Comparison of Ant Communities in Two Study Sites at Khao Nan National Park, Nakhon Si Thammarat Province

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ชื่อวิทยานิพนธ์ การเปรียบเทียบสังคมมดในสองพื้นที่บริเวณอุทยานแห่งชาติเขานัน จังหวัดนครศรีธรรมราช

ผู้เขียน นางสาวอัมพร พลับพลึง

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บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบสังคมมดในสองพื้นที่ เขตอุทยานแห่งชาติเขานัน จังหวัดนครศรีธรรมราช คือ บริเวณสำนักงานอุทยานและหน่วยห้วยเลข และศึกษาปัจจัยที่มีผลต่อสังคมมดในสองพื้นที่ดังกล่าว โดยเก็บตัวอย่างในช่วงเดือนมกราคม พ.ศ. 2549 ถึงเดือนมกราคม พ.ศ. 2550 ทุก 2 เดือน พื้นที่ศึกษาประกอบด้วยแปลงย่อยขนาด 30 X 30 เมตร จำนวน 3 แปลง ห่างกัน 500 เมตร และแต่ละแปลงประกอบด้วย 3 แปลงย่อย โดยใช้ 5 วิธีในการเก็บตัวอย่าง คือ การเก็บด้วยมือ การใช้ตะแกรงร่อนใบไม้ การใช้เหยื่อน้ำหวาน การใช้กับดักหลุม และการใช้ถุง Winkler

ผลการศึกษาพบมดทั้งสิ้น 10 วงศ์ย่อย 50 สกุล 228 ชนิด โดยพบสกุลที่มีการรายงานครั้งแรกในประเทศไทย 1 สกุล คือ *Tetheamyrma* บริเวณสำนักงานอุทยานพบมด 172 ชนิด จาก 47 สกุล 10 วงศ์ย่อย (75.44% ของจำนวนชนิดมดทั้งหมด) และบริเวณหน่วยห้วยเลขพบมด 162 ชนิด จาก 44 สกุล 9 วงศ์ย่อย (71.05% ของจำนวนชนิดมดทั้งหมด) โดยพบมดในวงศ์ย่อย Myrmicinae มากที่สุด (104 ชนิด, 45.61%) ตามด้วยวงศ์ย่อย Formicinae (50 ชนิด, 21.93%) Ponerinae (41 ชนิด, 17.98%) Dolichoderinae (14 ชนิด, 6.14%) Pseudomyrmicinae (5 ชนิด, 2.19%) Cerapachyinae (4 ชนิด, 1.75%) Aenictinae (4 ชนิด, 1.75%) Dorylinae (3 ชนิด, 1.32%) Ectatomminae (2 ชนิด, 0.88%) และ Amblyoponinae (1 ชนิด, 0.44%) ตามลำดับ ระดับสกุลที่พบมากที่สุด คือ สกุล *Pheidole* (31 ชนิด, 13.60%) รองลงมา คือ สกุล *Camponotus* (19 ชนิด, 8.34%) *Tetramorium* (16 ชนิด, 7.02%) *Pachycondyla* (15 ชนิด, 6.58%) *Polyrhachis* (13 ชนิด, 5.71%) และ *Crematogaster* (13 ชนิด, 5.71%) ตามลำดับ นอกจากนี้พบว่ามีมดที่พบได้ทั้งสองพื้นที่ 106 ชนิด (46.49%) และมี 66 ชนิด (28.95%) พบเฉพาะบริเวณสำนักงานอุทยาน และ 56 ชนิด (24.56%) พบเฉพาะหน่วยห้วยเลข โดยพบว่าสกุล *Recurvidris, Rhoptromyrmex, Emeryopone, Platythyrea, Philidris* และ *Mystrium* พบเฉพาะบริเวณสำนักงานอุทยาน และสกุล *Acanthomyrmex, Tetheamyrma* และ *Harpegnathos* พบเฉพาะที่หน่วยห้วยเลข

จากการวิเคราะห์การจัดกลุ่มของพื้นที่ตามความคล้ายคลึงของชนิดมดด้วยสถิติ Detrended Correspondence Analysis (DCA) พบว่า สามารถจัดกลุ่มพื้นที่ได้ 3 กลุ่ม คือ กลุ่ม I บริเวณสำนักงานอุทยาน และกลุ่ม II และ III บริเวณหน่วยห้วยเลข โดยผลจากการวิเคราะห์ความสัมพันธ์ระหว่างปัจจัยทางกายภาพและสังคมมด ด้วยสถิติ Canonical Correspondence Analysis (CCA) พบว่า อุณหภูมิดิน ปริมาณน้ำในดิน และปริมาณน้ำในเศษซากใบไม้ มีผลอย่างมีนัยสำคัญทางสถิติต่อการกระจายของสังคมมด (P = 0.001, eigenvalue axis 1 = .239, axis 2 = .119) โดยปัจจัยที่มีผลต่อสังคมมดมากที่สุด คือ อุณหภูมิดิน รองลงมาคือ ปริมาณน้ำในดิน และปริมาณน้ำในเศษซากใบไม้

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ABSTRACT

The present study aimed to compare ant communities in two different areas; Headquarters and Hui Lek stations, at Khao Nan National Park, Nakhon Si Thammarat Province and to examine the factors relation to the ant compositions in this area. Samples were collected bimonthly during January 2006 and January 2007 by five collecting methods; Hand collecting, Leaf litter sifting, Honey bait trap, Pitfall traps and Winkler extraction samples. Three permanent plots (30x30 m) were set up (500 meters from each other) which further subdivided into three subplots.

A total of 10 subfamilies, 50 genera and 228 species was recorded. *Thetheamyrma* is the new record in Thailand. 172 species in 47 genera and 10 subfamilies were found at Headquarters station (75.44% of total) and 162 species in 44 genera and 9 subfamilies were found at Hui Lek station (71.05% of total). Of which, Myrmicinae was the most diverse subfamily (104 species, 45.61%) followed by subfamily Formicinae (50 species, 21.93%), Ponerinae (41 species, 17.98%), Dolichoderinae (14 species, 6.14%), Pseudomyrmicinae (5 species, 2.19%), Cerapachyinae (4 species, 1.75%), Aenictinae (4 species, 1.75%), Dorylinae (3 species, 1.32%), Ectatomminae (2 species, 0.88%) and Amblyoponinae (1 species, 0.44%), respectively. *Pheidole* was the most diverse genus (31 species, 13.60%) followed by *Camponotus* (19 species, 8.34%) and *Tetramorium* (16 species, 7.02%) respectively. Among the total species, 106 species (46.49%) were shared between two stations whereas 66 species (28.95%) and 56 (24.56%) were particularly found at Headquarters and Hui Lek stations, respectively. It was found that *Recurvidris, Rhoptromyrmex*, *Emeryopone, Platythyrea, Philidris* and *Mystrium* were specifically found at Headquarters station and *Acanthomyrmex, Tetheamyrma* and *Harpegnathos* were specifically found at Hui Lek station.

Moreover, it was found that ants showed the association with habitat characteristics. Detrended Correspondence Analysis (DCA) was grouped the habitats based on the similarity of species composition into three groups; group I was at Headquarters station and groups II and III were at Hui Lek station. The correlations between the occurrence of ant species and environmental factors (Canonical Correspondence Analysis, CCA) revealed that three measured factors; soil temperature, water content of soil and water content in litter were important factors affected the ant compositions (P = 0.001, eigenvalue axis 1 = .239, axis 2 = .119). Of which, soil temperature was the most important one followed by water content of soil and water content in litter, respectively.

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CHAPTER 1

INTRODUCTION

1. General Introduction

Tropical rainforests are the most species-rich communities in the world, and it is generally accepted that animals and plants within tropical rainforests have co-evolved to reap mutual benefits from each other. Tropical rainforests are the richest terrestrial ecosystems on the planet (Heywood, 1995). They harbor the largest number of species, provide an environment for complex ecological interactions and processes, house valuable economic resources, and provide important environmental services at local, regional, and global levels. Tropical rainforests house many kinds of fauna and flora, which play an important role in this complicated ecosystem. Understanding of regional and local species diversity in tropical rainforest is a main knowledge for fulfillment ecological process and conservation around the world. The habitat complexity play an important role on species diversity that tropical rainforest would contribute in complexity of habitat (microhabitat). Microhabitats have contributed diversity of organisms, especially insect because number of species and individuals are highest in the tropical rainforest (Stork, 1991).

Terrestrial ant communities are ecologically dominant in many ecosystems around the world, particularly the tropical rainforests. In tropical rainforest, ant assemblages play an important role in the rainforest ecosystem because they function at many levels, for example, as predators, preys, detritivores, mutualisms, and herbivores (Alonso, 2000). Studying the ant community can help us to understand important components and relationships in tropical rainforest ecosystem. Social insects such as ants often constitute more than half the insect biomass in many terrestrial habitats (Wilson, 1990), Ants, in particular, are one of the most well represented insect groups (Hölldobler & Willson, 1990) and the ant community structure is strongly influenced by changes in the plant community structure. Thus, ant assemblages have been used as indicators for the investigation of forest fragmentation and the successful rehabilitation of tropical habitats (Wilson, 1990). Brown (1991) and Holloway and Stork (1991) proposed that general criteria for using ants as indicators are based on the following categories: 1) they are taxonomically and ecologically diverse; 2) they are easily sampled; 3) they are widely distributed; 4) their assemblages show high habitat fidelity; 5) they respond rapidly to perturbation and 6) they have been well studied taxonomically and ecologically.

Local and regional habitat characteristics have influenced species richness and community structure. These scales at which communities are studied, however, affects the detection of relationships between habitat characteristics and patterns of habitat selection, species diversity and species composition, but it may obscure observation of differences in how species perceive the scale of environmental variation. Over six decades, local and regional diversity were disturbed from anthropogenic cause and hence species diversity was damaged and changed, particularly in the tropical rainforest. In Thailand, tropical rainforests were confined to the Southern and Western Thailand (Whitmore, 1975) that its size was appeared to be fragmented and rapidly contracted on the mountain range. Thus, the tropical rainforest in Thailand can be defined by degree of disturbing into two types: primary and secondary forest.

Khao Nan National Park (KNNP) is a part of the Nakhon Si Thammarat mountain range. The total area of the park is 406 square kilometers. The main topography is a high mountain range extending from Khao Luang National Park. It is located in Nakhon Si Thammarat Province in southern Thailand and contains eight stations in the Park. Most of the area is productive rainforest, containing habitats which support wildlife and variable flora and natural resources. The rainforest provides the main source for rivers and supports the local human population, as well as providing habitats for wildlife and valuable flora. In the Headquarter, most area are primary rainforest that was covered mainly by many valuable plants such as Yang (*Dipterocarpus* sp.), Malacca Teak, Iron Wood, Thingan, Heritiera, Sumatrana, Kosterm and wild champak. In addition, there is one specific type of plant, which grows in large clusters in this area. Meanwhile, the Hui Lek station was covered by only one species of *Elateriospermum tapos* Blume. It seems to be dominant species and secondary forest. The fruit of *Elateriospermum tapos* Blume is edible and expensive and it is an important economic plant for the local people.

For over a decade, Khao Nan National Park has been continually disturbed in various ways with activities such as illegal logging, hunting and rubber planting, etc. These activities have affected many kinds of organisms, including terrestrial ant communities. Two types of different habitat were selected for this study. The first one was located at the headquarters station. This site is lowland forest, primary forest, the dominant trees are in the family of Dipterocarpaceae, Annonaceae, Euphorbiaceae and Lauraceae, which cover 60 % of the national park. The second selected habitat was Hui Lek station 40 kilometers away from the first site. This area has different characteristics from the first site in that there is less diversity of flora. The dominant species of plant in this area is *Elateriospermum tapos* Blume, which covers approximately 70 % of the study site. The vegetation structure would be classified to be secondary forest by Whitmore (1975) and ONEP (2004).

Therefore, the aims of this research were to compare ant communities in two different habitats and investigate environmental variation with ant assemblages. Understanding of ant communities would explain ecological processes and habitat conservation. Furthermore, our study is contributed to fulfill the understanding of the structure and function of forest fragmentation and modification of habitat.

2. Research questions

1. Are there any significant differences in terrestrial ant communities between the two study sites at Khao-Nan National Park?
2. What are the main factors that have influenced the terrestrial ant communities at Khao-Nan National Park?

3. Research objectives

1. To compare ant communities of two different habitats at Khao Nan National Park
2. To investigate the relationships between microclimate and terrestrial ant communities.

4. Hypothesis

Terrestrial ant communities at the two study sites at Khao Nan National Park are different.

5. Literature review

5.1 Ant and diversity

Given the ubiquitous nature and functional role in many ecosystems, ants have long been considered to be social insect belonging to the family Formicidae, Order Hymenoptera (Hölldobler and Wilson, 1990). They are the dominant species within animal communities in many tropical and temperate ecosystems in terms of biomass and the number of individuals. Many ants are largely omnivorous and opportunistic feeders, while some subfamilies and genera are comprised of highly specialized predators. Others largely live on vegetarian diets, including seeds, honeydew, plant nectar and food bodies (Hölldobler and Wilson, 1990). Ants have been currently classified into 16 subfamilies, 296 genera, and almost 15,000 species (Bolton, 1994).

Ant diversity in Thailand has been intensively studied since 1997, when the first meeting of ANet (International Network for the study of Asian Ants) was held in Thailand. At least four universities: Kasetsart University, Chiang Mai University, Khon Kaen University, and Prince of Songkla University start working in ant diversity and various aspects relating to ants. Wiwatwitaya (2003) claims that there are 800-1000 species of ant in Thailand, bases on the collection of ant at the Ant Museum at KU and ant fauna of Khao Yai National Park (Wiwatwattaya and Jaitrong, 2001).

In northern Thailand, Sonthichai (2000) recorded that ant diversity at Doi Chiang Dao in northern Thailand consists of 166 species in 49 genera of 8 subfamilies. A lot of papers have been studied about ants in other part of the country, especially southern part of Thailand.

In southern Thailand, there are many papers published on ant diversity in various areas. The distinguished works both ground dwelling and canopy ants were studied. Regarding to ground dwelling ant, Noon-anant et al. (2005) studied distribution and abundance of ant at lowland tropical rain forest at Hala Bala Wildlife Sancutuary at Narathiwat Province. It is composed of 255 species, 63 genera in 8 subfamilies. The preliminary survey of ants at Tarutao National Park, Satun Province recorded 61 species in 5 subfamilies (Watanasit et al., 2003). The ants of Klong U-Tapao Basin which includes Ton Nga Chang Wildlife Sancuary were studied by Watanasit et al. (2007). They found 248 species of ant in 50 genera and 7 subfamilies.

The canopy ant study exists only in southern Thailand because of time consume and difficult sampling methods. Watanasit et al. (2007) applied fogging chemical on canopy ant at a reserve area of Prince of Songkla University, which canopy trees are mainly secondary forest. They recorded 31 species, 14 genera and 5 subfamilies which is very small species of ants, comparing to tropical rain forest of Ton Nga Chang Wildlife Sanctuary and Khao Nan National Park. For example, Watanasit et al. (2005) found that a composition of canopy ant at Ton Nga Chang Wildlife Sanctuary consists of 118 morphospecies, 29 genera of 6 subfamilies. Besides, Jantarit et al. (2008) showed that canopy ant composition of Khao Nan National Park was diverse. It belongs to 205 morphospecies, 34 genera of 7 subfamilies.

From the studies mentioned above, it indicates that diversity of ant in Thailand is very diverse, especially in southern Thailand. The list of known ant species of Thailand which mainly recorded from ground dwelling was summarized by Jaitrong and Nabhitabhata (2005).

5.2 Habitat preference and vegetation type on ant composition

Tropical rainforests are renowned for their great diversity of both plant and animal, particularly the diversity of plant and insect groups (Erwin, 1988; and Stork, 1991). The amount of rain fall and radiation from the sun make an impact on environment factors of the forest. All year round, the amount of rain fluctuate at least 1,700 -10,000 mm. It is normally warm with temperature at 22-34 ^{o}C all year round and the average was humidity 60-80% at daytime and 95-100% at night time (Whitmore, 1990). Thus, Khao Nan National Park provides a clear cut picture of tropical rainforest. The vegetation is characterized by both evergreen and deciduous plants.

Many studies showed that composition of ant influenced by both biotic and abiotic factors, such as, elevation (Samson *et al.*, 1997), vegetation type (Bestelmeyer and Wiens, 2001), predation (Soares and Schoereder, 2001), topography (Vasconcelos *et al.*, 2003), temperature (Bestelmeyer, 2000), humidity (Kaspari, 1996) and habitat preference (Watanasit *et al.*, 2005).

Concerning vegetation type and habitat preference, especially forest type and human activities, forest area is disturbed by human activities, which makes forest becoming fragmentation. The effects of losing habitat and causing fragmentation reduce species abundance and richness (Brown and Kodrick-Brown, 1977). Turnover rates in insular biogeography: effects of immigration on extinction (Valerie *et al.*, 2007). Effect of fragmentation, habitat loss and within-patch habitat characteristics were studied on ant assemblages in semi-arid woodland of eastern Australia (Golden and Crist, 2000). They found that habitat fragmentation reduces ant composition in semi-arid woodland in Australia.

Regarding to habitat disturbance, many studies also indicated making an impact on ant community composition. For example, King *et al.* (1997) compare disturbed and undisturbed of vegetation rainforest on ant composition in Queenland, Australia. They found that ant species richness was more abundance at undisturbed vegeatation.

Anu and Sabu (2006) studied the diversity of litter ant assemblages in evergreen and deciduous forest vegetation types in Western Ghats, India. Their results showed a slight different in total ant species of both habitats. 22 species were found at evergreen forest while 23 species were sampled at deciduous forest. However, evenness in taxonomic spread was high in deciduous forest and low in evergreen forest.

In southern Thailand, Watanasit et al. (2007) also found that the vegetation type along Klong U-Tapao basin influences on ant species. Moreover, rubber plantation type (monoculture plantation and mixed plantation) can distinguish ant species (Watanasit and Nhu-eard, 2007).

From above studies, it concludes that vegetation type and habitat preference can make an impact on ant composition.

5.3Ant and Microclimate

Understanding the relationships of insects and environmental factors are one of central importance keys to estimate the ecological impacts and conservation biology (Stork, 1988; Hammond, 1995). There are several groups of insect to monitor and evaluate an effect of environmental change. Ants are one of biological indicator to be use for monitoring in several study sites such as Australia and South America (Folgarait, 1998; Andersen *et al*., 2002). The local distribution of ants was well known to be strongly influenced by environmental stress and disturbance.

With regard to microclimate, temperature and humidity have been identified as the main abiotic factors governing ant activity (Kaspari and Weiser, 2000; Hahn and Wheeler, 2002). Focusing on the environmental factors affecting terrestrial ant communities can be classified into three categories: (1) Soil temperature, (2) Water content in soil, and (3) Water content of litter. Those three categories correlate with temperature and humidity of microclimate.

According to soil temperature, it is a well know fact that soil is an important habitat for terrestrial ants, both on and below the surface. Killham (1994) stated that, in general, soil animals are sensitive to overheating and move down to the ground to avoid high temperatures. In tropical forest, soil temperatures at depths of 5 to 10 cm are typically cooler than the air temperature by 2 to 3 °C during the daytime, even in open areas (Campos, 2006). Thus, ants inhabit nests excavated in soil (Hillel, 1998).

Bollazzi *et al*. (2008) stated that ants dig their nests at various soil layers to provide an appropriate microclimate for colony growth. With some ant species, for example, *Acromyrmex*, soil temperature is the most relevant selective force influencing selection of their nest depth (Bollazzi *et al.*, 2008). For leaf-cutting ants, soil temperature is a powerful variable response in different contexts, such as brood or fungus relocation and food search (Kleineidam *et al.*, 2007). Some argue that many species of ants benefit from warmer soil temperature because cool temperatures are stressful for most species of ants, a largely thermophilic group (Hölldobler & Willson, 1990).

Water content of soil and water content of litter; particularly humidity are concerned to be important factors to influence on diversity of ants. An increase in humidity is often associated with increased insect abundance and activity (Levings and Windsor, 1996). Several study indicated that humidity has positively correlated with foraging activity of terrestrial ant (Kaspari and Weiser, 2000; Hahn and Wheeler, 2002). As know that terrestrial ants are played an important role to be predatory behavior and hence moist litter and moist soil are more likely to release nutrients and bolster populations of microbes and micro-fauna prey that form the base of the litter food web (Coleman and Crossley, 1996; Levings and Windsor, 1996). As a consequence, water content in soil and water content of litter are important parameters in determining their foraging activities of terrestrial ants leading to species composition of ant.

CHAPTER 2

MATERIALS AND METHODS

1. Study area

1.1. Location

The study area was located at Khao Nan National Park (KNNP) in Nakhon Si Thammarat Province, Southern Thailand. This area represents the typical forest type of southern Thailand. Its approximate location is between 8° 41 ′and 8° 58 ′N latitude and 99° 30 ′and 99° 99 ′E longitude. The approximate area of KNNP covers 406 square kilometers (around 272,500 *rai*) and the elevation ranges from 80-1,438 meters above sea level (Wittaya, 2000). Eight stations are located within the park: 1) Park Headquarters, 2) Klong Kai station, 3) Hui Kaew station, 4) Khong Gun station, 5) Khong Tha Ton station, 6) Hui Lek station, 7) Klong Lam Pan station and 8) Khong Yod Nam station. Main sources of rivers are also located in this area. It is a complex mountain ridge with a high diversity of floral and faunal species. This area is also home to a special deciduous plant, called *Elateriospermum tapos* Blume, which has a deciduous life-cycle in the short period of the dry season. Mature trees shed leaves annually from around February to March (Whitmore, 1972). In this study, two study sites were divided into two types by the different forest type: 1) primary forest (Park Headquarters at Sunandha waterfall) and 2) secondary forest (Hui Lek station) (Figure 1).

1.2. Topography

Khao Nan National Park consists of a complex mountain range along the north and south. The park is a part of the Nakhon Si Thammarat Mountain Range, and includes important mountains such as Khao Nan Yai, Khao Nan Mia, Khao Lek and Khao Chong Lom. Khao Nan Yai has altitudes of approximately 1,438 meters above sea level. Tropical rainforest is the main forest type in the park (Wittaya, 2000).

1.3. Climate

The climate is relatively constant and can be divided into two distinct seasons: wet and dry (Table.1). The wet season can be divided into the main rainy season from November-January and a lesser one from May-October, whereas the dry season is around February-April. The level of rainfall fluctuates between 2,000-3,500 mm per year (Department of Meteorology, Nakhon Si Thammarat Province, unpublished data). Most of the area consists of productive rainforest that causes high humidity and heavy continuous rainfall. It receives monsoons from both the east and the west coasts, and consequently the park receives a great deal of rain all year. The highest temperature range is between 28°C and 30 °C, and the lowest between 15°C and 17° C. The lowest temperatures are recorded in January and February.

Table 1 The annual precipitation (mm) measured at weather stations in Nakhon Si Thammarat Province from January 2006 to January 2007 (Thai Meteorological Department). Precipitations were classified into two seasons: dry season (< 100mm) and wet season (> 100 mm) (Whitmore, 1975).

Month	January (2006)	March	May	July	September	November	January (2007)
Precipitation (mm)	194.34	48.21	97	38.9	224.3	431.5	211.4
Season	wet	dry	dry	dry	wet	wet	wet

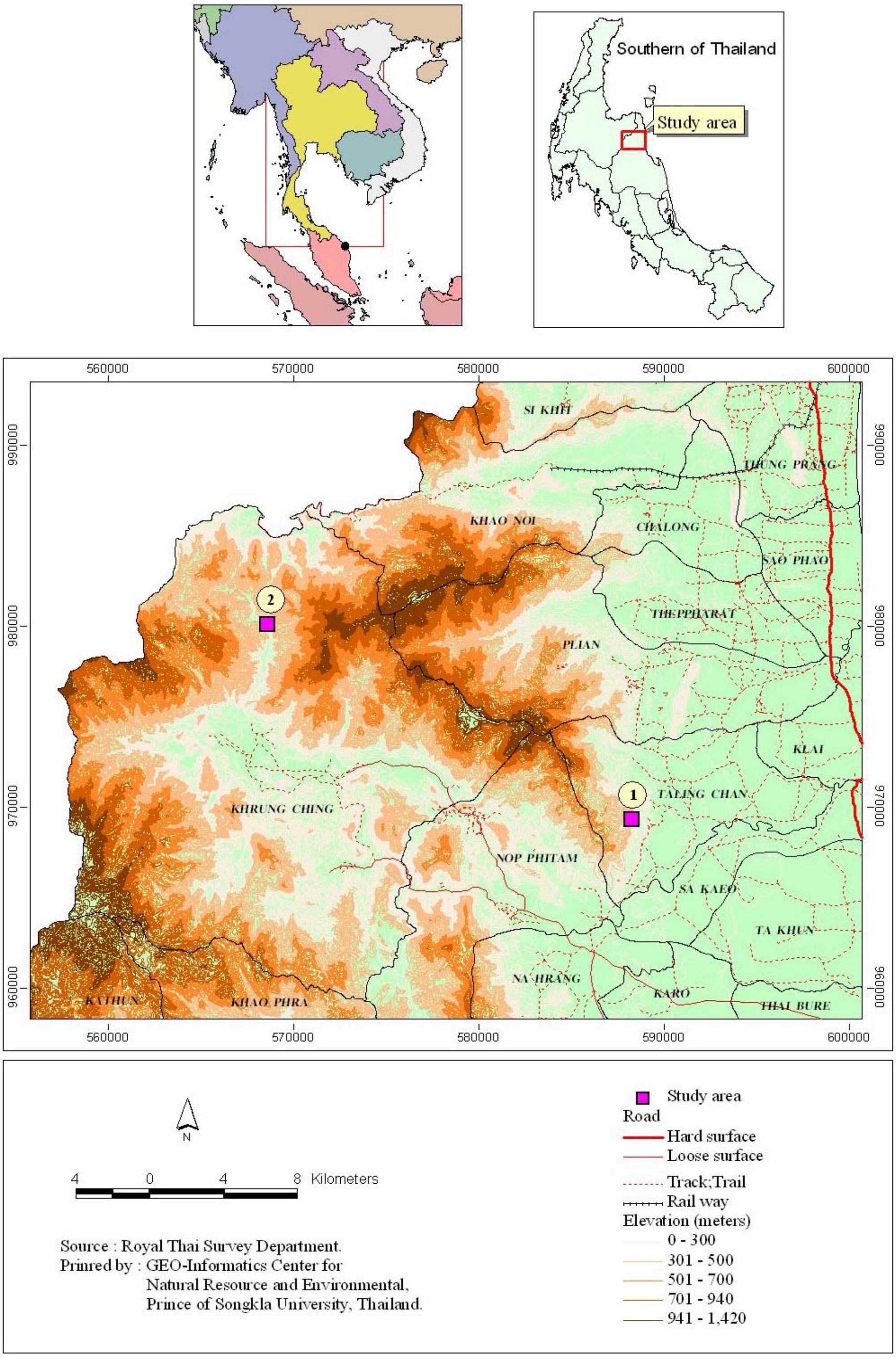


Figure 1 Map of Khao Nan National Park showing location of Study areas at Nakhon Si Thammarat Province. Number 1 = Headquarters station, Number 2 = Hui Lek station.

2. Study sites

Two different habitat types were chosen to be study sites. The first site was located at the headquarters of this park and the second site was at the Hui Lek station. The two study sites were located at a distance of approximately 40 km from each other. At each study site, three permanent plots of 30 x 30 m were set up, around 300 m from each other. Brief descriptions of each study site are explained below (Figures 2 and 3).

1) The Headquarters Station consists of complex mountain ranges to the north and south. It is situated at approximately 8^{o} 46' N latitude and 99^{o} 48' E longitude, and about 130-200 m above sea level. This habitat is characterized by dense forest of evergreen trees and a continuity of high canopy. This study site is representative of primary forest. Although some areas of this habitat were used for logging in the past, it is now recovering. The dominant species of plant include *Ficus* spp., C*aryota* spp., family Annonaceae, family Myrtaceae, family Myrtaceae, family Sterculiaceae, family Sapindaceae and family Euphobiaceae. The climate in this area is rather cool all year round with high humidity as well as heavy continuous rain (Wittaya, 2000) (Figure 2 A-F).

2) The Hui Lek station is commonly called *Pra* forest. It is located around 250-300 meters above sea level. This study site is representative of secondary forest and is dominated by a special deciduous plant called *Elateriospermum tapos* Blume or *Pra* in Thai. *E. tapos* is a common deciduous tree in South-East Asian tropical rainforests (Whitmore, 1972; Yong and Salimon, 2006) and is widely distributed in Thailand-Malaysia Peninsular. It has a deciduous life cycle in the short period of the dry season. Mature trees emerge at 45 meters and shed leaves annually around February to March (Whitmore, 1975; Osada *et al*., 2002). *E. tapos* is rarely found growing in clusters, so its clusters in this area are unique for a rainforest and it is only found at the Hui Lek station (Wittaya, 2000).

The Pra forest is characteristically dense with a continuity of high canopy, and a constant of temperature and humidity. Levels of precipitation and humidity are very high. There are other floras that can be seen in this area, such as family Anacardiaceae, Sapindaceae, Moraceae, Euphobiaceae, Arecaceae, Myrtaceae.

including *Eurycoma* spp. *Ardisia* spp., *Calamus* spp., *Lasianthus* spp., *Diospyros* spp (Figure 3 A-F).

(A) **(B)**

(C) **(D)**

(E) **(F)**

Figure 2 Study site at the Headquarter Station located near Sunandha waterfall. Note: (A)-(B) = permanent plot 1, (C)-(D) = permanent plot 2, (E)-(F) = permanent plot 3

(A)

(B)

(C)

(D)

(E)

(F)

Figure 3 Study sites at Hui Lek station. Note: (A)-(B) = The dominant species of plant is *Elateriospermum tapos*. (C) = permanent plot 1, (D)-(E) = permanent plot 2, (F) = permanent plot 3.

3. Experimental designs

This study was carried out during January 2006 to January 2007. Ant samples were collected bimonthly in both the wet and dry seasons. Altogether, seven experiments were carried out throughout this period. This region has only two seasons, the wet and dry season, with the most rainfall (3000-4500 mm/year) and shortest dry period (3-8 weeks) occurring in the far south (Whitmore, 1975; Maxwell, 2004). For this study, three permanent plots of 30 x 30 m were set up in each study type. The three permanent plots were a standard method for studying species composition and abundance of ants. As a consequence, a total of six permanent plots were chosen from both habitat types. Each plot was then divided into three subplots of 30 x 10 m (as shown in Figure 4) in order to collect and cover the terrestrial ant communities in their habitats above and below ground.

Physical factors were also measured in both areas, such as soil temperature, water content of litter, and water content of soil. For the soil temperature, a thermometer was used to record the soil temperature at 5 cm depth. In order to measure the water content of litter and soil, three locations within each subplot were chosen, and then nine locations from each permanent plot were sampled. To assess water content of litter, a mini-quadrate of 25 x 25 cm was placed at each spot selected. Then, all of the leaf litter on the ground surface was swept into a plastic bag. Afterwards, an amount of soil weighing 0.045 kg from each area was also scooped into a plastic bag to measure the water content of the soil. In laboratory conditions, the leaf litter and soil collected from each area were weighed and dried at 80 ^{o}C for a week and then they were weighed again to calculate the absolute water content of the litter and soil.

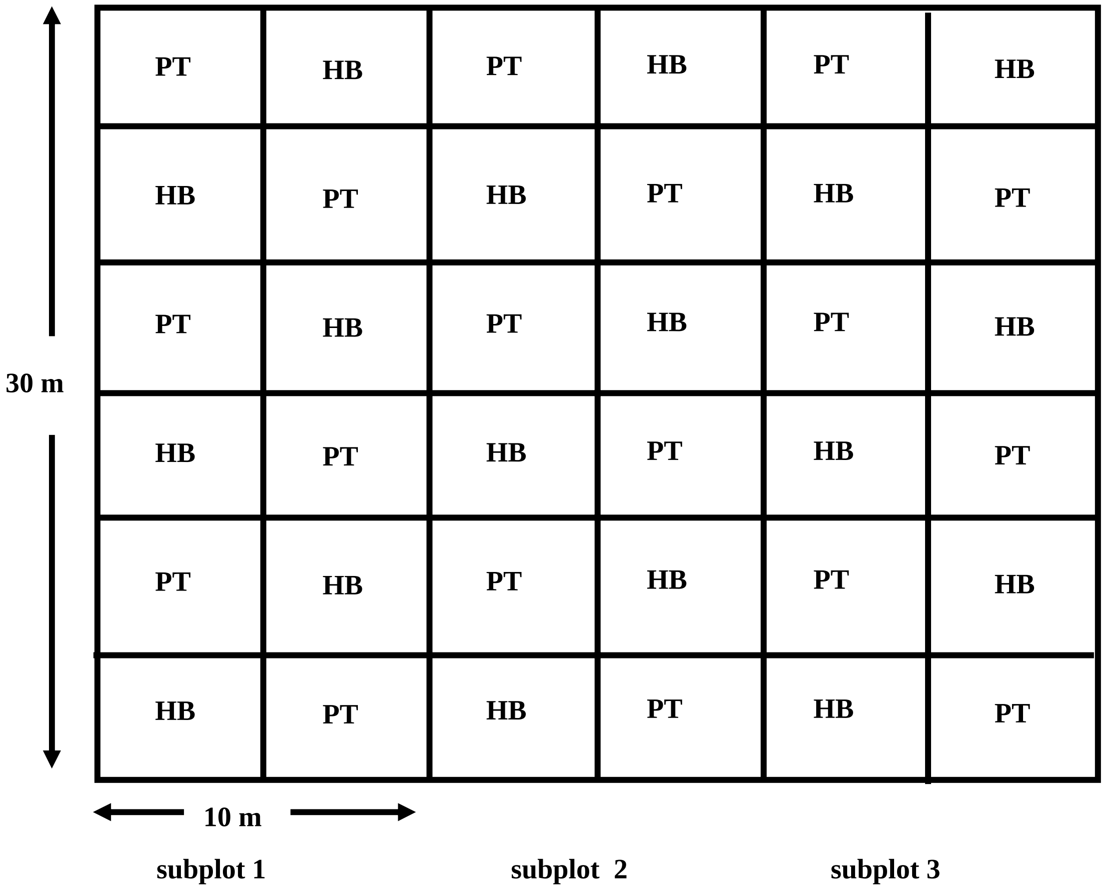


Figure 4 Three permanent plots (30x30 m) were set up in each study site. The permanent plot was divided into three subplots (10x30 m) for collecting ant by various methods. Note: WB = Winkler extraction samples or Winkler's Bags, HB= Honey Bait, PT= Pitfall Trap

3.1. Sampling method

In this study, five methods were used to sample terrestrial ants: Hand Collecting (HC), Leaf Litter Sifting (LL), Winkler extraction samples or Winkler's Bags (WB), Honey Bait (HB), and Pitfall Trap (PT).

3.1.1) Hand collecting (HC)

This method was used to collect ants on the ground from under rocks, logs, rotten wood, tree trunks, and from under bark. Specimens were collected by visual searching using hand-operated forceps and deposited in 70% ethanol. This procedure was carried out for 30 minutes in each subplot (Figure 5).

3.1.2) Leaf litter sifting (LL)

This method was used to sample ants above the ground surface and leaf litter. A quadrate (1x1 m) was randomly placed along the subplot for sampling leaf litter ants, and the leaf litter was sifted and sorted in a white pan (27 cm x 16 cm x 6 cm) to find ants. These specimens were stored in 80% ethanol. Likewise, this method was also carried out for 30 minutes per subplot. Thus, six samples were taken in each subplot (Figure 6).

3.1.3) Honey bait trap (HB)

This method was employed to sample ants on the ground attracted by nectar. Pieces of cotton material (7.0x5.5 cm.) soaked with a honey solution were placed at 5 m intervals, and thus there were six baited traps placed in each subplot (Figure 5). The concentration ratio of both solutions between honey and water solutions was 2:1. The sampled ants were collected within the cotton soaked and surrounding areas, including underneath the soil. The baited traps were left for 60 minutes (Agosti and Alonso, 2000). The ants collected in this manner were stored in 80% ethanol and the different species were identified (Figure 7).

3.1.4) Pitfall traps (PT)

Pitfall traps with a width and height of 12 cm and 15 cm respectively were used to collect terrestrial ants. Pitfall traps were buried with the rim flush to the soil surface and partly filled with a solution. The solution was a mixture of water and detergent (3:1). Baited tuna was set up over the traps. The traps were spaced at 5 m. intervals along the subplot (Figure 5). Thus, six pitfall traps were set up in each subplot and they were replaced every 24 hours. A roof (15x15 cm.) was used to cover the traps for protection against rain (Figure 8).

3.1.5) Winkler extraction samples or Winkler's bags (WB)

This method was designed to measure the abundance and species composition of terrestrial ants in the leaf litter and at the ground surface. Sampled ants in the litter were randomly collected within three quadrates (1x1 m.) per subplot and the litter was placed in Winkler bag (mesh) baskets (27x36 cm.) suspended from a wire frame (4x4 mm.) inside a canvas outer container, which was then tied to close across the top. The bags were hung consecutively for 72 hour periods. Sampled ants from the leaf litter sifting were seperated as the samples dried by being suspended from poles in bags. They were then deposited in 80 % ethanol. Thus, three Winkler extraction samples were collected in each subplot (Figure 9).

The sampled specimens were sorted and preserved in 80% ethanol, and pinned for further identification. Taxonomic keys by Bolton (1994; 1995; 2003) and Hölldobler and Wilson (1990) were used to identify the ant genera. The species levels were confirmed by Prof. Dr. Seiki Yamane and Dr. Decha Wiwatwitaya. The terrestrial ant specimens were deposited in the Department of Biology, Prince of Songkla University, and the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Thailand.

(A)

(B)

(C)

(D)

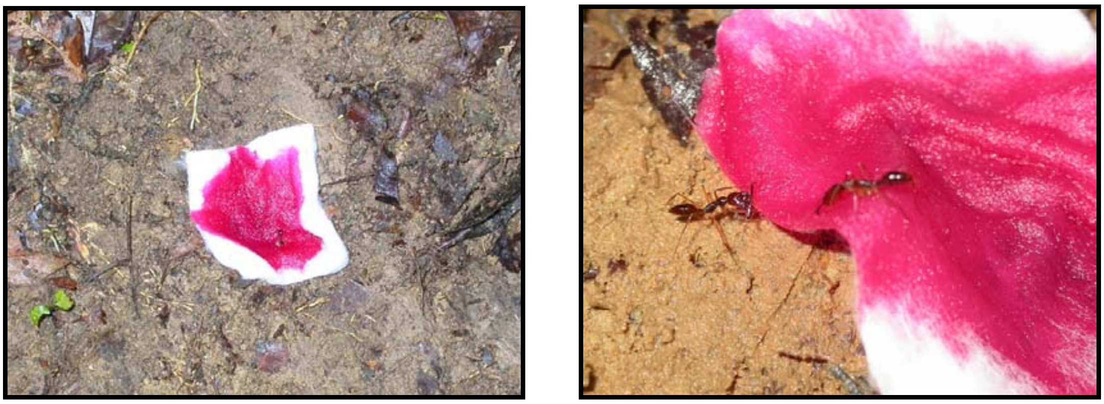
(E)

(F)

Figure 5 (A) - (F) = Hand collecting method (HC)

(A) **(B)**

Figure 6 (A)-(B) = Leaf litter sifting method (LL)



(A) **(B)**

Figure 7 (A)- (B) = Honey bait method (HB)

(A) **(B)**

Figure 8 (A)- (B) = Pitfall trap method (PT)

(A)

(B)

(C)

(D)

(E)

(F)

Figure 9 (A)-(E) = Winkler extraction samples or Winkler's bags method (WB)

3.2) Environmental factors

3.2.1) Temperature: soil temperature

Temperature is a factor that affects many processes related to insects, such as growth, development, and behaviour (Speight *et al*., 1999). It is also an important environmental factor affecting foraging ants. The air temperature and soil temperature were measured at two study sites using a thermometer. For soil temperature, thermometer was inserted in the soil surface about 100 mm depth, then recorded soil temperature.

3.2.2) Water content of litter and soil

Litter and soil samples were dried in an oven for seven days to remove all water content. The dried weight of the litter and soil samples provided fixed reference weights that were then used to quantify the amount of water in the litter and soil. Water content of litter and soil by weight was calculated using the following formula:

$$\%H_2O = \frac{(\text{wet weight litter and soil} - \text{oven-dried weight litter and soil}) \times 100}{\text{oven-dried weight litter and soil}}$$

3.3) Data analysis

3.3.1) Species diversity

The EstimateS software package was used to generate the smoothed species accumulation curve and the estimators for true species richness. A detailed description of these estimators can be found in Cowell and Coddington (1994). True species richness for each collecting site was estimated using Chao1 and first-order jackknife, two common nonparametric richness estimators that use species-by-sample data. Species distribution of terrestrial ant communities was analyzed by rank abundance plot for monitoring terrestrial ant communities between the two study sites.

3.3.2) Correlation between terrestrial ants and environmental factors

Canonical Correspondence Analysis (CCA) was used to evaluate the correlation between terrestrial ants and environmental factors. The main matrix represents species composition, while the second matrix represents environmental factors. Subsequently, the data was combined to analyze the relationships between ant communities and environmental factors by using the PC-ORD program Version 3.20. (McCune and Mefford, 1999).

CHAPTER 3

RESULTS

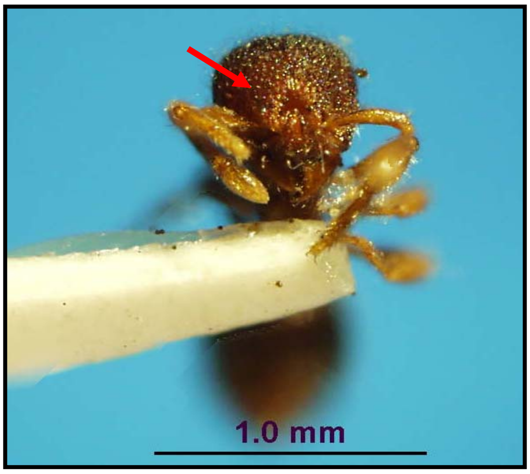
1. Species composition and species richness

A total of 10 subfamilies, 50 genera and 228 species of ants were recorded in this study (Table 2 and see Appendix 1). At the Headquarter station, a total of 172 species belonging to 47 genera were found (75.44% of total) and a total number at the Hui Lek station was 162 species belonging to 44 genera (71.05% of total) (Table 2). Among these, there was 74 ant species have been described, whereas, 154 species are new to science.

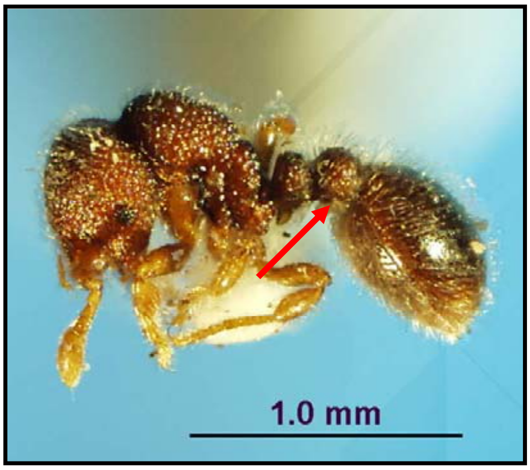
The proportions of species richness in each subfamily were shown in table 2. The highest number of species was found belonging to the subfamily Myrmicinae (104 species, 45.61%), followed by subfamily Formicinae (50 species, 21.93%), subfamily Ponerinae (41 species, 17.98%), subfamily Dolichoderinae (14 species, 6.14%), subfamily Pseudomyrmicinae (5 species, 2.19%), subfamily Cerapachyinae (4 species, 1.75%), subfamily Aenictinae (4 species, 1.75%), subfamily Dorylinae (3 species, 1.32%), subfamily Ectatomminae (2 species, 0.88%) and subfamily Amblyoponinae (1 species, 0.44%), respectively. The unique ant species was highest (28.51%) in the Headquarter station, whereas unique ant species at the Hui Lek station was 24.56% of total species. Furthermore, subfamily Amblyoponinae was recorded exclusively at the Headquarter station and there was only one species (*Mystrium camillae* Emery) found in the present study.

According to the proportion of genera (Table 3), *Pheidole* was the highest value (31 species, 13.60%) followed by *Camponotus* (19 species, 8.34%), *Tetramorium* (16 species, 7.02%), *Pachycondyla* (15 species, 6.58%), *Polyrhachis* (13 species, 5.71%) and *Crematogaster*, (13 species, 5.71%) respectively. Meanwhile, the highest abundance in each genus was showed in Table 2. It was shown that *Pheidole* was also the highest abundance (27 species, 11.84%), followed by *Camponotus* (15 species, 6.58%), *Pachycondyla* (14 species, 6.14%), *Tetramorium* (12 species, 5.26%), *Crematogaster* (10 species, 4.39%), and *Polyrhachis* (9 species, 3.95%) at the Headquarter station, whereas *Pheidole* was also highest abundance (27 species, 11.84%), followed by *Camponotus* (15 species, 6.58%), *Crematogaster* (11 species, 4.82%), *Tetramorium* (10 species, 4.39%), *Polyrhachis* (8 species, 3.51%), and *Monomorium* (7 species, 3.07%), respectively, at the Hui Lek station. At genera level, *Mystrium* (Amblyoponinae), *Philidris* (Dolichoderinae), *Recurvidris* (Myrmicinae), *Rhoptromyrmex* (Myrmicinae), *Emeryopone* (Ponerinae) and *Platythyrea* (Ponerinae) were found only at Headquarter station and *Acanthomyrmex* (Myrmicidae), *Tetheamyrma* (Myrmicinae) and *Harpegnathos* (Ponerinae) were recorded exclusively at Hui-Lek station.

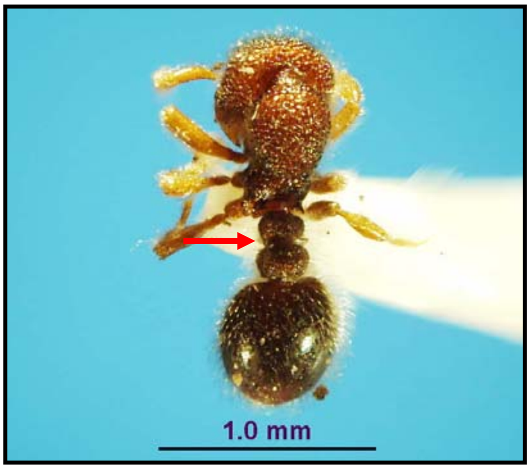
Interestingly, in this study there is one genus, genus *Tetheamyrma* of subfamily Myrmicinae, was the new record of Thailand. It was found from leaf litter at the Hui-Lek station by Hand-collecting method (Figure 10). The different diagnosis of *Tetheamyrma*'s worker is a monomorphic terrestrial myrmicine ants with the following combination of characters; upper surface of the head lacking grooves (antennal scrobes) and ridges (frontal carinae) (Figure 10A); two petiole and ventral surface of petiole (behind the process) and postpetiole with diffuse spongiform appendages (Figure 10B-C); antennae with 11 segmented and apical and preapical antennae segments much larger than preceding funicular segments and forming a conspicuous club of 2 segments (Figure 10D).



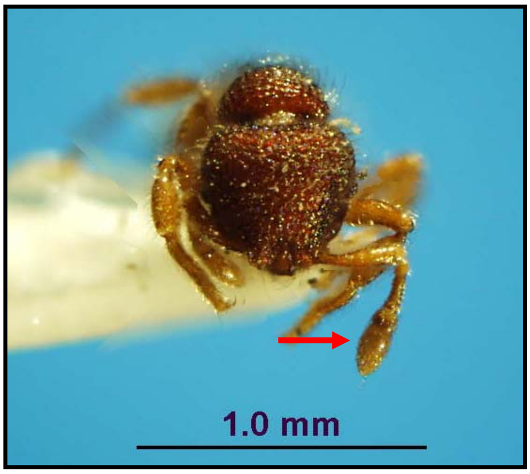
(A)



(B)



(C)



(D)

Figure 10 *Tetheamyrma* sp 1 has been describing to be new record genus of Thailand. Note: (A)= upper surface of the head, (B) = lateral view of petiole, (C) = dorsal view of petiole, and (D) = segment of antennae.

A species accumulation curve was fitted using Chao 1 estimator (Figures 11, 12). It is known to provide the least biased estimates for S**max* (Cowell and Coddington, 1994). Also, in the present study, this estimator provided least biased estimates for S**max* for both sites, 172 species in Headquarter and 162 species in Hui Lek, respectively.

Table 2 The total number of subfamilies, genera, and species of ants found at the Headquarter site and Hui Lek station between January 2006 and January 2007.

Subfamily	Headquarter station		Hui Lek station		Total of No. of Genera (%)	Total of No.of Species (%)
	Number		Number			
	Genera	Species	Genera	Species		
Aenictinae	1	3	1	3	1 (2%)	4 (1.75%)
Amblyoponinae	1	1	0	0	1 (2%)	1 (0.44%)
Cerapachyinae	1	3	1	3	1 (2%)	4 (1.75%)
Dolichoderinae	4	12	3	8	4 (8%)	14 (6.14%)
Dorylinae	1	2	1	3	1 (2%)	3 (1.32%)
Ectatomminae	1	1	1	2	1 (2%)	2 (0.88%)
Formicinae	9	35	9	38	9 (18%)	50 (21.93%)
Myrmicinae	18	80	18	78	20 (40%)	104 (45.61%)
Ponerinae	10	32	9	24	11 (22%)	41 (17.98%)
Pseudomyrmecinae	1	3	1	3	1 (2.04%)	5 (2.19%)
Total	47 (94%)	172 (75.44%)	44 (88%)	162 (71.05%)	50 (100%)	228 (100%)
(Unique)	6 (12.24%)	66 (28.95)	3 (6.12%)	56 (24.56%)		

Table 3 The proportion of species categorized by genera and subfamily using five sampling methods at the Headquarter site and Hui Lek station between January 2006 and January 2007.

Subfamily	Genera	No. of Species		
		Headquarter station	Hui Lek station	Total
Aenictinae	***Aenictus***	**3**	**3**	**4 (1.76%)**
Amblyoponinae	***Mystrium***	**1**	**0**	**1 (0.44%)**
Cerapachyinae	***Cerapachys***	**3**	**3**	**4 (1.76%)**
Dolichoderinae	***Dolichoderus***	**1**	**1**	**2 (0.88%)**
	Philidris	**1**	**0**	**1 (0.44%)**
	Tapinoma	**4**	**2**	**4 (1.76%)**
	Technomyrmex	**6**	**5**	**7 (3.07%)**
Dorylinae	***Dorylus***	**2**	**3**	**3 (1.32%)**
Ectatomminae	***Gnamptogenys***	**1**	**2**	**2 (0.88%)**
Formicinae	***Acropyga***	**3**	**3**	**4 (1.76%)**
	Anoplolepis	**1**	**1**	**1 (0.44%)**
	Camponotus	**15**	**15**	**19 (8.34%)**
	Echinopla	**1**	**1**	**2 (0.88%)**
	Euprenolepis	**1**	**1**	**2 (0.88%)**
	Oecophylla	**1**	**1**	**1 (0.44%)**
	Paratrechina	**3**	**5**	**5 (2.20%)**
	Polyrhachis	**9**	**8**	**13 (5.71%)**
	Pseudolasius	**2**	**2**	**3 (1.32%)**
Myrmicinae	***Acanthomyrmex***	**0**	**1**	**1 (0.44%)**
	Aphaenogaster	**1**	**1**	**1 (0.44%)**
	Cataulacus	**1**	**1**	**1 (0.44%)**
	Crematogaster	**10**	**11**	**13 (5.71%)**
	Lophomyrmex	**3**	**3**	**4 (1.76%)**
	Meranoplus	**1**	**2**	**2 (0.88%)**

Table 3 (Continued)

Subfamily	**Genera**	**No. of Species**		
		Headquarter station	**Hui Lek station**	**Total**
Myrmicinae	***Monomorium***	**7**	**7**	**9 (3.95%)**
	Myrmecina	**2**	**2**	**3 (1.32%)**
	Oligomyrmex	**2**	**2**	**3 (1.32%)**
	Pheidole	**27**	**27**	**31 (13.60%)**
	Pheidologeton	**2**	**2**	**4 (1.76%)**
	Pristomyrmex	**3**	**2**	**3 (1.32%)**
	Pyramica	**1**	**1**	**1 (0.44%)**
	Recurvidris	**1**	**0**	**1 (0.44%)**
	Rhoptromyrmex	**1**	**0**	**1 (0.44%)**
	Solenopsis	**2**	**2**	**3 (1.32%)**
	Strumigenys	**3**	**2**	**4 (1.76%)**
	Tetheamyrma	**0**	**1**	**1 (0.44%)**
	Tetramorium	**12**	**10**	**16 (7.02%)**
	Vollenhovia	**1**	**1**	**2 (0.88%)**
Ponerinae	***Anochetus***	**2**	**2**	**3 (1.32%)**
	Diacamma	**2**	**2**	**3 (1.32%)**
	Emeryopone	**1**	**0**	**1 (0.44%)**
	Hypoponera	**2**	**2**	**4 (1.76%)**
	Leptogenys	**4**	**6**	**7 (3.07%)**
	Harpegnathos	**0**	**1**	**1 (0.44%)**
	Odontomachus	**2**	**1**	**2 (0.88%)**
	Odontoponera	**2**	**2**	**2 (0.88%)**
	Pachycondyla	**14**	**6**	**15 (6.58%)**
	Platythyrea	**1**	**0**	**1 (0.44%)**
Pseudomyrmecinae	***Ponera***	**2**	**2**	**2 (0.88%)**
	Tetraponera	**3**	**3**	**5 (2.20%)**
Total	**50**	**172**	**162**	**228(100%)**

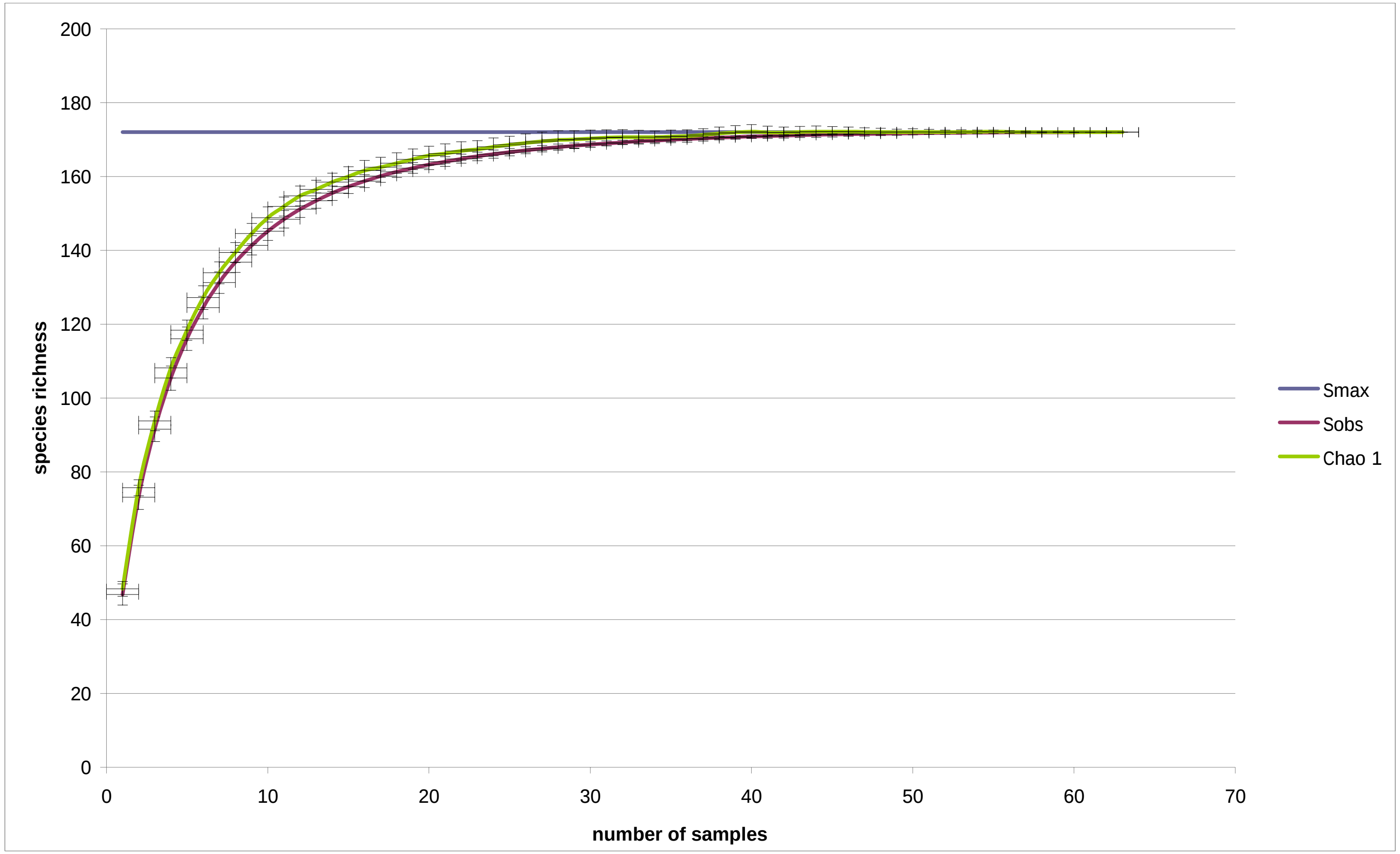


Figure 11 Performance of non-parametric estimator of species richness (Chao 1) for the present data set: ant assemblages collected at the Headquarters station. For all curves, each point is the mean of 100 estimates base on 100 randomization of sample accumulation order.

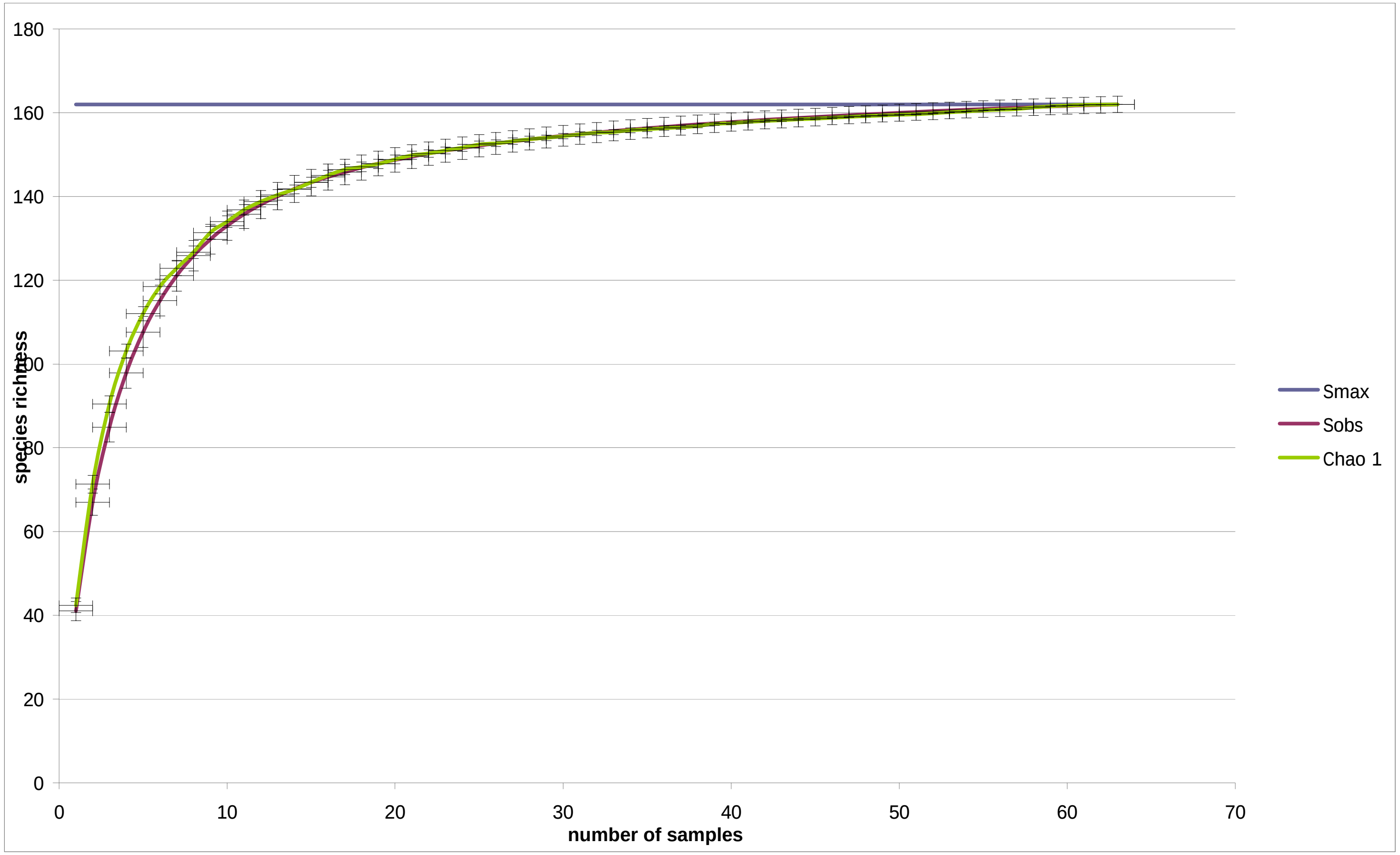


Figure 12 Performance of non-parametric estimator of species richness (Chao 1) for the present data set: ant assemblages collected at the Hui Lek station. For all curves, each point is the mean of 100 estimates base on 100 randomization of sample accumulation order.

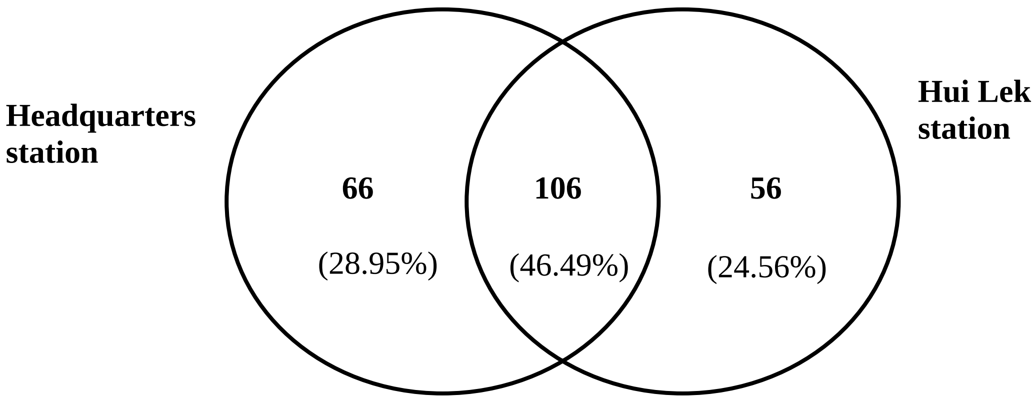


Figure 13 Venn's diagram of species composition of ant assemblages between Headquarter and Hui Lek stations.

The comparison between number of the ants in both study site showed that there are more ants at the Headquarter than Hui Lek stations (Table 2): subfamily level (10 Headquarter/9 Hui Lek), genera level (47 Headquarter/44 Hui Lek) and species level (172 Headquater/162 Hui Lek). According to sharing species between both stations (Figure 13), the result showed that there was 106 species (46.49%) were shared across the Headquarter and Hui Lek station. However, there were 66 species (28.95%) that were found only in Head quarter station, whereas 56 ant species (24.56%) were exclusively collected from Hui Lek station. In addition, *Recurvidris, Rhoptromyrmex*, *Emeryopone*, *Platythyrea*, *Philidris* and *Mystrium* were found only at Head quarter station whereas *Acanthomyrmex*, *Tetheamyrma* and *Harpegnathos* were found only at Hui Lek station.

2. Ant composition and collecting methods

The number of species collected by each method at the two study sites was shown in Table 4. The leaf litter sifting (LL) method resulted in the highest number of species (154 species, 67.54%), followed by the hand collecting (HC) method (148 species, 64.91%), the winkler's bags (WB) method (148 species, 64.91%), the pitfall trap (PT) method (131 species, 57.64%), and the honey bait trap (HB) method (55 species, 24.12%).

However, based on number of genera, it was found that the winkler's bags (WB) method resulted in the highest number collected (42 genera, 84%), followed by the leaf litter sifting (LL) method (41 genera, 82%), the hand collecting (HC) method (40 genera, 80%), the pitfall trap (PT) method (39 genera, 78%), and the honey bait trap (HB) method (23 genera, 46%). From both habitats types, three collecting methods were found to be ant-species specific (Appendix 1). There are 20, 6 and 5 species of ant species specific collected only by HC, LL and WB, respectively. The 20 ant species collected by HC as the followings: *Camponotus festinus* (F.Smith), *Camponotus (Karavaievia*) sp.1, *Polyrhachis (Myrma)* sp.1, *Polyrhachis (Myrma)* sp.2, *Polyrhachis (Myrmhopla) furcata* F. Smith, *Crematogaster (Crematogaster)* sp.3, *Crematogaster (Orthocrema)* sp.4, *Crematogaster (Paracrema)* sp.3, *Crematogaster (Paracrema)* sp.4, *Monomorium* sp.4, *Monomorium* sp.5, *Tetheamyrma* sp.1, *Vollenhovia* sp.2, *Leptogenys* sp.3, *Tetraponera* sp.1, *Tetraponera* sp.3, *Tetraponera* sp.4, *Aenictus* sp.2, *Mystrium camillae* Emery and *Dolyrus* sp.3. Six species collected by LL were *Acropyga* sp.2, *Myrmecina* sp.2, *Pheidologeton* sp.1, *Tetramorium* sp.9, *Philidris* sp.1, and *Gnamptogenys menadensis* (Mayr) and five species collected only by WB were *Acanthomyrmex* sp.1, *Recurvidris* sp.1, *Rhoptromyrmex* sp.1, *Emeryopone buttelreepeni* Forel and *Pachycondyla* sp.3.

Table 4 The proportion of genera and species of ants categorized by subfamilies collected using five methods at the Headquarter site and Hui Lek station between January 2006 and January 2007.

Subfamily	Honey bait trap (HB)		Pitfall trap (PT)		Hand collecting (HC)		Leaf litter sifting (LL)		Winkler's bags (WB)		Total of Genera (%)	Total of Spcies (%)
	Number		Number		Number		Number		Number			
	Genera	Species	Genera	Species	Genera	Species	Genera	Species	Genera	Species		
Aenictinae	0	0	1	2	1	4	1	3	1	2	1(2%)	4 (1.75%)
Amblyoponinae	0	0	0	0	1	1	0	0	0	0	1(2%)	1 (0.44%)
Cerapachyinae	0	0	1	2	1	4	1	3	1	2	1(2%)	4 (1.75%)
Dolichoderinae	2	6	3	9	3	11	4	11	3	9	4(8%)	14 (6.14%)
Dorylinae	0	0	1	2	1	2	1	2	1	1	1(2%)	3 (1.32%)
Ectatomminae	0	0	0	0	0	0	1	2	1	1	1(2%)	2 (0.88%)
Formicinae	6	8	8	29	8	40	9	25	9	32	9(18%)	50 (21.93%)
Myrmicinae	8	27	15	64	15	57	14	77	16	71	20(40%)	104 (45.61%)
Ponerinae	6	13	9	22	9	24	9	29	9	29	11(22%)	41 (17.98%)
Pseudomyrmecinae	1	1	1	1	1	5	1	2	1	1	1(2%)	5 (2.19%)
Total	23 (46%)	55 (24.12%)	39 (78%)	131 (57.46%)	40 (80%)	148 (64.91%)	41 (82%)	154 (67.54%)	42 (84%)	148 (64.91%)	50 (100%)	228 (100%)

3. Influence of study site on ant composition

The result of the Detrended Correspondence Analysis (DCA) revealed that habitat can be divided into three groups base on the similarity of ant species composition; group I (Headquarter station), group II and III (Hui Lek station) (eigenvalue axis 1= 0.375 and eigenvalue axis 2 = 0.286) (Figure 14). Group I comprise of *Technomyrmex albipes* (F. Smith), *Aenictus ceylonicus* (Mayr), *Camponotus (Myrmosaulus)* sp.1, *Monomorium pharaonis* (Linnaeus), *Monomorium* sp.1, *Pheidole rabo* Forel, Pheidole sp. 15, *Diacamma sculpturata* (F. Smith), *Acopyga* sp.1, *Paratrechina* sp.1, *Leptogenys mutabilis* F. Smith which are the dominant species in this group. Group II contains five most frequently found species: *Crematogaster* (*Paracrema*) sp.1, *Polyrhachis (Myrmhopla) armata* (Le Guillou), *Pachycondyla* sp.1, *Tetramorium pacificum* Mayr, *Aenictus laeviceps* (F. Smith). Group III comprised of 11 species: *Odontomachus rixosus* F. Smith, *Camponotus (Camponotus)* sp.1, *Hypoponera* sp.1, *Oligomyrmex* sp.1, *Pheidole* sp.1, *Pheidole* sp.2, *Camponotus rufifemur* Emery, *Tetramorium* sp.1, *Crematogaster (Orthocrema)* sp.2**,** *Acropyga acutiventris* Roger and *Odontoponera denticulata* (F. Smith).

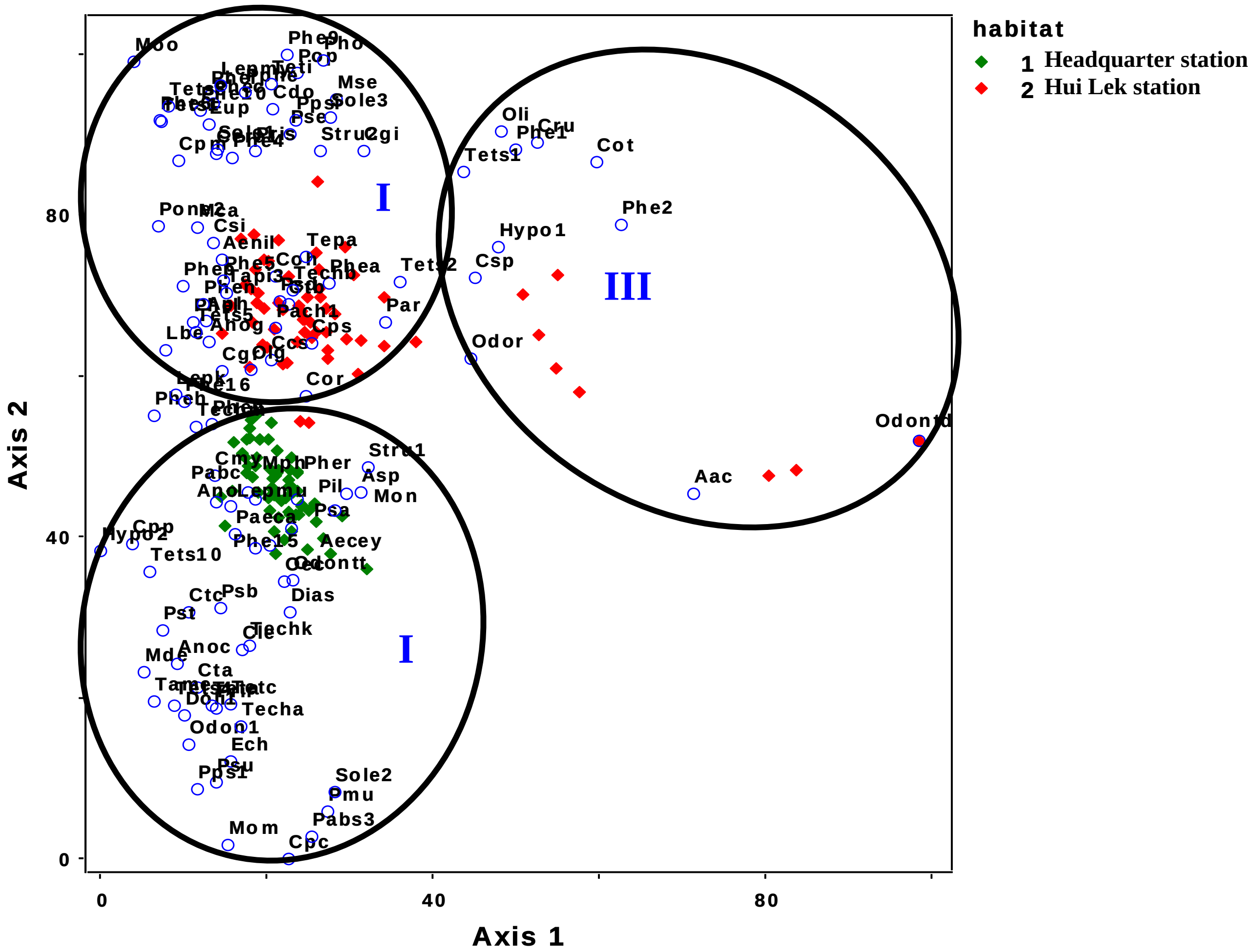


Figure 14 Detrended Correspondence Analysis (DCA) of ant assemblages (113 species) in two study sites collected by five sampling methods between January 2006 and January 2007 (1 = Headquarter station and 2 = Hui Lek station). Eigenvalue of axis 1 is 0.375 and the axis 2 is 0.286).

4. Relationships between species composition and environmental factors

Canonical Correspondence Analysis (CCA) demonstrated that site variance and environmental factors were mostly responsible for explaining the differences of ant species composition. For the two habitat variables, CCA evaluated the correlation between terrestrial ants and environmental factors.

Species were significantly correlated with three environmental factors, soil temperature, water content of litter (WCL), and water content of soil (WCS). Of which, these correlations can be explained with axis 1 and axis 2. The first axis showed Monte Carlo permutation test, P = 0.001, Pearson correlation coefficient, r = 0.879, Kendall correlation coefficient r = 0.656, eigenvalue = 0.239 and explained 5.7% of variation in species data. The second axis showed Monte Carlo permutation test, P = 0.001, Pearson correlation coefficient, r = 0.745, Kendall correlation coefficient r = 0.554, eigenvalue = 0.119 and explained 2.8% of variation in species data (Tables 5-6).

Species and their abundance were significantly correlated with three environmental factors; soil temperature (r^2 = 0.790), water content of litter (r^2 =0.252), and water content of soil (r^2 = 0.817). Soil temperature was positive correlated with ant species such as *Oligomyrmex* sp.2, *Aenictus laeviceps* (F. Smith), *Oecophylla smaragdina* (Fabricius), *Pheidole* sp.15, *Camponotus (Colobopsis) leonardi* Emery, *Anoplolepis gracilipes* (F. Smith), *Paratrechina* sp.2, *Polyrhachis (Myrmhopla) muelleri* Forel. In contrast, it was negative correlated with ant species such as *Pseudolasius* sp.3, *Camponotus (Tanaemyrmex)* sp.2, *Pheidole butteli* Forel, *Strumigenys* sp.1, *Crematogaster (Orthocrema)* sp.1, *Polyrhachis (Myrmhopla) armata* (Le Guillou), *Solenopsis* sp.3, *Strumigenys* sp.2, *Camponotus (Dinomyrmex) gigas* (Latreille) (Figure 15). Moreover, it was clearly shown that these ant species were found at Headquarter station (Figure 16).

The water content of soil (WCS) had a significantly positive correlation with the distribution of ant species such as *Pheidole nodifera* (F. Smith), *Pheidole* sp.10, *Pheidole* sp.9, *Acropyga acutiventris* Roger, *Odontoponera denticulata* (F. Smith), *Tetramorium* sp.1, *Pheidologeton pygmaeus* Emery, *Pheidologeton silenus* (F. Smith). On the contrary, it was negatively correlation with ant species such as *Crematogaster (Paracrema) modiglianii* Emery, *Pheidole rabo* Forel, *Paratrechina* sp.1, *Tetramorium* sp.5, *Odontoponera transversa* (F. Smith), *Technomyrmex kraepelini* Forel, *Pachycondyla (Brachyponera) chinensis* (Emery), *Camponotus (Tanaemyrmex)* sp.3, *Pheidole huberi* Forel (Figure 15). The water content of litter (WCL) also was positive correlated with ant species such as *Pheidole pieli* Santschi , *Pachycondyla* sp.1, *Pheidole angulicollis* Eguchi, *Monomorium* sp.2. Whereas, it was negatively correlation with ant species such as *Pheidole clypeocornis* Eguchi, *Pachycondyla (Brachyponera)* sp.3, *Camponotus (Tanaemyrmex)* sp.1 and *Camponotus (Myrmosaulus)* sp.1 (Figure 15).

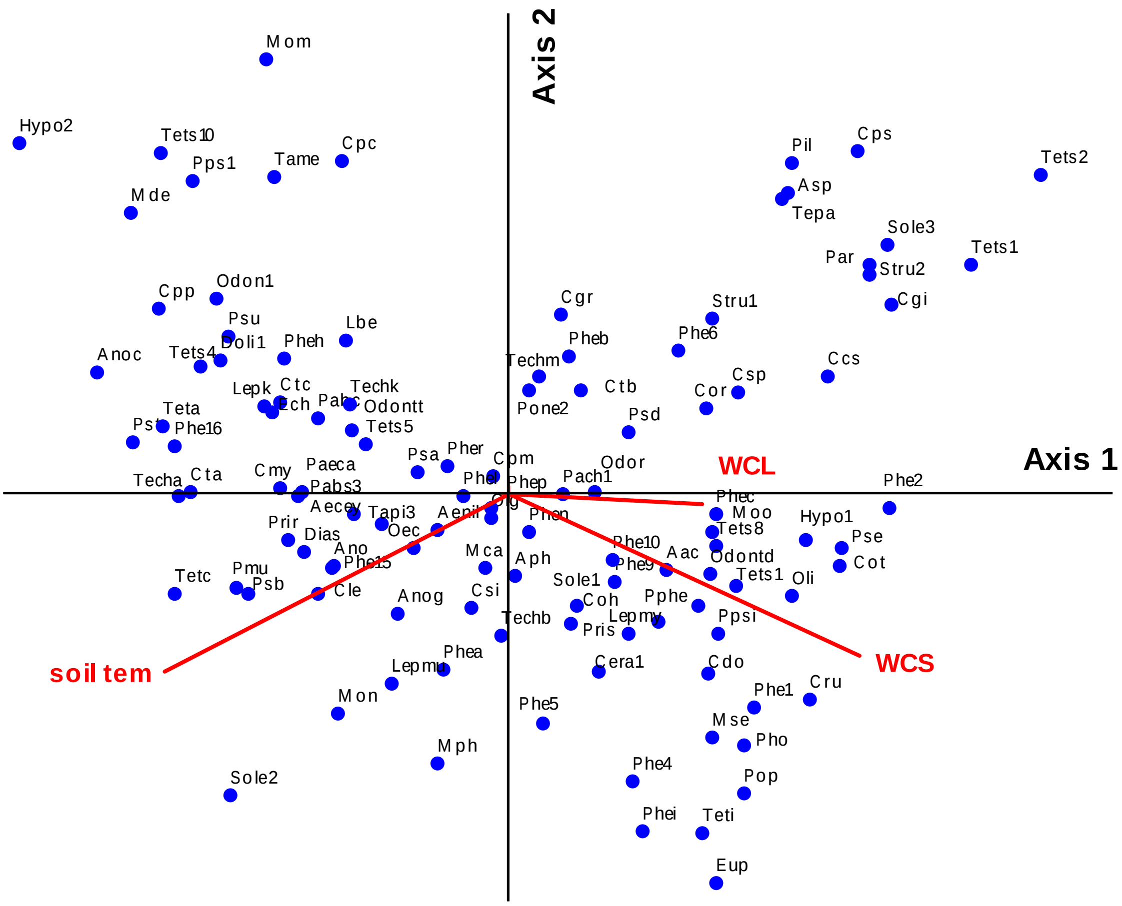


Figure 15 Canonical Correspondence Analysis (CCA) of ant species composition. The analysis showed the correlation between species and environmental factors (Monte Carlo permutation test, *P* = .0010, The eigenvalue axis 1 = .239, axis 2 = .119)

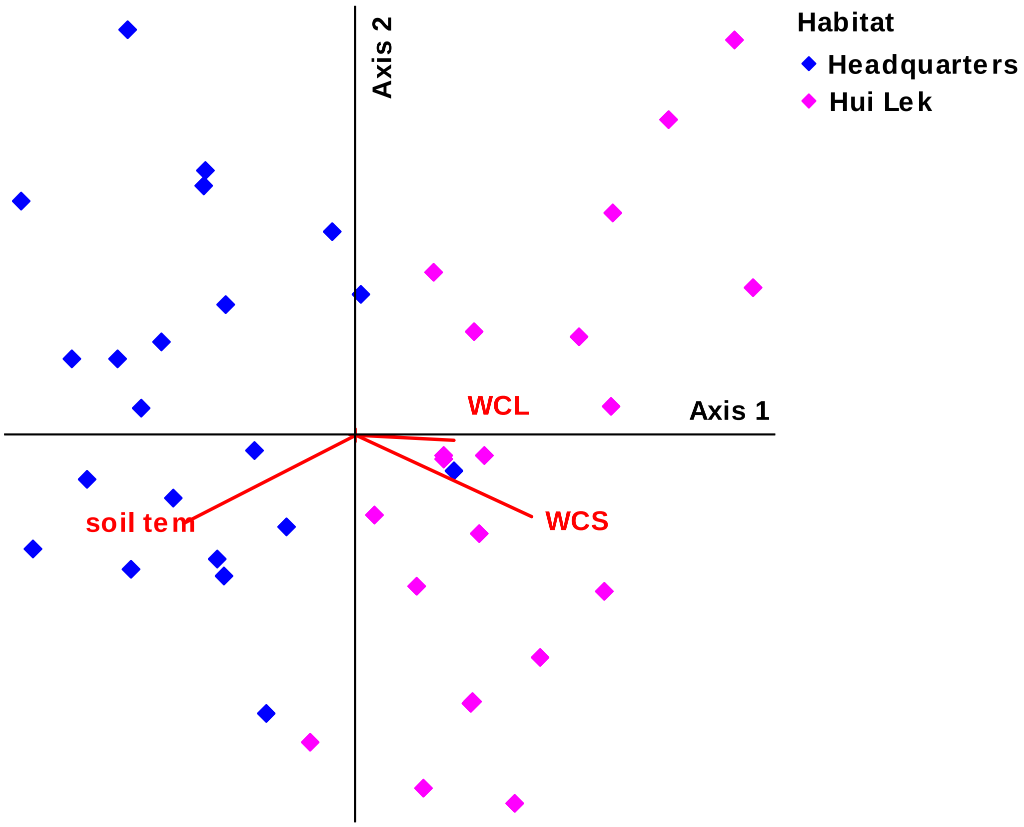


Figure 16 Canonical Correspondence Analysis (CCA) of ant species composition. The analysis showed the correlation between habitat and environmental factors (Monte Carlo permutation test, *P* = .0010, The eigenvalue axis 1 = .239, axis 2 = .119).

Table 5 Canonical correspondence analysis for environmental data

Number of canonical axes: 3

Total variance ("inertia") in the species data: 4.226

	Axis 1	Axis 2	Axis 3
Eigenvalue	.239	.119	.043
Variance in species data			
% of variance explained	5.7	2.8	1.0
Cumulative % explained	5.7	8.5	9.5
Pearson Correlation, Spp-Envt*	.879	.745	.676
Kendall (Rank) Corr., Spp-Envt	.656	.554	.428

* Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables. Set to 0.000 if axis is not canonical.

Table 6 The Monte-Carlo test for species-environmental correlations

	Real data	Randomized data Monte Carlo test, 999 runs			
Axis	Spp-Envt Corr.	Mean	Minimum	Maximum	p
1	0.879	0.512	0.407	0.698	0.001
2	0.745	0.491	0.369	0.657	0.001
3	0.676	0.468	0.341	0.619	0.001

p = proportion of randomized runs with species-environment correlation greater than or equal to the observed species-environment correlation; i.e.,

p = (1 + no. permutations >= observed)/(1 + no. permutations)

Table 7 Pearson and Kendall Correlations with Ordination Axes N= 126

Axis:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
soil temp	-0.889	0.790	-0.727	-0.456	0.208	-0.294	0.038	0.001	0.230
WCL	0.502	0.252	0.422	-0.024	0.001	0.020	0.865	0.748	0.317
WCS	0.904	0.817	0.751	-0.420	0.176	-0.277	0.086	0.007	-0.198

CHAPTER 4

DISCUSSION

1. Species composition and species richness

A total of 228 terrestrial ant species recorded in the present study. This number is almost the same as the similar studies at Hala Bala Wildlife Sancutuary at Narathiwat Province, 255 species, (Noon-anant *et al.*, 2005) and Ton Nga Chang Wildlife Sancuary, 248 species, (Watanasit *et al.*, 2007). Among the total species, 75.44 % (172 species) and 71.05 % (162 species) were recorded from Headquarter and Hui-Lek stations, respectively. The total species found at Headquarter and Hui Lek station is equal as Chao 1 (S*max) estimator. The sample studied in the present study were the representatives of all seasons in year round and also be collected by five collecting methods which covered all microhabitats in the studied area.

Pheidole of subfamily Myrmicinae and *Camponotus* of subfamily Formicinae were dominant genera in both stations. This result was coincided with Wiwatwitaya's research (2003) that from the number of ant species found in Khao Yai National Park 800-1,000 species, the result also showed that genus *Pheidole* and *Camponotus* were dominant genera. In addition, they are known as common genera in tropical rainforest of the Oriental region (Brown, 2000; Eguchi, 2001). In addition, several studies reported that subfamily Myrmicinae is a common subfamily which is widely distributed from Thailand to Indo-Australian archipelago (Bolton, 1995; Hashimoto *et al.*, 2001; Hölldobler & Wilson, 1990; Noon-anant *et al.*, 2005; Jaitrong and Nabhitabhata, 2005; Watanasit *et al.*, 2007; Watanasit *et al.*, 2008).

Although, 112 species were common species between both stations, there were several genera were restricted in each area such as *Recurvidris, Rhoptromyrmex, Emeryopone, Platythyrea*, *Philidris* and *Mystrium* were restricted in the Headquarter station whereas *Acanthomyrmex*, *Tetheamyrma* and *Harpegnathos* were exclusively found in the Hui-Lek station. The present study indicated that the restricted ant species may have been influenced by specific microhabitat and difference of physical factors such as temperature, humidity and precipitation (Kaspari and Weiser, 2000; Hahn and

Wheeler, 2002). Moreover, environmental stress and disturbance also can influence the species composition (Folgarait, 1998; Andersen *et al.*, 2002). This result can be explained by the ecological niche and biological behavior. Ecological niche plays an important role in an ecosystem. Describing a typical ant niche is as vexing as describing a typical ant colony. The variety of diets, nest sites, life spans and associations of ants in any given habitat make ants a diverse group in ecosystem (Coleman and Crossley, 1996; Levings and Windsor, 1996). In this study, *Recurvidris, Rhoptromyrmex, Emeryopone, Platythyrea, Philidris* and *Mystrium* were found only at Headquarter station because this area contains high variety of diets, suitable nest sites and associations of ants. Regarding habitat, *Recurvidris* has been reported from the forest area, lying under leaf litters (Sheela *et al*., 2000). Members of the genus *Rhoptromyrmex* are described by Bolton (1986) as general feeders, by collecting living and dead arthropods, tending homoptera and feeding at plant nectarines. *Platythyrea* form small colonies in soil, in rotten wood or in hollow twigs on trees. Some are specialist predators on termites while others have a broader diet including a range of invertebrates. Some of the tropical species are known to run rapidly on logs or tree trunks when foraging while others forage singly. Species of *Philidris* form large nests containing many thousands of workers in cavities of living plants or in rotten wood above the ground. Some species are associated with plants which have special swollen stems in which the ants nest (these plants are called myrmecophytes, and include the genera *Myrmecodia* and *Hydnophytum*). *Philidris* workers are very aggressive when disturbed and swarm in large numbers to attack intruders. Many species are also polymorphic, with workers varying greatly in size and with some having enlarged heads. These large-headed workers are equipped with powerful jaws which they use while excavating nests in tough plant tissues and rotten wood. *Mystrium* are presumably predacious, especially of Chilopoda, but this has yet to be confirmed. Specimens have been found under rocks or dry logs on the ground and in leaf litter. They lie motionless when disturbed (Hölldobler and Wilson, 1990). In addition, *Emeryopone buttelreepeni* Forel, single species found in the present study, was found under leaf litter. Of which in general, these genera were found in leaf litter or foraging in loose columns on the ground, on logs and on low vegetation. They were known to feed on a range of smaller arthropods such as Hemiptera both above and below the ground. Nests are in soil or under bark on rotten logs and in surrounding soil. Thus, ecological niche of these genera were known to restrict clearly for microhabitat which can be found in Headquarter station. Meanwhile, *Acanthomyrmex*, *Tetheamyrma* and *Harpegnathos* were collected exclusively at Hui Lek station. This area comprised dry forest and homogeneous plant habitat (Santisuk and Larsen, 2005) that the ecological niche was suitable for these three genera. *Tetheamyrma* was firstly described in leaf litter at Sabah, Malaysia (Bolton, 1994). This genus is rare in the original place and also in the adjacent countries and it was found as the new record in Thailand. According to the ecological niche, *Tetheamyrma* live in leaf litter or foraging in loose columns on the ground which can be found at Hui Lek station. These microhabitats were similar to the habitats previously reported of the member of this genus (Bolton, 1991). However, knowledge of their food habit was scant and required further studies. Members of genus *Acanthomyrma* have harvesting behavior and their nests are under bark on rotten logs and in surrounding soil (Moffett, 1985). In addition, they have broad diets, fruits and seeds, invertebrates and probably accepting a variety of sugary materials as well (Moffett, 1985; Bolton, 1994). *Harpegnathos* is a ground dwelling genus. It is distributed in the Indo-Australian region, particularly in Southeast Asia (Bolton, 1994). In Southeast Asia, this genus was reported from Malaysia, Indonesia and Thailand (Jaitrong and Nabhitabhata, 2005). Jaitrong and Nabhitabhata (2005) reported that this genus was found in two study sites, Sakatrat Biosphere Reserve and Thung-Salangluang National Park in Thailand. This genus was commonly found in the dry forest which their nest were under rock, grit mix and clay soil.

As the results above, it indicated that the species composition would be explained by the difference of ecological niche in each study site and biological behavior of their genera for regulation the differences of terrestrial and species composition in both study sites.

2. The relationships between study sites and ant composition

Ant showed association with the habitat characteristics. that the results show that the number of species occurs in both stations as equal as number of species appears preferentially in definite type of habitats. *Technomyrmex modiglianii* Emery, *Anoplolepis gracilipes* (F. Smith), *Pheidole longipes* (F. Smith)**,** *Pheidole nodifera* (F. Smith)**,** *Odontomachus rixosus* F. Smith**,** *Odontoponera denticulata* (F. Smith)**,** *Odontoponera transversa* (F. Smith)**,** *Pachycondyla (Ectomomyrmex)astuta* F. Smith are highly adaptive ants which can be found in wide range of environmental factors including high diverse of diets. Thus they were found at both sites and at all time throughout the year as the studies in Kao Yai National Park (Wiwatwitaya, 2003) and Huay Khayeng, Thong Pha Phum District, Kanchanaburi Province (Buamas, 2005).

The species-habitat associations were clearly shown in three groups; I, II and III. Habitat in group I located at Headquarter station. This group contains diverse type of ant species; ants forming small colony as indicated by a number of *Recurvidris* sp.1, *Rhoptromyrmex* sp.1, *Emeryopone buttelreepeni* Forel, *Platythyrea* sp.1, *Philidris* sp.1, *Mystrium camillae* Emery. Moreover, it included species which prefer open area, high diverse diets and nesting area such as *Technomyrmex albipes* (F. Smith), *Aenictus ceylonicus* (Mayr), *Camponotus (Myrmosaulus)* sp.1, *Monomorium pharaonis* (Linnaeus), *Monomorium* sp.1, *Pheidole rabo* Forel, *Pheidole* sp.15, *Diacamma sculpturata* (F. Smith), *Acopyga* sp.1, *Paratrechina* sp.1, *Leptogenys mutabilis* F. Smith (Wiwatwitaya, 2003). The other two groups contained the samples taken from Hui Lek station. Of which, group II contained five most frequently found species: *Crematogaster* (*Paracrema*) sp.1, *Polyrhachis (Myrmhopla) armata* (Le Guillou), *Pachycondyla* sp.1, *Tetramorium pacificum* Mayr, *Aenictus laeviceps* (F. Smith). These ant species are mostly found in mixed deciduous forest and dry evergreen forest (Khumtong and Jaitrong, 2004). Consistently with the characteristics of this habitat which mostly covered with *Elateriospermum tapos* Blume. This plant will shed leaves during February and March every year (Whitmore, 1972). Thus, it is highly possible that ant species composition relevant with this characteristic of the habitat.

However, the important characteristics of habitat gathered in group III are low temperature and high humidity, samples taken in wet season (November, 2006). The representative species of this group, *Pheidole* sp.1, *Pheidole* sp.2, *Odontomachus rixosus*, *Tetramorium* sp., *Hypoponera* sp.1, *Oligomyrmex* sp.1, *Acropyga acutiventris* and *Odontoponera transversa* were typical for relatively low temperature and high humidity area Moreover, they also commonly found in the leaf litter and underground habitat (Bolton, 1994; 1995; 2003).

3. The relationships between ant composition and environmental factors

The environmental factors measured in the present study showed the different in each habitat and sampling time. However, the analysis of CCA did not show a strong relation between species composition and the environmental factors by explaining only 35.80% of the data (Figures 15-16 tables 4-6; axis 1 and 2 together). Nevertheless, among three important factors, soil temperature is the most affective factor to ant species composition in this area. *Oecophylla smaragdina* (Fabricius), *Oligomyrmex* sp.2, *Aenictus laeviceps* (F. Smith), *Pheidole* sp.15, *Camponotus (Colobopsis) leonardi* Emery, *Anoplolepis gracilipes* (F. Smith), *Paratrechina* sp.2 and *Polyrhachis (Myrmhopla) muelleri* Forel inhabitant at ground surface, leaf litter and open area. Thus, it is possible that these species have higher tolerance to high temperature (up to 29 ^{o}C) than other species. Moreover, high soil temperature also activated feeding behavior of *Leptogenes kitteli* (Mayr) and *L. mutabilis* F. Smith. (Brüehl *et al.*, 1999; Brown, 1973). However, there are also group of ants which is not prefer high temperature such as *Pseudolasius* sp.3, *Camponotus (Tanaemyrmex)* sp.2, *Pheidole butteli* Forel, *Strumigenys* sp.1, *Crematogaster (Orthocrema)* sp.1, *Polyrhachis (Myrmhopla) armata* (Le Guillou), *Solenopsis* sp.3, *Strumigenys* sp.2, *Camponotus (Dinomyrmex) gigas* (Latreille) (Hölldobler and Wilson, 1990).

In addition, the water content of soil (WCS) and water content of litter (WCL) also influenced ant species composition. Ants such as *Pheidole nodifera* (F. Smith), *Pheidole* sp.10, *Pheidole* sp.9, *Acropyga acutiventris* Roger, *Odontoponera denticulata* (F. Smith), *Tetramorium* sp.1, *Pheidologeton pygmaeus* Emery and *Pheidologeton silenus* (F. Smith) which mostly building nest in soil and under leaf litter seem to be correlated with high water content of soil and water content of litter. Several studies showed that humidity has positively correlated with foraging activity of terrestrial ant (Kaspari and Weiser, 2000; Hahn and Wheeler, 2002). Concerning with foraging activities, terrestrial ants play an important role to be predatory behavior and hence moist litter and moist soil are more likely to release nutrients and bolster populations of microbes and micro-fauna prey that form the base of the litter food web (Coleman and Crossley, 1996; Levings and Windsor, 1996). Thus, water content in soil and water content of litter are important parameters in determining their foraging activities of terrestrial ants.

CHAPTER 5

CONCLUSIONS

A total terrestrial ants found in the present study was 228 species, 50 genera. Of which, one new record genus, *Tetheamyrma*, was found. The present of this genus in Thailand fulfill the figure of the geographical range of this genus in South East Asia. It also supports the idea that there are still more ant taxa waiting for the discovering in Thailand forest.

Moreover, the results from the present study showed that ant communities in term of species richness and species composition were different between two studied sites. Species richness at Headquarters station was higher than at Hui Lek station. 46.49% of total species (228 species) were shared between both stations whereas up to 53.51% of the species were specifically found at each station, 28.95% and 24.56 % at Headquarters and Hui Lek station, respectively. The most important factors influenced ant communities in this area are soil temperature, water content in soil and water content in litter. These factors affected the feeding behavior, foraging activities and building nest. Thus, it was found that a number of ants can be particularly found at only particular area. Of which, *Recurvidris*, *Rhoptromyrmex*, *Emeryopone*, *Platythyrea*, *Philidris* and *Mystrium* found only at Headquarters station and *Acanthomyrmex*, *Tetheamyrma* and *Harpegnathos* were specifically found at Hui Lek station.

Nevertheless, there are other physical factors which also can influence the ant species composition such as precipitation and humidity, including other resources such as food and microhabitats. It can be suggested that further study on these factors in microscale would support the explanations of the relation between ant species composition and environmental factors.

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APPENDICES

APPENDIX 1

Table 1 Species of ants at Headquarter site and Hui Lek station by using hand collecting (HC), leaf litter sifting (LL) winkler extraction samples (WB), honey bait (HB) and pitfall trap (PT) during January 2006-January 2007.

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
Subfamily Aenictinae											
1. *Aenictus ceylonicus* (Mayr).	-	+	+	+	-	-	-	+	+	+	4
2. *Aenictus laeviceps* (F. Smith)	-	+	+	+	+	-	+	+	+	-	5
3. *Aenictus* sp.1	-	-	+	+	-	-	-	-	-	-	2
4. *Aenictus* sp.2	-	-	-	-	-	-	-	+	-	-	1
Subfamily Amblyoponinae											
5. *Mystrium camillae* Emery	-	-	+	-	-	-	-	-	-	-	1
Subfamily Cerapachyinae											
6. *Cerapachys* sp.1	-	-	+	-	-	-	+	+	+	+	4
7. *Cerapachys* sp.2	-	-	+	-	-	-	+	+	+	+	3
8. *Cerapachys* sp.3	-	-	+	-	-	-	-	-	-	-	2
9. *Cerapachys* sp.4	-	-	-	-	-	-	-	+	+	-	1
Subfamily Dolichoderinae											
10. *Dolichoderus* sp.1	-	-	+	+	-	-	-	-	-	-	5
11. *Dolichoderus thoracicus (F. Smith)*	-	-	-	-	-	-	+	+	+	+	2
12. *Philidris* sp.1	-	-	-	+	-	-	-	-	-	-	1
13. *Tapinoma melanocephalum (Fabricius)*	+	+	+	-	+	-	-	-	-	-	4
14. *Tapinoma* sp.1	-	-	+	-	-	+	-	+	+	-	3
15. *Tapinoma* sp.2	-	+	+	-	+	-	-	-	-	-	3
16. *Tapinoma* sp.3	-	+	-	+	+	+	+	-	+	-	4
17. *Technomyrmex albipes (F. Smith)*	+	-	+	-	+	-	-	-	-	-	5
18. *Technomyrmex butteli* Forel	-	+	+	+	+	-	+	-	+	+	4
19. *Technomyrmex kraepelini* Forel	+	+	+	+	+	-	+	-	+	+	7
20. *Technomyrmex modiglianii* Emery	+	+	+	+	+	+	+	+	+	+	7
21. *Technomyrmex* sp.1	-	-	-	-	-	-	+	+	+	-	2

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
22. *Technomyrmex* sp.2	-	-	+	+	-	-	-	-	-	-	3
23. *Technomyrmex* sp.3	-	+	-	-	+	-	+	-	+	+	2
Subfamily Dorylinae											
24. *Dorylus* laevigatus (F. Smith)	-	-	+	-	+	-	+	-	+	-	3
25. *Dolyrus* sp.2	-	-	-	+	-	-	+	-	+	-	3
26. *Dolyrus* sp.3	-	-	-	-	-	-	-	+	-	-	1
Subfamily Ectatomminae											
27. *Gnamptogenys menadensis* (Mayr)	-	-	-	-	-	-	-	-	+	-	1
28. *Gnamptogenys* sp.1	-	-	-	+	-	-	-	-	-	+	2
Subfamily Formicinae											
29. *Acropyga acutiventris* Roger	-	-	+	+	+	-	-	+	+	+	7
30. *Acopyga* sp.1	-	-	-	+	-	-	-	+	+	+	4
31. *Acopyga* sp.2	-	-	-	+	-	-	-	-	-	-	2
32. *Acopyga* sp.3	-	-	-	-	-	-	-	+	+	-	1
33. *Anoplolepis gracilipes* (F. Smith)	+	+	+	+	+	+	+	+	+	+	7
34. *Camponotus festinus* (F. Smith)	-	-	-	-	-	-	-	+	-	-	1
35. *Camponotus rufifemur* Emery	-	-	-	-	-	-	+	+	-	-	4
36. *Camponotus (Camponotus)* sp.1	-	+	+	-	-	-	-	+	+	+	7
37. *Camponotus (Camponotus)* sp.2	-	-	+	-	-	-	-	+	-	-	2
38. *Camponotus (Colobopsis) leonardi* Emery	-	-	+	-	+	-	-	+	-	+	5
39. *Camponotus (Colobopsis)* sp.1	-	-	+	-	+	-	-	+	-	+	2
40. *Camponotus (Colobopsis)* sp.2	-	-	+	-	-	-	+	+	-	-	3
41. *Camponotus (Colobopsis)* sp.3	-	-	+	-	+	-	-	-	-	-	2
42. *Camponotus (Dinomyrmex) gigas* (Latreille)	-	-	-	-	-	-	-	+	+	-	7
43. *Camponotus (Karavaievia)* sp.1	-	-	+	-	-	-	-	-	-	-	2
44. *Camponotus (Myrmosaulus) singularis* (F. Smith)	-	+	+	-	+	-	+	+	-	+	6
45. *Camponotus (Myrmosaulus)* sp.1	-	-	+	+	+	-	+	+	-	+	5

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
46. *Camponotus (Myrmosaulus)* sp.2	-	-	-	-	-	-	+	-	-	+	1
47. *Camponotus (Tanaemyrmex)* sp.1	+	+	+	+	+	-	-	-	-	-	6
48. *Camponotus (Tanaemyrmex)* sp.2	-	+	+	+	+	-	+	+	-	+	7
49. *Camponotus (Tanaemyrmex)* sp.3	-	+	+	+	+	-	+	+	-	-	7
50. *Camponotus* sp.1	-	-	+	-	-	-	-	-	-	+	2
51. *Camponotus* sp.2	-	-	+	-	+	-	-	+	-	-	2
52. *Camponotus* sp.3	-	-	-	-	-	-	+	+	+	-	3
53. *Echinopla* sp.1	-	-	+	+	+	-	-	-	-	-	5
54. *Echinopla* sp.2	-	-	-	-	-	-	+	+	-	-	2
55. *Euprenolepis procera* (Emery)	-	-	-	-	-	+	+	-	+	+	4
56. *Euprenolepis* sp.1	-	+	+	+	-	-	-	-	-	-	3
57. *Oecophylla smaragdina* (Fabricius)	+	+	+	+	+	-	+	+	-	-	7
58. *Paratrechina opaca* (Emery)	-	-	-	-	-	+	+	-	+	+	5
59. *Paratrechina* sp.1	+	+	-	+	+	+	+	-	+	+	7
60. *Paratrechina* sp.2	-	+	-	+	+	-	+	-	+	+	6
61. *Paratrechina* sp.3	-	-	-	-	-	+	-	-	-	+	3
62. *Paratrechina* sp.4	-	-	-	+	+	-	+	-	-	+	3
63. *Polyrhachis furcata* (F. Smith)	-	-	-	-	-	-	+	+	-	-	1
64. *Polyrhachis (Myrma) illaudata* Walker	-	+	+	+	-	-	+	-	+	-	7
65. *Polyrhachis (Myrma) hopla* Forel	-	-	-	-	-	-	+	+	-	+	4
66. *Polyrhachis (Myrma) striata* Mayr	-	-	+	-	+	-	-	-	-	-	4
67. *Polyrhachis (Myrma)* sp.1	-	-	+	-	-	-	-	+	-	-	1
68. *Polyrhachis (Myrma)* sp.2	-	-	-	-	-	-	-	+	-	-	2
69. *Polyrhachis (Myrmhopla) armata* (Le Guillou)	-	+	+	+	+	-	+	+	+	+	4
70. *Polyrhachis (Myrmhopla) calypso* Forel	-	+	+	-	+	-	-	-	-	-	3
71. *Polyrhachis (Myrmhopla) muelleri* Forel	-	-	+	-	-	-	-	-	-	-	4
72. *Polyrhachis (Myrmhopla)* sp.1	-	+	+	+	+	-	+	+	-	+	4

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
73. *Polyrhachis (Myrmhopla)* sp.2	-	+	+	-	-	-	-	-	-	-	2
74. *Polyrhachis (Myrmhopla) furcata* F. Smith	-	-	-	-	-	-	-	+	-	-	1
75. *Polyrhachis (Myrmhopla)* sp.4	-	+	+	-	+	-	-	-	-	-	3
76. *Pseudolasius* sp.1	-	-	-	-	-	+	+	-	-	+	5
77. *Pseudolasius* sp.2	-	-	-	+	+	-	-	-	-	-	6
78. *Pseudolasius* sp.3	-	+	+	+	+	-	+	-	-	+	4
Subfamily Myrmicinae											
79. *Acanthomyrmex* sp 1	-	-	-	-	-	-	-	-	-	+	2
80. *Aphaenogaster* sp.1	-	+	-	+	+	-	-	-	+	-	4
81. *Cataulacus granulatus* Latreille	-	+	+	+	+	-	+	-	+	+	6
82. *Crematogaster cf dolni*	-	-	-	-	-	-	-	+	-	+	5
83. *Crematogaster (Crematogaster)* sp.1	-	-	+	+	+	-	+	+	+	-	4
84. *Crematogaster (Crematogaster)* sp.2	-	-	+	+	-	-	-	+	-	-	3
85. *Crematogaster (Crematogaster)* sp.3	-	-	+	-	-	-	-	-	-	-	2
86. *Crematogaster (Orthocrema)* sp.1	-	-	+	+	-	-	+	+	+	-	5
87. *Crematogaster (Orthocrema)* sp.2	-	-	-	-	-	-	+	+	-	+	5
88. *Crematogaster (Orthocrema)* sp.3	-	-	+	+	-	-	+	+	-	+	6
89. *Crematogaster (Orthocrema)* sp.4	-	-	+	-	-	-	-	-	-	-	3
90. *Crematogaster (Paracrema) modiglianii Emery*	-	-	+	-	+	-	+	+	-	+	6
91. *Crematogaster (Paracrema)* sp.1	-	-	+	-	-	-	-	+	+	-	4
92. *Crematogaster (Paracrema)* sp.2	-	-	+	+	+	-	-	+	-	+	5
93. *Crematogaster (Paracrema)* sp.3	-	-	+	-	-	-	-	+	-	-	4
94. *Crematogaster (Paracrema)* sp.4	-	-	-	-	-	-	-	+	-	-	1
95. *Lophomyrmex bedoti* Emery	+	+	+	+	+	-	+	+	+	+	7
96. *Lophomyrmex* sp.1	-	+	-	-	+	-	+	-	+	+	3
97. *Lophomyrmex* sp.2	-	+	-	+	-	-	-	-	-	-	3

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
98. *Lophomyrmex* sp.3	-	-	-	-	-	-	+	-	-	+	2
99. *Meranoplus castaneus* F. Smith	+	+	+	-	+	-	+	+	-	+	5
100. *Meranoplus* sp. 1	-	-	-	-	-	-	+	+	-	-	3
101. *Monomorium destructor* (Jerdon)	-	+	-	+	+	-	-	-	-	-	4
102. *Monomorium floricola* (Jerdon,)	-	+	-	+	-	-	+	-	-	+	3
103. *Monomorium pharaonis* (Linnaeus)	-	+	+	-	+	-	+	-	-	+	5
104. *Monomorium sechellense* Emery	-	-	-	-	-	-	-	+	+	+	4
105. *Monomorium* sp.1	-	+	+	+	-	-	+	-	+	-	4
106. *Monomorium* sp.2	-	-	-	+	+	-	+	-	+	-	4
107. *Monomorium* sp.3	-	-	-	-	+	-	-	-	+	+	3
108. *Monomorium* sp.4	-	-	+	-	-	-	-	-	-	-	4
109. *Monomorium* sp.5	-	-	-	-	-	-	-	+	-	-	1
110. *Myrmecina* sp.1	-	-	+	-	-	+	-	-	+	-	3
111. *Myrmecina* sp.2	-	-	-	+	-	-	-	-	-	-	2
112. *Myrmecina* sp.3	-	-	-	-	-	+	-	-	+	-	1
113. *Oligomyrmex* sp.1	-	-	-	-	-	-	+	-	+	+	5
114. *Oligomyrmex* sp.2	+	+	-	+	+	-	-	-	+	+	4
115. *Oligomyrmex* sp.3	-	+	-	-	+	-	-	-	-	-	3
116. *Pheidole angulicollis* Eguchi	-	+	+	+	+	+	+	-	+	+	4
117. *Pheidole annexus* Eguchi	+	-	-	+	+	+	+	-	+	+	3
118. *Pheidole aristotelis* Forel	+	+	+	+	+	-	-	-	-	-	3
119. *Pheidole butteli* Forel	-	+	+	-	+	-	+	+	-	-	6
120. *Pheidole cariniceps* Eguchi	-	-	-	-	+	-	+	-	+	+	4
121. *Pheidole clypeocornis* Eguchi	-	-	-	-	-	+	-	+	-	+	6
122. *Pheidole huberi* Forel	-	+	-	+	+	-	+	+	-	+	4
123. *Pheidole longipes* (F. Smith)	+	+	+	+	+	+	+	+	+	+	7
124. *Pheidole nodifera* (F. Smith)	+	+	+	+	+	+	+	+	+	+	5
125. *Pheidole pieli* Santschi	-	+	+	+	+	+	+	+	+	+	7
126. *Pheidole plagiaria* F. Smith	-	+	-	+	+	-	-	-	-	-	3

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
127. *Pheidole rabo* Forel	-	+	-	+	+	+	-	-	+	+	4
128. *Pheidole rugifera* Eguchi	-	-	+	+	+	-	+	+	+	-	3
129. *Pheidole sarawakana* Forel	-	+	-	-	-	-	-	-	+	+	2
130. *Pheidole* sp.1	-	-	-	-	-	+	+	-	-	+	4
131. *Pheidole* sp.2	-	-	-	-	-	+	-	+	+	+	4
132. *Pheidole* sp.3	-	-	-	-	-	-	+	-	-	+	2
133. *Pheidole* sp.4	-	-	+	-	+	+	+	+	+	+	6
134. *Pheidole* sp.5	-	-	+	-	-	-	+	-	+	+	6
135. *Pheidole* sp.6	+	-	-	+	-	-	+	-	-	+	5
136. *Pheidole* sp.7	-	-	+	+	-	+	+	-	-	+	3
137. *Pheidole* sp.8	-	-	-	+	-	-	+	-	+	-	2
138. *Pheidole* sp.9	-	+	+	-	+	-	+	-	+	+	5
139. *Pheidole* sp.10	+	-	-	-	-	+	-	+	+	-	4
140. *Pheidole* sp.11	-	-	+	+	-	-	+	-	-	+	3
141. *Pheidole* sp.12	+	+	-	+	-	-	-	-	-	-	3
142. *Pheidole* sp.13	-	+	-	-	-	+	-	-	+	-	2
143. *Pheidole* sp.14	+	-	-	+	-	-	+	-	+	-	2
144. *Pheidole* sp.15	+	+	+	+	+	+	+	-	+	+	7
145. *Pheidole* sp.16	-	+	+	+	+	-	+	-	+	+	5
146. *Pheidole* sp.17	-	+	-	+	+	-	-	-	-	-	1
147. *Pheidologeton pygmaeus* Emery	-	-	-	-	-	+	+	-	+	-	4
148. *Pheidologeton silenus* (F. Smith)	-	-	-	-	-	-	+	-	+	-	5
149. *Pheidologeton* sp.1	-	-	-	+	-	-	-	-	-	-	2
150. *Pheidologeton* sp.2	-	+	+	-	+	-	-	-	-	-	4
151. *Pristomyrmex rigidus* Wang & Minsheng	-	-	+	+	+	-	-	-	-	-	5
152. *Pristomyrmex* sp.1	-	-	-	+	+	-	+	-	+	+	4
153. *Pristomyrmex* sp.2	-	-	-	+	-	-	+	-	+	+	2
154. *Pyramica* sp.1	-	-	+	-	-	-	+	+	-	-	2
155. *Recurvidris* sp.1	-	-	-	-	+	-	-	-	-	-	1
156. *Rhoptromyrmex* sp.1	-	-	-	-	+	-	-	-	-	-	2

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
157. *Solenopsis* sp.1	-	+	-	+	+	+	+	-	+	+	7
158. *Solenopsis* sp.2	-	-	+	+	-	-	-	-	-	-	4
159. *Solenopsis* sp.3	-	-	-	-	-	-	-	+	+	+	4
160. *Strumigenys* sp.1	-	-	-	+	+	-	+	-	+	+	6
161. *Strumigenys* sp.2	-	-	-	-	-	-	-	+	-	+	5
162. *Strumigenys* sp.3	-	+	-	+	+	-	-	-	-	-	3
163. *Strumigenys* sp.4	-	+	-	+	-	-	-	-	-	-	3
164. *Tetheamyrma* sp 1	-	-	-	-	-	-	-	+	-	-	1
165. *Tetramorium cutalum*	-	+	-	+	+	-	-	-	-	-	4
166. *Tetramorium parvum* Bolton	-	-	+	+	+	-	-	-	-	-	3
167. *Tetramorium insolen* (F. Smith)	-	-	-	-	-	-	+	+	+	-	6
168. *Tetramorium kraepelini* Forel	-	+	-	+	-	-	+	-	+	+	3
169. *Tetramorium pacificum* Mayr	-	+	-	+	+	-	+	+	+	+	7
170. *Tetramorium* sp.1	-	-	-	-	-	-	-	+	+	+	6
171. *Tetramorium* sp.2	-	-	-	-	-	-	+	+	+	+	5
172. *Tetramorium* sp.3	-	-	-	-	-	-	+	-	+	+	3
173. *Tetramorium* sp.4	-	-	+	-	+	-	-	-	-	-	6
174. *Tetramorium* sp.5	-	+	-	+	-	-	+	-	+	+	5
175. *Tetramorium* sp.6	+	-	+	+	-	-	+	-	+	-	3
176. *Tetramorium* sp.7	-	-	-	+	-	-	+	-	+	+	2
177. *Tetramorium* sp.8	+	-	-	+	-	-	+	+	+	-	4
178. *Tetramorium* sp.9	-	-	-	+	-	-	-	-	-	-	1
179. *Tetramorium* sp.10	-	-	-	+	+	-	-	-	-	-	5
180. *Tetramorium* sp.11	-	-	-	+	-	-	-	-	-	-	2
181. *Vollenhovia* sp.1	-	-	-	-	-	-	+	-	+	+	3
182. *Vollenhovia* sp.2	-	-	+	-	-	-	-	-	-	-	1
Subfamily Ponerinae											
183. *Anochetus graeffei* Mayr	-	-	-	-	+	-	-	+	+	-	4
184. *Anochetus* sp.1	-	+	-	-	+	-	-	-	-	-	6

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
185. *Anochetus* sp.2	-	-	-	-	-	-	-	+	+	+	3
186. *Diacamma sculpturata* (F. Smith)	-	-	+	-	-	-	+	+	-	-	4
187. *Diacamma* sp.1	-	-	+	-	+	-	-	-	-	-	3
188. *Diacamma* sp.2	-	-	-	-	-	+	-	-	+	+	2
189. *Emeryopone buttelreepeni* Forel	-	-	-	-	+	-	-	-	-	-	1
190. *Hypoponera* sp.1	-	-	-	-	-	+	-	+	+	+	5
191. *Hypoponera* sp.2	-	-	-	-	-	-	-	-	+	+	3
192. *Hypoponera* sp.3	-	+	-	+	+	-	-	-	-	-	5
193. *Hypoponera* sp.4	-	-	-	+	+	-	-	-	-	-	3
194. *Leptogenys kraepelini* Forel	-	-	-	+	+	-	-	+	+	-	6
195. *Leptogenys kitteli* (Mayr)	-	+	+	+	-	-	-	-	-	-	3
196. *Leptogenys mutabilis* F. Smith	-	-	+	-	-	-	+	+	-	+	4
197. *Leptogenys myops* (Emery)	-	-	-	-	-	-	-	+	+	-	4
198. *Leptogenys* sp.1	-	-	+	-	-	-	+	+	-	-	3
199. *Leptogenys* sp.2	-	-	-	-	-	-	+	+	-	-	3
200. *Leptogenys* sp.3	-	-	-	-	-	-	-	+	-	-	2
201. *Harpegnathos venator* (F. Smith)	-	-	-	-	-	+	+	-	-	-	3
202. *Odontomachus rixosus* F. Smith	+	+	+	+	+	+	+	+	+	+	7
203. *Odontomachus* sp.1	+	+	-	+	+	-	-	-	-	-	4
204. *Odontoponera denticulata* (F. Smith)	+	+	+	+	+	+	+	+	+	+	7
205. *Odontoponera transversa* (F. Smith)	+	+	+	+	+	+	+	+	+	+	7
206. *Pachycondyla (Brachyponera) chinensis* (Emery)	-	+	-	+	+	-	+	+	+	+	6
207. *Pachycondyla (Brachyponera)* sp.1	-	+	-	+	+	-	-	-	-	-	3
208. *Pachycondyla (Brachyponera)* sp.2	-	-	-	-	-	-	+	+	+	-	2
209. *Pachycondyla (Brachyponera)* sp.3	+	+	+	+	+	-	-	-	-	-	4
210. *Pachycondyla (Ectomomyrmex) astuta* F. Smith	+	+	+	+	+	+	+	+	+	+	7

Table 1 (Continued).

Species	Headquarter					Hui Lek					Frequency
	HB	PT	HC	LL	WB	HB	PT	HC	LL	WB	
211. *Pachycondyla (Ectomomyrmex)* sp.1	+	+	-	+	+	-	+	-	-	+	3
212. *Pachycondyla (Ectomomyrmex)* sp.2	-	-	-	+	+	-	-	-	-	-	3
213. *Pachycondyla (Mesoponera)* sp.1	+	+	-	-	-	-	-	-	-	-	2
214. *Pachycondyla (Mesoponera)* sp.2	+	-	-	+	+	-	-	-	-	-	3
215. *Pachycondyla* sp.1	-	+	-	+	+	+	+	-	+	-	4
216. *Pachycondyla* sp.2	-	-	-	+	+	-	-	-	-	-	3
217. *Pachycondyla* sp.3	-	-	-	-	+	-	-	-	-	-	1
218. *Pachycondyla* sp.4	-	-	+	+	-	-	-	-	-	-	3
219. *Pachycondyla* sp.5	-	-	+	+	-	-	-	-	-	-	2
220. *Pachycondyla* sp.6	-	-	+	+	+	-	-	+	+	-	3
221. *Platythyrea* sp.1	-	+	+	-	-	-	-	-	-	-	2
222. *Ponera* sp.1	-	-	-	-	+	-	-	-	+	+	3
223. *Ponera* sp.2	-	-	+	+	+	-	+	-	+	-	4
Subfamily Pseudomyrmecinae											
224. *Tetraponera attenuata* F. Smith	+	+	+	+	+	-	-	-	-	-	6
225. *Tetraponera* sp.1	-	-	+	-	-	-	-	+	-	-	3
226. *Tetraponera pilosa* (F. Smith)	-	-	-	-	-	-	-	+	+	-	5
227. *Tetraponera* sp.3	-	-	+	-	-	-	-	-	-	-	3
228. *Tetraponera* sp.4	-	-	-	-	-	-	-	+	-	-	2

Table 2 Codes for ant species at Headquarter site and Hui Lek station (for Detrended Correspondence Analysis and Caconical Correspondence Analysis)

Species	Species code
Subfamily Aenictinae	
1. *Aenictus ceylonicus* (Mayr).	Aecey
2. *Aenictus laeviceps* (F. Smith)	Aenil
3. *Aenictus* sp.1	Aenic1
4. *Aenictus* sp.2	Aenic2
Subfamily Amblyoponinae	
5. *Mystrium camillae* Emery	Mystr1
Subfamily Cerapachyinae	
6. *Cerapachys* sp.1	Cera1
7. *Cerapachys* sp.2	Cera2
8. *Cerapachys* sp.3	Cera3
9. *Cerapachys* sp.4	Cera4
Subfamily Dolichoderinae	
10. *Dolichoderus* sp.1	Doli1
11. *Dolichoderus thoracicus* (F. Smith)	Doli2
12. *Philidris* sp.1	Phili1
13. *Tapinoma melanocephalum* (Fabricius)	Tame
14. *Tapinoma* sp.1	Tapin1
15. *Tapinoma* sp.2	Tapin2
16. *Tapinoma* sp.3	Tapin3
17. *Technomyrmex albipes* (F. Smith)	Techa
18. *Technomyrmex butteli* Forel	Techb
19. *Technomyrmex kraepelini* Forel	Techk
20. *Technomyrmex modiglianii* Emery	Techm
21. *Technomyrmex* sp.1	Techno1
22. *Technomyrmex* sp.2	Techno2
23. *Technomyrmex* sp.3	Techno3
Subfamily Dorylinae	
24. *Dorylus laevigatus* (F. Smith)	Dory1
25. *Dolyrus* sp.2	Dory2
26. *Dolyrus* sp.3	Dory3

Table 2 (Continued).

Species	Species code
Subfamily Ectatomminae	
27. *Gnamptogenys menadensis* (Mayr)	Gnamt
28. *Gnamptogenys* sp.1	Gnamp1
Subfamily Formicinae	
29. *Acropyga acutiventris* Roger	Aac
30. *Acopyga* sp.1	Asp
31. *Acopyga* sp.2	Asp2
32. *Acopyga* sp.3	Asp3
33. *Anoplolepis gracilipes* (F. Smith)	Ano
34. *Camponotus festinus* (F. Smith)	Cfe
35. *Camponotus rufifemur* Emery	Cru
36. *Camponotus (Camponotus)* sp.1	Ccs1
37. *Camponotus (Camponotus)* sp.2	Ccs2
38. *Camponotus (Colobopsis) leonardi* Emery	Cle
39. *Camponotus (Colobopsis)* sp.1	Ccos1
40. *Camponotus (Colobopsis)* sp.2	Ccos2
41. *Camponotus (Colobopsis)* sp.3	Ccos3
42. *Camponotus (Dinomyrmex) gigas* (Latreille)	Cgi
43. *Camponotus (Karavaievia)* sp.1	Cks1
44. *Camponotus (Myrmosaulus) singularis* (F. Smith)	Csi
45. *Camponotus (Myrmosaulus)* sp.1	Cmy
46. *Camponotus (Myrmosaulus)* sp.2	Cmy2
47. *Camponotus (Tanaemyrmex)* sp.1	Cta
48. *Camponotus (Tanaemyrmex)* sp.2	Ctb
49. *Camponotus (Tanaemyrmex)* sp.3	Ctc
50. *Camponotus* sp.1	Cas1
51. *Camponotus* sp.2	Cas2
52. *Camponotus* sp.3	Cas3
53. *Echinopla* sp.1	Ech1
54. *Echinopla* sp.2	Ech2
55. *Euprenolepis procera* (Emery)	Eup
56. *Euprenolepis* sp.1	Eupre1

Table 2 (Continued).

Species	Species code
57. Oecophylla smaragdina (Fabricius)	Oec
58. *Paratrechina opaca* (Emery)	Pop
59. *Paratrechina* sp.1	Psa
60. *Paratrechina* sp.2	Psb
61. *Paratrechina* sp.3	Par3
62. *Paratrechina* sp.4	Par4
63. *Polyrhachis furcata* (F. Smith)	Polyf
64. *Polyrhachis (Myrma) illaudata* Walker	Pil
65. *Polyrhachis (Myrma) hopla* Forel	Pho
66. *Polyrhachis (Myrma) striata* Mayr	Pst
67. *Polyrhachis (Myrma)* sp.1	Psts1
68. *Polyrhachis (Myrma)* sp.2	Psts2
69. *Polyrhachis (Myrmhopla) armata* (Le Guillou)	Par
70. *Polyrhachis (Myrmhopla) calypso* Forel	Polycal
71. *Polyrhachis (Myrmhopla) muelleri* Forel	Pmu
72. *Polyrhachis (Myrmhopla)* sp.1	Polys1
73. *Polyrhachis (Myrmhopla)* sp.2	Polys2
74. *Polyrhachis (Myrmhopla) furcata* F. Smith	Polys3
75. *Polyrhachis (Myrmhopla)* sp.4	Polys4
76. *Pseudolasius* sp.1	Pse
77. *Pseudolasius* sp.2	Psu
78. *Pseudolasius* sp.3	Psd
Subfamily Myrmicinae	
79. *Acanthomyrmex* sp 1	Acant
80. *Aphaenogaster* sp.1	Aph
81. *Cataulacus granulatus* Latreille	Cgr
82. *Crematogaster cf dolni*	Cdo
83. *Crematogaster (Crematogaster)* sp.1	Ccs
84. *Crematogaster (Crematogaster)* sp.2	Ccs2
85. *Crematogaster (Crematogaster)* sp.3	Ccs3
86. *Crematogaster (Orthocrema)* sp.1	Cor
87. *Crematogaster (Orthocrema)* sp.2	Cot

Table 2 (Continued).

Species	Species code
88. *Crematogaster (Orthocrema)* sp.3	Coh
89. *Crematogaster (Orthocrema)* sp.4	Coo
90. *Crematogaster (Paracrema) modiglianii* Emery	Cpm
91. *Crematogaster (Paracrema)* sp.1	Cps
92. *Crematogaster (Paracrema)* sp.2	Cpp
93. *Crematogaster (Paracrema)* sp.3	Cpc
94. *Crematogaster (Paracrema)* sp.4	Cps4
95. *Lophomyrmex bedoti* Emery	Lbe
96. *Lophomyrmex* sp.1	Loph1
97. *Lophomyrmex* sp.2	Loph2
98. *Lophomyrmex* sp.3	Loph3
99. *Meranoplus castaneus* F. Smith	Mca
100. *Meranoplus* sp. 1	Meras1
101. *Monomorium destructor* (Jerdon)	Mde
102. *Monomorium floricola* (Jerdon,)	Monof
103. *Monomorium pharaonis* (Linnaeus)	Mph
104. *Monomorium sechellense* Emery	Mse
105. *Monomorium* sp.1	Mon
106. *Monomorium* sp.2	Moo
107. *Monomorium* sp.3	Mori
108. *Monomorium* sp.4	Mom
109. *Monomorium* sp.5	Monom
110. *Myrmecina* sp.1	Myrm1
111. *Myrmecina* sp.2	Myrm2
112. *Myrmecina* sp.3	Myrm3
113. *Oligomyrmex* sp.1	Oli
114. *Oligomyrmex* sp.2	Olg
115. *Oligomyrmex* sp.3	Oligom
116. *Pheidole angulicollis* Eguchi	Phea
117. *Pheidole annexus* Eguchi	Phean
118. *Pheidole aristotelis* Forel	Phear
119. *Pheidole butteli* Forel	Pheb

Table 2 (Continued).

Species	Species code
120. *Pheidole cariniceps* Eguchi	Phec
121. *Pheidole clypeocornis* Eguchi	Phei
122. *Pheidole huberi* Forel	Pheh
123. *Pheidole longipes* (F. Smith)	Phel
124. *Pheidole nodifera* (F. Smith)	Phen
125. *Pheidole pieli* Santschi	Phep
126. *Pheidole plagiaria* F. Smith	Phepl
127. *Pheidole rabo* Forel	Pher
128. *Pheidole rugifera* Eguchi	Pheru
129. *Pheidole sarawakana* Forel	Phesa
130. *Pheidole* sp.1	Phe1
131. *Pheidole* sp.2	Phe2
132. *Pheidole s*p.3	Phe3
133. *Pheidole* sp.4	Phe4
134. *Pheidole* sp.5	Phe5
135. *Pheidole* sp.6	Phe6
136. *Pheidole* sp.7	Phe7
137. *Pheidole* sp.8	Phe8
138. *Pheidole* sp.9	Phe9
139. *Pheidole* sp.10	Phe10
140. *Pheidole* sp.11	Phe11
141. *Pheidole* sp.12	Phe12
142. *Pheidole* sp.13	Phe13
143. *Pheidole* sp.14	Phe14
144. *Pheidole* sp.15	Phe15
145. *Pheidole* sp.16	Phe16
146. *Pheidole* sp.17	Phe17
147. *Pheidologeton pygmaeus* Emery	Pphe
148. *Pheidologeton silenus* (F. Smith)	Ppsi
149. *Pheidologeton* sp.1	Phei1
150. *Pheidologeton* sp.2	Phei2
151. *Pristomyrmex rigidus* Wang & Minsheng	Prir

Table 2 (Continued).

Species	Species code
152. *Pristomyrmex* sp.1	Pris1
153. *Pristomyrmex* sp.2	Pris2
154. *Pyramica* sp.1	Pyra1
155. *Recurvidris* sp.1	Recu1
156. *Rhoptromyrmex* sp.1	Rhop1
157. *Solenopsis* sp.1	Sole1
158. *Solenopsis* sp.2	Sole2
159. *Solenopsis* sp.3	Sole3
160. *Strumigenys* sp.1	Stru1
161. *Strumigenys* sp.2	Stru2
162. *Strumigenys* sp.3	Stru3
163. *Strumigenys* sp.4	Stru4
164. *Tetheamyrma* sp 1	Tethea1
165. *Tetramorium cutalum*	Tetc
166. *Tetramorium parvum* Bolton	Tetb
167. *Tetramorium insolen* (F. Smith)	Teti
168. *Tetramorium kraepelini* Forel	Tetk
169. *Tetramorium pacificum* Mayr	Tepa
170. *Tetramorium* sp.1	Tets1
171. *Tetramorium* sp.2	Tets2
172. *Tetramorium* sp.3	Tets3
173. *Tetramorium* sp.4	Tets4
174. *Tetramorium* sp.5	Tets5
175. *Tetramorium* sp.6	Tets6
176. *Tetramorium* sp.7	Tets7
177. *Tetramorium* sp.8	Tets8
178. *Tetramorium* sp.9	Tets9
179. *Tetramorium* sp.10	Tets10
180. *Tetramorium* sp.11	Tets11
181. *Vollenhovia* sp.1	Vollen1
182. *Vollenhovia* sp.2	Vollen2

Table 2 (Continued).

Species	Species code
Subfamily Ponerinae	
183. *Anochetus graeffei* Mayr	Anog
184. *Anochetus* sp.1	Anoc1
185. *Anochetus* sp.2	Anoc2
186. *Diacamma sculpturata* (F. Smith)	Dias
187. *Diacamma* sp.1	Diaca1
188. *Diacamma* sp.2	Diaca2
189. *Emeryopone buttelreepeni* Forel	Emeryb
190. *Hypoponera* sp.1	Hypo1
191. *Hypoponera* sp.2	Hypo2
192. *Hypoponera* sp.3	Hypo3
193. *Hypoponera* sp.4	Hypo4
194. *Leptogenys kraepelini* Forel	Lepk
195. *Leptogenys kitteli* (Mayr)	Leptok
196. *Leptogenys mutabilis* F. Smith	Lepmu
197. *Leptogenys myops* (Emery)	Lepmy
198. *Leptogenys* sp.1	Lepto1
199. *Leptogenys* sp.2	Lepto2
200. *Leptogenys* sp.3	Lepto3
201. *Harpegnathos venator* (F. Smith)	Harpeg1
202. *Odontomachus rixosus* F. Smith	Odor
203. *Odontomachus* sp.1	Odon1
204. *Odontoponera denticulata* (F. Smith)	Odontd
205. *Odontoponera transversa* (F. Smith)	Odontt
206. *Pachycondyla (Brachyponera) chinensis* (Emery)	Pabc
207. *Pachycondyla (Brachyponera)* sp.1	Pabs1
208. *Pachycondyla (Brachyponera)* sp.2	Pabs2
209. *Pachycondyla (Brachyponera)* sp.3	Pabs3
211. *Pachycondyla (Ectomomyrmex)* sp.1	Pachye1
212. *Pachycondyla (Ectomomyrmex)* sp.2	Pachye2
213. *Pachycondyla (Mesoponera)* sp.1	Pachym1
214. *Pachycondyla (Mesoponera)* sp. 2	Pachym2

Table 2 (Continued).

Species	Species code
215. *Pachycondyla* sp.1	Pach1
216. *Pachycondyla* sp.2	Pach2
217. *Pachycondyla* sp.3	Pach3
218. *Pachycondyla* sp.4	Pach4
219. *Pachycondyla* sp.5	Pach5
220. *Pachycondyla* sp.6	Pach6
221. *Platythyrea* sp.1	Platyt1
222. *Ponera* sp.1	Pone1
223. *Ponera* sp.2	Pone2
Subfamily Pseudomyrmecinae	
224. *Tetraponera attenuata* F. Smith	Teta
225. *Tetraponera* sp.1	Tetras1
226. *Tetraponera pilosa* (F. Smith)	Tetras2
227. *Tetraponera* sp.3	Tetras3
228. *Tetraponera* sp.4	Tetras4

APPENDIX 2

Figure 1 *Acanthomyrmex* sp.1

Figure 2 *Acropyga acutiventris* Roger

Figure 3 *Aenictus ceylonicus* (Mayr)

Figure 4 *Aenictus laeviceps* F. Smith

Figure 5 *Anochetus graeffei* Mayr

Figure 6 *Anochetus* sp.1

Figure 7 *Anochetus* sp.2

Figure 8 *Anoplolepis gracilipes*

Figure 9 *Aphaenogaster* sp.1

Figure 10 *Camponotus (Myrmosaulus) singularis* (F. Smith)

Figure 11 *Camponotus (Myrmotarsus)* sp.1

Figure 12 *Camponotus (Tanaemyrmex)* sp.1

Figure 13 *Camponotus (Tanaemyrmex)* sp.2

Figure 14 *Camponotus (Tanaemyrmex)* sp.3

Figure 15 *Camponotus* sp.2

Figure 16 *Cataulacus grannulatus* Latreille

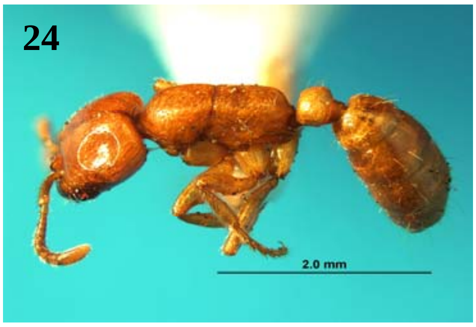


Figure 17 *Cerapachys* sp.2

Figure 18 *Cerapachys* sp.3

Figure 19 *Crematogaster (Orthocrema)* sp.1

Figure 20 *Crematogaster (Paracrema) modiglianii* Emery

Figure 21 *Diacamma* sp.1

Figure 22 *Dolichoderus* sp.1

Figure 23 *Dolichoderus thoracicus* (F. Smith)

Figure 24 *Dorylus laeviagatus* (F. Smith)

Figure 25 *Echinopla* sp.1

Figure 26 *Emeryopone buttelreepeni* Forel

Figure 28 *Euprenolepis procera* (Emery)

Figure 28 *Gnamptogenys* sp.1

Figure 29 *Harpegnathos venator* Donisthorpe

Figure 30 *Hypoponera* sp.1

Figure 31 *Leptogenys kitteli* (Mayr)

Figure 32 *Leptogenys krapelini* Forel

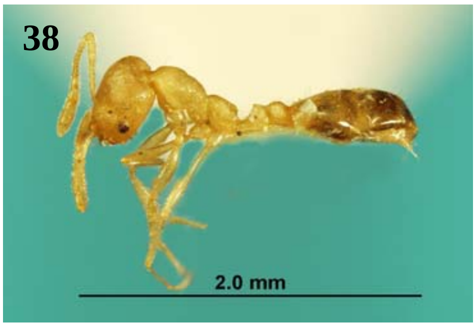


Figure 33 *Leptogenys mutabilis* (F. Smith)

Figure 34 *Leptogenys myops* (Emery)

Figure 35 *Leptogenys* sp.1

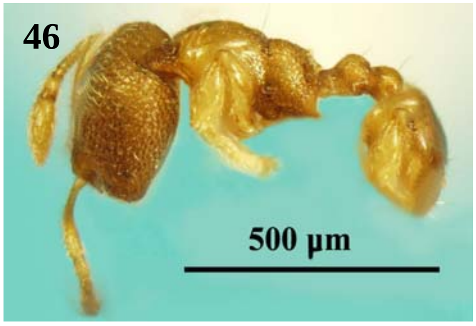
Figure 36 *Lophomyrmex bedoti* Emery

Figure 37 *Meranoplus castaneus* F. Smith

Figure 38 *Monomorium pharaonis* (Linnaeus)

Figure 39 *Monomorium sechellense* Emery

Figure 40 *Myrmecina* sp.2



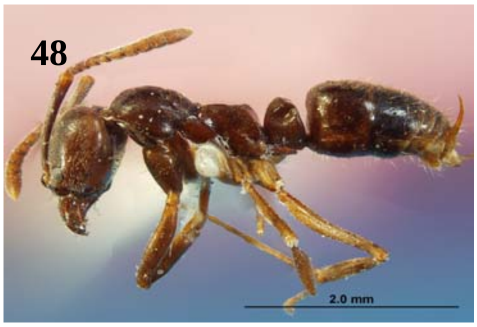


Figure 41 *Mystrium camillae* (Emery)

Figure 42 *Odontomachus rixosus* F. Smith

Figure 43 *Odontoponera denticulata* (F. Smith)

Figure 44 *Odontoponera transversa* (F. Smith)

Figure 45 *Oecophylla smaragdina* (Fabricius)

Figure 46 *Oligomyrmex* sp.1

Figure 47 *Oligomyrmex* sp.3

Figure 48 *Pachycondyla (Brachyponera) chinensis* F. Smith

Figure 49 *Pachycondyla (Brachyponera)* sp.1

Figure 50 *Pachycondyla (Ectomyrmex)* sp.1

Figure 51 *Pachycondyla (Mesoponera) astute* F. Smith

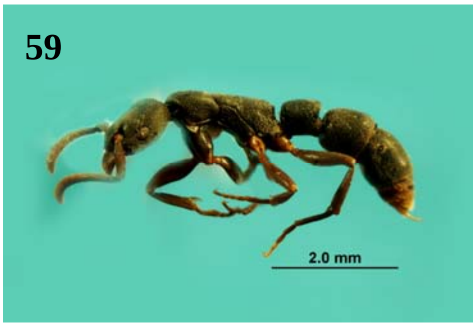
Figure 52 *Paratrechina opaca* Emery

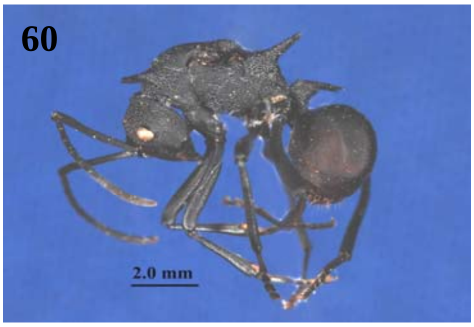
Figure 53 *Pheidole longipes* (F. Smith) (Minor worker)

Figure 54 *Pheidole longipes* (F. Smith) (Major worker)

Figure 55 *Pheidole plagiaria* F. Smith (Minor worker)

Figure 56 *Pheidole plagiaria* F. Smith (Major worker)





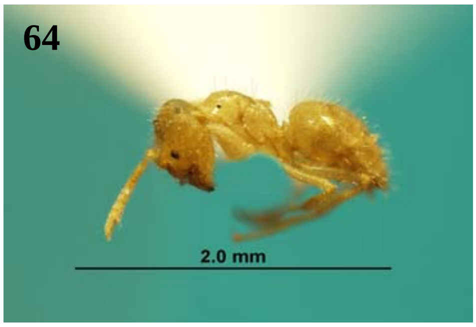


Figure 57 *Pheidologeton silensis* (F. Smith)

Figure 58 *Philidris* sp.1

Figure 59 *Platythyrea parallela* (F. Smith)

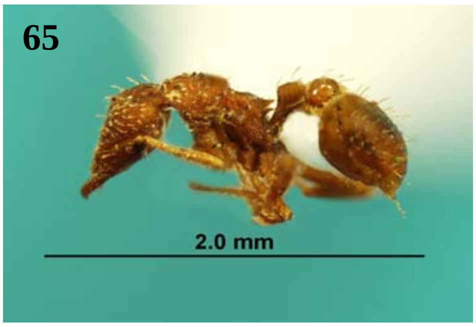
Figure 60 *Polyrhachis (Myrmhopla) armata (Le Guillou)*

Figure 61 *Polyrhachis (Myrmhopla) furcata* F. Smith

Figure 62 *Ponera* sp.1

Figure 63 *Pristomyrmex rigidus* (Wang & Minsheng)

Figure 64 *Pseudolasius* sp.2



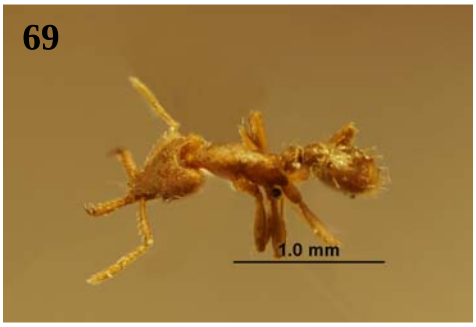


Figure 65 *Pyramica* sp.1

Figure 66 *Recurvidris* sp.1

Figure 67 *Rhoptromyrmex* sp.1

Figure 68 *Solenopsis* sp.3

Figure 69 *Strumigenys* sp.2

Figure 70 *Strumigenys* sp.3

Figure 71 *Technomyrmex albipes* (F. Smith)

Figure 72 *Technomyrmex kraepelini* Forel

Figure 73 *Technomyrmex modiglianii* (Emery)

Figure 74 *Technomyrmex* sp.1

Figure 75 *Tetheamyrma* sp.1

Figure 76 *Tetramorium pacificum* Mayr

Figure 77 *Tetraponera attenuata* F. Smith

Figure 78 *Tetraponera pilosa* (F. Smith)

Figure 79 *Tetraponera* sp.4

Figure 80 *Vollenhovia* sp.1

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List of Publication and Proceeding

Watanasit, S., Saewai, J. and Phlappleung, A. 2007. Ants of the U-Tao Basin, Southern Thailand. *Asian Myrmecology* 1: 69-79.

Watanasit, S., Noon-anant, N. and Phlappleung, A. 2008. Diversity and ecology of ground dwelling ants at Khao Nan National Park, Southern Thailand, Songkhla. *Songklanakarin Journal of Science and Technology* 30(6): 707-712.