrite-nitrogen (mg/l)	0.006 (0.0006)	0.025 (0.0093)	0.031 (0.0126)	NS
Phosphate-phosphorus (mg/l)	0.22 (0.05)	0.28 (0.05)	0.44 (0.13)	NS
Ammonia-nitrogen (mg/l)	0.23 (0.055)	0.16 (0.023)	0.19 (0.039)	NS

* P < 0.05; NS, not significant. a, b and ab, superscript

The mean values of total alkalinity varied from 73.47 to 79.2mg/l with the highest in Bagerhat Sadar and the lowest in Noakhali Sadar. There was no significant difference ($p > 0.05$) of total alkalinity among the farming areas. The chlorophyll a concentration was more or less higher in Bagerhat Sadar compare to other zones over the culture period (Fig. 1c). There was significant difference ($p < 0.05$) of chlorophyll *a* among the farming areas.

Nitrate-nitrogen (NO_3-N) concentrations ranged from 0.037 to 0.139mg/l. The NO_3-N concentration was always lower in Noakhali Sadar than Mymensingh and Bagerhat Sadar (Fig. 1d). There was significant difference ($p < 0.05$) of NO_3-N among the farming areas. The ranges of NO_2-N were found to vary from 0.002 to 0.009, 0.003 to 0.143, and 0.007 to 0.180 mg/l in Noakhali Sadar, Bagerhat Sadar and Mymensingh, respectively. The NO_2-N concentration was also lower in Noakhali Sadar compare to other farming zones over the culture period (Fig. 1e). The average monthly fluctuation of NH_3-N in three farming zones was shown in Fig. 1 (f). There was no significant difference ($p > 0.05$) of NH_3-N among Noakhali Sadar, Bagerhat Sadar and Mymensingh. The values of phosphate-phosphorous (mg/l) were found to vary from 0.06 to 0.86, 0.04 to 0.68, and 0.04 to 1.97mg/l in Noakhali Sadar, Bagerhat Sadar and Mymensingh, respectively.

Farm effluent quality parameters

The result of the effluent quality parameters of the selected farms have been shown in Table 2. The mean concentration of nutrients of effluent water were found to vary from 0.063 to 0.093 mg/l of NO_3-N, 0.008 to 0.010 mg/l of NO_2-N, 0.19 to 0.22 mg/l of PO_4-P and 0.08 to 0.17 mg/l of NH_3-N. The highest concentrations of all nutrients in effluent water were found in Mymensingh and the lowest concentrations were found in Noakhali Sadar (Table 2). There was no significant variation in nutrients concentration of discharged effluent among the prawn farming areas.

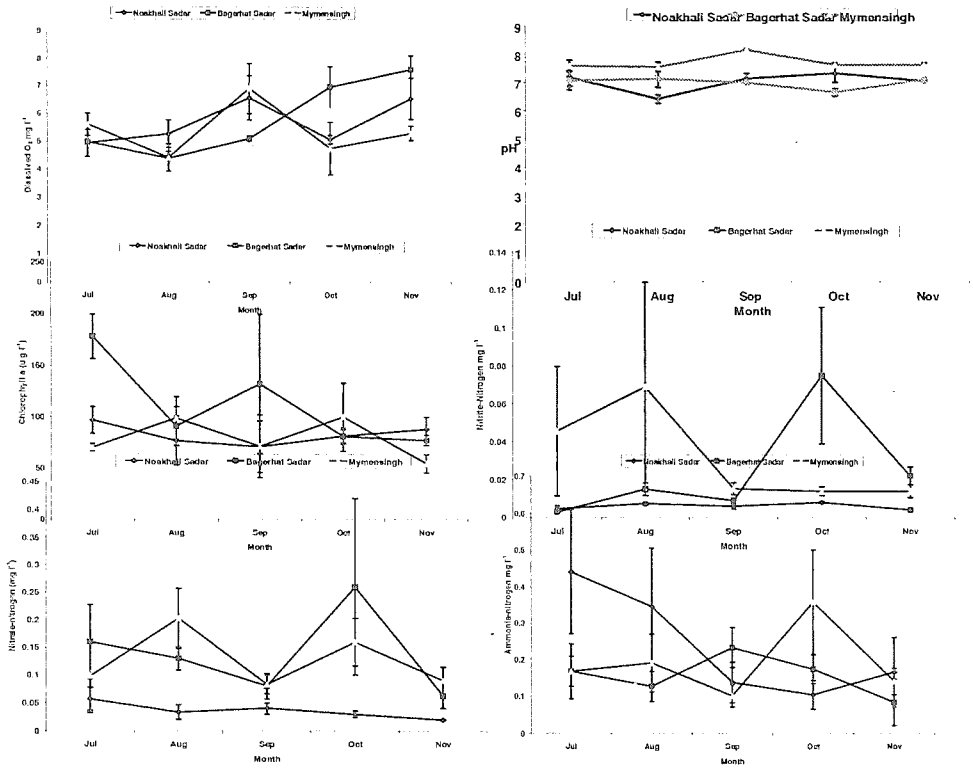

Fig. 1. Average monthly fluctuation of (a) dissolved O_2, (b) pH, (c) chlorophyll *a*, (d) nitrate-nitrogen, (e) nitrite-nitrogen, and (f) ammonia-nitrogen in three prawn farming zones of Bangladesh.

Table 2. Means (±SE) of effluent water quality parameters recorded from different study area. Values are means of 3 sampling dates and three ponds *(N=9)*

Parameter (Mean± S.E)	Noakhali Sadar	Bagerhat Sadar	Mymensingh	ANOVA
DO (mg/l)	5.51 (0.58)	5.66 (1.29)	4.77 (0.14)	NS
Nitrate-nitrogen (mg/l)	0.063 (0.017)	0.068 (0.023)	0.093 (0.050)	NS
Nitrite-nitrogen (mg/l)	0.008 (0.004)	0.008 (0.002)	0.010 (0.003)	NS
Phosphate-phosphorus (mg/l)	0.19 (0.05)	0.22 (0.07)	0.22 (0.05)	NS
Ammonia-nitrogen (mg/l)	0.08 (0.02)	0.12 (0.04)	0.17 (0.08)	NS

Feed quality parameters

The result of the feed quality parameters of the selected farms have been shown in Table 3. The analysed moisture, protein, lipid, ash, crude fibre and nitrogen free extract (NFE) were varied from 9.53 to 10.47%, 27.21 to 31.84%, 6.61 to 7.11%, 9.7 to 17.42%, 9.12 to 11.12% and 26.91 to 37.97% in commercial feeds and 9.52 to 11.2%, 20.66 to 23.54%, 9.91 to11.48%, 10.46 to 17.8%, 12.02 to 12.10% and 25.96 to 35.86% in home made feeds. The highest percentage (31.84%) of crude protein was found in CP feed and

the lowest protein content (20.66%) was found in diet 1 collected from the Noakhali region.

Table 3. Proximate composition (%) of the selected feed samples

Feed	Moisture	Protein	Lipid	Ash	Crude fibre	NFE[1]
Saudi-Bangla	10.47	28.97	7.11	17.42	9.12	26.91
CP feed	9.53	31.84	6.79	9.7	11.12	32.02
Quality feed	9.65	27.21	6.61	14.81	10.36	37.97
Diet-1	9.52	20.66	11.48	10.46	12.02	35.86
Diet-2	9.58	23.54	11.02	17.80	12.10	25.96
Diet-3	11.2	22.43	9.91	10.74	10.22	35.50

[1] Nitrogen free extract calculated as 100 -% (moisture + Protein + Lipid + Ash +Fibre)
Diet 1-3 : Farm made feed from Noakhali, Bagerhat and Mymensingh region

Production performance

The results of production performance of prawn and fish of the selected farms have been shown in Table 4. The average annual yield of prawn was estimated at 411.9 kg/ha. The highest average annual yield of prawn in polyculture system was found in Bagerhat Sadar (512.6 kg/ha) followed by Mymensingh (402.8 kg/ha) and the lowest was found in Noakhali Sadar (320.4 kg/ha). The average annual fish production was found to be 777.0 kg/ha. The highest average annual yield of fish was found in the Noakhali Sadar (1190.2 kg/ha) followed by Mymensingh (720.4 kg/ha) and the lowest was found in Bagerhat Sadar (420.3 kg/ha). In Bagerhat Sadar zone farmers also rear shrimp with prawns in the same gher. The average annual production of shrimp was found to be 126.3 kg/ha.

Table 4. Average production data of selected farms by zone

	Average production/ha (kg)			
Species	Mymensingh	Noakhali Sadar	Bagerhat Sadar	Total
Prawn	402.8	320.4	512.6	411.9
Fish	720.4	1190.2	420.3	777.0
Shrimp	-	-	126.3	126.3

Discussion

Temperature was found to vary from 29.84 ^{0}C to 30.93 ^{0}C, while the mean value (± SE) was 30.33±1.35 ^{0}C, which was suitable for growth of plankton and freshwater prawn. Hoq *et al.* (1996) recorded that water temperature ranged from 27.5 to 30.5 ^{0}C was suitable for the growth of freshwater prawn. Temperatures below 14 ^{0}C or above 35 ^{0}C are generally lethal, 29-31 ^{0}C being optimal for prawn as reported by Akiyama *et al.* (1982) and Mukhopadhyay *et al.* (2003). Variation in water temperatures among farming areas were significant ($p<0.05$). This variation of water temperature among farming areas may be due to the variation in water depth. Water transparency is a gross measure

of productivity. There is a remarkable negative correlation between transparency and production. An opposite result was observed in Noakhali Sadar because most of the farms were newly constructed and more turbid compare to the other farming areas.

The concentrations of dissolved oxygen in the study areas were generally fluctuated and having the range from 3.2 to 8.7 mg/l. Hoq *et al.* (1996) recorded dissolved O_2 ranging from 4.0 to 5.9 mg/l in five prawn farmers ponds, which were suitable for prawn culture. Mohanta (2000) reported dissolved O_2 ranging 5.20 to 8.10 mg/l in broodstock pond of freshwater prawn in India. pH values varied from 6.19 to 8.20, which was more or less similar to the findings of Jia-Mo *et al.* (1988), Hoq *et al.* (1996) and Hossain *et al.* (2000). Although freshwater prawns have been raised in ponds with a pH range of 6.19 to 8.20 with no apparent short term adverse effects, it is best to avoid a pH below 6.5 or above 9.5 (D'Abramo and Brunson 1996). Nitrate and Nitrite concentration was always lower in Noakhali Sadar mainly due to lesser amount of inputs were used in prawn farming compare to the other farming zones. Nitrites at concentration of 1.8 mg/l have caused serious problems in hatcheries but there is no definitive information as to the toxicity of nitrite in grow-out periods of prawn (D'Abramo and Brunson 1996). Strauss, Robinette and Heinen (1991) reported that juveniles prawn should not be exposed>1 mg/l at pH 9.0 and > 2 mg/l at pH 8.5. In the present study, all of the water quality parameters in the major prawn farming areas of Bangladesh were within the suitable range for prawn culture (Akiyama *et al.* 1982, Jia-Mo *et al.* 1988, Hoq *et al.* 1996, Mohanta 2000, Hossain *et al.* 2000).

The concentration of nutrients of effluent water were found to vary from 0.063 to 0.093 mg/l of NO_3-N, 0.008 to 0.010 mg/l of NO_2-N, 0.19 to 0.22 mg/l of PO_4-P and 0.08 to 0.17 mg/l of NH_3-N. All of the nutrient measured in effluent water were found to acceptable level as reported by Davis (1993), and did not seem to pose a direct treat to the recipients.

Growth, health and reproduction of freshwater prawn primarily dependent upon adequate supply of nutrient both in terms of quantity and quality in feed. Protein is the major growth-promoting factor in feed. Mukhopadhyay *et al.,* 2003 conducted a study to evaluate the nutrients requirement of prawn for growth and other physiological functions and observed above 30% protein required for maximum growth and protein efficiency. In the present study, the protein contents were 27.21 to 31.84% in commercial feed and 20.66 to 23.54% in home made feed. Therefore, it was found that commercial feeds were more effective to achieve better production of freshwater prawn. Lipids are primarily included in formulated diet to maximize the protein sparing (Hasan 2001). The analysed crude lipid contents varied from 6.61 to 7.11% in commercial feeds and 9.91to11.48% in home made feeds. The other chemical composition of prawn feeds varied with the source of feeds and ingredients used to prepare feed.

Prawn farmers use supplementary feed differently, depending on their experience and the practices they employ. Boonyaratpalin and New (1993) noted that many farmers make their own feed for *Macrobrachium.* For example, in Thailand most typical formulations containing trash fish, soybean meal, corn meal, broken rice and sometimes shrimp shell meal are commonly used. Many authors (Law *et al.* 1990, Durairaj *et al.*

1992, and MacLean *et al.* 1989) stated that high production and survival rate of prawns fed on low-cost feeds rely on locally available ingredients. Mazid and Mahmood (1992) demonstrated the benefits of supplemental feeding of *M. rosenbergii* as opposed to fertilization alone. Therefore, it is concluded that as most of the prawn farmers are poor therefore, they may use the home made feed other than the nutritionally balanced more expensive commercial feed to increase the existing production level of freshwater prawn.

The production of prawn is quite variable because of simple culture method, averaging 411.9 kg/ha in polyculture system. The average annual production of prawn (head on) was estimated at 432.6 kg/ha in Bagerhat area (Ahmed 2003) and 200 to 300 kg/ha/crop (Chapman and Abedin 1998). Hoq *et al.* (1996) reported that prawn productivity varied from 162 to 428 kg/ha in Bangladesh after 10 months rearing with fish. The present production level was more or less similar with the above reported prawn productivity.

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