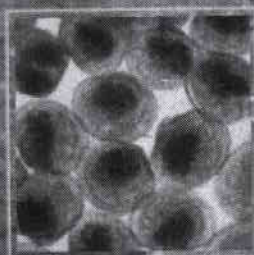
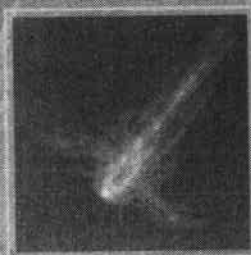
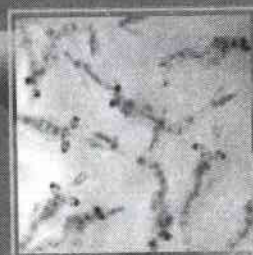


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RESEARCH ON THE LARVICULTURE OF TIGER SHRIMP *PENAEUS MONODON* WITH HIGH STOCKING DENSITIES USING RECIRCULATING BIOFILTER SYSTEM

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Introduction

In backyard shrimp hatcheries in Vietnam, recirculating aquaculture/biofilter systems (RAS or RBS) have been used in recent years with different levels of installation and technology. However, this practice is mainly based on experience and a lot of improvement could be made. This research aimed to find out the best RBS in terms of functional structure, highest stocking density, and proper initial level of rearing water for shrimp larviculture.

Materials and methods

Four experiments rearing from nauplii (N) or postlarva 1 (PL1) to PL15 were performed in Can Tho University. Experiment I consisted of three rearing systems (treatments) with the same stocking density of 120 PL1.l⁻¹: Popular RBS = only biofilter, Upgraded RBS = biofilter and protein skimmer and Improved RBS = biofilter, protein skimmer and ozonation (ozone injected into the protein skimmer with residual ozone concentration maintained at 0.1mg l⁻¹). Experiment II comprised 4 treatments on the density of stocked PL (210, 270, 330, and 390 PL1.l⁻¹). Experiment III was made up of 6 treatments on the density of stocked N (150, 300, 450, 600, 750, and 900 PL1.l⁻¹). Experiment IV was designed as a factorial experiment with two factors: Stocking N density at 3 levels (150, 300, and 450N.l⁻¹) and Initial water level at 2 levels (20 and 50% of maximum water volume). Thus, the last experiment composed of 6 treatments namely (stocking N density × initial water level): 150×20, 150×50, 300×20, 300×50, 450×20, and 450×50. The last 3 experiments were carried out in the improved RBS. Duration of the first 2 and last 2 experiments lasted 15 (from PL1 to PL15) and 21 days (from N to PL15), respectively. Water recirculation was initiated at the beginning (PL1 stage) in the first 2 experiments and at mysis II stage in the last 2 experiments.

Shrimp nauplii were obtained from the wild brooders and PL1 were collected from an experimental hatchery using a popular RBS. All experiments were stocked N or PL1 from the same female brooder. They were disinfected by 25mg.l⁻¹ formalin in 15min prior to stocking. Rearing water of 30g.l⁻¹ was prepared by mixing 100g.l⁻¹ brine and tap water and then disinfected by chlorination (30mg l⁻¹ in 48h). The full structure of a rearing system for one treatment included 3 rearing cylindrical 100-l tanks (i.e.; 3 replicates) connected to a central biofilter (200-l tank) and a protein skimmer (20cm diameter and 100cm height). All tanks were made of fibreglass. Feeding (using live *Chaetoceros calcitrans*, *Artemia* cysts from Vinh Chau, Vietnam and micro-encapsulated feeds from INVE Group, Belgium) and daily management followed the common-used protocol for backyard shrimp hatcheries in Vietnam (Thanh et al., 2006).

Environmental parameters (temperature, pH, TAN, nitrite, and nitrate) were recorded periodically. Criteria or their combination for treatment evaluation at the end of experiments (at PL15 stage) included survival rate and postlarval density at the end of experiments, total length, individual dry weight, muscle over gut index, stress mortality (% of dead PL15 after 60min exposed in 200mg.l⁻¹ formalin) and larval stage index (calculated based on 8 stages: nauplii, zoeae 1-3, mysis 1-3 and PL1 are assigned 1 to 8, respectively). In addition, total bacterial count was also determined. The results of experiment III and IV are evaluated based on the sum of scores of all evaluating criteria. The value of the same criterion of every treatment is scored based on the result of statistical treatment. Significantly better values are assigned higher scores (modified from Wickins and Lee, 2002). Using Statistica 6.0 software, Tukey HSD test is applied to compare means of evaluating criteria between treatments and factorial analysis is also used in experiment IV for detecting any possible interaction between factors.

Results and discussions

All environmental parameters were suitable for shrimp. In experiment I, among all evaluating criteria, only two were significantly different ($p < 0.05$), i.e. total length (highest in Improved RBS, 12.1 ± 0.5 mm) and total bacterial count (highest in Upgraded RBS, $21.67 \pm 5.51 \times 10^3$ CFU.ml⁻¹). In combination, the improved RBS can be considered as the best rearing system. In experiment II, most evaluating criteria are similar, except the density of PL15 is significantly higher ($p < 0.05$) in treatment 330 and 390 PL1.l⁻¹ (253 ± 26 and 261 ± 12 PL15.l⁻¹, respectively) compared to the remaining treatments. Therefore, it is possible to stock up to 390 PL1.l⁻¹ in the improved RBS. In experiment III, most evaluating criteria are significantly different, except the muscle:gut ratio and stress mortality. The total score of treatment 450N.l⁻¹ is highest (= 26, Table I). In experiment IV, most evaluating criteria are significantly different, except the muscle:gut ratio and total bacterial count. The total score of treatment 300×20 is highest and the next is that of treatment 450×20 (= 19.5 and 18, respectively; Table II).

Table I. Evaluation criteria for PL15 at the end of experiment III

Evaluation criterion	Treatment (Stocking density of N l ⁻¹)					
	150	300	450	600	750	900
Survival rate*	53.9±	60.6±	55.9±	35.9±	33.8±	21.5±
(%)	0.7 ^d [4]	0.3 ^f [6]	0.7 ^e [5]	0.4 ^a [3]	0.4 ^b [2]	0.4 ^a [1]
PL density*	81±	182±	252±	215±	254±	194±
(ind l ⁻¹)	1 ^a [1]	1 ^b [2]	1 ^c [5]	2 ^c [4]	3 ^c [5]	3 ^c [3]
Total length	9.9±	9.6±	9.8±	9.3±	9.3±	9.2±
(mm)	0.1 ^c [4]	0.2 ^{bc} [3]	0.1 ^c [4]	0.1 ^{ab} [2]	0.1 ^{ab} [2]	0.1 ^a [1]
Dry weight	0.6±	0.5±	0.6±	0.6±	0.5±	0.5±
(mg ind ⁻¹)	0.0 ^f [4]	0.0 ^{ab} [2]	0.0 ^{bc} [3]	0.0 ^{abc} [2.5]	0.06 ^a [1]	0.0 ^a [1]
Muscle:gut ratio	5.3±	6.3±	6.7±	6.0±	6.0±	5.7±
Stress	0.58 ^a [1]	0.58 ^a [1]	0.6 ^a [1]	1.0 ^a [1]	0.0 ^a [1]	0.6 ^a [1]
mortality (%)	10.0±	16.7±	13.3±	23.3±	23.3±	26.7±
Larval stage	0.0 ^a [1]	11.5 ^a [1]	15.3 ^a [1]	5.8 ^a [1]	5.8 ^a [1]	5.8 ^a [1]
index	7.9±	7.9±	7.8±	7.6±	7.3±	7.0±
Total bacterial count	0.1 ^d [5]	0.1 ^d [5]	0.1 ^{cd} [4]	0.2 ^{bc} [3]	0.1 ^b [2]	0.1 ^a [1]
(10 ³ CFU ml ⁻¹)	1.91±	0.24±	0.43±	1.49±	3.92±	2.61±
Total score of treatment	0.32 ^{bc} [2]	0.22 ^a [4]	0.37 ^{ab} [3]	0.90 ^{abc} [2.5]	2.71 ^c [1]	1.46 ^{bc} [2]
	[22]	[24]	[26]	[19]	[15]	[11]

* Data of PL1 (due to low survival of PL15). Values (mean ± standard deviation [score]) in the same row followed by the same superscript letter are not statistically different ($p \geq 0.05$, Tukey HSD test).

Table II. Evaluating criteria for PL15 at the end of experiment IV.

Evaluating criterion	Treatment (Stocking density of N l ⁻¹ × Initial water volume in %)					
	150×20	300×20	450×20	150×50	300×50	450×50
Survival rate	43.9±	72.8±	66.2±	41.0±	49.6±	47.7±
(%)	1.3 ^{ab} [2]	1.2 ^c [4]	2.9 ^c [4]	2.5 ^a [1]	3.4 ^b [3]	2.8 ^{ab} [2]
PL density	66±	218±	298±	62±	149±	215±
(ind l ⁻¹)	2 ^a [1]	4 ^c [3]	13 ^d [4]	4 ^a [1]	10 ^b [2]	13 ^c [3]
Total length	9.9±	9.6±	9.8±	10.1±	9.6±	9.4±
(mm)	0.1 ^{ab} [2]	0.2 ^{ab} [2]	0.1 ^{ab} [2]	0.2 ^b [3]	0.1 ^{ab} [2]	0.4 ^a [1]
Dry weight	0.5±	0.6±	0.5±	0.7±	0.6±	0.6±
(mg ind ⁻¹)	0.1 ^a [1]	0.0 ^{ab} [2]	0.0 ^a [1]	0.0 ^f [4]	0.0 ^{bc} [3]	0.0 ^{ab} [2]
Muscle:gut ratio	5.3±	6.3±	6.67±	6.0±	6.0±	5.7±
Stress	0.6 ^a [1]	0.6 ^a [1]	0.58 ^a [1]	1.0 ^a [1]	0.0 ^a [1]	0.6 ^a [1]
mortality (%)	6.7±	16.7±	23.3±	10.0±	16.7±	20.0±
Larval stage	5.8 ^a [4]	5.8 ^{abc} [2.5]	5.8 ^c [1]	0.0 ^{ab} [3]	5.8 ^{abc} [2.5]	0.0 ^{bc} [2]
index	7.2±	7.6±	7.55±	6.7±	7.1±	7.1±
Total bacterial count	0.1 ^{bc} [3]	0.0 ^f [4]	0.07 ^c [4]	0.3 ^a [1]	0.1 ^b [2]	0.1 ^b [2]
(10 ³ CFU ml ⁻¹)	38.54±	37.86±	43.68±	32.78±	18.20±	17.95±
Total score of treatment	13.57 ^a [1]	11.08 ^a [1]	16.93 ^a [1]	1.80 ^a [1]	8.45 ^a [1]	10.81 ^a [1]
	[15]	[19.5]	[18]	[15]	[16.5]	[14]

Values (mean ± standard deviation [score]) in the same row followed by the same superscript letter are not statistically different ($p \geq 0.05$, Tukey HSD test).

There was also significant ($p < 0.05$ and 0.01) interaction between two factors on the most evaluating criteria. Figure 1 shows a typical interaction of density of PL15 that positively and negatively relates to the stocking density and initial water level, respectively. Meanwhile, popular stocking densities in backyard hatch-

eries range from 100 to 200N.l⁻¹. Lower initial water volume resulted in algae that were fresher due to more feeding times.

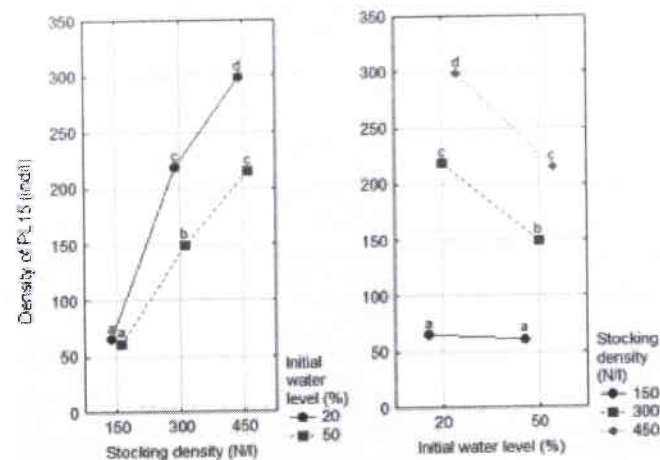


Fig. 1. Interaction between stocking density and initial water level on density of PL15 at the end of experiment IV. Different letters over plots denote significant difference ($p < 0.01$).

Conclusions

The improved biofilter system (biofilter, protein skimmer, and ozonation) is the best rearing system. The best stocking densities are 390 PL1.f⁻¹ and 300-450N.l⁻¹ for rearing to PL15 with the best initial over full water volume of 20%.

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