Journal of Sustainability Science and Management 2008 Volume 3 (2): 41-51

A COMPARATIVE STUDY OF TRADITIONAL AND IMPROVED TRADITIONAL CULTURE SYSTEM OF BLACK TIGER SHRIMP (*Penaeus monodon*) IN KHULNA, BANGLADESH

[1,2]K. D. SIMON, [2]F. A. FLOWRA, [2]M. I. HOSSAIN, [3]R. ISLAM, [3]K. A. HUQ AND [1,*]A. G. MAZLAN
[1]Marine Science Programme, Faculty of Science and Technology, National University of Malaysia, 43600 UKM Bangi, Selangor D.E., MALAYSIA; [2]University of Rajshahi, Rajshahi 6205, BANGLADESH; [3]Fisheries and Marine Resource Technology Discipline, Khulna University, KHULNA.

** Corresponding Author : e-mail: mag@ukm.my or magfish05@yahoo.com*

Abstract : A comparative study of bio-economic feasibility of black tiger shrimp (*Penaeus monodon*) was carried out in Dacope and Paikgacha Upazila of Khulna district, Bangladesh. A total of six Ghers (a special type of agricultural field with raised high surrounding banks/borders situated by the side of a river) from different locations of the greater Khulna district were selected as study area. The study observed the following attributes: growth, growth rate (GR), survival rate (SR), production, production rate (PR), production cost (PC), net profit (NP), gross profit (GP), and ratio of profit (RP) to total cost (TC). The size of the ponds in T and IT culture systems varied in size from 15 to 39 acres respectively. No nursing practice was observed either in T or in IT ponds. Nevertheless, fertilizers and supplementary feeds were used in the IT culture system as post-stocking management. The pond dike system was found to be stronger in IT ponds than in T ponds. No apparent variations of water quality parameters were observed in T and IT ponds throughout the culture period. The average growth rate of shrimp was higher in T ponds than that of IT ponds while the average survival rate was found to be higher in IT ponds than T ponds. Additionally, the average PR, PC, GP and NP was higher in IT ponds compared to T ponds. Moreover, RP to TC per kg of shrimp in T and IT ponds was higher in IT ponds compared with T ponds. This study found that IT culture system was more economical and profitable than that of the T culture system in terms of NP, GP and RP to TC. However, GR was higher in the T culture system than the IT culture system, which is attributed to the lower stocking of post-larval shrimp in T ponds.

KEYWORDS: Black tiger shrimp (*Penaeus monodon*), Gher, Improved traditional culture system, Khulna, Traditional culture system

Introduction

Shrimp cultivation has a long history in Bangladesh, and has experienced a rapid growth over the past two decades in response to expanding global demand for shrimp. Export of shrimps from Bangladesh has increased sharply (Bangladesh Centre for Advanced Studies 2001). Shrimp of species *Penaeus monodon* is an important economic resource and supports a large industry in Bangladesh. In mid 1980s, shrimp farming has played a key role in the economy of Bangladesh, since it was the second most important export product. Consequently, the surface area allocated to shrimp farming has increased from 64,000 ha in 1989-1990 to 170,000 ha in 2003 and the number of shrimp farms increased from 10,300 in 1998 to 40,000 in 2003 (DoF, 2002; Nuruzzaman and Muniruzzaman, 2003). The total farmed shrimp production was estimated to be 64,970 Metric ton (Mt) in 2002, and the country earned about US$ 350 million from the export of about 29,700 Mt of processed shrimp in this period (DoF, 2002).

Shrimp in Bangladesh are mostly cultured in Ghers, a special type of agricultural field with raised surrounding banks/borders situated by the side of a river. Ghers are used to cultivate rice in winter and shrimp production in summer. The culture practice begins by trapping the shrimp larvae that enter the farm with tidal water during high tide using an indigenous sluice gate (box type). In addition to the target species of shrimp (*P. monodon*), other species of shrimp and fish including predatory fish also enter the farm, causing low production values for shrimp. The traditional/T grow-out pond (Gher) is comparatively smaller than improved traditional/IT ponds. In the T culture systems water intake is entirely tidal based. Hence, no aeration and no feed or fertilizers were applied in the large T Ghers during the entire grow-out period.

In contrast, IT culture systems use some pre- and post-stocking management practices. The two main centers of shrimp production are located in the Khulna, Satkhira, and Bagerhat districts in the Southwest and the Chittagong and Cox's bazaar districts in the Southeast areas of Bangladesh (Wahab et al. 2003). The present paper demonstrates the differences between the T and IT shrimp culture systems currently practised in the South west part of Bangladesh.

Materials and Methods

The study was carried out between February and August 2005 at Dacope and Paikgacha upazila in the Khulna District (Figure 1). Six Ghers of varying sizes were randomly selected from several farm owners, including three T and three IT culture systems. Pre-stocking management practice was performed, including dike reparations and ploughing (two times at weekly intervals).

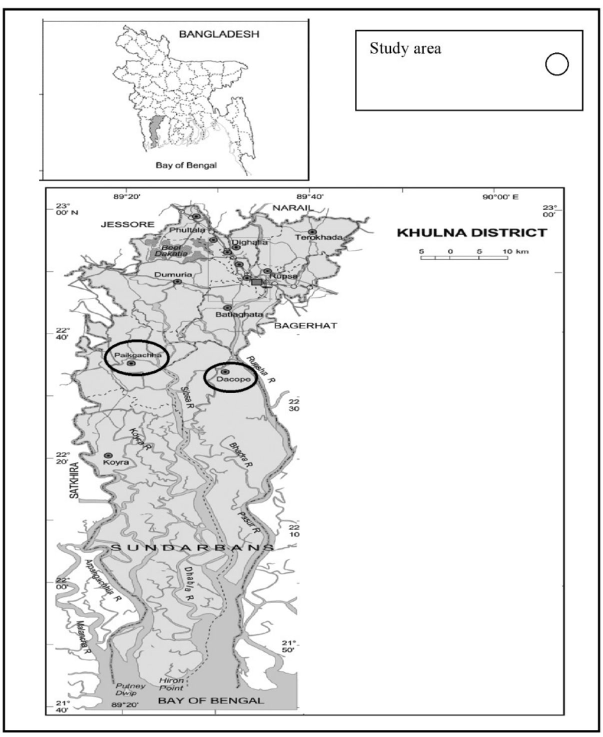

Figure 1. Map of Khulna district indicating the two study areas within Dacope and Paikgacha upazila.

Lime (CaO 200 kg/acre; $CaMg(CO_3)_2$ 40 kg/acre) was applied 10-15 days after ploughing in both T and IT ponds. Ghers were fertilized with 12 kg/acre urea, 8 kg/acre of Triple super phosphate (TSP) and 200 kg/acre of cow dung one week before stocking in both T and IT culture systems.

Acclimatization was done in hapa (small containment) for newly stocked PLs in both culture systems and diseased shrimp observed in the hapa were immediately removed. During grow-out management oilcake and rice bran (3 kg/acre) were used to feed shrimps once a day, either during the morning or evening, in the IT pond.

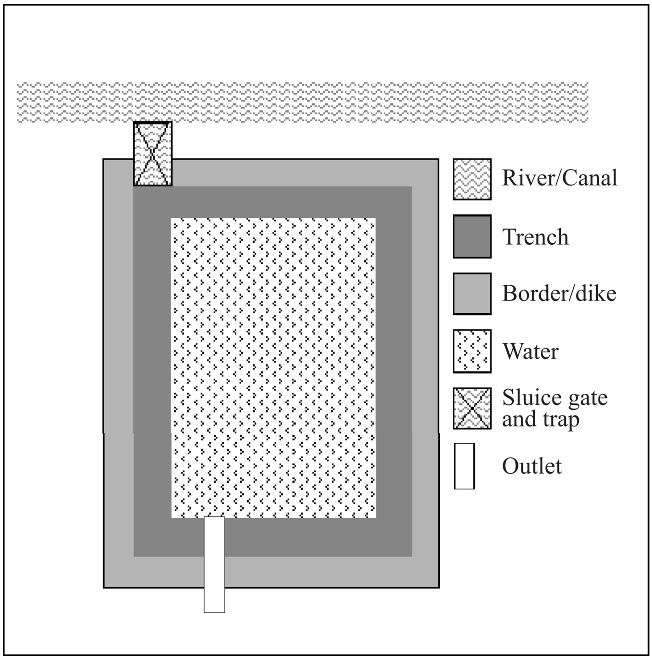

Figure 2. Diagrammatic figure of a Gher in two culture systems

In order to eliminate predators, rotenone (0.75 kg/acre) was applied after watering in both the culture systems. The manual sampling of the Ghers was carried out every fortnight. Sample collection and on-site measurements were carried out in daylight, between 10:00 AM and 1.30 PM. The following measurements were recorded: temperature (ºC), salinity (ppt) (Refractometer, mod. 4200/ REV A/05-95, Conductivity meter), pH (pH meter, mod. EC 10 portable pH meter, Hach) and water transparency (Secchi disc). Additionally, soil type, the quality of Gher dike, water volume, water color and the presence or absence of aquatic weeds were also observed. The sampled Ghers Dacope and Paikgacha contain one main water inlet point and one or two different outlet points (Figure 2).

A portion of the water volume of the Gher was routinely exchanged over 4-6 days during the full and new moon. It was observed that, the frequency of inflow–outflow within the exchange period changed from pre–harvest towards the harvest period. The water level fluctuated between 10 and 20 cm every fortnight, which indicates an exchange rate in the range of 0–10% volume/day. Unlike systems that is solely use to produce shrimp, complete drainage of the Gher was not practical. Instead, at the end of the cycle, a combined harvest of the remaining shrimp, other fishes, and planting of rice takes place. To keep the rice fields wet, the outlet gates were locked to maintain a few inches of water within the Gher. There was no peak harvest period at the end of the cycle but frequently harvesting was done during water exchange over a long period. Final harvest and planting of rice were carried out in early August (Table 1). Partial harvest (using traps and cast nets) was carried out when the shrimp size reached about 50g. At the end of July and near the beginning of August total harvest was done. In the case of Gher owners who completely drained out water, harvesting of shrimp was by hand picking. Production rate and cost data were collected and analysed to determine the economic feasibility of the two culture systems.

Growth rate (GR, g/day) was estimated using the formula: GR (g/day)=W_2-W_1/T_2-T_1. FCR and SR were calculated fortnightly as FCR (Food Conversion Ratio) =Weight of food presented (kg)/weight of animal produced (kg) and SR (Survival Rate) =Stock of shrimp at sampling time/ Total no. of shrimp stockedx100. Finally, stock was calculated as Stock=Mean no of shrimp in the net/Dimension of cast net x pond size.

Table 1: Pre- and post-stocking management systems of Ghers

Steps of Gher management		Months						
		Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Pre-stocking management		▬						
Stocking of shrimp fry		▬	▬	▬	▬	▬	▬	
Post-stocking management	Partial harvest			▬	▬	▬		
	Total harvest						▬	▬

Results

The IT ponds were comparatively bigger than the T ponds (Table 5). The bottom soils were mostly loamy types (Table 2). Water temperature was found to fluctuate between 26 ºC and 34 ºC. Salinity varied between 10 to 19 ppt and 9 to 18 ppt in T and IT ponds respectively (Table 3). The pH values in all the T and IT ponds ranged from 7 to 9 while water transparency in all T and IT ponds varied between 25 cm and 40 cm. Water depth was almost similar in both ponds between 80 cm and 98 cm in T ponds and 80 cm to 100 cm in IT ponds. Throughout the culture period, water color of the ponds was green and aquatic weeds were present in most of the Ghers (Table 3).

Among the six (3 T and 3 IT) ponds, a comparatively higher growth by weight was found in ponds T_3 and IT_3. The final average growth by weight of *P. monodon* after 120 days was 34.1±0.79 g in T ponds and 26.57±0.12 g in IT ponds. The overall growth rates were 0.27 g/day and 0.21 g/ day in T and IT ponds respectively (Table 6). At the end of 120 days of culture in three T and three IT ponds the average growth rate was the same (0.042 g/day, Table 4).

Table 2: Percentage distribution of Ghers according to bottom soil type

Types of soil	No. of *Gher*	Percentage (%)
Loamy	3	50
Sandy loamy	2	33.33
Clay-loamy	1	16.67
Total	6	100

Table 3: Water quality parameter at brackish water shrimp farms
in Dacope and Paikgacha upazila in Khulna, Bangladesh.

Culture days	T							IT						
	Pond	Water temperature (ºC)	Salinity (ppt)	pH	Water transparency (cm)	Water depth (cm)	Aquatic weeds	Pond	Water temperature (ºC)	Salinity (ppt)	pH	Water transparency (cm)	Water depth (cm)	Aquatic weeds
0	T_1	27	12	7.5	30	95	+	IT_1	28	10	7.5	25	100	+
	T_2	26	11	7	35	96	+	IT_2	29	12	8	32	90	-
	T_3	27	11	8	38	96	-	IT_3	28	11	7	40	95	+
15	T_1	29	14	8	35	93	+	IT_1	30	11	8	35	95	-
	T_2	30	13	7.5	37	90	+	IT_2	30	13	8.5	28	85	+
	T_3	29	14	8.5	30	92	-	IT_3	29	13	7.5	34	90	-
30	T_1	31	16	7.5	34	90	+	IT_1	31	13	7	30	93	+
	T_2	30	15	8	38	84	-	IT_2	30.5	14	7.5	35	84	-
	T_3	31.5	15	7	28	87	+	IT_3	31	14	7	32	87	+
45	T_1	33.5	17	8.5	35	87	+	IT_1	32	16	7.5	34	90	-
	T_2	31.5	16	7	25	83	+	IT_2	31	15	8	32	83	+
	T_3	32	16	7.5	35	85	-	IT_3	32	16	8.5	37	85	-
60	T_1	33	18	7.5	37	84	+	IT_1	31.5	17	7	25	86	+
	T_2	32	17	8.5	32	82	+	IT_2	33	16	7	30	82	-
	T_3	32.5	17	8	40	83	-	IT_3	32	17	7.5	35	83	+
75	T_1	33.5	19	8.5	28	81	+	IT_1	33	18	8	30	83	-
	T_2	33	18	8	35	80	-	IT_2	32.5	17	8.5	32	80	+
	T_3	33.5	18	8.5	38	81	+	IT_3	34	18	8	34	81	-
90	T_1	32.5	14	8	30	90	+	IT_1	31	13	7.5	34	95	+
	T_2	33	13	7.5	37	86	-	IT_2	30	11	8	30	85	-
	T_3	32.5	14	8	35	88	+	IT_3	30	13	8	36	90	-
105	T_1	33	12	8.5	35	94	+	IT_1	32	11	8	35	98	+
	T_2	32.5	12	8	40	92	+	IT_2	31	10	8.5	29	94	-
	T_3	32.5	13	8.5	38	93	-	IT_3	31	11	8.5	31	96	+
120	T_1	29.5	10	7.5	36	98	+	IT_1	30.5	9	8.5	30	99	-
	T_2	13	11	8.5	38	96	+	IT_2	29	9	7.5	25	97	+
	T_3	30.5	10	7	40	97	-	IT_3	31	10	7	33	98	+

Bi weekly routine sampling, +: present, -: absent

Higher mortalities occurred during the early stage of the culture period. Within 30 and 45 days of culture 37 - 45% of the PLs (Post larvae) died in T ponds and 18 - 20% of the PLs died in IT ponds (Figure 5). The production rate of *P. monodon* in pond T_3 was better than that of pond T_1 and T_2 while the production rate of IT_2 was better than that of the pond IT_1 and IT_3 (Table 5). The overall average FCR of *P. monodon* after 120 days was 1:1.14 in IT ponds (Table 5).

The average ratio of profit to total cost (TC) for the three T ponds was approximately 98.%, indicating a poor profitability of the culture system in brackish water, while the average ratio of profit to TC for the three IT ponds was approximately 150%, indicating a good profitability of the culture system (Table 5).

The overall average Production cost (PC)/ acre, Gross Profit (GP)/acre and Net Profit (NP)/ acre of three T ponds were US$ 387, US$ 640 and US$ 508 respectively (Table 6). Average PC/acre, GP/acre and NP/acre of three IT ponds were US$ 835, US$. 1592 and US$ 1457 respectively (Table 6).

Table 4: Growth rate of *Penaeus monodon* by weight (g/day) in 3 T (T_1, T_2, T_3) and 3 IT (IT_1, IT_2, IT_3) ponds

Culture days	Growth rate (g/day)				Growth rate (g/day)			
	Pond no.			Average	Pond no.			Average
	T_1	T_2	T_3		T_1	T_2	T_3	
0	-	-	-	-	-	-	-	-
15	0.167	0.193	0.187	0.182	0.167	0.18	0.273	0.207
30	0.467	0.467	0.48	0.471	0.333	0.333	0.267	0.311
45	0.467	0.5	0.433	0.467	0.467	0.467	0.367	0.411
60	0.4	0.4	0.433	0.411	0.3	0.3	0.433	0.4
75	0.333	0.333	0.267	0.311	0.167	0.167	0.133	0.144
90	0.2	0.133	0.2	0.178	0.1	0.1	0.087	0.085
105	0.093	0.066	0.133	0.097	0.06	0.06	0.047	0.056
120	0.006	0.053	0.066	0.042	0.053	0.04	0.033	0.042

Table 5: Total and average survival rate, feed used, Food conversion ration, production, production rate, production cost, and profit of Penaeus monodon culture in 3 T and 3 IT ponds

Item	T ponds				IT ponds			
	T_1	T_2	T_3	Average	IT_1	IT_2	IT_3	Average
Pond size (Acre)	7	31	8	15.33	49	35	33	39
Stocking density (PL/acre)	7,450	8,300	8,000	7,917	15,800	17,300	16,500	16,533
Initial average length (cm)	1.31	0.83	1.28	1.14	1.43	1.44	1.75	1.54
Final average length (cm)	16.15	16.25	16.72	16.37	15.12	15	15.02	15.05
Initial average weight (g)	1.5	1.6	2	1.7	1.5	1.8	1.9	1.73
Final average weight (g)	33.5	33.8	35	34.1	26.7	26.5	26.5	26.57
Survival rate (%)	45	49	55	49.67	70	75	72	72.33
Total feed used (kg)	NU*	NU*	NU*	-	17,640	12,600	11,880	14,040
FCR	-	-	-	-	1: 1.22	1: 1.05	1: 1.14	1: 1.14
Total production (kg)	786.16	4,261.40	1,232	2,093.19	14,469.80	12,034.31	10,389.06	12,297.72
Production rate (kg/acre)	112.31	137.46	154	134.59	295.30	343.84	314.82	317.99
Production cost (US$/kg)	3.43	2.85	2.50	2.93	2.73	2.64	2.65	2.63
Profit/kg	164.44	208.72	238.82	203.99	244.12	259.97	251.11	251.73
Ratio of profit to total cost (%)	64.35	98.79	131.81	98.32	138.8	162.44	148.68	149.97
Net profit (US$/acre)	335.79	521.66	657.736	508.72	1310.712	1625.19	1437.36	1457.756
Gross profit (US$/acre)	472.15	36,175.48	790.29	640.06	1446.704	1762.08	1570.14	1592.97
Production cost (US$/acre)	385.47	21,559.61	385.71	387.72	808.32	863.59	833.24	835.28

NU*= Not used

Table 6: Comparison of economic feasibility matrix between T and IT culture systems

Average Item	T	IT	Merits of IT system
Growth rate	0.27 (g/day)	0.21 (g/day)	-0.06 (-22.22 %)
Survival rate	50%	72%	+22%
Production rate	135 (kg/acre)	318 (kg/acre)	+183 (135.56%)
Production cost	387.72 (US$/acre)	835.28 (US$/acre)	+24,616 (115.43%)
Gross profit	640.06 (US$/acre)	1592.97 (US$/acre)	+52,411 (148.88%)
Net profit	508.71 (US$/acre)	1457.75 (US$/acre)	+52,197 (186.55%)
Stocking density	7,917 (PL/acre)	16,533 (PL/acre)	+8,616 (108.83%)
Average pond size	15.33 acre	39 acre	+23.67 (150.40%)
Production cost	2.92 (US$/kg)	2.63 (US$/kg)	-16 (-9.94%)
Profit	3.70 (US$/kg)	4.58 (US$/kg)	+48 (23.53%)
Ratio of profit to total cost	98.32 %	149.97%	+51.65 %

Discussion

This study found that there is no direct effect of pond size on PR. Loamy and clay soils are the best for *P. monodon* culture (Paul 1996). However in 60% of the contained loamy soils, a lack of appropriate management systems resulted in low production values.

In both T and IT ponds the growth rate of shrimp was found to be directly related to water temperature. Chiu (1988), Apud (1989), and Annon (1986) reported that the recommended water temperature for *P. monodon* culture is 25-30 ºC. In this study water temperature fluctuated between 26 ºC and 34 ºC (Table 3). Fluctuations in salinity below 8 ppt or above 18 ppt have been blamed for the retarded growth of penaeid shrimp (Boyd and Fast, 1992). The recommended level of water transparency for shrimp farming is between 35 and 60 cm (Annon, 1992). The water transparency in this experiment remained lower than the recommended values throughout most of the culture period in all the T and IT ponds. There was no effect of water transparency on the growth of *P. monodon* in all the T and IT ponds, indicating that the presence of natural food was optimum.

The ideal water depth for shrimp culture is 1.0 to 1.2 m (Annon 1992). Average depth should be approximately 0.9 m, with a minimum of 0.75 m and a maximum of 1.2 m (New and Singholka 1985). The desirable water depth could not be maintained in the T ponds due to poor dike management. The increase of water depth in all the T and IT ponds from June to July may be due to increased rainfall. While the decline of water level in all the T and IT ponds was due to seepage and evaporation.

Different trends were found for each of the culture system investigated. The salinity varied from 10 to 19 ppt in T ponds and 9 to 18 ppt in IT ponds and both were favorable for shrimp growth (Table 3). The optimum range for water pH for shrimp culture is 7-9 (Boyd and Fast, 1992). A higher pH (pH >9) has a harmful effect on shrimp production. To maintain pH level at the optimum range, lime was applied regularly in the IT ponds. Nevertheless, no significant difference between pH values in IT and T ponds was evident.

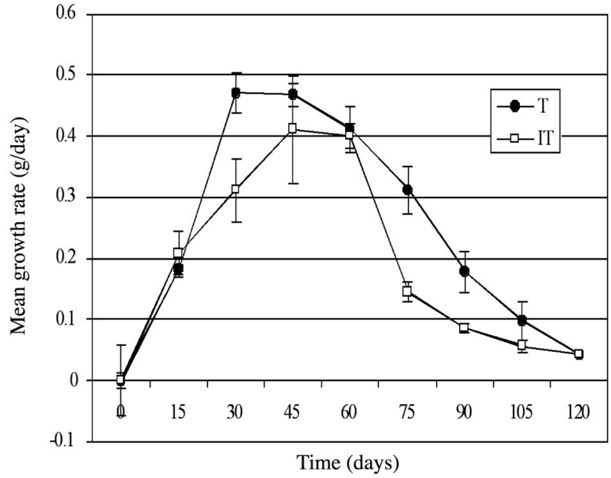

Figure 3. Growth rate of *P. monodon* (g/day) in T and IT ponds.

GR (g/day) of shrimp was relatively higher in T culture ponds (Figure 3) because of a lower stocking density. Initially the mean growth (g) was similar in the two culture systems but after some time the mean growth was higher in IT ponds (Figure 4). Conversely the SR of the shrimp was higher in IT culture systems, which may be due to the post stocking management of IT Ghers (Figure 5).

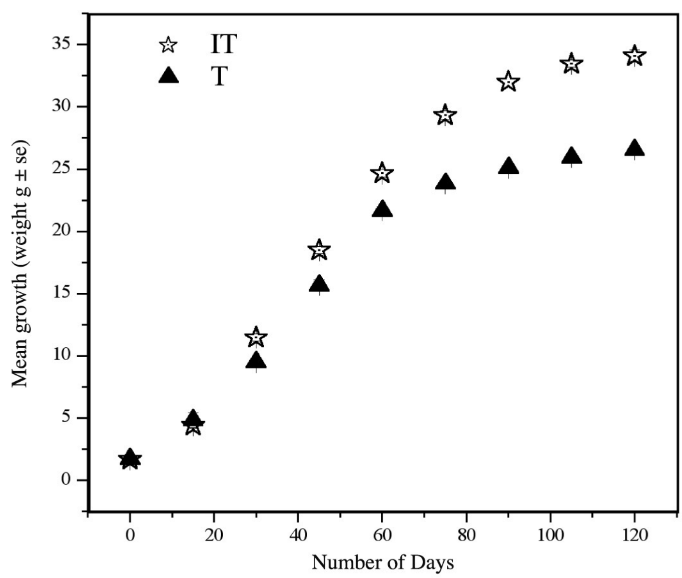

Figure 4. Mean growth (weight, g) of shrimp within T and IT culture system

Among the T and IT ponds, a higher growth by weight was found in ponds T_3 and IT_3 (Table 4). This higher rate may be attributed to moderate temperature and salinity for pond and temperature, salinity, and water transparency for pond IT_3. The growth of *P. monodon* in T and IT ponds was quite acceptable compared to the results of research in brackish water carried out elsewhere. Hossain *et al.* (1992), for example, found a growth rate 21.65± 0.81 g in 120 days with stocking density of 5 PL/m^2. In another experiment in brackish water, Hoq *et al.* (1994) reported a weight gain of 27.99 ± 2.07 g in 105 days with a stocking density of 4 PL/m^2. Felix and Sukumaran (1988) found a final harvesting weight of 19.0 g in 105 days with a stocking density of 5 PL/m^2 and Biswas (1996) found 33.05 ± 2.12 g in 150 days with a stocking density of 5 PL/m^2 in fresh water ponds.

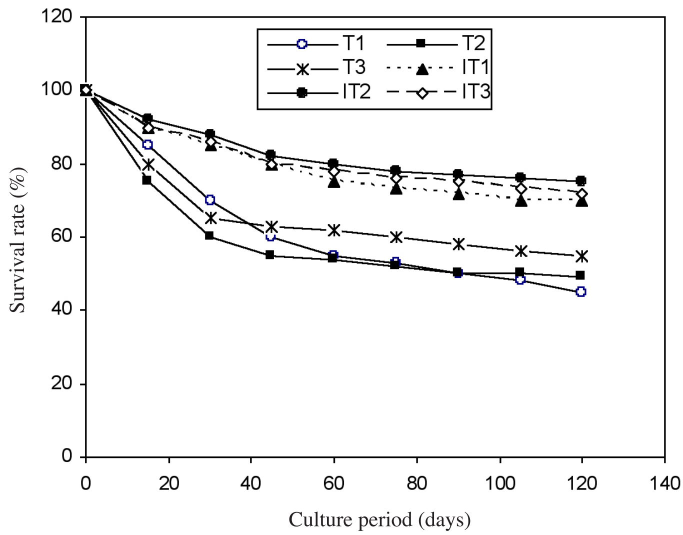

Figure 5. Survival rate (%) of *P. monodon* in T and IT ponds

The overall growth rates of 0.27 g/day and 0.21 g/day in T and IT ponds respectively are satisfactory compared to those reported by Hossain (1992), Hoq (1994), Felix, Sukumaran (1988) and Biswas (1996). The growth rates reported by these researchers were 0.18g/day, 0.28g/day, 0.15g/day, and 0.05g/day respectively. These results are comparable to the findings of Mokizuki (1979), Apud *et al.* (1981) and the T_1 treatment (5 PL/m^2) of Hossain *et al.* (1992).

A higher value for the growth rate may be attributed to a longer period of culture. Salinity could also be the primary reason for such a high daily growth rate (Chakraborti *et al.* 1985). The comparatively higher growth rate of shrimp in T ponds may be due to the lower stocking density (2 PL/m^2) compared to that of the IT ponds (4 PL/m^2). Higher mortalities were observed during the early stage of the culture period in all of the T and IT ponds. Lester and Pante (1992) suggested that extremely high or low salinity is deleterious to shrimp at the early stages of development.

The production rate of *P. monodon* in pond T_3 was better than that of pond T_1 and T_2 because of less fluctuation of physico-chemical parameters and a high level of natural productivity in the pond (Table 5). This production rate was lower than those reported by Hoq *et al.* (1994), Felix and Sukumaran (1988), Hossain *et al.* (1992), Biswas (1996), Rahman (1990) and Liao (1981) in T ponds . The production rate of IT_2 was better than that of pond IT_1 and IT_3 due to less fluctuation of various physico-chemical parameters, good feeding responses, and a high level of natural productivity in the pond (Table 5).

The overall average FCR of *P. monodon* after 120 days was 1:1.14 in IT ponds. This FCR was highly satisfactory compared to the findings of 1:1.69 and 1:1.78 by Liao (1981) in a semi-intensive culture method for the same species and 1:1.67 by Biswas (1996) in freshwater with a stocking density of 5 PL/m^2. The average ratio of profit to total cost for the three T ponds was about 98%, indicating a poor profitability of the culture system in brackish water, while the average ratio of profit to total cost from the three IT ponds was about 150%, indicating a good profitability of the culture system (Table 6). In general shrimp farming under extensive culture system would generate a profit in excess of 200% (Hoq *et al.* 1994).

Conclusion

The brackish water shrimp industry in the Khulna region is dominated by T and extensive culture systems. It is clear from this study that the IT culture system is better in all aspects of economic viability (SR, PR, NP, GP, and RP) than the T culture system. Nevertheless, the daily GR of shrimp in IT culture system is lower than that of the T culture system. This is likely due to the effect of higher stocking densities in the IT culture system. Likewise, PC in the IT culture system is about (115%) higher than the T culture system, which could be compensated by the TP. The higher PR in the IT culture system is due to a higher stocking rate of PL, use of feed, regular use of lime, fertilizers, chemicals and better pond management.

Acknowledgements

The authors gratefully acknowledge suggestions and criticisms of two anonymous reviewers. The authors would like to thank the Bangladesh Fisheries Research Institute (Brackish water Station, Paikgacha, Khulna) for their kind cooperation during the sampling period. The contribution of the analytical staff at the Soil Resource Development Institute (SRDI) is duly acknowledged. Thanks are also due to all the participating shrimp farmers. The authors are fully indebted to Dr. Madan Mohan Dey, regional director and senior scientist, World Fish Center, Penang, Malaysia, for his enormous encouragement and scientific comments.

References

Annon (1992). Prawn Raising Manual. The B-MEG Shrimp Technical Service Group, the Shrimp Sales Group and the Calatrava Research Grouup. Feed Biseness San Miguel Foods, Inc., pp 8 – 15.

Annon (1986). Shrimp Culture: Pond Design Operation and Management. Selected pub. No. 2 for commemorating World Food Day. Net Work of Aquaculture Centre in Asia, Bangkok, Thailand, pp 15-48.

Apud, F. D. (1989). Recent developments in prawn pond culture. Aquaculture extension pamphlet no. 1, May, 1989. Aquaculture Department, SEAFDC, Tigbauan, IIoilo, Philippines, p 24,

Apud, F. D, Gonzales K, Deatras N. (1981). Survival, growth and production of *Penaeus monodon* (Fab.) at different stocking densities in earthen ponds with flow through system and supplementary feeding. Fisheries Research journal of Philippines, (6), 1-9,

BCAS (Bangladesh Centre for Advanced Studies) (2001). Women and children study, Dhaka, Bangladesh: Author.

Biswas, A. K. (1996). Experimental Monoculture of *Penaeus monodon* (Fabricius, 1798) in freshwater ponds at beel kodalia, Mollahat, Bagerhat. A thesis by Bachelor of Science in Fisheries and Marine Resource Technology, Khulna University. p 28.

Boyd, C. E., Fast, A. W. (1992). Pond monitoring and management. In: Marine Shrimp Culture: Principles and Practices, edited by A. W. Fast and L. J. Lester, Elsevier, Amstardam, pp 497 - 508.

Chakraborti, R.K., Ravichandran, P., Halder, D.D., Mandal, S.K., Sanfui, D. (1985). Same physico-chemical characteristics of Kakdeeip Brackish Water ponds and their influence on the survival, growth and production of *Penaeus monodon* (Fab.). Indian J. Fish. (32), 224 - 235.

Chiu, Y.N. (1988). Water quality Management for intensive prawn ponds. In: Technical Considerations for the Management and Operation of Intensive Prawn Farms, edited by Y.N Chiu, L.M. Santos and R.O. Juliano, U .P. Aquaculture Society, IIoilo City, Philippines, pp 102-125.

DoF (Department of Fisheries) (2002). Fish Week Compendium. Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh, p57.

Felix, S., Sukumaran, N. (1988). Performence of *Penaeus indicus* and *Penaeus monodon* under mono and mixed culture system. In: Proceedings of the First Indian Fisheries Forum, edited by M. M. Joseph. Asian Fisheries Society. Indian Branch, Mangalorer, pp 129 -130.

Hoq, M.E., Halder, G.C., Begum, M. (1994). Experimental pond culture of tiger Shrimp, *Penaeus monodon* (Fab.) with various stocking rates and supplemental feeding. Progressive Agriculture, 5 (2): 55 - 61.

Hossain, S.M.Z , Corre, J.R.V., and Tolcdo, C.E. (1992). Effect of stocking densities on the growth, survival and production of *Penaeus monodon* (Fabricius). Bangladesh Journal of Zoology, 20(1): 35-42.

Lester, L.J., Pante, M.J.R. (1992). Penaeid temperature and salinity responses. In: Marine Shrimp Culture: Principles and Practices, edited by A.W. Fast and L. J. Lester. Elsevier, Amsterdam, pp 515 – 534.

Liao, I.C. (1981). Status and problems of grass prawn culture in Taiwan. Paper presented at the ROC - Japan Symposium on Mariculture, Taipei, Taiwan, R.O.C. pp 1 -35.

Mokizuki, H. (1979). Recent Prawn Culture In The Philippines. Philippine J. Fish 16: 39-125.

New, M.B., Singholka, S. (1985). Brackish water prawn farming. A manual for the culture of *P. monodon* FAO Fish Tech. Paper, Rev. 1225.

Nuruzzaman, M., Muniruzzaman (2003). Impacts of shrimp industry on coastal communities. Paper Presented in the Workshop on Present Status of Coastal and Marine Resources of Bangladesh and Future Potentials for Poverty Alleviation held in BRAC Auditorium, Mohakhali, Dhaka, Bangladesh.

Paul, S.K. (1996). Chingri Adhunik Chash Projukti O Upokulyo Paribesh Babosthapona (Modern Shrimp culture technology and coastal environment management), Dhaka-1205.

Rahman, M. A. (1990). Effect of some limnological parameters of tiger shrimp *Penaeus monodon* production under semi-intensive culture. A thesis by Master of Science (Fisheries) in Fisheries Biology and Limnology, Bangladesh Agricultural University, Mymensingh. p 1.

Wahab, M.A., Bergheim, A, Braaten, B. (2003). Water quality and partial mass budget in extensive shrimp ponds in Bangladesh. Aquaculture 218: 413-423.