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RESEARCH ARTICLE

Growth, Survival and Production of Pacific White Shrimp *Litopenaeus vannamei* at different stocking densities under semi intensive culture systems in Andhra Pradesh

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Abstract

The objective of this study was to evaluate the growth, survival and production of *Litopenaeus vannamei* during 120 days of culture period with 5 stocking densities. To maintain sustainability in production pattern, pond water quality and stocking density play the key role and are directly related to growth, survival and yield. Experiment was carried out in commercial brackish water ponds at Karlapalem, Guntur district, Andhra Pradesh. In the present study *Litopenaeus vannamei* in different ponds at stocking densities 40/m^2, 50/m^2, 60/m^2, 70/m^2 and 80/m^2 larvae with an average size goes to 0.80g. After the completion of the experimental period of 120 days the production was 3541.2, 4205.4, 5192.6, 5962.2 and 5046.6kg and the survival was 80.4, 79.6, 78.4, 78.2 and 73.4 percent with respect to the above stocking densities. The mean average weight of the shrimp at harvest was 31.8, 30.7, 30.8, 30.4 and 29.4 gm respectively. This shows that the relationship between stocking density and average body weight is highly significant. Average body weight increases with less stocking density and vice versa. In the present observations it was concluded that *L.vannamei* is successful in brackish water environment and the survival and growth directly related to stocking density.

INTRODUCTION

In the recent years aquaculture intensification has become a common practice throughout the world. Farmers are reporting with higher stocking densities, artificial fertilization of the ponds and supplementary feeding using artificial feeds to get the maximum profit from a unit area. There is always a chance of stress to the growing organism with the over intensification. Under stress the pathogens present in the pond may enter and cause disease resulting in severe mortality. During the last few years Asian countries were severely affected with many viral diseases and faced massive economic losses particularly due to continuous outbreak of White Spot Disease (WSD). In India outbreak of WSSV to tiger shrimp *Penaeus monodon* has spread and caused large scale mortalities and severe damage to shrimp aquaculture industry. The pacific white shrimp *Litopenaeus vannamei* has become the main crustacean species produced through culture, with production exceeding that of tiger shrimp *Penaeus monodon* since 2003. The production of this species has been increased from 186,113 tons in 1999 to over 2.3 mmt in 2007.

Generally survival, growth and production of shrimp depend on the type of culture system (e.g. extensive, intensive and semi-intensive). Stocking rates for high density in aquaculture are typically thousand fold greater than wild environments. In ponds usually high density exacerbates the problems with water quality and sediment deterioration. Water quality management became the limiting factor because of higher feeding rates and greater stocking densities in the intensive farming. The physico-chemical factors of the pond water and quality of supplementary feed as individual or synergistically plays important role on the growth, survival and shrimp production, which together determine the ultimate yield. The ecosystem and biota of the culture pond may also influence the production performance of shrimp culture. Subrahmanyam, 1973, Varghese et al., 1975, 1982 and Liao, 1977 stated the effect of water temperature, salinity, pH and dissolved oxygen concentration on the shrimp growth and survival.

Many studies have aimed to increase the shrimp production through manipulating of stocking density, fertilization, artificial feeding and opening of new lands for culture and combination of different species into culture system (Varghese et al., 1975; Chakraborti et al., 1985; Krishna, 2006). In practice, the densities at which farmers keep their stock are based on the experience and institution with codes of practice and hand books being used as guide. Information regarding effect of stocking density of the shrimp performance during intensive culture is limited, inconsistent and some time controversial.

Pacific white shrimp, *Litopenaeus vannamei*, is one of the most intensively cultivated shrimps all over the world (Perez Farfante and Kensley 1997) because of the reduced risk of catastrophic diseases and favorable environmental conditions (Boyd 2002; Zhu et al., 2006). Several authors described about the growth in shrimp culture systems based on stocking density (Cailout et al., 1976; Sedgwick 1979; Maguire and Leedow 1983) and some authors have reported an inverse relationship between growth and stocking density (Lee et al., 1986; Sandifer et al., 1987; Whay-Ming and Yew-Hu, 1992; Daniels et al., 1995). No proper research has yet been done on the effect of stocking density in long term survival and growth performance of *L.vannamei.* Hence it was aimed to evaluate the effect of different stocking densities on the survival and growth of *L.vannamei* for the present study.

Material and Methods:

For the present study commercial brackish water ponds located near Karlapalem, Guntur district, Andhra Pradesh, India was used. They were treated as Pond1 (P1), Pond2 (P2), Pond3 (P3), Pond4 P4) and Pond5 (P5). They were stocked at a density of 40 pcs/m^2 in pond1, 50 pcs/m^2 in pond2, 60 pcs/m^2 in pond3, 70 pcs/m^2 in pond4 and 80 pcs/m^2 in pond 5. All the experimental ponds were in duplicate and size goes to 0.5hac. All the ponds were dried, tilled and limed before stocking. Water is pumped from the estuarine canal with the help of motors and provided with filter bags. Crab fencing and bird netting were made. Application of organic and inorganic fertilizers and chlorination process were done before stocking the post larvae. Healthy and disease free post larvae collected from Hatchery CP Aquaculture Ltd., Gudur were stocked at a size of 0.80g. They were confirmed negative for the White Spot Syndrome Virus (WSSV) and Taura Syndrome Virus (TSV) through Polymerase Chain Reaction (PCR Assay) before packing. After the completion of acclimatization post larvae were released.

Total culture period goes to 120 days. Pond aeration was maintained through paddle wheel aerators. Supplemented feed (CP Aquaculture India Pvt Ltd) was used four times daily and check trays were used to maintain proper feeding management. Feed was adjusted based on the expected survival and biomass. To monitor the shrimp growth, sampling was carried fortnightly by Seine net at first fifteen days and through cast net for the remaining culture period. Analyses of physico-chemical parameters for all the ponds were carried using standard methods (APHA, 1989). Field test instruments were used to analyze water pH (Digital mini-pH meter, model 55), Temperature & Dissolved Oxygen (YSI-58), Transparency (Sacchidisc, Boyd, 1990), Total ammonia (APHA, 1989), and Phosphorous (model 21D).

At each sampling weights for growth increments were recorded. Average Daily Gain (ADG), Specific Growth Rate (SGR), and Feed conversion ratio (FCR) were calculated from the sampling data. Final weight gain%, Survival rate%, Total Yield (Kg) and Total feed fed (Kg) were recorded at the end of experiment. All the results were statistically analyzed by two way analysis of variance (ANOVA). According to Steel and Torrie (1980) the significant differences among treatments (40, 50, 60, 70 and 80 pcs/m^2) were performed at a level of $P<0.05$ significance.

Growth parameters:

After harvesting the experimental ponds total yield, survival rate and total feed consumption were recorded and the following growth parameters were calculated for studying the growth performance of *Litopenaeus vannamei* at different stocking densities.

a. Average daily gain (g) (ADG)

$$\text{Average daily gain (g) (ADG)} = \frac{\text{Final weight (g)}}{\text{Duration of culture (days)}}$$

b. Final Weight Gain %

$$\text{Final Weight Gain \%} = \frac{\text{Final Weight (g)} - \text{Initial Weight (g)}}{\text{Initial Weight (g)}} \times 100$$

c. Specific growth rate (SGR)

$$\text{SGR} = \frac{\ln(\text{Final weight (g)}) - \ln(\text{Initial weight (g)})}{\text{Duration of Culture}} \times 100$$

d. Survival rate %

$$\text{Survival rate \%} = \frac{\text{No of shrimp harvested}}{\text{No of shrimp stocked}} \times 100$$

e. Feed Conversion Ratio FCR

$$\text{FCR} = \frac{\text{Total feed fed (dry wt.) (Kg)}}{\text{Total Yield (kg)}}$$

Results and Discussion:

After completion of the experimental period of 120 days the productions were observed as 3541.2kg, 4205.4kg, 5192.6kg, 5962.2kg and 5046.6kg and the percentage survival was 80.4, 79.6, 78.4, 78.2 and 73.4 with respect to the densities of $40/m^2$, $50/m^2$, $60/m^2$,$70/m^2$ and $80/m^2$. The data in our present study showed that as the density increased to certain level production also increased i.e. up to $70pcs/m^2$ (Table:1). Wyban *et al.*, (1987) also reported the declined growth and increased yield with increased density in penaeid shrimps. Hanson and Goodwin (1977); Maguire and Leedow (1983) and Allan and Maguire (1992) reported that the growth reduction in shrimp at higher densities attributed to reduction in grazing activity of a pond. Kungvankij and Chua, (1986) and Tidwell *et al.*, (1999) also stated that best economic results were possible at optimum stocking density and that may depend upon the area of the pond, the required harvesting size of the shrimp and the number of crops per year. They also stated that in culture system different stocking densities will be used for different shrimp species. Similar results were observed by Apud *et al.,(*1981); Maguire and Leedow (1983); Sandifer *et al.*, (1987).

The physico-chemical parameters of water play crucial role in the culture systems. Maintenance of water quality is essential for optimum growth and survival of shrimp. The summary of the present observation was given in Table:2. Excess feed, fecal matter and metabolites will exert tremendous influence on the water quality of shrimp farm (Soundarapandian and Gunalan, 2008). In the present study the salinity was maintained in between 7.35 to 8.29 ppt in all experimental ponds. However, the shrimp tolerates the salinities of even 2.45ppt (Parker *et al.*, 1974). Several works have reported good growth and survival of *L.vannamei* in brackish water range from 10-35ppt was ideal for shrimp culture (Karthikean, 1994 and Gunalan *et al.*, 2010). Sowers and Tommasso (2006) observed the higher growth in low salinity (2ppt) water than in seawater. Wang *et al.*, (2004) reported that the favorable pH range of 7.6-8.6 for *L.vannamei.* The pH of pond water is influenced by many factors, including pH and the source of water, acidity of bottom soil and shrimp culture inputs and biological activity. The level of dissolved oxygen in pond water depends in the balance of autotrophic and heterotrophic production and cloudy weather also influenced dissolved oxygen concentration. Several workers have reported on the Survival and growth of *L.vannamei* in different densities and salinities (Wyban *et al.*, 1988; Samocha *et al.*, 1993, 1999; Araneda, 2008, Neal *et al.*, 2010, Karuppasamy et al., 2013 and Gautam et al., 2014). Temperature can affect shrimp growth directly controlled by food consumption and nutrients availability in the food. The cultured shrimp grows best in a temperature range from 24-32^{o}C (Fast and Lannan, 1992). Temperature has pervasive controlling effect on growth (Das and Saksena, 2001). During the experimental period the temperature was recorded between 32-35^{o}C. The values of the FCR are 2.81, 2.39, 2.45, 2.68 and 3.12 at $40/m^2$, $50/m^2$, $60/m^2$, $70/m^2$ and $80/m^2$ respectively. Values of the FCR increased significantly ($P<0.05$) with increased shrimp density. Roethlisberg (1998) stated that increasing density and shrimp biomass had negative effect on growth. In the present study also it was clearly indicated that at $80pcs/m^2$ of stocking density the yield was decreased compared to the $70pcs/m^2$. Sandifer *et al.*, (1987) noticed that increasing stocking density reduces the feed conversion efficiency. This decrease is probably due to crowding at high densities leading to stress in the organisms (Foster and Bread, 1974). Large organisms were also seemed to dominate smaller ones during feeding and in competition for space particularly in the higher density treatments. This agrees with Haran *et* *al.,* (2004); and Arnold *et al.,* (2006), who reported that high densities lead to greater dominance and hierarchy placement of large organisms over small ones in terms of feed, refuge and reproduction. Apparently, territoriality added to social interactions creates inhibitory effect on growth and survival that is augmented population density increases. Similar results were observed by [Lee *et al.,* 1986, Sandifer *et al.,* 1987, Whay-ming and Yew-Hu 1992, Daniels *et al.,* 1995, Reid and Arnold 1992, Williams *et al.,* 1996 Davis and Arnold 2000, Van Wyk *et al.,* 1999 and Samocha *et al.* 2004]. Survival rate of growing *L.vannamei* were 80.4, 79.6, 78.4, 78.2 and 73.4 with respect to the densities 40/m^2, 50/m^2, 60/m^2, 70/m^2 and 80/m^2 respectively. The survival rate was maximum at 40/m^2 and minimum at 80/m^2. The survival rate decreased with the increasing stocking densities. Apud *et al.,* (1981) found that increasing density of *P.monodon* from 2.5 to 20pcs/m^2 resulted slight and significant ($P \leq 0.05$) reductions in survival. Wyban et al., (1987) stated the suitable stocking densities for *L.vannamei* were 5 to 21pcs/m^2 and Sandifer *et al.,* (1987) stated it was 10 to 40pcs/m^2 for *P.monodon*. Similar results were observed by Nunes and Parsons (1998) for semi intensive culture system. They suggested that for semi intensive culture system to get 69-71.9% of survival rate, 14.3pcs/m^2 is suitable. The present findings were found similar and agreed with the results of all the above said.

The results showed that the cultured shrimp biomass increased as shrimp stocking density increased to certain level. The total production was 3541.2, 4205.4, 5192.6, 5962.2 and 5046.6kg pcs/m^2 at 40/m^2, 50/m^2, 60/m^2, 70/m^2 and 80/m^2 stocking density respectively. Average production of shrimp was significantly ($p<0.05$) different among densities. Maintenance of health of the shrimp stocks in farming situations should focus on maintenance of healthy environment in the ponds at all phases of the culture cycle in order to prevent problems in the ponds before they occur and reduce the likelihood of disease transmission outside the ponds.

Table-1: Growth parameters of *L.vannamei* at different stocking densities.

Parameter	**40/m^2**	**50/m^2**	**60/m^2**	**70/m^2**	**80/m^2**
Initial weight(g)	0.8.	0.80	0.80	0.80	0.80
Final weight(g)	31.8	30.7	30.8	30.4	29.4
% wt gain	3875.0	3737.5	3750.0	3700.0	3575.0
SGR (%day)	3.0614	3.0956	3.0523	3.0178	2.9654
ADG g/pcs/day)	0.2213	0.2321	0.2439	0.2569	0.2316
FCR	2.18	2.39	2.45	2.68	3.12
Survival %	80.4	79.6	78.4	78.2	73.4
Feed consumption	5542.6	6430.2	7940.5	8864.0	9873.4
Total Yield(Kg)	3541.2	4205.4	5192.6	5962.2	5046.6

Table-2: Summary of water quality parameters for *L.vannamei* under different stocking densities.

Parameter	**40/m^2**	**50/m^2**	**60/m^2**	**70/m^2**	**80/m^2**
Temperature	36.3 ± 1.9	35.9 ± 2.6	36.5 ± 2.2	35.8 ± 2.9	36.1 ± 2.3
D.O(mg/l)	6.21 ± 1.25	5.9 ± 1.68	5.4 ± 1.08	4.9 ± 1.56	4.6 ± 1.76
pH	7.9 ± 0.3	7.7 ± 0.5	7.2 ± 0.4	7.4 ± 0.8	7.4 ± 1.2
Transparency	39.6 ± 4.6	38.6 ± 5.4	37.5 ± 4.9	38.2 ± 5.6	39.2 ± 5.1
Alkalinity	172.5 ± 6.7	169.6 ± 6.4	164.2 ± 5.9	160 ± 6.8	164.2 ± 7.2
Hardness	183.2 ± 7.5	185.3 ± 7.3	178.2 ± 7.8	169.5 ± 5.9	172.8 ± 8.2
Total $NH_{3(}$mg/l)	0.14 ± 0.07	0.16 ± 0.06	0.12 ± 0.05	0.13 ±0 .08	0.16 ± 0.06
Nitrates(mg/l)	0.06 ± 0.01	0.08 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.08 ± 0.01
Nitrites(mg/l)	1.39 ± 0.12	1.31 ± 0.1	1.21 ± 0.1	1.31 ± 0.13	1.42 ± 0.15
Phosphates(mg/l)	0.12 ± 0.02	0.15 ± 0.03	0.17 ± 0.02	0.12 ± 0.03	0.13 ± 0.04
Salinity(ppt)	8.29 ± 1.2	7.35 ± 1.3	7.46 ± 1.4	7.59 ± 1.5	7.87 ± 1.8

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