

**REVISION OF ANTS FORMERLY KNOWN AS  
GENUS *PACHYCONDYLA* (HYMENOPTERA:  
FORMICIDAE: PONERINAE) OF SABAH**



**ANATI BINTI SAWANG**

**UMS**  
UNIVERSITI MALAYSIA SABAH

**INSTITUTE FOR TROPICAL BIOLOGY AND  
CONSERVATION**

**UNIVERSITI MALAYSIA SABAH**

**2015**

**REVISION OF ANTS FORMERLY KNOWN AS  
GENUS *PACHYCONDYLA* (HYMENOPTERA:  
FORMICIDAE: PONERINAE) OF SABAH**

**ANATI BINTI SAWANG**



**THIS IS SUBMITTED IN PARTIAL  
FULFILLMENT FOR THE DEGREE OF MASTER  
OF SCIENCE**

UNIVERSITI MALAYSIA SABAH

**INSTITUTE FOR TROPICAL BIOLOGY AND  
CONSERVATION**

**UNIVERSITI MALAYSIA SABAH**

**2015**

## DECLARATION

I hereby declare that the material in this dissertation is my own except for the quotations, excerpts, equations, summaries, and references, which have been dully acknowledge.

16 February 2015

---

Anati Binti Sawang

PP20118003



UMMS  
UNIVERSITI MALAYSIA SABAH

## CERTIFICATION

NAME : **ANATI BINTI SAWANG**  
MATRIC NO. : **PP20118003**  
TITLE : **REVISION OF ANTS FORMERLY KNOWN AS GENUS  
*PACHYCONDYLA* (HYMENOPTERA: FORMICIDAE:  
PONERINAE) OF SABAH**  
DEGREE : **MASTER OF SCIENCE (BIODIVERSITY AND  
BIOSYSTEMATICS)**  
VIVA DATE : **15 OCTOBER 2014**



DECLARED BY;

**UMS**  
UNIVERSITI MALAYSIA SABAH

Signature

---

**2. CO-SUPERVISOR**

Assoc. Prof. Dr. Homathevi Rahman

Signature

---

## ACKNOWLEDGEMENTS

Thanks are extended to The Government of Malaysia, through the Ministry of Higher Learning, Universiti Malaysia Sabah (Grant FRG0286-STWN-2/2010) as well as MyMaster for the financial supports that enable me to complete this research.

I wish to express my deepest gratitude and appreciation to my supervisor, Dr. Bakhtiar Effendi Yahya who has been patient enough to advice, guide and supervise me throughout the past few years in completing this research and thesis. Special thanks and gratitude to Dr. Homathevi A/P Rahman (co-supervisor), Professor Seiki Yamane from Kagoshima University and Dr. Steve Shattuck from Australian National Insect Collection (ANIC) for their kind advice and guidance.

Thanks are also extended to the officer and curator at the visited depositories for their kind help and cooperation rendered and all staff for their kind assistance: all staff from forestry Department especially Dr. Chey Vun Khen and Dr. Arthur Y. C. Chung, staff from Sabah Park especially Mr. Sinail Dunsul, staff from Yayasan Sabah in Danum, Imbak, and Maliau Basin and all staff from Institute for Tropical Biology Conservation (ITBC).

Special appreciation goes to my parents and family, to whom I owe a lot, for their love supports, advice, prayers and blessings. To those I do not mention I would like to thank all of you for your helps and assistances. The best thing is from Allah, and the weakness is from us, as poor human beings.

Anati Binti Sawang

16 February 2015

## ABSTRACT

Taxonomic status of the ant genus *Pachycondyla* Smiths, F. 1858 is the most complex in Ponerine ants. *Pachycondyla* is heterogeneous and proved to be non-monophyletic genus. As part of Borneo Island, Sabah is an important study site which is facing habitat change that affects ant diversity. Recent study by Schmidt and Shattuck in 2014 rearranged the *Pachycondyla* into several genera and most of the genera are revived. This study aims at i. revising the taxonomy of ant genus formerly known as *Pachycondyla* ant in Sabah; ii. studying the distribution of ant genus formerly known as *Pachycondyla* ants in Sabah; iii. studying the nesting behavior of ants formerly known as genus *Pachycondyla* ant in Sabah. Revision on formerly known as genus *Pachycondyla* ants from Sabah was conducted through specimen collection and examinations of specimens from BORNEENSIS, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah; Insects Collection Centre of Forest Research Centre, Sepilok; Entomological museum, Sabah Parks and Seiki Yamane Collection, Department of Earth and Environmental Sciences and Faculty of Science Kagoshima University. Fresh specimens of ants were collected from several places around Sabah by using colony search method. Six genera of ants formerly known as genus *Pachycondyla* have been recognized which are *Brachyponera*, *Buniapone*, *Ectomomyrmex*, *Euponera*, *Mesoponera* and *Pseudoneoponera*. A total of 20 species with six new species and three subspecies raised to full species based on morphological characters of worker caste. Five species with a new species are recognized in ant genus *Brachyponera*: *P. flavipes* Yamane, 2007, *luteipes* (Mayr, 1862), *obscurans* (Walker, 1859), *pilidorsalis* Yamane, 2007 and *villus* sp. nov. Ant genus *Buniapone* is represented only by one species: *B. amblyops* (Emery, 1887). Five species are recognized in genus *Ectomomyrmex* with three new species: *E. astuta* Smith, 1858, *E. Keningauensis* sp. nov., *E. leeuwenhoekii* (Forel, 1886), *E. magnus* sp. nov and *E. maliauensis* sp. nov. Genus *Euponera* only represented by one species: *E. sharpi* (Forel, 1901). Four species are recognized in genus *Mesoponera* which two are new and one raised to full species: *M. kilau* sp. nov, *M. javana* (Forel, 1905) stat. nov., *M. rubra* Smith, 1857 and *M. similerubra* sp. nov. Four species of which two are raised to full species are recognized in genus *Pseudoneoponera*: *P. brevior* (Forel, 1901) stat. nov., *P. debilior* (Forel, 1901) stat. nov., *P. sandakana* (Wheeler, 1919) and *P. tridentata* Smith, 1958. The distribution of ants formerly known as genus *Pachycondyla* was high in Danum, Gunung Tambuyukon, Imbak, Keningau, Poring and Maliau Basin where the forests are pristine and under good management. Several rare species such as *P. brevior* was only recorded in Maliau, *P. sandakana* from Sandakan, Poring and Danum and *P. debilior* from Poring, Gunung Tambuyukon and Imbak. Ant formerly known as genus *Pachycondyla* prefer nesting in dead wood as shown in *P. tridentata*, *P. debilior*, *M. similerubra* and *M. rubra*. Genus *Brachyponera* and *P. brevior* on the other hand prefer building their nest in the soil and leaf litter.

Keywords: Formicidae, *Pachycondyla*, key identification, morphological description, Sabah.

# TABLE OF CONTENTS

	Page
<b>TITLE</b>	i
<b>DECLARATION</b>	ii
<b>CERTIFICATION</b>	iii
<b>ACKNOWLEDGEMENT</b>	iv
<b>ABSTRACT</b>	v
<b>ABSTRAK</b>	vi
<b>TABLE OF CONTENTS</b>	vii
<b>LIST OF TABLES</b>	xiii
<b>LIST OF FIGURES</b>	xiv
<b>LIST OF PHOTOGRAPHS</b>	xviii
<b>CHAPTER 1: INTRODUCTION</b>	1
1.1 Introduction to Ants Formerly known as Genus <i>Pachycondyla</i> of Sabah	1
1.2 Historical Review	2
1.3 Biology and Ecology	3
1.4 Significance of Study	3
1.5 Objectives	4
<b>CHAPTER 2: LITERATURE REVIEW</b>	5
2.1 Introduction to Hymenoptera: Formicidae (Ants)	5
2.1.1 Ant Morphology	6
2.1.2 Behaviour and Ecology of Ant	8
2.1.3 Ants Relationship with Environment	9
2.2 Introduction to Taxonomy	10
2.2.1 Ant Taxonomy and Evolution	10

2.2.2 Taxonomy Revision of Ants Formerly known as genus <i>Pachycondyla</i>	11
a. Taxonomy History of the ants Formerly known as Genus <i>Pachcondyla</i>	13
b. Morphological Characteristics of Ants Formerly known as Genus <i>Pachycondyla</i>	19
2.3 Distribution of Ant Genus Formerly Known as <i>Pachycondyla</i>	21
2.3.1 Study of Ants Formerly known as Genus <i>Pachycondyla</i> in Sabah, Borneo, Malaysia	21
2.4 Bionomics of Ant Genus Formerly Known <i>Pachycondyla</i> of Sabah	22
2.4.1 Nesting Behaviour of the Ants Formerly known as Genus <i>Pachycondyla</i>	23
<b>CHAPTER 3: METHODOLOGY</b>	24
3.1 Materials	24
3.1.1 Museum collection	24
3.1.2 Fresh specimens	25
3.1.3 Sampling Methods	25
a. Searching of Ant's Colony	25
b. Collection of Ants using Handy Sifter	25
c. Collection of Foraging Ants	25
3.2 Sampling Site of Fresh Specimens	26
3.2.1 Crocker Range Park	26
a. Inobong	26
b. Mahua	26
3.2.2 Danum Valley Conservation Area	27
3.2.3 Imbak Canyon conservation Area	27
3.2.4 Kinabalu Park	27
a. Gunung Tambuyukon	27
b. Poring	28
c. Sayap	28
3.2.5 Kalabakan Forest Reserves	28



3.2.6 Maliau Basin Conservation Area	28
3.2.7 Sandakan	28
3.2.8 Sapulut Forest Reserves (Nurud Urod, Sungai Siliawan, Batu Punggul, Sansiang)	29
3.2.9 Tawau Hills Park	29
3.2.10 Universiti Malaysia Sabah (UMS) Peak	
3.3 Observation of Morphological Features	31
3.4 Measurements and Indices	29
3.5 Distribution of Ant Genus Formerly Known as <i>Pachycondyla</i> in Sabah	31
3.6 Nesting Behaviour	32
<b>CHAPTER 4: RESULTS AND DISCUSSIONS</b>	<b>33</b>
4.1 Taxonomic Revision of Ant Genus Formerly Known as <i>Pachycondyla</i> of Sabah	33
4.1.1 Identification Key to Genera of Ants Formerly known as Genus <i>Pachycondyla</i>	34
4.2 Genus <i>Brachyponera</i>	37
4.2.1 Identification Key to Ant Genus <i>Brachyponera</i> of Sabah	37
4.2.2 Species Description	40
a. <i>Brachyponera flavipes</i> (Yamane, 2007)	40
b. <i>Brachyponera luteipes</i> (Mayr, 1862)	42
c. <i>Brachyponera obscurans</i> (Wheeler, 1858)	45
d. <i>Brachyponera pilidorsalis</i> (Yamane, 2007)	47
e. <i>Brachyponera villus</i> sp. nov.	50
4.3 Genus <i>Buniapone</i>	52
4.3.1 Species Description	53
a. <i>amblyops</i> (Emery, 1887)	53
4.4 Genus <i>Ectomomyrmex</i>	57
4.4.1 Identification Key to ant genus <i>Ectomomyrmex</i> of Sabah	57
4.4.2 Species Description	58

a. <i>Ectomomyrmex astuta</i> Smith, 1858	58
b. <i>Ectomomyrmex keningauensis</i> sp. nov	61
c. <i>Ectomomyrmex leeuwenhoekii</i> Forel, 1915	63
d. <i>Ectomomyrmex magnus</i> sp. nov.	65
e. <i>Ectomomyrmex maliauensis</i> sp. nov	67
4.5 Genus <i>Euponera</i>	70
4.5.1 Species Description	70
a. <i>Euponera sharpi</i> (Forel, 1901)	70
4.6 Genus <i>Mesoponera</i>	73
4.5.1 Identification key to Ant Genus <i>Mesoponera</i> of Sabah	73
4.5.2 Species Description	75
a. <i>Mesoponera javana</i> stat. nov (Forel, 1905)	75
b. <i>Mesoponera kilau</i> sp. nov	77
c. <i>Mesoponera rubra</i> Smith, 1857	80
d. <i>Mesoponera similerubra</i> sp. nov.	83
4.7 Genus <i>Pseudoneoponera</i>	86
4.7.1 Identification key to genus <i>Pseudoneoponera</i> of Sabah	87
4.7.2 Species Description	89
a. <i>Pseudoneoponera brevior</i> (Forel 1901) stat. nov.	89
b. <i>Pseudoneoponera debilior</i> (Forel, 1901) stat. nov.	91
c. <i>Pseudoneoponera sandakana</i> , Wheeler, 1919	94
d. <i>Pseudoneoponera tridentata</i> , Smith, 1858	97
4.8 Taxonomy of the Ant Genus Formerly Known as <i>Pachycondyla</i> of Sabah	99
4.9 Distribution of Ant Genus Formerly known as <i>Pachycondyla</i> in Sabah	102
4.10 Nesting Behaviour of Ant Genus Formerly Known as <i>Pachycondyla</i> in Sabah	109
<b>CHAPTER 5: CONCLUSION</b>	115
5.1 Revision of The Ant Genus Formerly Known as <i>pachycondyla</i> of Sabah	115

5.2 Distribution of Ant Genus Formerly Known as <i>Pachycondyla</i> in Sabah	115
5.3 Nesting Behaviour of Ant Genus Formerly Known as <i>Pachycondyla</i> of Sabah	116
<b>REFERENCES</b>	117
<b>APPENDIX A</b>	125
<b>APPENDIX B</b>	128
<b>APPENDIX C</b>	129



UMS  
UNIVERSITI MALAYSIA SABAH

## LIST OF TABLES

	Page
Table 2.1	Synonyms of <i>Pachycondyla</i> 14
Table 2.2	Summary of Taxonomic History of Ant Genus <i>Pachycondyla</i> 15
Table 3.1	Specimens Depositories and their Abbreviations 24
Table 3.2	Measurements and Abbreviation 30
Table 3.3	Sample Data of Nest Site 32
Table 4.1	Habitat and nesting site of <i>Pachycondyla</i> ants in Sabah 111



UMS  
UNIVERSITI MALAYSIA SABAH

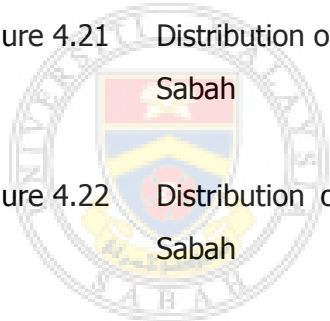
## LIST OF FIGURES

	Page
Figure 2.1	7
General morphological feature of ant in lateral view based on Bolton, 1994	
Figure 2.2	7
General head morphological feature of ant based on Bolton, 1994	
Figure 2.3	19
Morphological feature of <i>Pachycondyla</i> ant in lateral view	
Figure 2.4	20
Head morphological feature of <i>Pachycondyla</i>	
Figure 3.1	26
Sampling Site of fresh specimens of ant genus <i>Pachycondyla</i> in Sabah	
Figure 3.2	32
Sample map of Distribution of Genus <i>Brachyponera</i>	
Figure 4.1	41
Morphological feature of <i>B. flavipes</i> (a) Head in full-face view; (b) body in lateral view; (c) Body in dorsal view	
Figure 4.2	43
Morphological feature of <i>B. luteipes</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	
Figure 4.3	46
Morphological feature of <i>B. obscurans</i> a) Head in full-face view;(b) body in lateral view; (c) Body in dorsal view	
Figure 4.4	48
Morphological feature of <i>B. pilidorsalis</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	
Figure 4.5	51
Morphological feature of <i>B. villus</i> (a) Head in full-face	

view; (b) Body in lateral view; (c) Body in dorsal view

Figure 4.6	Morphological feature of <i>B. amblyops</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	54
Figure 4.7	Morphological feature of <i>E. astuta</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	59
Figure 4.8	Morphological feature <i>E. keningauensis</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	61
Figure 4.9	Morphological feature of <i>E. leeuwenhoekii</i> (a) Head in full-face view; (b) Body in lateral view; (c) body in dorsal view	64
Figure 4.10	Morphological feature of <i>E. magnus</i> (a) Head in full-face view; (b) Body in lateral view; (c) body in dorsal view	66
Figure 4.11	Morphological feature of <i>E. maliauensis</i> (a) Head in full-face view; (b) Body in lateral view; (c) body in dorsal view	68
Figure 4.12	Morphological feature of <i>E. sharpi</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	71
Figure 4.13	Morphological feature of <i>M. javana</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	76
Figure 4.14	Morphological feature of <i>M. kilau</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	78
Figure 4.15	Morphological feature of <i>M. rubra</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	81

Figure 4.16	Morphological feature of <i>M. similerubra</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	84
Figure 4.17	Morphological Feature of <i>P. brevior</i> (a) Head in full-face view; (b) Body in full lateral view; (c) Body in dorsal view	90
Figure 4.18	Morphological feature of <i>P. debilior</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	93
Figure 4.19	Morphological feature of <i>P. sandakana</i> (a) Head in full-face view; (b) Body in lateral view; (c ) Body in dorsal view	95
Figure 4.20	Morphological feature of <i>P. tridentata</i> (a) Head in full-face view; (b) Body in lateral view; (c) Body in dorsal view	98
Figure 4.21	Distribution of <i>Brachyponera</i> ants species richness across Sabah	103
Figure 4.22	Distribution of <i>B. amblyops</i> ants species richness across Sabah	104
Figure 4.23	Distribution of <i>Ectomomyrmex</i> ants species richness across Sabah	105
Figure 4.24	Distribution of <i>E. sharpi</i> ants species richness across Sabah	106
Figure 4.25	Distribution of <i>Mesoponera</i> ants species richness across Sabah	107
Figure 4.26	Distribution of <i>Pseudoneoponera</i> ants species richness across Sabah	108







## LIST OF PHOTOGRAPHS

		Page
Photograph 4.1	Nest of <i>P. tridentata</i> in dead wood	110
Photograph 4.2	Nest of <i>E. leeuwenhoekii</i> in leaf litter	110
Photograph 4.3	Nest of <i>P. brevior</i> in soil	111



UMS  
UNIVERSITI MALAYSIA SABAH

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction to Ants Formerly known as Genus *Pachycondyla* Smith, 1858

The ants formerly known as genus *Pachycondyla* was erected by Smith, in 1858 (Bolton, 1995) based on a type species *Formica crassinoda* by subsequent designation of a worker specimen from Surinam (Emery, 1901). The formerly known genus is the largest group within the Ponerinae subfamily and known as predatory ant, having specific morphological characters to enable them to be efficient predators (Mora, Perez-Lachaud, and Lachaud, 2008). The latest revision of this genus by Schmidt and Shattuck (2014) revealed that genus *Pachycondyla* is not occur in Borneo. This genus has been separated into several revived genera (*Brachyponera*, *Euponera*, *Ectomomyrmex*, *Mesoponera* and *Pseudoneoponera*) and a new genus of *Buniapone*.

Study of behaviour of ants formerly known as *Pachycondyla* are popular due to their primitive behaviour as well as their low numbers of workers in the colony which makes the observation are much easier. Several study which relate to the *Pachycondyla* ants including their behaviour in hunting termites (Inara and Paulo, 1995), morphological structure of their pretarsus (Orivel, Malherbe and Dejean, 2001). Taxonomy study of *Pachycondyla* ants is very complex due to the heterogeny of the genus that now been separated into several genera from the phylogenetic study with additional to the DNA analysis (Schmidt and Shattuck, 2014).

In previous study, Hashimoto (2003) and Fisher (2010) distinguished ants formerly known as genus *Pachycondyla* of Borneo from other genera in Ponerinae ant based on several characteristics: 1) Mandible triangular, with seven or more teeth; 2) Anterior section of frontal lobes and antennal sockets very closed together; 3) Tibiae of hind legs each with two spurs, a large and pectinate spur and a smaller

simple spur. 4) Pretarsal claws on the hind legs simple, without preapical teeth on their inner surface.

There are 289 species and subspecies of ants formerly known as genus *Pachycondyla* worldwide that are mainly distributed in the world tropics and subtropics regions (Bolton, 2014). Martin, Dirk, Shingo Hosoishi, Bakhtiar Effendi Yahya and Rudolf (2011) reported that there are 15 species occur in Borneo which are now been separated into different genera: *Buniapone (amblyops)*, *Neoponeras (apicalis)*, *Ectomomyrmex (astuta and leeuwenhoekii)*, *Parvaponera (darwinii indica)*, *Pseudoneoponera (insularis, insularis brevior, tridentata, tridentata debilior and sandakana)*, *Brachyponera (luteipes, obscurans and pilidorsalis)*, *Pachycondyla (obtusa and vidua)*, *Mesoponera (rubra)* and *Euponera (sharpi)*.

To date, there is no published work on the taxonomy and bionomics of recent ants formerly known as genus *Pachycondyla* ants in Sabah. This study will provide an updated list of ant previously known as genus *Pachycondyla* ant species of Sabah. Preliminary revision of ants formerly known as genus *Pachycondyla* of Sabah was started by Bakhtiar and Wong (2010). The research provides information of preliminary revision of ants formerly known as genus *Pachycondyla* status of Sabah, access the status of collection in major collection centres and general information of distribution of ant formerly known as genus *Pachycondyla* in Sabah.

## 1.2 Historical Review

Taxonomic status of ants genus *Pachycondyla* Smith, F. 1858 is the most complex in Ponerine ants. *Pachycondyla* is heterogeneous and proved to be non-monophyletic genus. Some genera that were erected earlier which were later synonymized as *Pachycondyla* were *Bothroponera* (Mayr, 1862), *Megaponera* (Mayr, 1862), *Paltothyreus* (Mayr, 1862), *Ectomomyrmex* (Mayr, 1867), *Ophthalmopone* (Forel, 1890), *Euponera* (Forel, 1891), *Pseudoponera* (Emery, 1900), *Brachyponera* (Emery, 1900), *Mesoponera* (Emery, 1900), *Eumecopone* (Forel, 1901), *Hagensia* (Forel, 1901), *Neoponera* (Emery, 1901), *Trachymesopus* (Emery, 1911), *Xiphopelta* (Forel, 1936), *Termitopone* (Wheeler, 1936), *Syntermitopone* (Wheeler, 1936), *Wadeura* (Weber, 1936), and *Pseudoneoponera* (Donisthorpe, 1943).

The confusions of the development of new genera *Neoponera* Emery (1901) and *Termitopone* Wheeler (1936) which later synonymized with *Pachycondyla* by Brown (1973) was due to the heterogeneity of the genus (Mayr 1863, Roger 1863, Mackay 2010). In addition, the morphological characters used to separate the genera and subgenera are not consistent.

There is no single derived character between species that can be used to define *Pachycondyla*. Due to that, the genus later has been categorizing as paraphyletic or polyphyletic. Thus, the separation of the genus into several genera is particularly attractive (Mackay and Mackay, 2010). Later on, study of the molecular phylogenetics of ponerine ants (Schmidt, 2013) shows that the *Pachycondyla* ants as a combination of unrelated species which suggested that likely to be separated and revert into older names such as *Bothroponera*, *Brachyponera* and *Mesoponera*. To date, ant genus *Pachycondyla* been separated into fragmented genera and most of genera been revived. In Sabah, all specimens of genus *Pachycondyla* been separated into different genera and genus *Pachycondyla* does not occur in Sabah (Schmidt and Shattuck, 2014).

### **1.3 Biology and Ecology**

Members of this genus are predatory where they usually hunt for their food solitary. Every predatory ant have morphological characters specific to enable them to be efficient predator (Mora *et al.*, 2008). Among those features are like having a sting, a long and strong mandible with teeth along masticatory margin (Fisher, 2010). These features make the species of ant genus formerly known as *Pachycondyla* be efficient predator ants to enable it to dominate the habitat of the land-rich tropical arthropod species (Maryati, 1997).

Ants of the genus formerly known as *Pachycondyla* built their nest in the soil or logs, leaf litter or foraging on ground (Agosti, 2000). Most of species in *Pachycondyla* are scavengers and predators (Alexander, 2002).

### **1.4 Significance of Study**

Most of forests in Sabah have been highly degraded to fragmented and isolated forest

surrounded by highly altered agricultural landscape (Bruhl, Maryati Mohamed and Linsenmair, 1999). The forest disturbances influence the reduction of species richness and diversity (Wüzberg, 2001). Due to that, urgent study needed to collect the data of biodiversity in forest of Sabah especially ant which is sensitive to the changes of the forest (Underwood and Fisher, 2006). This study would provide significant contribution in response to the Agenda 21, the Biodiversity Convention, of the United Nation on the Environment and Development (UNCED), which is known as Rio de Janeiro, Brazil in June 1992 (Zakri, 1997).

As the study of taxonomy and bionomics of ants formerly known as genus *Pachycondyla* ant in Sabah is new, this study will provides the information of the taxonomic status of ants formerly known as genus *Pachycondyla* ant in Sabah. Species list, identification key, description of species, distributional data and nesting behavior of the ants formerly known as genus *Pachycondyla* were included all these information would contribute to better understanding of this genus.

In addition, contribution of this study would also likely to introduce new species, update the systematical status and providing additional specimens collection data in museums as references for further study of ants formerly known as genus *Pachycondyla*. Identification key to species level will be significant for references in study of ecology and behaviours of ants as well as additional figures of morphological references to make the identification of ants become easier.

### **1.5 Objectives of the Study**

The objectives of this research are:

- a. To study the taxonomy of ants formerly known as genus *Pachycondyla* ants of Sabah
- b. To study the distribution of ants formerly known as genus *Pachycondyla* ants in Sabah
- c. To study the nesting behaviour of different species of ant formerly known as genus *Pachycondyla* in Sabah.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction to Hymenoptera: Formicidae (Ant)

Order Hymenoptera is a group of insects consists of sawflies, bees, wasps and ants. According to Bolton (2003) diagnosis, Formicidae is an eusocial vespid aculeate with a wingless worker caste, forming perennial colonies.

Ants are one of the invertebrate insects that are abundance in the terrestrial ecosystems except tundra and extremely cold-wet areas (Ward, 2007). The number of ants in worldwide are more than 12 000 described species (Bolton, 2014) and there are still more in the process of identifying. They are usually been studied for their interesting social behaviours, foraging habits and their associations with other organisms (Holldobler and Wilson, 1990).

As any others social insects, ants community composed of different caste in the colony to maintain the longevity of the colony. The caste in ant's colony consists of the reproductive (queen and male) and the workers. Each different caste has a different role in maintaining the colony. The reproductive caste which are the queen and the male are important for reproduction while the workers playing important roles in managing the nest, provided the food, and protect the colony from the threat.

Morphology of ants among different caste usually differs from one another. The differences in their morphology enhance them to act proactively for their colony survival (Maryati, 1993). The productive caste are having their wings for them to search their mate from others colony to enhance the genetic variation. The major workers caste or soldier are usually having large mandible to protect the nest and the colony. The minor workers usually having smaller mandible to enable them managing the nest easier and carrying food to the nest for the colony.

Ants interact with one another using pheromone. The pheromone is the chemical substances that secreted by their body. In addition, they can also interact using the antennae and eyes. The interaction within the ants is very important as to maintain the colony. The communication usually used in tracking the prey for the predatory ants that are working in a group to hunt down their prey such as *Leptogenys*, *Aenictus* and *Pheidole* ants. Pheromone can be used as alerting signals to alert other ants in the same species when the danger approached (Maryati, 1997). The ants also use the pheromone in making their trail for orientation between nest and resources. In addition, they also use pheromone in recruiting nest mates when they discovered foods.

### **2.1.1 Ant Morphology**

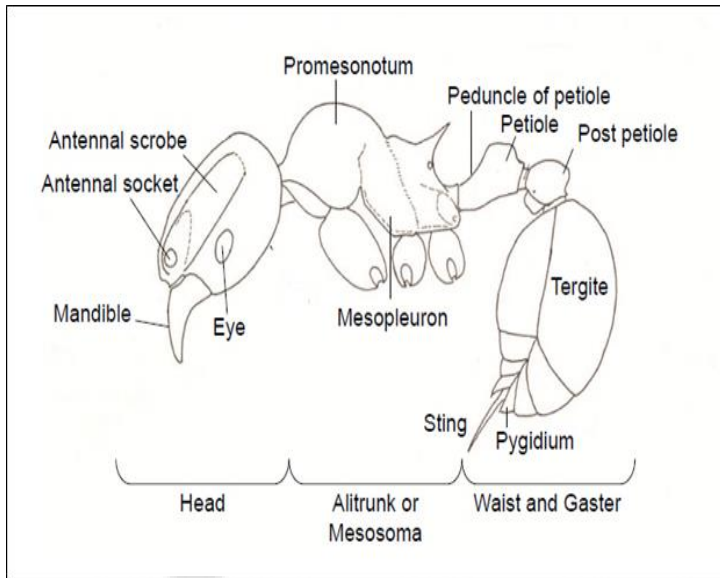
Morphology of ants is unique to each species. Thus, taxonomists on the ant's systematic are using the morphological character to build the identification key to differentiate the ants until species level.

Ant body has three distinct parts namely head, alitrunk or mesosome and waist or gaster (Figure 2.1). Head is prognathous shape in female castes (workers and queens) and consists of mainly sensory organs which are eye and antenna and also including mandible. Eye used for movement detection but sometimes ants like *Aenictus* species does not have eyes and fully depend on antenna and pheromone for the interaction.

The antennae of family Formicidae comprises of four to 12 antennal segments in female castes and nine to 13 antennal segments in male caste. The geniculate antenna that can bend like an elbow (Maryati, 1997) is used to detect chemical, vibration and sometimes used to transmit and receive signals through touch. Mandible is important to transport foods to nest, manipulate object which is used in the construction of the nest and defense mechanism (Mora, Perez-Lachaud and Lachaud, 2008). Legs attached to alitrunk and mainly used as important structure for mobility.

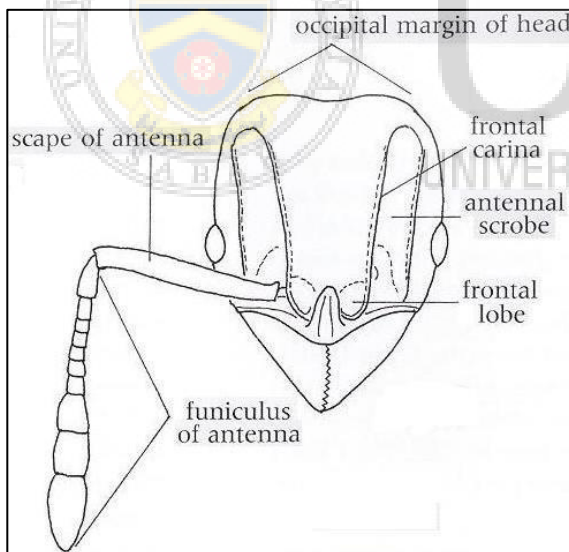
The existence of petiole (a node part that connects the abdomen and the alitrunk) or sometimes with additional postpetiole structure for Myrmicinae and

Pseudomyrmicinae subfamilies is important to distinguish ant from other groups of Hymenoptera. Waist and gaster or known as abdomen consist of important internal organs and excretory systems which is modified in worker caste into stings for defense mechanism (Mora *et al.*, 2008).



**Figure 2.1 : General morphological feature of ant in lateral view.**

Source : Bolton, 1994



**Figure 2.2 : Head morphological feature of ant based on Bolton (1994).**

Source : Bolton, 1994

The reproductive ants have wings that enable them to fly out from their nest to mate with other reproductive of same species from different colony. This will enhance their genetic sources to success a new colony. Queen of family Formicidae is deciduous