Short communication

Pond-reared Malaysian prawn _Macrobrachium rosenbergii_ with the biofloc system

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**A B S T R A C T**

Physicochemical parameters of water and survival rate, growth, and body composition of the Malaysian prawn _Macrobrachium rosenbergii_ were recorded and evaluated for six months in two nursery rearing systems: biofloc and traditional cultivation. The study was conducted in a shade house (300 m⁻³, plastic mesh, 90% shade) in four rectangular ponds (20 m⁻¹). Stocking was at 37 prawns m⁻² (0.025 g⁻¹) and fed twice daily with a commercial diet. Daily temperature, dissolved oxygen, pH, NH₃-N, NO₃-N, NO₂-N, and turbidity were recorded daily and the weight and length of the prawns were recorded each month. Water quality parameters were similar in both treatments, except transparency, which was significantly higher under traditional cultivation (36.10 ± 2.06 cm⁻¹) compared with the biofloc system (7.01 ± 1.52 cm⁻¹) at the end of the study. Survival rate was >85% under both treatments, but final size was significantly higher in the biofloc system (11.54 ± 1.87 g⁻¹, 15.18 ± 8.27 cm⁻¹) than in the traditional system (10.67 ± 2.26 g⁻¹, 12.57 ± 7.89 cm⁻¹). Protein (51.19%) and lipid (13.84%) content in harvested prawns was significantly higher in the biofloc system, which we ascribe to the nutritional contribution of complementary food. The results strongly suggest that the biofloc nursery system is a profitable alternative for locations where climatic and water restrictions do not allow traditional prawn cultivation and also contributes to sustainable use of water and improved nutritional quality of the prawns.

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1. Introduction

Aquaculture maintains steady growth as an alternative to open sea fisheries. Projections to 2030 indicate that aquaculture could produce 50% of the total production of seafood (FAO, 2004). A major challenge is to reduce water consumption required for maintaining quality and quantity of effluent and the amount of dissolved solids generated during production. Techniques to provide sustainable alternatives that would reduce environmental impact without affecting the health and growth of the crop organisms are essential. One option for the development of sustainable practices in aquaculture is biofloc technology.

The biofloc forms in pond water as the flocculent aggregates organic material, nitrogen-fixing bacteria, and algae in suspension, which serve as food for cultivated fish or crustaceans and promotes direct use of toxic metabolites by degrading the activity of the bacteria and algae (Avnimelech, 2007). The biofloc feed results from adding carbon sources to regulate the ratio of C:N that naturally varies between 15:1 and 20:1 (Asaduzzaman et al., 2008). The presence of bacteria in biofloc has the advantage of decreasing concentrations of ammonium in the water, which, in turn, significantly improves the quality of the water for cultivation (Avnimelech and Lacher, 1999; Crab et al., 2007; Schryver et al., 2008). Biofloc technology has been successfully tested for shrimp (Burford et al., 2004) and to a lesser extent tilapia (Crab et al., 2009). Many aquaculture species can be grown efficiently in biofloc, including prawns, which are a detritivorous, opportunistic species that feeds on bacteria, fungi, and decomposing material (Milstein et al., 2001; Serfling, 2006). Among crustaceans that are economically important in aquaculture is the Malaysian prawn _Macrobrachium rosenbergii_, an omnivorous freshwater crustacean that consumes a wide variety of plants and animals, either living or decomposing, and also accepting balanced artificial diets. This prawn requires large areas and volumes of water, partly related to territoriality and competence; hence, cultivation in some countries has not achieved expected development, although the prawn adapts to many environments. Favorable production technology has been available for over 50 years. The grow-out of freshwater prawns is generally carried out in earthen ponds. These structures are usually cheap and simple to construct and operate, and with suitable management and simple inputs, allows for development of natural food, both planktonic and benthic microorganisms. Since semi-intensive culture is more expensive, there are more appropriate approaches for commercial farms (New and Singholkha, 1984; New, 2002; Muir and Lombardi, 2010).

For intensive and semi-intensive prawn cultivation, traditional production of postlarvae (PL) is recommended with hatchery and nursery systems to maximize production efficiency in grow-out ponds. In nursery production, PL can be cultivated at much higher densities for the 1 to 3 months necessary for grow-out production (New, 2002). In temperate climates, nursery-raised PL are required...
at the beginning of the outdoor season; therefore, production of juveniles occurs during the colder months of winter and early spring. At pond stocking, juveniles of the appropriate size and number must be available at the same time (Coyle et al., 2010).

Currently, there is little information on production of Malaysian prawns with biofloc technology, so it is difficult to establish the relevance of this technology and critical activities to improve production, however it is important to consider using this technique during nurseries because the presence of biofloc can significantly improve feed efficiency of prawn PL and quality during grow-out production. This study was intended to generate useful information for nursery-rearing and sustainability of prawn production by assessing the productivity and health of the Malaysian prawn with biofloc technology.

2. Materials and methods

Because the variation of temperature in winter in some areas bordering the Gulf of Mexico prevents farming of the Malaysian prawn, they remain in a nursery system in a shade house for six months (30 m × 10.5 m × 4.5 m high) covered with a cloth that reduced sunlight by 90%. The shade cloth reduced light intensity and provided moderation of temperature.

2.1. Experimental system

The experimental system consisted of four rectangular ponds (R1, R2, R3, and R4), covered with high-density polyethylene (1 mm thick). Each pond was 2 m × 10 m × 1.3 m deep. The water depth was 1.0 m; each pond contained 20 m³ of water. Aeration was constantly supplied with a 2 HP blower connected to a PVC pipe (3.81 cm inside diameter), located on the bottom of the ponds.

The water came from an artesian well (10.16 cm diameter and 6 m deep) connected to a 2 HP pump through a PVC hydraulic line (5.08 cm inside diameter), located on the bottom of the ponds. The water was used for cooling the pond to maintain the water temperature, the water was also used for cooling the pond to maintain the water temperature.

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2.2. Experimental design

A completely randomized design was used with two treatments (types of cultivation: biofloc, consisting of 3 replicates (R2, R3, and R4), and traditional cultivation, the control, with only one replicate (R1)). The lack of sufficient infrastructure made a division of one control pond to three treatment ponds preferable than two in each treatment. We used 2960 postlarvae (PL 5) at a stocking density of 740 per replicate (37 organ m⁻²). Average initial weight was 0.025 g and average initial length was 1.1 cm. The PL were purchased from a commercial hatchery.

Four days before stocking the PL, the ponds were filled to 30% capacity and fertilized with 900 mL liquid chelated fertilizer (Poliquel Multi, Biochemical Group Mexicano, Saltillo, Mexico) at a concentration of 3 mL per 20 L of water to stimulate primary production and zooplankton (Morlarty and Pullin, 1987). Every day, 1.96 g of molasses, at a C:N ratio of 20:1 for promoting biofloculation and bacterial growth, was added to the three experimental ponds. Asaduzzaman et al. (2008) state that feed protein contains 16% N and 70% of the nitrogen intake is excreted as ammonium. If the prawns consume 1 kg of feed with 35% protein, containing 16% nitrogen, then, the amount of nitrogen consumed by a prawn is 56 g and the amount of nitrogen excreted by the prawns is ~39.2 g. If the molasses has a C:N ratio of 20:1, 1 g of nitrogen required 20 g of carbon; hence, 39.2 g of nitrogen required 784 g of carbon. Sierra-De La Rosa (2009) states that molasses contains 40% carbon, so if 784 g C is equal to 40%, then 100% will be 1960 g molasses.

During cultivation, the prawns in the treatment ponds and the control pond were fed twice daily (09:00 and 16:00 h) with a commercial shrimp diet (Silver Cup, Group El Pedregal Silver Cup®, Toluca, Mexico) containing 35% protein. The food was distributed around the perimeter and the central area in the ponds to reduce the bull effect. The food level was adjusted monthly, based on growth after the initial biomass of prawns during the first month of cultivation.

2.3. Physicochemical variables in water

Dissolved oxygen (DO; mg/L), temperature (°C), and pH of the water of the two treatments were recorded daily at 21:00 (YSI556 MPS multi-probe, YSI, Yellow Springs, OH). Each week, transparency...
was determined with a Secchi disk; concentrations of ammonia (NH₃-N mg L⁻¹), nitrates (NOₓ-N mg L⁻¹) and nitrates (NOₓ-N mg L⁻¹) were determined by colorimetric tests (Nutrifin kits, Hagen, Baie d’Urfé, QC, Canada). Water was supplied through a PVC pipe system (10.16 cm diameter), connected to a 2 HP Jacuzzi pump with PVC pipe (5.16 cm diameter). During the study of the control pond, 30% of the water was exchanged every third day, and 60% every two weeks to adjust for the physicochemical variables in the water, such as concentration of ammonia. In treatments R2, R3, and R4, water was added only to maintain the water level after losses from evaporation.

2.4. Response variables

Every 30 days, 90 prawns were randomly removed from the control pond and 30 from each of the biofloc (R2, R3, and R4) ponds with a nylon net (1/8 × 20 cm × 45 cm) to measure 90 prawns per treatment. Prawns were placed on a dry cloth to remove excess water. Initial length (from tip of rostrum to tip of telson) was measured with a mechanical caliper (±0.1 cm); juveniles were measured with a ruler. Weight was determined with an analytical balance.

2.5. Body composition

At the end of the trial, proximal composition (％) of crude protein, total lipids, moisture, and ash was determined in triplicate for 10 prawns from each treatment by standard methods (AOAC, 1990).

2.6. Statistical analysis

Prior to statistical analysis, data were tested for normality and homogeneity of variances, using the Kolmogorov–Smirnov test and Leven’s test, respectively (Zar, 1999). Survival data were transformed to arcsin for analysis (Sokal and Rohlf, 2003). Two-way ANOVA was performed to detect differences between replicates within the same treatment. To determine the existence of differences between treatments (biofloc and control) for each of these parameters, two-way ANOVA was used, using treatment and date as fixed factors (Sokal and Rohlf, 2003; Zar, 1999). For comparison of means, Tukey’s test was used. All analyses were done using the Statistica 7.0 software (Statsoft, Tulsa, OK). Statistical significance was set at $P < 0.05$.

3. Results

3.1. Physicochemical variables in water

Based on ANOVA results, the water quality parameters between replicates (R2, R3, and R4) in each month were similar for all variables, so they were grouped into a single biofloc treatment (BT) for subsequent analysis between the control and BT treatments. ANOVA revealed significant differences between BT and control treatments in all months for all variables, which were associated with the seasons (Table 1). In general, the water quality variables for biofloc and control treatments in every month were within the optimum ranges for cultivation (Table 2).

Dissolved oxygen remained above the optimum for cultivation (>5.5 mg L⁻¹). Ammonium, nitrates, and nitrites were below 0.1, 5.0, and 0.25 mg L⁻¹, respectively, in both treatments, but temperature and pH, decreased from the fourth month of study (6 °C (27 to 21 °C) and 0.5 pH (8.9 to 8.5) for the biofloc and control treatments from the initial levels) with no significant fluctuations in pH during the day. Water transparency in the ponds varied with treatment. The biofloc ponds had lower transparency, which decreased over time (from 27.37 ± 2.06 to 7.01 ± 1.52 cm) as in the ponds with the control treatment (from 26 ± 3.70 to 36.10 cm).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>T (°C)</th>
<th>DO (mg/L)</th>
<th>pH</th>
<th>Transparency (cm)</th>
<th>Length (cm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicates (BT)</td>
<td>2</td>
<td>0.82</td>
<td>0.30</td>
<td>0.60</td>
<td>0.99</td>
<td>0.45</td>
<td>0.76</td>
</tr>
<tr>
<td>Month</td>
<td>5</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Replicates × month</td>
<td>10</td>
<td>1.00</td>
<td>0.99</td>
<td>0.86</td>
<td>1.00</td>
<td>0.13</td>
<td>1.00</td>
</tr>
<tr>
<td>Error</td>
<td>522</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BT = biofloc treatment.

3.2. Response variables

ANOVA comparisons between treatments and months (Table 3) showed statistical differences in growth (length and weight), but no interaction between factors. Prawns in the biofloc treatment were larger than those in the control during the first five months, but with no statistical difference. Starting in the sixth month, differences in weight gain and length were statistically significant, higher in the biofloc treatment than in the control (Fig. 2).

Survival rate of prawns was similar in both treatments (ANOVA $P > 0.05$), suggesting that there was no effect of density on growth rate and weight gain. The apparent food conversion ratio of the prawns in the control was significantly higher than the prawns in the biofloc treatments (Table 4).

3.3. Body composition

Proximate analysis of prawns at the end of the study indicates that BT prawns had significantly more protein and lipid content than CT prawns. CT prawns had more moisture and ash content. This is an indicator of the nutritional condition of the prawns (Table 5).

4. Discussion

4.1. Water variables

Physicochemical parameters were within the range recommended for nursery-reared Malaysian PL prawns (New and Singholka, 1984), with the exception of the temperature which decreased over time. In general, the declining temperature corresponded with the seasonal changes between July and December, with cold fronts present in November and December. As cultivation was carried out under shade, the temperature remained within the tolerance range (15–35 °C) of the species (Fujimura and Okamoto, 1970); however, the range of temperature was lower than required, and this could affect the growth rate of the PL and juveniles. Optimal growth and survival indicate a temperature range of 27 to 33 °C (Sandifer et al., 1983). Sandifer and Smith (1985) report that growth and survival rates decrease when temperatures are less than 22 °C and greater than 32 °C.

The steady decline in water transparency in BT ponds likely reflects the progressive formation of bioflocs with the increase of bacteria (Avnimelech and Lacher, 1999). They suggest that bacterial colonies increase with the amount of food available, derived from food for the prawns and the addition of carbon at a concentration that kept the C:N ratio at 20:1. This encourages bacteria to use prawn waste as nutrients and prevent toxic products in the culture system (Avnimelech and Lacher, 1999; Asaduzzaman, 2008). In contrast, the water quality in the CT pond was maintained mainly by constant water changes because the high mortality in indoor nurseries usually results from low levels of dissolved oxygen and high concentrations of nitrogenous compounds (Zimmermann and Sampaio, 1998). Die-offs from acute nitrite toxicity in commercial nursery systems occur when nitrite levels reach >4 mg L⁻¹ and nitrite and ammonia levels reach >3 mg L⁻¹ (Coyle et al., 2010). To optimize water quality in the BT ponds, it is
necessary to provide bacteria (biovoc) to maintain the concentration of ammonia at ≤1 mg L⁻¹.

Although we had only one pond for traditional cultivation which may cause some uncertainty in the results, important culture conditions such as temperature and lighting were identical in both tanks. Numerous studies have demonstrated the benefits of cultivating shrimp in biofloc-rich water compared with clear water. These benefits include higher growth rate, higher feed conversion ratio, and supply of various nutrients by the microbial community (Burford et al., 2004; Moss, 1995; Moss et al., 2006; Wasiela et al., 2006).

In general, in tanks where the biofloc technology is applied, benefits will be higher than in traditional production; however, it is important to maintain control of the concentration of biofloc (algae, bacteria, and zooplankton within the floc) because it can lead to anoxia. Wasiela et al. (2006) show that biofloc culture increases turbidity, as did Beveridge et al. (1991), Brune et al. (2003), and Hargreaves (2006). Rakocy (1989) describes a simple method to maintain the concentration of bioflocs and eliminate solids that cause turbidity in the culture by using conical-shaped settling tanks in the recirculation systems.

To control sediment and suspended matter, maintaining the concentration of biofloc requires temperature limits (25.9 ± 2.19 °C), which in our case was maintained with shade cloth, which moderated insolation (~2500 lx). Lowering temperature regulates the metabolism and growth of microalgae and the composition of their biomass. The optimal temperature range for the growth of most algae is 18–22 °C (FAO, 2008).

4.2. Response variables

Survival rate of prawns (85%) was similar among treatments and significantly higher than previous results for nursery prawn systems and outdoor cultivation. Our results in both intensive treatments were successful. Time in the nursery increased to 180 days, with the goal of increasing environmental temperature. The prawns were stocked in semi-intensive systems to obtain commercial size rapidly. This is considered important because juveniles are more resistant to predation, cannibalism, and fluctuating environmental conditions than PL (New and Singhkola, 1984; New, 2002). Despite stocking densities in indoor nurseries usually varying from 500 to 6000 PL/m², depending primarily on the duration of cultivation (Zimmermann and Sampaio, 1998), in this study an initial density of 37 prawns m⁻² was used because Sandifer et al. (1983) suggest that stocking density should be inversely proportional to the cultivation period. Higher stocking density typically results in lower survival rate and average weight. In this case, we expected survival that permits commercial cultivation when the initial density was 37 prawns m⁻², which is high relative to recommendations for semi-intensive and intensive prawn densities (5–10 and 20 prawns m⁻², respectively). According to Valenti and Daniel (2000), the survival rate in Malaysian shrimp farming is 40–60% in commercial operations. In our study, the high survival rate could be an effect of increased contact area throughout the water column because we used boxes of plastic mesh suspended in the water and fixed by plastic ropes, as well as shelters placed at the bottom of tanks; this greatly reduced aggression and cannibalism, especially during molting. Coyle et al. (2010) state that substrate in nursery prawn systems decreases the energy required for agonistic encounters and may provide additional food resources from the growth of periphyton on the substrate. Further, artificial substrate increases the amount of two-dimensional space for prawns in relation to the volume of the tank, yielding higher survival rate, production, and feed conversion (Coyle et al., 2010). The growth of prawns in the BT was significantly high than in the CT. The differences are likely from the biofloc effect on the feeding habits of the PL and juveniles that graze on settled waste or sludge (Coyle et al., 2010). In cultivation systems, crustaceans feed continuously and the biofloc system provides a rich source of natural food; in agreement with Coyle et al.’s (2010) observation, prawns prefer natural over commercial food. Heinen and Mensi (1991) propose the same explanation. It is not necessary to provide more than one feeding each day for juveniles because prawns graze throughout each 24 h period on feed colonized by microorganisms, thus providing supplementary food.

Information regarding nutritional requirements of PL and juvenile prawns varies, depending on the type of feed provided during production. In our study, commercial shrimp feed was used because there is no customized feed available in the local market. According to Hari and Kurup (2003), the survival rate of juvenile shrimp increased to 96.7% when fed protein at 30% and 35% content. For the CT shrimp, the commercial diet could meet essential requirements, which was the only source of nutrients.

Although the prawns were not raised long enough to reach commercial size (>50 g), the results are encouraging and indicate that it is possible to raise juvenile prawns in a nursery shade house during winter, which subsequently allows the prawns to reach commercial size by spring. Coyle et al. (2010) mention that multi-stage stocking systems are used to increase pond production, optimize growth, and avoid dominance relationships, beginning with PL stocked in nursery ponds at 200–400 PL m⁻² for 60 to 90 days. Juveniles (0.3–0.5 g) are then harvested from nursery ponds and stocked at 20 to 30 PL m⁻² in juvenile ponds. Juveniles are then harvested after 2 to 3 months and monthly thereafter to remove prawns weighing 9 to 15 g. In our

Table 2

<table>
<thead>
<tr>
<th>Month</th>
<th>Treatment</th>
<th>T (°C)</th>
<th>DO (mg L⁻¹)</th>
<th>pH</th>
<th>Transparency (cm)</th>
<th>Ammonia (mg L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CT</td>
<td>BT</td>
<td>CT</td>
<td>BT</td>
<td>CT</td>
<td>BT</td>
</tr>
<tr>
<td>1</td>
<td>27.79 ± 0.22b</td>
<td>27.76 ± 0.76b</td>
<td>5.85 ± 0.84a</td>
<td>5.21 ± 0.70a</td>
<td>8.99 ± 0.23b</td>
<td>8.92 ± 0.18b</td>
</tr>
<tr>
<td>2</td>
<td>27.30 ± 0.39ab</td>
<td>27.28 ± 0.38b</td>
<td>5.57 ± 0.82b</td>
<td>6.03 ± 0.70b</td>
<td>8.95 ± 0.22b</td>
<td>8.85 ± 0.15ab</td>
</tr>
<tr>
<td>3</td>
<td>27.34 ± 0.58b</td>
<td>27.31 ± 0.57b</td>
<td>5.89 ± 2.01b</td>
<td>5.21 ± 2.00b</td>
<td>8.90 ± 0.11ab</td>
<td>8.81 ± 0.18b</td>
</tr>
<tr>
<td>4</td>
<td>25.86 ± 0.42b</td>
<td>25.90 ± 0.52b</td>
<td>6.04 ± 0.66b</td>
<td>6.08 ± 0.70b</td>
<td>8.77 ± 0.26b</td>
<td>8.70 ± 0.23b</td>
</tr>
<tr>
<td>5</td>
<td>25.20 ± 1.03b</td>
<td>25.23 ± 1.10b</td>
<td>5.97 ± 1.73b</td>
<td>5.93 ± 1.69b</td>
<td>8.72 ± 0.15b</td>
<td>8.63 ± 0.12b</td>
</tr>
<tr>
<td>6</td>
<td>21.91 ± 1.73b</td>
<td>21.95 ± 1.71b</td>
<td>5.69 ± 0.48b</td>
<td>5.77 ± 0.60ab</td>
<td>8.53 ± 0.07b</td>
<td>8.51 ± 0.07b</td>
</tr>
<tr>
<td>Opt. value</td>
<td>22–28</td>
<td>4–12</td>
<td>7–9</td>
<td>30–45</td>
<td>&lt;0.1</td>
<td>&lt;</td>
</tr>
</tbody>
</table>
Different superscript letters in some values denote significant differences at $P < 0.05$. AFCR = apparent food conversion rate. GG = gain in growth. N = number of surviving prawns at the end of the study.

According to Kurup and Prajith (2010), cultivation with biofloc of *M. rosenbergii* provides a high survival rate (~87%), and additional shelters allow stocking density that is 200% higher than customary. The evidence supports the role of biofloc technology, higher densities of shelters, and shade house systems in yielding a shrimp production of 200%, without affecting survival and reducing the “bull effect” Jayachandran (2001), wherein subordinate males are attacked by the dominant male. This behavior appeared to decrease with additional shelters and screens, the latter distributed throughout the water column. Also, if food is properly distributed along the suspended grid lines, territorial behavior is reduced, as in our study.

### 4.3. Body composition

From proximal analysis, protein and lipid levels were higher in prawns in the biofloc treatment, which have a strong preference for natural food, probably because these are more efficiently digested, compared to commercial diets. Hence, biofloc material contributes to better nutrition and feeding efficiency (Ekasari et al., 2010). Additionally, the biofloc reduces expenditure of energy to find food, which leads to greater storage of energy in muscles and tissues (protein and lipid), which in turn, reduced the quantity of moisture present in BT prawns.

Biofloc technology also decreased water consumption during cultivation, compared to the control. While the traditional cultivation pond used 596 m$^3$ of water to maintain quality, the biofloc ponds of the same size used only 44 m$^3$ of water to replace losses by evaporation. This is 7% of the replacement volume used in traditional cultivation. Electrical power for pumping water was reduced by about 98.8%, which is similar to the findings of Avnimelech and Lacher (1999), Crab et al. (2007), and Schryver et al. (2008).

### 5. Conclusions

Under the conditions of this study, biofloc technology has many advantages for nursery-reared, postlarval Malaysian prawns, including maintenance of optimal water quality, higher survival rate, less expenditure for water and control of waste, higher nutritional quality, and smaller impacts on the environment.

### Acknowledgments

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### References


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**Table 4**

Survival rate, length, weight, and AFCR (mean ± SD) in prawn harvested at the end of cultivation.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>Survival rate (%)</th>
<th>Weight (g)</th>
<th>Length (cm)</th>
<th>GG (%)</th>
<th>AFCR (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>632.00</td>
<td>85.40ª</td>
<td>12.57 ± 7.89ª</td>
<td>10.67 ± 2.26ª</td>
<td>48,432.81ª</td>
<td>2.74ª</td>
</tr>
<tr>
<td>Biofloc</td>
<td>631.00</td>
<td>85.31ª</td>
<td>15.18 ± 8.27b</td>
<td>11.54 ± 1.87b</td>
<td>58,510.03b</td>
<td>2.27b</td>
</tr>
</tbody>
</table>

*N = number of surviving prawns at the end of the study.

GG = gain in growth.

AFCR = apparent food conversion rate.

Different superscript letters in some values denote significant differences at $P < 0.05$.

**Table 5**

Proximal composition (mean ± SD) in prawn harvest at the end of cultivation (six months).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture (kg)</th>
<th>Proximal analysis (N = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total protein</td>
</tr>
<tr>
<td>Control</td>
<td>69.57 ± 0.07ª</td>
<td>49.09 ± 0.01ª</td>
</tr>
<tr>
<td>Biofloc</td>
<td>66.76 ± 0.14ª</td>
<td>51.19 ± 0.01ª</td>
</tr>
</tbody>
</table>

Protein, lipids, and ash are based on dry weight.

Different superscript letters in some values denote significant differences at $P < 0.05$. 

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**Fig. 2.** Comparison (means ± SD) of total weight (g) and total length (cm) of Malaysian prawn *Macrobrachium rosenbergii* during cultivation in two systems.