Study on the Efficiency of Three Different Feeding Techniques in the Culture of Pacific White Shrimp (*Litopenaeus vannamei*)

Tanthip Napaumpaiporn*, Niti Chuchird and Wara Taparhudee

ABSTRACT

The efficiency of three different shrimp feeding techniques used in intensive culture of white shrimp (*Litopenaeus vannamei*) was compared, with feeding trials conducted in Tha Chang district, Surat Thani province. The experiment had 3 treatments employing the 3 feeding techniques, namely, manual feeding (technique 1), automatic feeding with time setting (technique 2), and automatic feeding with sound detection (technique 3). Each treatment utilized 3 1-ha ponds with polyethelene sheet lining (PE). Stocking density was 75 post-larvae (PL)/m^2 and culture period was 120 days. Results showed that the average daily growth (ADG) from techniques 2 and 3 were 0.21 and 0.24 g/day, respectively, which were higher than that obtained from technique 1 (0.18 g/day). The feed conversion ratio (FCR) from techniques 1 to 3 were 1.5, 1.4 and 1.3, respectively. The best mean body weight was found in shrimp fed by technique 3 at 24.52g while the poorest weight was 15.92g found in shrimp fed by technique 1. No significant differences in survival rates were found in all treatments. The yield from techniques 1 to 3 were 1,672, 1,739.3 and 1,848.3 kg/rai, respectively. Water quality parameters in the experimental ponds were within the suitable ranges for shrimp culture.

Keywords: Pacific white shrimp, Auto-feeding by time setting, Auto-feeding by sound detection, Manual feeding

INTRODUCTION

At present, most of the marine shrimp producing countries in Asia are culturing Pacific white shrimp because they have been genetically bred to grow fast in high yield systems. Pacific white shrimp industry grew into a major source of income for Thailand, generating around 100,000 million Baht per year (Limsuwan, 2000). Even though feed accounts for 40-60% of the operational cost, feeding practices remained labor-intensive. For small ponds, farmers walk around the edge of the pond to feed the shrimp, while rowboats are used for larger ponds. In most farms, 4 feeding trays are positioned per pond to control feed consumption. Feeds are added and the amount of left-over feed after a certain period of time is checked and the daily feed amounts calculated (Limsuwan,

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Aquaculture Business Research Center, Faculty of Fisheries, Kasetsart University, Bangkok 10900 Thailand
*Corresponding author, e-mail: pb_2027@hotmail.com

2010; Tacon and Barg, 1998; Gonzalez-Rodriguez and Abdo de le parra, 2004). Feeding methods have been continuously modified to make it easier for shrimp farmers to monitor shrimp growth and accurately estimate their yield. However, an important change is about to occur in shrimp feeding that will fully industrialize the shrimp production business. As it has been seen in industrialized countries, labor is becoming scarce and more expensive, so technology has been applied to replace the manpower. Automatic feeding machines have been used for some time in other fields of aquaculture, such as finfish farming, but for shrimp farming, automatic feeding technique has only been developed and tested in for a few years. The prototypes have now been improved to give better results and most farms (medium and large farms) have converted from manual feeding to automatic feeding machines.

Five years ago, automatic feeding by sound detection system developed by AQ1 systems company for cultured finfish has passed its research experiment and improved feeding technology through sound to control and adjust the feeding rate in automatic feeders. AQ1 is a system which was developed to feed shrimp using voice which occurs when a shrimp is consuming feed, via a voice detection machine. In this machine, specific algorithms can measure the hunger level of shrimp which in turn controls the amount before the feed is released from an automatic feeding machine at an appropriate level corresponding to the demand of shrimp. The proper use of this system will reduce feed cost and improve the growth rate of shrimp.

The aim of this study is to compare three feeding techniques to increase the efficiency of shrimp feeding with the reduction of the cost of shrimp production.

MATERIALS AND METHODS

The study was carried out in a private shrimp farm in Tha Chang district, Surat Thani province. Nine shrimp ponds were used. Each of them was about 1 hectare in size and 1.6 meters in depth. Every pond was lined by polyethelene (PE). The water from Bang Pu canal was pumped into a sedimentation pond, then it passed the treatment pond, after which it was kept in the reservoir before using. The ponds were separated into 3 treatments, with 3 ponds per treatment. Each pond was stocked with 75 post-larvae(PL)/m^2 of Pacific white shrimp. All ponds were cultured around 120 days from July to October 2011.

The first treatment involved feeding the shrimp manually, broadcasting the feed from a boat around the pond. Shrimp were fed four times daily (0700, 1100, 1500, 1900 hrs) with commercial pelleted feed. Some amount of feed (10-15 g) was also placed on the feeding tray. After 1-2 hours the amount of feed in the tray was checked to adjust the feed for the next meal. The amount of feed in the next meal was decreased if a lot of feed was left in the tray, and the amount of feed in the next meal was increased if only shrimp feces were found on the feeding tray.

The second treatment involved using an automatic feeder with a timer, and shrimp were fed with commercial feed from 0700 to

1900 hrs. Two feeding machines were set-up at the deepest area of the pond and placed around 30 meters apart. A time setting for feeding was done on the basis of evaluating feed consumption through the feeding trays. A feeding tray was placed on the pond bottom around the feeding area. The tray was checked about 1-2 hours after feeding. If a lot of feed was found on the tray, the time for feeding was decreased, but if no feed was found on the tray, the feeding time was increased.

The third treatment involved using an automatic feeder that detects the sound of shrimp feeding. AQ1 calculates the feed amount and time of feed released from the machine depending on the sound of feed being consumed. Then, the information would be assessed by the computer which, in this trial, was set close to the radio signal sender stick on an antenna which received a signal from all the ponds. It was set high at around 15 meters. Each pond could be controlled through the internet for the evaluation by updating the software and one hydrophone was provided to control the operation of 2 feeding machines.

Data collection was also done for water quality parameters. pH was recorded with pH meter HANNA HI 9026. Dissolved oxygen (DO) was monitored with an Oxy Guard Handy Alpha. Salinity was measured with an American Optical refractometer-type salinometer. Alkalinity, total ammonia and nitrite were measured according to APHA (1992). Average daily gain (ADG), feed conversion ratio (FCR), mean body weight (BW), survival rate and yield were calculated according to the formula below:

ADG (g/day) = Total weight gained by the shrimp / total days of culture

FCR = Total feed used / total weight of the harvested shrimp

mean BW (g) = 1000 (g) / number of shrimp in 1000 g

survival rate (%) = (Number of shrimp at harvested / initial stocking) x 100

yield (kg / rai) = Total production / size of the pond (rai)

All data from three treatments were statistically compared by using one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Water quality during culture period

Table 1 presents the mean values and standard deviation of the water quality parameters during culture trials. The average pH in the morning ranged from 7.51 – 7.61 in the treatments and the afternoon pH ranged from 8.01-8.09. No differences in pH were observed among treatments ($p>0.05$). Limsuwan (2000) indicated that pH of water during the day should not vary by more than 0.5 because the change in pH will stress shrimp and have an effect on growth. The optimum pH for shrimp culture is 7.5-8.5 (Boyd and Tucker, 1998).

Table 1. Mean ± standard deviation of water quality parameters in ponds farming Pacific white shrimp

Parameters	Treatment		
	Manual Feeding	Auto-feeding by time setting	Auto-feeding by sound detection
pH (morning)	7.61 ± 0.21[a]	7.51 ± 0.19[a]	7.55 ± 0.26[a]
pH (noon)	8.09 ± 0.25[a]	8.01 ± 0.21[a]	8.08 ± 0.20[a]
DO (morning) mg/l	5.71 ± 0.74[a]	5.43 ± 0.88[a]	5.34 ± 0.80[a]
DO (noon) mg/l	6.39 ± 0.91[a]	6.09 ± 0.83[a]	6.32 ± 0.69[a]
Salinity (ppt)	10.11 ± 0.58[a]	10.63 ± 0.75[a]	11.08 ± 0.30[a]
Alkalinity (mg/l)	79.00 ± 10.73[a]	79.00 ± 10.73[a]	79.07 ± 12.91[a]
Ammonia (mg/l)	0.61 ± 0.04[a]	0.33 ± 0.03[a]	0.30 ± 0.04[a]
Nitrite (mg/l)	1.53 ± 0.30[a]	0.95 ± 0.80[a]	0.89 ± 0.50[a]

Values followed by different letters are significantly different at $p>0.05$

The average dissolved oxygen (DO) ranged from 5.34-5.71 mg/l in the morning and 6.09-6.39 mg/l in the afternoon. No statistically significant differences ($p>0.05$) were found. Management in the ponds could control DO to optimum level which was more than 4 mg/liter (ppm) throughout the culture period according to Boyd (1989). Although Pacific white shrimp was raised at high stocking densities, the DO level in the pond was suitable for culture due there were enough numbers and appropriate position of aerators in the pond (Limhang, 2005).

The average alkalinity was 79 mg/liter (ppm) which was lower than the normal range (more than 100 ppm) due to heavy rain during the rainy season. However, no differences in alkalinity were observed among treatments ($p>0.05$). Agricultural lime was applied in each pond periodically to maintain alkalinity at optimum level (80-150 ppm) according to Chanratchakool (1994). Salinity was 10-11 ppt, which was within the suitable range for culturing white shrimp according to Smith and Lawrence (1990), Bray *et al*. (1994), Samocha *et al*. (2001). The total ammonia concentration ranged from 0.33-0.61 mg/l and nitrite concentration ranged from 0.95-1.53 mg/l.

Feed Conversion Ratio (FCR)

The FCR of all treatments were within acceptable ranges (1.4-1.6) as expected by the farm, as shown in Figure 1. A notable exception was found in treatment 3 (auto-feeding by sound detection), where the lowest FCR of 1.30 was achieved. Auto-feeding by time-setting also showed a low FCR of 1.42. However, this study indicated

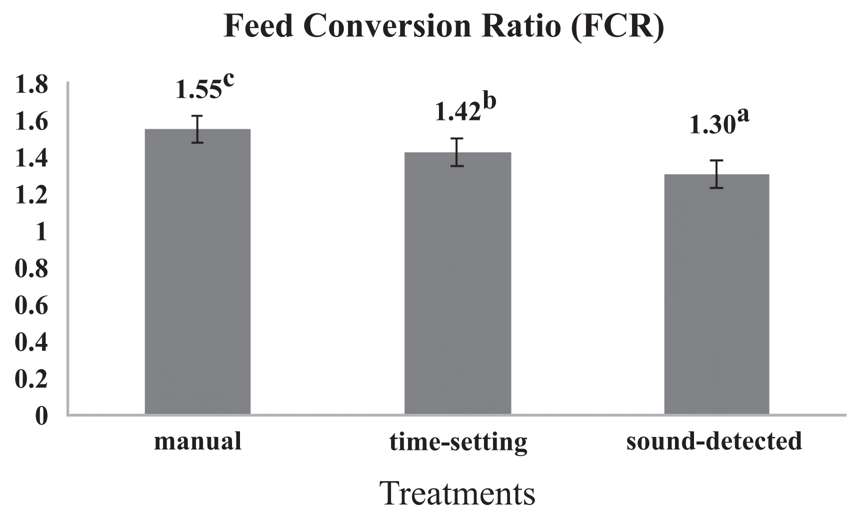

Figure 1. Final feed conversion ratio of each treatment. Values are means and error bars indicate standard deviation of the mean

that automatic feeding could manage the amount of feed during culture period better than manual feeding. Auto-feeding by sound detection gave the lowest FCR because the amount of feed from automatic feeding machine was controlled by actual demand at each time, and a small amount of feed was released each time. In contrast, manual feeding showed that an excess of feed was broadcasted into the pond each time. Limsuwan (2011) reported that when a large amount of pelleted feed are fed at once, some of the feed remain in the water for some time, afterwhich they gradually lose their scent, so the shrimp will not seek it out to eat it. The leftover feed is washed to the center of the pond bottom, where it decomposes and generates ammonia. When ammonia level rises, water quality declines. As the amount of organic matter in the pond increases, and the longer the shrimp are raised, the amount of dissolved oxygen in the water drops. In this way, leftover feed has an effect on the growth rate, survival rate, yield and feed conversion ratio (Limsuwan, 2011).

Average Daily Growth (ADG; g/day)

The average daily growth rates of shrimp from the three treatment groups are shown in Figure 2. The trials showed that shrimp fed with automatic feeders had an ADG higher than shrimp fed manually, but these were not statistically different ($p > 0.05$). Shrimp fed automatically had good ADG because automatic feeding has good feed management, especially the auto-feeder with sound detection. Auto-feeding with sound detection can evaluate the amount of feed in each meal and provide just enough for the shrimp. The profit making capacity of shrimp farms depends on good farm management and maintaining good water quality. When DO in the water is low, shrimp growth rate becomes slow, and the FCR is very high due to overfeeding. Excess feed causes a build-up of waste materials in

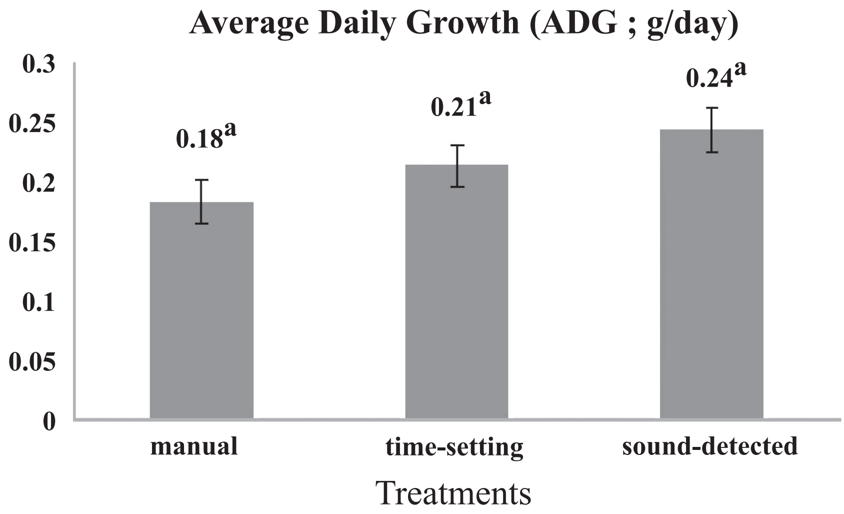

Figure 2. Average daily growth rate over the entire culture period. Values are means and error bars indicate standard deviation of the mean

the pond, which encourages the growth of disease-causing bacteria. When DO in the pond drops over the course of the culture period, the shrimp are likely to get sick (Limsuwan, 2012 ; Somboon *et al*., 2012).

Average Body Weight (g)

At the time of harvest the combined mean body weight which included partial harvest values showed that auto-feeding by sound detection produced the largest shrimp, and feeding manually produced the smallest size (Figure 3). The result showed that shrimp fed automatically by sound detection had the highest average body weight which was achieved through high efficiency feeding. This is due to the fact that automatic feeding can manage the amount of feed better than manual feeding. In the latter, uneaten feed and feces will be degraded by microorganisms to carbon dioxide, ammonia and other inorganic substance. Some of the feed components absorbed by culture species will be converted to biomass and removed from the pond during harvesting. However, majority of the absorbed nutrients will be oxidized to carbon dioxide through respiration or transformed to ammonia and other metabolic and catabolic wastes and excreted (Boyd, 2008). Ammonia concentration in treatment 1 was highest which possibly caused the shrimp to grow slower than in the other treatments.

Survival rate (%)

The result showed that survival rate was above 70% in all treatments. There were no significant differences; however the survival rate of shrimp using auto-feeding by sound detection was the highest (Figure 4). For shrimp farms, most farmers should maintain water quality especially dissolved oxygen (DO) , which should not drop below 4 ppm even in the pre-dawn hours. It is recommended that the number of aerators should be increased in order to produce

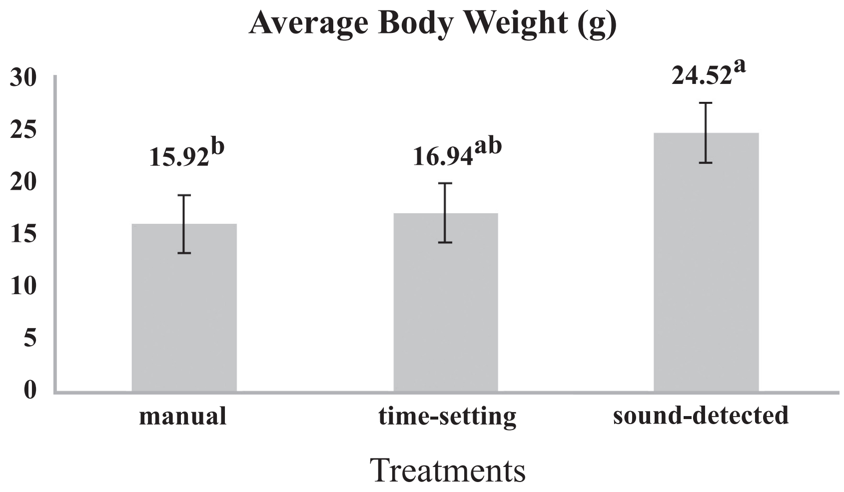

Figure 3. Final average body weight for all treatments. Values are means and error bars indicate standard deviation of the mean

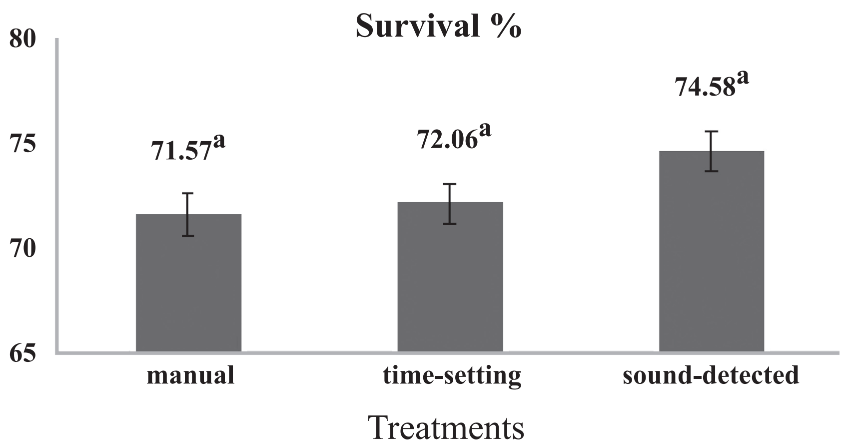

Figure 4. Survival rate from all treatments at final harvest. Values are means and error bars indicate standard deviation of the mean

large biomass and maintain DO levels above 4 ppm even in the morning, as this can lead to profit yielding shrimp farming with faster growth rate, high survival and lower FCR (Limsuwan, 2012; Nonwachai, 2011).

Yield (Kg/rai)

The results showed that shrimp production after harvest ranged between 1600-1800 kg/rai in all treatments and they were not different significantly; however, shrimp which were fed automatically by sound detection still showed the highest yield (Figure 5). The farm which maintains good water quality in culture ponds could obtain a successful yield. If the amount of DO in the pond is too low, shrimp will eat

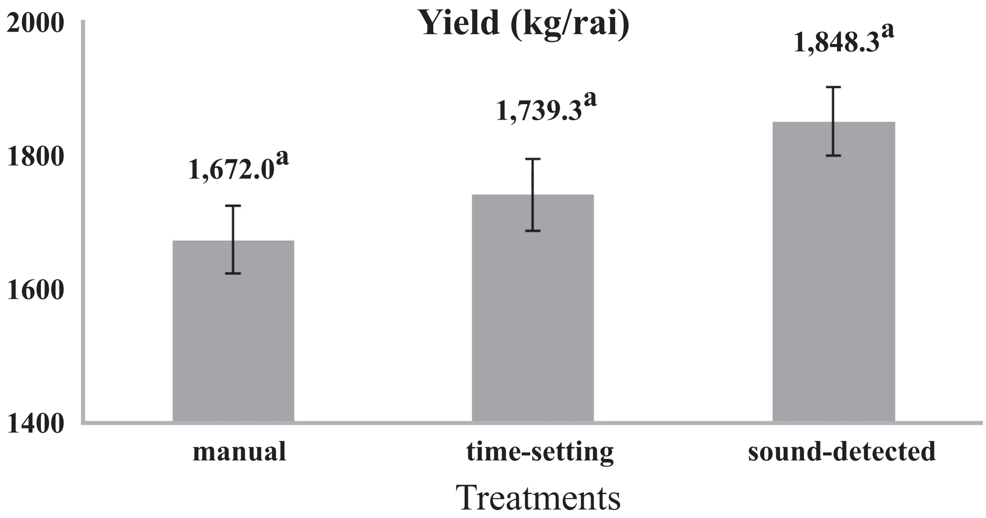

Figure 5. Shrimp production of all treatments at final harvest. Values are means and error bars indicate standard deviation of the mean

less and there will be more leftover feed. The most appropriate DO for shrimp health and normal growth is from 4 ppm up to the saturation point (Limsuwan, 2012; Nonwachai, 2011).

CONCLUSION

The ponds using automatic feeding with time setting and automatic feeding with sound detection (techniques 2 and 3) obtained greater average daily growth rate (ADG), survival rate, and yield, and less feed conversion ratio (FCR) compared to ponds without automatic feeders.

ACKNOWLEDGEMENT

The authors would like to thank Tawee Farm, AQ1 systems and Bayer Thai Company Limited for all the support and advice they provided during the conduct of this research.

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