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PRODUCTIVITY AND ECONOMICS OF SHRIMP (*Penaeus monodon,* FABRICIUS) CULTURE IN LOW SALINITY WATERS

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Abstract: Black tiger shrimp, *Penaeus monodon* (Fabricius) is a non-piscine organism becomes most important aquatic resource of Bangladesh in the last decades. Traditionally it is cultured in 15-30 ppt salinity. Effect of different low salinity on its survival, growth, production and economic return was observed in three salinity levels 10 ppt, 7 ppt and 5 ppt for 110 days. Juvenile shrimps (approximately 5g each) were stocked at 4 m^{-2} density. It was observed that salinity had no significant effect on the survival of *P. monodon*. However, reduced salinity had significant ($p< 0.05$) negative impact on individual average growth rate, average weight gain per 14 days, production per unit area (ton/ ha.) and thus economic return. This study revealed that although *P. monodon* culture is possible in low salinity, the higher salinity ensures better production and economic return.

Key words: Black tiger shrimp, *Penaeus monodon*, shrimp culture, low salinity and economic return

Introduction

Shrimp is the most precious fishery resource, occupying top rank among the popular and high quality foods for human. Culture of this shrimp has attracted considerable attention in recent years not only because of its value as food supply but also of its high potential as a foreign exchange earner. Few decades ago, shrimp was generally considered as a secondary crop in traditional fish farming practices. In recent years due to higher income from shrimp, many farmers have converted their rice fields, salt beds and fishponds into shrimp farms (Mostafa, 1998).

Bangladesh earns handsome amount of foreign currency by exporting shrimp every year. In the fiscal year 1996-1997 total exported shrimp was 25742 mt. The export earning was 11889 million taka. In 2000-2001 fiscal year it was increased to 29713 mt that earned 18852 million taka. Shrimp and prawn sector alone contributes 7.88 % of the total fish production of our country (Hoque, 2004).

P. monodon, a euryhaline species, is cultured worldwide in salinities ranging from 15 to 30 ppt. (Anon, 2003; Chanratchakool, 2003; Chen, 1985). The salinity tolerance of *P. monodon* is 0-40 ppt and the most suitable salinity is 15-25 ppt (Das, 1998). Despite being saline water organism *P. monodon* can easily adapt with changing salinities (Das, 1998). However, the information about shrimp culture in low salinity is unavailable.

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The present study was undertaken to investigate the growth, survival, production and economics of *P. monodon* in low salinities below the recommended suitable salinity range with an artificial feeding and improved pond management system.

Materials and Methods

The data used in the present study were collected from a semi-intensive culture farm, "Gazi Fish Culture Ltd" Dakope, Khulna. It is a Shrimp Culture Project of SABINCO (Saudi Bangladesh Industrial and Agriculture Investment Company Ltd.), Bangladesh. The culture was conducted for 110 days from July 20 to November 10, 2007.

Experimental ponds: Out of eighty grow out ponds of the farm, six ponds were selected (for three treatments with two replicates) for the present study. Each pond was 4000 m^2 in size. Three salinity levels such as, 10 ppt, 7 ppt and 5 ppt for the treatments T1, T2 and T3 respectively with two replicates were maintained in the experiments. All the ponds were prepared following same procedure. Each pond was equipped with 2 inlets, 2outlets and 2 paddle wheels for exchanging and maintaining water quality. The water depth was maintained at 1.1-1.2 m throughout the culture period. Shrimp fry of 5g mean body weight were collected from the hatchery of Gazi Fish Culture Ltd. After 40 days of rearing, the juvenile shrimp were released into the grow out ponds with the same density of 4 individuals m^{-2}. A commercial pelleted feed, CP Feed was used to feed the stock.

Estimation of growth, survival and production: Sampling of shrimp weight was carried at 14 days intervals by using cast net. Feeding tray was used to monitor shrimp health and growth. The shrimp from each sample were weighed individually to estimate the growth. After 110 days of culture survival, body weight and production was estimated through complete harvesting by draining out the pond water. Calculations for estimating survival, average body weight and production per hectare were done for each treatment separately. The growth rate (GR) was calculated by using following formula of Bagnal (1978).

Growth Rate (GR) = Weight (g) gained on n^{th} days/ Total culture days (up to n^{th} day)

Where, “n” represent the shrimp age.

Calculation for economics: The economic analysis was done on the basis of production costs and sales value of the crop and the economic return among the different treatments were compared.

Juvenile: The juvenile shrimp was bought at a price of tk. 2500 per thousand.

Feed: The price of feed used (CP shrimp feed) varies with the types of feed (starter - finisher). The costs of feed were calculated for different treatments separately.

Labour: Generally, single culture cycle per year is practiced in the culture ponds. Yearly salary for pond associated personnel was calculated to estimate the costs for labour for the production per hectare per year.

Power: Power costs include costs for pumping, aeration and lighting. The total costs for fuel used in generators and running pumps during the culture period were recorded. The power cost for production per hectare was estimated.

Value of the crop: At harvest, the selling price for the heads-on shrimp was determined based on the offered price for each grade of the harvested shrimp. The recognized grades and the price offered for each grade are presented in Table 1.

Table 1. Weight categories and market value for head-on shrimp *(Penaeus monodon)* on November, 2007.

Count (no kg^{-1})	Weight range (g $indv^{-1}$)	Selling price (tk kg^{-1})[a]
<15	>30	550
15 -20	30-25	460
20-30	25- 20	350
>30	<20	300

[a] The total price value of shrimp produced per hectare in different treatments has been calculated separately.

Estimation of economic return: The economic return was estimated by subtracting the production cost/ha from the value of the produced shrimp/ha in different treatments. Percentage of economic return in different treatments also has been calculated by using the following formula.

Economic return ha^{-1}= (Crop value ha^{-1}) – (Production cost ha^{-1})

% of Economic Return = (Economic return ha^{-1}/Production cost) × 100

Results

Survival, growth and production: Table 2 shows the growth, survival and production performance of the treatments T1, T2 and T3. The variation in survival rates (91.12±2.56, 87.5±2.31, 85.74±2.11) for T1, T2 and T3 were found to be insignificant ($p > 0.05$). The highest (91.12±2.56) and the lowest (85.74±2.11) survival were found in T1 and T3 respectively. The growth rate of shrimp varied significantly among the treatments ($p < 0.05$). The highest average growth rate (0.2905±0.0007 g day^{-1}) was achieved for T1 while the lowest rate (0.2205±0.0007 g day^{-1}) was for T3. Significant difference ($p<0.05$) was observed in individual average growth of *P. monodon* (32.033g, 29.79g, 23.30 and 24.29 g) among the treatment in T1, T2 and T3 respectively. T1 (10 ppt salinity) and T3 showed the highest (32.03 g) and the lowest (24.329 g) growth rate respectively. Similarly, the highest production (1126.5±26.16 kg ha^{-1}) was found in T1 while the lowest (778.75±19.45 kg ha^{-1}) was noticed in T3 (Table2).

Table 2. Average growth, survival and production of Penaeus monodon in different treatments in three different salinity.

Treatment no	Salinity (ppt)	Average growth rate (g day^{-1})	Average wt gained (g)	Survival rate (%)	Production (kg ha^{-1})
T1	10	0.2272±0.051	32.033±0.06	91.12±2.56	1126.5±26.16
T2	7	0.2207±0.037	29.790±0.06	87.5±2.31	1006.25±26.51
T3	5	0.1923±0.021	24.29±0.01	85.735±2.11	778.75±19.45

Production costs

Post larvae: Details of the *P. monodon* production cost are presented in Table 3. The juveniles were stalked in rearing ponds from the hatchery at an average price of tk. 2.5 per individuals. The cost for stocking juveniles in each pond was 40,000 tk.

Feed: The CP Shrimp Feed was used for an average price of tk. 83. The total cost for feed varied as the feed consumption ratio (FCR) and the growth in each 14 days was different in different treatments. The highest (tk 260,000) and the lowest (tk 2,22,750) costs ha^{-1} for feed were paid for T1 and T3 respectively.

Table 3. Summery of production costs for *P. monodon* culture.

Treatment no.	Items	Cost/pond (tk)	Costs (tk ha^{-1})	Total costs (tk ha^{-1})
T1	1. Shrimp	80,000	200,000	5,52,000
	2. Feed	104,000	260,000	
	3. Power, labour and accessories (20% of others)	36,800	92,000	
		Total = 173,000		
T2	1. Shrimp	80,000	200,000	540000
	2. Feed	100,000	250,000	
	3. Power,labour and accessories (20% of others)	36,000	90,000	
		Total = 216,000		
T3	1. Shrimp	80,000	200,000	4,87,250
	2. Feed	89,100	222,750	
	3. Power, labour and accessories (20% of others)	33,820	84,550	
		Total = 202920		

Power, labour and others: Twenty four labors were engaged to manage the experimental ponds of the Farm. The cost of Electricity is also including in the production cost. However the total costs of Power, labour and others like transport and the other loss was not exceed the amount of 20% of the total cost for feed and shrimp fry. The total production costs was the highest in T1 (432,500 tk ha^{-1}) and the lowest in T3 (387,250 tk ha^{-1}). The costs varied mainly due to the difference in the amount of feed used in the pond.

Crop value: The crop value and the results of economic return have been presented in Table 4. The crop value was dependent on the basis of size distribution of the harvested shrimps. As the average highest size (32 g) was produced in T1, it earned highest average selling price, tk 545 kg^{-1} while the lowest average selling price was gained from T3 (average individual weight 24 g), 380 tk kg^{-1}.

Table 4. Summary of the crop value and economic return *of Penaeus monodon*

Treatment no	Average selling price (tk kg^{-1})	Crop value (tk ha^{-1})	Economic return (in tk)	Economic return ha^{-1} (in tk)	Percentage of economic return
T1	545	1227,612	270,245	675,612	122.93
T2	478	961,975	168,790	421,975	78.14
T3	380	599,450	96,860	242,150	49.70

Economic return: The highest economic return (kg ha^{-1}) was achieved in T1 (tk. 675,612 ha^{-1}) while it was the lowest (tk. 242,150ha^{-1}) in T3. Similarly, the highest (122.93%) and the lowest (49.70%) percentage of economic return were accounted for T1 (10 ppt salinity) and T3 (5 ppt salinity) respectively.

Discussion

The present study was conducted in three different low salinities to observe the survival, growth, production and economics of *Penaeus monodon.* Hossain *et al*. (1992) reported that little effort was made to evaluate the growth, survival, production and economics of the species under semi-intensive culture system. No documents could be found on the culture of *P. monodon* in low saline waters. Thus it was difficult to compare the results of the present study with other similar studies. The different average growth rate (0.2272±0.051, 0.2207±0.037 and 0.1923±0.021 g day^{-1}) observed in the present study for *P. monodon* were dissimilar to average results (0.17 g day^{-1}) for commercial ponds stocked with *P. monodon* in New South Wales (Allan, 1989) and Geoff and Greg (1992). The differences may be due to the difference in culture environment, especially temperature. Present results indicate that different salinities influenced the growth of *P. monodon*. In this experiment *P. monodon* were stocking with a higher initial weight (5±0.12 g) and survival rate of different experimental ponds were non significant. This result was similar to by Sandifer *et al*. (1987) (average initial weight 1.3 g and densities 10-40 shrimps m^{-2}) and Wyban *et al*. (1987) (average initial weight 2.7 g and densities of 5-20 shrimps m^{-2}) who found that density had no effect ($p<0.05$) for survival of *Penaeus vannamei.*

Water temperature in the experimental ponds varied significantly ($p<0.05$) from 24.2 ^oC to 28.8 ^oC. Growth of shrimp was found related to the water temperature and showed a suitable range of 28 ^oC to 32 ^oC for *P. monodon* growth. Hossain *et al.* (1992) observed that the growth of *P. monodon* was better at temperature above 28.6 ^oC.

In this experiment, the salinity in T1 was found suitable for higher growth of *P. monodon* in the present study. This is in contrast with those findings reported by Chiu (1988) and Apud (1989). Hossain (1992) also observed better growth of *P. monodon* at salinity below 26 ppt. To gain a better production, the farmers in Australia place great emphasis on maintaining low salinity levels in *P. monodon* ponds (Chaing and Liao, 1986).

The salinity of all the culture ponds was 5-10 ppt among different treatments in the present study. *P. monodon* is a euryhaline species grow well from 15-30 ppt salinity. Das (1998) reports 15-25 ppt salinity is the most suitable range for *P. monodon* culture even it can tolerate zero ppt salinity level. Villarreal *et al*. (2003) shows the poor growth of juvenile brown shrimp, *Farfantepenaeus californiensis* over 25 ppt salinity. The protozoa level of *Metapenaeus monoceros* larvae display better tolerance to high rather than lower salinity. The lowest and highest critical salinity is 22 and 55 ppt respectively (Kumlu *et al.,* 2001).

Collins and Russell (2003) successfully cultured *P. monodon* in low saline waters by increasing the potassium content from 5.9 mg l^{-1} to 40 mg l^{-1} and achieved good survival rate. The result indicates that potassium ion plays important role in the survival of *P. monodon* in inland saline water. Rahman *et al*. (2005) reported that, the salinity of freshwater ponds was increased to 2-5 ppt by mixing the coastal water to culture *P. monodon* in Thailand. The results of this experiment were similar to those of Rahman *et al.*, (2005).

The experiment was conducted during late summer and in the time of Rainy season when the temperature and the salinity tends to move downwards. During culture period salinity of Vorda river was 12-13 ppt. Salinity was maintained by addition of freshwater from the reservoirs of the farm. Both the temperature and salinity were below the recommended range for suitable growth of *P. monodon* but the growth of the shrimp was satisfactory. The final weight of shrimps was 32, 29 and 24 g in T1, T2 and T3 respectively. Among the different treatments there was no significant difference of survival rate although the production, average weight and economic return were differed significantly. The probable cause of greater survival rate was the lower stocking density (4 individuals m^{-2}) and higher initial weight of stocked shrimp (5 g). Hence, higher initial weight increases the survival rate of *P. monodon.* Size as well as age of shrimp has also increase the survival rate and tolerance to the lower salinity. McGrow *et al.* (2002) transferred different age (10, 15 and 20 days) of Post larvae in different lower salinity (0, 1, 2, 4, 8, and 12 ppt) and found survival of PL_{10} in 0, 1, 2 ppt was significantly lower than the PL_{10} in 4, 8 and 12 ppt salinity. They also observed 10 day old PL acclimatized to 4 ppt salinity with a good survival and 15-20 days old PL acclimatized in 1 ppt with a good survival. In present study the stocked juvenile shrimp was 40 day old and showed good survival rate. This is in agreement with the study of McGrow *et al.* (2002). Though 28-32 ^{o}C temperatures is recommended for better growth but in this study the temperature better growth was found in 24-28 ^{o}C temperature.

From present research it is evident that the economic return was higher (122.93%) in T1 where the salinity level was 10 ppt and it was 78.14% and 49.70% in 7 ppt and 5 ppt respectively. Mostafa *et al*. (2001) observed 69% economic return from 21 PL m^{-2} and 49% from 12 PL m^{-2} where they found highest 27.53 and 22.16 g individual weight respectively. This result is quite different from the present study. However, from the present experiment it is evident that for low salinity culture comparatively higher salinity is preferable for *P. monodon.*

Conclusion

The present study indicates that the lower salinity of water is suitable for *P. monodon* culture as growth, survival and production of the species show a good performance. The results also show that, with the increasing of salinity, the growth and survival of the species increased as well as the total production (kg ha^{-1}) increased. However, economic analysis shows that, with increasing production, costs did not significantly increased. This result indicates that *P. monodon* can tolerate a low salinity level with a good survival and economic return although higher salinity is better for its culture.

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