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Effect of higher salinities on growth and survival of pacific white shrimp, *Litopenaeus vannamei* (Boone, 1931)

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Abstract: The growth and survival of *Litopenaeus vannam*ei post larvae was measured in controlled different salinities condition 35ppt (T1), 40ppt (T2), 45ppt (T3) and 50ppt (T4) were maintained. Group of Shrimp post larvae (weight 0.032 g ± 0.002) were stocked at a density of 35 nos. /aquarium in above salinity ranges. Animals were fed with commercial feed (35% Crude Protein) @ 5% of body weight four times a day. The results indicate that higher SGR was observed in T2 (1.99±0.08) followed by T1 (1.75±0.07), T3 (1.54±0.06) and T4 (1.49±0.17). Highest survival (100 %) was recorded in T1 followed by T2 (96.42%), T3 (94.99%) and T4 (74.21%). From the results of the present study it could be seen that higher salinity significantly reduced the growth and survival of *L. vannamei* but will also open study area of physiological adaption of animal at higher saline water in performance of organisms.

Keywords: Growth, Higher salinities, *Litopenaeus vannamei*, Specific growth rate, Survival

INTRODUCTION

Aquaculture is currently one of the fastest growing food production systems in the world. Aquaculture production of India was 50, 70, 851 tonnes by contributing about 8.29% of the total world fish production in 2011 (FAO, 2013). India has achieved considerable production increases in aquaculture, especially in the production of freshwater fishes and shrimps. The development of coastal aquaculture in India has been concentrated mainly on shrimps and some commercially important marine fishes (Anonymous, 2010).

In a comparison made in the production between *P. monodon* and *L. vannamei* it was observed that the estimated production of P. monodon increased from 0.76 lakh tones during 2008-09 to 1.36 lakh tonnes during 2011-12 over a period of four years, *L. vannamei* production increased from 1,731 MT on 2009-10 to 80,717 MT during 2011-12 registering a remarkable growth within a period of three years. *L. vannamei* contributed 88.84 to the overall shrimp production of about 31 lakh tones in 2014 (Ramraj, 2014).

Currently, Pacific white shrimp is rapidly replacing the black tiger shrimp as the main farmed species in the country. The main reason for this change is that *L. vannamei* has a faster growth, higher stocking rate and yield, and incurs lower production costs than *P. monodon*. In shrimp aquaculture, growth and survival of the individuals are influenced by number of ecological factors, salinity being one of the most important of them. In India, majority of the coastal aquaculture farms have higher salinity problem. It has been demonstrated in some Gulf countries that *L. vannamei* can be cultured successfully at higher salinity (Abbas *et al.*, 2010).Looking to this, studies on the effect of higher salinity on growth and survival of L. vannamei was proposed. However, increasing salinity beyond a particular level may lead to increase in production cost. Therefore, the aim of the present study was to find out the exact (optimum) level of salinity in L. vannamei to get higher growth and survival.

MATERIALS AND METHODS

L. vannamei post larvae were brought from shrimp hatchery, Kotda (20o 41' N, 70o 50') to the wet laboratory. The Post larvae were acclimatized in 500 liters capacity plastic tank. The experiment consisted of 4 treatments with four replica tanks per treatment. In this experiment four different treatments designated as T1, T2, T3 and T4 corresponds to salinities. In T135ppt salinity, in T2 40 ppt salinity, in T3 45 ppt salinity and T4 50 ppt salinity were maintained. The experiment was conducted adoption completely randomized design (CRD). The experiment was carried out in rectangular plastic aquariums of 2 x 2 x 1.5 feet. The aquariums were scrubbed and cleaned with chlorinated water, flushed thoroughly, dried before use and arranged on stands in wet laboratory. The treatments were designed as follows:

T1= water salinity 35 ppt (Control),
T2= water salinity 40 ppt,
T3= water salinity 45 ppt and
T4= water salinity 50 ppt

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Desired treatment salinities were prepared by mixing of treated seawater and by addition of brine solution (Helm and Bourne, 2004). Salinities were determined by refractometer (Atago Ltd, Japan) calibrated with distilled water. Aquariums were filled with 40 liters of filtered sea water.

Shrimp post larvae (weight 0.036 g ± 0.002) were stocked at a density of 35 nos./aquarium in all 16 aquarium tanks. Shrimp post larvae were fed with commercial shrimp feed at the rate of 5% of body weight four times a day during the culture period. During the first week, the shrimp post larvae were maintained on a combination of Artemia nauplii and commercial feed. Thereafter shrimp were fed with commercial feed four times daily at morning (6:00 a.m.), afternoon (12:00 p.m.), and evening (6:00 p.m.) and in night time (10:00 p.m.). Shrimp in each tank were appraised weekly and their feed ration was adjusted accordingly. Growth of shrimp post larvae was measured at week interval. All animals were collected from each tank and individual weight was measured. Mean weight of animals in each tank was calculated at week interval.

Water quality was maintained by regular replenishment of 20% of bottom water from each tank. Before morning feeding and evening feeding tanks were siphoned out by small tube to remove uneaten feed and waste. The pH and temperature were measured by pH meter (Hanna, Portugal) and mercury thermometer respectively. Salinities were determined by refractometer (Atago Ltd, Japan) calibrated with distilled water. Dissolved oxygen and alkalinity were measured using APHA (2005) methods. Survival, Feed conversion ratio (FCR) specific growth rate (SGR) (El- Sayed, 1999) and production were calculated as follows:

Mean weight increment = Final average body – Initial average body weight

SGR= [(Loge W2 – Loge W1) /T2-T1] x 100

Where,

T1 and T2 are 0 and 63th day of the experiment and

W2= weight of shrimp at time T2,

W1 = weight of shrimp at time T1

FCR = Feed intake (g) / Weight gain (g)

Survival (%) = (No. of shrimp survived after experiment/No. of shrimp stocked) x 100

Statistical design and analysis: One way Analysis of Variance ‘ANOVA’ tests (Snedecor and Cochran, 1968) was applied to check the significant difference among the treatments. The pairs of treatments that differed significantly were determined by one factor CRD design.

RESULTS

The present study observed that there was no significant effect of treatments on weight gain in initial three weeks, but from fourth week onwards significant ($P<0.05$) difference in weight gain was observed among treatments (Fig.1).

Higher SGR was observed in T2 treatment (1.99%) followed by treatment T1 (1.75 %), T3 (1.54 %) and T4 (1.49 %).Statistical analysis showed that there is significant ($P<0.05$) difference among treatments (Table 1).It could be seen from the result of the present study that specific growth rate reduced with increase salinity.

Among the salinity tested, the best FCR (1.98±0.02) was recorded in treatment T2 followed by T1 (2.17 ± 0.04), T3 (2.1 ± 0.02) and T4 (2.14 ± 0.06). All the treatments significantly differed from each other ($p<0.05$).

Among the salinity tested, the highest survival (100 %) was recorded in treatment T1 followed by T2 (96.42%), T3 (94.99%) and T4 (74.21%). The lowest percentage survival was observed for treatment T4 (74.21%).

Table 1. Growth parameter of *L. vannamei* in different treatment during study period.

Parameter	Treatments			
	T1 (35ppt)	**T2 (40 ppt)**	**T3 (45 ppt)**	**T4 (50 ppt)**
Initial weight (g)	0.034 ± 0.002^{d}	0.023 ± 0.002^{e}	0.022 ± 0.002^{d}	0.032 ± 0.001^{e}
Final weight (g)	1.152 ± 0.048^{b}	1.293 ± 0.11^{c}	1.010 ± 0.040^{c}	0.982 ± 0.054^{d}
Live weight gain(g)	1.118 ± 0.79^{a}	1.269 ± 0.89^{b}	0.988 ± 0.70^{b}	0.950 ± 0.68^{b}
Daily weight gain (g)	0.017 ± 0.005^{c}	0.020 ± 0.07^{d}	0.015 ± 0.04^{c}	0.015 ± 0.04^{cd}
Survival (%)	100±00	96.42 ± 1.33^{a}	94.99 ± 1.62^{a}	74.21 ± 8.27^{a}
Specific growth rate (SGR) (%)	1.75 ± 0.07^{bc}	1.99 ± 0.08^{d}	1.54 ± 0.067^{b}	1.49 ± 0.17^{c}
Feed conversion ratio (FCR)	2.17 ± 0.04^{b}	1.98 ± 0.02^{e}	2.10 ± 0.02^{d}	2.14 ± 0.06^{d}

Mean ± SD of four replicates; Different superscript indicates significantly different from each other ($P<0.05$).

Table 2. Water quality parameter during study period.

Parameter	T1	T2	T3	T4
pH	7.94±0.11	7.96±0.06	7.99±0.04	7.97±0.06
Dissolve Oxygen (ppm)	5.46±0.37	5.45±0.50	5.43±0.34	5.42±0.35
Temperature (^{0}C)	21.93±1.05	22.04±1.05	21.97±0.99	22.02±0.90
Alkalinity (ppm)	107±0.99	110±1.1	106±1.02	104±0.97

Mean ± SD of four replicates

Statistical analysis showed that there was significant difference in survival rate among all the treatments at each week interval (p>0.05).

Water parameter: Constant aeration was provided in all the tanks to keep the dissolve oxygen level above 5 ppm. Water quality parameters (Temperature 22.04 ± 1.05^0C to 22.02 ± 0.90^0C; pH 7.94 ±0.11 to 7.99 ± 0.04; dissolved oxygen 5.43 ± 0.34 to 5.46 ± 0.37ppm and Alkalinity 104 ±0.97 to 107 ± 0.99 ppm) were maintained within the optimum range by regular water exchange (Table no. 2).

DISCUSSION

Effect of higher salinities on growth (g) of *L. vannamei*: Based on mean weight calculated at the end of experiment higher growth rate was observed at 40 ppt salinity and lower growth was observed at 50 ppt (Table 1). Higher weight gain was observed in 35 ppt and 40 ppt salinity than in 45 and 50 ppt salinity.

Similar to Rizk *et al.* (2002) reported that *P. kerathurus* post larvae the optimum salinity range for growth of *P. japonicus* was 30 ppt and in our study higher weight gain was observed in 40 ppt salinity. In addition Zhu *et al.* (2004) studied the effect of Na/K ratio on growth of *L. vannamei* juveniles, and stated that at higher salinities the rate of Na increased and affected the growth. This result is in agreement with the known fact that at lower salinity higher growth rate is observed (Menz and Blake, 1980; Pante, 1990; Bray *et al.*, 1994; Somochaet *et al.,* 1998; and McGraw *et al.,* 2002).

Menz and Blake (1980) and Bray *et al.* (1994) reported that the *L. vannamei* is a euryhaline species that can tolerate a wide range of salinities (0.5–45 gL-1). In addition Mair, (1980); Cawthorne *et al.* (1983); Kumulu and Jones, (1995); Rosas *et al.* (1999) and Tsuzuki *et al*. (2000) found that the age range for tolerance to widely fluctuating salinity levels for most penaeid PL has been reported in between PL10 and PL40. According to this reference *L. vannamei* grow better in hyper saline water. Similar Bray et al., 1994 reported that *L. vannamei* grow better in salinities below the isosmotic point. The different optimum salinities for growth in different species generally correspond to the differences in their osmotic capacities. Species with higher hyper-OC grow better in the lower salinities, whereas species with lower hyper-OC grows better in the highest salinities. The results obtained in our work provide evidence that *L. vannamei* higher growth increment was in 40 ppt.

Effect of higher salinities on survival of *L. vannamei* : The results of the present study indicate that the survival rate reduced with increase in salinities. This is in agreement with the result obtained by Palafox *et al.* (1997) and Perez – Velazquez *et al*. (2007). Mcgraw *et al*. (2002) reported that the longer salinities adjustment period could also result in better survival rate. Chen *et al*. (1995) studied the survival, growth and osmolality of the haemolymph and the water content in the tissues of *Fenneropenaeus chinensis* juveniles, concluding that the osmolality of the haemolymph increased with an increase in salinity, and decreased with an increase in temperature.

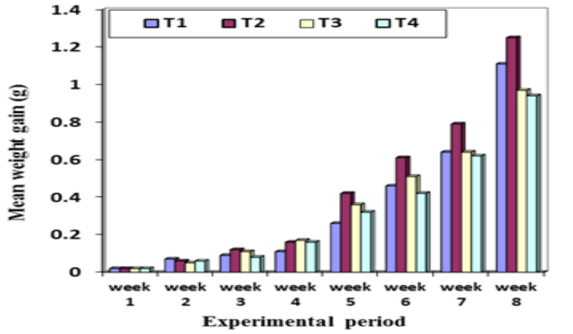

Fig. 1. *Mean weight gain (g) of L. vannamei in different treatments during study period.*

Most penaeid shrimps are known to be euryhaline species growing in a wide range of salinities, at least during their nursery stages. In the current work, the animals had consistently better survival, greater weight gain at 35 ppt and 40 ppt than at higher salinities, indicating that their optimal culture salinity 40 ppt. Salinity optima for the larval culture of the same species inhabiting the north-eastern Mediterranean were also reported to be between 30 and 35 ppt (Kumlu *et al.,* 1999; Kumlu and Eroldogan, 2000). In a study by Harpaz and Karplus (1991), carried out in Israel, 40-day-old PL of the same species had highest survival rate at 36 ppt and slow growth and low survival at 9 ppt.

Conclusion

Based on the results obtained from the present study conducted, it was concluded that higher growth increment in treatment 2(40 ppt) and highest survival in treatment 1(35 ppt) in *Litopenaeus vannamei* can be obtained. Therefore on the basis of the result it is revealed that the treatment 2 i.e. 40 ppt salinity is better for weight gain and 35 ppt salinity is better for survival of *L. vannamei.* It may also be concluded from the present study that higher salinity beyond 40 ppt significantly reduces growth and survival in *L. vannamei*. Also the food conversion ratio, specific growth rate and percentage weight gain were found very good in 40 ppt salinity (T2).

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