Bangladesh J. Fish. Res., 1(1) : 53-63
Bangladesh Fisheries Research Institute

Effect of stocking density on growth of tiger shrimp (*Penaeus monodon* Fab.) fed on commercial formulated diets

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Abstract

Three different stocking rates in a semi-intensive pilot shrimp project was adopted in duplicates of three treatments designated as T_1, T_2 and T_3 having initial per metre square stocking density of shrimp of 40, 44 and 51 respectively of 0.025 g size post larva. The study was conducted for 84 days. Commercial pelleted diets designated as starter - 1, 2, 3 and grower were fed at a satiation level during the study period with a feeding frequency of 4 to 5 times per day. Feed rationing was based on the survivability, body weight and tray checking. Five to twenty five percent of the pond water was exchanged daily. Sampling was done for growth after every 2nd week. Monthly sampling was done for mortality in the ponds. Mean weight gain of the shrimp in treatments T_1, T_2 and T_3 were 16.96 ± 1.14, 16.04 ± 1.38 and 14.08 ± 1.17 g respectively and T_1 with a low stocking density showed a significantly best growth among the treatments. Total mortality in treatments T_1, T_2 and T_3 were as 30.00, 39.77 and 31.37% respectively. Significantly higher feed conversion ratio (FCR) of 1.87 was obtained with shrimp in treatment T_3 followed by shrimp in T_1 and T_2 with FCR values of 1.70 and 1.41 respectively. A positive correlation of growth and salinity was observed during the study. Total production per unit area was the highest in the treatment T_3 (4928 kg/ha) and followed by T_1 (4747 kg / ha) and T_2 (4251 kg/ ha). The result show significantly negative correlation between individual growth and density.

Key words : *P. monodon*, Stocking density, Formulated diets

Introduction

Bangladesh has about 2.5 million ha of coastal tidal lands, of which 2.2 million ha of lands may be suitable for brackish water aquaculture. Total shrimp production of Bangladesh in 1994 - 95 is reported to be 10,1778 mt of which

47,830 mt comes from inland water, 23,445 mt comes from marine water and 30,503 mt from coastal area of which 80% of total shrimp production comes from natural sources (Paul 1996). Most shrimp farms in Bangladesh are operated on a very extensive basis, relying on natural productivity and have little or no managements. A few farmers are claiming production levels of 900 kg / ha /year with improved cultural practices. This can be achieved to an average production of 4,500 to 7,200 kg/ha / year by encouraging the introduction of more intensive shrimp farming methods.

It is reported that 30,000 ha of potential area at Cox's Bazar is suitable for developing semi-intensive culture farm of Peneaid shrimp (C. P. Shrimp News 1994). Natural tidal fluctuations of this area permit easy entrance and elimination of expected saline water. Depending on the stability of salinity 2 crops per year may be obtained by culturing Peneaid species. Moreover, Peneaid shrimp species may be stocked at a higher density than *Macrobrachium* sp. which return a higher yield in comparison to later. Considering potentials, Peneaid shrimp is much more suitable for semi-intensive culture system. Semi-intensive culture of Penaeid shrimp in this country has developed recently. In semi-intensive culture of penaeid shrimp a good water quality management and proper utilization of supplied food may afford a fruitful result. In this aspect proper food rationing plays an important role. However, high feeding rates results in organic load which alter pond environment leading to mass mortality of shrimp particularly in ponds stocked with high densities (Clifford 1992). The optimum stocking density together with water quality management and feed rationing paves for developing semi-intensive culture of Penaeid shrimp.

For sustainable development of semi-intensive farming system, the study has been undertaken with the objectives to investigate the effect of stocking density on the growth and survival of tiger shrimp (*Penaeus monodon*) using commercial pelleted diets in order to assess the growth performance and feed utilization efficiencies.

Materials and methods

The experiment was conducted between September 1993 and December 1993 in six culture ponds of Beximco Fisheries Ltd. located at Khurushkul, on the bank of the river Bakkhali in the coastal district of Cox's Bazar, Bangladesh. A total area of about 5.5 hectares comprising 3.93 hectares of water area was selected for the study. The farm consisted of 7 ponds, a single reservoir, a network of water discharge and feeder canals. A good water supply and drain-out system was there in the farm where water could be pumped to the reservoir (during spring-tide water entered in the reservoir through the sluice gate via the lift-valve), to get in to the feeder canal. The water in the reservoir is treated to settle the suspended material. A coarse and fine meshed net protected the entrance of undesirable particle and organism to the feeder canal. Discharge of water was maintained by gravitational forces through PVC pipes which was set at three different levels of water for elimination of desired level water as per requirements. Six paddle wheels for each pond were used for aeration and elimination of waste product.

For the study a total of six ponds comprising two replicates for each of treatment T_1, treatment T_2 and treatment T_3 with stocking densities of 40, 44 and 51 nos. post larvae of shrimps per metre square respectively were selected. Before starting of the experiment, black soil of the pond bottoms were removed followed by sun drying for 7 days. Lime was used at a rate of 250 kg/ha on the bottom and slope of these ponds. The water depth of the ponds were kept up to 1 meter. Urea and Triple-super-phosphate (TSP) at a rate of 7 kg/ha and 4 kg / ha respectively were then sprayed on paddle wheel for production of Phytoplankton and Zoo-plankton. Tea seed cake, at a rate of 8 ppm was applied three days after entering water for killing of unexpected organisms in ponds. After three days, the ponds were ready for stocking shrimp fry .

The fry (PL_{10} to PL_{20}) having mean weight of 0.025 g and mean length of 18.00 mm) of tiger shrimp (*Penaeus monodon*) were collected from "The Niribili private nursery and hatchery, Ltd", Cox's Bazar, Bangladesh. Commercial pelleted diets designated, Starter-1, starter-2, starter-3 and grower obtained from Saudi-Bangla fish feed Ltd., Mymensingh containing 30.57, 38.00, 38.00 and 36.00% crude protein mostly fish meal based respectively were used in the feeding trials (Table 1). Blind feeding was continued 7 days after stocking, considering 10% mortality. Weekly sampling was done for getting mean weight of shrimps in each pond. Feeding frequency varied between 4 - 5 times per day depending on the mean weight of the shrimps. Starter-1 was fed upto 0.1 g mean body weight of shrimp. Starter-2, starter-3 and grower were fed upto 0.5 g, 3 g and 20 g size respectively from the lower limit.

Table 1. Proximate composition of the commercial diets (% dry matter basis) used in the feeding trials (obtained from Soudi-Bangla Fish Feed Ltd, Bangladesh)

	FEED			
Components	Starter-1	Starter-2	Starter-3	Grower
Dry matter	81.50	87.40	87.50	88.00
Crude protein	37.50	43.47	43.42	40.90
Crude lipid	3.44	3.27	3.47	4.04
Ash	22.08	20.02	16.00	13.63
Crude fibre	4.29	4.34	6.28	4.68
[1]Nitrogen free extract (NFE)	32.70	28.90	0.83	5.75
[2]Gross energy (Kcal/g)	3.76	3.91	4.01	4.13

[1] *Nitrogen free extract as 100 - %(Moisture + crude protein + crude lipid + Crude fibre + ash)*

[2] *The energy value of the feeds calculated as adopted by Dare and Edwards (1975) considering protein =5.5 Kcal/g;lipid = 9.45 Kcal/g and carbohydrate = 4.2 Kcal/g*

For feeding, 1 m^2 hanging-feeding-tray platforms for each 1600 m^2 water area were set at 2 to 3 meters far from the bank by a pair of bamboo pole and a strong plank. Total daily ration allocated for feeding tray was divided by the no. of trays per pond and spread out on the tray during feed broadcast. The unfed food on trays were collected, pooled and dried for each pond and used to adjust subsequent feed ration. Gut contents of shrimp were checked for under feeding and full feeding.

Routine water quality measurement was done during the experimental period. Among these, dissolved oxygen was measured by YSI 57 DO meter before sun rise and at 4.00 p.m. daily. Temperature, pH, salinity and transparency (secchi-disc method) were measured once daily and ammonia was measured (by field method) monthly. Depending on the requirements water was exchanged about 5 to 25% daily and water depth was maintained 1 meter up to 30th day of culture and up to 1.75 meters for the rest. At the primary culture stage a small amount of water was exchanged for maintaining expected phytoplankton and zooplankton level which are natural food for fry and also a controlling factor of "lab lab" and dissolved oxygen. Fertilization was done as per requirements for maintaining transparency at expected level of 30 to 40 cm. Lab lab was collected by scoop net immediately after floating. Lime was applied in the pond water, 30 days after stocking at a rate of 5 ppm and continued weekly for rest of the culture period. Paddle wheels of 2 HP in each pond were used for occasional agitation upto 20 days of culture period. Sampling by cast net was done after every 2nd week of stocking. One hundred shrimps were weighed and measured for each pond. For estimation of mortality, cast net was operated randomly in 5 to 7 pre-selected places and the captured shrimps were counted. The area covered by the sampling cast net was measured and compared by some terrestrial casting. Efficiency of cast net was considered at 80% (Pers. com. Uddin, Farm Manager, Beximco Fisheries Ltd., Cox's Bazar). Total stocking was then determined by using following formula.

$$\text{Estimated stock} = \frac{\text{Mean No. of shrimp per capture X Total area of pond}}{\text{Measured mean area covered by cast net}} \text{X } 0.8$$

Then survivability was calculated. Initial harvesting was done by cast net and finally by lantern net and hand picking. During harvesting, mean weight and number of harvested shrimps were recorded and finally survivability was calculated.

The experimental diets, carcass composition of shrimps under the experiment were analyzed for proximate analysis by the method described in AOAC (1980). For initial carcass analysis of shrimp a group of significant number of fry (weighing about 20g fry from the initial stock) were sacrificed at the beginning of the experiment, and used for proximate analysis for moisture, crude protein, crude lipid and ash, and considered as initial carcass composition. The final carcass composition of harvested shrimp samples from each replicate was dried in oven at 105°C for 24 hours and ground by meat grinder to be analyzed in the same process.

The following nutritional performances were measured from the recorded data.

(a) Weight gain (%) = [(final weight - initial weight)/initial weight] X 100
(b) Specific growth rate (SGR %/day) = [(ln final weight - ln initial weight)/time (in days)] X 100where, ln = natural log, log base 2.303
(c) Food conversion ratio (FCR) = dry food fed/live weight gain
(d) Protein efficiency ratio (PER) = live weight gain/protein fed
(e) Apparent net protein utilization (ANPU) = protein retained/protein ingested) X 100

One-way analysis of variance (ANOVA) was done to find the significant difference among the treatment means followed by the Duncan's new multiple range test using minitab (Rhyan & Joiner 1985) as package on microcomputer.

Results

The water quality in respect of temperature, dissolved oxygen, salinity, transparency, ammonia etc. have been shown in Table 2. Temperature during the experimental period in different period in different treatments T_1, T_2 and T_3 ranged between minimum value of 24.4 and maximum value of 29.5^{0}C having no significant variation in weekly temperature. Similarly, dissolved oxygen ranged from 4.28 to 5.88 mg/l in the morning and 7.45 to 8.98 mg/l in the evening showing no significant variation (p>0.05) on weekly observation among the three treatments (Table 2). Salinity varied within a range between 17.2 and 25.8 ppt. having no significantly different (p>0.05) values within weekly observation. The mean pH values in different weeks in the treatments T_1, T_2 and T_3 were 7.78 to 8.69, 7.87 to 8.73 and 7.72 to 8.82 respectively and did not vary on weekly values. Transparency of the pond water varied from 31.71 cm in T_2 at the start to 72.0 cm at the end (Table 2). Ammonia was always below 0.002 mg / l$^-$.

Table 2. Water quality parameters in respect of temperature, dissolved oxygen, salinity, pH and transparency of the different treatments during experimental period

Treatment	Temperature(^{0}C)		Dissolved Oxygen (mg /l)		Salinity (ppt)		pH		Transparency (cm)			
	Mini-	Maxi	Mini	Maxi	Mini	Maxi	Mini-	Maxi	Mini-	Maxi	Mini-	Maxi
T_1	24.5	29.5	4.3	5.6	7.6	9.0	17.4	25.8	7.8	8.7	32.2	51.8
T_2	4.4	29.4	4.7	5.9	7.5	9.0	17.2	25.4	7.9	8.7	31.7	72.0
T_3	24.5	29.5	4.3	5.8	7.5	9.0	17.5	25.5	7.9	8.7	32.7	45.7

The mean body weight gain of shrimps during the experiment in different treatments are presented in Fig 1. Significantly higher ($p<0.05$) growth was observed with shrimp in treatment T_1 (lowest stocking density) followed by treatment T_2 and T_3 respectively. The nutritional parameters of shrimp, *P. monodon* measured in various treatment groups during experimental period are shown in Table 3. Specific growth rate (SGR) of shrimp in treatments T_1, T_2 and T_3 were 3.41, 3.38 and 3.31 respectively and were not significantly different ($p>0.05$) whereas, significantly different ($p<0.05$) values of food conversion ratio (FCR) of the treatments T_1, T_2 and T_3 were 1.70, 1.41 and 1.87 respectively (Table 3).

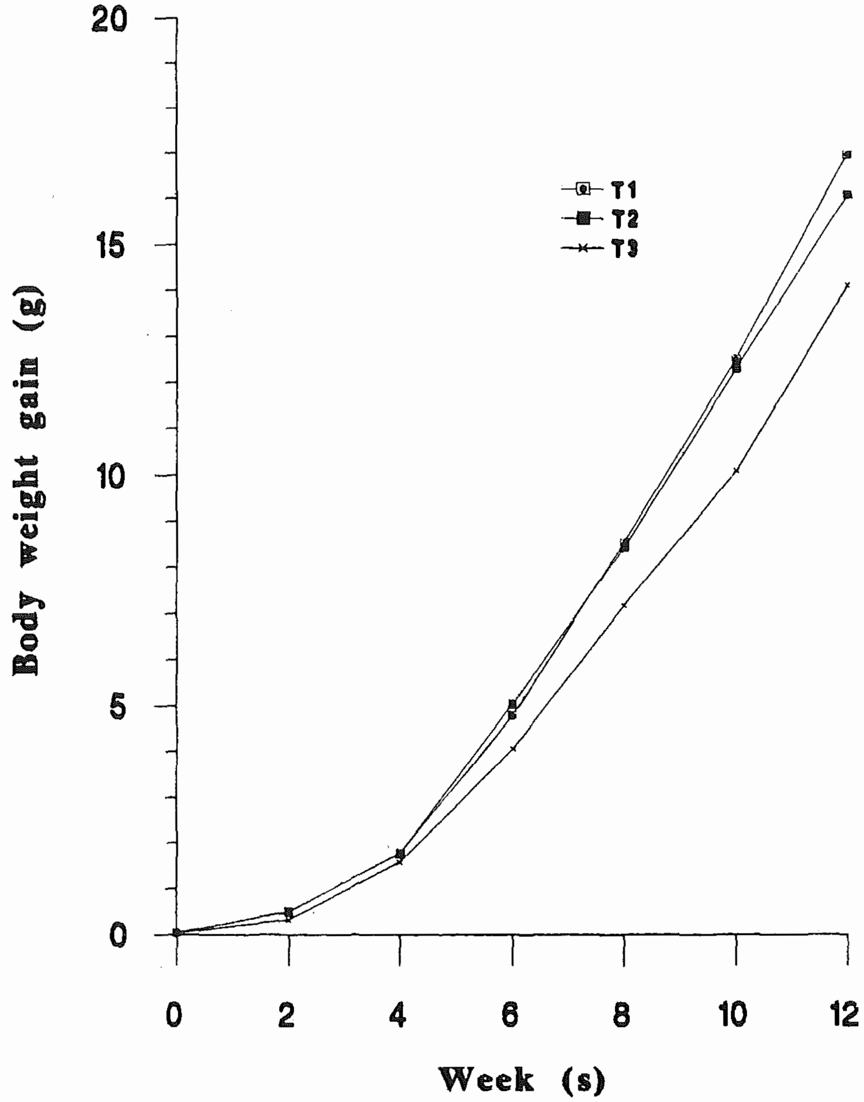

Fig. 1. Weight gain of *Penaeus mondon* in three treatment groups fed on different diets during 12 weeks of experimental period.

Table 3. Different growth parameters of *Penaeus monodon* in various treatment groups during 84 days of feeding trial

Parameters	Treatments		
	T_1	T_2	T_3
Initial mean weight (g/No.)	0.025	0.025	0.025
Final mean weight (g/No.)	16.96 (±1.14)	16.04 (±1.38)	14.08 (±1.17)
Mean weight gain (g/No.)	16.93^a (±0.45)	16.02^b (±0.35)	14.05^c (±0.65)
Specific growth rate (SGR)	3.41^a (±0.07)	3.38^a (±0.04)	3.31^a (±0.05)
Food conversion ratio (FCR)	1.70^a (±0.04)	1.41^b (±0.14)	1.87^c (±0.06)
Protein efficiency ratio (PER)	1.58^a (±0.05)	1.91^b (±0.12)	1.43^c (±0.08)
Apparent net protein utilization (ANPU) (%)	26.42^a	31.84^b	23.88^c
Survivability (%)	70.00	60.23	68.63
Production (Kg/ha)	4747	4251	4928

Different superscripts in the same row represent significant difference (p<0.05) of mean values

The food conversion ratio (FCR) values were calculated ignoring the effects of natural diets but on the basis of fed supplemented dry pellets only. The protein efficiency ratio (PER) of the treatment T_2 was significantly higher ($p<0.05$) (1.91) than other treatments (Table 3). Apparent net protein utilization (ANPU) values by the shrimp in different treatments fed various diets were 26.42, 31.84 and 23.88 for T_1, T_2 and T_3 respectively.

Survival rate was estimated twice during the experimental period and finally after harvesting. A massive mortality was occurred in the treatment T_2 just after stocking. Survivability was highest (70%) in treatment T_1 followed by T_3 (68.63%) and T_2 (60.23%).

Although, final mean weight-gain of individual shrimp in the treatment T_1 was the highest (16.96 g) (Table 3), total production per hectare was not the highest in this treatment due to its lower stocking density. However, the production calculated on the basis of final harvesting were 4747, 4251 and 4928 kg ha^{-1} in the T_1, T_2 and T_3 treatments respectively.

Discussion

Salinity in the range of 15 to 25 ppt were usually considered more suitable for *P. monodon* grow-out (Boyd 1989). Chiu (1988) also reported that the optimum range of salinity for *P. monodon* farming should be within 20 to 25 ppt. The salinity in this experiment, was found within this limit which indicates a favourable condition for growth and survival of *P. monodon.*

Liao and Murai (1986) reported that the oxygen respiration rate of *P. monodon* remained constant at dissolved oxygen (DO) concentrations above 3.0 to 4.0 mg/l. In the present study dissolved oxygen (DO) measured in the morning (before sun rise) in the treatments were within the safe level (Table 2).

In the present study pH values in ponds were not below 7.72 (Table 2). This shows a reciprocal relationship between the salinity and pH values. Nakra (1994) stated that the optimum range of secchi disc reading should be between 30 and 60 cm during Juvenile stage, above and between 25 and 40 cm to the sub-adult and final stage. In this study among the mean transparency level of three treatments, the mean value in the treatment T_2 was above the optimum level of Juvenile shrimp. Massive mortality during the experimental period in the treatment T_2 might be due to the low productivity (Nakra 1994). However, the transparency in treatment T_3 was optimum from beginning of the stocking period and a greater survivability in that treatment might be due to optimum natural productivity.

The initial stocking density of the treatments in the present study were much higher in comparison to the stocking density practiced at other farms of the Cox's Bazar coast (Pers. comm. with other farm Managers). The stocking densities of the treatment T_1, T_2 and T_3 finally reduced to 28, 26.5 and 35 per metre square respectively due to uneven and massive mortality. However, the individual growth achieved by shrimp in the treatment T_1 was the highest (16.96g). Roy (1992) recorded pond water temperature in the winter season 20-30°C and in the summer season 25-32.5°C in his experiment, conducted at Aquaculture Farm Ltd., Cox's Bazar. Nakra (1994) stated the optimum range of temperature for the Black Tiger Shrimp (*P. monodon*) was between 28 °C-30°C. Chiu (1988) also pointed out the temperature range of 25-32°C was the optimum for *P. monodon* farming. Therefore, lower individual weight of *P. monodon* in this study might be affected by the temperature below the optimum level (Apud *et al.* 1985).

In spite of these, individual weight gain by the shrimp of treatment T_1 was highest and followed by T_2 and T_3 (Table 3). It might be due to the lower density, maintained from initial stocking in the treatment T_1. Significant difference of individual weight gain was observed in the treatment T_3 (14.08) compared to T_1 (16.96) and T_2 (16.04). It may be explained as the stocking density of treatment T_3 was much higher ($51/m^2$) than T_1 ($40/m^2$) and T_2 ($44/m^2$) treatments. Wyban (1987) showed a negative co-relation between stocking density and growth. Similarly, values of 3.41, 3.38 and 3.31 for specific growth rate (SGR) found in treatments T_1, T_2 and T_3 might also be due to the effect of stocking density.

Chanratchakool *et al.* (1993) stated that the total FCR varies depending on the stocking density; quality of feed and the size at which the shrimps are harvested, but ideally it should not be higher than 2. They also stated that weekly FCR varies over the production cycle and between populations, but as a rough guide it should be between 1 and 1.5 in the early stages of the cycle and 1.5 and 2.5 in the later stages. Table 3 showed the FCR values of three treatments which were not greater than ideal value, but inspite of higher stocking density in the treatment T_2 FCR was lower than treatment T_1. It might be due to the higher mortality in the T_2 treatment which lowered the stocking density of treatment T_2 in comparison to T_1. The values of FCR in all the treatments indicates that the feeds (Starter - 1, 2, 3 and grower) were in category of good quality diets as because the mean FCR values were 1.70, 1.41 and 1.87 in T_1, T_2 and T_3 respectively. Similar result was obtained by Sedgwick (1979) with shrimp. He reported that FCR increased with level of rations fed and with the mean weight of the prawn as they grew.

It may be explained that growth was affected by the increase of total biomass due to higher stocking density which ultimately decreased the efficiency of food conversion with higher FCR value. From Fig. 1 it is seen that individual weight gain in shrimp in treatment T_3 was lower than those in T_1 and T_2 from the beginning of culture but FCR was higher than other two treatments. According to Sedgwick (1979) it seemed to be logical. He found that greatest efficiency of food conversion was achieved with relatively poor growth rate and he suggested to sacrifice some conversion efficiency to take full advantage of growth rate.

Apparent net protein utilization (ANPU) was the highest in the treatment T_2 (31.84) followed by T_1 (26.42) and T_3 (23.88). Protein efficiency ratio value was also highest in treatment T_2 (1.91) followed by T_1 (1.58) and T_3 (1.43). The ANPU and PER values in the present study indicates the better utilization of dietary protein.

Result of the study showed that stocking density affected the individual weight gain of shrimp but mortality may not be correlated with the stocking density. Therefore, similar experiment should be conducted with lower stocking density to compare the growth efficiency and mortality. Considering the disease problem of neighboring farms it was also recommended that farms should be situated at a reasonable distance from each other for avoiding entrance of polluted water-discharge.

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(Manuscript received 9 July 1996)