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The effects of the decomposition of mangrove leaf litter on water quality, growth and survival of black tiger shrimp (*Penaeus monodon* Fabricius, 1798)

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Abstract

An experiment was conducted for 8 weeks at the Cantho University, Vietnam, to determine the acceptable level of mangrove leaf litter load and its effect on water quality, growth and survival rate of tiger shrimp (*Penaeus monodon*). Shrimps were cultured in plastic tanks containing 50 L of brackish water (salinity of 15‰). Leaf litter of *Rhizophora apiculata*, *Avicennia officinalis*, *Excoecaria agallocha* and *Acacia auriculiformis* were loaded to tanks at rates of 0.0 (control), 0.125, 0.25, 0.5, 1.0 and 2.0 g L^{-1} with and without aeration. Tiger shrimp post-larvae (PL; 0.05 ± 0.01 g) obtained from the shrimp hatchery of Cantho University were stocked at a density of 20 PL per tank and fed with pelleted feed containing 38% protein at a rate of 10% body weight (BW) day^{-1}.

The high leaf-loading rates significantly reduced dissolved oxygen (DO) and survival rates of shrimp in the non-aerated treatments, and all shrimps died after 2 days in the treatments with loading rates above 0.5 g L^{-1}. Leaf litter loads significantly increased tannin content, chemical oxygen demand (COD), H_2S and pH in the aerated treatments. Stepwise regression analysis showed COD, tannin and H_2S concentrations had negative effects on shrimp growth in the aerated treatments. Tannin concentration was found to be highest in the treatments with *Excoecaria* (32 mg L^{-1}) and *Avicennia* (24 mg L^{-1}) leaves. However, there were no significant differences in growth and survival rates of shrimp among the aerobic treatments loaded with different leaf types. The results of this study showed that moderate load of mangrove leaves could play an important role in promoting shrimp growth and survival in aerobic condition. Mangrove leaves at a loading rate of 1 g L^{-1} positively influenced both the survival and growth rate of shrimps.
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Keywords: Mangrove leaves; Decomposition; *Rhizophora*; *Avicennia*; *Excoecaria*; *Acacia*; *Penaeus monodon*; Shrimp culture; Water quality

1. Introduction

Integrated mangrove–shrimp culture systems are well established in Asian countries such as Indonesia

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(Sukardjo, 2000), Malaysia (Sze and Ahmad, 2000), the Philippines (Aypa and Bagonguis, 2000), Thailand (Tanan and Tansutapanich, 2000), Myanmar (Win, 2000) and Vietnam (Tuan et al., 1997; Binh et al., 1997; Be, 2000; Johnston et al., 2000). This farming system has been developed to conserve mangrove resources and enhance economic gains to coastal farmers (Fitzgerald, 2000). Apart from shrimp, the farmers culture various aquatic organisms such as crabs, fish and bivalves (Takashima, 2000; Minh et al., 2001; Christensen, 2003) using various production practices. The mangroves, comprising both replanted and naturally grown trees and non-mangrove trees such as *Acacia*, cover 20–80% of farm area (Tuan et al., 1997; Takashima, 2000; Fitzgerald, 2000, Buu and Phuong, 2000). While some farmers grow mangroves and shrimp in separate areas of the farm, others use alternating rows to culture mangroves on the pond dikes (or platform) and shrimp in the adjacent ditches (or ponds) (Johnston et al., 2000; Fitzgerald, 2000). Fallen leaves from mangrove-forestry grown on the platform supply "green manure" to shrimp ponds that promote natural food webs in the integrated system (Fitzgerald, 2000). Wild shrimp juveniles are highly dependent on this mangrove detritus, which account for 84% carbon in the shrimp body (Chong et al., 2001). Recent intensification of shrimp sub-component using commercial feeds might have reduced the importance of fallen mangrove leaves in shrimp nutrition.

Despite the above advantages, concerns have been expressed on potential water and sediment quality deterioration caused by overloading of mangrove leaf litters (Johnston et al., 2000; Sukardjo, 2000; Fitzgerald, 2000) and reduction in natural food production (Alongi, 1987; Herrera-Silveira and Ramirez-Ramirez, 1996; Lee, 1999) in shrimp ponds. Extracts of some substances from root, bark and stems from some mangrove species have been reported to be toxic to fish and prawns (Krishnamoorthy et al., 1995; Madhu and Madhu, 1997). In this regard, there are several unanswered research questions. For example, what is the acceptable level of leaf litter fall into shrimp ponds? Do all mangrove species reduce water quality in shrimp ponds? Are some mangrove species more harmful than the others? The results of an experiment conducted at the Cantho University, Vietnam, to answer the above questions are presented in this paper. The experiment emphasized the effects of leaf litter-loading rates of three mangrove species, i.e., *Rhizophora apiculata*, *Avicennia officinalis* and *Excoecaria agallocha*, and one non-mangrove species *Acacia auriculiformis* that are commonly planted on the dykes of shrimp farms in the Mekong Delta, on water quality parameters, growth and survival of tiger shrimp (*Penaeus monodon*) juveniles under aerated and non-aerated dissolved oxygen (DO) regimes. The results presented in this paper are expected to be useful for improving integrated mangrove forestry–shrimp farm design.

2. Methods

An experiment was conducted for 8 weeks using four types of leaves (*R. apiculata*, *A. officinalis*, *E. agallocha* and non-mangrove *A. auriculiformis*), five loading rates, i.e., 0.125, 0.25, 0.5, 1.0 and 2.0 g dry weight (DW) L^{-1} and two aeration regimes (aerated and not aerated). The aerated and non-aerated control treatments without addition of leaves were employed to evaluate the treatment effect. Above loading rates were based on a field survey conducted to evaluate leaf litter fall on shrimp ponds and mangrove platform in the lower Mekong Delta (Hai, 2005).

A total of 126 circular plastic containers (70 L) were used for the experiment to provide each treatment with three replicates. The containers were placed outdoor under an opaque roof at the Cantho University, Vietnam. Brine water (120‰ salinity) was transported from a salt pan of Bac Lieu province of Vietnam, diluted to 15‰ using tap water, and treated with chlorine at 20 mg L^{-1}. The chlorinated brackish water was kept static for 1 day and then aerated for 5 days prior to use. Fifty liters of 15‰ water was transferred to the experimental containers. Water was not exchanged during the experiment to evaluate the cumulative effect of leaf decomposition on growth and survival of shrimp. Each tank in the aerated treatment was aerated using one air stone (diameter 2 cm) connected to an electric air blower.

Newly fallen or yellow leaves from the four plant species were collected from the Forestry-Fisheries Enterprise 184 in Ca Mau Province, Vietnam, and transported to the experimental site. The leaves were well mixed and random samples were wrapped in

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