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Effects of feeding frequency on feed leaching loss and grow-out patterns of the white shrimp *Litopenaeus vannamei* fed under a diurnal feeding regime in pond enclosures

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Abstract

Feed management plays a major role in the economical and environmental status of shrimp farms. It involves basic aspects such as when, where and how much to feed. Studies were conducted under pond conditions in order to determine the effects of feeding frequency on the grow-out patterns of *Litopenaeus vannamei*. Feed loss of crude protein (CP), lipid and dry matter (DM) over different water exposure periods were also investigated. In a commercial shrimp farm, 25 open-bottom enclosures (5 treatments and 5 replicates) of 50 m^2 each were installed in a 7.43-ha grow-out pond and stocked at 80 shrimp/m^2 (2.7 ± 1.52 g body weight). Shrimp were fed a commercial pelleted feed, delivered exclusively in feeding trays 2 (at 0700 and 1700 hours), 3 (at 0700, 1100 and 1500 hours), 4 (at 0700, 1000, 1300 and 1500 hours), 5 (at 0700, 0900, 1200, 1500 and 1700 hours) and 6 times/day (at 0700, 0900, 1100, 1300, 1500 and 1700 hours). Feed was made available over continuous 24-h periods and remains were collected at next feeding. After 8 h of water immersion, feed CP and lipid level dropped from 39.58% to 34.07% and from 9.25% to 7.88%, respectively. Leaching of feed CP and lipid was not statistically different over the study period. Long feed water exposure generated significant losses in DM. Leaching of DM reached 4.65 ± 0.34% after the first hour of water immersion, peaking at 8 h (10.20 ± 0.48%). Shrimp were harvested at day 84 of grow-out, when average body weight ranged from 9.7 ± 1.75 to 10.9 ± 1.90 g. No shrimp performance benefit could be detected by adopting higher diurnal feeding frequencies. Although shrimp fed five times/day showed superior grow-out performance indices, at harvest no statistical differences were detected in shrimp survival (64.1 ± 11.7%), shrimp yield (0.46 ± 0.08 kg/m^2) and feed conversion ratio (2.85 ± 1.42) between feeding treatments. Also, no consistent growth pattern could be detected in relation to feeding treatments over the rearing cycle. The present study demonstrated that when feed rations are only adjusted at a weekly basis, using as the only criteria shrimp estimated biomass, delivering feed more than twice per day is not advantageous in the grow-out of *L. vannamei*.

Keywords: Shrimp; Feeding; Frequency; *Litopenaeus*

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1. Introduction

Production of farm-reared shrimp has increased significantly in tropical and subtropical areas of the world. In 2002, a total of 1,292,476 Mt of shrimp were harvested from aquaculture farms, accounting for more than US$ 7.3 billion in revenue (FAO, 2004). This rapid expansion has raised environmental concerns (Naylor et al., 2000), leading to a series of studies ranging from static and integrated farming systems (Burford et al., 2003; Wang, 2003), treatment of farm effluents (Tilley et al., 2002; Jackson et al., 2003) to the use of alternative ingredients in shrimp feeds (Smith et al., 2000; Forster et al., 2003).

Contradictorily, little attention has been given to the improvement of feed management practices, despite their potential to reduce economical and environmental pressure in shrimp farms. The tripod of traditional shrimp feed management combines population sampling to estimate gains of stocked shrimp biomass, the use of feeding tables to adjust weekly feed rations, and, sometimes, the daily monitoring of feed remains from feeding trays to serve as an indicator of feed consumption and population survival. Feeding rates, times of feed delivery, feeding frequency and feed dispersal method vary considerably depending on the farmed species, shrimp body weight, farm size, intensification level and water and feed quality. Although some countries have adopted more complex feeding protocols (Nunes and Suresh, 2001; Nunes, 2003, 2004), most feed management technologies have remained practically unchanged since the mid 1980s.

In shrimp grow-out, it has always been thought that a higher number of daily rations led to a faster shrimp growth, a better feed conversion efficiency and an improved water quality (Sedgwick, 1979; Robertson et al., 1993; Jaime et al., 1996). However, more recently, opposing data have suggested no benefit in multiple feed rations in *Litopenaeus vannamei* and *Penaeus monodon* culture (Velasco et al., 1999; Smith et al., 2002). Different from most Latin American countries, in Brazilian grow-out farms, shrimp are fed three to four times daily exclusively in feeding trays. In such conditions, feed delivery is conditioned to a diurnal feeding schedule to allow collection and visual accounting of feed remains and immediate adjustment of next meal. In general, feeding more than twice per day is not desirable in shrimp farming as it represents a more labor-intensive method. The present study aimed at evaluating the effect of feeding frequency on feed leaching loss and grow-out patterns of the white shrimp *L. vannamei* fed under a diurnal feeding regime in pond enclosures.

2. Material and methods

2.1. Study site and experimental design

The study was conducted in a 7.43-ha shrimp grow-out pond located in a commercial shrimp farm CEAQUA Ceará Aquacultura Ltda. The farm is situated in the northeastern region of Brazil at the latitude 04°09′7.8″ S and longitude 38°09′2.8″ W. The study consisted of five diurnal feeding frequencies 2, 3, 4, 5 and 6 times/day. Five replicates were assigned for each treatment, arranged in a Latin square design. Experimental units consisted of 25 open-bottom enclosures, with 50 m^2 (5 m in width and 10 m in length) internal area. Enclosures were built with a blue polyethylene 4.0-mm diameter mesh net with 1.90-m height (Tecelagem Roma Ltda., Tatuí, São Paulo, Brazil). They were spaced 11 m apart and placed 30 and 27 m from the pond walls and paddle-wheel aerators, respectively. Enclosure set-up followed the methodology described by Nunes and Parsons (1999).

2.2. Pond preparation

Enclosures were installed in the pond prior to water filling, but after soil drying, tilling and liming. Soil treatment started with sun-drying during a 30-day period. This was followed by liming with the application of 40 and 120 kg/ha of calcium hydroxide ($Ca(OH)_2$) in the internal water drainage canals and pond plateau, respectively. After 5 days, all remainder water puddles were sterilized with a total of 35 kg of liquid calcium hypochlorite. The following day, 7.4 kg/ha of 15–0–0 inorganic fertilizer with 3.5% SiO_2 and 25% Na (Nutrilake®, SQM Brasil, São Paulo, Brazil) were distributed over the pond internal water drainage canals. The pond bottom was