THE DIVERSITY OF TERMITE FAUNA (ORDER: ISOPTERA) AT MAHUA, CROCKER RANGE PARK, SABAH

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DECLARATION

I, hereby, admit that this is my own work except quotation and captions that has been given the related sources.

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This research was carried out to determine the termite diversity and abundance at Mahua. A pictorial identification key was developed for termite fauna for general use and non-taxonomist. Mahua is a primary forest that located at Crocker Range Park, Sabah. A standardised belt transect (100m x 2m) is used for termite sampling. Three transects were run around the area of Mahua. A total of 19 species from 15 genera were collected in this study. The termite species comprises of family Rhinotermitidae (three species, two genera) and Termitidae (16 species, 13 genera). Shannon-Wiener Diversity Index shows higher termite diversity at Mahua. There were also more evenness among the termite species in the area. Relative abundance of termite species at Mahua was 150. Sub-family Termitinae was the sub-family with higher diversity (ten species) and abundance (107 hits) collected in this study. Species Pericapritermes dolichocephalus (John) found abundant at Mahua with 44 hits. There were also some rare species like Hirtitermes spinocephalus (Oshima), Nasutitermes neoparvus Thapa and Pericapritermes paraspeciosus Thapa, which found only once or twice at Mahua. Moreover, wood-feeders and hypogeal nest-builders dominated the termite assemblages. This feeders play an important role in the wood decomposition process in the forest. Identified termite species from previous study were also included in this study in order to construct the pictorial identification key. Cluster analysis was done for these termites. A pictorial identification key was constructed for 26 termite species using soldier morphology that were identified from cluster analysis. There were twelve new records of termite species for Mahua recorded in this study. Hence, the termite species list of Mahua is updated through this study. Termites play an important role in ecosystem of Mahua. Further research need to be done to identify factor that influence the abundance of termites at Mahua.
ABSTRAK

KEPELBAGAIAN DAN TABURAN ANAI-ANAI (ORDER: ISOPTERA) DI MAHUA, TAMAN BANJARAN CROCKER, SABAH

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LIST OF SYMBOLS AND ABBREVIATIONS

m  meter
%  percent
km  kilometer
m²  one per meter square
gm²  gram per meter square
1.1 Termites

Termites are polymorphic and eusocial insects grouped under the order Isoptera. The order Isoptera is derived from the Greek words, in which ‘isce’ means equal and ‘pteran’ means wing. The combination of the words refers to the equal size and shape of the wing (Gibb & Oseto, 2006). Termites are also known as “white ants”. They are common in tropical soils especially in the tropical rain forest (Acda, 2007). Termites could also be found in some temperate regions and rain forests located in Africa, South America and Southeast Asia (Eggleton et al., 1994).

They are divided into ‘lower’ and ‘higher’ group of families. The ‘lower’ termite’s gut contains symbiotic flagellate protozoans. This enables cellulose digestion in termite gut and the digest food passed on by trophallaxis through oral or anal feeding (McGavin, 2001). Inverse situation occur in ‘higher’ termites. The symbiotic flagellate protozoans are absent in their gut. They degrade cellulose using their own enzymes (Ohkuma, 2003). Mastotermitidae, Kalotermitidae, Termopsidae, Hodotermitidae and Rhinotermitidae are grouped in ‘lower’ termite families, while in the ‘higher’ termite family there is only one family known as Termitidae (Toda & Kitching, 1999).
Termites live in colonies. Each colony consists of several millions of individual. These individuals are recognized as nymphs, workers, soldiers, queen and the king (Wilson, 1971). The entire individuals in a colony are dependent on each other. Hence, the disappearances of either one will affect the whole colony greatly.

According to fossil records, the termites have existed on this planet over 120 million years ago (Triplehorn & Johnson, 2005). There were several attempts made in order to identify the phylogeny of termites however, it still remained unsolved. Phylogenetically, termites (Isoptera) said to be sister group with a primitive group of wood-dwelling cockroaches (Blattaria) (Thorne et al., 2000). The termites have styli in the rear end of the abdomen as in cockroaches (Harris, 1957). Both termites and cockroaches are hemimetabolus (Homathevi, 2003). Mastotermes darwinensis Froggatt, the primitive species of termite from Australia have some similar characteristics with some cockroaches (Triplehorn & Johnson, 2005). Furthermore, the folded anal lobe in the hind wing and an egg mass of the termites resembles the oothecae of the cockroaches. The relationship between termite and cockroaches gives an idea that termites evolved during the late Permian, approximately 200 million years ago (Triplehorn & Johnson, 2005).

At present, about 2600 species of termites have been identified across the world, consisting of 281 genera and seven families (Kambhampati & Eggleton, 2000). In Sabah, only three types of families have been identified. They are Kalotermitidae, Rhinotermidae, and Termidae. These families include 33 genera and 103 species (Thapa, 1981; Tho, 1992). The termites are also classified into five groups according to their feeding group consisting of wood-feeders, litter forages, micro-epiphyte feeder, soil-feeders and soil-wood interface-feeders (Eggleton et al., 1997).

Termites are being prey by many other species especially ants. The termites always attacked by ants. Hence, the soldier plays an important role to defense the colony. Moreover, many specialized vertebrate predators also have termites as their
prey. Many birds and mammals such as sun bears, aardvark, aardwolf, pangolins, armadillos, anteaters, sloth bears and echidnas feed on termites (McGavin, 2001).

Termites could be viewed in a positive and also in a negative way. They bring benefits to the environment and at the same time become nuisance to humans. Economically, they cause significant destruction of wood and wood products (Gibb & Oseto, 2006). For an example, the *Coptotermes formosanus* Shirakl, a subterranean termite had caused billions of dollars of damage for the past 50 years across United States (Adams & Raj, 2005). *Heterotermes indicola* had destroyed an entire township in India (Kirton, 2005). Furthermore, their function is determined by the type of species, their feeding group as well as their nesting behavior (Homathevi & Tawatao, 2003). Termites are usually neglected by the naturalist due to their small size and dull color. They also easily dry up and became fragile if they are not preserved in alcohol (Harris, 1957).

1.2 Justification

The aim of this study is to identify termite diversity at Mahua, Crocker Range Park and to develop an identification guide for the termite fauna of Mahua. Mahua at Crocker Range Park, Sabah is one of the developing tourist places in Sabah. This site has been a research area for the local and international scientist too. Several studies on plant diversity (Isa et al., 2002) and certain insect orders such as Lepidoptera, Homoptera (Zaidi et al., 2002) and Coleoptera, have been conducted here. However, there is less researches associated to the diversity of termites at Mahua. Hence, this study will provide data on the termites diversity at Mahua together with an identification guide for future researchers.

Although, there are many studies on termites in Sabah, most of the researches are ecological based studies. Taxonomic studies have been solely
concentrated on certain group of termites. The existing identification key for termites could not give explanation in the form of pictures. It is very technical for general use. In this study, a pictorial guide for termites of Mahua will be developed to ease identification. It can be used by other researchers and also non-taxonomist to identify the termite to the species level. Furthermore, this study is also an effort to increase identification guides for insects in Sabah. Hence, the present study is given emphasis on termite. The officers at Mahua could also use the key to explain termite diversity of Mahua to the tourists with less difficulty.

1.3 Objectives

The objectives of this study are:

a) To study the diversity and abundance of termites at Mahua.

b) To construct a pictorial identification key for the termites at Mahua.
CHAPTER 2

LITERATURE REVIEW

2.1 Colony Structure

The social system of a termite colony is formed by the workers (male and female), soldiers (male and female), primary reproductives (a queen and a king) and secondary reproductives (neotenes) (Figure 2.1). Each of the castes can be differentiated morphologically and has different function in the colony (Gibb & Oseto, 2006). The colony contains high number of workers compared to other caste. The worker and soldiers are the wingless form of sterile adults. They are also known as helpers or neuter caste of Isoptera (Miura, 1998). This is because they give up their own reproduction to support a number of reproductive individuals. Basically the workers provide food for the colony, give care for the egg-laying queen and construct new tunnels and chambers (Higashi et al., 2000; Gibb & Oseto, 2006).

The soldiers have greatly enlarged heads. They also have powerful biting mandibles. Hence, they are able to defend the colony and nest from attacks by other insects (Gibb & Oseto, 2006). They also protect the colony through defensive secretions. The colony is defended by the workers in the absence of soldiers. They use their robust and unspecialized mandibles to attack ants or termites from other colony, which are their main predators (Noirot & Darlington, 2000).
The king and queen play an important role in the reproduction (Gibb & Oseto, 2006). The adult termites with wings are ready for reproduction and will lose their wings after mating. The queen’s abdomen will get swollen and is in immobile stage after a successful mating (Triplehorn & Johnson, 2005). This condition is known as physogastry (Gibb & Oseto, 2006). The termites of family Kalotermitidae do not have distinct worker caste. The nymphs take over the function of the worker in the colony. The development of the nymph to a winged adult is stopped temporarily or permanently according to the needs of the community (Harris, 1957).

![Figure 2.1 Castes within a termite colony](http://www.britannica.com/EBchecked/topic-art/553123/44299/Termite-castes)
2.2 Morphology of Termites

Termites body is divided into three parts, head, thorax and abdomen (Triplehorn & Johnson, 2005). Features of these parts differ among the castes in the colony. Each of the part consists of different morphological characteristics with specific function.

Head is an important part for termites. More morphological characteristics found in this part as shown in the Figure 2.2 and Figure 2.3. The termites have chewing type mouthparts. The mandibles of the soldier caste are stout, triangular and well developed for chewing wood (Harris, 1957). In specialized subfamily Nasutitermitinae the mandibles are replaced with nasus, an elongated projection of the fontanelle (Homathevi, 2003). The soldiers also used the frontal gland to secrete toxic fluid to defense the colony and ejected through an opening onto the enemy (Triplehorn & Johnson, 2005). Moreover, the antennae are either moniliform or filiform in shape. It consists of small bead-like segments (Harris, 1957). Most of the castes have reduced compound eye except the alates. The, antennae function as sensory organ which help in the communication between the castes in the colony.

The thorax is further divided into three parts, pronotum, mesonotum and metanotum (Sornnuwat, 2004). The formation of equal size of front and hind wings occur in the thorax. This characteristic also distinguishes termites from other insects. The wings are not found in the nymphs, workers, and soldiers. It is only found in the termites that have reached the reproductive stages. Each of the wings is membranous (Gibb & Oseto, 2006). Furthermore, termites also have segmented body. The abdomen consists of ten segments (Gibb & Oseto, 2006; McGavin, 2007). A pair of cerci present in the ninth segment of the abdomen in the soldier caste. The size of the abdomen is different between the castes. The abdomen also broadly jointed to the thorax (Triplehorn & Johnson, 2005).
Figure 2.2  Major characteristics of soldier head (Source: Tho, 1992).
Figure 2.3  Head morphology of an alate, *Globitermes sulphureus*  
(Source: Tho, 1992).
2.2.1 Differences between Termites and Ants

Termites are always assumed to be the same as ants by many people. Nonetheless, termites are totally different from ants (Higashi et al., 2000). They have some external structures that distinguish them from each other (Figure 2.4). Termites are soft-bodied and are usually light-colored while ants are hard-bodied and dark in color. The antennae of termites are not elbowed as seen in ants. The front and hind wings are equal in termites but the hind wings are smaller than the front wings in ants (McGavin, 2007). In rest, the wing held flat over in termites while the wing of ants held above the body. Moreover, the termites consist of both sexes where the reproductives and sterile castes are developed from fertilized eggs. The sterile castes in ant only made up from females. All females, sterile castes and reproductive castes are develop from unfertilized eggs (Higashi et al., 2000; Triplehorn & Johnson, 2005). Furthermore, the workers in termites are either female or male, while all workers are female in ants (Higashi et al., 2000).

Figure 2.4 Differences in morphology between termite and ant (Source: http://www.ameritest.us/termites.html).
2.3 Biology

2.3.1 Life Cycle

Termites have simple metamorphosis (Figure 2.5) (Triplehorn & Johnson, 2005). Bonding occurs in the colony between the royal pair (king and queen) in order to start the reproduction. Then, they excavate a nuptical chamber. A new colony is established after copulation occurs within the chamber (Gibb & Oseto, 2006). After that, a dispersal flight from the parents colony happens in the matured nest. This is known as swarming time for the termites. They leave the colony together in a pair and start a new family. The royal pair is long lived, perhaps as long as 50 years (Gibb & Oseto, 2006). The pair termites shed their wings and seeking shelter according to their nesting behavior. After a nesting site is ready, the queen of the pair starts to lay eggs. The eggs were taken care by both parents until first nymph emerge. The first emerged nymphs are white and feeble. They are active as they hatch and moves around the chamber (Harris, 1957).

The young termites reach a stage to continue their development to next stage after two moults. Their development is directed into three ways and end up as matured termite either as their parents (king and queen), workers or soldiers. In addition, all the larvae become workers in the initial stage of a colony foundation (Harris, 1957; Elzinga 2004). They only consist of efficient jaws without wings and eyes. After a certain time, larvae with large head and jaws are found in the colony. These larvae developed into soldiers (Harris, 1957). After the colony is well organized and have numerous numbers of worker and soldier caste, the larvae start to appear with wing pads on their shoulders. These are the nymphs that developed into winged adults. The full cycle of development is complete in the colony as the winged adults are formed. The female parent became a machine for producing eggs until the complete of the developmental cycle (Harris, 1957). The queen also involved in pheromonal regulation of colony. This helps the queen to control the production of each caste in the colony (Elzinga, 2004; Triplehorn & Johnson, 2005).
Supplementary reproductives develop in a colony when the king and queen in a colony die or part of the colony separated from the parent colony. They develop within a colony and take over the function of king and queen in their absence. They are slightly sclerotized and pigmented. A short wing pads present (brachypterous) or absent (apterous) in their body (Elzinga, 2004) and have reduced compound eyes. The supplementary reproductives develop from the nymphs and do not leave the nest. They achieve sexual maturity without reaching the fully winged adult stages (Elzinga, 2004; Triplehorn & Johnson, 2005).

Figure 2.5  Life cycle of termite  
REFERENCES


