A Comparison Study on Production and Plankton between Two Water Exchange Rates of Recirculating Shrimp Culture (*Penaeus monodon*) System Using Low Salinity Water

Tanyanan Kaweekityota[1], Wara Taparhudee[2], Chalor Limsuwan[1] and Niti Chuchird[1]

ABSTRACT

A recirculating shrimp culture system was studied at a commercial shrimp farm in Thailand. Low salinity water was used for supply in the farm. Four experimental ponds were employed. Postlarvae 15 (PL 15) were stocked at a density of 44 PL/m^2. After 60 days of culture, two water exchange rates (i.e. 10% of pond water volume, once and twice a week) were tested. The system production from low percentage water exchange rate was 824±96.2 kg/rai, average weight of 20.9±1.84 g, The production from high percentage water exchange rate was 876±46.0 kg/rai, average weight of 23.4 ±2.33 g, growth rate of 0.17±0.05 g, survival rate of 56.4±1.2 % and FCR of 1.55 ±0.06. growth rate of 0.15±0.064 g/day, survival rate of 56.3±1.6 % and FCR of 1.55±0.06. However, there was not a statistically significant difference. Most water quality parameters were in an acceptable range. A large number of blue-green algae were often found during the culture period. Results show that the water exchange rate of 10% once a week could obtain acceptable production results, which was not a statistically significant difference from the other rate. Therefore shrimp culture in recirculating systems using low salinity water with water exchange starting 60 days after culture, using 10% of pond water volume every week, was found acceptable.

Key words : *Penaeus monodon*, recirculating system, low salinity water, water exchange rate

---

[1]Department of Fishery Biology, Faculty of Fisheries, Kasetsart University, Bangkok 10900. Thailand
[2]Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Bangkok 10900. Thailand

INTRODUCTION

Due to shrimp culture collapse in many areas in Thailand, particularly along the coastal saline water sources, culture in freshwater areas have been developed in order to avoid viral diseases and water pollution. To grow shrimp in these areas, shrimp farmers should manage the farms using recirculating systems to prevent diseases from outside and to protect the environment from saline water diffuses into freshwater sources.

In intensive shrimp culture system particularly recirculating systems, water exchange is an essential practice to eliminate wastes and toxic metabolites that can be harmful to shrimp (Hopkins *et al*., 1993; Martinez-Cordova *et al*., 1995; Lorenzen *et al*., 1997). Water exchange rates in commercial farms generally range from less than 2% to more than 100% per day (Martinez -Cordova *et al*., 1997). Therefore water pumping cost is one of the most important operating costs in intensive and semi -intensive shrimp culture (Usha *et al*., 1993). It is estimated around 10-15% of the total overhead.

Therefore if the farmer can reduce this cost with less pumping, they will increase profit. In this study, two water exchange rates (10% of volume once and twice a week) were observed in a recirculating system farm. Water quality, plankton and production were compared.

MATERIALS AND METHODS

<u>Location</u>

The recirculating system of a commercial shrimp farm in Pihuchang district, Banglan amphor, Nakhonprathom province was evaluated. The farm comprised of a 30 rai reservoir with 25 meter depth (soil from this pond was sold that was why the pond was very deep). Due to availability, only four culture ponds were used for this experiment. The area of each pond was 3.42, 3.43, 3.63 and 3.40 rai. Each pond was supplied with five 11 hp (horse-power) diesel paddlewheel aerators and an aerator comprised of 48 paddles. Pond preparation waste from the previous crop was removed from the ponds and ponds were dried for 20 days. After that lime was used to spread over the pond, at a rate of 1,000 kg/rai (6.25 rai=1 hectare). Water was pumped from the reservoir and adjusted to a water salinity of 5 ppt, by adding high salinity water. Shrimp larvae quality was examined for WSSV-free (white spot syndrome virus) using the PCR technique. Postlarvae 15 (PL 15) stocking density was 44 PL/m^2.

Shrimp was fed by 45% protein feed 4 times a day (i.e. 7:00, 11:00, 16:00 and 20:00 h). Feed was adjusted everyday. After 60 days of culture, the pond water was exchanged. Two ponds were exchanged 10% once a week and the other two ponds were 10% twice a week. After 35 days of culture, shrimp were sampled and weighted using a castnet at least two times in each pond every 2 weeks. This experiment was done for one crop (135 days).

<u>Water quality analysis</u>

Water samples from each pond were collected using a water sampler tube at two opposite locations, 0.5 m under the water surface. A water sample in each location was preserved in a 500 ml plastic bottle. Dissolved oxygen, pH and temperature were measured everyday, using an oxygen meter, pH meter ORION (model Sa 520) and thermometer, respectively between 6:00-7:00 h. and 14:00-16:00 h. Salinity, conductivity, total ammonia, nitrite-nitrogen, alkalinity, hardness, total dissolved solids, total suspended solids and chlorophyll a were measured once a week. Salinity and conductivity were measured by using salinometer model YSI 30/10 FT. Total ammonia-nitrogen, nitrite-nitrogen, alkalinity and hardness were measured by titration method (Strickland and Parsons, 1972). Total solids, total suspended solids and chlorophyll a were analyzed by standard method (APHA *et al*., 1992).

<u>Phytoplankton study</u>

An eight liter water sample was collected at the same place, as the water sample for quality analysis. The water was filtered using a 20 μm plankton net and 100 ml of water was collected in a 135 ml plastic bottle. The water sample was preserved by 4% formalin. Two water samples were collected from each pond and were mixed before studying. Plankton identification was done following Shirota (1996), Wongrat (1998;1999) by using the Sedwick-Rafter counting cell.

<u>Data analysis</u>

Shrimp production, weight gain, growth rate, survival rate, FCR and the water quality parameter data were analyzed by using the One-sample t-test to compare the means between two treatments. Differences were considered significant at an alpha level of 0.05.

RESULTS

Production

The high percentage water exchange ponds obtained better results than those of low percentage water exchange ponds. The production from low percentage water exchange pond was 824±96.2 kg/rai in compared to 878±46.0 kg/rai for high percentage water exchange pond. However, there was not a significant difference between two water exchange levels. Other results in table 1 were weigh gains, growth rates, survival rates and FCRs. Both treatments had similar results and no significant differences.

Table 1 Production of two different water exchange rate systems

System	Production (kg/rai)	Weight gain (g)	Growth rate (g/day)	Survival rate (%)	FCR
Low water exchanged	824 ± 96.2	20.9 ± 1.84	0.15 ± 0.06	56.3 ± 1.6	1.58 ± 0.06
High water exchanged	878 ± 46.0	23.4 ± 2.33	0.17 ± 0.05	56.4 ± 1.2	1.55 ± 0.06

Water quality

Water quality parameters from both treatments are shown in table 2. Most water quality the culture period were still at an acceptable level for shrimp growth. The dissolved oxygen level was significantly different between two systems at $P<0.05$ level. The high exchange water rate ponds acquired higher average dissolved oxygen levels than the low water exchange ponds.

Table 2 Water quality of two different water exchange rate systems

Parameter	Time	Low water exchanged system	High water exchanged system
Dissolved oxygen (mg/l)	Morning*	4.3 ± 0.4	4.7 ± 0.5
	Afternoon*	8.3 ± 0.8	8.6 ± 0.8
pH Morning	Morning	7.5 ± 0.3	7.5 ± 0.3
	Afternoon	7.8 ± 0.5	7.8 ± 0.5
Temperature (^{O}C) Morning	Morning	29.9 ± 1.1	29.9 ± 1.0
	Afternoon	31.5 ± 1.2	31.5 ± 1.2
Salinity (ppt)		4.1 ± 0.5	4.2 ± 0.7
Conductivity (ds/m)		7.5 ± 0.8	7.6 ± 1.2
Total ammonia-nitrogen (mg/l)		0.10 ± 0.10	0.12 ± 0.12
Nitrite-nitrogen (mg/l)		0.08 ± 0.08	0.04 ± 0.04
Alkalinity (mg/l)		112.0 ± 11.1	103.0 ± 16.4
Hardness (mg/l)		1874 ± 226	1953 ± 352
TSS (mg/l)		40.0 ± 20.6	38.0 ± 15.6
TDS (mg/l)		5118 ± 813	5378 ± 1117
Chl a (mg/m^3)		168.0 ± 115.1	145.0 ± 88.6

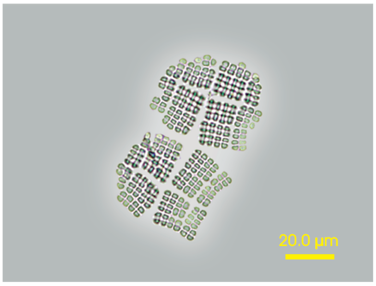
* it is significantly different (P<0.05) abundance of plankton

The average number of plankton were 14,298±9,474 cell/ml in low water exchange system ponds and 8,613±5,145 cell/ml in high water exchange system ponds. During the first 60 days of culture without water exchange, the number of plankton in the experiment ponds were similar. However, after 60 days of culture, all the ponds started water exchange at the two designed rates until harvest. It was found that there was a significant difference between the two water exchange system ponds (P<0.05) (Table 3). On average, the total plankton in the low water exchange rate ponds was greater than that of the high water exchange rate ponds.

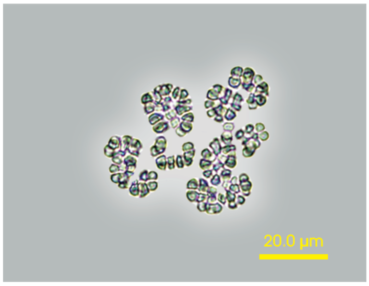
Table 3 Number of plankton (cell/cc) in two different water exchange rate systems

Week	Water exchange	Mean+S.D.	t	df	P
1-8 (1-60 days)	Low	7,686 ± 5,128	-0.372	14	>0.05
	High	8,866 ± 7,355			
9-19 (60-135 days)	Low	19,108 ± 9,096	3.684	20	<0.05
	High	8,429 ± 3,113			

During culture period, genera of plankton were similar in the ponds of two systems. It found 46 genera in five phylum of phytoplankton which were 12 genera of Cyanophyceae (blue-green algae), 22 genera of Chlorophyceae (green algae), 3 genera of Euglenophyceae (euglenoids), 7 genera of Bacillariophyceae (diatom) and 2 genera of Dinophyceae (dinoflagellate). Zooplankton was found in 18 genera of three phylum which were 2 genera of Protozoa, 15 genera of Rotifera and 1 genus of Arthropoda. Blue-green algae was the most often found during the culture period,in addition to *Merismopedia* sp., *Chroococcus* sp., *Phormidium* sp., *Oscillatoria* sp. and *Coelosphaerium* sp. etc. (Figure 1-5)

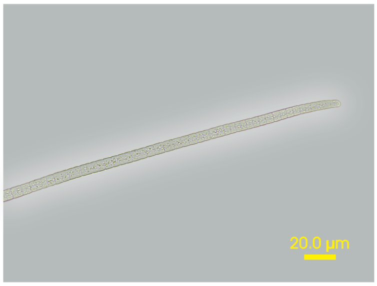


Merismopedia sp.

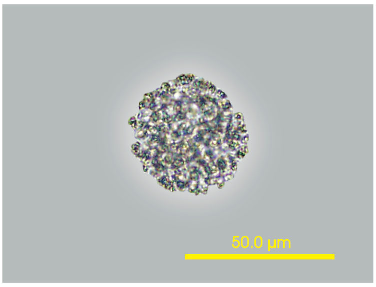


Chroococcus sp.

Phormidium sp.



Oscillatoria sp.



Coelosphaerium sp.

DISCUSSION

The recirculating shrimp culture system using low water salinity could obtain an acceptable production in both water exchange rates. The water quality levels were also suitable for shrimp growth. A high water exchange rate could dilute concentrations of unionized chemicals and reduced the waste from the ponds more efficiency than the lower exchange rate. However, in this experiment the stocking density of 44 PL/m^2 did not show a difference in production between two water exchange rates. This is probably because the stocking density of 44 PL/m^2 did not show a difference in production between two water exchange rates. This is probably because the stocking density rate was not too high so the culture system could maintain in this condition. Chanratchakool *et al*. (1994) commented that in a well-managed pond, with consistent water quality, shrimp can be stocked at a density of 40 to 50 shrimp/m^2. This study results is supported by the study of Hopkins (1994), Martinez and Seijo (2001) and Lemonnier *et al*. (2003) who has revealed that increasing water exchange rate is not cause any significant change in the average quality of the rearing environment (water and sediment) during the whole growout period. This has also no significant effect on shrimp growth, survival or production. Similarly, Martinez *et al*. (1995) studied in white shrimp (*Litopenaeus vannamei*) culture and found that a water exchange rate of 5% or lower affected water quality as well as growth, survival and yield of the white shrimp. While a rate of 7.5% was almost as good as rates of 10% and 15%.

Moreover, to run shrimp farm under the low water exchange rate system could reduce 50% of power cost (diesel/electricity for pumping) compared to the high water exchange rate system.

CONCLUSION

Shrimp culture in recirculating systems using low salinity water with the stocking density of 44 PL/m^2 could be performed by using a low water exchange rate at 10% of water volume every week starting 60 days after the culture.

ACKNOWLEDGEMENTS

The authors would like to thank the National Research Council of Thailand for financial support.

LITERATURE CITED

APHA, AWWA. and WEF. 1992. **Standard Method for Examination of Water and Wastewater.** 18th ed. American Public heath Association, Washington, D.C.

Chanratchakool, P., J. F. Turnbull and C. Limsuwan. 1994. **Health Management in Shrimp Ponds.** Aquatic Animal Heath Research Institute, Kasetsart University Campus, Bangkok. 91 p.

Hopkins, J.S., R.D. Hamilton II, P.A. Sandifer, C.L. Browdy and A.D. Stokes. 1993. Effects of water exchange rate on production, water quality, effluent characteristics and nitrogen budget of intensive shrimp ponds. **J. World Aquac. Soc.** 24(3) : 304-320.

Hopkins, J.S. 1994. Elimination of water exchange in intensive shrimp ponds : technology for water quality management. **Abstracts World Aquaculture Society Meeting,** Louisiana.

Lemonnier, H., J.L.M. Martin, R. Brizard and J. Herlin. 2003. Effect of water exchange rate on waste production in semi-intensive shrimp ponds during the cold season in New Caledonia. **J. World Aquac. Soc.** 34 (1) : 40-49.

Lorenzen, K., J. Struve and V.J. Cowan 1997. Impact of farming intensity and water management on nitrogen dynamics in intensive pond culture: a mathematical model applied to Thai commercial shrimp farms. **Aquac. Res.** 28(7) : 493-507.

Martinez-Cordova, I.R., H. Villarreal-Colmenares and M. Porchas-Cornejo. 1995. Culture of white shrimp *Penaeus vannamei* in low water exchange ponds in Sonora. **Mex. World Aquac.** 26 :47-48.

Martinez-Cordova, L., H. Villarreal-Colmenares, M. Porchas-Cornejo, J. Naranjo-Paramo and A. Aragon-Noriega. 1997. Effect of aeration rate on growth, survival and yield of white shrimp *Penaeus vannamei* in low water exchange ponds. **Aquac. Eng.** 16 : 85-90.

Martinez, A. J. and J. C. Seijo. 2001. Economics of risk and uncertainty of alternative water exchange and aeration rates in semi-intensive shrimp culture systems. **Aquaculture Economics and Management 5(3/4).** Available source: http://www.uq.edu.au/aem/abstract5_09.pdf#search='Economics%20of%20risk%20and%20uncertainty%20of%20alternative%20water%20exchange%20and%20aeration%20rates%20in', 30 June 2005.

Shirota, A. 1996. **The Plankton of South Vietnam: Freshwater and Marine Plankton.** OTCA, Japan. 462 p.

Strickland, J.D.H. and T.R. Parsons. 1972. **A Practical Handbook of Seawater Analysis.** 2nd ed. Fisheries Research Board of Canada, Bulletin 169, Ottawa, Canada.

Usha, R. G., T. C. Redi and K. Ravindranath. 1993. Economic of brackishwater prawn farming in Nellore District of Andrha Pradesh State. **India Journal of Aquaculture in the Tropics.** 8(2) : 221-230.

Wongrat, L. 1998. **Zooplankton.** Kasetsart University Press, Bangkok. 787 p. (in Thai)

Wongrat, L. 1999. **Phytoplankton.** Kasetsart University Press, Bangkok. 851 p. (in Thai)