UNIVERSITI PUTRA MALAYSIA

EFFECT OF WATER QUALITY AND MARINE PHYTOPLANKTON COMMUNITY STRUCTURE ON SHRIMP PRODUCTION IN TROPICAL PONDS

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By

MOHD ROZHAN BIN ZAKARIA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

June 2009

DEDICATION

This piece of work is dedicated to my wife and daughter, Rozaini and Raihana, my parents and the rest of my family members for their love, enthusiasm and inspiration…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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June 2009

Chairman: Fatimah Md. Yusoff, PhD

Faculty: Science

Production of giant black tiger shrimp (*Penaeus monodon*) in earthen ponds in the tropical region may vary as the pond matures, depending on water quality and phytoplankton community structure. The objectives of the present study were to determine water quality and marine phytoplankton succession in ponds of different ages, to nutritional value of isolated species of a dominant cyanobacterium in the shrimp ponds in comparison with a beneficial diatom and green alga and to investigate how phytoplankton community structure could be affected by alteration of macronutrient concentrations in mixed cultures. The field study was carried out in an intensive shrimp farm in Kuala Selangor, Malaysia. Phytoplankton and water samples were collected from ponds of different ages categorized as new (<1yr), intermediate (2-5yrs) and old (>10yrs), for 16 weeks of shrimp culture. Fluctuation of nutrient and chlorophyll-*a* concentrations were not different from other tropical

shrimp ponds in the region. Cyanobacteria (five genera), diatoms (24 genera), dinoflagellates (four genera) and green algae (three genera) were four dominant groups of phytoplankton found in all the shrimp ponds. Diatoms were dominant during the early stage of the culture in new ponds whilst blue–green algae dominated intermediate and old ponds throughout the culture period. Shrimp production in new ponds were significantly higher than intermediate and old ponds ($p<0.05$) probably due to the abundance of diatoms at the beginning of the culture cycle, suitable as live feed for zooplankton and shrimp larvae. *Pseudanabaena tenuis* was found abundant in all pond categories throughout the culture period. The cyanobacterium was isolated for surface structure and proximate analysis in the laboratory. Result showed that *P. tenuis* have lower nutritional value in comparison with a common diatom (*Chaetoceros calcitrans*) and a green alga (*Chlorella pyrenoidosa*), indicating that is was not part of consumable algae among grazers. All the above microalgae species were used in the nutrient enrichment bioassays in the laboratory to determine the growth and competition among species when grown singly and in mixed cultures. The result showed that the diatom grew well in single cultures and competed successfully over other microalgae in mixed cultures when silica concentrations increased whilst other essential growth nutrients were not limited. This present research gives an idea of how shrimp production in ponds of different ages could be affected by water quality and phytoplankton community structure and how alteration of nutrient concentrations could be use to stimulate growth of beneficial algae and suppress harmful algae in mixed culture systems which need further research for better understandings.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN KUALITI AIR DAN STRUKTUR KOMUNITI FITOPLANKTON MARIN KE ATAS PENGELUARAN UDANG DALAM KOLAM TROPIKA

Oleh

MOHD ROZHAN BIN ZAKARIA

Jun 2009

Pengerusi: Fatimah Md. Yusoff, PhD

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Penghasilan udang harimau (*Penaeus monodon*) dari kolam-kolam tanah di kawasan tropika mungkin berbeza dengan peningkatan umur kolam, bergantung kepada kualiti air dan struktur komuniti fitoplankton. Objektif kajian ini adalah untuk menentukan kualiti air dan struktur fitoplankton marin pada kolam-kolam udang berlainan umur, mengkaji struktur permukaan serta analisis proksimat spesis sianobakteria dominan dalam kolam udang dengan membuat perbandingan ke atas sejenis diatom dan alga hijau bermanfaat serta mengkaji bagaimana pengubahsuaian kepekatan nutrien boleh memberi kesan ke atas struktur komuniti fitoplankton dalam kultur campuran. Kajian lapangan telah dijalankan di sebuah ladang ternakan udang di Kuala Selangor, Malaysia. Sampel air dan fitoplankton telah diambil dari kolam-kolam pelbagai peringkat umur yang dikategorikan sebagai kolam baru (< 1 tahun),

kolam pertengahan (2-5 tahun) dan kolam lama (>10 tahun) selama 16 minggu masa penternakan. Fluktuasi kepekatan nutrien dan klorofil-*a* tidak berbeza dari ladang ternakan udang lain. Sianobakteria (lima genera), diatom (24 genera), dinoflagelat (empat genera) dan alga hijau (tiga genera), merupakan empat kumpulan besar fitoplankton yang terdapat dalam kolam-kolam tersebut. Diatom merupakan kumpulan dominan dalam kolam baru semasa peringkat awal penternakan udang sementara alga biru hijau adalah dominan di dalam kolam pertengahan dan kolam lama sepanjang tempoh penternakan. Penghasilan udang dalam kolam baru adalah lebih tinggi dengan perbezaan yang nyata ($p<0.05$) berbanding kolam pertengahan dan kolam lama, yang berkemungkinan disebabkan oleh kelimpahan diatom yang sesuai sebagai makanan hidup untuk zooplankton dan larva udang semasa peringkat awal penternakan. *Pseudanabaena tenuis* didapati mempunyai kelimpahan yang tinggi dalam setiap kategori kolam sepanjang tempoh penternakan. Sianobakterium tersebut telah dipencilkan untuk kajian struktur permukaan dan analisis proksimat di dalam makmal. Keputusan mendapati bahawa *P. tenuis* mempunyai nilai nutrisi yang rendah jika dibandingkan dengan sejenis diatom (*Chaetoceros calcitrans*) dan alga hijau (*Chlorella pyrenoidosa*) di mana ianya menunjukan bahawa sianobakterium tersebut bukanlah pilihan sebagai makanan hidup di kalangan peragut. Kesemua spesies mikroalga tersebut telah digunakan untuk bioesei nutrien di dalam makmal untuk mengetahui pertumbuhan dan persaingan setiap spesies apabila dikultur secara berasingan dan di dalam kultur campuran. Keputusan menunjukan bahawa diatom tersebut mempunyai pertumbuhan yang baik serta mampu mengatasi spesis mikroalga lain dengan peningkatan kepekatan silika sementara kepekatan nutrien lain yang penting untuk pertunbuhan adalah tanpa had. Penyelidikan terkini ini telah menyumbang kepada idea bagaimana kualiti air dan struktur komuniti fitoplankton

boleh memberi kesan ke atas penghasilan udang dalam kolam yang berlainan peringkat umur. Penyelidikan ini juga membolehkan kita mengetahui bagaimana pengubahsuaian kepekatan nutrien boleh meningkatkan pertumbuhan alga yang berguna di samping mengurangkan pertumbuhan alga yang tidak dikehendaki di dalam sistem kultur campuran yang memerlukan kajian lebih lanjut untuk pemahaman yang lebih berkesan.

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I certify that an Examination committee met on 16th June 2009 to conduct the final examination of Mohd Rozhan Bin Zakaria on his degree thesis entitled 'Marine Phytoplankton Community Structure of Tropical Shrimp Ponds' in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the Master of Science.

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Masters of Science. The members of the Supervisory Committee were as follows:

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Date: 16 October 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MOHD ROZHAN BIN ZAKARIA

Date:

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
Chl-*a*	Chlorophyll-*a*
1DHA	docosahexaenoic acid
DO	dissolved oxygen
EPA	eicosapentaenoic acid
N	north
$NaNO_2$	anhydrous sodium nitrite
NH_3^+	ammonia
NH_3-N	ammonia-nitrogen
NH_4^+	ammonium
NO_2^-	nitrite
PL	postlarvae
PUFA	polyunsaturated fatty acid
rpm	rotation per minute
SFA	saturated fatty acid
SGR	specific growth rate
TAN	total ammonia nitrogen
TP	total phosphorus

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Intensive marine shrimp farming has steadily increased over the last decades in order to meet the world's market demand although the industry has suffered major problems in sustaining the growth of shrimp aquaculture such as disease outbreak, environmental degradation and poor management. Marine shrimp, the giant black tiger prawn, *Penaeus monodon* has attracted much attention from aquaculturists in the Asia and Pacific region due to the technological breakthroughs in its life cycle control (Samocha, 2004), the development of a variety of commercial feeds along with the establishment of more efficient farming practices and firm market prices and demand (Kuperan, 1988). However, according to Sampaio *et al* (as cited in Case, Lec, Leitao, Anna, Schwamborn, and Junior, 2008), rapid development in the shrimp aquaculture industry has been accompanied by increasingly controversial debates over the environmental, social, and economic impacts. In Malaysia, *P. monodon* production varies from one farm to the other depending on the pond sediment quality, water source and application of responsible aquaculture practices (FAO, 1997).

Yusoff *et al.* (2002) demonstrated that shrimp production was closely related to the quality of the water used for the shrimp farming. Water quality in shrimp ponds usually deteriorates with the progressed culture period due to the accumulation of

organic matter from excess feed and metabolites. Briggs and Funge-Smith (1994) reported that only 15% of the feed was converted into fish flesh whilst the rest went into the water and sediment. Changes in water quality and increased availability of nutrients affect the phytoplankton composition in shrimp ponds. Phytoplanktons are microscopic algae which have the ability to float and derive light as the source of energy to produce their own food. These organisms are the primary producers in the aquatic environment. It is accepted by pond managers that shrimp production is better if there is a stable and relatively high abundance of beneficial phytoplankton species such as diatoms and low in harmful ones such as cyanobacteria and dinoflagellates (Alonso-Rodriguez and Paez-Osuna, 2003).

Noxious species of blue-green algae like *Oscillatoria* spp., *Pseudanabaena* spp. and *Microcystis* spp. caused water deterioration and give bad odor to shrimp flesh (Izaguirre and Taylor, 1998), whilst certain species of dinoflagellates such as *Alexandrium tamarense,* has been reported to cause mortality of *Penaeus monodon* in Taiwan in 1989 (Huei-Meei *et al.*, 1993). On the other hand, diatom species such as *Chaetoceros calcitrans,* and *Skeletonema costatum* and certain chlorophytes such as *Chlorella* sp., *Tetraselmis tetrahele*, *Isochrysis* sp. and *Nannochloropsis oculata* have long been used as live feeds in aquaculture as they are highly nutritious especially in long-chain polyunsaturated fatty acids (PUFA's) (Brown *et al.*, 1989; Molina Grima *et al.*, 1995; Viron *et al.*, 2000). In semi intensive shrimp farming system with large ponds, these live feeds are most likely important as a food source than the meager amount starter feed that the farmers habitually throw into the pond at the beginning of the rearing cycle (Fujimura, 1991). Therefore, in most aquaculture system such as marine shrimp ponds, fertilizers are often applied to promote

beneficial phytoplankton growth (Alonso-Rodriguez and Paez-Osuna, 2003). This is accomplished by repeated small amounts of fertilizers that results in an N:P ratio of 20:1 (Boyd and Daniels, 1994). If the nutrients are not consistently supplied, depression of phytoplankton population will occur and consequently cause slow growth of the marine shrimp itself (Hunter *et al.*, 1987).

Yusoff *et al.* (2002) reported that there was a shift from the dominance of beneficial phytoplankton species at the beginning of culture period, to the noxious species of cyanobacteria after a month of culture. Species succession in aquatic environments starts with small flagellates and diatoms, followed by dinoflagellates which are relatively bigger in size. Cyanobacteria are usually the dominant species at the final step as they can thrive under stressful conditions for other organisms and when nitrogen compounds are scarce.

Phytoplankton succession either in the field or experiments such as in mixed cultures is important as some researchers argue that studying the behavior of phytoplankton in pure cultures are particularly unnatural since the phytoplankton community is never wholly monospecific (Fogg and Brenda, 1987). Experiments were done to determine the interaction, competition and succession between different species of phytoplankton in a mixed culture towards environmental factors such as temperature, light intensity and nutrient availability. Harrison and Davis (1979) analyzed factors influencing species selection outdoor for continuous phytoplankton cultures while studies by D' Elia *et al.* (1979) and Regan and Ivancic (1984) dealt with mixed cultures under laboratory conditions. However, there is a paucity of information on growth characteristics, biochemical composition and nutritive value of mixed culture