Intensive nursery of the Pacific White Shrimp *Litopenaeus vannamei* in greenhouse-enclosed raceways using low and high-protein diets under no water exchange

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*Aquaculture 2010*
San Diego, Mar 1-5
Introduction

- Traditional shrimp farming greatly relies on water exchange to maintain water quality
- This has resulted in massive crop losses due to disease outbreaks and to the degradation of receiving steams
- Raising SPF shrimp under biosecure conditions, minimizing the use of potentially contaminated water, and reducing or eliminating effluents can greatly improve shrimp farming sustainability
Introduction

- Previous studies have indicated good shrimp yields using low water exchange practices.
- Because feed is the major driving force of intensive production systems, it is important to optimize its use to maximize growth and minimizing water quality deterioration.
- In limited or no water exchange systems, feed quality and its effect on the culture medium can play a major role in shrimp performance.
Objectives

A 62-d trial was conducted with postlarvae of the Pacific White Shrimp, *Litopenaeus vannamei* to improve feed management and water quality during the nursery phase under no water exchange.

Specific objectives were:

1. To determine the effect of substituting high-protein for low-protein feed on shrimp growth, survival and selected water quality indicators.
Objectives

2. To determine if molasses can be used to prevent ammonia and nitrite build up in a zero exchange system

3. To study the effect of no exchange on water quality and shrimp performance

4. To evaluate the benefit of using a continuous dissolved oxygen monitoring system as a management tool
Material & Methods

- The study was carried out in four 40 m$^3$ (68.5 m$^2$) EPDM lined greenhouse-enclosed raceways (RW) at the Texas AgriLife Research Mariculture Laboratory, Corpus Christi, TX

- Each RW was equipped with a center longitudinal fiberglass partition positioned over a 5.1 cm PVC pipe with sprayer nozzles
Material & Methods

- Each RW had eighteen 5.1 cm airlifts, and six 1m long air diffusers for mixing and circulation.
- Airlifts & diffusers were positioned equally throughout the RWs and were operated continuously using a 3 hp regenerative blower.
- In addition, each RW had, a centrifugal 2 hp pump and a Venturi injector.
Material & Methods

- The Venturi was capable of injecting atmospheric air or a mixture of oxygen and air.
- Dissolved oxygen was continuously monitored in each RW by a YSI 5200 Recirculating System Monitor.
Material & Methods

- Raceways were filled with natural seawater, chlorinated to 10 ppm, and dechlorinated by aeration.
- Salinity was adjusted to 30 ppt using municipal freshwater.
- TSS & VSS were controlled by using foam fractionators.
Material & Methods

- Each RW was fertilized with 225 g urea, 32 ml phosphoric acid and 290 g sodium silicate.
- The following day they were inoculated with *Chaetoceros muelleri* (70,000 cells/mL).
- Each RW was stocked (5,000 PL/m³), a day after the algae inoculation, with ten to twelve-day-old postlarvae (PL₁₀-₁₂) *L. vannamei*. 
Material & Methods

- From Day 10 through Day 18, each RW received 500 mL of molasses every other day to promote bacterial floc development.
- From Day 19 on, molasses supplementation was based on the ammonia level using 6 g of carbon for each 1 g of ammonia found in the culture medium as described by Samocha et al. (2007).
- From Day 30 until termination no molasses was added as ammonia concentrations were consistently below 0.5 mg/L.
Material & Methods

- PL were fed newly hatched *Artemia* nauplii (~40/PL/d for four days)
- For the first 26 days PL were fed a combination of dry diets to include: PL Redi-Reserve (Zeigler Bros. Inc.); Surestart #3 & #4 (Salt Creek Inc.); and Fry #0 & #1 (Rangen Inc.)
- Shrimp were sampled twice/wk to monitor health and growth and to adjust daily rations
Material & Methods

- Beginning Day 27, shrimp in two RWs were fed 30% CP Rangen Fry #2 while those in the other two RWs were fed Fry #2 with 40% CP
- Diet particle size was increased to Fry #3 and #4 according the shrimp size
- Rations ranged from 50% of the total estimated shrimp biomass for the first days after stocking to 4% of the estimated biomass during the final week of the trial
Material & Methods

- Rations were adjusted based on feed consumption
- Feed was distributed by hand four times per day
- During the last 18 days of the study, an additional feeding (30% of total daily ration) was delivered by three belt feeders/RW
Material & Methods

- Temperature, dissolved oxygen, pH, salinity, and algal cell density were monitored daily.

- Turbidity, alkalinity, and settleable solids (SS) were monitored every other day.

- TAN, NO$_2$, NO$_3$, PO$_4$, cBOD$_5$, TSS, and VSS were monitored once a week.
Material & Methods

- Data was analyzed using SPSS statistical software.
- Repeated measures ANOVA was used to determine significant differences between treatments in water quality indicators.
- One way ANOVA was used to determine differences between treatments in survival, mean final weights, FCR, and yields.
- All differences were analyzed at significance level of $\alpha = 0.05$. 
Results

- No statistically significant differences were found between the two treatments in temperatures, DO, and pH.
- Statistically significant differences were found between treatments in alkalinity and nitrate-N.
- No statistically significant differences were found between treatments in mean final weight of the shrimp.
## Results

Means for water quality indicators monitored during a 62-d nursery trial

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low Protein (30%)</th>
<th>High Protein (40%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM</td>
<td>PM</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>27.6</td>
<td>28.7</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>5.7</td>
<td>5.7</td>
</tr>
<tr>
<td>pH</td>
<td>7.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>31.2</td>
<td>29.3</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>163.9</td>
<td></td>
</tr>
<tr>
<td>Settleable solids (mL/L)</td>
<td>5.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Algae (cell/mL x 10⁴)</td>
<td>242.7</td>
<td>193.8</td>
</tr>
</tbody>
</table>
## Results

**Means for weekly water quality indicators during a 62-d nursery trial**

<table>
<thead>
<tr>
<th>RW</th>
<th>cBOD₅</th>
<th>TAN</th>
<th>NO₂-N</th>
<th>RP</th>
<th>TSS</th>
<th>VSS</th>
<th>Alk</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>18</td>
<td>0.85</td>
<td>4.15</td>
<td>3.1</td>
<td>223</td>
<td>115</td>
<td>155&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>40%</td>
<td>19</td>
<td>0.75</td>
<td>5.8</td>
<td>3.9</td>
<td>208</td>
<td>108</td>
<td>145&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Weekly variations in water quality of the raceways during a 62-d nursery study using low (30% CP) and high-protein (40% CP) feeds.
Weekly variations in water quality of the raceways during a 62-d nursery study using low (30% CP) and high-protein (40% CP) feeds.
# Results

Summary by treatment of shrimp performance criteria at the end of 62-d nursery trial

<table>
<thead>
<tr>
<th>Variables</th>
<th>30% CP</th>
<th>40% CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final weight (g)</td>
<td>0.94 ± 0.00</td>
<td>1.03 ± 0.02</td>
</tr>
<tr>
<td>SGR (%/day)</td>
<td>11.03 ±0.01</td>
<td>11.19 ±0.05</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>82.29 ±11.26</td>
<td>84.13 ±6.07</td>
</tr>
<tr>
<td>FCR</td>
<td>0.91 ± 0.05</td>
<td>0.82 ± 0.05</td>
</tr>
<tr>
<td>Yield (kg/m³)</td>
<td>3.70 ± 0.49</td>
<td>4.18 ± 0.23</td>
</tr>
</tbody>
</table>

*High consumption of natural food*

Low FCR
Conclusions

- No significant differences in shrimp performance when fed the low-protein diet (30% CP) compared to high-protein feed (40% CP)
- The higher levels of nitrate and nitrite found in the high-protein diet are most likely because of the higher nitrogen content of the feed
- Molasses can be used to enhance development of bacterial floc and to prevent ammonia build up in the culture medium
- Molasses supplementation was not effective in preventing nitrite build up
Acknowledgements

- Funding: Texas AgriLife Research; USAID, The National Academy of Sciences; Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES); Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)
- Feeds: Zeigler Bros. & Rangen Inc.,
- PL Supply: Harlingen Shrimp Farms
- DO monitoring systems: YSI Inc.
- Foam fractionators: Aquatic Eco System
- Air diffusers: Colorite Plastics
- RWs liner: Firestone Specialty Products