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Study on the Effect of Culture Management and Stocking Density on the Production of Shrimp (*P. monodon*) in Semi-intensive Farming System

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Abstract: A three and half month study was undertaken to evaluate the effect of culture management and stocking density on the growth and survival of *Penaeus monodon* in semi-intensive system of farming. Three treatments with stocking densities of 20 PL/m^2, 25 PL/m^2 and 30 PL/m^2 wereapplied and considered as treatment T_1, T_2 and T_3, respectively. All the ponds were supplied with commercial pelleted feed of different grades and amount (ranging from 10 to 2.8 percent of total biomass weight) based on the age and growth of shrimp. A significant ($p<0.05$) higher production (3876.66 kg/ha) was obtained from T_2 and the study showed a positive correlation between the culture managed of shrimp farm and the shrimp production and an inverse relation between stocking density and survival rate.

Key words: Management, stocking density, production, *P. monodon*, semi-intensive

Introduction

Shrimp, *Penaeus monodon* plays a significant role to the export earning and income generation in Bangladesh. Bangladesh has about 2.5 million ha coastal tidal lands of which 2.3 million ha could be used for shrimp cultivation. The shrimp farming area of Bangladesh has already been increased from 0.05 million ha in 1983-84 to about 0.16 million ha in 1996-97 (Ahmed, 1999). Because of variation in elevation of coastal lands, extend and degree of salinity of water and inundation, various types of shrimp culture has been practicing in the country since the beginning of the century. In spite of considerable development in shrimp culture techniques, about 75 percent of farming operations are still under traditional extensive farming. Less than only 0.03 percent are under semi-intensive culture system and rest (about 25%) are under improved extensive culture (Ahmed, 1999). Therefore, it appears that there is much potentiality for vertical expansion of shrimp farming by shifting culture techniques from traditional extensive to improved extensive, semi-intensive and intensive types. Due to the high price and demand of shrimp in the international market, expansion of shrimp culture, particularly *P. monodon* has been taking place in the country from the mid 70's. "Less investment and high profit" mentality of most of the shrimp farmers led to emphasize the horizontal expansion of farming in the country by generating many social and environmental conflicts. Based on the suitability of culture area, semi-intensive shrimp farming in Bangladesh has been started before one decade in the Cox's Bazaar area, by this time which has extended to many other coastal points of the country with variable management practices and input utilization. Stocking density is one of the most important culture parameter upon which not only the yield of shrimp but also the intensity of farm management depends. Thus despite of serious nature of current shrimp culture problems of the country particularly for traditional system of farming, it is possible to increase production as well as profit and reduce environmental damage through the application of currently available shrimp farm management and production technique (Chanratchakool *et al.,* 1998). Therefore, in this respect, application of culture management approaches and determination of the optimum stocking density of shrimp in semi-intensive culture condition for sustainable resource utilization under prevailing environmental condition is important.

Materials and Methods

Experiment site and pond preparation: The study was conducted for a period of three and half month (16th February to 30th May) in nine culture ponds each of 0.05 ha size at the coastal belt of Cox's Bazaar district, Bangladesh. The ponds were prepared by complete dewatering and drying in January. Repairing of pond dykes, inlets and outlets, removing black soils also completed by January and liming ($CaCO_3$) done at the rate of 250 kg/ha. Water to be used was also treated with lime to settle the suspended materials and allowed to enter the ponds through feeder canal slowly maximum up to 1.2 m depth in 5 days period. Any intrusion of undesirable organism and particle was prevented by setting fine meshed (1 mm) net with the inlets.
Chemical fertilizer namely urea and TSP were applied at a rate of 35 kg/ha and 20 kg/ha respectively, for the production of both, phytoplankton and zooplankton. Four paddle wheels (2 HP each) were fixed to each pond for aeration. Fermented tea seed cake was applied at the rate of 15 ppm 3 days before stocking the shrimp PL for killing the undesirable fish species present in the water body.

Shrimp PL stocking and management practices: Hatchery produced *P. monodon* (PL_{15}-PL_{20}) having, a mean weight of 0.006 g were collected and acclimatized properly before releasing to the ponds. Three stocking densities such as 20, 25 and 30 PL/m^2 denoting as T_1, T_2 and T_3 respectively were compared. Each stocking density having three replications was assigned into a randomized block design.
Commercial pellet feeds from Saudi-Bangla Fish Ltd. (starter-1, 2 and 3, grower and finisher) were used up to 1.5 g (starter-1 and 2), 5.0 g (starter-3), 10.0 g (grower) and 23.09 (finisher) body weight and onwards respectively. The proximate composition (factory standard) of feed are shown in Table 1. Shrimp were started to feed thrice daily after 5 days of stocking at a rate of 10 percent total biomass weight (assuming 10% mortality). Percent application of feed finally reduced to 2.8 percent prior to final harvest of shrimp with consequent increase in individual body weight and the frequency of feeding adjusted at 5 to 6 times in the last month of culture. Estimation of biomass and feeding were done following the methods, as described by Chakraborty *et al.* (1997).
As required, water was exchanged to about 20 to 30 percent daily and average water depth was maintained 1 meter up to first 30th day of culture and up to 1.2 meters for rest of the days but never less than one meter. Pond water was exchanged at lower percentage during the initial culture days to allow natural food organisms to grow during the whole culture period. Paddle wheels were operated from 4 to 20 hours daily based on age, shrimp

growth and length of culture period. The aerators were put in such a way that could privilege maximum wastes out during water exchange and kept the culture environment friendly.

Data recording and analysis: Individual total length and weight of randomly selected one hundred and fifty shrimps, caught by cast net from different places of each pond were recorded weekly for growth study. The total production and survival rate were estimated directly at harvest.

Water temperature, transparency, dissolved oxygen (DO), salinity and pH were monitored daily using a Celsius thermometer, Secchi disk, DO meter (YSI Model 571 refractometer (ATAGOS-Mill) and digital pH meter respectively. Presence of un-ionized ammonia and alkalinity ($CaCO_3$) level was also monitored weekly basis by using titrimetric methods. Analysis of variance (ANOVA) followed by Duncan's new multiple range test was carried out to find out any significant differences for different growth parameters among the treatments (Gomez and Gomez, 1984).

Results

Water quality: The values of different water quality parameters of the study ponds are presented in Table 2. The water temperature during the study period ranged from a minimum of 25°C to a maximum of 31°C. The daily water temperature of ponds under all treatments were found almost similar in all the treatments during study period. Low water temperature was recorded during the month of February, which gradually increased with a peak in April. Though the average lowest value of water transparency (33 cm) was observed in T3 but the highest value (41 cm) of the same was observed in T_2. For all the treatments the range of transparency was found to vary greatly.

The values of the dissolved oxygen (DO) content ranged from a minimum of 6.0 ppm to a maximum of 7.7 ppm. Salinity in all culture ponds was higher during February and March, afterwards it decreased with the onset of monsoon. The range of salinity during the culture period was within 25-30 ppt. The pH values of the pond water were found in alkaline range during the study period with a minimum of 7.50 to a maximum of 8.50. The lowest average value of pH was recorded with the treatment T_1 (8.0) whereas the highest was with the treatments T_2 and T_3 in the months of February and April. Alkalinity level for T_1, T_2 and T3 was found as 220, 225 and 238 ppm respectively. In all the case higher level of alkalinity recorded in the month of March-mid May. Presence of un-ionized ammonia was almost nil in all the treatments. Negligible amount of un-ionized ammonia was reported from T_1 and T_2 (0.01 and 0.02 ppm, respectively).

Growth and production of shrimp: The growth performances of shrimp obtained in the different experimental ponds during the study are shown in Table 3. The mean weight gain in shrimp with treatment T_1 was higher compared to treatments T_2 and T_3 but there was no significant difference ($p>0.05$) between the treatments. No significant difference also in the specific growth rate (SGR) value was found among the treatments. On the other hand, the food conversion ratio (FCR) of 1.57 with the treatment T, was found significantly lower ($p>0.05$) than those of 1.84 and 1.90 with treatment T_2 and T_3 respectively (Table 3). Survival rate was significantly ($p>0.05$) low in T_3 The average total production of shrimp at final harvest in treatments T_1, T_2 and T_3 were 3685.00, 3876.66 and 3539.60 kg/ha respectively and were found to vary significantly ($p>0.05$) among each other (Table 3). The treatment T2 i.e. with an initial stocking density of 25 shrimp/m^2 produced significantly highest yield followed by the treatment T_1 with a density of 20 shrimp PL/m^2.

Discussion

The values of water quality parameters reveals that all these are in the acceptable range for shrimp culture without any significant variation ($p>0.05$) among the treatments. The variation in water temperature of 25-31°C in the shrimp ponds during the study period was associated with normal climatic change of the experimental area (Roy, 1992). The temperature was found quite suitable for *P. monodon* growth *as* described by Chiu (1988) and Nakra (1994). The recommended optimum range of transparency was recommended by Nakra (1994) as 30-60 cm. In the present study the average of transparency was recorded between 38-41 cm which is within the recommended range and proves the presence of required amount of food particles in the water body. For other parameters, 5.0-7.5 ppm for DO, (Yung, 1990), 10-30 ppt for salinity (Chiu, 1988; Chanratchakool *et al*., 1995), 7.5-8.5 for pH (Liao and Murai, 1986; Chanratchakool *et al*., 1995) in *P. monodon* farming were recommended. Thus considering the recommended range the present study reveals that a favourable environmental condition prevailed in shrimp ponds. The average alkalinity of the ponds under different treatments were found to range from 200-238 ppm with a minimum 180 ppm and a maximum of 300 ppm. The variation in water alkalinity was found to vary directly with the salinity level of the water of the culture ponds, which might due to the presence of carbonates and bi-carbonates in the saline water that varies with the degree of salinity. The presence of negligible amount of un-ionized ammonia in some ponds and absence in other ponds means good water quality management that prevents organic break down process.

Though an inverse relation was observed in individual shrimp growth (weight) with the rate of stocking but no significant variation was observed in specific growth rate of shrimp within the treatments. Similar observations were also reported by Wyban *et al*. (1987) for *P. monodon* culture. Therefore, a negative correlation was found between stocking density and shrimp growth. But in case of survival, the rate was found to vary inversely with stocking density with significant difference among the treatments. Because in addition to disease risks, biological variables like amounts of natural and supplementary food presence in the pond, oxygen tension and build-up of metabolic wastes could be responsible for decline in shrimp growth as stocking density increased. As noted above, due to use of well prepared ponds, feeding and periodically exchanged with treated water having desired salinity and provision for sufficient aerators, differences among treatments with respect to water quality were largely eliminated.

An ideal FCR value for shrimp culture was recommended as not more 2.0 by Chanratchakool *et al*. (1995). In the present study higher FCR value was observed in the treatment T_3. Though a significantly lower value found for T_1 but the average values obtained from different treatments are found in agreement with the recommended value for *P. monodon* growth. Among the three treatments highest production rate of shrimp (3876.66 kg/ha) was obtained in treatment T_2 followed by treatment T_1 (3685.00 kg/ha) and treatment T_3 (3539.60 kg/ha) respectively. Lower yield and survival (47%) of shrimp in treatment T_3 might be due to the higher stocking density (30 PL/m^2). Chakraborty *et al*. (1997) obtained a production rate of 4928 kg/ha from semi-intensive culture in 84 days, where they find mean weight gain of 17 g with a survival rate of 60-70 percent. Compare to the above, the present findings can be considered as more promising as the individual weight gain is much higher. Ahmed *et al*. (1999) showed that in well managed traditional shrimp farming of Bangladesh where stocking density varies from 0.75 to 1.5 shrimp PL/m^2. After 120 days of culture, shrimp attain about 44g weight with more than 50 percent survival.

Table 1: Proximate composition of the commercial pelleted diet (96 dry matter basis) used in the experiment

Components	Types of feed			
	Starter-1	Starter-2	Starter-3	Grower
Dry matter	82.30	86.46	87.30	88.20
Crude protein	36.50	42.41	43.40	40.70
Crude lipid	3.64	4.20	3.67	4.24
Ash	22.05	20.09	16.02	13.43
Crude fibre	4.35	4.32	5.28	4.48
Nitrogen free extract (NFE)[1]	32.68	29.92	1.83	5.95
Gross energy (Kcal/g),	3.86	3.95	4.02	4.19

1 = NFE as 100% (moisture + crude protein + crude lipid + crude fibre + ash)

Table 2: Mean yalyes,of water quality parameters in of ponds under various treatments during the study period

Treatment	Water quality parameters						
	Temp (°C)	Dissolved Oxygen (Mg/l)	Salinity (ppt)	pH	Transp (cm)	Alkalinity (ppm)	Un-ion Ammonia (ppm)
T1	27.7	7.0	30.0	8.0	40	220	0.001
	(25-30)	(6.7-7.7)	(25-33)	(7.7-8.3)	(32-54)	(180-280)	(0.00-0.003)
T2	27.5	6.9	30.0	8.1	41	225	0.02
	(25-29)	(6.5-7.5)	(25-33)	(7.5-8.2)	(28-59)	(185-295)	(0.01-0.005)
T3	27.9	6.9	30.00	8.2	33	238	0.00
	(25-29)	(6.0-7.6)	(25-33)	(7.7-8.5)	(25-48)	(175-300)	-

Table 3: Mean values of various growth parameters of *P. monodon* in different stocking densities

Growth parameters	Stocking density		
	T_1 (20/m^2)	T_2 (25/m^2)	T_3 (30/m^2)
Initial weight(g)	0.006	0.006	0.006
Final weight (g)	33.50	30.11	25.20
Food conversion ratio[1]	1.57 ± 0.01^b	1.84 ± 0.01^a	1.90 ± 0.01^a
Specific growth rate (% day)[2]	6.50 ± 0.01^a	6.42 ± 0.02^a	6.25 ± 0.02^a
Survival (%)	55.00 ± 0.03^a	51.50 ± 0.04^a	$46.82*0.02^b$
Production (kg/ha)	3685.00 ± 29.5^a	3876.66 ± 17.0^a	3539.60 ± 32^b

1 = Dry food teed/live weight gain

2 = {(L_n Final weight-L_n initial weight/time in days} × 100, where L_n = natural log, log base 2.303

Values with similar superscripts are not significantly different at 5% level of significance

Whereas for un-managed farms growth of shrimp and survival was much less. Presence of high organic load in the pond due to high stocking rate and feed application affecting water quality and putting the cultured animal physiologically in a highly stressed condition. In addition, flash flood and heavy rain fall sometimes suddenly changes the physico-chemical parameters such as salinity and reduces the buffering capacity of pond water and cause stress to the shrimp. Such stress might cause immunodepression in shrimp and they become more susceptible to pathogen. The susceptibility of shrimp towards pathogen depends on general health condition of juveniles, biological and other aqua-ecological stresses causes due to farm management problems. But in the present study due to the application of proper water quality management measures, no such adverse affect was noted that hampered shrimp growth and production, any way.

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