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COMPARATIVE EVALUATION OF *PENAEUS MONODON* (FABRICIUS, 1798) CULTURE IN DIFFERENT SALINE GROW-OUT SYSTEMS IN INDIA

Vijaykumar, B. S. and *Maharajan, A.

Department of Zoology, Khadir Mohideen College, Adirampattinam-614 701, Thanjavur Dist, Tamil Nadu, India

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ABSTRACT

Present study was conducted for a period of 156 days (February - July, 2010) in three earthen ponds of each 10000m^2 area in different salinities. *P. monodon* seeds were stocked at a density of 15 nos /m^2 in all the ponds. The water quality parameters such as temperature, salinity, hydrogen ion concentration (pH), dissolved oxygen and alkalinity were monitored. The alkalinity at pond I,II and III showed a significantly value (60-130ppm,180 to 230ppm and 220-260ppm) at 86 DOC. The Pond II showed higher survival rate than that of pond I and III. The survival at the time of harvest was 86.6% for pond I, 95.6% for pond II and 72.6% for pond III at 142, 114 and 156 DOC respectively. The Average Body Weight (ABW) gained during the 114 DOC was 33.16±0.83g, 23.44±0.62g and 17.83±0.28g for pond II, I and III respectively. The Average Daily Growth (ADG) at the time of harvest was 0.23g for pond I, 0.29g for pond II and 0.17g for pond III at 142, 114 and 156 DOC respectively. Among the ponds, Feed Conversion Ratio (FCR) was found to be lower in pond II, followed by pond I and pond III. A similar trend was observed for Specific Growth Rate (SGR) also, in which pond II showed 37% higher SGR than pond III and 29.31% higher than pond I. Pond II obtained higher harvested biomass of shrimps at lesser DOC (4928 kg in 114 DOC) than pond I (4390 kg in 142 DOC) and pond III (3150 kg in 156 DOC). The Revenue Over Investment (ROI) was maximum for pond II (99%), followed by a moderate ROI at pond I (60%) and the least was for pond III (10%) respectively.

INTRODUCTION

Aquaculture is one of the fastest growing sectors that ensure a mammoth role in satisfying the protein requirements of the burgeoning populace. It is rapidly expanding in developing countries and is generally regarded as an efficient means of increasing protein production and income generation (Pullin, 1993).Shrimp farming in India developed at a phenomenal rate in the last decade. Congenial conditions such as availability of unutilized coastal land, successful transfer of hatchery and grow-out technology, increased export demand and opening up of the economy in 1990s paved way to the rapid expansion of commercial intensive shrimp aquaculture. *Penaeus monodon*, are widely cultured crustacean species around the world. Shrimp culture contributing to a significant portion of national income through export earnings. India stands as the fifth highest producer of farmed shrimps (Felix et al., 2007). India is bestowed with an extensive coast line and brackish water area with vast potential for coastal aquaculture activities. The saline wetlands in India are estimated to the tune of 70 lakh hectare (Agarwal et.al., 1982). The Godavari delta in Andhra pradesh is having significant high saline alkaline area and this could be effectively utilized for aquaculture activities by making use of the fresh water resources during the flood or by using low saline ground water. Physico-chemical parameters of water plays a very vital role that determines the fate of culture. Among this, salinity is one of the most important abiotic factors in aquaculture, though many crustacean species exhibit some degree of euryhalinity (Pequeux, 1995). Salinity is a masking factor that modifies numerous physiological responses such as metabolism, growth, life cycle, nutrition and intra-and inerspecific relationships (Venkataramiah et al., 1974). Salinity is said to be a prime factor that plays a very vital role in the physiology and growth of shrimps that ultimately decides the fate of culture. The physiological responses are believed to be essential to assess the animal performance at different environmental conditions (Menezes et al., 2006). Staples and Heales (1991) emphasized that salinity influence the food consumption and conversion efficiency thereby affects the growth and survival of cultured penaeid shrimps. Understanding the importance, several studies have been conducted to determine effects of salinity alone or in

Corresponding author: Maharajan, A.
Department of Zoology, Khadir Mohideen College, Adirampattinam-614 701, Thanjavur Dist, Tamil Nadu, India

conjunction with other abiotic factors on the osmoregulatory ability of commercially important penaeid species. Mair (1980) conducted salinity tolerance experiments in penaeid shrimps suggested that salinity preference changed with size in such a fashion that post larvae adapted quickly to lower salinities than the other age groups. The age of tolerance to wide salinity fluctuations for most penaeid post larvae is between PL10 and PL40 (Tsuzuki et al., 2000); during this period farmer can subject them for acclimatizing to low-saline well waters. The post larvae and juveniles of most of the penaeid species adapt and osmoregulates well at lower salinities than their adults. Studies conducted by Parado-Estepa et al., (1987). Although few studies addressed the impact of salinity on survival (Ogle et al., 1992), and growth (Ponce-Palafox et al., 1997) of *P. vannamei*, the estimation of optimal salinity for the growth of white shrimps is still controversial.

Farming of shrimp in inland low saline water has been undertaken in many parts of the world. Particularly, the culture of white shrimp, *P. vannamei*, has become a rapidly growing industry in low saline areas due to its wide tolerance to salinities ranging from 1 to 50 psu (McGraw et al., 2002). The ability of *P. vannamei* to grow at high salinities has also been demonstrated for aquaculture purposes in dry regions (Martínez-Cordova et al., 1997). Earlier works on this line suggested that the optimum salinity for the culture of *P. monodon* ranges from 15 to 25 psu (Chen, 1985). A thorough and careful investigation on the role of salinity and its aftermath on the survival and growth of *P. monodon* is found wanting. The present study is framed in this backdrop with the objective of analyzing the semi-intensive culture of *P.monodon* in low, medium and high salinities in Godavari delta region of Andhra pradesh. Present study has been directed so as to generate information pertain to various biological and economic factors such as survival, Average Body Weight (ABW), Average Daily Growth (ADG), Specific Growth Rate (SGR), Food Conversion Ratio (FCR) and cost analysis in different salinities.

MATERIALS AND METHODS

Description of the study area

The present study was conducted in three growout ponds with pronounced salinity variation, each of 1 ha water spread area. The pond I is a low saline (2-5psu) culture pond and is located at Kumaragiri (Lat.16°35' 40.9" N; Long. 82°17'35.8'' E). The pond II is a medium saline (15-20 psu) culture pond and is located at Yedhurlanka (Lat. 16° 40' 55.41''N; Long. 82° 5' 47.67"E). The pond III is a high saline culture pond where the water salinity ranges from 30- 40 psu and is located at Antervedi (Lat.16° 21' 37.71"N; Long.81°45' 19.6" E). (Plate 3). The present study was conducted for a period of 156 days (February -July, 2010) in 3 earthen ponds of each 10000m^2 area.

Stocking

Healthy and WSSV negative (PCR tested) *P. monodon* seeds were procured from a commercial hatchery near Kakinada. Post larvae (PL- 20) with an average initial weight of 0.02gm were selected and acclimatized to pond water temperature and salinity and stocked at a density of 15 shrimps /m^2 in all the ponds. All the three experiments were conducted concurrently under semi-intensive production conditions. The shrimps were fed with CP feed (Charoen Pokhpond Aquaculture India Pvt. Ltd.).Feeding rate ranged between 2.5 and 10% of body weight per day. The feed ratio was divided in to 4 times a day (06:00, 11:00, 16:00 and 21:00 hr).

Water Quality Parameters

The water quality parameters in the pond are strictly monitored in the morning hours daily at different corners of the pond. Temperature, salinity, hydrogen ion concentration (pH), dissolved oxygen and alkalinity were monitored *in situ.* Water temperature and dissolved oxygen were measured with the aid of portable electronic meter (Lutron, model no. DO-5510). The water salinity was measured by using a hand refractometer (Atago, Japan, Model no.440449). pH and alkalinity were measured using test kits (Advance pharma Co. Ltd., Method-colorimetry). For the sake of convenience in interpretation, the data were pooled up in 14 days interval. The harvest was conducted at 142 DOC in pond I, 114 DOC in pond II and 156 DOC in pond III.

Assessment of Survival, Growth and Food Conversion Ratio (FCR)

Shrimps in each pond were sampled at every 7days interval to assess the growth. The survival, Average Body Weight (ABW), Average Daily Growth (ADG), Specific Growth Rate (SGR) and Food Conversion Ratio (FCR) were calculated using the formula mentioned below.

Average Body Weight (ABW)

$$\text{ABW (g)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

Survival

$$\text{Survival (\%)} = \frac{\text{Number of shrimps survived at the end of the experiment}}{\text{Number of shrimps stocked at the beginning experiment}} \times 100$$

Estimated survival (based on feeding rate)

$$\text{Survival (\%)} = \frac{\text{Biomass (kg)}}{\text{Average body weight (ABV)}} \times 100$$

$$\text{Biomass (kg)} = \frac{\text{Total feed (Kg) used on the day of estimation}}{\text{Percentage of feed (based on feed chart)}}$$

Average Daily Growth (ADG)

$$\text{ADG (g)} = \frac{\text{Average final weight}}{\text{Number of days of culture}}$$

Food Conversion Ratio (FCR)

$$\text{FCR} = \frac{\text{Total Feed Consumed (Dry weight basis)}}{\text{Wet weight of shrimps produced}}$$

Specific Growth Rate (SGR)

$$\text{SGR (\%)} = \frac{\text{Final mean weight} - \text{Initial mean weight} \quad \text{X } 100}{\text{Duration of the Experiment}}$$

Statistical analysis

The results of survival, ABW, ADG, SGR and FCR were arranged in 14 days interval for the sake of easy interpretation. The results are statistically treated with the help of computer package (MS-Excel and SPSS software, version 10.0). To maintain uniformity and for the sake of comparison, the graph, tables so also the statistical treatments were represented evenly for 114 DOC only. The results are presented as mean ± SD (standard deviation). Differences between mean values of growth parameters were analysed by two-way Analysis of Variance (ANOVA) followed by testing for multiple range comparisons between means (Duncan's Multiple Range Test) and the differences between means were checked for significance at level $P < 0.05$.The cost analysis was worked out individually for each pond covering all factors pertain to expenditure. The production cost per kg of shrimp against all major expenditure was calculated with special emphasis on profit and Revenue Over Investment (ROI) so as to get a clear picture of economics.

RESULTS

Water Quality Parameters

Water quality parameters were recorded from all the ponds daily and the results are pooled up in 15 days interval and are portrayed in graphs.

Water Temperature

The results of water temperature are depicted in Fig. 1. The temperature in all the three ponds varied from 27 to 30.7 °C. No pronounced variation in temperature was found between the ponds. Among all the ponds, the minimum was recorded during the 15 DOC and the maximum was recorded during 72 DOC.

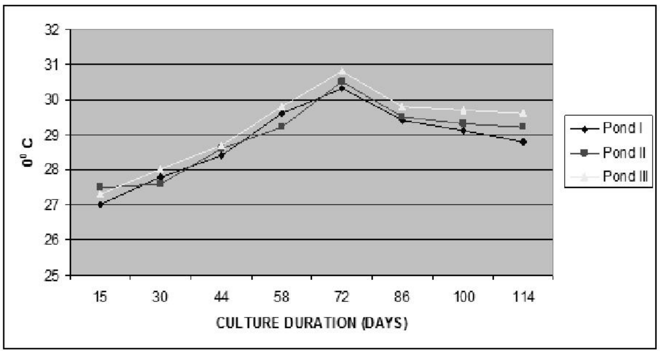

Fig. 1. Water temperature (^{o}C) recorded in all the ponds (I-III) during the study period.

Salinity

The results of salinity are detailed in Fig. 2. The salinity in pond I was ranged between 4 to 6 psu, in pond II between 14-16 psu and in pond III between 34-36 psu throughout the study period.

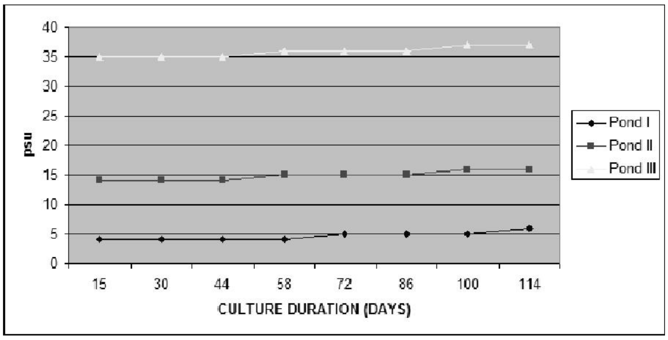

Fig. 2. Salinity (psu) recorded in all the ponds (I-III) during the study period.

Hydrogen ion concentration (pH)

The details of pH are portrayed in Fig. 3. The pH was ranged between 7.5 and 8.2. The pH displayed an optimum range at all the experimental ponds during the culture period. In pond I & II, the pH ranged between 7.8 to 8.2, whereas in pond III it ranged from 7.5 to 8.2 respectively.

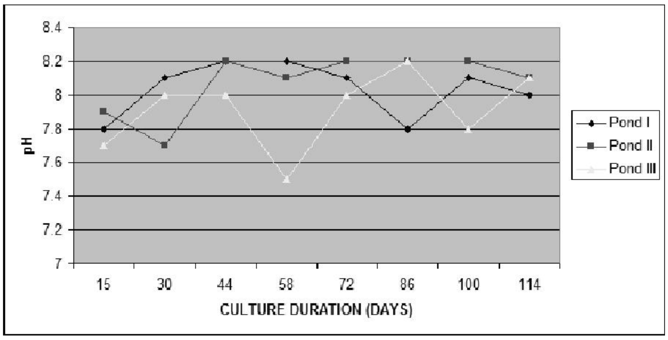

Fig. 3. pH recorded in all the ponds (I-III) during the study period.

Dissolved oxygen

The variation in dissolved oxygen levels between the grow-out ponds during the entire days of culture are pooled up in Fig. 4. In general, high dissolved oxygen levels were recorded during the early days of culture. In pond I, the level varied from 4 to 6.5 ml/l, in pond II it was 4 to 6.5 mg/l and in pond III the dissolved oxygen level varied from 4 to 5.5 ml/l respectively.

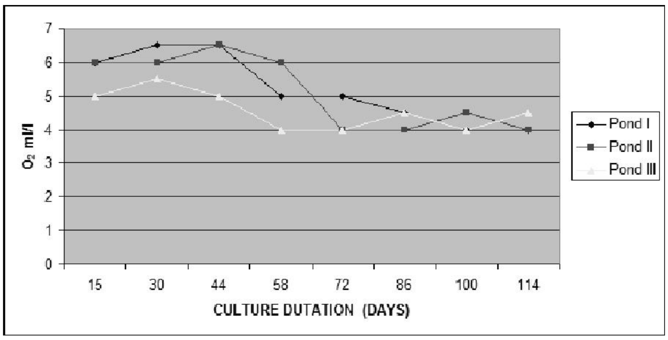

Fig. 4. Dissolved oxygen (O_2ml/l) recorded in all the ponds (I-III) during the study period.

Alkalinity

The results of alkalinity are detailed in Fig.5. The alkalinity at pond I showed a significantly lower value (60ppm) during the initial days of culture and had a gradual increase as the culture proceeds with the maximum level (130ppm) during 86 days of culture. In pond II and III, the alkalinity showed a higher range (180 to 230ppm in pond II and 220 to 260ppm in pond III respectively).

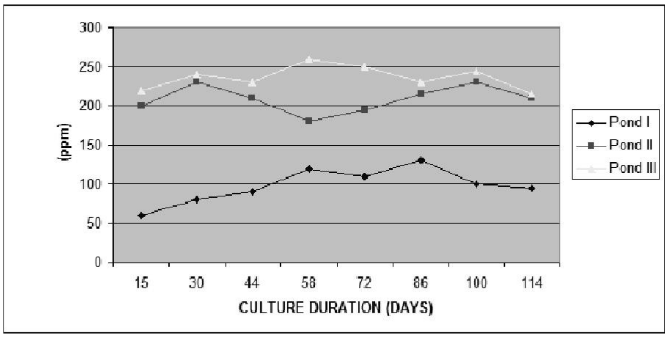

Fig. 5. Alkalinity (ppm) recorded in all the ponds (I-III) during the study period.

Growth Parameters

P.monodon post larvae were checked for survival in happa after 48 hours of stocking. pond I and II observed higher survival (90% and 95%) than pond III (80%) respectively. Based on the happa survival, the feeding was adjusted in each experimental pond. The shrimps were fed with CP feed (Charoen Pokh pond Aquaculture India Pvt. Ltd.). The feeding schedule was based on the feed chart given by the CP Company. Blind feeding was done for the first 25 days. Later the feeding ration was adjusted based on the check tray observation and periodic sampling.

Survival

The results of the survival rate are depicted in Fig. 6. The survival at 30 DOC was 90.33±2.08% in pond I, 92.33±2.08% in pond II, which showed significance ($p \leq 0.05$) with each other. But pond III showed the least survival of 76±1%. The survival at pond I was 80.67%, in pond II was 95.67% and in pond III was 70.67% at 114 days. The survival at the time of harvest was 86.6% for pond I, 95.6% for pond II and 72.6% for pond III at 142, 114 and 156 DOC respectively. Except for the significance between pond I and II during 30 days, all other duration showed a varied significance between the ponds. The analysis of variance (2-way) showed significant difference in survival between the days of culture and also between the culture ponds ($P \leq 0.05$).

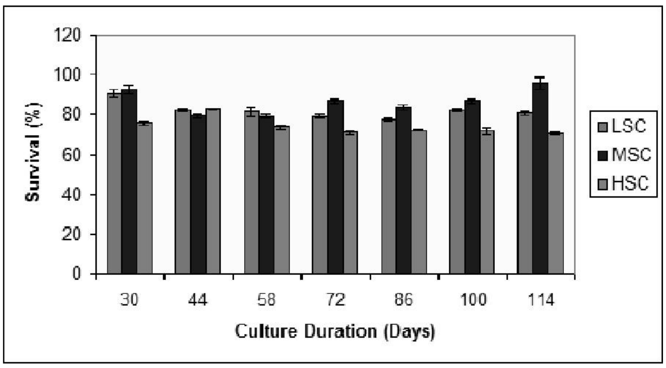

Fig. 6. Survival (%) of *P. monodon* cultured in ponds I to III up to 114 days of Culture

Average Body Weight (ABW)

The results of growth performance based on Average Body Weight (ABW) are detailed in Fig.7. The average body weight of shrimps at 30 DOC was 2.33 ±0.05g in pond I, 3.64±0.09 g in pond II and 2.26±0.06 g in pond III. The ABW in all the three ponds varied significantly ($p \leq 0.05$) from the beginning of the culture to 114 DOC and harvest. The average weight gained during 114 DOC in pond I 23.44±0.62g and in pond III was 17.83±0.28g; which showed significantly lower values ($p \leq 0.05$) than pond (II 33.16±0.83g). The pond II exhibited fastest growth (33.14g) in 114 days, and was harvested 28 days before Pond I and 42 days before pond III. In general, the shrimps grown at pond III showed poor growth performance from the beginning of the culture and attained a harvestable size of 28.58g only at 156 days. The analysis of variance (2-way) showed significant difference in Average Body weight between the days of culture and also between the culture ponds ($p \leq 0.05$)

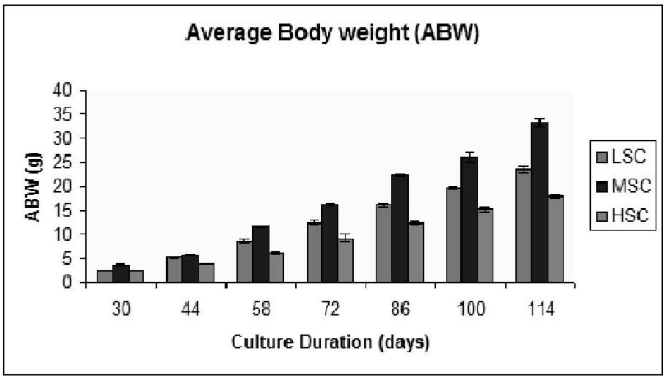

Fig. 7. Average Body weight (ABW) (g) of *P. monodon* cultured in ponds I to III up to 114 days of culture.

Average Daily Growth (ADG)

The results of growth performance based on Average Daily growth (ADG) are depicted in Fig. 8. The ADG at 30 DOC for pond I (0.07±0.00g) was significant with pond III, whereas pond II showed fairly higher ADG value (0.12±0.01g). The Average Daily growth at 114 days for pond II was recorded to be the maximum (0.29±0.01g) compared to pond I (0.20±0.01g) and pond III (0.15±0.00g) respectively. There was continues increment in ADG as the culture days proceeds. Comparatively, pond II revealed higher ADG followed by pond I, while pond III showed lesser values throughout the culture period. The Average Daily Growth (ADG) at the time of harvest was 0.23g for pond I, 0.29g for pond II and 0.17g for pond III at 142, 114 and 156 DOC respectively. The analysis of variance (2-way) showed significant difference in Average Daily Growth between the days of culture and also between the culture ponds ($p \leq 0.05$).

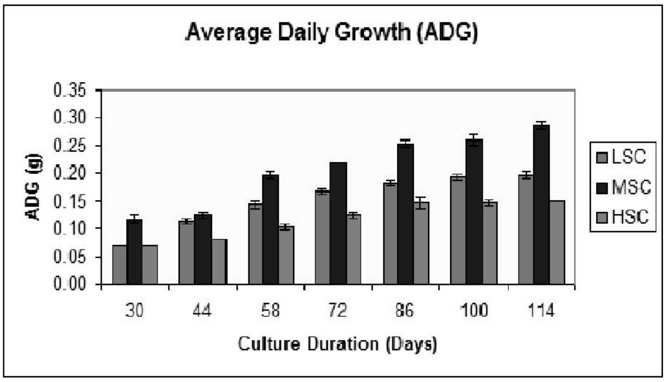

Fig.8. Average Daily Growth (ADG) (g) of *P. monodon* cultured in ponds I to III up to 114 days of culture

Food Conversion Ratio (FCR)

The results of the food conversion ratio are detailed in Fig. 9. The FCR in all the three ponds varied significantly ($p \leq 0.05$) from the beginning of the culture up to the harvest. The FCR of shrimps at 30 DOC was 1.06±0.07 in pond I, 1.17±0.07 in pond III and the lowest was 0.83±0.03 in pond II respectively. The FCR widely ranged from 1.57±0.02 to 2.06±0.06 at 100 days and varied significantly ($p \leq 0.05$) at all ponds. The final FCR for pond II at 114 days was 60.83 % less than pond III and 34.26% less than pond I. At harvest, the pond III showed higher FCR (2.4) than pond II (1.42) and pond I (1.89) respectively. The analysis of variance (2-way) showed significant difference in FCR between the days of culture and also between the culture ponds ($P \leq 0.05$).

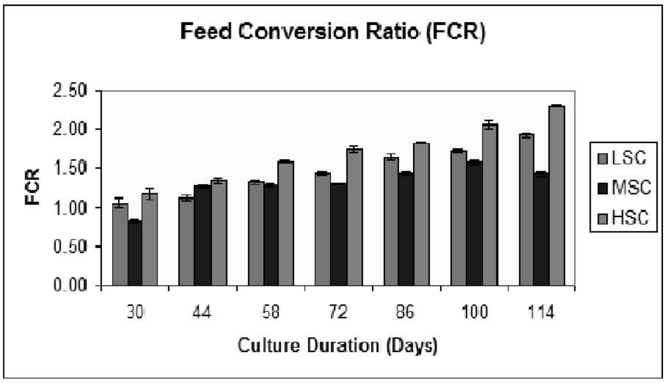

Fig. 9. Food Conversion Ratio (FCR) (g) of *P. monodon* cultured in ponds I to III up to 114 days of culture.

Specific Growth Rate (SGR):

The results of the SGR at different salinities are presented in Fig. 10. The SGR of shrimps at 30 DOC was 7.69±0.15% in pond I, 7.45±0.22% in Pond III and 12.06±0.3% in pond II respectively. At 100 days, the SGR varied greatly between pond I (19.71±0.23%), pond II (26.09±1.02%) and pond III (15.21±0.48%) respectively. The SGR at 114 days for pond II was recorded to be the maximum (29.06±0.73%) compared to pond I (20.54±0.54%) and pond III (15.62±0.25%). Throughout the culture period, higher SGR was observed at pond II, followed by pond I and pond III. At harvest, pond II showed 37% higher SGR than pond III and 29.31% higher than pond I respectively. Pond III showed a lesser SGR compared with pond I (-20.98%) and pond II (- 37%) respectively. The analysis of variance (2-way) showed significant difference in SGR between the days of culture and also between the culture ponds ($P \leq 0.05$).

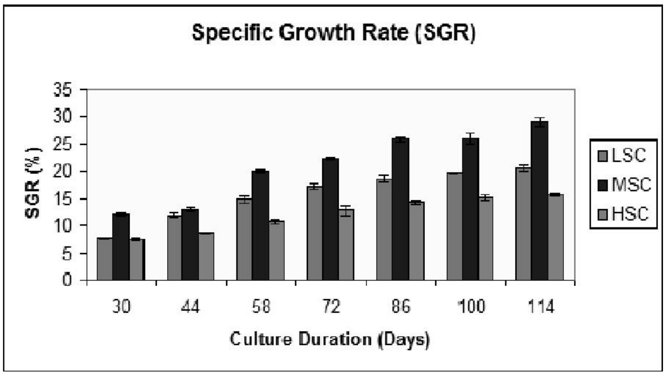

Fig. 10. Specific Growth Rate (SGR) (%) of *P. monodon* cultured in ponds I to III up to 114 days of culture.

Cost Analysis

The details of harvested shrimp biomass is detailed in (Table 1 and Fig.11). Pond II obtained comparatively good harvest in shorter time (4928 kg at 114 DOC) than other ponds. The culture period for pond I, II and III had a varied duration (142, 114, and 156 days respectively) and different biomass production (4390 kg,4928kg, and 3150kg respectively).The production cost analysis was worked out individually and are given in Table 2. The feed cost of accounted to the maximum expenditure in all the three experimental culture. The cost of feed per kilogram of shrimp in pond III was maximum (Rs.120.59), whereas the pond I recorded 21.55% less (Rs.94.60/kg) and pond II recorded 41.17% (Rs.70.94/kg) less expenditure than the pond III. The next major expenditure was the energy cost. The pond III showed the maximum power cost per kg shrimp (Rs.27.99), followed by pond I (Rs.19.74/kg) showing a reduced cost by 41.99% than pond III. The least expenditure was obtained by pond II (Rs.13.22/kg) which was comparatively 111.72% less than pond III and 49.31% less than pond I respectively. The lease cost includes lease for land, generator and aerators for a single crop (6 months) respectively. The probiotics used for soil, water and feed accounted for 6% of the total expenditure at pond I, whereas pond II showed 7.06% and pond III 4.26% respectively. The seed cost in pond III were high (Rs.11.43/kg shrimp) when compared to pond I (Rs.8.20/kg shrimp) and pond II (Rs.7.305/kg shrimp). The labour cost per crop in pond III was 1.99 fold more than the pond II and 1.56 fold more than the pond I.

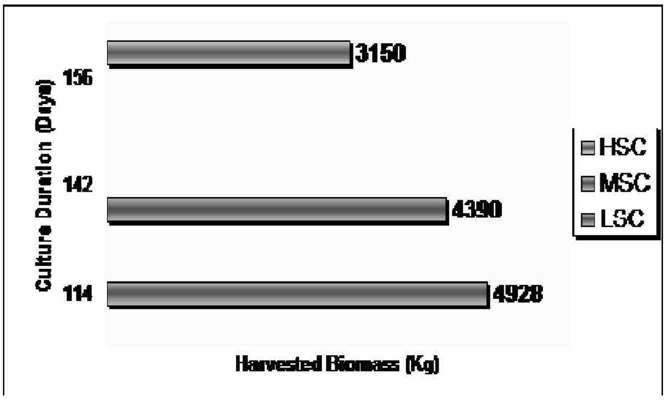

Fig. 11. Total Harvested biomass of *P.monodon* at end of the culture a pond I, pond II and pond III.

Table 1. Pond wise summary of semi – intensive shrimp farming pertain to stocking, harvest and growth

Culture Details	Pond I	Pond II	Pond III
Pond area (m^2)	10,000 m^2	10,000 m^2	10,000 m^2
Initial stocking (Nos.)	1,50,000	1,50,000	1,50,000
Density (Nos./m^2)	15	15	15
Stocking date	10/02/2010	12/02/2010	18/02/2010
Days of Culture(DOC)	142	114	156
Date of harvest	01/07/2010	05/06/2010	23/07/2010
Biomass harvested(Kg)	4390	4928	3150
Total feed consumed (Kg)	8311	6992	7597
FCR	1.89	1.42	2.4
ABW (gm)	33.14	33.14	28.58
ADG (gm)	0.23	0.29	0.18
SGR (%)	23.3	29.06	18.3
Survival (%)	86.6	95.6	72.6

Table 2. Economics and profit analysis (pond wise) of the semi intensive shrimp farming

Cost Details Per Crop	Low saline culture (pond I)		Moderate saline culture (pond II)		High saline culture (pond III)	
	Total cost	Cost/Kg shrimp	Total cost	Cost/kg shrimp	Total cost	Cost/kg shrimp
Feed (Rs.)	4,15,550	94.60	3,49,600	70.94	3,79,850	120.59
Seed (Rs.)	36,000	8.20	36,000	7.30	36,000	11.42
Electricity (Rs.)	86,640	19.74	65,136	13.22	88,176	27.99
Bleaching (Rs.)	13,050	2.64	13,050	2.97	13,050	4.14
Lime (Rs.)	Nil	Nil	7,500	1.52	6,250	1.98
Probiotics (Rs.)	42,825	9.76	45,375	9.21	28,200	8.95
Chemicals (Rs.)	6,000	1.37	10,500	0.47	2,000	0.63
Labour (Rs.)	25,000	5.69	22,000	4.46	28,000	8.89
Lease (Rs.)	62,500	14.24	70,000	14.20	62,500	19.84
Fencing (Rs.)	3,000	0.68	3,000	0.60	3,000	0.95
Others (Rs.)	20,000	4.56	20,000	4.06	10,000	3.17
Total expenditure(Rs.)	7,10,565	161.88	6,42,161	130.31	6,57,026	208.58
Total income(Rs.)	11,41,400	260.00	12,81,280	260	7,24,500	230
Profit (Rs.)	4,30,835	98.14	6,39,119	129.69	67,474	21.42
Revenue Over Investment (ROI) %	60		99		10	

The overall production cost per kg of shrimp was minimum for pond II (Rs.130.31), followed by pond I (Rs.161.88/kg shrimp), whereas the highest production cost was observed in pond III (Rs.208.58/kg shrimp) respectively. For pond III, the production cost per kg of shrimp increased by 37.5% and 22.3%, when compared to pond II and pond I respectively. The profit per kg of shrimps for pond II (Rs.129.64) showed six fold increase than pond III and 1.32 fold increase than pond I. Likewise the profit per kg of shrimp for pond I (Rs.98.14) increased to 4.58 fold than pond III and decreased to 0.32 fold than pond II. The Revenue Over Investment (ROI) was maximum for pond II (99%). A moderate ROI was seen for pond I (60%), whereas the ROI (10%) was least for pond III.

DISCUSSION

Water Quality Parameters

The water quality parameters play a very vital role in the successful culture of aquatic organisms. In *P.monodon* culture the hydrological parameters such as salinity, pH, dissolved oxygen and alkalinity levels ranks a crucial role in the fate of the growth and survival of shrimps especially in semi intensive systems. The variations of dissolved oxygen, temperature and salinity are the key factors in the culture system which plays an important role in keeping the prawn in good condition (Shigueno 1972). Water temperature is probably the most important environment variables in shrimp culture, because it directly affects metabolism, oxygen consumption, growth, moulting and survival. Boyd (1992) opined that the optimum temperature range in culture ponds is between 25 to 30^{o}C that accelerates the growth of shrimps and the level greater than this range is lethal to the cultured organisms. The temperature in all the three ponds varied from 27 to 30.7 °C with no pronounced variation was found between the ponds. Boyd and Fast (1992) opined that the optimum temperature range in culture ponds is between 25 to 30^{o} C that accelerates the growth of shrimps and the level greater than this range is lethal to the cultured organisms Salinity is one of the most prime environmental parameter in shrimp culture that decides the fate of culture. In the present study, the salinity ranged from 4 to 6 psu in pond I, 14 to 16 psu in pond II and 35 to 37 psu in pond III. The salinity closer to is osmotic point (14 to 16 psu) resulted in increased growth in pond II than other ponds. The growth of *P. monodon* will be at optimum in salinities of 15psu and 20psu (Cheng and Liao, 1986). In the present study the pH range flanked within the optimum level for penaeid shrimp culture. Ramakrishna Reddy (2000) recommended an optimum pH of 7.5 to 8.5 for *P.monodon* culture. The dissolved oxygen level was maintained at 4 to 6.5 mg/l during the culture period in all the ponds which is proved to be an optimum range in the semi intensive culture of shrimps**.** Even the lowest level of dissolved oxygen observed (4ml/l) was also suitable for high survival and growth rate of *P.monodon.* This was attained probably due to continuous aeration in the pond. A similar observation was made in the study of McGraw et al., (2001).

Growth Performances

The estimation of preliminary survival was based on the assessment of post larvae stocked in happa. Poor survival and lack of accurate prediction in the early phase of grow-out are the major obstacles during the culture. However after 30 DOC, the response of shrimps to the feeding trays is more legible and this will gave a clear idea of survival for the successive phase of culture. Thus the use of feeding trays is considered inevitable in shrimp farming. Post larvae of *P.monodon* aged between PL 7 and 22 proved better survival and growth at 20 and 25 psu than at high salinities (40 ppt) indicates that their optimal salinity is in the lower range. This is in accordance with the work of Raj and Raj (1982) whom studied the salinity preference of post larvae and juveniles of *P. indicus.* The results of survival obtained in the present study revealed that shrimps in pond II exhibited fairly higher survival (96%) than that of pond I (81%), whereas in pond III which is a high saline culture, showed comparatively poor survival (71%). It is also clear from the present investigation that, shrimp production increased significantly with the stocking density and survival, this is in agreement with the report of Allan and Maguire (1992). Michael (1996) opined that poor shrimp survival leads to less yield though the growth rate and shrimp size at harvest were good.

In the present study, shrimps grown at medium salinity (pond II) had better growth performance, when compared with shrimps cultured either in low (pond I) or high salinity levels (pond III), suggesting that the best productivity of *P.monodon* is in the moderate salinity level of 15-20 psu. The growth of *P. monodon* will be at optimum in salinities of 15psu and 20psu and at high or low salinities affects the molting frequency (Boyd, 1989). Similarly, Huang (1983) reported that *P. vannamei* performed better growth at salinities of about 20 psu and poorest at 5 psu and 45 psu respectively. The Standard Growth Rate (SGR) and the Average Daily Growth (ADG) was also influenced by the salinity in such a fashion that pond II showed an increased ADG and SGR during all the sampling intervals. The final mean ADG is to the tune of 0.23g, 0.29g, 0.18g and SGR is about 23.3%, 29.06% and 18.3% in pond II, I and III respectively. The results of the present findings are comparable to the SGR reported by Teruel et al., (2003).Parado-Estepaet et al., (1987) reported that food consumption and conversion ratio is correlated with water temperature and salinity of the grow-out. In the present study, it was observed that food consumption of shrimps reared at pond II was much lower in comparison with those cultured in pond I and pond III respectively.

Since the temperature was nearly constant between the culture ponds, variation in food consumption was mainly related to salinity (Kumlu et al., 1999**)**. Sandiferet et al., (1991) reported that intensive shrimp culture typically has a Feed Conversion Ratio (FCR) of 2.0 or above. But the FCR value observed in this study showed promising results. pond I (1.89) and pond II (1.42) showed a better FCR which might be attributed to the favorable salinity conditions; whereas pond III exhibited feed conversion ratio of about 2.4 which might be due to the influence of high salinity. Therefore it is safe to vouch that salinity plays a decisive role in increased survival rate and enhanced shrimp growth that will significantly improve the profitability of shrimp farming, Run Yu *et al.* (2006) suggested that either high growth rate or high survival rate would imply a high biomass. Low-saline groundwater is an abundant source of many arid regions which has great potential for aquaculture (Dennis and Kevin, 2003). Commercial and viable culture of *P. vannamei* (Samochav et al., 1998) and *P.monodon* (Cawthorne et al*.,* 1983) has been successfully carried out in moderate saline inland ground water. No pronounced problems have been reported in culturing shrimps in the saline ground waters of inland or coastal low-lying saline-alkaline areas. China has been exploiting and ameliorating the saline-alkaline wetland by using the fish pond-agricultural terrace system in the Yellow River Delta for decades. It is prominent that this type of aquaculture could not only reduce the salinization of the soil around the pond area, but also be a good way for the sustainable development of the agricultural economy (Cheng, 1993).

Cost Analysis

Feed is the most important expensive item for a semi-intensive shrimp culture practice. Pond III showed high FCR (1:2.4) which might be attributed to less survival and slow growth rate. Concurrent to this, the cost of feed/kg shrimp increased exponentially in pond III (Rs.120.59), compared to pond I (Rs. 94.60) and pond II (Rs.70.94) Overfeeding results in higher cost of feed per unit shrimp produced (Peter, 1998). Besides, Wyban et al., (1995) opined that excess feeding can cause deterioration of water quality that leads to poor growth and survival with a consequent reduction in production and economic return. The proper assessment of check trays are treated as a guide for adjusting feeding rates (Allan et al., 2006). The second major expenditure accounting to the production cost is the power cost. The slow growth rate increased the duration of culture in pond III (156 days) and pond I (142 days), resulted in increased utilization of electricity, which in turn increase the power cost / kg shrimp by (Rs.27.99) and (Rs. 9.74) respectively. However pond II with least culture period (114 days), showed the economical (Rs.13.22) power cost / kg shrimp. Seed is another major expenditure item All the experimental ponds were stocked with the same stocking density, but the harvest results showed that the lowest seed cost / kg of shrimp produced was achieved in pond II (Rs.7.30) compared to pond III (Rs.11.45) and Pond I (Rs.8.20).

The might be credited to the good productivity (in terms of harvested biomass) in pond II (4928 kg/ha), compared to pond III (3150 kg/ha) and Pond I (4390 kg/ha) respectively. Because of good survival (95 %) in pond II, the frequency of probiotic application so to improve soil condition was doubled (weekly once), compared to pond I (once in 2 weeks) and Pond III (once in 10 days). Though the quantity of probiotic applied was comparatively higher for pond II, but the cost of probiotics per kilogram of shrimp was still lesser (Rs.9.2) compared to pond I (Rs.9.76) and pond III (Rs.8.95). A similar trend was observed for the cost of chemicals applied and for manpower. Because of the saline and alkaline soil nature of pond I, little expenditure were made for liming, whereas in pond II (Rs.1.52) and pond III (Rs.1.98) ,expenditure were made for liming, but accounted only a smaller proportion compared to the total expenditure. The profit per kilogram of shrimp was worked out which showed that pond II exhibited 6 fold increase than pond III and 1.32 fold increase than pond I respectively. Correspondingly, results of economic evaluation indicated that the Revenue Over Investment (ROI) was maximum for pond II (99%), followed by pond I (10%) and the least was observed at pond III (10%). The results of the present study revealed that by utilization of the fresh water sources of Godavari and low saline ground water from saline and alkaline area gave more ROI in pond I than the culture in Pond III. There are no pronounced environmental and economical problems in culturing shrimps by utilising saline ground waters in the inland or coastal low lying saline-alkaline areas. Shrimp species such as *P.vannamei* (Samochaet et al., 1998a) and *P.monodon* (Flaherty and Vandergeest, 1998) have been commercially reared in grow-outs using the saline inland ground water in arid and semi arid regions. China has been exploiting and ameliorating the saline-alkaline wetland by using the fish pond-agricultural terrace system in the Yellow River Delta for decades. In some places of New South Wales, Australia, utilization of saline alkaline area for aquaculture purpose is very successful.

Conclusions

From the present study it is clear that, the survival, growth performance, carrying capacity of the pond and the maximum profitability was found good in moderate salinity culture (pond II). Because of the minimum ROI in high saline culture, it is concluded that the effort made in the high saline culture area (pond III) to produce *P.monodon* should be diverted towards low saline and moderate saline ponds to get the maximum productivity and ROI.

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