UNIVERSITI PUTRA MALAYSIA

IDENTIFICATION AND DIVERSITY OR TERMITE (INSECTA: ISOPTERA) IN OIL PALM PLANTATION ON PEAT SOIL IN SARAWAK, MALAYSIA

KON THIAN WOEI

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By

KON THIAN WOEI

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

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

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By

KON THIAN WOEI

May 2013

Chairman: Associate Professor Joseph Bong Choon Fah, PhD.

Faculty: Agriculture and Food Sciences, Bintulu.

Termites are the major decomposers in tropical region but yet their occurrences in oil palm plantation especially in peat soil are generally treated as pest. Three sampling plots of oil palm plantations in peat area with different years of palm establishment period were selected in the central region of Sarawak. These were Semanok (SM), Setuan (ST) and Sessang (SS), with years of oil palm establishment at 5-7, 6-8, 13-15 years in the sampling plot respectively. Modified belt transect sampling (50 × 6 m) was used to sample termites species. Soil block (25 × 25 × 30 cm) was collected from each of 10 points in a 50 × 50 m plot at SM site for soil macro-invertebrate study. Modified transect sampling had successfully sampled a total of 18 species of termites from 2 families (Rhinotermitidae and Termitidae), 5 subfamilies (Rhinotermitinae, Coptotermitinae, Termitinae, Macrotermitinae and Nasutitermitinae) and 11 genera (*Coptotermes, Schedorhinotermes, Termes, Macrotermes, Nasutitermes, Globitermes, Amitermes, Parrhinotermes, Pericapritermes, Havilanditermes* and *Prohamitermes*). A new species of genus

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Nasutitermes was found with close relationship with *N. regularis*. Highest species diversity was shown on site SS (H'= 2.118), followed by ST (H'= 2.048) and SM (H'= 2.002). SM and ST site shared the most similar species as compared to SS site. All plantation sites have termite dominantly feeding on rotten wood as a result of abundant dead woods in the peat soil after site clearing. This also brings the high species richness of wood-nester in SM and ST sites. Site SS had both wood nester and hypogeal nester being the highest nesting groups. Study also showed higher encounter of soil-feeding termite in longer established plantation. It indicates the gradual shifting of soil condition towards a stabilized environment which favours the successful settlement of soil feeder termite species. Results of soil invertebrate sampling in SM site showed highest species diversity in 0-10 cm layer of soil (H'= 2.25), followed by 10-20 cm (H'= 1.45) and 20-30 cm (H'= 0.74). While termite was significantly higher in relative density with increasing depth of soil (0-10 cm= 21.23%, 10-20 cm= 42.52% and 20-30 cm= 81.12%) which could be advantaged from being preyed by ants (Hymenoptera: Formicidae) which were higher in density from soil surface to 10 cm soil depth with relative density of 31.84%. Drained peat soil allowed the presence of soil invertebrates including termites, which also indicated their high tolerance to soil acidity. It is evident from this study that termite which had the ability to kill oil palm tree was attributed to *Coptotermes curvignathus*. Morphological study of distance of mandible tooth on worker termites showed significant difference among species under genus *Coptotermes*, *Schedorhinotermes* and *Nasutitermes*. Femur-tibia index also showed significant differences among species of genus *Coptotermes, Schedorhinotermes* and *Nasutitermes*. Hence, these new morphometric keys might be able to help differentiate termite which has similar morphological appearance. Molecular

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identification by mitochondrial DNA cytochrome oxidase II (COII) gene and 16S rRNA gene were shown to be able to identify termite species down to genus level. Identification down to species level depends on the availability of gene sequence deposited in the database. Nevertheless, the importance of conventional method shall not be ignored but to work out with molecular method for more convincing termite identification as well as to help in inferring phylogeny relationship of termite species.

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Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGENALPASTIAN DAN DIVERSITI ANAI-ANAI (INSECTA: ISOPTERA) DI LADANG KELAPA SAWIT BERTANAH GAMBUT DI SARAWAK, MALAYSIA

Oleh

KON THIAN WOEI

Mei 2013

Pengerusi: Profesor Madya Joseph Bong Choon Fah, PhD.

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Anai-anai merupakan pengurai yang utama di kawasan tropika. Namun kewujudan mereka di kawasan ladang kelapa sawit terutamanya di kawasan tanah gambut sering dianggap sebagai perosak. Tiga ladang kelapa sawit bertanah gambut telah dipilih dari kawasan pertengahan Sarawak sebagai tapak persampelan iaitu Semanok (SM), Setuan (ST) dan Sessang (SS) masing-masing mempunyai tahun penanaman 5-7 tahun, 6-8 tahun dan 13-15 tahun. Persampelan spesis anai-anai dilakukan dengan menggunakan kaedah persampelan jalur transek yang diubah-suai (50 × 6 m), manakala persampelan makro-invertebrata dilakukan dengan mengumpul blok tanah berukuran 25 × 25 × 30 cm untuk 10 titik kawasan dalam satu plot berukuran 50 × 50 m. Kaedah persampelan jalur transek yang diubah-suai telah berjaya mengumpul sejumlah 18 spesis dari 2 famili (Rhinotermitidae dan Termitidae), 5 subfamili (Rhinotermitinae, Coptotermitinae, Termitinae, Macrotermitinae dan Nasutitermitinae) dan 11 genera (*Coptotermes, Schedorhinotermes, Termes, Macrotermes, Nasutitermes, Globitermes, Amitermes,*

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Parrhinotermes, Pericapritermes, Havilanditermes dan *Prohamitermes*). Satu species terbaru daripada genus *Nasutitermes* telah dijumpai di mana ia mempunyai hubungan rapat the *N. regularis*. Kawasan SS mencatat kepelbagaian spesis yang tertinggi (H'= 2.118), diikuti dengan kawasan ST (H'= 2.048) dan kawasan SM (H'= 2.002). Perbandingan ketiga-tiga kawasan menunjukkan spesis di kawasan SM lebih menyerupai spesis di kawasan ST berbanding dengan kawasan SS. Kayu reput yang banyak dalam tanah gambut selepas pembersihan tapak penanaman di semua kawasan ladang menyebabkan kebanyakan anai-anai adalah yang memakan kayu reput. Ini juga membawa kepada spesis anai-anai bersarang dalam kayu yang banyak di kawasan SM dan ST. Manakala kawasan SS pula mempunyai spesis bersarang dalam kayu dan hypogeal yang terbanyak berbanding dengan kaedah bersarang yang lain. Kajian ini juga menunjukkan lebih banyak anai-anai yang memakan tanah ditemui di kawasan ladang yang lebih lama. Ini menunjukkan keadaan tanah berubah secara beransur-ansur kepada persekitaran yang stabil di mana spesis anai-anai yang memakan tanah boleh mendiami kawasan tersebut dengan berjaya. Keputusan persampelan makro-invertebrate di kawasan SM menunjukkan kepelbagaian spesis yang tertinggi di antara lapisan tanah 0-10 cm (H'= 2.25), dikuti dengan lapisan 10-20 cm (H'= 1.45) dan lapisan 20-30 cm (H'= 0.74). Kepadatan relatif anai-anai pula meningkat dengan peningkatan kedalaman tanah (0-10 cm = 21.23%, 10-20 cm = 42.52% dan 20-30 cm = 81.12%) di mana ia boleh mengelak daripada dimakan oleh semut (Hymenoptera: Formicidae) yang mempunyai kepadatan relatif yang tinggi pada lapisan tanah 0-10 cm (31.84%). Tanah gambut yang telah disalirkan air membolehkan invertebra tanah termasuk anai-anai wujud di kawasan tersebut. Ini juga menunjukkan anai-anai mempunyai daya toleransi yang tinggi dengan keasidan tanah. Kajian ini membuktikan anai-anai

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Coptotermes curvignathus bekerupayaan menyebabkan kematian pokok kelapa sawit. Kajian morfologi jarak gigi rahang bawah anai-anai pekerja menunjukkan perbezaan yang nyata bagi spesis dibawah genus *Coptotermes*, *Schedorhinotermes* dan *Nasutitermes*. Indeks femur-tibia juga menunjukkan perbezaan diantara spesis bawah genus *Coptotermes*, *Schedorhinotermes* dan *Nasutitermes*. Justeru, kedua-dua kunci morfometrik yang baru ini berupaya membantu membezakan anai-anai yang mempunyai penampilan morfologi yang serupa. Pengenalpastian secara molekular dengan menggunakan gen DNA mitokondria cytochrome oxidase II (COII) dan 16S rRNA menunjukkan keupayaan pengenalpastian spesis anai-anai ke tahap genus. Pengenalpastian sampai tahap spesis bergantung kepada maklumat susunan gen yang ada dalam pangkalan maklumat. Namun demikian, kepentingan kaedah konvensional tidak harus diketepikan tetapi harus digunakan sejajar dengan kaedah molekular untuk pengenalpastian yang lebih menyakinkan serta membantu dalam kajian hubungan filogeni pada spesis anai-anai.

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I certify that a Thesis Examination Committee has met on 31 May 2013 to conduct the final examination of KON THIAN WOEI on his thesis entitled "Identification and Diversity of Termite (Insecta: Isoptera) in Oil Palm Plantation On Peat Soil in Sarawak, Malaysia" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. Members of the Supervisory Committee were as follows:

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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.

_____

KON THIAN WOEI

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LIST OF ABBREVATIONS

EDTA	Ethylenediaminetetraacetic acid
UV	Ultra-violet
TBE	Tris-borate EDTA
BLAST	Basic Local Alignment Search Tool
°C	Degree Celcius
PCR	Polymerase Chain Reaction
MgCI	Magnesium Chloride
dNTP	Deoxy nucleotide triphosphate
DNA	Deoxy ribonucleic acid
rRNA	Ribosomal ribonucleic acid
H’	Shannon Index
E	Evenness
D	Simpson Index
G	Gravity
GB	Gel binding

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CHAPTER 1

INTRODUCTION

Oil palm, (*Elaeis guineensis* Jacq.) is an indigenous plant of West Africa and was first introduced into Malaysia in the early 1870's. The first commercial oil palm planting was commenced in 1917 in Tennamaram Estate, Selangor. It was not until the late 1950's, when Malaysia faced the sharp decline in natural rubber price, that the oil palm cultivation kicked-off with rapid expansion following recommendation from World Bank Mission in 1955, as well as government diversification policy to reduce dependence on natural rubber and to solve issue of rural poverty and landlessness. Millions of hectares of lands have been converted to oil palm plantation ever since to meet the increasing global demand of palm oil, especially when its commercial potential as biodiesel had been introduced lately as a way to reduce automobile pollution to the environment. The development of oil palm industry had hence not only promotes national growth and development, but also contributes to poverty eradication among rural populace.

Oil palm trees were initially planted mostly in mineral soil. Later, due to the shortage of mineral soil and remaining lowland forest dwindles as a result of rapid infrastructures development, oil palm cultivation has ventured into peat soil. As with mineral soil, oil palms in peat are also prone to attack by pests such as rhinoceros beetles, bagworms, and termites.

Termites, which are the most dominant invertebrate living socially in tropical ecosystem, belong to order Isoptera. This particular group of soil organism is part of

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the natural ecosystem, and presence of termites is not, by itself, evidence of a pest problem. Of more than 2800 described species of termite in the world, only about 185 species are pests which constituted about 6.6% of the total discovered termite species (Verma *et al*., 2009). Termites are considered as pest when economic damage is caused by termite activities. It is their diets which are mainly of wood and cellulotic plant materials, which lead them to be recognized as a destructive pest when they damage the wooden structure of building, wood furniture, paper, cloth, tree plantation like oil palm and rubber, fruit trees and growing crops, causing a steady loss of property and amenity. Global damage caused by termites are in the billions (USD) each year (Lewis, 2006). Latest estimates of termite damage in Malaysia are hardly available in published literatures. However, Lee (2002a) had reported that the cost for termite control has accounted for 50% of the pesticide industry's business, hitting a total of USD10 million in year 2000. The lack of knowledge on biology and behaviour of termite species has made the oil palm industry rely heavily on chemical insecticide to control and eliminate termites.

There have been many ecological studies concerning termite in Malaysia and most of the studies were conducted in Peninsular Malaysia primarily in rainforests. In East Malaysia, termite study can be tracked back to 1984 in Sabah where Thapa (1981) had published a book entitled '*Termite of Sabah*' from which the termite samples were collected within the state of Sabah and some parts in Sarawak. This book together with the book '*Termite of Peninsular Malaysia*' by Tho (1992) had become the major source of references by local termite researchers for termite identification. Nevertheless, the available data do not represent the entire environment notably in the state of Sarawak that is favourable for termite activity.

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Hence, this study was intended to provide a better understanding of termite occurring in peat soil that will eventually contribute towards effective oil palm management strategies as well as biodiversity conservation of fauna in peat area plantation.

Identification of termite species was generally relied on morphological characteristics in the old days. This technique is still widely used by biologist at present as it provides a convenient and cheap identification system (Kirton, 2005). Advanced techniques are coming up to assist in more accurate species identification especially when dealing with two morphologically almost identical species (Kirton, 2005). Hence this study was carried out to assess new morphometric keys for species identification and differentiation, as well as comparing the ability of two genetic markers in identification of termite species.

As biodiversity and conservation publication particularly in oil palm plantation was mostly on mammals and birds but less on insect (Turner *et al.*, 2008), this project was, therefore, initiated with the objectives:-

1. To evaluate termite species richness and functional group composition in oil palm plantation in peat soil and their ecological roles.
2. To identify the termite species through morphological and molecular approaches.

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LIST OF PUBLICATIONS

1. Kon, T.W., C.F.J. Bong, J.H.P. King and C.T.S. Leong. 2012. Biodiversity of termite (Insecta: Isoptera) in tropical peat land cultivated with oil palms. *Pakistan Journal of Biological Sciences* **15**(3): 108-120. DOI: 10.3923/pjbs.2012.108.120

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