How to Prevent High Feed Conversion Ratio in Shrimp Farming

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ABSTRACT

In shrimp farming, feeding management is becoming more and more important because feed cost is about 40 – 50% of the total cost for intensive culture. Improper or incorrect feeding management could reduce profits during period of low prices. Past experience and analysis of shrimp farming operations in several countries show that the most common mistake in shrimp feed management is overfeeding,which results in high feed conversion ratio (FCR) and production costs. Feeding the appropriate amount enables the shrimp to grow quickly, thereby achieving optimal production. This paper explains the problems encountered with feed management especially overfeeding, and some experiments which could explain the reasons behind these problems and how to solve them, to help shrimp growers to improve their efficiency and remain competitive during the global economic crisis.

Key words: Feed conversion ratio, Pacific white shrimp, *Litopenaeus vannamei*

INTRODUCTION

In the past, Pacific white shrimp (*Litopenaeus vannamei*) was produced mainly in North and South America, while marine shrimp, mainly the black tiger shrimp (*Penaeus monodon*) was produced in Asia (China, Indonesia, Thailand and Vietnam). However, currently most marine shrimp producing countries in Asia are culturing Pacific white shrimp because they have been genetically bred to grow fast and produce high yields even when raised at high stocking densities. The volume of white shrimp produced in the world has increased steadily and the price has dropped as a result. At the same time, the major importing countries (USA, EU and Japan) are experiencing economic recession, which has affected the sale of shrimp. In order for shrimp farmers to remain competitive and financially stable in a sustainable way they must be able to decrease costs or increase production efficiency.

Causes of high feed conversion ratio (FCR)

The five most common mistakes in feed management which result in high feed conversion rates are as follows :

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1. Unusually high water temperature

This is a common problem in farms where ponds are covered with plastic sheets (green-house). Normally, white shrimp will eat the most and grow best when water temperature is between 28 and 30°C, but in the hot season when the ponds are covered with plastic, the morning temperature rises up to 31°C and the afternoon temperature to 33 – 34°C. This causes the shrimp to eat more than normal. When shrimp growers adjust the amount of feed after inspecting the feeding tray and find that the feed has all been consumed, they add more feed.

A comparison study was done using 10 white shrimp weighing 12 g each placed in six 100-liter aquaria with seawater of 25 parts per thousand (ppt) salinity. The water was aerated constantly and three tanks were kept at 29±1°C, considered the optimum temperature for white shrimp, while three aquaria were kept at 33±1°C, which is the temperature during the hot season in farms with ponds covered with plastic sheets. Normally, at 29±1°C, 12 g shrimp will be fed 3 times a day at 3% of body weight each day, so at each feeding they should receive 1% of their body weight in feed. In the experiment the shrimp in the aquarium with 29±1°C temperature were fed 1% of their body weight at each feeding, 3 times a day, but the shrimp in the aquarium with 33±1°C were allowed to eat as much as they could, with additional feed added as necessary within 2 hours. The experiment revealed that shrimp at a higher temperature ate 36.5% more feed than those at 29±1°C (Table 1).

Table 1. Feed intake of *L. vannamei* at 29±1ºC and 33±1ºC

Days	**Feeding Times**	**Feed intake (g) (33±1ºC)**			**Feed intake (g) (29±1ºC)**		
		Rep 1	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**
	8.00 am.	1.7	1.7	1.6	1.2	1.2	1.2
Day 1	1.00 pm.	1.6	1.6	1.7	1.2	1.2	1.2
	6.00 pm.	1.7	1.7	1.7	1.2	1.2	1.2
	8.00 am.	1.53	1.53	1.6	1.2	1.2	1.2
Day 2	1.00 pm.	1.65	1.65	1.55	1.2	1.2	1.2
	6.00 pm.	1.63	1.63	1.65	1.2	1.2	1.2
		1.635	1.635	1.633	1.2	1.2	1.2
	Average		**1.638**			**1.2**	

* N.B. At 29±1ºC feeding rate was maintained at 1% each meal (1.2 g/ feeding time)

However, a comparative digestibility study showed that the shrimp's ability to digest carbohydrate, fat and protein was not significantly different at 29±1°C and at 33±1°C (Table 2).

Table 2. Percent digestibility of shrimp reared at two different water temperatures

Temperatures	Carbohydrate (g/100g)	Fat (g/100g)	Protein (%N x 6.25) (g/100g)
29±1ºC	85.56±2.65[a]	92.07±0.61[a]	89.40±1.94[a]
33±1ºC	83.24±2.00[a]	91.21±1.48[a]	90.23±1.16[a]

N.B. Values in the same column followed by the same letters are not significantly different (P>0.05)

In another study we conducted, white shrimp with an average weight of 10 g each were kept in 500-liter fiberglass tanks filled with 300 liters of seawater (25 ppt) at 25 shrimp per tank (25/m^2). They were divided into 3 groups, with 3 tanks for each group, as follows:

Group 1 : 29±1°C water temperature and fed 3% of their body weight each day

Group 2 : 33±1°C water temperature and fed 3% of their body weight each day

Group 3 : 33±1°C water temperature and fed 36.5% more than the other 2 groups (based on the results of the previous study).

The water temperature was kept constant using heaters. Shrimp were sampled every 7 days to determine their weights. Water quality was analyzed every 7 days. The amount of feed was adjusted following the method of Limsuwan and Chanratchakool (2004) for an experiment of 49 days. The shrimp in Group 3 were fed 36.5% more than those in Groups 1 and 2 at every feeding according to the actual remaining shrimp.

Results showed that in the first 2 weeks the shrimp in group 3 grew faster than the other 2 groups (Table 3). The shrimp in group 2 grew the slowest of all 3 groups

Table 3. Average body weight (g) and daily gain (ADG) of *L. vannamei* from three experimental groups

Culture period (Days)	Group 1		Group 2		Group 3	
	Weight (g)	ADG (g/day)	Weight (g)	ADG (g/day)	Weight (g)	ADG (g/day)
7	11.93±0.96[a]	0.28	11.60±1.29[a]	0.23	12.13±1.18[a]	0.3
14	14.07±1.54[a]	0.31	12.40±1.04[b]	0.11	14.80±1.89[a]	0.38
21	14.80±1.37[a]	0.1	13.93±1.58[a]	0.22	14.93±1.71[a]	0.02
28	16.00±1.56[a]	0.17	14.60±1.88[b]	0.1	15.73±1.53[ab]	0.11
35	17.47±1.41[a]	0.21	17.30±1.64[a]	0.39	17.80±1.92[a]	0.3
42	18.47±2.03[ab]	0.14	17.30±1.85[a]	0	19.40±2.17[b]	0.23
49	20.00±1.25[a]	0.22	18.20±1.98[b]	0.13	20.80±2.15[a]	0.2

N.B. Values in the same row followed by different letters are significantly different (P<0.05) because they were only given as much feed as the shrimp in group 1 but they were kept at a higher temperature and their feeding capacity was higher. However, in weeks 3 and 4 the shrimp in group 3 did not grow any faster than those in group 1 because the amount of ammonia and nitrite was higher than in groups 1 and 2 (Table 4) as a result of the larger amount of feed added each day.

Table 4. Water quality parameters during rearing period

Culture period (Days)	Treatment	pH	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L)	Ammonia-N (mg/L)	Nitrite-N (mg/L)
7	Group 1	7.62±0.12[a]	100.00±14.49[a]	5,681.33±199.11[a]	0.61±0.9[a]	4.67±0.59[a]
	Group 2	7.71±0.06[a]	86.22±22.96[a]	7,025.47±167.11[b]	1.34±0.29[b]	4.07±1.48[a]
	Group 3	7.70±1.00[a]	101.33±38.16[a]	7,025.78±200.42[b]	0.86±0.29[a]	4.45±1.57[a]
14	Group 1	7.76±0.03[a]	191.11±45.27[a]	6,337.78±70.87[a]	0.67±0.21[a]	7.49±0.88[a]
	Group 2	7.66±0.14[a]	101.33±37.25[a]	7,346.67±200.33[b]	1.02±0.33[a]	3.47±3.82[ab]
	Group 3	7.62±0.06[a]	268.22±122.76[a]	7,373.33±197.61[b]	0.91±0.42[a]	1.79±1.63[b]
21	Group 1	7.68±0.02[a]	138.89±32.39[a]	6,285.33±124.76[a]	0.67±0.72[a]	5.73±8.04[a]
	Group 2	7.67±0.03[a]	155.56±27.62[a]	8,548.89±473.81[b]	1.08±0.72[a]	66.67±23.09[b]
	Group 3	7.61±0.06[a]	188.44±68.02[a]	7,929.33±199.03[c]	1.50±0.0[a]	80.00±0.87[b]
28	Group 1	7.67±0.01[a]	99.33±40.61[a]	6,268.47±143.81[a]	0.25±0.00[a]	3.30±4.12[a]
	Group 2	7.65±0.05[a]	112.44±51.44[a]	8,919.56±856.87[b]	1.08±0.72[a]	58.20±37.41[b]
	Group 3	7.76±0.11[a]	151.11±68.70[a]	8,996.44±693.02[b]	1.58±1.37[a]	79.97±1.31[b]
35	Group 1	7.64±0.08[a]	96.22±38.71[a]	6,325.33±74.86[a]	1.17±1.58[a]	1.17±0.75[a]
	Group 2	7.57±0.03[a]	106.00±31.35[a]	7,931.11±255.82[b]	1.52±0.03[a]	79.67±0.86[b]
	Group 3	7.64±0.02[a]	147.56±29.33[a]	8,702.67±1,149.07[b]	2.00±0.87[a]	80.83±0.58[b]
42	Group 1	7.56±0.07[a]	102.90±2.03[a]	6,708.00±136.17[b]	0.67±0.72[a]	0.93±0.57[ab]
	Group 2	7.62±0.04[a]	104.00±0.15[a]	7,162.20±184.06[a]	2.83±0.29[b]	1.46±0.23[a]
	Group 3	7.55±0.05[a]	104.67±1.35[a]	6,350.53±240.04[b]	2.25±0.90[b]	0.63±0.57[b]
49	Group 1	7.57±0.03[a]	91.11±1.56[a]	6,839.10±243.59[b]	2.08±1.58[a]	0.28±0.02[a]
	Group 2	7.62±0.08[a]	91.67±0.51[a]	8,275.23±513.45[a]	4.83±0.28[a]	78.73±2.36[b]
	Group 3	7.62±0.06[a]	91.67±0.47[a]	7,039.56±16.65[b]	3.16±1.75[a]	0.57±0.25[a]

N.B. Values in the same column followed by different letters are significantly different ($P<0.05$)

Also, at this stage some of the shrimp in group 3 started to die probably because of the deteriorating water quality. When water was changed more frequently to improve water quality the shrimp in group 3 began to grow more quickly again. At the end of the experiment the shrimp in group 3 had the highest mean weight at 20.80 g but the survival rate was only 65%. By comparison, the average weight of the shrimp in group 1 was 20 g, which was not significantly different from group 3, but the survival rate was 96%, which was significantly different. Shrimp in group 2 (temperature at 33±1°C but fed the same amount as group 1) had the lowest growth rate with a final mean weight of only 18.20 g with a survival rate of 92%, which was significantly higher than that in group 3.

These results indicate that when the water temperature is higher than optimal and the shrimp are fed as much feed as they could consume at that temperature, the quality of water decreases until it is detrimental to the health of the shrimp. This will result in slower growth rate and eventually death if water is not changed or nothing is done to improve water quality.

In order to prevent this problem, the temperature should be managed so that it does not exceed 31°C by opening the plastic window to lower the temperature during the day (Figure 1.). If the temperature is still higher than 31°C, feeding should be kept at the same level as that at 29±1°C.

Figure 1. Plastic sheet should be opened to reduce temperature during hot days

2. Overfeeding

Overfeeding is a common problem when farmers determine the amount of feed to give based on the amount remaining in the feeding trays. Instead, farmers should set the maximum amount of feed to be given based on the density of shrimp. They should be aware of how many shrimp were stocked into each pond and should keep track of the survival rate to know how many shrimp are remaining before calculating the realistic amount of feed to give. For example, if one million shrimp were stocked and after 65 days they weigh an average of 12 g each with a survival of 80%, the appropriate amount of feed could be calculated as follows :

$$\text{Total shrimp weight} = 800{,}000 \times 12 \text{ g}$$

$$\text{Total feed} = \frac{3 \times 9{,}600{,}000}{100} = 288 \text{ kg}$$

(shrimp of average weight 12 g should eat 3% of their body weight each day). If the farmer has set the maximum feed limit at each stage then it will be unlikely that the shrimp will be overfed.

3. Over Frequent feeding

Normally white shrimp are fed 3 to 5 times a day. For instance, the feeding times might be 07:00, 11:30, 16:00 and 20:30, which is about 4.5 hours apart each time. This is suitable when the water temperature is 29±1ºC. On some farms, the shrimp are fed 4 times in the space of 9 hours in a working day, such as at 8:00, 11:00, 14:00, and 17:00, which is only about 3 hours apart each time. With this frequency, there is a high likelihood that feed will be left-over between feeding. In cases where it is not feasible to feed the shrimp after 17:00 because it would require higher labor costs, the way to solve the problem is to reduce the number of feedings between 8:00 and 17:00 to just 3, or to feed the shrimp at 8:00, 12:30 and 17:00. This will enable the shrimp to eat more efficiently and keep the FCR lower.

4. Too fast water current from aerators

Where shrimp are raised at high population densities, several aerators are required to keep the level of dissolved oxygen in the water high enough (more than 4mg/l) (Boyd, 1989; Limsuwan, 2000). However, in some farms the position of the aerators is not suitable, creating fast water current in the ponds, especially in ponds lined with polyethylene (PE). If all the aerators are operating during feeding, some of the feed might be carried to the middle of the pond by the water current. During the later stages of the culture period, large amounts of sediment and sludge tend to accumulate and if the pelleted feed is mixed into it, the shrimp will not be able to eat it and it will be wasted. The way to prevent the problem is to turn off some of the aerators during feeding time so that the water current will not carry the feed to the middle of the pond. However, all the aerators should never be turned off at the same time, especially when shrimp are bigger. (Figure 2)

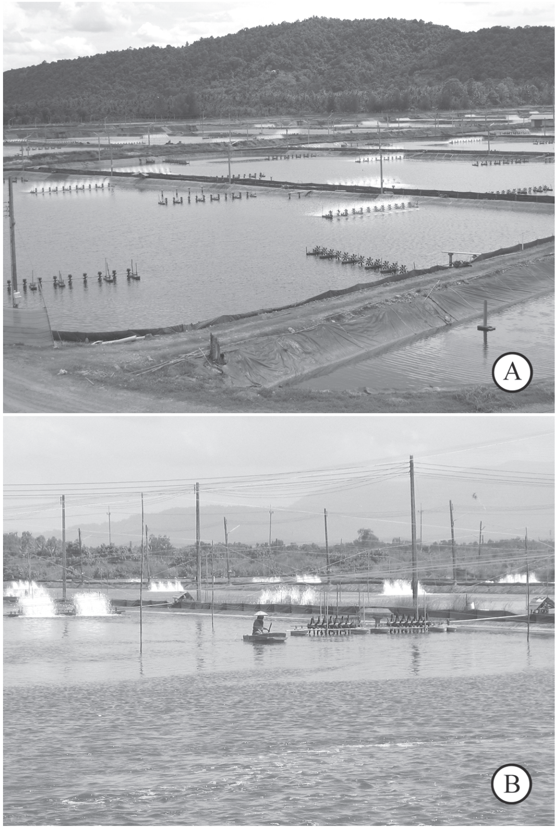

Figure 2. A,B Some aerators must be turned off during feeding.

5. Insufficient aeration

If there are not enough aerators to provide sufficient oxygen in the pond, the problem may not become apparent during the first 50 days of culture because water quality is still good, but after a certain amount of sediment accumulates the level of oxygen near the pond bottom will drop to below the optimum level for shrimp feeding and growth (lower than 4mg/l) (Boyd, 1989) (Figure 3). The shrimp will grow more slowly and will get weaker. At the center or middle of theponds in particular, sludge will build up until there is insufficient oxygen for the aerobic bacteria to continue breaking it down. Then anaerobic bacteria will take over the decomposition process, which means that decomposition will proceed more slowly and the bacteria will emit by-products which are harmful to aquatic animals, such as ammonia, nitrite and hydrogen sulfide (Hargreaves, 1988). In some cases where there are other complications such as low water alkalinity and pH due to a proliferation of snails or mussels (Limsuwan, 2000), the farmer may be forced to harvest the shrimp early. If the shrimp are raised to its full size, the FCR will be high as well as the cost of production. The way to prevent the problem of insufficient aeration is to restrict the number of shrimp released into each pond to within an appropriate number so that there will be sufficient oxygen and the pond bottom will remain acceptably clean throughout the culture period.

Figure 3. Grow-out pond with insufficient number of aerators

All of these five problems are common mistakes in shrimp feed management which the author has observed on many shrimp farms in several countries. The author hopes that the recommendations herein will be useful for shrimp farmers to apply to their own situation to improve efficiency and remain competitive during challenging economic times.

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