TAXONOMY OF *Leptogenys* ANTS (FORMICIDAE: PONERINAE) IN SABAH

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INSTITUTE FOR TROPICAL BIOLOGY AND CONSERVATION
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ABSTRACT

This study focuses on the taxonomy of ant genus *Leptogenys* (Formicidae: Ponerinae) in Sabah, Malaysia, Borneo. Study compose of three objectives namely to revise the ant genus *Leptogenys* of Sabah followed by the study of their distribution and nesting record. Specimen observation conducted mainly through the institutional image type specimen and fresh specimen collection. Fresh specimen collection samplings involve active manual sampling. Throughout the study, there are 12 known species distinguished namely *L. borneensis Wheeler, 1919, L. chalybaea (Emery, 1887), L. diminuta (Smith, 1857), L. distinguenda* (Emery 1887) stat. nov.*, L. kitteli (Mayr, 1879), L. kraepelini Forel 1905, L. mutabilis (Smith, 1861), Leptogenys modiglianii Emery 1900, L. myops (Emery, 1887), Leptogenys nero* Forel 1913 stat. nov.*, L. parvula Emery, 1900, L. peugueti André 1887* and six new species *Leptogenys hispida* sp. nov, *Leptogenys oculatus* sp. nov, *Leptogenys parvaborneensis* sp. nov, *Leptogenys scabra* sp. nov, *Leptogenys seikii* sp. nov and *Leptogenys spicata* sp. nov. While the study on the distribution shown most of *Leptogenys* species habitat found in primary than secondary forests such as Danum Valley, Tawau Hill Park, Sapulut, and Maliau Basin. The Urban landscape and Small Island recorded so far does not support the habitat of *Leptogenys*. Nest of this ant comprise of dead wood, soil, leaf litter and below the stone.

ABSTRAK

TAKSONOMI SEMUT Leptogenys (HYMENOPTERA : FORMICIDAE) DI SABAH

Kajian ini berfokuskan kajian taksonomi terhadap semut daripada genus Leptogenys di negeri Sabah, Malaysia, Borneo. Kajian ini tebahagi kepada tiga objektif utama, pertama untuk mengkaji semula semut genus Leptogenys di Sabah diikuti dengan kajian terhadap taburan dan rekod sarang semut ini. Pemerhatian spesimen dibuat melalui pemerhatian gambar tip spesimen daripada institusi dan juga pemerhatian spesimen segar yang dikumpul sepanjang kajian ini. Persampelan spesimen segar dikutip melalui teknik aktif manual. Secara keseluruhannya, terdapat 18 spesies yang telah dikenal pasti dimana 12 daripada spesies tersebut ialah L. borneensis Wheeler, 1919, L. chalybaea (Emery, 1887), L. diminuta (Smith, 1857), L. distinguenda (Emery 1887) stat. nov.*, L. kitteli (Mayr, 1879), L. kraepelini Forel 1905, L. mutabilis (Smith, 1861), Leptogenys modiglianii Emery 1900, L. myops (Emery, 1887), Leptogenys nero* Forel 1913 stat. nov.*, L. parvula Emery, 1900, L. peugueti André 1887 dan enam spesies baru Leptogenys hispida* sp. nov, *Leptogenys oculatus* sp. nov, *Leptogenys parvaborneensis* sp. nov, *Leptogenys scabra* sp. nov, *Leptogenys seikii* sp. nov and *Leptogenys spicata* sp. nov.*. Kajian menunjukkan taburan genus Leptogenys tertumpu di kawasan hutan primari berbanding hutan sekunder seperti di Lembah Danum, Sapulut, and Maliau Basin. Setakat ini, Leptogenys belum dijumpai di kawasan lanskap bandar dan pulau-pulau kecil. Sarang semut ini terdiri daripada kayu-kayu mati, dalam tanah dan dibawah batu.*

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LIST OF ABBREVIATIONS

Asl	Above Sea Level
BOR	BORNEENSIS Insect Collection, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Sabah, Malaysia
BMNH	The Natural History Museum, London, United Kingdom
E	East
EL	Eye Length
CASC	California Academy of Sciences, San Francisco, California USA
CI	Cephalic Index
CL	Clypeal lamella
CLM	Clypeal lobe median
DPI	Dorsal Petiole Index
HL	Head Length
HW	Head Width
LPI	Lateal Petiole Index
MG	Metanotal Groove
MHNG	Musee d'Histoire Naturelle Genève, Geneva, Switzerland
MI	Mandibular Index
ML	Mandible Length
Mm	Millimeter
MSNG	Museo Civico di Storia Naturale, Genoa, Italy
N	North
OI	Ocular Index
OUMNH	Oxford University Museum of Natural History, Oxford, England
PD	Propodeal declivity
PH	Petiole high
PL	Petiole length
PTL	Petiole Dorsal Length
PTW	Petiole Dorsal Width
PW	Pronotal Width
SI	Scape Index
SKY	Seiki Yamane

SL	Scape Length
TL	Total Length
WL	Weber's Length

CHAPTER 1

INTRODUCTION

1.1 The Ant Genus *Leptogenys* Roger, 1861

Leptogenys was first described and established by Roger in 1861 based on species *Leptogenys falcigera* subsequent designation of Bingham from Sri Lanka in 1903 (Bolton, 1995). The genus belongs to the subfamily Ponerinae of the family Formicidae. Currently, there are 265 species, 27 subspecies and one fossil species of *Leptogenys* recorded throughout the world (Bolton, 2014) and the species richness of the genus is mostly centred in tropical region and Australian region but lack of distribution studies (Guénard *et al*, 2010). There are 25 species and 11 subspecies described from the Indo-Australian region, and one of them was from Malaysia (Bolton, 2014). Nine species of *Leptogenys* have been described from Borneo (Bolton, 1995) and recent study describe one of them were from Sabah (Bakhtiar and Chiang, 2010). There are five earlier genera that have been established before designation by Bingham which later become valid *Leptogenys* synonym. These synonymize genera are *Lobopelta* 1862 Mayr, *Prionogenys* 1895 Emery, *Machaerogenys* 1911 Emery, *Odontopelta* 1911 Emery, *Dorylozelus* 1915 Forel and *Microbolbos* 1948 Donisthorpe (Bolton, 2014).

1.2 Biology of *Leptogenys*

Leptogenys ant can be found in a primary forest or even disturbed area. Only a few species can adapt urban condition. Nesting of this species is usually in a form of rotten wood on the ground, in the soil, cavities of log or fallen, stone, branches and even beneath the bark. Certain species exhibit the behavior of the army ants which do not have main nest which only involve only simple bivouac made from leaf litter. *Leptogenys* ants are predator and scavenger species. Most of *Leptogenys* are active during the night which this relates with their favorites food preference active time soil fauna. This ant can be generalists which follow the army ant lifestyle. This ant equipped with powerful sting thus making them easy to paralyze their prey. Although they equipped with powerful sting, there are organism still manage to

attack *Leptogenys* such as scuttle fly (Disney and Fayle, 2008) and invasive ant *Pheidole megacephala* whose can kill *Leptogenys* (Dejean *et al*, 2008).

1.3 Significance of Study

Lack of data on species in the genus can be frustrating in identification of specimen in a museum. The study of taxonomy and bionomics of ant in Sabah is still new. While this study focused on ant genera, *Leptogenys* can be interesting ant genus to be studied. They can be found almost in any forest in Sabah and commonly encountered at night by park's ranger. Some of the species in this genera is nomadic where this characteristic rarely shown in other ant genera. To understand this genus better, we need more information. This study provide information which may help us to understand this species more based on complete description of species, species list, identification key, distributional data and even ecological data of this species such as nesting behavior and distributional data in Sabah. As for the result, new species may be introduced and contribution of specimen collection data to institutional. Furthermore, identification key to species level will help the researcher to identify their specimen easily without a need of an expert.

1.4 Objectives

The objectives of this study are:

a. To study the taxonomy of *Leptogenys* ants in Sabah

b. To study the distribution of *Leptogenys* ants in Sabah

c. To study nesting behavior of different species of *Leptogenys* ants in Sabah

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Formicidae

Ant is a hymenopteran which is grouped under same insect as bees and wasp. There is only one family of ant namely Formicidae. There are 16, 000 of ant have been described so far and there still a lot of ants have not yet identified (Antweb). Little is known about the history of ant origin. The oldest fossil of ant known from cretaceous age proved that ant actually linked with nonsocial aculeate wasp where morphology character of this ant still shown primitive wasp-like traits (Hölldobler and Wilson, 1990). Ant is known for its eusociality, thus regard them as a superorganism. These traits lead this creature to be one of the most successful organism on earth. Eusociality in ant is unique which involve the division of structural society structure known as caste (Hölldobler and Wilson, 1990). Every ant has their own unique caste. Common castes include reproductive members such as queen and male (alates) and non-reproductive member major worker and minor worker (Hölldobler and Wilson, 1990). The reproductive member is important in the survival of the species. Major and minor worker usually have its role usually not very different from each other. Major worker, for instance, has large morphology suit for nest protection from a threat (Hölldobler and Wilson, 1990). Common task done by worker caste includes collecting food, maintaining the nest and feeding the brood (Hölldobler and Wilson, 1990). Some workers are capable of laying an unfertilized egg either for reproductive mean or for the nutrient. An egg that is laid for the nutrient is called trophic egg (Hölldobler and Wilson, 1990).

Ant lives in various types of habitat and niche ranged from a floor of forest up to the canopy and urban area which is a highly disturbed ecosystem. Ant can live in major city that can be called urban heat island where temperature can be high enough more than 10^{o}C than rural temperature and this prove ant high tolerant toward high temperature (Angilletta *et al*, 2007).

Ant has a common characteristic which possess slim waist that separate thorax and abdomen compared to other hymenopteran known as the petiole. Sometimes, slim waist discrete into two segments, this second segment known as postpetiole. All ants have elbowed shape antennae (geniculate), the presence of metapleural gland above the hind pair of coxae and the presence of wingless worker caste (Heterick, 2009). These characters define what an ant is. Termite is common mistaken as an ant because of the same size and lives in social.

Pheromone is one of the characters that define ant when it comes to communication since they are the eusocial insect. Communication in ant can be complex as they are capable of secreting multiple pheromones (Jackson and Ratnieks, 2006). Pheromones can be secreted through glandular sources such as Dufour's gland, poison gland, anal glands, and gland on the feet (Jackson and Ratnieks, 2006). Ant detects them through their antennae (Jackson and Ratnieks, 2006). Pheromones are also used for alarming and signaling. Some species share pheromone trail such as *Camponotus rufifemur* and *Crematogaster modiglianii* although this is not exactly mutual sharing but a strategy to exploit partner's food resources. This strategy is known as olfactory eavesdropping (Menzel *et al*, 2010).

2.2 Behavior and Ecology of Ant

2.2.1 The Importance of Ant

Ant is a successful organism. The reason for this creature to be a success organism in wild is the eusocial behavior. They can work competently their own or in a group in respond to task depend on the situation; they are also the only predator that is eusocial. The elongation of the mandible as working tool makes this organism versatile in working. The last part is the innovation of metapleural gland. This gland acid is active against fungi and bacteria and this help in colonization in the microorganism-ridden environment (Hölldobler and Wilson, 1990).

Ant is a surprising important insect in the environment where rich in biomass and diversity. Their biology affects environment and cost efficient as Bioindicators (Alonso and Agosti, 2000). In natural, ant act as a seed disperser, protect plant, act as decomposer and nutrient cycling. Some of these properties can be used to human advantages. We can manipulate ant as biological pest control

and even use them as biology indicator to determine ecosystem health.

a. Ant as Biological Control

Ants serve as a biological control in many parts of the world. Ant as plant protector against pest insect is rather popular in nature itself. Plants do evolve react to this relationship creating something called Myrmecophytes (Stanton and Palmer, 2011). Human tried to design this relationship to the specific plant. Study such as use *Oecophylla smaragdina* to prevent *Helopeltis theobromae* (cocoa pest) from attacking cocoa proven to be useful (Chin *et al*, 1988). However, there is a flaw in unmonitored biological control which could result in interspecific resource competition occur between species introduce as biological control and native species. Furthermore, invasive species is hard to notice especially insect (Simberloff and Stiling, 1996).

b. Ant as Seed Dispersal

Seed dispersal through organism is one of mechanism that helps plant to disperse from main trees. Ants are most common insect involve in this dispersion. Ecological interaction of ant and plant that involve in moving seed of plant to other location is known as Myrmecochory (Fisher *et al*, 2008). Myrmecochory is responsible for the increase of dispersal distance from the parent tree (Andersen, 1988). Plants have certainly evolved in this mean of dispersal which shown changing of structure of seed to attract ant (Fisher *et al*, 2008). Elaiosomes is small structure locate at outer surface of the seed which attract ant which compose of lipids, amino acids, soluble carbohydrate, protein and starch. This chemical structure can be differing among plant possibly to attract specific target of ant species (Fisher *et al*, 2008). When ant brings the seed to the nest, they consume elaiosome. Plant does make them easier to consume elaiosome without damaging the seed plus seed placed in high nutrient soil thus increase odd for germination (Lobstein and Rockwood, 1993). Some plant seed germinate faster when the elaiosomes is removed (Lobstein and Rockwood, 1993).

c. Ant as Nutrient Cycler (Moving Soil)

Ant is capable in modifying soil properties physically and chemically. Chemical characteristic is altered due to food remains, faeces, foraging activities and mandibular gland secretion that decompose which increase distribution of organic matter and mineral nutrient in the soil. Physical alteration of soil done by an ant in building a nest, while construction underground chamber give soil aeration to the soil (Beare *et al*, 1997). All these activities increase soil nutrient, which increase in nitrogen content and phosphorus provide high nutrient to the soil which good for plant development (Wagner *et al*, 2004).

d. Ant as Bioindicator

Biological monitoring can be done through chemical method. Chemical method surely able to measure ecosystem health, but this method does not look directly at biological responses to the pollution. Ant can be used to detect habitat disturbance. Ant lives in stationary colonies which do not easily move to other habitat make this organism as an ideal for monitoring. They can be resampled repeatedly using same method thus can provide information on vegetation, prey abundance, soil quality in a period of time (Alonso and Agosti, 2000). Certain species of ant for example *Pheidole Megachepala* can be used as bioindicator (King *et al*, 1998). *Pheidole Megachepala* is an alien species that invade pacific island where this ant can devastate native species of invertebrate and native ant (Gillespie and Reime, 1993). Thus, with this knowledge we can indicate that with the present of this species mean the ecosystem is disturbed.

2.2.2 Interaction between Ant and Plant

The symbiosis between ant and plant occur a long time ago. In term of trophic interaction, ant usually considered as carnivorous or scavenger and only a few of ants entirely depend on the plant as a source of nutrient (Herbivorous). The herbivorous term has wide meaning, for instance, the interaction of ant leaf cutter in neotropical regard as herbivores (Urbas *et al*, 2007). Other than that, the ant that feed on the honeydew either from plant or arthropod is also known as herbivores (Oliveira and Freitas, 2004). This relationship gives birth of plant that adapt to an ant which provide food and even shelter for the ant and as return ant protect this plant from varies of arthropod that harm the plant. This mutualism

relationship between ant and plant is called Myrmecophytes (Oliveira and Freitas, 2004). Example of this relationship is shown by *Crematogaster borneensis* and several *Macaranga* species which is *Macaranga triloba*, *M. hypoleuca*, *M. hosei* and *M. hulletti* where Macaranga provide shelter in hollow internodes and food bodies, while ant provide protection against herbivores and plant competition (Fiala and Helbig, 1989). There are also cases for mutualism which neither harm nor benefits host between ant and plant for example ant genus *Camponotus* and *Crematogaster* occupy hollow stems of the plant (Schultz and McGlynn, 2000).

2.2.3 Interaction between Ant and Other Arthropods

Ant do interact between other arthropods as much interaction as a plant. Certain arthropods even evolve with ant. The major relationship between ant and arthropod is a predator. Many of ant inept in predatory thus specialize either their morphology or behavior for instance *Leptogenys* sync with their prey isopod (Maschwitz *et al*, 1989). Counterpart of become predator, ant also represent food source for other organism. Ants can become easy food source due to their lifestyle which lives in a stationary nest, abundance in number and long-lived (Elgar and Allan, 2004). Some arthropod specializes themselves on preying ant, for example, some species of spider *Cosmophasis bitaeniata* feed on the larva of *Oecophylla smaragdina*. They are capable of mimicking cuticle hydrocarbon of *Oecophylla smaragdina*, thus able to avoid ant detection (Elgar and Allan, 2004). Other interaction common between ant and other animal particularly arthropod is the ant-homopteran association. Ant that feed on the honeydew secretion by homopteran comes from several subfamilies namely Dolichoderinae, Formicinae and Myrmicinae. This symbiosis also arises mutualistic relationship. A situation where Lasius ants feed on the honeydew secreted by aphids and as mutual partner ant protects aphids. This ant is not only feeding on the honeydew secretion of aphids but also preying on the aphids (Offenberg, 2001). We can relate that this behavior is same as a human where cow domesticated by human for food and milk.