SPECIES COMPARISON OF TERMITES (ISOPTERA) IN PRIMARY FOREST OF TAWAU HILLS PARK, SABAHAND ADJACENT COCOA PLANTATION AREA

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THIS THESIS IS SUBMITTED AS A PARTIAL REQUIREMENT TO OBTAIN BARCHELOR OF SCIENCE (Hons.) DEGREE

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I declare that this dissertation is my own work with the exception that all short forms and quotes are stated their sources for each of them.

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ABSTRACT

A study of termite diversity was carried out from December 2005 to January 2006 at primary forest of Tawau Hills Park and a cocoa plantation in Tawau, Sabah. The objectives of this study were to determine termite diversity in Tawau Hills Park, to compare the termite diversity between primary forest and cocoa plantation and also to determine how forest changes affect termite diversity. Three standardized transect sampling (100m x 2m) were conducted on each site. A total of 23 species of termite were encountered in this study. Shannon-Wiener diversity index showed that primary forest had significantly higher species diversity (1.19) compared to cocoa plantation (0.37). Termite assemblages and feeding group structure also differed significantly between the two sites. Four feeding group of termite were collected in primary forest but wood-feeders were found more abundant in cocoa plantation. Conversion of primary forest into cocoa plantation significantly increased light intensity, lowered soil moisture, lowered food supply (soil nutrient and dead tree logs) and also intensely increased human disturbance. This suggested that conversion tend to decrease termite diversity. However, there was no significant correlation between environmental variables and species encountered in this study.

ABSTRAK

Satu kajian telah dijalankan dari Disember 2005 sehingga Januari 2006 di hutan primer Taman Bukit Tawau dan sebuah ladang koko di Tawau, Sabah. Objektif kajian ini adalah menentukan kepelbagaian anai-anai di Taman Bukit Tawau, membandingkan kepelbagaian anai-anai antara hutan primer dengan ladang koko serta menentukan pengaruh perubahan hutan terhadap kepelbagaian anai-anai. Tiga persampelan transek piawai (100m x 2m) dijalankan di setiap kawasan kajian. Sebanyak 23 spesies anai-anai telah ditemui dalam kajian ini. Indeks kepelbagaian Shannon-Wiener telah menunjukkan bahawa hutan primer mempunyai kepelbagaian anai-anai yang lebih tinggi secara signifikan (1.19) berbanding dengan ladang koko (0.37). Kelompok anai-anai dan struktur pemakanan anai-anai juga berbeza antara dua kawasan kajian ini. Empat struktur pemakanan anai-anai telah ditemui di hutan primer. Walaubagaimanapun, pemakan kayu didapati lebih banyak terdapat di ladang koko. Penukaran hutan primer kepada ladang koko telah meningkatkan keamatan cahaya, menurunkan kelembapan tanah, mengurangkan bekalan nutrisi (nutrisi tanah dan batang kayu mati) secara signifikan dan juga menambahkan gangguan manusia dengan kadar yang mendadak. Ini mencadangkan bahawa penukaran hutan primer kepada ladang koko akan menurunkan kepelbagaian anai-anai. Walaubagaimanapun, hubungan korelasi yang signifikan tidak wujud antara pembolehuabah persekitaran dengan jumlah spesies yang ditemui dalam kajian ini.

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%	percent
˚C	degree Celsius
g	gram
yr	year
a.s.l.	above sea level
ha	hectare
ft	feet
cm	centimeter
km	kilometer
m	meter
μ	micro
mol	molar
H_2O	water
C	carbon
H	hydrogen
Π	pi
L	length
D	diameter
ppm	parts per million
vol	volume

CHAPTER 1

INTRODUCTION

1.1 Termite

Termites are eusocial insects which belong to the order Isoptera and usually known as "white ants" (Lee & Wood, 1971). Termites comprise of about 281 genera and over 2600 described species (Kambhampati & Eggleton, 2000). Isoptera consists of seven families that are phylogenetically separated into lower and higher termites. Mastotermitidae, Kalotermitidae, Hodotermitidae, Termopsidae, Rhinotermitidae and Serritermitidae make up the lower termites while Termitidae is considered as the higher termites. The termite fauna of Peninsular Malaysia is represented by three families. These families are Kalotermitidae, Rhinotermitidae and Termitidae, which comprise a total of about 175 species from 42 genera (Tho, 1992).

Ahmad (1968) and Thapa (1981) are among the earliest researchers who carried out research projects of termites in Malaysia. Thapa (1981) produced his monograph entitled 'Termites of Sabah' which increase the information about termites in our country.

Collins (1984) had published and compared the termite species found in West Malaysia and East Malaysia. He recorded about 106 species of termites in West Malaysia and 97 species of termites in Sabah and Sawarak. He also asserted a total of 72 termite species in Mulu, Sarawak.

The present studies of termite assemblages in Sabah have shown that Sabah is rich in termite diversity. Homathevi (1999) had collected 38 species of termites from Danum Valley Conservation Area, 26 species of termites from Tabin Core Area, 21 species of termites from Kabili-Sepilok Forest Reserve, 14 species of termites from Gunung Rara Forest Reserve, 16 species of termites from Serimsim and 28 species of termites from Tawau Hills Park. Johnathen (2003) had compared the termite species that were found in Tunku Abdul Rahman Park Islands. He had found 17 species of termites in Manukan Island, 8 species of termites in Memutik Island, 16 species of termites in Gaya Island, 15 species of termites in Sulug Island and 15 species of termites in Sapi Island. All the termite species found in the islands belong to the Rhinotermitidae and Termitidae families.

1.2 Research justification

This research aims to obtain a list of termite species which can be found in the Tawau Hills Park, using the standardized termite diversity assessment protocol developed by Eggleton *et al.* (1999). This research also aims to compare the termite diversity between undisturbed area and disturbed area. Due to the financial limitation and time constrain, this research was only carried out in the primary forest and cocoa plantation. The primary forest is identified as the undisturbed area while the cocoa plantation is identified as the undisturbed area. The parameters which were measured in this study are the soil chemical, soil moisture and light intensity.

1.3 Objectives

The objectives of this study are:

a. To determine the termite diversity in Tawau Hills Park

b. To compare the termite diversity between the primary forest and the cocoa plantation

c. To determine how forest changes affect the termite diversity

1.4 Hypothesis

The hypothesis of the study is converting the forest into cocoa plantation area will reduce the termite diversity compared to the primary tropical rainforest of Tawau Hills Park which are undisturbed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The termites (order Isoptera) are a group of hemimetabolous eusocial insects allied to the cockroaches (order Blattodea) (Lavelle, 2001). Recent morphological and molecular studies supported a scheme in which cockroaches and mantids are sister groups and termites are a sister group to the cockroaches-mantids clades (Thorne & Carpenter, 1992; Kambhampati, 1996).

The order Isoptera comprises more than 2,400 currently-described species in 271 genera divided among seven families. Many species still remain to be described, particularly in the tropical and sub-tropical regions (Eggleton *et al.*, 1996). Termite diversity and composition are highly variable across continents and along latitudinal gradients which are predominantly due to the climatic and geological history of landmasses and ecological zones (Bignell & Eggleton, 2000).

Termites can be distinguished from ants (order Hymenoptera) by having both female and male soldiers and workers while ants only have female soldiers and workers. The second important characteristic is that termites, being hemimetabolous insects, have a gradual and progressive development through a series of nymphal instar, instead of beginning life as helpless larvae (Barrington, 1979).

2.2 Classification of termites

Termites comprise of roughly 281 genera and 2600 described species that can be fit in seven families (Kambhampati & Eggleton, 2000). Termite families can be divided into two groups, 'lower termites' and 'higher termites' based on the composition of the symbiont microbiota in the termite's gut. The guts of the 'lower termites' contain flagellate protozoans and bacteria while the guts of the 'higher termites' contain a variety of prokaryotic microbes that do not have flagellate (Homathevi, 1999).

The 'lower termites' comprise of six families which are Mastotermitidae, Kalotermitidae, Hodotermitidae, Termopsidae, Rhinotermitidae and Serritermitidae while the higher termites comprise of only one family which is Termitidae. In Malaysian forest, only three families were recorded and they are Kalotermitidae, Rhinotermitidae and Termitidae.

2.2.1 Kalotermitidae

The Kalotermitidae is the widest global distribution dry-wood termite family which can be found in tropical forest canopies (Eggleton & Tayasu, 2001). These termites are characteristically single-piece, wood-feeding termites but some exception does arise such as the kalotermitid *Paraneotermes simplicornis* which is an intermediate nester (Bignell & Eggleton, 2000).

According to Krishna (1970), this family includes 25 genera with four genera are known from Tertiary fossils (*Eotermes, Prokalotermes, Proelectrotermes* and *Electrotermes*) and five from both living and fossil species (*Neotermes, Kalotermes, Calcaritermes. Incisitermes* and *Cryptotermes*). Tho (1992) states that *Cryptotermes, Glyptotermes and Neotermes* are cosmopolitan in distribution and occur widely in the Indo-Malayan region.

2.2.2 Rhinotermitidae

Rhinotermitidae are wood-feeding termite family which is widely distributed across tropical, subtropical and temperate regions (Bignell & Eggleton, 2000). The Rhinotermitidae can be divided into six subfamilies: Coptotermitinae, Heterotermitinae, Psammotermitinae, Termitogetoninae, Stylotermitinae and Rhinotermitinae (Krishna, 1970) and 15 genera (Bignell & Eggleton, 2000). The common genera that can easily found in Malaysian forests are *Coptotemes, Heterotermes, Parrhinotermes, Prorhinotermes, Schedorhinotermes* and *Termitogeton* (Thapa, 1981; Tho, 1992).

2.2.3 Termitidae

The most significant features which differentiate this family from other termite families are the major change in gut structure and the lost of flagellate symbionts (Bignell, 1994; Donovan *et al.*, 2001). This family is the largest among the seven termite families with approximately 85% of all known genera in the world

(Kambhampati & Eggleton, 2000). This family only has four subfamilies which are Amitermitinae, Macrotermitinae, Nasutitermitinae and Termitinae.

The subfamily Amitermitinae is the most primitive and has evolved from the family Rhinotermitidae (Krishna, 1970). The *Apicotermes*-group Apicotermitinae are soil feeders that nest diffusely in the soil or as secondary occupants in others termite nests whereas the *Anoplotermes*-group Apicotermitinae are soldierless soil feeders that form diffuse underground nests in the soil (Bignell & Eggleton, 2000).

The subfamily Macrotermitinae contains fungus growing termite species that feed on a wide range of dead and living plant materials which is fully processed by their fungal symbionts (the basidiomycete, Termitomyces) on fungus combs in the nest (Darlington, 1994). Macrotermitinae is known to be orientated from Africa, and of the 13 recorded genera, only four common genera: *Macrotermes, Odontotermes, Hypotermes* and *Microtermes* are found in Malaysian forest (Homathevi, 1999).

The subfamily Nasutitermitinae is a highly specialized form of the higher termites where most of the genera found in Malaysian forest are wood feeders. The genera that have been recorded in Sabah are *Aciculioiditermes, Bulbitermes*, *Havalanditermes*, *Hirtitermes*, *Hospitalitermes*, *Lacessititermes*, *Leucopitermes*, *Longipeditermes*, *Nasutitermes*, *Oriensubulitermes*, *Proaciculitermes* and *Subulioiditermes* (Homathevi, 1999; Eggleton *et al.*, 1999).

The subfamily Termitinae includes both the soil-feeding and wood-feeding species that are diverged widely in Peninsular Malaysia and nine of the twelve Oriental genera can be found (Collin, 1988).

2.3 Biology

2.3.1 Colony structure and life cycle

The termite colony consists of different castes which are primary reproductives (king and queen), soldiers and workers. All forms usually comprise individuals of both sexes, but only in the reproductives termites' sexual organs undergo complete development. There are also some replacement reproductives which are juveniles that will attain sexual maturity in the absence of the king and queen. The typical termite colony is founded by a single king and queen but there are some exceptions where multiple queens (polygyny) and kings (polyandry) have been observed in colonies of several termites species (Roisin, 1993).

The king and queen are actively reproductives in the termite colony. The king shows little change in morphological after it sheds its wings and his sole task is to fertilize the queen. In contrast, the queen's abdomen shows great increasing in size as the ovaries enlarge and egg-laying capacity increases (Lee & Wood, 1971). The queen then becomes immobile and lives in her royal chamber.

Soldiers are individuals with strongly sclerotized heads showing defensive adaptations, such as enlarged mandibles, a stopperlike shape, or a frontal gland able to produce a defensive secretion (Roisin, 2000). Termite species in more primitive families including the Kalotermitidae, Hodotermitidae, Serritermitidae and Termopsidae have not been shown to be chemically defended with the exception of the monotypic Mastotermitidae, in which soldier secrete a quinone-laden buccal fluid (Moore, 1968). Soldiers are always unable to moult and premantary sterile (Roisin, 2000). The soldiers always perform tasks such as defending the nest from predatory ants and securing the foraging road of the workers.

Workers are individual resulted from an early, irreversible deviation from the pathway to the imago, and performing helper task (Roisin, 2000). The workers collect and process foods to ensure the termite colony's continuous survival. Workers also feed the young larvae, soldiers, older nymphs, reproductives and unflown alates with stomodeal foods (Lavelle, 2001). Some soldierless termite workers play an important role in defending the nest from the enemy.

Alates are the only termite castes that have wings. These alates will swarm out from their nest, mate and lay eggs to form new colonies. Swarming is timed by light and climatic factors (Howse, 1970). The eggs which are laid by the queen will hatch and then pass through several larva stages before becoming the nymphs. The nymphs will later grow into sterile workers or soldiers. The termite life cycle is hemimetabolus.

2.3.2 Trophic group

The basic food for termites are plant material; either living, recently dead, dead but in various stages of decomposition or soil rich in organic matter (Wood, 1978). Most termite species feed on dead-plant materials above, at or below the soil surface. These may include the dead foliage of grasses and other types of vegetation, woody materials including roots, seeds, the faeces of higher animals and other materials (Lavelle, 2001).

Generally five major groups which can be recognized. These groups consist of wood-feeder, soil- feeder, soil-wood interface feeders, litter-feeders and grass-feeders (Bignell & Eggleton, 2000). However, there are minor feeding groups which feed on fungi, algae, dung, vertebrate corpses and lichen on tree bark (Bignell & Eggleton, 2000). Some termite species can fit into more than one trophic group especially those under unfavorable conditions (Collin, 1989). The five major groups are:

i. **Wood-feeders**. These are termites that feed on woods and woody litters, including dead branches that still are attached to the trees. Most lower termites and all the subfamilies of Termitinae except the Apicotermitinae are wood-feeders (Bignell & Eggleton, 2000). In some cases, the wood that termites consume will become the colony centres while some Macrotermitinae having subterranean or epigeal nests in which fungus gardens are cultivated (Donovan *et al.*, 2001). Some termite species of Coptotermes will attack living woods and cause damage to rubber trees in Malaysia and timber tree in Australia (Adamson, 1960).

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