TIGER SHRIMP (*Penaeus monodon*) GROWTH AT DIFFERENT STOCKING DENSITIES IN HIGH SALINITY POND USING MANGROVE RESERVOIR

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ABSTRACT

High salinity pond water ranging from 33—45 ppt between July and October is one of the problems occurred in western part of South Sulawesi brackishwater ponds. It is necessary to know if tiger shrimps grow well in such salinity, since the optimum salinity range for the growth of tiger shrimp is 15—25 ppt. The objective of the research is to know the tiger shrimp production at different stocking densities cultured in high salinity pond in mangrove reservoir. Twelve pond compartments of 500 m² each were arranged randomly for three treatments of shrimp stocking densities i.e. 4, 6, and 8 pcs./m², where each treatment was in three replications. The result of study showed that shrimp production at 6 pieces/m² was higher than that of 4 and 8 pieces/m², with more efficient feed conversion was obtained in this stocking density (1.3) compared to treatment 4 pieces/m² (1.5) and treatment 8 pieces/m² (>3).

KEYWORDS: **high salinity, production, stocking densities**

INTRODUCTION

Over 30,000 ha of brackishwater ponds are available in South Sulawesi, Indonesia where most of them are only used for milkfish culture during period of dry season (April to October), since there was high salinity regimes (ranging from 33—45 ppt) and commonly no source of fresh water to dilute saline water to attain optimum salinity for tiger shrimp culture.

Tiger shrimp, *Penaeus monodon* is a euryhaline omnivore tolerant to wide range of salinity from 5 ppt to 35 ppt. However, the optimum salinity for the shrimp growth in brackish water pond is between 10 and 30 ppt (Chanratchakool *et al.*, 1995; Tsai *et al.*, 2002). Earlier study on the effect of different salinity level on the growth of tiger shrimp was reported by Suwirya *et al.* (1986), that shrimp growth rate at the salinity 31—32 ppt was lower than that in salinity of 17—20 ppt. Furthermore, Gunarto *et al.* (2003) conducted research on tiger shrimp growth in high salinity (33—45 ppt) and they found that daily growth rate of the shrimp ranged between 0.11 and 0.23 g/day.

Water salinity is important for osmoregulation in shrimp cultured in brackishwater pond. Osmoregulation for salt water fish requires constant intake of water and excretion of ions (Boyd, 1990). Poernomo (1978) reported that at high salinity most of energy gained from feed is used for osmoregulation to keep their body fluid balanced to their environment.

Pellet is often used to increase shrimp production in culture pond, but not all of given feed is eaten. Uneaten feed and shrimp waste will spoil water quality in shrimp ponds leading to disease-outbreak considered as the main cause of failure of shrimp harvest. Boyd (1999) reported that organic matters originated from feed, faeces, and dead phytoplankton is suitable substrates for the growth of pathogenic microbes.

Study to minimize nutrient loading and pathogenic organisms from shrimp culture using mangrove reservoir conducted by Ahmad & Mangampa (1999) showed that mangrove is capable to stabilize NO_3-N and PO_4-P concentrations as well as to inhibit *Vibrio* spp.

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growth. Mangroves also trapped solid waste and nutrient discharged from shrimp ponds (Robertson & Phillips, 1995 *in* Boyd, 1999). Mangrove stand also has high potential for biofilter since many macrobenthic organisms such as molluscs species living in mangrove as filter feeder organisms capable of absorbing excessive phytoplankton, organic matter, fungi and flagellates as their feed (Imai, 1971).

Considering available brackishwater pond resources in South Sulawesi with its economical value of tiger shrimp, if only milkfish is cultured during dry season it will result in small income for fish farmers because of low price of milkfish in the local market. It is necessary to find out tiger shrimp production at different stocking densities cultured in high salinity pond in mangrove reservoir.

MATERIAL AND METHOD

This experiment was conducted in Marana Pond Station of RICA Maros from July to October 2003 where water salinity range during this period was 33—45 ppt. Twelve experimental ponds of 500 m² in size were used for tiger shrimp culture. One mangrove pond compartment of 2,000 m² in size was used for reservoir, three other pond reservoirs were used respectively for, *Gracillaria* sp., R1 (1,000 m²), milkfish, R2 (1,000 m²), and effluent R3 (1,500 m²) (Figure 1). About 300 kg of *Gracillaria* sp., were stocked at R1 reservoir as nutrient biofilter. Milkfish juveniles (2,500 pcs) were stocked at R2 reservoir as organic biofilter. The effluent pond reservoir, R3 was also stocked with milkfish and seaweed *Gracillaria* sp.

Pond preparation for shrimp grow-out including drying, cleaning of accumulated waste, disinfection, liming and fertilizing was based on the procedure introduced by Mangampa *et al.*, (1999). Water recirculation in pond was performed as seen in Figure 1. At high tide, water from the creek enter to the mangrove reservoir, after one night then the water was flowed to *Gracillaria* sp. reservoir, to milkfish reservoir, and finally distributed to shrimp pond compartments.

Tiger shrimp post larvae (PL-40) were stocked in pond at different stocking densities of 4, 6, and 8 pcs./m², with four replications each. Commercial feed was given after two weeks from stocking at 30% of total biomass/day and gradually decreased to 3% of total biomass/day coincided with increasing shrimp size after three months culture in ponds.

Water in the ponds was maintained at about 80—90 cm depth and it was exchanged regularly during high tide for about 10%—15% of the total volume. The discharged water from the shrimp compartment was flowed to effluent reservoir (R3) and after one night it was flowed to the mangrove reservoir.

Shrimps were sampled randomly every two weeks at 30 pieces/pond and weighted individually using an electrical balance to monitor their growth. Water quality parameters like salinity, dissolved oxygen, water temperature, NH_4-N, NO_2-N, NO_3-N, PO_4-P, pH, and total organic matter (TOM) were monitored every other week and analyzed using the procedures introduced by Haryadi *et al.*, (1992).

Shrimp production, growth-rate, feed conversion ratio and survival rate of the treatments were tabulated and analyzed descriptively.

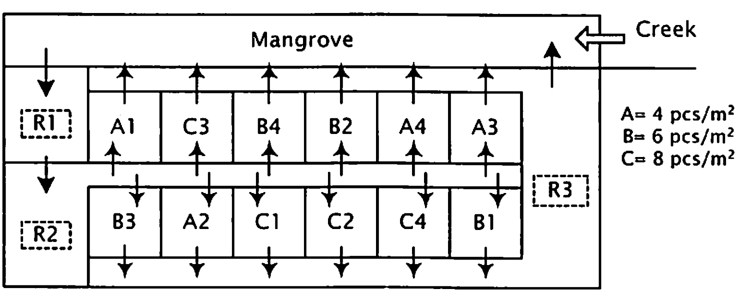

Figure 1. Scheme of semi-closed water recirculation systems in tiger shrimp culture at different stocking densities

RESULTS AND DISCUSSION

After 91days culture period only the shrimps from four pond compartments were harvested (two ponds from treatment 4 pcs./m^2, one pond from treatment 6 pcs./m^2 and one pond from treatment 8 pcs./m^2), whereas the other shrimps were totally dead because of *White Spot Syndrome Virus* infection. Due to high salinity (33—45 ppt) during experiment, shrimp growth rate was relatively slow. Shrimp growth rate, production, survival rate and feed conversion ratio were showed in Table 1. The highest shrimp production (20.8 kg/500 m^2) was obtained in treatment 6 ind./m^2 and the lowest (4.9 kg/500 m^2) was in treatment (8 pcs/m^2.

The most efficient feed conversion (1.3) was also obtained in treatment 6 pcs./m^2 and the highest was in treatment 8 pcs./m^2 (>3). In treatment 4 pcs./m^2, there were two pond compartments harvested with the production of 10—13 kg/500 m^2. The feed conversion ratio for treatment 4 pcs./m^2 (1.5) was higher than that of treatment 6 pcs./m^2 (1.3). In treatment 8 pcs./m^2 only one pond compartment was harvested and the shrimp production was very low (4.9 kg/500 m^2) because of the WSSV infection.

Water salinity influences shrimp growth rate. Poernomo (1978) reported that at high salinity most of energy gained from feed is used for osmoregulation to keep their body fluid balanced to their environment. It means that in high salinity level, shrimp growth rate will decrease. Mangampa *et al.* (1994) reported that at salinity range of 5—20 ppt stocked with 60-d stunted post larvae for 90-d culture, daily shrimp growth rate was 0.19 g/day and feed conversion ratios were between 1.3—1.5. Machluddin *et al.* (2003) also reported at salinity range of 15—42 ppt stocked with 40 days post larvae for 120-d culture, daily shrimp growth rates were between 0,11—0,17 g/day. Furthermore shrimp growth rate also was studied at the different shrimp stocking densities in ponds. Tonnek (2003) reported that slow growth rate of the shrimp was caused by high water salinity level (45 ppt) in their experimental pond. They obtained daily shrimp growth rate of 0.096 g/day (4 pcs/m^2), 0.098 g/day (6 pcs/m^2) and 0.15 g/day (8 pcs/m^2). While Gunarto *et al.* (2003), in earlier study in high salinity level ranging between 33 to 45 ppt during 110 days of culture at stocking density of 6 pcs/m^2, daily shrimp growth rate ranged from 0.11—0.23 g/day and the most efficient feed conversion ratio was 2.62.

Water salinity level at present study was similar (33—45 ppt) to salinity level in Tonnek (2003) study. Daily shrimp growth rate in present study were 0.16 g/day (treatment 4 pcs./m^2), 0.17 g/day (treatment 6 pcs./m^2), and 0.098 g/day (treatment 8 pcs./m^2) and the most efficient feed conversion ratio was 1.3 obtained in treatment 6 pcs./m^2 (Table 1). Both of shrimp growth rates at different stocking densities resulted in present study and by Tonnek *et al.* (2003), likely shrimp growth rate of 4 and 6 pieces/m^2 obtained in present study was higher than that of Tonnek (2003). It might be caused by different size of experimental pond compartment used for their study, which 500 m^2 each size of pond used by Gunarto *et*

Table 1. Performances of tiger shrimp after 91 days of culture at different stocking densities using mangrove reservoir and during high water salinity level (33—45 ppt)

Production factors	Treatments (pcs/m^2)		
	4	6	8
Pond size (m^2)	500	500	500
Size at the stocking (g)	0.04 ± 0.026	0.04 ± 0,051	0.04 ± 0.026
Size at the harvest (g)	14.7 ± 4.9	15.8 ± 5.4	8.9 ± 3.9
Daily growth rate (g/ day)	0.163	0.175	0.098
Survival rate (%)	53.2	58.1	22.8
Shrimp production (kg)	12.4	20.8	4.9
Feed conversion ratio	1.5	1.3	>3

Source: Gunarto *et al.* (2004)

al. (2003) and 250 m² each size of pond used by Tonnek (2003) respectively. Study in laboratory proved that shrimp growth rate was influenced by salinity levels as reported by Suwirya *et al.* (1986) that the growth rate of tiger shrimp was significantly lower at salinity 31—32 ppt than that at salinity 17—20 ppt and 12—15 ppt. Beside water quality parameters, size of pond for shrimp culture and feed management were thought to influence to the shrimp growth rate. With respect to high water salinity level in the ponds during this current study, it used lower feed percentages mainly during ebb tide.

Shrimp stocking density at treatment 6 pcs/m² seems better from economically view point than that at treatment 4 pcs/m² and treatment 8 pcs/m² because it gained highest survival rate (58.1%) and shrimp production (20.8 kg) compared to treatment 4 pcs/m² with survival rate 53.2% and shrimp production 12.4 kg / 500m² and treatment 8 pcs/m² with survival rate 22.8% and shrimp production 4.9 kg / 500 m². It was thought that there was a relationship between shrimp stocking density and intensity of WSSV infection. At the highest shrimp stocking density (8 pcs/m²), it might be the most polluted pond from excessive feed, feces, respiration, and shrimp excretion good media for pathogenic organisms that stimulated disease outbreak.

The WSSV outbreak in this experiment was thought to be an impact of WSSV outbreak in surrounding pond areas, since traditional farmers drained their pond water after they got WSSV shrimp disease. Several efforts to prevent WSSV horizontal- transmitted infection at present study was conducted by increasing water level in healthy pond, application of dolomite weekly at 10 ppm, no water exchanges for a few days, but WSSV could still infect the ponds mainly through water seepages and carrier organisms such as crabs and other wild crustaceans.

Water Quality

Mean value of water quality parameters are showed in Table 2. Ammonium-N in treatment 8 pcs/m² (0.5 mg/L) was higher than that in treatment 4 pcs/m² (0.4 mg/L) and treatment 6 pcs/m² (0.3 mg/L). It proved that in higher density culture system would receive more feed and consequently more remaining feed and other metabolites finally stimulated microorganism activities in decomposition organic materials into ammonia and carbon dioxide.

Water quality parameters measured in all treatments including ammonium-N were not significantly different (P>0.05). Ammonia is the most common toxicant resulted from excretion by cultured animals and mineralization of organic detritus like unconsumed feed and feces. Ammonia in the ponds exists in both ionized ($NH4^+$) and un-ionized (NH_3) forms. The toxicity of ammonia to the shrimp is attributed

Table 2. Average of water quality parameters in shrimp culture and reservoir ponds

Water quality parameters	Average and standard deviation of water quality parameters in culture ponds and reservoir ponds					
	Mangrove	R2	4 pcs/m²	6 pcs/m²	8 pcs/m²	R3
Salinity (ppt)	38.1±3.6	38.1±3.5	38.4 ±3.6	38.3 ±3.7	38.4 ±3.9	37.4 ±4.2
Dissolved Oxygen (mg/L)	3.9 ± 1.1	5.4 ± 1.7	6.1±0.5	6.4 ±0.91	6.2 ±0.6	4.7 ±1.4
pH	7.8 ±0.4	8.1±0.3	8.5 ±0.2	8.6 ±0.2	8.6 ±0.1	8.1±0.3
Alkalinity (mg/L)	68.6 ±12	68.8 ± 11.0	68.3 ± 13	72.9 ± 12	69.6 ± 12	73.1± 13.9
TOM (mg/L)	15.9 ±6.9	20.7 ± 16.3	17.8 ±7.7	16.7 ±8.8	16.0 ± 11	16.3 ±8.8
Amonium-nitrogen (mg/L)	0.6 ± 0.6	0.4 ± 0.4	0.4 ± 0.4	0.3 ± 0.3	0.5 ± 0.6	0.3 ± 0.3
Nitrite-nitrogen (mg/L)	0.1±0.2	0.1±0.2	0.1±0.2	0.1±0.2	0.06 ±0.1	0.1±0.2
Nitrate- nitrogen (mg/L)	0.2 ±0.1	0.2 ±0.14	0.3 ±0.3	0.2 ±0.2	0.3 ±0.3	0.2 ±0.1
Phosphate (mg/L)	0.8 ± 0.8	0.7 ± 0.8	0.8 ± 0.8	0.7 ± 0.8	0.8 ± 0.7	0.6 ± 0.8

Mangrove: mangrove reservoir pond; R2: seaweed reservoir pond; R3: reservoir ponds for discharged water to the un-ionized form. Exposure to high concentration of ammonia in pond water may affect the shrimp in several ways. Earlier study at the same pond was considered that increasing of total ammonium-N in pond water presumed to stimulate WSSV outbreak (Gunarto *et al.*, 2003). Meanwhile from data obtained in 2004, it seemed that there was no correlation between the change of water quality in shrimp pond and WSSV outbreak (Gunarto *et al.*, 2005).

The effects of ammonia on the shrimp growth rate was studied by Boyd (1990) that ammonia concentration at 0.45 mg/L was able to decrease about 50% shrimp growth rate in the ponds. Wickins (1976) reported that ammonia concentration in the water at 0.25 mg/L was able to kill all penaeid shrimp including *P. monodon*. Furthermore Cholik (1986) stated that the safe concentration in the pond water of shrimp culture should be less than 1.5 mg/L for ammonium-nitrogen and 0.1 mg/L for ammonia.

Nitrite is an intermediate product of ammonia either in the bacterial nitrification of ammonia or in the bacterial denitrification of nitrate. In present study nitrite concentrations were from undetected to 0.617 mg/L (mean 0.1 mg/L) in treatment 4 pcs/m^2, from undetected to 0.619 mg/L in treatment 6 pcs/m^2 (mean 0.1 mg/L) and from undetected to 0.628 mg/L (mean 0.06 mg/L) in treatment 8 pcs/m^2. These data clearly showed gradual increase of nitrite concentration in pond water corresponded to increase of shrimp stocking density. Continuation of feeding input to the cultured shrimp was also considered as the main factor influencing the increase of nitrite and it clearly decreased after the feeding was stopped (Gunarto *et al.*, 2005). It seems that the increase of nitrite concentration is closely related to unconsumed feed and feces accumulation in ponds. This finding was similar to the result of Chen *et al.* (1989) that concentration of nitrite increase directly with culture period and might reach as high as 4.6 mg/L.

Accumulation of nitrite in pond water may deteriorate water quality, reduce shrimp growth, increase oxygen consumption and even cause shrimp mortality. Toxic effect of nitrite on shrimp depends on shrimp stage and water salinity. Chen & Chin (1988) reported that the 24—h LC 50 of nitrite-N to tiger shrimp were 5.0 mg/L, 13.20 mg/L, 20.65 mg/L, and 54.76 mg/L, respectively for nauplius, zoea, mysis, and postlarvae. Furthermore Lin *et al.* (2003) reported that nitrite will be more toxic at lower salinity than at high salinity level. In present study salinity ranges were 35—45 ppt (mean 38.4 ppt/) in treatment 4 pcs/m^2, 34—45 ppt (mean 38.3 ppt) in treatment 6 pcs/m^2, and 33—45 ppt (mean 38.4 ppt) in treatment 8 pcs/m^2. Other water quality parameters for all treatments were temperature 27°C—30.4°C, pH 8.16—8.87, and dissolved oxygen 5.14—6.42 mg/L.

Nitrate is a final product in the nitrification process and relatively not toxic to fish. Nitrate concentrations in present study were quite low, namely 0.04—0.88 mg/L for treatment 4 pcs/m^2, 0.03—0.67 mg/L for treatment 6 pcs/m^2 and 0.05—0.97 mg/L for treatment 8 pcs/m^2. Tsai & Chen (2002) reported that the acceptable level of nitrate in aquaculture should be less than 20 mg/L and toxicity of nitrate to juvenile *P. monodon* increases as salinity decreases from 35 ppt to 15 ppt. At 35 ppt the 48 - h LC 50 was 4,970 mg/L, while at 15 ppt the 48 - h LC 50 was 2,876 mg/L of nitrate. Low nitrate concentration in all pond water in present study might be as the impact of biofilter organisms such as mangrove, seaweed (*Gracillaria* sp.), and phytoplankton which utilize this nitrate in the water for support their life (Neori *et al.*, 1996; Ahmad *et al.*, 1999).

Phosphate concentrations in culture ponds and reservoir were relatively stable. High concentration of phosphate (0.8 mg/L) was found in mangrove reservoir, culture pond of 4 and 8 pcs/m^2, while low concentration of phosphate (0.6 mg/L) was found in reservoir pond for discharged water (R3). For protection of the coastal and marine environment from euthrophication, the phosphate concentration is recommended to be at 0.05 mg/L and 0.015 mg/L respectively (Choo & Tanaka, 2000). It is listed for water quality standard for shrimp farm effluent including phosphate concentration to be less than 0.3 mg/L (Boyd, 2003). Based on this level, phosphate concentrations in present study for the whole ponds were much higher than that of the recommended concentration. It might be as an impact of routine application of super phosphate SP 36 at every week to stimulate phytoplankton bloom.

The highest (20.7 mg/L) of total organic matter (TOM) was obtained in seaweed reservoir ponds (R2) and the lowest (15.95 mg/

L) in mangrove reservoir pond for influent water. Mangrove reservoir pond was stocked with slipper oysters that their presence was able to minimize TOM in mangrove pond water since oysters is a filter feeder organisms. Madeali *et al.* (2004) stated that TOM concentration in shrimp pond water should be less than 30 mg/L. TOM accumulation at 30—50 mg/L was able to enhance population of pathogenic organisms, resulted in shrimp stress, low appetite and furthermore easily to be infected by those pathogenic organisms.

CONCLUSIONS

The highest shrimp production was obtained in treatment 6 pcs/m^2 (20.8 kg/500 m^2), while treatment 4 and 8 pcs/m^2 shrimp production were 12.4 and 4.9 kg /500 m^2 respectively. These low production seemed to be affected by WSSV infection mostly occurred at the higher shrimp stocking density.

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