การเปรียบเทียบความหลากหลายทางชนิดและความชุกชุมของมดในพื้นที่ทุ่งหญ้า และพื้นที่ปลูกป่า ณ ตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน

นางสาววิศนีย์ ศุภสาร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ปีการศึกษา 2554

COMPARISON OF SPECIES DIVERSITY AND ABUNDANCE OF ANTS IN GRASSLAND AND REFORESTATION AREA AT LAI NAN SUB DISTRICT, WIANG SA DISTRICT, NAN PROVINCE

Miss Wissanee Suppasan

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Zoology

Department of Biology

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Thesis Title	COMPARISON OF SPECIES DIVERSITY AND ABUNDANCE OF ANTS IN GRASSLAND AND REFORESTATION AREA AT LAI NAN SUB DISTRICT, WIANG SA DISTRICT, NAN PROVINCE
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Field of Study	Zoology
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วิศนีย์ ศุภสาร : การเปรียบเทียบความหลากหลายทางชนิดและความชุกชุมของมดในพื้นที่ทุ่งหญ้าและพื้นที่ปลูกป่า ณ ตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน (COMPARISON OF SPECIES DIVERSITY AND ABUNDANCE OF ANTS IN NATURAL GRASSLAND AND REFORESTATION AREA AT LAI NAN SUB DISTRICT, WIANG SA DISTRICT, NAN PROVINCE) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร.ดวงแข สิทธิเจริญชัย, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม: อ.ดร.ชัชวาล ใจซื่อกุล, 119หน้า.

ทุ่งหญ้าเป็นแหล่งอาศัยที่มีสังคมของกลุ่มสิ่งมีชีวิตที่ความเฉพาะเจาะจงทุกวันนี้มนุษย์มีกิจกรรมใช้ประโยชน์จากพื้นที่ทุ่งหญ้าอย่างมากมาย ก่อให้เกิดผลกระทบต่อสิ่งมีชีวิตที่อาศัยอยู่ในพื้นที่ทุ่งหญ้าหลายอย่าง งานวิจัยนี้เป็นการวิจัยเพื่อสืบค้นและเปรียบเทียบความหลากหลายและความชุกชุมของมดระหว่างพื้นที่ทุ่งหญ้าและพื้นที่ป่าปลูกในตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน การเก็บตัวอย่างมดใช้ทั้งหมด 6 วิธี คือ การจับด้วยมือภายในกำหนดเวลา, กับดักน้ำหวาน, กับดักโปรทีน, กับดักหลุม, การร่อนซากใบไม้และการร่อนดิน โดยทำการเก็บตัวอย่างทุกเดือนในทั้งสองพื้นที่ศึกษาตั้งแต่เดือนมิถุนายน 2553 ถึง มิถุนายน 2554

ชนิดของมดที่พบในพื้นที่ศึกษาทั้งสองพื้นที่ พบมดทั้งหมด 34 ชนิด (23 ชนิดซึ่งระบุชนิดได้และอีก 11 ชนิดที่ยังระบุชนิดไม่ได้) จาก 22 สกุลใน 6 วงศ์ย่อย แม้ว่าค่าดัชนีความหลากหลายบ่งชี้ว่าความหลากหลายของชนิดมดในพื้นที่ป่าปลูก (0.65) มีมากกว่าในพื้นที่ทุ่งหญ้า (0.62) แต่อาจกล่าวได้ว่าความหลากหลายทางชนิดของมดในทั้งสองพื้นที่ไม่มีความแตกต่างกันโดยดูจากค่าดัชนีความเหมือนที่มีค่าสูงถึง 92%

นอกจากความต่างของลักษณะของพื้นที่ในระหว่างพื้นที่ศึกษาทั้งสองแล้ว ความผันผวนของสภาพแวดล้อมอันเนื่องมาจากปัจจัยฤดูกาลก็เป็นปัจจัยหนึ่งที่อาจส่งผลต่อการแปรปรวนของมด ค่าดัชนีความเหมือนระหว่างฤดูฝนและฤดูแล้งในพื้นที่ศึกษาทั้งสองมีช่วงประมาณ 84-91% รูปแบบความหลากชนิดของมดแสดงว่าพื้นที่ศึกษาทั้งสองไม่มีความแตกต่างทั้งในลักษณะแหล่งอาศัยและฤดูกาล

ผลการศึกษาในพื้นที่ทั้งสอง พบมด 3 ชนิดที่มีความสัมพันธ์อย่างมีนัยสำคัญกับปัจจัยทางกายภาพ นอกจากนี้ยังพบว่ามดในกลุ่มที่มีความจำเพาะกับสภาพภูมิอากาศและกลุ่มที่มีการดำรงชีวิตที่จำเพาะ เป็นมดชนิดเด่นที่พบในพื้นที่ป่าปลูกแต่ไม่พบในพื้นที่ทุ่งหญ้า จะเห็นได้ว่ามดบางชนิดอาจใช้เป็นดัชนีสำหรับเฝ้าระวังการเปลี่ยนแปลงจากการรบกวนแหล่งอาศัยได้เป็นอย่างดี

ภาควิชา...................ชีววิทยา..............ลายมือชื่อนิสิต………………………………..……………………..

สาขาวิชา..................สัตววิทยา...........ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก…………………………....

ปีการศึกษา...............2554……………ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม……………………………

5272543923 : MAJOR ZOOLOGY
KEYWORDS : GRASSLAND/ SPECIES DIVERSITY OF ANT/ FUNCTIONAL GROUPS / REFORESTATION AREA

WISSANEE SUPPASAN : COMPARISON OF SPECIES DIVERSITY AND ABUNDANCE OF ANTS IN GRASSLAND AND REFORESTATION AREA AT LAI NAN SUB DISTRICT, WIANG SA DISTRICT, NAN PROVINCE. ADVISOR: ASST. PROF.DUANGKHAE SITTHICHAROENCHAI, Ph.D., CO-ADVISOR : CHATCHAWAN CHAISUEKUL,Ph.D., 119 pp.

Grassland is a community with specific composition of living organisms. Nowadays, grasslands are used extensively by human activities that cause various effects on living organisms. This research was to investigate and compare the diversity and abundance of ants between in grassland and reforestation area at Lai Nan Sub-district, Wiang Sa district, Nan province. Six sampling methods: hand capture with constant time, sugar baiting trap, protein baiting trap, pitfall trap, leaf litter sifting, and soil sifting, were conducted monthly in the two study areas from June 2010 to June 2011.

The overall species richness of ants was 34 species (23 species and 11 morpho-species) from 22 genera in six subfamilies. The Shannon Weiner species diversity index indicated that the diversity was higher in reforestation area (0.65) than in grassland (0.62). The diversity of ants was not different between the two study areas from the high Sorensen's similarity coefficient (92%).

Besides different habitats, the environmental fluctuations due to seasonal factors also affected the variation of ants. The Sorensen's similarity coefficient between wet and dry seasons in two study areas among seasons was 84-91%. The pattern of ant diversity showed that the two study areas were not different between the habitat and season.

The first four highest abundant ants, three species were significantly correlated with some physical factors in two study areas. Afterwards, all collected ants were classified into six functional groups as Dominant Dolichoderinae, SubordinatCamponotini, Climate Specialists, Cryptic Specialists, Generalized Myrmicinae, and Specialists Predators. Both Climate Specialist and Cryptic Specialists were dominated in reforestation areabut not in grassland. Accordingly, ants could be used as indicators for monitoring changes of the disturbance habitat as well.

Department : Biology	Student's Signature ....
Field of Study : Zoology	Advisor's Signature ....
Academic Year : 2011	Co-advisor's Signature ....

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CHAPTER I

INTRODUCTION

Rising of human populations as the increase human activities have an encouraged agricultural conversion, expansion, and resource extraction of natural habitats on a large scale. As a result, natural habitat areas increasingly changed and fragmented (Kaspari and major, 2000). Over the past few periods, Thailand's natural habitats have been altered and disturbed continuously in every part. The difference in land management can affect to different diversity patterns of plants and animals in those areas. Land use changes alter the environmental factors, such as relative humidity, temperature, soil and vegetation, and also influence diversity patterns through the food webs. When a forest is changing, the ecosystem is modified and subsequently has impacts on the species composition of the inhibiting faunas.

Indicator taxa are used to detect environmental changes. The ecological responses of selected taxa that are sensitive to habitat modification are used as representation of conditions for the opposite taxa within the space. Moreover, ants are used as bioindicators in Australia for several years (Alonso, 2000). Ants possess many benefits to be used as ecological indicators for monitoring the environmental changes. They have several notable characters, like easiness to gather and monitor, high diversity, widespread throughout the planet, taxonomically well-studied cluster, and serving many necessary roles in the ecosystem (Alonso and Agosti, 2000).

With the increasing loss of habitats and biodiversity around the world, there's an urgent need for biodiversity assessments be supplemented throughout the conservation designing method (Alonso, 2000) in addition to factors influencing biodiversity variation, such as habitat and land use types. Most researches on ants in Thailand not only were principally conducted in protected areas, primarily in natural forests, but also the analysis focus was solely on taxonomic aspect space. Therefore, Thailand still has restricted analysis addressing the results of various land uses on ant communities.

Reforestation can be use of measuring for making the hole in which a seedling or plant can be inserted. Generally, soil microbe can optionally be used to increase survival rates in hardy environments. A debatable issue in managing reforestation is whether or not the succeeding forest will have the same biodiversity as the original forest. If the forest is replaced with only one species of tree and all other vegetations are prevented from growing back, a monoculture forest similar to agricultural crops would be the result. However, most reforestations involve the planting of different feedlots of seedlings taken from the area often of multiple species. Another important factor is the natural regeneration of a wide variety of plants and animal species that can occur on a clear cut. In some areas the suppression of forest fires for hundreds of years has resulted in large single aged and single species forest stands. The logging of small clear cuts and or prescribed burning, actually increases the biodiversity in these areas by creating a greater variety of tree stand ages and species

Ant diversity in Thailand has been investigated in many habitat types, especially in natural forests and agricultural areas, but there are very few reports from grassland ecosystems. Nan is a province in the north of Thailand where grassland is commonly found throughout the area. Most grassland ecosystems in the province were previously forests and integrated by human activities in the past, mostly for agricultures, but, some of the areas have been being managed and reforested recently. The changes in the environment status lead to necessity for investigating the ant species richness and their abundance in the grassland ecosystems. The diversity and abundance of ants in grassland and reforestation area from grass at Lai Nan subdistrict, Wiang Sa district, Nan province should be studied to provide some important basic knowledge for land use and management planning of reforestation ecosystems.

1.1 Objectives

1. To study and compare species diversity of ant between grassland and reforestation area.
2. To determine and compare the correlation between some physical factors and the abundance of important ant species in each study site.

CHAPTER II

LITERATURE REVIEW

2.1 Diversity of ants

Ants are classified in an exceedingly single family, the Formicidae, within the order Hymenoptera (Hölldobler and Wilson, 1990). There are twenty three subfamilies of ants consisted of 287 genera with about 12,000 described species, with a possibility of a broader range of species nevertheless to be described worldwide (Bolton et al., 2006). Though tropical forests are the least extensively surveyed areas, they still have the highest diversity recorded in Asia (Hölldobler and Wilson, 1990). In Thailand, there are 9 subfamilies: Aenictinae, Cerapachyinae, Dolichoderinae, Dorylinae, Formicinae, Leptanilinae, Myrmicinae, Ponerinae, and Pseudomyrmicinae (Wiwatwitaya and Jaitrong, 2001).

The native diversity of ants is additionally high. In wet tropical forests in Madagascar, 471 species in 36 genera were found (Fisher, 2000). A survey of a primary rainforest within the Kinabalu National Park, Sabah, Borneo yielded 524 species in 7 subfamilies and 73 genera (Brühl, Gunsalam and Linsenmair, 1998), whereas 120 species in 5 subfamilies and 49 genera were recorded in Pasoh Forest Reserve, wet Malaysia (Malsch, 2000).

A variety of ants species had been reported in mainland Southeast Asia. Their widespread distribution includes habitats starting from forests to agricultural lands to urban areas. The pristine forests were reported to contain higher diversity of ants than in secondary forest and agricultural land. Nine subfamilies, 60 genera and 211 species of ants were listed from an higher hill dipterocarp forest in northern Peninsular Malaysia (Mutafa et al. 2011) similar to 9 subfamilies and 206 species of ants at Ton Nga Chang wildlife Sanctuary in Songkhla province in southern Thailand (Watanasit et al. 2000, Watanasit and Noon-anan 2005) and 9 subfamilies, 62 genera and 218 species of ants at KhaoYai national park in central Thailand (Wiwatwittaya 2003). Ant species diversity was studied in several elements of Thailand. In Bala forest at Hala-Bala wildlife sanctuary reported 9 subfamilies, 73 genera and 246 species by Wiwatwitaya and Jaitrong (2001), Narathiwat province were found 225 species in 63 genera of 8 subfamilies by Noon-anant (2003). At Sakaerat environmental analysis station, Nakhon Ratchasima province reported 9 subfamilies, 56 genera and 131 species by Hasin (2008).

In distinction, the entire of 5 subfamilies, 23 genera and 46 species of ants were reported in secondary dry dipterocarp forest, grassland and mango plantation in Nan province, northern Thailand (Sitthicharoenchai and Chantarasawat 2006), and also the total of 7 subfamilies, 48 genera and 130 species of ants were reported in Montana forest, forest fallowed, jungle tea and annual crop in Chiang Mai province, northern Thailand with highest ants diversity in natural forests than in agro-forests and agricultural areas (Sakchoowong et al. 2008).

2.2 The role of ant in ecosystem

Although the proportion of biomass represented by ground-dwelling ants as compared with different soil microfauna (e.g. termites and earthworms) within the tropics varied from comparatively low (0.02-5%) to high (80%) (Hölldobler and Wilson, 1990), in terms of population density, when at an occasional relative biomass ants build a so much larger contribution ranging generally from 7-53% (Lavelle and Pashanasi, 1989). One third of the whole animal biomass of the Amazonia terra firm rain forest was comprised of ants and termites, with every hectare of soil containing in more than eight million ants and one million termites (Hölldobler and Wilson, 1990). Indeed, each arboreal and ground dwelling ants play numerous and necessary ecological roles. In addition to the high abundance and species richness of ants, ecological roles are consisting of arrays of interactions among ants and different organism. They will operate in an ecosystem as predators, preys, detritivores, mutualists, herbivores, or in combos and their functions are sometimes associated with the species and genera they belong to (Alonso, 2000; Schultz and McGlynn, 2000). Additionally, they produce mycorrhizal reservoirs that have effects on nutrient immobilization, water movement, nutrient cycling, soil movement and different physical and chemical changes to the soil profile (Folgarait, 1998; Philpott and Armbrecht, 2006)

2.3 Ants as bioindicators

Ants are widely considered as powerful monitoring tools in environmental management because of their nice abundance, diversity and purposeful importance; their sensitivity to perturbation and therefore the ease with that they will be sampled (Majer, 1983; Andersen, 1997). Ants as bioindicators are currently widely adopted within the Australian mining as a part of best-practice environmental management. Ants bioindicators has conjointly been applied to a large vary of different land-use things (Andersen, 1990), as well as off-site mining impacts (Read, 1996; Madden and Fox, 1997; Hoffmann et al., 2000), forest management (Neumann, 1992; York, 1994), conservation assessment (Yeatman and Greenslade, 1980, Clay and Schneider, 2000) and grazing impacts in rangelands (Landsberg et al., 1999). The utilization of ants as bioindicators is supported by a macro scale purposeful cluster theme, that has been used extensively to analyze biogeograpghic patterns of community composition and therefore the response of ant communities to disturbance (Greenslade, 1978; Andersen, 1997).

2.4 A list of functional groups

There are seven such ant functional groups and their major representatives in Australia whose relative abundance varies predictably in relation to environmental stress and disturbance (Andersen 2000) (Table 2.1).

Table 2.1 Summary of functional groups of Australian ants, based on habitat requirements and competitive interactions with characteristics (Andersen 2000).

Group and major taxa	Characteristics
Dominant Dolichoderinae (DD) - *Iridomyrmex*	Such environments are hot and open ones, and these are often dominated both numerically and functionally by highly aggressive Dolichoderines.
Subordinated Camponotini (SC) - *Camponotus* - *Polyrhachis* - *Opisthorium*	Most are behaviorally submissive to Dominant Dolichoderines, and many are ecologically segregated from them owing to their large body size and often nocturnal foraging.

Table 2.1 (Continued)

Group and major taxa	Characteristics
Climate Specialists (CS)	
● Cold and tropical climate specialists - *Prolasius* - *Notoncus* - *Oecophylla* - *Tetrapopera* - *Pheidologeton* *Monomorium*	Both cold and tropical climate specialists are characteristics of habitats where the abundance of Dominant Dolichoderines is low aside from their habitat tolerances. They are often unspecialized ants.
● Hot climate specialists - *Melophorous* - *Myrmecocystus* - *Ocymyrmex* - *Meranoplus* - *Monomorium*	Conversely, the characteristic of Dominant Dolichoderines is most abundance and the posses as range of physiological, morphological and behavioral specializations relating to their foraging ecology, which reduce their interaction with other ants.
Cryptic Species (CrS) - *Solenopsis* - *Hypoponera* - *Pheidologeton* - *Plagiolepis* - *Anopholepis*	These are small to minute species, predominantly Myrmicines and Ponerines, that nest and forage primarily within the soil, litter and rotting logs. They are most diverse and abundant in forested habitats and are a major component of leaf litter ants in the rainforest.

Table 2.1 (Continued)

Group and major taxa	Characteristics
Opportunists (OP) - *Paratrechina* - *Tetramorium* - *Tapinoma* - *Cardiocondyla*	These are unspecialized poorly competitive, reduced species, whose distributions appear to be strongly influenced by competition from other ant. They often have vary wide habitat distributions, but predominate only ant sites where stress or disturbance severally limit and productivity and diversity, and therefore where behavioral dominant is low.
Generalized Myrmicinae (GM) - *Crematogaster* - *Monomorium* - *Pheidole*	Species of *Crematogaster, Monomorium* and *Pheidole* are ubiquitous members of ant communities throughout the warmer regions of the world, and they are often among the most abundant ants. As discussed later in this chapter, there is often competitive tension between them and Dominant Dolichoderines including in tropical rainforest.

Table 2.1 (Continued)

Group and major taxa	Characteristics
Specialists Pedators (SP) - *Pachycondyla* - *Leptogenys* - *Cerapachyinae* - *Odontoponera*	This group comprises medium-sized to large species that are specialist predators of other arthropods. They include solitary foragers, such as species of Pachycondyla, as wells group raiders, such as species of Leptogenys. Except for direct production, they tend to have little interaction with other ants owing to their specialized diets and typically low population densities.

* The description in each functional group, which described by Andersen 2000

There are seven such ant functional groups, and their major representatives in Australia are list in Table 2.2

Table 2.2 Summary of functional groups of Australian ants based on their relationships to environmental stress and disturbance.

Functional group	Ants species in Australia
1. Dominant Dolichoderinae	*Anonychomyrma, Froggattella, Iridomyrmex, Paryrius, Philidris*
2. Subordinate Camponotini	*Calomyrmex, Camponotus, Opisthopsis, Polyrhachis*
3. Climate specialists	
a. Hot	*Melophorus, Meranoplus, Monomorium* (part)
b. Cold	*Monomorium* (part), *Notoncus*, *Prolasius*, *Stigmacros*
c. Tropical	Many taxa
4. Cryptic Species	Very many small myrmicinaines and ponerines, including *Hypoponera*, most Dacetonini, and *Solenopsis*
5. Opportunists	*Paratrechina, Rhytidoponera, Tetramorium*
6. Generalized Myrmicinae	*Crematogaster, Monomorium, Pheidologeton*
7. Specialist Predators	*Bothroponera, Cerapachys, Leptogenys, Myrmecia*

The seven practical terms as the following:

1. Dominant Dolichoderinae

This group of ants is abundant, highly active and aggressive species, exerting a powerful competitive influence on alternative ants. The ants favor hot and open habitats such as *Iridomymex, Anonychomyrma.*

2. Subordinate Camponotini

The ants often co-occure with and behaviorally submissive to Dominant Dolichoderines. With massive body size, and natural foragers such as *Camponotus, Polyrhachis, Opisthosis*.

3. Climate specialists

Hot climate specialists, taxa custom are made to arid environments with morphological, physiological or behavioral specializations that scale back their interaction with Dominant Dolichoderinaines*; Melophorus, Meranoplus, Monomorium* (part). For cold climate specialists, the ants distribute centered on the cool-temperature zone and occur in habitats where Dominant Dolichoderines are usually not abundant such as *Oecophylla, Tetraponera*, and several alternative tropical taxa.

4. Cryptic Species

There are tiny to minute species, predominantly Myrmicines and Poneries, which nest and forage primarily at intervals soil, litter, and leaf litter. They're most various and abundant in forested habitat and are a significant part of leaf litter ants in rainforest. *Solenopsis, Hypoponera*, several alternative tiny Myrmicinines and Ponerines.

5. Opportunist

There are unspecialized, poorly competitive, ruder species, whose distributions seem to be strongly influenced by competition from alternative ants. They usually have terribly wide habitat distribution, however predominate solely at sites where stress or disturbance severally limit ant productivity and variety, and so where behavioral dominance is low such as *Rhytidoponera, Parathechina, Aphenogaster, Tetramorium*.

6. Generalized Myrmicinae

Species of *Crematogaster, Monomorium*, and *Pheidole* are ubiquitous members of ant communities throughout the hotter regions of the planet, and that they are usually among the foremost abundant ants.

7. Specialist Predators

This cluster contains medium-sized to massive species that are specialist predators of alternative arthropod. They embrace solitary foragers, like species of *Pachycondyla*, yet as cluster raiders, like species of *Leptogenys*. Aside from direct predation, they have a tendency to own very little interaction with alternative ants attributable to their specialized diets and generally low population densities.

2.5 Influence of the physical factors on the ant diversity

Several biological and physical factors might have an effect on species richness and abundance of ant communities inhibiting specific surroundings (Ríos-Casanova, Valiente-Banuet, and Rico-Gray, 2006) as a result of ants tiny size that build they heat up and dry out a lot of quickly, physical issue, like temperature, solar radiations, and water, might play a crucial role in determining ant diversity (Bestelmeyer, 1997). Ants, as ecotherms, and constrained to forage once they are heat enough, however, not too heat.

The lowest temperature with 10ºC leads to that most ants forage and stop foraging a lot of higher than 40ºC, with 30ºC are the period of temperature for foraging on ants (Hölldobler and Wilson, 1990). These environmental conditions will limit the distribution and abundance of ants. In Balaforest at Hala-Bala Wildlife Sanctuary, Narathiwat province, Noon-anant (2003) found that the temperature was absolutely correlated with variety of species of *Pheidologeton*. However, the negatively correlated with variety of species of *Meranoplus, Tetramorium, Amblyopone*, and *Platythyrea.* Humidity was absolutely correlated with variety of *Cerapachys, Monomorium,* and *Solenopsis*, however negatively correlated with variety of species of *Acanthomyrmex, Cataulactus*, and *Crematogaster.* Seasonal amendments influence the amount of species in genus *Aenictus, Pheidole*, and *Pyramica*, considerably totally different between the wet and also the dry seasons (Noon-anant, 2003). Vegetation structure conjointly affected the incidence of direct solar radiation, soil temperature, and water evaporation. Sites with complicated vegetation structure offer higher conditions for ant activities than web site with straightforward structure (Retana and Cersá, 2000)

2.6 Methods to estimate ant diversity

Ants, in general, are terribly simple to sample. The techniques for collected sample such as baiting techniques, pitfall traps, aspirators, litter sifting, Berlese-Tullgren or Winkler funnels for litter or soil core samples, and hand collectins with forceps or nets are among the foremost common strategies to sample ground foraging ants. Of these strategies are simple to use, cheap, and not incredibly time consuming (Hölldobler and Wilson, 1990). A comparison of the litter and soil ant fauna have showed that a mixture of strategies can make sure to complete an illustration of the ant fauna as is expected. The success of any sampling protocol has used alongside every methodology, further as a careful interpretation of the information that accounts for the limitation of the methodology (Bestelmeyer et al. 2000). Infact, various study have noted the requirement to use quite one methodology in quantifying ant diversity (Olseson, 1991; Bestelmeyer et al., 2000; Hashimoto, Yamane, and Mohamed, 2001).

2.7 Ant diversity in the natural and other habitats in northern part Thailand

A variety of ant species had been reported in mainland Southeast Asia. Their widespread distribution includes habitats ranging from forests to agricultural lands to urban areas. The pristine forests were reported to contain higher diversity of ants than in secondary forest and agricultural land. The total of 5 subfamilies, 23 genera and 46 species of ants were reported in secondary dry dipterocarp forest, grassland, and mango plantation in Nan province, northern Thailand (Sitthicharoenchai & Chantarasawas 2006); and the total of 7 subfamilies, 48 genera, and 130 species were reported in Montana forest, forest fallow, jungle tea, and annual crop in Chiang Mai province, northern Thailand with the highest ant diversity in natural forests than in agro-forests and agricultural areas (Sakchoowong et al. 2008).

However, there is currently no data concerning about the range of ants in these habitats that are changed from the natural forest, nevertheless such changes within the land-use patterns have resulted in space that considerably differ in vegetative cover, management, and some environmental factors and so would be expected to have modified the ant species composition and abundance.

CHAPTER III

METHODOLOGY

3.1 Study sites

The study was conducted at the Chulalongkorn University Forestry and Research Station a 300-ha area located at Lai Nan sub-district, Wiang Sa district, Nan province in northern Thailand (UTM zone 47Q: N2051960-2054260 and E0688400-0690360). The study was conducted in two habitats. The first area was grassland dominated by cogon grass (*Imperata cylindrical*), and the second area was a reforestation area, a mixture between three year-old dry dipterocarp seedlings and cogon grass and. Each habitat was approximately 60x60 m^2 and surrounded by dry dipterocarp forests.

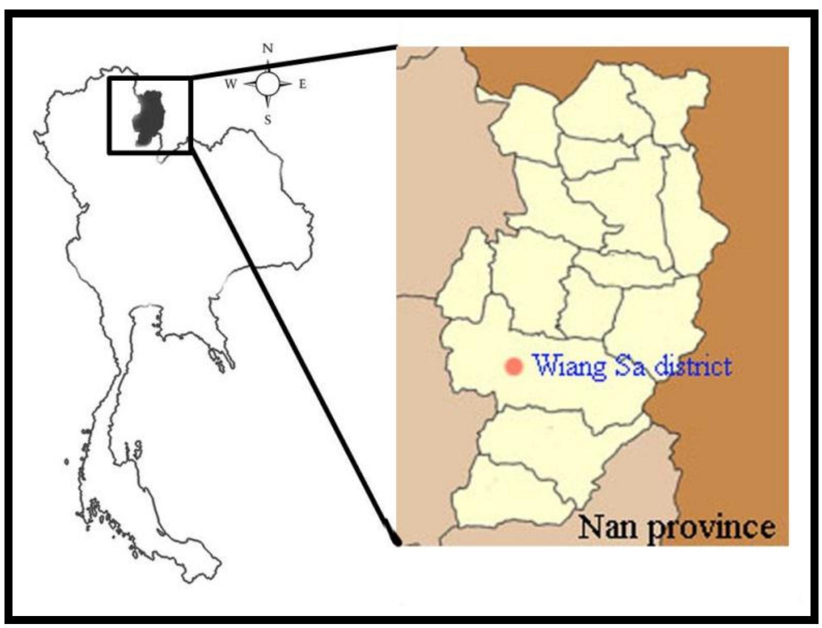

Figure 3.1 Map of WiangSa district, Nan province of northern Thailand.

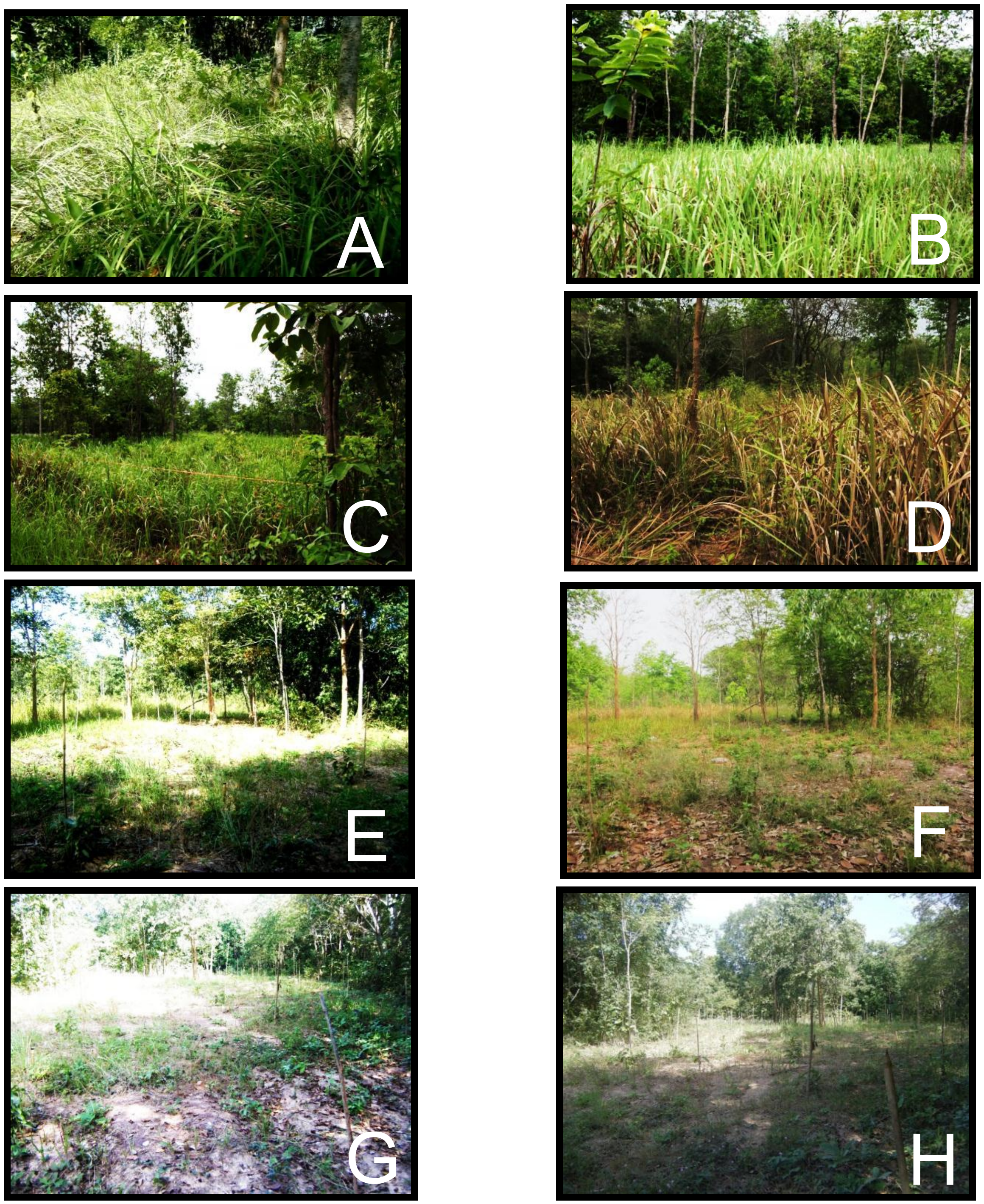

Figure 3.2 The study sites; A – D grasslands and E- H reforestation areas in Lai Nan subdistrict, Wiang Sa district, Nan province

The Chulalongkorn University Forestry and Research Station has been established for more than 10 years. Most of the area was secondary deciduous dipterocarp due to earlier human disturbances, such as burning, logging, and farming; and the cessation of the disturb in the area resulted in various stages of successions, such as grassland and the secondary dry dipterocarp forests. Some of grassland has been cleared for reforestation of dry dipterocarp forests in 2010.

3.1.1 Grassland area

The studied grassland was the open-spaced area fallowed for 20 years. The dominant species of plants had been cogon grass of proximate 1 m height due to the soil composition of clay loam and sandy loam and some disturbance, such as burning and clear-cutting.

3.1.2 Reforestation area

The study plot was grassland as described in 3.1.1, but it has been managed to cultivate dry dipterocarp seedlings for reforestation purpose since 2010. The seedling was about 3 years old of mixed dry dipterocarp species with 1 m height and 2 m spacing. The seedling was irrigated weekly during the first year and the plots were cleared by mowing every 3 months. There was some cogon grass of approximately 0.5 m height between seedling and siam weed (*Chromolaena odorata*) approximately.

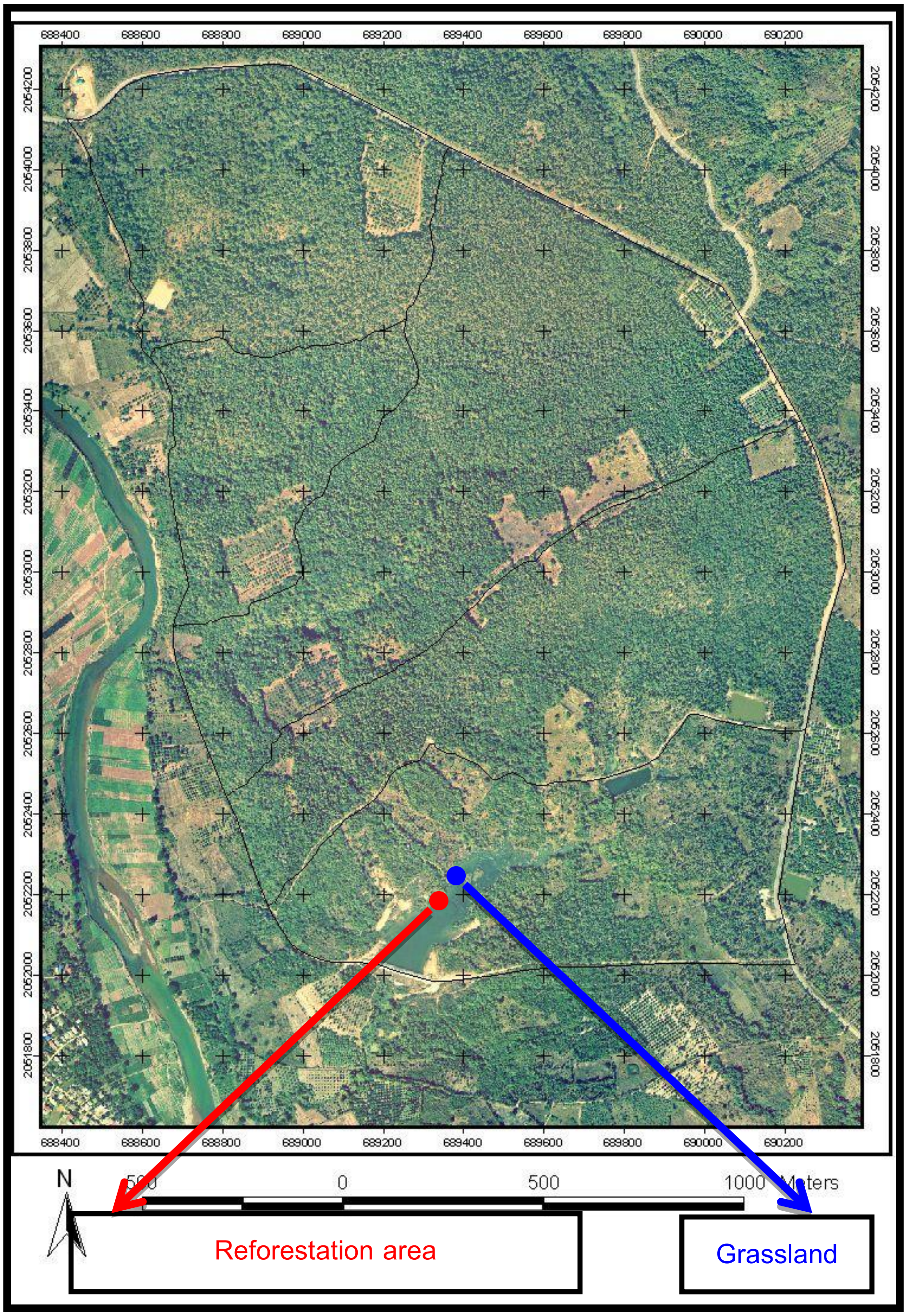

Figure 3.3 The study site map in Lai Nan subdistrict, Wiang Sa district, Nan province of Thailand, depicting the two study habitats in 2010-2011; grassland and reforestation area

3.2 Ant Collections

The two study habitats were grassland and reforestation area. A permanent plot of 30 x 30 m^2 was designated inside the 50 x 50 m^2. Each permanent plot (30 x 30 m^2) was divided into four quadrats of 15 x 15 m^2 and each quadrats was sub-divided into nine plots of 5 x 5 m^2. Each habitat was conducted sampling every month from June 2010 to June 2011 covering wet season (May - November) and dry season (December - April). The wet and dry seasons of this study were determined by the humidity, soil temperature, and soil moisture in each month. In order to thoroughly survey the ant diversity, six collecting methods were conducted in both grassland and reforestation area monthly for 13 months. The six collecting methods were 1) hand capture with constant time to comprehensively collect most ants species, 2) sugar baiting to estimate composition and richness of herbivorous ants, 3) protein baiting to estimate composition and richness of carnivorous ants, 4) pitfall trapping to estimate the abundance and species composition of active on the soil surface, 5) leaf litter sifting to collect ants in the leaf litter on soil surface, and 6) soil sifting to collect underground ants in soil (Agosti et al. 2000, Bestemeyer et al. 2000, Krebs 1999, Greenslade 1972, Mutafa et al., 2011, Torchote et al. 2010).

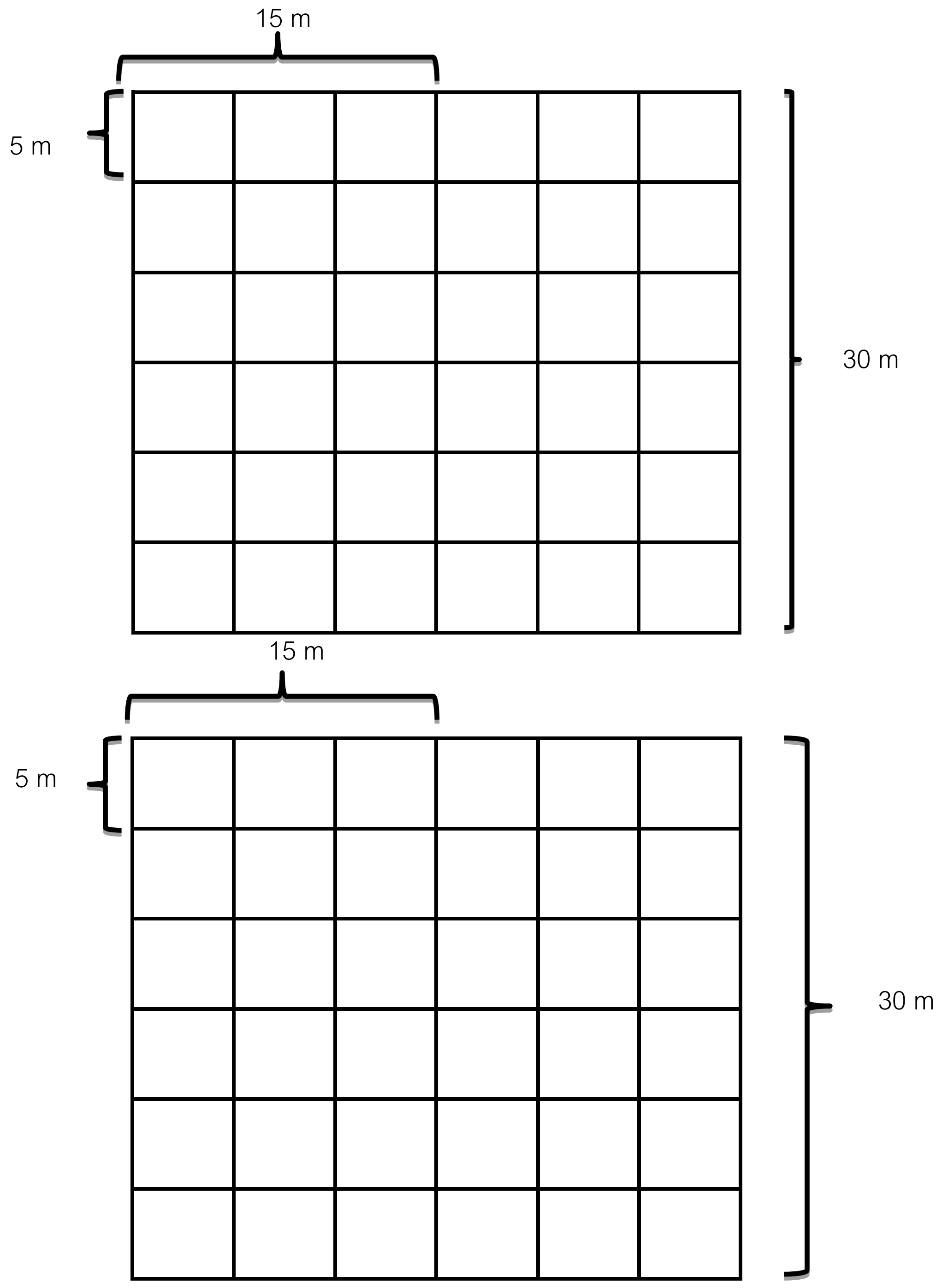

Figure 3.4 The picture showed the pattern of study habitats in both A. grassland and B. reforestation area

3.2.1 Handing capture with constant time

One person collected ants for approximately 3 hours to cover each of permanent plots. The collector walked in back and forth pattern along the edge of twelve (5 x 15 m^2) strips in the permanent plot (figure 3.4). The ants in each habitat were collected in two alternating time periods, in the morning and in the afternoon. The ants were extensively searched for on the bare ground, in the leaf litter, under stones, in decaying logs and under, and on shrubs and from bases up to 1.5 m. on trees. The ants were collected using forceps and gathered into a plastic vial filled with 70% ethyl alcohol. Each vial was labeled according to its habitat, collecting method, and collecting date.

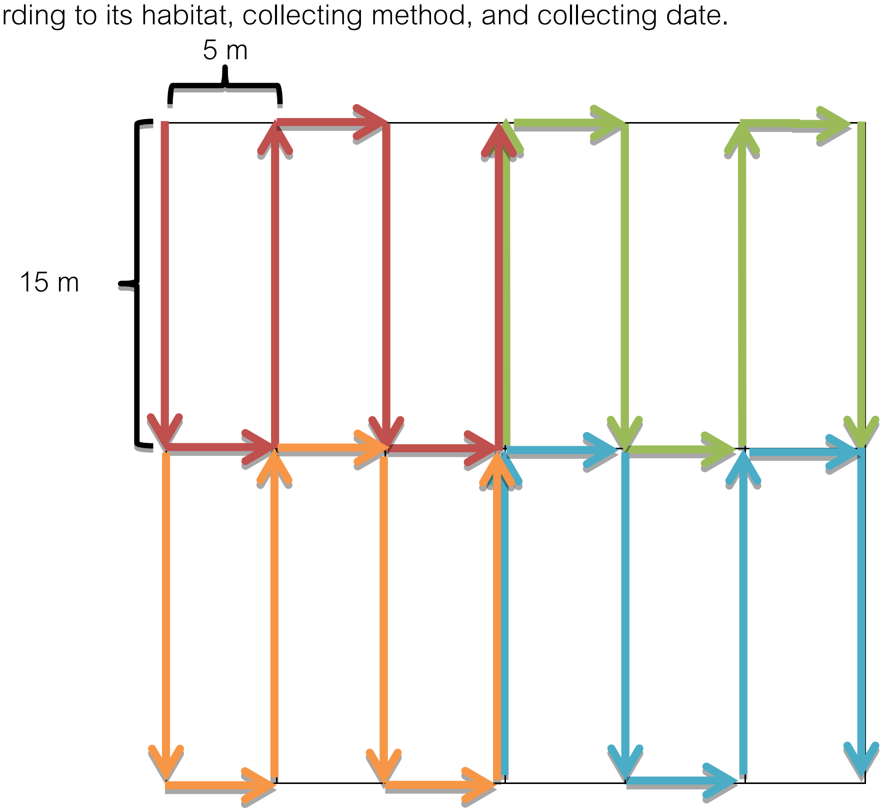

Figure 3.5 The picture showed the direction of walked in each plot in two study habitats within both A. grassland and B. reforestation area

3.2.2 Sugar baiting trap

Two grams of sugar solution (13%, 2 ml) were placed on the center of a piece of cotton cloth to use as a baited. The baited cloth was placed in the middle of each thirty six 5x5 m^2 plots in each permanent plot, and then ants on the cloth were collected after 15 minutes. The ants found in each bait were collected into a plastic vial filled with 70% ethyl alcohol. Each vial was labeled according to its plot, habitat, collecting method, and collecting date. In total, there were 36 baits per each study habitat and the baited samplings had been conducted once every month for 13 months.

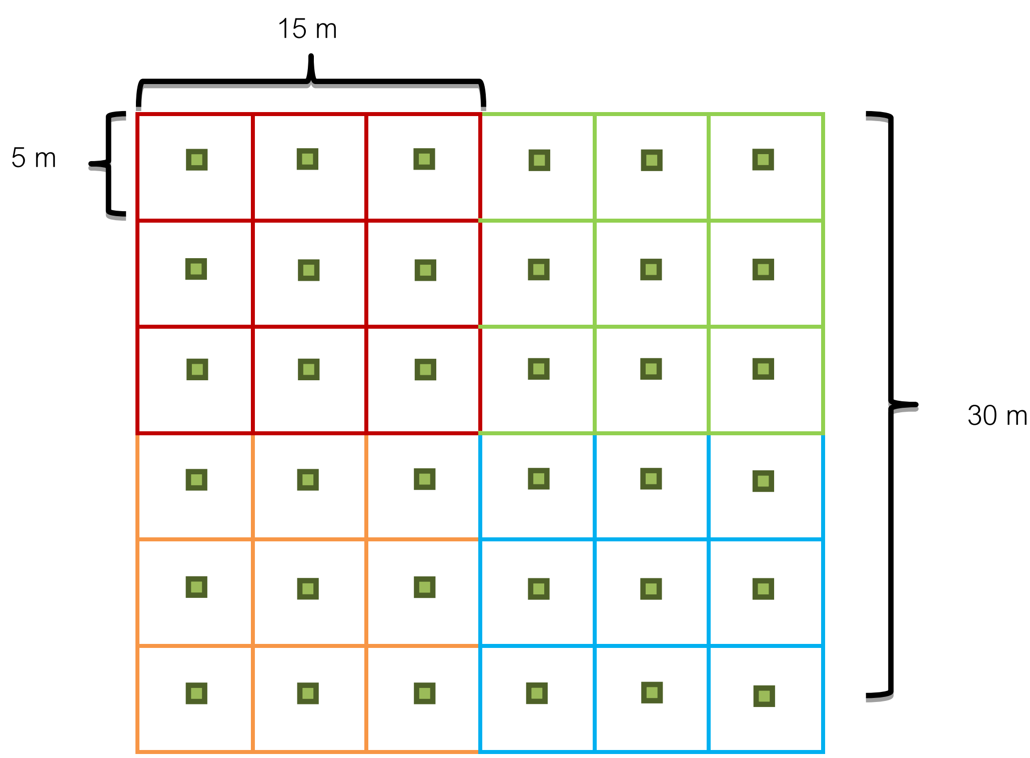

Figure 3.6 The picture showed the pattern of sugar baiting trap in two study habitats within both A. grassland and B. reforestation area

3.2.3 Protein baiting trap

Two grams of canned tuna fish were placed on the center of a piece of cotton cloth to use as a baited. The baited cloth was placed in the middle of each thirty-six 5x5 m^2 plots in each permanent plot, and then ants on the cloth were collected after 15 minutes. The ants found in each bait were collected into a plastic vial filled with 70% ethyl alcohol. Each vial was labeled according to its plot, habitat, collecting method, and collecting date. In total, there were 36 baits per each study habitat and the baited samplings had been conducted once every month for 13 months.

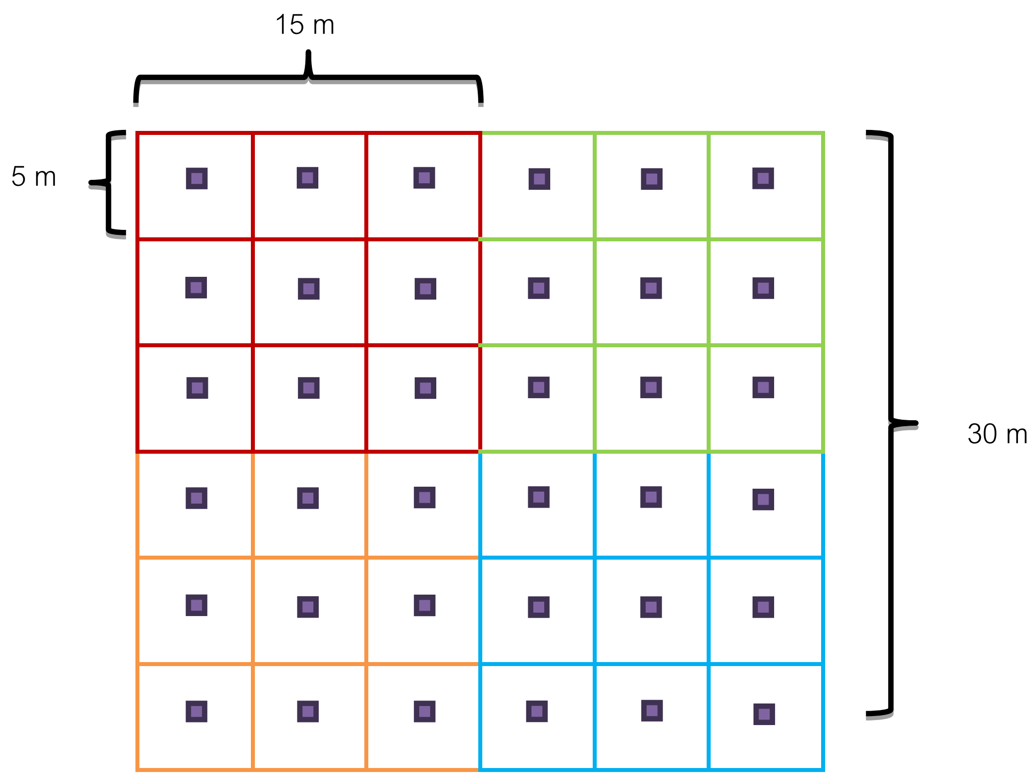

Figure 3.7 The picture showed the pattern of protein baiting trap in two study habitats within both A. grassland and B. reforestation area

3.2.4 Leaf litter sifting

Each permanent plot was divided into thirty-six 5x5 m^2 plots, similar to the baiting method detailed above. The leaf litter was collected from within 1x1 m^2 quadrat positioned in the center of each selected (5x5 m^2) plot. After collection, the leaf litter samples were sieved with a 0.8 x 0.8 cm^2 mesh and the ants were collected using forceps and gathered into a plastic vial filled with 70% ethyl alcohol. Each vial was labeled according to its plot, habitat, collecting method, and collecting date. In total, there were 36 baits per each study habitat and the baited samplings had been conducted once every month for 13 months.

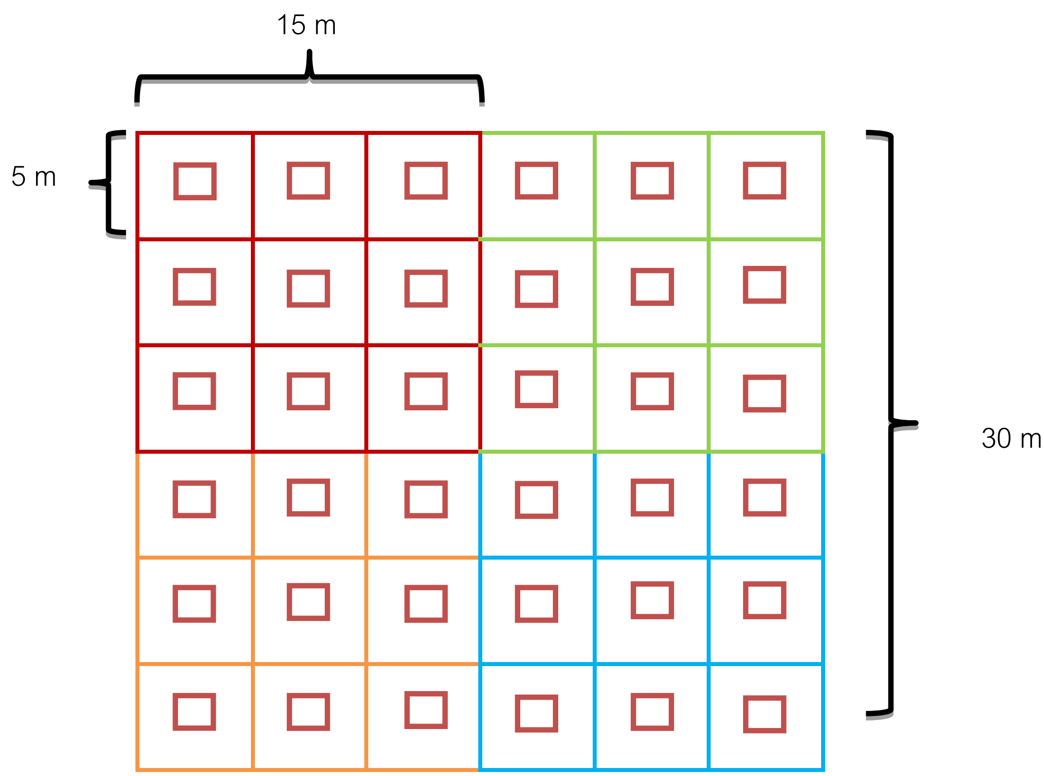

Figure 3.8 The picture showed the pattern of leaf litter sifting trap in two study habitats within both A. grassland and B. reforestation area

3.2.5 Soil sifting

The soil was sampled in the same sampling plot as the leaf litter sample (above) in each site. In the center of the leaf litter sampling quadrat, the soil was collected in an area of 25 x 25 cm^2 with 5 cm in depth from the soil surface. The soil samples were sieved with a 0.8 x 0.8 cm^2 mesh and the ants were collected using forceps and gathered into a plastic vial filled with 70% ethyl alcohol. Each vial was labeled according to its plot, habitat, collecting method, and collecting date. In total, there were 36 baits per each study site and the baited samplings had been conducted once every month for 13 months.

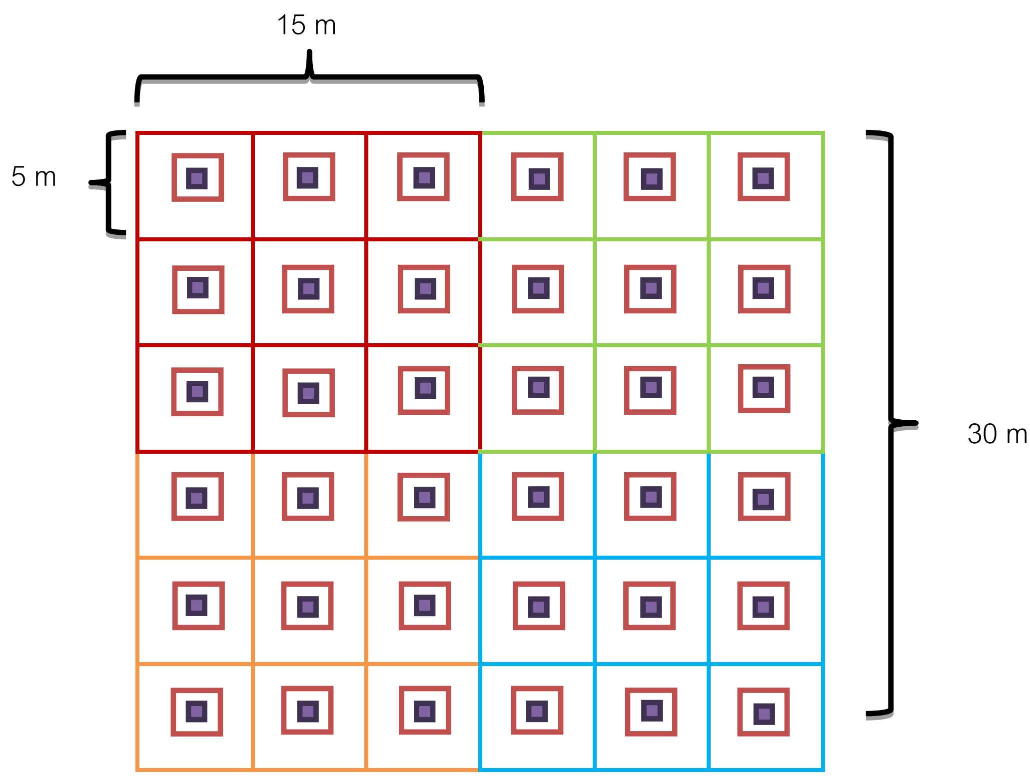

Figure 3.9 The picture showed the pattern of soil sifting trap in two study habitats within both A. grassland and B. reforestation area

3.2.6 Pitfall traps

Each permanent plot was divided into thirty-six 5x5 m^2 plots, similar to the baiting method detailed above. A hole was dug in the center of each 5x5 m^2 plot. A plastic cup (8 cm diameter x 12 cm height) was placed in a hole with the lip of the track level with the soil surface. Petroleum gel was applied around the inner lip of trap and a 2% (v/v) (alkylbenzene sulfonate Sunlight®, Unilever Thai Holding Comp) detergent solution was poured into the trap to a depth of about 2 cm. Each trap was not placed directly on any ants nest. Samples were collected after 24 hours and preserve in labeled plastic vials containing 70% ethyl alcohol. Each vial was labeled according to its plot, habitat, collecting method, and collecting date. In total, there were 36 traps per each study site and the trap samplings had been conducted once every month for 13 months

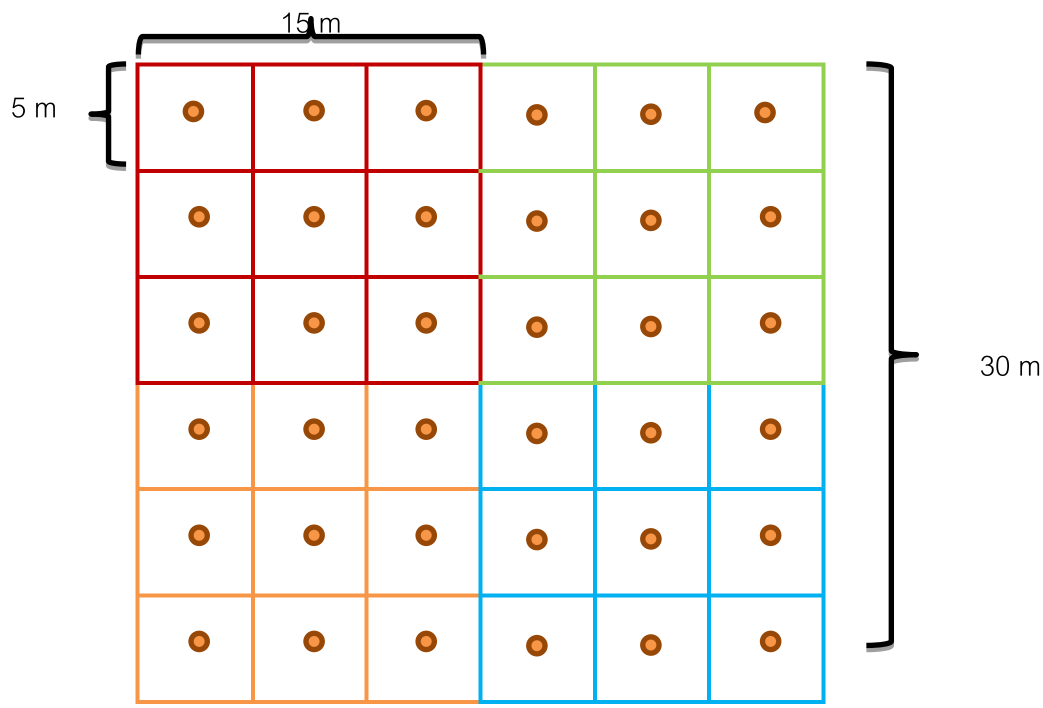

Figure 3.10 The picture showed the pattern of pitfall trap in two study habitats within both A. grassland and B. reforestation area

Figure 3.11 The picture showed six collecting methods in two study habitats: A. Hand capture with constant time, B. Sugar baiting trap, C. Protein baiting trap, D. Pitfall trap, E. Leaf litter sifting, and F. Soil sifting at Lai Nan subdistrict, Wiang Sa district, Nan province

3.3 Study of physical factors

3.3.1 Soil physical factors

Soil moisture content and soil temperature were measured for each of the soil sample collected from each sampling quardrat as the soil and leaf litter sample in each study site.

3.3.1.1 Soil moisture content (Garden et al, 2001)

Fifty grams of soil from 25x25x5 cm^3 soil sampling adjacent to soil used in 3.2.6 was dried in 105°C oven. The soil was then weighed and recorded in grams and brought back in the oven for more evaporation. The procedure was repeated every 24 hours until there were not changes into the weight of the soil. It was assumed that at this point was no water left in the soil. The percentage of soil moisture content was calculated as:

Soil moisture content (%) = $\frac{fresh\ weight\ of\ soil\ sample - dry\ weight\ of\ soil\ sample}{dry\ weight\ of\ soil\ sample} \times 100$

3.3.1.2 Soil temperature

The soil temperature was measured about 5 cm^3 depth by digital thermometer in the field.

3.3.1.3 Soil pH (Department of Biology, Faculty of Science, Chulalongkorn University, 2000)

The soil was mixed with distilled water with 2:1 (w/v) ratio. The soil suspension was left to stand for 30 minutes. The pH-indicator paper (Merck KGaA, 64271 Darmstadt, Germany) was immersed into the soil suspension and the changed color was compared with standard color.

3.3.2 Relative humidity and air temperature

The relative humidity and air temperature were measured in the same sampling quardrat as soil moisture content was measured by the digital thermo-hygrometer (THP2 supco) in the field.

3.3.3 Monthly total rainfall

The monthly total rainfall data of the study period was obtained from the meteorological station at Lai Nan subdistrict, Wiang Sa district, Nan province about 3 km from the study plot.

3.4 Ant identification

The specimens were identified to genera and species levels based on the keys by Bolton (1994), Jaitrong and Nabhitabhata (2005), and Wiwatwitthaya and Jaitrong (2001). The unidentified specimens using the above keys were then compared with reference collections at Ant Museum, Faculty of Forestry, Kasetsart University and at Museum of Zoology, Faculty of Science, Chulalongkorn University. Unidentified specimens after using keys and comparing with the reference collection were coded based on their reference collections, for example the sp. of AMK is code the ant specimen in the Ant Museum, Kasetsart University, and the sp. of CUMZ for is the code for ant specimen in the Chulalongkorn University Museum of Zoology.

3.5 Data analyses

The species richness of ants and Sorensen's similarity coefficient were calculated from all six collecting methods while the abundances of ants and remain subsequence indices were calculated from five collecting methods without hand collection because of its inherent bias cannot be used to reliably support the relative abundance of each species.

The Shannon – Weiner's species diversity index (Kreb, 1999) was used to calculate the diversity of ants collected from the five of the six collecting methods, 1) sugar baiting trap, 2) protein baiting trap, 3) pitfall trap, 4) leaf litter sifting, and 5) soil sifting. This is because hand collection with its inherent bias cannot be used to reliably support the relative abundance of each species. The formula of the Shannon – Weiner's species diversity index used is presented below:

$$H' = -\sum_{i=0}^{s}(p_i)(ln p_i)$$

Where,	H'	=	Species diversity index
	S	=	Number of species
	p_i	=	Proportion of the total sample belong to i^{th} species

The evenness index (Krebs, 1999) was calculated to determine the equal abundance of ants in each site as following:

$$Evenness = \frac{H'}{H'max}$$

Where,	H'	=	Observed index of species diversity
	H'max	=	Maximum possible index of diversity

The measurement of dominance species index (Odum, 1971) in each habitat, was calculate using the equation as following:

$$\boldsymbol{D} = \Sigma\ (p_i)^2$$

Where,	*D*	=	Index of dominance
	pi	=	proportion of the total sample belonging to i^{th} species

The Sorensen's similarity coefficient (Krebs, 1999) was used to measure the beta-diversity or similarity between two study sites as following:

$$S = \frac{2a}{2a + b + c}$$

Where,	S	=	Sorensen's similarity coefficient
	a	=	Number of species in site A and site B
	b	=	Number of species in site B but not in site A
	c	=	Number of species in site A but not in site B

CHAPTER IV

COMPARISON OF SPECIES DIVERSITY AND ABUNDANCE OF ANTS IN GRASSLAND AND REFORESTATION AREA IN LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE

4.1 Introduction

Ants play an essential role in terrestrial ecosystems, both in terms of biomass and diversity (Hölldobler & Wilson 1990, Calcalterra 2010). They are commonly used in monitoring programs and in natural areas restoration planning because of their abundance, relative easiness in sampling and in identification, and also their rapid response to changes in habitat quality (Andersen et al. 2002, Kaspari & Majer 2000). Additionally, some parameters of their community structures, such as richness and relative abundances, including functional composition are also related to the environments, making them suitable for studying biodiversity and evaluating the environmental status (Andersen et al.2002).

Requirement for expansion of plant cultivation and animal farming, invasion of natural forests, grassland and fallowed areas caused by human activities have expanded the range of direct impact on the ecosystem, organismic, and populations living in these areas. Such changes would directly affect several organisms because they are responding to the rapidly changing environment. In this study, ants species diversity were compared between grassland and reforestation area at Lai Nan subdistrict, Wiang Sa district, Nan province. Ants species compositions in both areas provide fundamental knowledge that could be utilized for agriculture, grassland management and changes in the habitat.

4.2 Materials and Methods

In each of the two difference habitats, a permanent plot of 30 x 30 m^2 was selected as a sampling area. Each study area was conducted sampling every month, from June 2010 to June 2011. Six sampling methods were used to study the species diversity of ants in each habitat as explained in Chapter III.

4.3 Results

4.3.1 Species diversity of ants between the two study habitats

The total of 34,075 individuals was collected in both study sites. These specimens were identified in 34 species (23 species and 11 morpho-species) from 22 genera in 6 subfamilies. The 30 species of ants were found in grassland and in reforestation area, 32 species of ants were found (Table 4.1).

Table 4.1 The species composition between grassland and reforestation area in six collecting methods: hand capture with constant time, pitfall trap, sugar baiting trap, protein bating trap, leaf litter sifting and soil sifting were conducted sampling every month, from June 2010 to June 2011 in Lai Nan subdistrict, Wiang Sa district, Nan province

Species composition	Grassland	Reforestation area
Subfamily Cerapachyinae		
Cerapachys sp.	✓	✓
Subfamily Dolichoderinae		
Iridomyrmex anceps (Roger, 1863)	-	✓
Tapinoma melanocephalum (Frbricius, 1793)	✓	✓
Subfamily Formicinae		
Anophlolepis gracilipes (Fr. Smith, 1857)	✓	✓
Camponotus nicobaarensis (Mayr, 1865)	✓	✓
Camponotus rufograucus (Jerdon, 1851)	✓	✓
*Camponotus Seri*ceus (Fabricius, 1775)	✓	✓
Oecophylla smaragdina (Fabricius, 1775)	✓	✓
Paratrechina longiconis (Latreille, 1802)	✓	✓
Paratrechina sp.4 of AMK	✓	✓
Plagiolepis sp.2 of AMK	✓	-
Polyrhachis proxima (Roger, 1863)	✓	✓
Subfamily Myrmicinae		
*Cardiocondyla emery*i (Forel, 1*881)*	✓	✓
Crematogaster rogenhoferi (Mayr, 1879)	✓	✓
Crematogaster sp.6 of AMK	✓	✓
Crematogaster sp.9 of AMK	✓	✓
Meranoplus bicolor (Guerin-Menerille, 1844)	✓	✓
Monomorium chinense (Santschi, 1925)	✓	✓
Monomorium destructor (Jerdon, 1851)	✓	✓
Monomorium floricola (Jerdon, 1851)	✓	✓
Monomorium pharaonis (Linnaeus, 1758)	✓	✓
Pheidole carpellinii (Emery, 1887)	✓	✓
Pheidole sp.2	✓	✓
Pheidole sp.3		✓

Table 4.1 (Continued)

Species composition	Grassland	Reforestation area
Pheidologeton affinis (Jerdon, 1851)	✓	✓
*Pheidologe*ton *diversus (Jerdon, 1851)*	✓	✓
Solenopsis geminata (Fabricius, 1804)	✓	-
Tetramorium sp.2 of AMK	✓	✓
Subfamily Ponerinae		
Hypoponera sp.	✓	✓
Leptogenys sp.1 of AMK	✓	✓
Odontoponera denticulata (Fr. Smith, 1858)	✓	✓
Pachycondyla rufipes (Jerdon, 1851)	-	✓
Pachycondyla sp.	-	✓
Subfamily Pseudomyrmecinae		
Tetraponera ruflonigra (*Jerdon, 1851)*	✓	✓
Species Richness	30	32

Four ants species were found only in reforestation area; *Iridomyrmex anceps*, *Pheidolole* sp.3, *Pachycondyla rufipes* and *Pachycondyla* sp. Two ant species were found only in grassland, *Plagiolepis proxima* and *Solenopsis geminata*. The remaining 28 ant species were commonly found in both grassland and reforestation area (Figure 4.1).

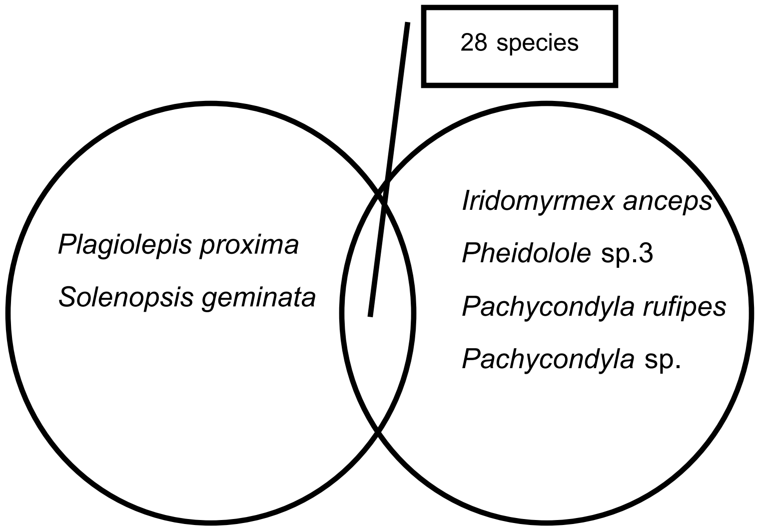

Figure 4.1 The pie chart showed ant species found in the two study habitats, grassland and reforestation areas at Lai Nan subdistrict, Wiang Sa district, Nan province

4.3.2 The ant genera between the two study habitats

As shown in Table 4.2, these collected ants belong to six subfamilies; Cerapachyinae, Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. The Myrmicinae was the subfamily with the highest number of ants species and similarity in grassland and reforestation area (15 species). In grassland, the ants found belonged to subfamilies Formicinae (9 species), followed by Ponerinae (3 species), Cerapachyinae, Dolichoderinae and Pseudomyrmicinae (1 species), comparably, subfamilies Formicinae (8 species), Ponerinae (5 species), Dolichoderinae (2 species), Cerapachyinae and Pseudomyrmicinae (1 species) were found in grassland (Table 4.2) (Figure 4.2).

Table 4.2 The subfamily, genera and number of species in two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province.

Subfamily	Genera	Number of Species	
		Grassland	Reforestation area
Cerapachyinae	*Cerapachys*	1	1
	Total	**1**	**1**
Dolichoderinae	*Iridomyrmex*	0	1
	Tapinoma	1	1
	Total	**1**	**2**
Formicinae	*Anopholepis*	1	1
	Camponotus	3	3
	Oecophylla	1	1
	Paratechina	2	2
	Plagiolepis	1	0
	Polyrhachis	1	1
	Total	**9**	**8**
Myrmicinae	*Cardiocondyla*	1	1
	Crematogaster	3	3
	Meranoplus	1	1
	Monomorium	4	4
	Pheidole	2	3
	Pheidologeton	2	2
	Solenopsis	1	0
	Tetramorium	1	1
	Total	**15**	**15**

Table 4.2 (Continue)

Subfamily	Genera	Number of Species	
		Grassland	Reforestation area
Ponerinae	*Hypoponera*	1	1
	Leptogenys	1	1
	Odontoponera	1	1
	Pachycondyla	0	2
	Total	**3**	**5**
Pseudomyrmecinae	*Tetraponera*	1	1
	Total	**1**	**1**
Total	**22**	**30**	**32**

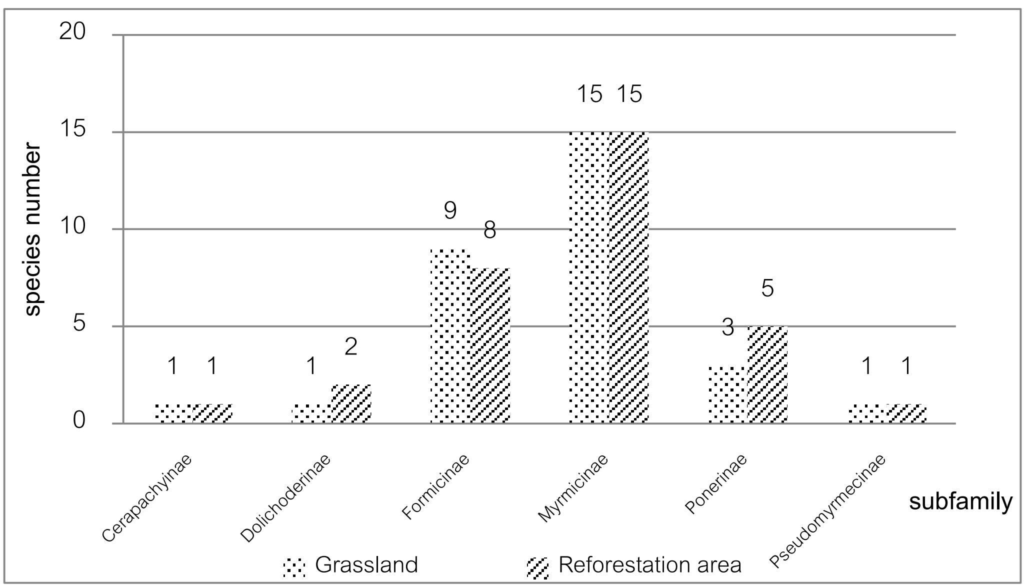

Figure 4.2 The ant species number in each subfamily among the two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province

The number of ants subfamilies and the number of ants genera were similar in the grassland and a reforestation area (6 subfamilies, 20 genera). With respect to the comparative ant communities between the two study habitats, the species richness in a reforestation area (32 species) was higher than grassland (30 species) (Table 4.3).

Table 4.3 The total number of subfamilies, genera, and species richness of the ants in the grassland and reforestation area at Lai Nan subdistrict, Wiang Sa district, Nan province.

Study sites	Subfamilies	Genera	Species richness
Grassland	6	20	30
Reforestation area	6	20	32

The highest percentage of ants species numbers in grassland was Myrmicinae (50.00%), followed by Formicinae (30.00%) and Ponerinae (10.00%), whereas the rest subfamilies were lower than 5% (Figure 4.3). The highest percentage of the ant species number in reforestation area was Myrmicinae (46.88%), followed by Formicinae (25.00%) and Ponerinae (15.63%), whereas the rest were lower than 7% (Figure 4.4).

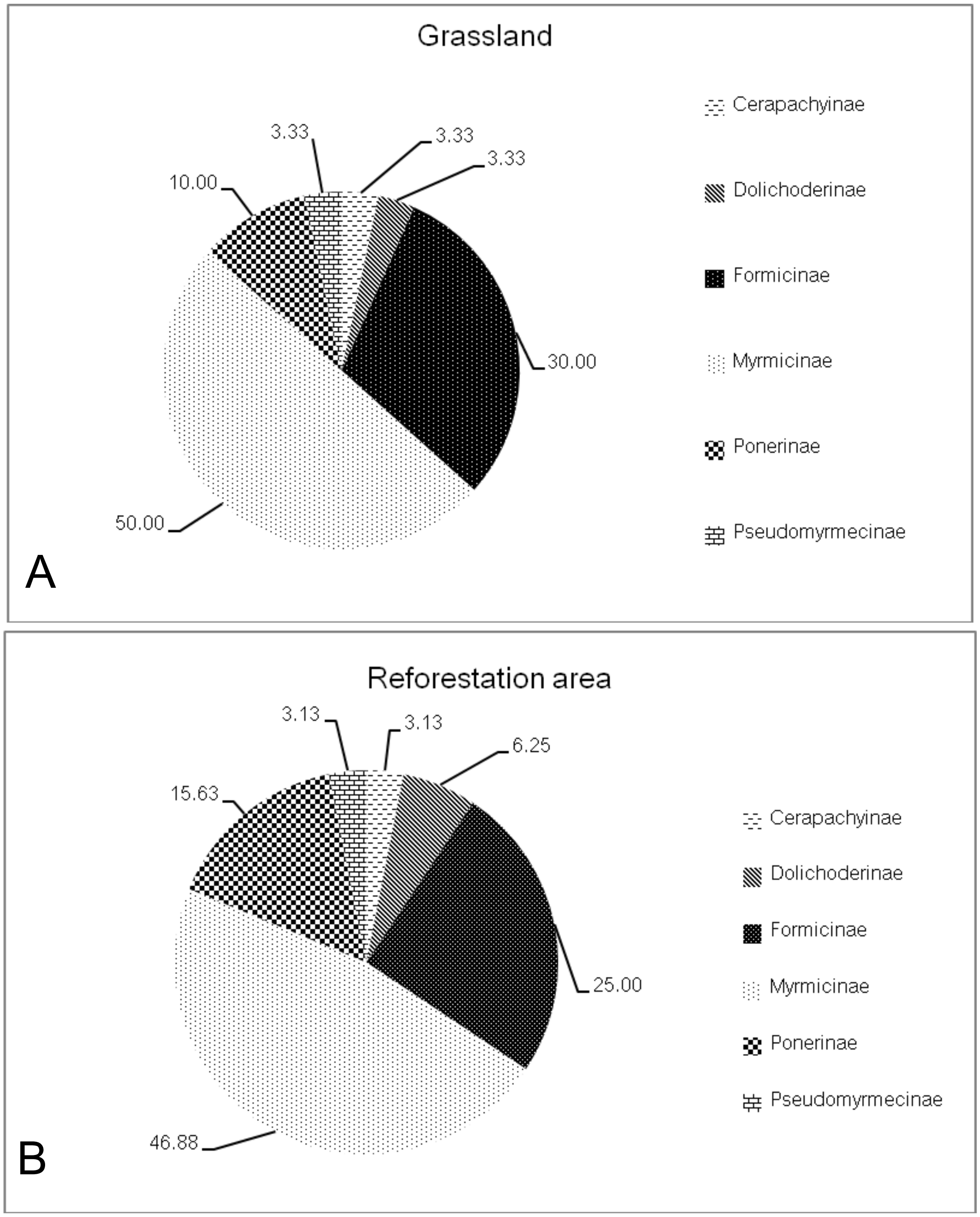

Figure 4.3 The pie chart showed the proportion of ants in each subfamily found in grassland (A) and reforestation area (B) at Lai Nan subdistrict, Wiang Sa district, Nan province

4.3.3 Species diversity index among the two study habitats

The Shannon – Weiner's species diversity indicated that the year around diversity in a reforestation area (0.65) was higher than grassland (0.62). The evenness index of ants in a reforestation area (0.19) was higher than grassland (0.18). The mean of species diversity index of 13 months in reforestation area (0.54±0.39) was not significantly different (*t*-test = 0.729, df = 24, $p \leq 0.05$) from in grassland (0.52±0.32). The Sorensen's similarity coefficient was high at 0.92 between the grassland and reforestation area (Table 5.4).

Table 4.4 Indices of ant diversity from the two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province.

Study site	H'	Mean±SE	Dominance	Evenness	Sorensen's
Grassland	0.62	0.52±0.32	0.04	0.18	0.92
Reforestation area	0.65	0.54±0.39	0.06	0.19	

* The Sorensen's similarity coefficient of 0.92

* Mean±SE was the mean of species diversity index of 13 months

4.3.4 The abundance of important ants between the two study habitats

The most abundance of ants was *Pheidologeton diversus* in both study habitats. *P.diversus* in a reforestation area (7,516 individuals) was higher than grassland (6,426 individuals). The second most abundant in grassland was *Oecophylla smaragdina* (1,835 individuals) and in reforestation was *Pheidologeton affinis* (2,239 individuals) (Figure 4.3).

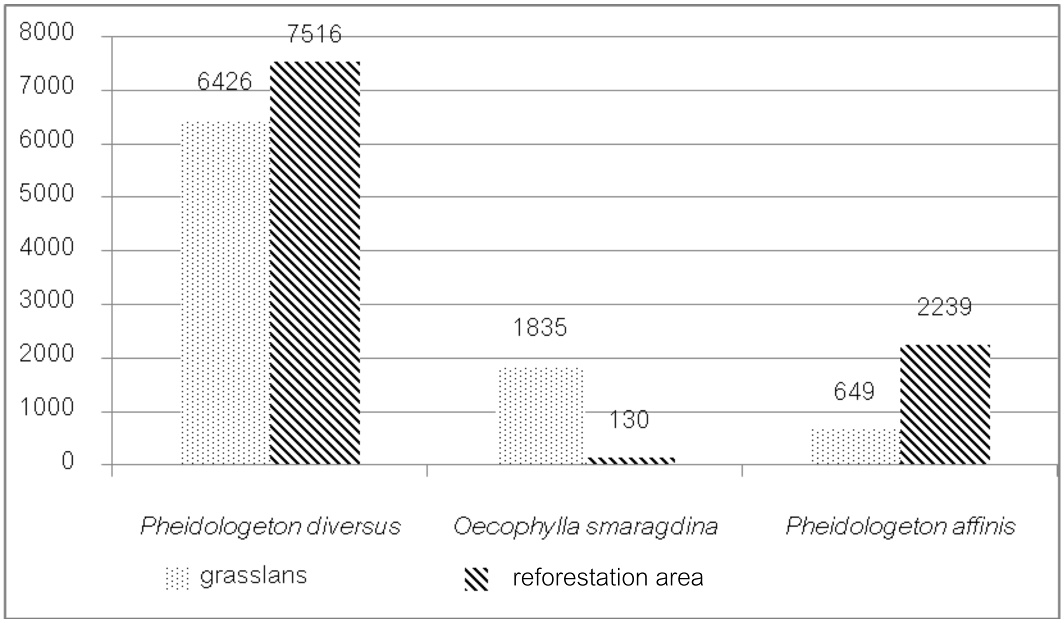

Figure 4.4 The graph show the most abundant ants were found in the two study habitats (grassland and reforestation area).

4.4 Discussion

The overall of 28 ants species were found in both study habitats reflecting their broad range of microhabitats. Two ants species found only in grassland, *Plagiolepis* sp.2 of AMK, and *Solenopsis geminata*, have underground nests and a ground surface foraging behavior. The grassland has an open-spaced area and mixed of sandy loam which may facilitate the two unique species that may prefer clay loam to build underground nests than the homogenous sandy loam in a reforestation area. Four ants species were only found in a reforestation area because these species are capable of nest underground building, under litter, and indeed branches which were more available in a reforestation area than in grassland. Moreover, reforestation area may have high availability of food, both carbohydrates and proteins due to its open-space leading to cases of foraging by several ants.

Pheidologeton diversus was the most abundant ant in grassland and reforestation area because this species was commonly found in a wide range of habitat and its colonies nesting site was generally moist soil. Another possible reason, *P. diversus* usually forms large colonies containing a large number of workers and were found all year around often found in soil or under rocks (Torchote, 2008). *P. diversus* regularly forms long columns for foraging on small animals and nectar. They can be easily collected by either hand collecting, pitfall trapping and particularly by both protein and sugar baitings. *Oecophylla smaragdina* (weaver ants) was the second most abundant ant in grassland because they also forage on small animals and nectar as *P. diversus* , but they build their nest on trees using living leaves. So their nesting sites were limited in grassland of forms long columns for foraging and found a specific microhabitat. Therefore, weaver ants foraged in grassland came from colonies nesting in adjacent forest, and they were less abundant than *P. diversus*. Moreover, these two ant species were mutually exclusive probably due to their food range comparison and their aggressiveness. However, *P. affinis* was commonly found together with the *P. diversus* because their similarity foraging behavior and nesting sites, but *P. affinis* was less than *P. diversus,* so *P. affinis* may not out-complete with the most abundant *P. diversus.* Moreover, both *P. diversus* and *P. affinis* were more abundant in a reforestation area than *Oecophylla smaragdina*. Reforestation area had a high leaf litter on the ground which was the preferred habitat for *Pheidologeton* spp. The reduction in member of *Pheidologeton* spp. found in grassland may be because of the low leaf litter character of the area whereas their character is suitable for and supports the available niche for *O. smaragdina*.

In the future, relative high diversity in a reforestation area should be observed because of the increase diversity in plant communities and increasing microhabitat, such as canopy cover and leaf litter. The leaf litter, soil moisture content and leaf litter biomass have been reported to increase ant diversity (Bourmas 2005 and Hasin 2008). The difference in leaf litter biomass in each habitat type was affected to the soil fauna that was the food source of ants (Bourmas, 2005). Moreover, the variation of microhabitats such as leaf litter and under stones in the grassland and a reforestation area affected on the numbers of ants. Some species, *Cerapachys* sp., *Iridomyrmex anceps.*, and *Pachycondyla* sp*.,* were found only in a reforestation area, but not in grassland, because these lives in specific habitats, such as under the decayed log and leaf litter. The varying in habitats types and food sources affected to the species diversity of ants (Anderson, 2000).

From Figure 4.3, the proportion of subfamilies corresponds to properties reported by the study of Wiwatwitthaya and Rojanawongse (2001), Phoonjumpa (2002), Suriyapong (2003), Bourmas (2005), Hasin (2008) and Torchote (2008), which found that the Myrmicinae was the most diverse subfamiliy, followed by Formicinae and Ponerinae, respectively. This is because Myrmicinae is a largest subfamily of ants in the world found in all major habitats (Hölldobler and Wilson, 1990, Bolton, 1990).

Cerapachyinae and Pseudomyrmicinae were less common than the other subfamilies because the groups have to live in some specific habitats and were reported only 2 genera in Thailand (Wiwatwittaya and Jaitrong, 2001). *Cerapachys* sp. was found nesting only in the leaf litter and forage as generalist predators. Moreover, the species have limited number of workers, so it was rarely collected (Wiwatwittaya and Jaitrong, 2001; Hasin, 2008), *Tetraponera* sp. was found nesting in the twig and plant cavity and forage on the ground (Wiwatwittaya and Jaitrong, 2001), so it was rarely collected in grassland or a reforestation area which had none of mature trees to provide communities. From the result, the measure of ants in species richness and diversity indices were not different because of the space between the two study sites, which were not far away, around 200 m with the similarity index were 0.92.

CHAPTER V

SPECIES DIVERSITY OF ANTS BETWEEN THE WET AND THE DRY SEASONS iN GRASSLAND AND REFORESTATION AREA

5.1 Introduction

Seasonality in Thailand can be differentiated by temperature and relative humidity, and it can be separated into three distinct seasons, rainy, winter, and summer. Variation of seasonal changes in several factors, such as temperature, rainfall, relative humidity, and soil temperature, can affect diversity and the composition of several organisms. Rainfall can influence tropical insects in various ways, such as causes physical damage from heavy rain, increasing livelihood of contracting diseases by increasing microclimatic humidity, and increasing water loss by evaporative cooling (Speight and Wylie, 2001). Ants have been adapted to the changing environment. The temperature, humidity and rainfall were the physical factors positively and negatively affecting to the ants population in the ecosystem. Consequently, these factors also affect on the energy flow in ecosystems, which the ants response to the movement from one place to another place (Hölldobler and Wilson, 1990).

Therefore, this chapter will be discussed on the different ants species composition among seasons in the two study habitats which may show different response in ants species diversity according to the land use types. However, this study used two seasons as the wet and the dry seasons defined by the total rainfall in each month. The months which had the total rainfall higher than 100 mm were designated as the wet/rainy season (Whitmore, 1975). This study provides the basic knowledge about the effects of the seasons on the change of ants species diversity in the different habitat types.

5.2 Materials and Methods

5.2.1 Sampling methods

In each of the two study habitats, a permanent plot of 30 x 30 m^2 was selected as a sampling area. Ants in each study area were sampled monthly from June 2010 to June 2011 which was divided into wet season (May to November) and dry season (December to April). Six sampling methods were used to study the species diversity of ants in each habitat as explained in Chapter III.

5.2.2 Study of physical factors

The physical factors were measured in each habitat as explained in Chapter III.

5.3 Results

5.3.1 The determination between the wet and the dry seasons

The rainy season in this study was from May to September and the dry season was from October to April (Figure 5.1). In the Figure 5.1, the rainfall in March 2011 was unusually higher than the other months in the dry season compared to March 2010. From the retroat data of Meteorological Department in 2005 -2010, the rainy season in total rainfall within the period 8 years ago were more 100 mm/month but if the total rainfall less than 100 mm/month was dry season (whitemore, 2002). In 2010, it was different another year because in March 2010 had a total rainfall more than 100 mm/month. So, we were divided 8 years ago which in March was the dry season.

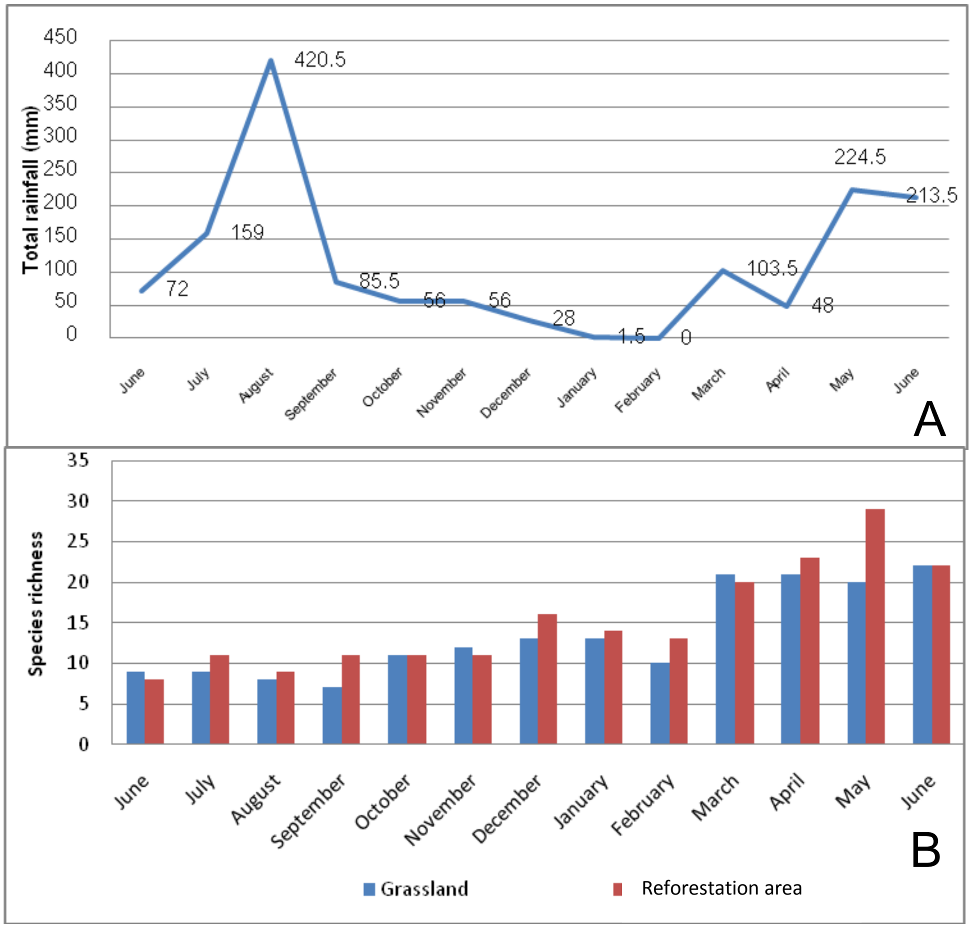

Figure 5.1 The total rainfall (mm) of each month, A the total rainfall from June 2009 to June 2010 and the total rainfall from June 2010 to June 2011, B the seasonal variation of species richness of ants in each month from June 2010 to June 2011 in the two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province

5.3.2 Comparisons of environmental factors between the wet and the dry seasons in the two study habitats

The air temperature (*t*-test = 0.031, df = 11, $p \leq 0.05$), soil temperature (*t*-test = 0.001, df = 11, $p \leq 0.05$) and soil moisture content (*t*-test = 0.033, df = 11, $p \leq 0.05$) in grassland were significantly different between the wet and the dry seasons, while the relative humidity (*t*-test = 0.303, df = 11, $p \leq 0.05$) was not significantly different between the two different seasons. The air temperature (*t*-test = 0.021, df = 11, $p \leq 0.05$), soil temperature (*t*-test = 0.021, df = 11, $p \leq 0.05$) and soil moisture content (*t*-test = 0.013, df = 11, $p \leq 0.05$) in a reforestation area were significantly different between the wet and the dry seasons, while the relative humidity (*t*-test = 0.202, df = 11, $p \leq 0.05$) was not significantly different between the two seasons (Table 5.1).

Table 5.1 The mean of environmental factors between the wet season (May to November) and the dry season (December to April) in each study habitat (by Independent *t* - test at p $\leq$ 0.05) at Lai Nan subdistrict, Wiang Sa district, Nan province

Environmental factors	Seasons	Grassland (mean±SE)	Reforestation area (mean±SE)
Relative humidity (%)	Wet	48.90±5.47[a]*	51.54±2.53[a]*
	Dry	41.31±4.52[a]*	45.07±3.84[a]*
Air temperature (°c)	Wet	36.23±0.44[a]	35.89±1.18[a]
	Dry	33.50±0.95[b]	31.73±1.02[b]
Soil temperature (°c)	Wet	31.16±0.68[a]	35.89±1.18[a]
	Dry	24.48±1.22[b]	31.73±1.02[b]
Soil moisture content (%)	Wet	13.69±2.11[a]	10.89±1.57[a]
	Dry	6.77±1.92[b]	4.79±1.36[b]

* Similarly the letters mean no significant difference between the two seasons in each habitat.

5.3.3 The species diversity between the wet and the dry seasons in each study

The highest ant species richness was found in the reforestation area, in the wet season (31 species), followed by the dry season in grassland (27 species) and the lowest species richness was similar in the wet season in grassland and the dry season in a reforestation area (26 species) (Figure 5.2). The species diversity index was highest in wet and dry seasons in the reforestation area (0.67), followed by the dry season in grassland (0.60) and lowest in the wet season in the grassland (0.57), respectively. Evenness index was higher in the dry seasons in the reforestation area (0.21), followed by the wet season in a reforestation area (0.20), and lowest in both wet and dry seasons in the grassland were similar (0.17) (Figure 5.2).

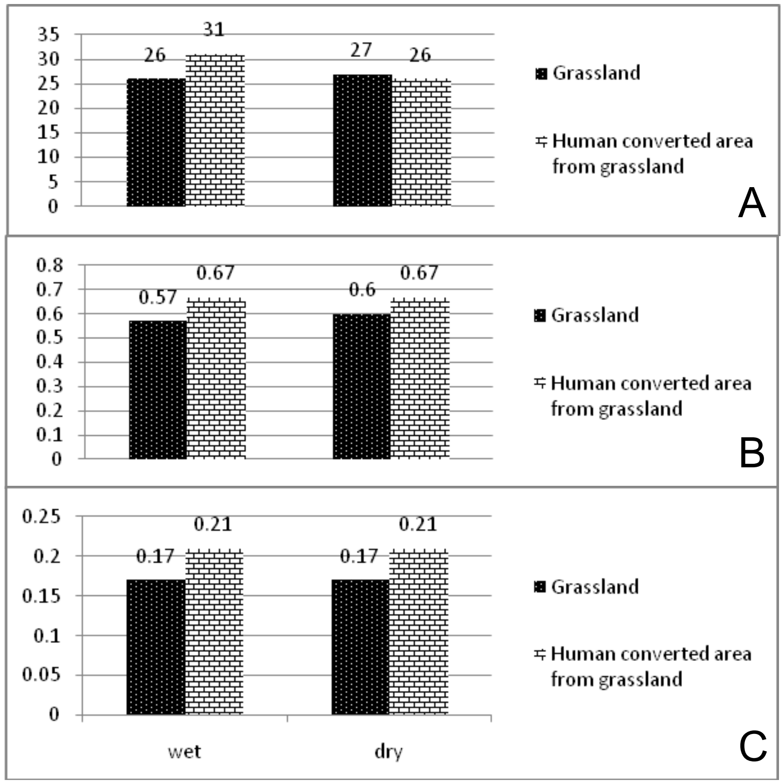

Figure 5.2 A. the species richness, B. species diversity index, C. evenness index, between the wet and the dry seasons in two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province

Additionally, the Shannon Weiner index of ants between seasons in the two study habitats has increased from June 2010 (Figure 5.3). In Figure 5.3, the total collecting ants in 13 months were increased. Therefore, if the collecting data had done for more time, the ant species richness will be increased until reaches to the equilibrium level of the diversity of ant.

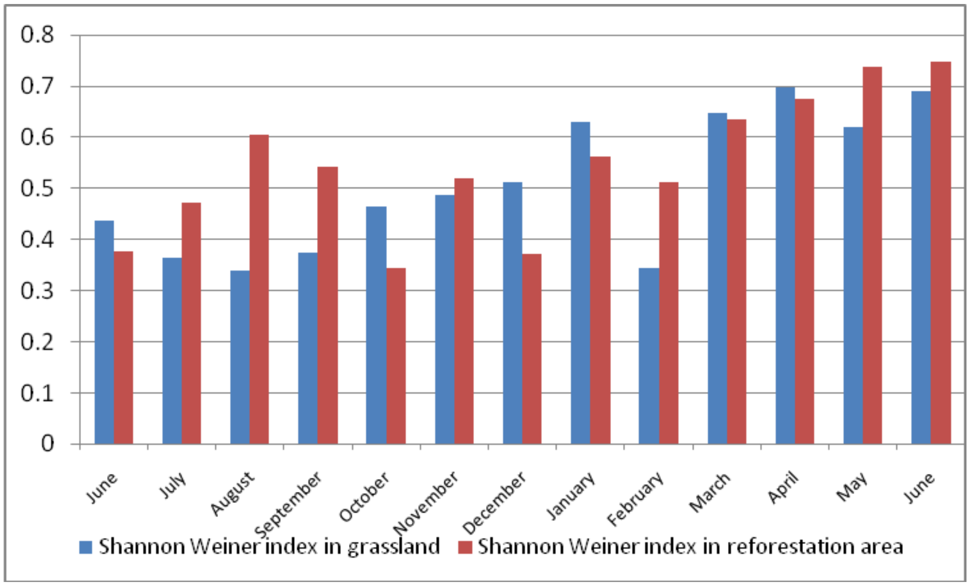

Figure 5.3 The Shannon Weiner index of ant species in each month from June 2010 to June 2011 in the two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province

5.3.4 The species similarity between seasons in each study site

The Sorensen's similarity coefficient was used to indicate the species similarity between the wet season and the dry season in each habitat. In grassland, the Sorensen's similarity coefficient between each habitat and each season were ranging from 0.84-0.91. The highest similarity coefficient was between the dry season in grassland and the wet season in reforestation area (0.91), followed by between the wet and dry seasons in reforestation area (0.90). The similarity coefficient was similar in between wet and dry seasons in grassland, and between the dry seasons in grassland and reforestation area (0.89), and between wet season in both areas (0.85), respectively. The lowest similarity was between the wet season in grassland and the dry season in reforestation area (0.84). The Sorensen's similarity coefficient of ants was a period 0.84 – 0.91 which nearby between the wet and the dry seasons in two study habitats at Lai Nan subdistrict.

5.3.5 Presence of ants between the wet and the dry seasons in each study site

There were 17 common ants species, such as *Anopholepis gracilipes, Camponotus nicobarensis, Camponotus rufoglacus,* and *Oecophylla smaragdina*, were commonly found in both the wet and the dry seasons and in all habitats as shown in Table 5.3. The ant species were found only in wet season in grasslanad, *Plagiolepis* sp.4 of AMK, and *Solenopsis geminata*. The ant species was only found wet season in reforestation area, *Pachycondyla rufipes*. The ant species were found only dry season in reforestation area, *Iriomyrmex ancep*. and *Pachycondyla* sp. The wet season in both areas, *Crematogaster rogenhoferi*, *Crematogaster* sp.6 of AMK, *Crematogaster* sp.9 of AMK and *Hyponera* sp. were found *Tetraponera ruflonigra* was the only ant species found in the dry season in both habitats of grassland and in reforestation area (Table 5.3). From the total collecting methods in six methods, hand collecting method was the best in the diversity of ant, the second method, both baiting trap and pitfall trap were bias but we could be found nearly diversity of ant in study habitats. The method which less found but specific were leaf litter sifting and soil sifting, because the most ants in the two methods lived and built their nest in soil (Table 5.3.).

Table 5.2 Species composition in the wet and the dry seasons between grassland and reforestation area in all collecting methods; sugar baiting trap (S), protein baiting trap (Pr), hand constant time (H), leaf litter sifting (L), and soil sifting (So) at Lai Nan subdistrict, Wiang Sa district, Nan province

Species composition	Grassland												Human											
	wet						dry						wet						dry					
	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So
Subfamily Cerapachyinae																								
Cerapachys sp.				+									+			+	+							
Subfamily Dolichoderinae																								
Iridomyrmex anceps (Roger, 1863)																	+							+
Tapinoma melanocephalum (Frbricius, 1793)		+	+	+			+	+	+	+	+		+	+	+		+							
Subfamily Formicinae																								
Anophlolepis gracilipes (Fr. Smith, 1857)	+	+	+	+	+		+	+	+	+			+	+	+	+	+		+	+	+	+		+
Camponotus nicobaarensis (Mayr, 1865)	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+
Camponotus rufograucus (Jerdon, 1851)	+	+	+	+				+					+	+	+	+				+				
Camponotus Sericeus (Fabricius, 1775)	+			+									+			+				+				
Oecophylla smaragdina (Fabricius, 1775)	+	+	+	+	+		+	+	+	+			+	+	+	+			+	+	+	+		
Paratrechina longiconis (Latreille, 1802)	+	+		+			+	+		+			+	+		+			+	+		+		
Paratrechina sp.4 of AMK	+	+		+			+	+		+			+	+		+			+	+		+		
Plagiolepis sp.2 of AMK				+																				
Polyrhachis proxima (Roger, 1863)								+					+	+		+								

Table 5.2 (Continued)

Species composition	Grassland												Human											
	wet						dry						wet						dry					
	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So
Subfamily Myrmicinae																								
Cardiocondyla emeryi (Forel, 1*881)*	+																		+	+		+		
Crematogaster rogenhoferi (Mayr, 1879)	+	+	+	+	+								+	+	+	+	+	+						
Crematogaster sp.6 of AMK				+									+	+	+	+	+							
Crematogaster sp.9 of AMK	+			+												+								
Meranoplus bicolor (Guerin-Menerille, 1844)	+	+					+	+					+	+		+		+	+					
Monomorium chinense (Santschi, 1925)	+	+			+		+	+					+	+		+		+	+					+
Monomorium destructor (Jerdon, 1851)	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+		
Monomorium floricola (Jerdon, 1851)	+	+						+	+				+	+					+	+				
Monomorium pharaonis (Linnaeus, 1758)	+	+	+	+	+	+		+	+				+	+	+	+	+	+	+	+				
Pheidole carpellinii (Emery, 1887)	+	+						+					+	+					+					
Pheidole sp.2	+	+						+					+	+					+					

Table 5.2 (Continued)

Species composition	Grassland												Human											
	wet						dry						wet						dry					
	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So	S	Pr	H	P	L	So
Pheidole sp.3	+	+						+					+	+					+					
Pheidologeton affinis (Jerdon, 1851)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pheidologeton diversus (Jerdon, 1851)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Solenopsis geminata (Febricius, 1804)				+																				
Tetramorium sp.2 of AMK											+												+	
Subfamily Ponerinae																								
Hypoponera sp.	+													+										
Leptogenys sp.1 of AMK	+	+	+	+				+	+	+			+	+	+	+								
Odontoponera denticulata (Fr. Smith, 1858)	+	+	+	+	+		+	+	+	+			+	+	+	+			+	+	+	+		
Pachycondyla rufipes (Jerdon, 1851)														+		+								
Subfamily Ponerinae																								
Pachycondyla sp.																							+	
Subfamily Pseudomyrmecinae																								
Tetraponera ruflonigra (Jerdon, 1851)		+						+						+										

5.4 Discussion

The species richness (31 species) and diversity index (0.67) were the highest in the wet season in a reforestation area because the study habitat might have more nest sites availability from more abundant leaf litter that could support a certain group of ants, Generalized Myrmicinae. Moreover, the food supplies were also an important factor. Food availability was an obviously critical determinant of the species distributions with specialized diets, such as seed harvesters and specialist predators (Andersen, 2000). Only one out of four Specialist Predators, *Pachycondyla rufipes* was only found in the wet season in a reforestation area. The dry season in both sites had a low leaf litter and soil moisture content with high temperature. These conditions were not suitable for ants and their preys, so lower ants species were found. In the wet season, leaf litter and soil moisture contents were high. The condition was suitable for many soil faunas which were preyed by ants (Torchote, 2008).

The wet season in a reforestation area (31 species) had a higher species richness than the wet season in grassland (26 species) because the wet season in a reforestation area had more food sources than grassland. Several food sources, such as insects and other arthropods, were more abundant in open ground in reforestation area and these food sources provide a suitable niche for Specialists Predators. Thus, the species richness in reforestation area was higher than the species richness in grassland.

The rainfall and temperature may also be important factors in the tropical areas (Levings, 1983). In both study habitats, the species richness was highest during the early rainy season. The highest of species richness in grassland were found in June 2011 and in reforestation area was found in May 2011. The species richness was below average during the maximum rainfall in August (420.5 mm) (Figure 5.1). In both study habitats, the heavy rains may inhibit the foraging activities in most species. The highest of species richness in grassland was found in June 2011 and in reforestation area was found in May 2011 which both months has a high the total rainfall. These months in the start of raining season have physical factors suitable for the ants such as the total rainfall, relative humidity, air temperature, soil temperature, and soil moisture content. Therefore, when comparing to the ant species that prefer moist condition, the species that prefer dry condition could have low ability to survive in the habitat (Torchote, 2008).

The high similarity indices between both seasons and both habitats (0.84 - 0.91, Table 5.3) showed that there were majority of common species between both habitats of this study due to the proximity of both study habitats, similarity canopy cover, surrounding dry dipterocarp forests. Most common ant species utilized both areas regardless of season and similarity physical factors in each season of both study habitats might be the constant soil moisture content thought out the year (Table 5.1) because in reforestation area was irrigated all year round, especially in the dry season. These activities made the grassland have soil moisture content higher than the reforestation area, leading to a relatively high abundance of soil arthropods, which being found in all year round and the areas where presence of those predatory ant species. Because the soil arthropods in moisture areas may remain active for longer periods than individuals in dry areas, the soil arthropods in grassland may be more abundance than other reforestation area at the same time. This may increase the prey available to the predatory ants in grassland.

Of 17 ant species, found in both wet and dry seasons and in two study habitats depict the adaptability of these species to environmental changes, were influenced by the seasons in two study habitats. Temperature, relative humidity, and total rainfall in each month were the important physical factors affecting on the increase and decrease or the stability of ant population in the ecosystem. These physical factors also affected on the difference in foraging behavior of the workers in the each species. Moreover, some species were specific to temperature period, moisture, and rainfall (Hölldobler and Wison, 1990; Andersen, 2000

CHAPTER VI

ABUNDANCE OF IMPORTANT ANTS AND SOME RELATED PHYSICAL FACTORS IN TWO HABITAT TYPES, GRASSLAND AND REFORESTATION AREA

6.1 Introduction

Expansion of plant cultivation and animal farming, invasion of natural forests, grassland and fallowed areas initiated by human activities have magnified the range of direct impacts on the ecosystems and organisms. Such biotic changes would directly affect on several organisms because of their rapid responding against the changing environment. In addition, the changes of physical factors such as relative humidity, soil temperature, and air temperature, are also important factors affecting on organisms which inhabits microhabitat in the areas. The relationship between ants and physical factors that will determine nest building, foraging, and other activities of ants. The foraging behaviors of ants normally response to the weather, and period within a day (Hasin, 2008). Consequently, ants are one of the most suitable organisms to monitor changes in the natural habitats.

This study investigated the abundances of some dominant ant species and their relations to some physical factors between the two areas. The data will provide some fundamental knowledge for grassland management and changes in the habitats.

6.2 Materials and Methods

6.2.1 Sampling methods

In each of the two different habitat, a permanent plot of 30 x 30 m^2 was selected as a sampling area. Each study area was conducted sampling every month, from June

2010 to June 2011 and the study period was divided into wet season (May to November) and dry season (December to April). Six sampling methods were used to study the species diversity of ants in each habitat as explained in Chapter III.

6.2.2 Study of physical factors

The physical factors were used to study in each habitat as explained in Chapter III.

6.3 Results

6.3.1 Physical factors between the two study habitats

The mean of most physical factors, relative, air temperature, soil temperature, soil moisture were not significant between the two different study sites, except the mean of soil temperature between the two study habitats that were significantly different. (Table 6.1)

Table 6.1 The mean of physical factors within each study site at Lai Nan subdistrict, Wiang Sa district, Nan province

Physical factors	Mean of physical factors ± SE	
	Grassland	Reforestation area
Relative humidity (%)	44.81 ± 3.53[a]	48.06 ± 2.46[a]
Air temperature (°c)	34.77 ± 0.66[a]	33.65 ± 0.95[a]
Soil temperature (°c)	27.56 ± 1.19[a]*	33.65 ± 0.95[b]*
Soil moisture content (%)	9.96 ± 1.68[a]	7.60 ± 1.32[a]

* The mean of physical factors in the two different study sites *p*-value $\leq$0.05

6.3.2 Highly abundant ant species in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 16,157 individuals in the overall study period. The grassland had communities that were numerically dominated by *Pheidologeton diversus* (39.77%) (Figure 6.2) (Figure 6.1 – A, B), which accounted for 6,426 individuals of all ants in this site, followed by *Oecophylla smaragdina* (11.36%) (Figure 6.2) (Figure 6.1 - B), *Crematogater rogenhoferi* (7.95%) (Figure 6.2) (Figure 6.1 - C) and *Monomorium destructors* (6.59%) (Figure 6.2) (Figure 6.1 - D) (Table 1-B - Appendix B).

Reforestation area

The total abundance all ant species found in reforestation area was 17,917 individuals in the overall study period. The reforestation area had communities that were numerically dominated by *Pheidologeton diversus* (43.14%) (Figure 6.3), which accounted for 7,516 individuals of all ants in this site, followed by *Pheidologeton affinis* (12.85%) (Figure 6.3) (Figure 6.1 - F), *Camponotus nicobarensis* (7.80%) (Figure 6.3) (Figure 6.1 - G) and *Anopholepis gracilipes* (5.96%) (Figure 6.3) (Figure 6.1 – H) (Table 2-B - Appendix B).

A. *Pheidologeton diversus* (major)

B. *Pheidologeton diversus* (minor)

C. *Oecophylla smaragdina*

D. *Crematogater rogenhoferi*

E. *Monomorium destructors*

F. *Pheidologeton affinis*

G. *Camponotus nicobarensis*

H. *Anopholepis gracilipes*

Figure 6.1 Dominant ant species in the grassland, A. *Pheidologeton diversus* (major), B. *Pheidologeton diversus* (minor), C. *Oecophylla smaragdina,* D. *Crematogater rogenhoferi,* E. *Monomorium destructors*, and dominant species in reforestation area, F. *Pheidologeton affinis,* G. *Camponotus nicobarensis,* H. *Anopholepis gracilipes*

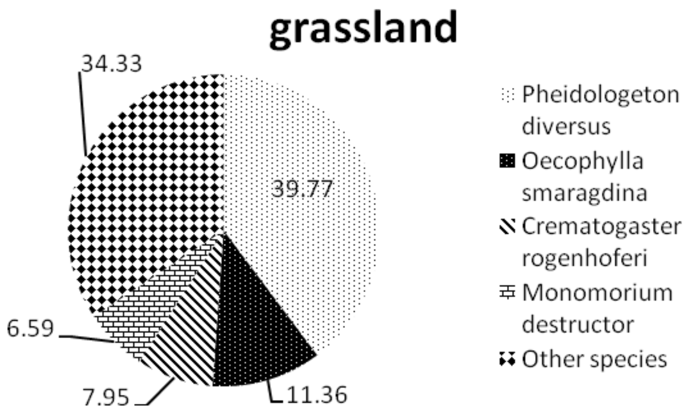

Figure 6.2 The pie chart showed the proportions of the relative abundance of important ants in grassland at Lai Nan subdistrict, Wiang Sa district, Nan province

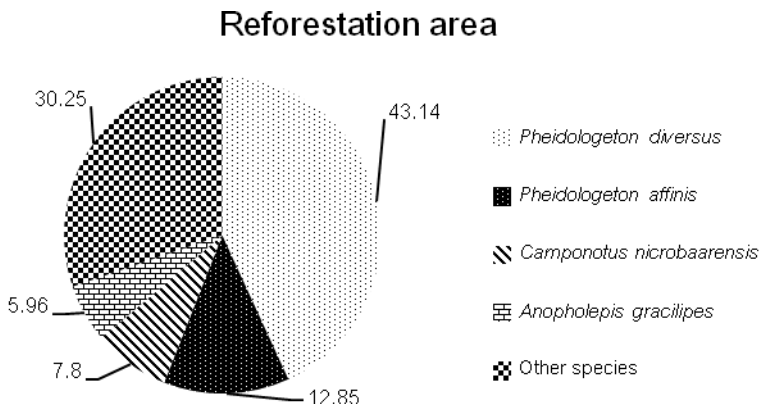

Figure 6.3 The pie chart showed the proportions of the relative abundance of important ants in reforestation area at Lai Nan subdistrict, Wiang Sa district, Nan province

6.3.3 Comparison in abundance of important ant species between the two study habitats

The common important ant species in both study habitats as *Pheidologeton diversus*. The mean abundance of *Oecophylla smaragdina* (t-test = 0.002, df = 24, $p \leq$ 0.05), *Crematogaster rogenhoferi* (t-test = 0.33, df = 24, $p \leq$ 0.05), *Camponotus nicobarensis* (t-test = 0.045, df = 24, $p \leq$ 0.05) and *Monomorium destructor*(t-test = 0.044, df = 24, $p \leq$ 0.05), were significantly different between the two different study habitats ($p \leq 0.05$). Ant species were found in the both habitats, whereas *O. smaragdina, C. rogenhoferi* and *M. destructor*, respectively, were the most found in grassland. The *P. affinis, C. nicobarensis* and *A. gracilipes* were the most found in a reforestation area. The abundance of *P. diversus* was highest in the both study sites (Table 6.2).

Table 6.2 The Mean * abundance of important ant species in each study habitat at Lai Nan subdistrict, Wiang Sa district, Nan province

Important ants species	Mean abundance (±SE)	
	Grassland	Reforestation area
Pheidologeton diversus	494.31±202.21 [a]	578.15±192.83 [a]
Pheidologeton affinis	49.92±18.91 [a]	172.23±61.37 [a]
Oecophylla smaragdina	141.15±34.43 [a*]	10.00±5.27 [b*]
Crematogaster rogenhoferi	98.77±24.12 [a*]	36.77±13.06 [b*]
Camponotus nicobarensis	53.93±9.63 [a*]	104.54±21.31 [b*]
Monomorium destructor	81.92±18.27 [a*]	36.62±10.48 [b*]
Anopholepis gracilipes	57.62±19.88 [a]	79.92±31.39 [a]

* The mean of abundance in the two different study sites p-value ≤ 0.05

6.3.4 Correlation between the abundance of important ant species and some physical factors in the two study habitats

In grassland, the abundance of two ant species, *Oecophylla smaragdina* and *Camponotus nicobarensis*, correlated with some physical factors. *Oecophylla smaragdina* and *Camponotus nicobarensis* were significant negatively correlated with the relative humidity (*p*-value = 0.047, r = -0.560, *p*-value = 0.524, r = -0.195, respectively) (Table 6.3).

In reforestation area, *Camponotus nicobarensis* was highly negatively correlated only with soil moisture content (*p*-value = 0.006, r = -0.720). *Monomorium destructor* was high positively correlated with air temperature (*p*-value = 0.089, r = 0.490) and soil temperature (*p*-value = 0.089, r = 0.490), similarity *Anopholepis gracilipes* was high positively correlated with air temperature (*p*-value = 0.029, r = -0.602) and soil temperature (*p*-value = 0.029, r = -0.602) (Table 6.3).

Table 6.3 Correlation coefficient * between some physical factors and abundance of important ant species in the two study habitats at Lai Nan subdistrict, Wiang Sa district, Nan province

Study site	Species	Physical factors	r	*p*-Value
Grassland	*Oecophylla smaragdina*	Relative humidity	-0.560	0.047*
		Air temperature	-0.387	0.192
		Soil temperature	-0.387	0.192
		Soil moisture content	-0.551	0.051
	Camponotus nicobarensis	Relative humidity	-0.195	0.524
		Air temperature	-0.219	0.473
		Soil temperature	-0.219	0.473
		Soil moisture content	-0.658	0.014*
Reforestation area	*Camponotus nicobarensis*	Relative humidity	-0.379	0.201
		Air temperature	-0.137	0.655
		Soil temperature	-0.137	0.655
		Soil moisture content	-0.720	0.006*
	Monomorium destuctor	Relative humidity	0.107	0.727
		Air temperature	0.490	0.089*
		Soil temperature	0.490	0.089*
		Soil moisture content	0.363	0.223
	Anopholepis gracilipes	Relative humidity	0.297	0.324
		Air temperature	0.602	0.029*
		Soil temperature	0.602	0.029*
		Soil moisture content	0.006	0.986

* The *r* - value in each row was correlation coefficient between the physical factors and the abundance of ants in each study site by Spearman's rank correlation at $p \leq 0.05$.

6.4 Discussion

The differences of the physical factors occurred in study habitats may be caused by the pattern of land use management. The high relative humidity in reforestation area may be due to the higher canopy cover than grassland. The ground covers protected this area from heat and resulted it less in water loss. Moreover, the air temperature and soil moisture content in the reforestation area was lower than grassland. These physical factors represented the low temperature in this area. It may be caused by highly percentage and varies of tree canopy cover more than in grassland. The study physical factors were not significantly different between both grassland and reforestation area, except soil temperature that was significantly different between the two areas as shown in the Figure 6.4 which reported about the soil temperatured fluctuation during studying period. First collection (June 2010 to February 2011), the mean of soil temperature in grassland was lower than in reforestation area because grassland was a clay loam with suitable preserve humidity (Figure 6.4). The texture of soil in reforestation area was sandy loam which preserved humidity poorly than clay loam in grassland.

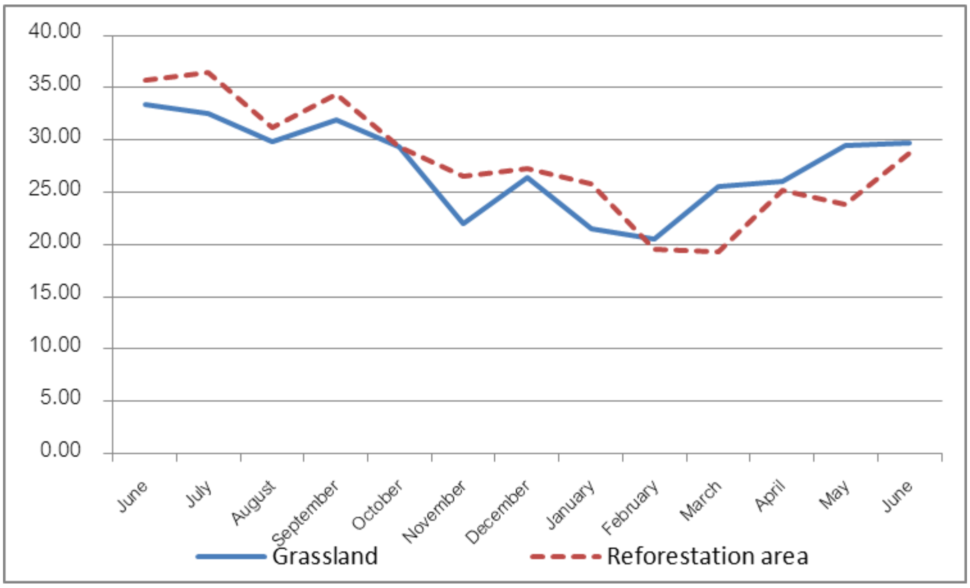

Figure 6.4 Monthly soil temperature (5 cm depth) in two study habitats

In the two study habitats, *Pheidologeton diversus* was the highest abundant ant species (Table 1-A,B Appendix A). They formed large colonies and contained large number of workers and were found all year around (Torchote, 2008). This species is commonly found in the widely habitats and their colonies like a clammy soil, *Pheidologeton diversus* is often found in soil or under rock, and preyed on small animals. *P. diversus* was reported in the open area, such as urban community in Bangkok (Senthong, 2003) and surrounding Ratchaburi Power Plant, Rachaburi province (Thienthaworn, 2004). *P. diversus* was also reported in four forest types at Sakaerat Environmental Research Station, Nakhon Ratchasima province (Hasin, 2008), found in the teak plantation at Huai Kayeng sub-district (Torchote, 2008), but was not found in Bala forest at Hala-Bala Wildlife Sanctuary, Narathiwat province (Noon-anant, 2003). Thus, this confirms that *P. diversus* may prefer disturbed habitats.

Four ant species, *Oecophylla smaragdina*, *Crematogaster rogenhoferi, Monomorium destructor,* and *Camponotus nicrobaarensis* were signifaicantly different between the two study habitat. Then, the 4 important ants species were chosen to calculate the correlation with some physical factors in two study habitats. In grassland, the abundance of two ant species, *Oecophylla smaragdina* and *Camponotus nicobarensis*, correlated with the relative humidity. The negative correlation with relative humidity of important ant shown *Oecophylla smaragdina* and *Camponotus nicobarensis* were affecting to change of a variation of relative humidity, if a high relative humidity was found less of these ants. In reforestation area, *Camponotus nicobarensis* was highly negative correlated only with soil moisture content. If a low percentage of soil moisture content was found, a high abundance of *Camponotus nicobarensis. Monomorium destructor* and *Anopholepis gracilipes* were highly positively correlated with air temperature and soil temperature. These ants were affecting changes of air temperature and soil temperature. At high levels of air temperature and soil temperature factors, we found high abundance of ants but the temperature that not too high which would be suitable for the foraging behavior of ants.

In this study, grassland ecosystem is distinct from the other ecosystems in term of ant species compositions. Fewer ant species were found in grassland than in dry dipterocarp forest possibly due to the limited number of microhabitats.

CHAPTER VII

COMPARISON OF SOME COLLECTION METHODS WITH FUNCTIONAL GROUPS OF ANTS IN GRASSLAND AND REFORESTATION AREA AT LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE

7.1 Introduction

Functional group was the group of organisms in natural and tries to be a group of ant. The use of functional group has facilitated intercontinental comparison of community structure in intertidal and freshwater invertebrates, phytophagous insects, reptile, birds and mammals. The use of functional groups has also enabled comparisons of entire ecosystems with matching climates and landforms (Andersen 1997). To understand the structure of ants requires the identification of functional group of ants predictable to the basic fundamental in response to stress and disturbance (Andersen 2000). Such group has been identified for ants based on the Australian study (Greenslade 1978, Andersen 1995, 1997, 2000). There are 7 ant functional groups and their major representatives in Australia whose relative abundance varies predictably in relation to environmental stress and disturbance (Andersen 2000)

The main objective of this work was to study the comparisons of some methods with functional groups of ants in grassland and reforestation area at Lai Nan subdistrict, Wiang Sa district, Nan province.

7.2 Materials and Methods

In each of the two different habitats, a permanent plot of 30 x 30 m2 was selected as a sampling area. The surveys on each site were conducted every month, from June 2010 to June 2011 were divided wet season (May to November) and dry season (December to April). The three sampling methods, pitfall trap, leaf litter sifting and soil sifting were used to study the species diversity of ants in each habitat as explained in Chapter IV.

7.3 Results

7.3.1 Functional groups of ants in the two study habitats

7.3.1.1 Functional groups in the two study habitats

This study was divided into 7 functional groups consist of 1) Dominant Dolichoderinae (DD); *Iridomyrmex* was only one species, 2) Subordinated Camponotini (SC); *Camponotus* and *Polyrhachis*, were four species in two genera, 3) Climate Specialists (CS); *Oecophylla, Tetraponera, Pheidologeton, Monomorium* and *Meranoplus* were 9 species in 5 genera, 4) Cryptic species (CrS); *Solenopsis, Hypoponera, Pheidologeton*, *Plagiolepis,* and *Anopholepis* were 6 species in 5 genera, 5) Oppotunists (OP); *Paratrechina, Tetramorium, Tapinoma*, and *Cardiocondyla*, were 5 species in 4 genera.

The means of functional groups population were not significantly different between the two study habitats ($p \leq 0.05$), except Dominant Dolichoderinae (t-test = 0.006, df = 24, $p \leq 0.05$) and Subordinate Camponotini (t-test = 0.002, df = 24, $p \leq 0.05$) while were significantly different, respectively (Table 7.2).

Table 7.1 The means of abundance in functional groups within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a*]	0.77±0.44 [b*]
Subordinate Camponotini (SC)	66.62±13.36 [a*]	144.38±30.47 [b*]
Climate Specialists (CS)	849.54±202.89 [a]	923.38±233.09 [a]
Cryptic Specialist (CrS)	602.38±219.89 [a]	835.77±269.65 [a]
Opportunist (OP)	79.23±30.49 [a]	84.38±32.11 [a]
Generalized Myrmicimae (GM)	272.92±39.05 [a]	189.77±36.15 [a]
Specialist Predators (SP)	66.77±14.67 [a]	70.23±19.83 [a]

* The mean of abundance in the two study habitats p-value $\leq$0.05

7.3.1.2 High ant functional groups in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 25,187 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 11,044 individuals of all functional groups in this study site and was highest in grassland (43.85%), followed by Cryptic Specialists (31.09%), Generalized Myrmicinae (14.09%) and the other functional groups in grassland less than 7% ,respectively. The Dominant Dolichoderines had the lowest percentage in grassland (Figure 7.1).

Reforestation area

The total abundance of all ant species found in reforestation area was 29,233 individuals in overall study period. The reforestation area had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 12,004 individuals of all functional groups in this study site and was highest (41.45%), followed by Cryptic Specialists (37.52%), Generalized Myrmicinae (7.58%) and the other functional group less than 7%, respectively. The Dominant Dolichoderines was the lowest in the percentage in reforestation area (Figure 7.1).

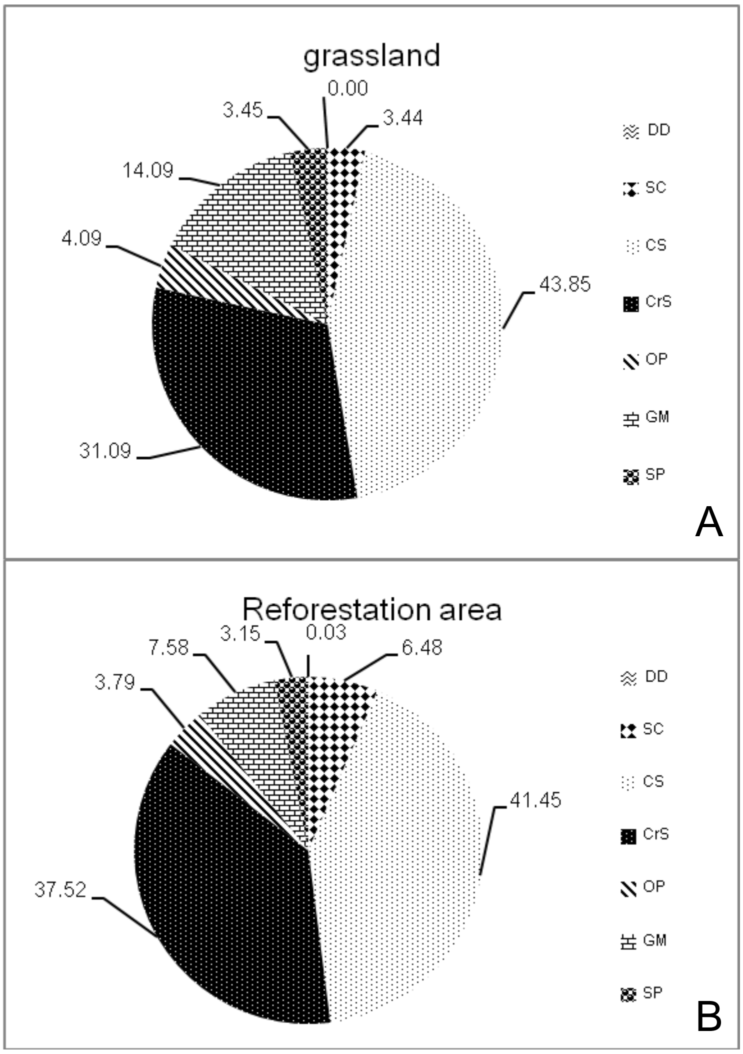

Figure 7.1 Graph showed the relative abundance of ant species in each functional group according to the functional groups: Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP) and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B)

7.3.1.3 Comparison in abundance of important functional groups in the two study habitats

The Figure 7.2 showed the most abundance of functional groups of ant found in both study habitats in grassland and in reforestation area. The highest abundance of Climate Specialists (CS) caught was in the both areas, followed by Cryptic Specialist (CrS), and Generalized Myrmicinae. Climated Specialists and Cryptic Specialists were higher in a reforestation area than grassland, whereas Generalized Myrmicinae (GM) was higher in grassland than reforestation area (Figure 7.2).

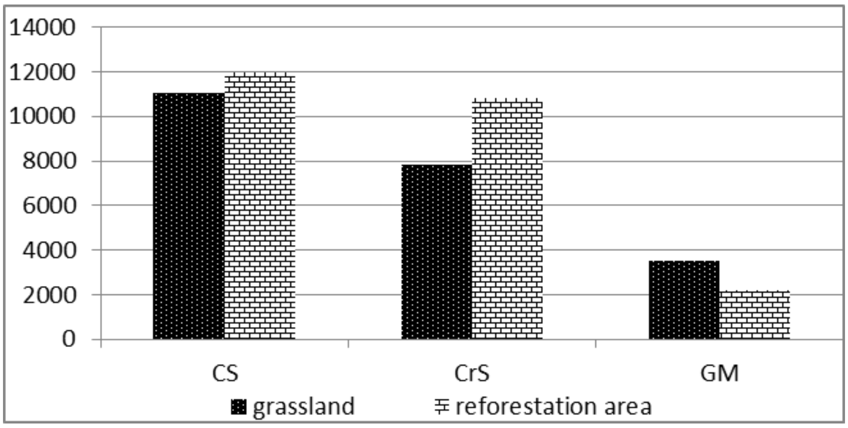

Figure 7.2 Graph showed the most abundance of functional groups of in Climate Specialists (CS), Cryptic Specialists (CrS), and Generalized Myrmicinae in all collecting methods in grassland and reforestation area.

7.3.2 Comparison functional groups of ant with pitfall trap in the two study habitats

7.3.2.1 Functional group in the two study habitats within pitfall trap

The means of functional groups population were not significantly different between the two study habitats ($p \leq 0.05$) (Table 7.3).

Table 7.2 The means of functional groups in the pitfall trap within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a]	0.00±0.00 [a]
Subordinate Camponotini (SC)	17.15±4.87 [a]	34.31±4.87 [a]
Climate Specialists (CS)	258.69±61.38 [a]	195.38±57.53 [a]
Cryptic Specialist (CrS)	209.00±69.09 [a]	219.23±63.51 [a]
Opportunist (OP)	10.00±3.95 [a]	8.38±4.42 [a]
Generalized Myrmicimae (GM)	60.62±13.01 [a]	28.62±13.28 [a]
Specialist Predators (SP)	27.08±6.07 [a]	19.23±5.24 [a]

* The mean of abundance in the two study habitats sites *p*-value $\leq$0.05

7.3.2.2 High ant functional groups of pitfall trap in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 7,573 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 3,363 individuals of all functional groups in this study site and was highest in grassland (44.41%), followed by Cryptic Specialists (35.88%), Generalized Myrmicinae (18.41%) and the other functional groups in grassland less than 7% ,respectively. The Dominant Dolichoderines was the lowest abundance in the functional groups in grassland (Figure 7.3).

Reforestation area

The total abundance of all ant species found in reforestation area was 6,567 individuals in overall study period. The reforestation area had functional groups that were numerically dominated by Cryptic Specialists (CrS), which accounted for 2,850 individuals of all functional groups in this study site and was highest (43.40%), followed by Climate Specialists (38.68%), Subordinated Camponotini (6.79%) and the other functional groups in reforestation area from less than 7%, respectively. The Dominant Dolichoderines was the lowest abundance in the functional groups in reforestation area (Figure 7.3).

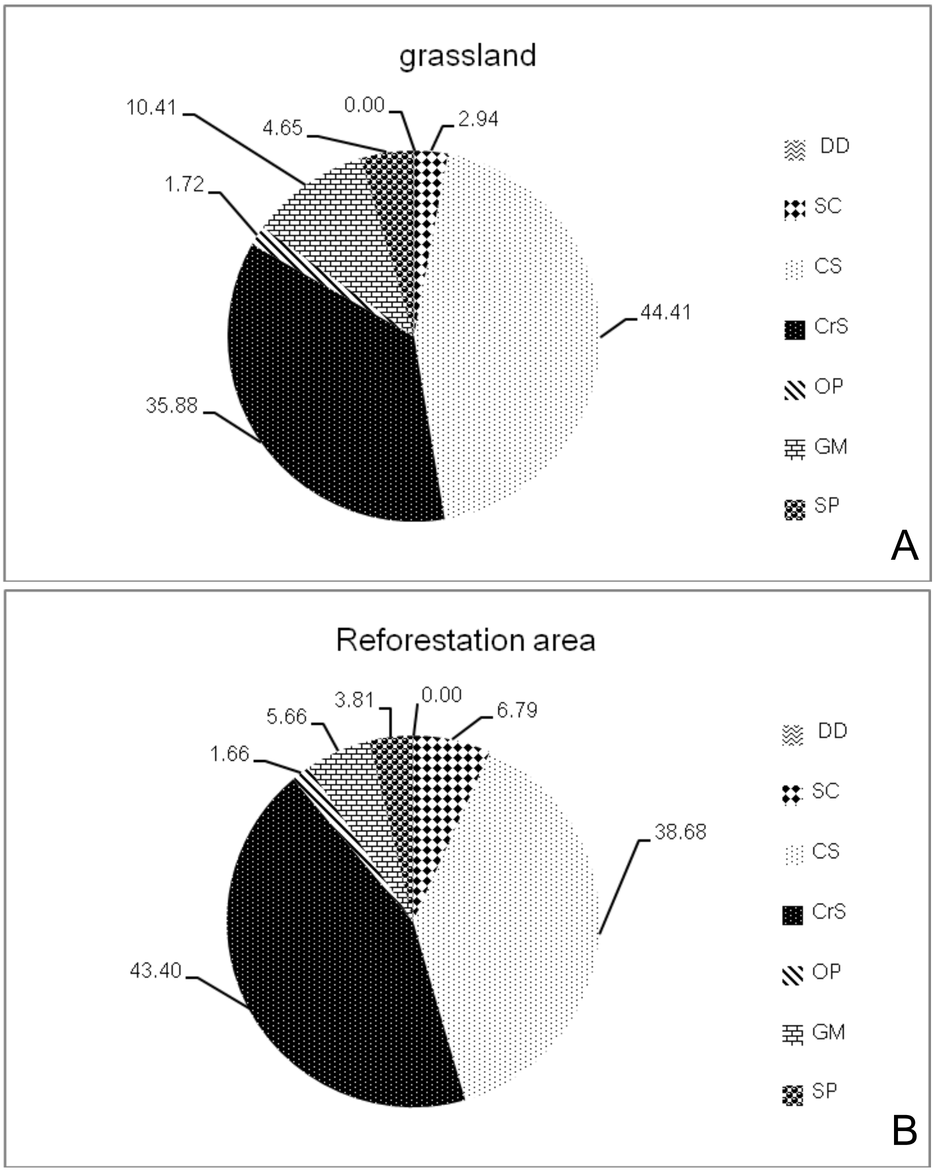

Figure 7.3 Graph showed the relative abundance of ant species in each functional group according to the functional groups about the pitfall trap method: Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP), and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B).

7.3.2.3 Comparison in abundance of important functional groups in the two study habitats

The Figure 7.4 showed the most abundance of functional groups of ant found in the two study habitats within grassland and reforestation area. The abundance in the both areas, Cryptic Specialist (CrS) was higher than Climate Specialists (CS). The Climated Specialists (CS) in the grassland was higher than in reforestation area, whereas the Cryptic Specialist (CrS) was higher in a reforestation area than grassland (Figure 7.4).

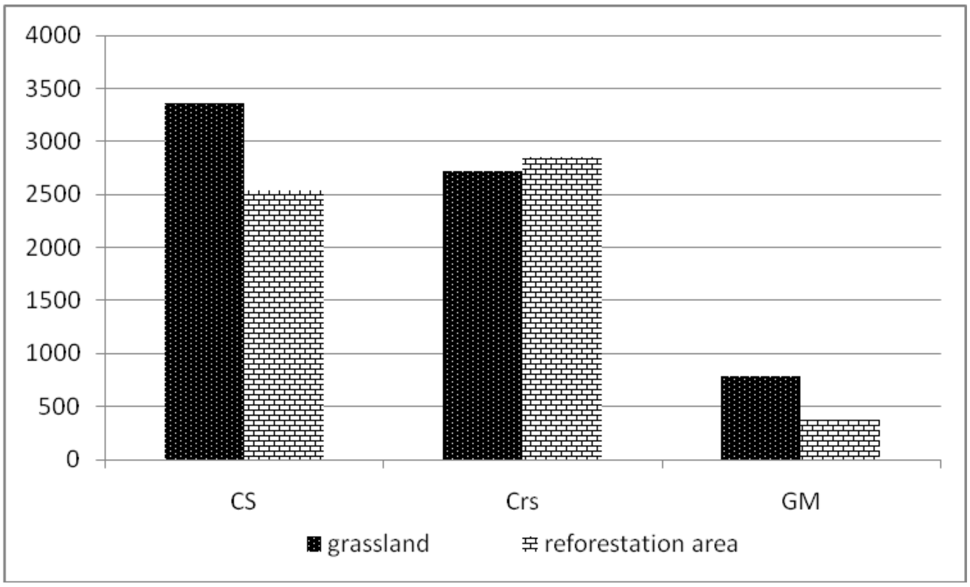

Figure 7.4 Graph showed the most abundance of functional groups of in Climate Specialists (CS), Cryptic Specialists (CrS), and Generalized Myrmicinae within pitfall trap methods in grassland and reforestation area.

7.3.3 Comparison functional groups of ants with leaf litter sifting in the two study habitats

7.3.3.1 Functional groups in the two study habitats within leaf litter sifting

The means of functional groups population were significantly different between the two study habitats ($p \leq 0.05$), Dominant Dolichoderinae (*t*-test = 0.000, df = 24, $p \leq 0.05$), Climate Specialists (*t*-test = 0.017, df = 24, $p \leq 0.05$), Cryptic Specialists (*t*-test = 0.017, df = 24, $p \leq 0.05$), and Opportunists (*t*-test = 0.004, df = 24, $p \leq 0.05$), respectively, except Subordinate Specialists (*t*-test = 0.072, df = 24, $p \leq 0.05$), Generalized Myrmicinae (*t*-test = 0.328, df = 24, $p \leq 0.05$), and Specialists Predators which were not significantly different between the two study habitats ($p \leq 0.05$) (Table 7.4).

Table 7.3 The means of functional groups in the leaf litter sifting within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a*]	0.62±0.33 [b*]
Subordinate Camponotini (SC)	0.77±0.50 [a]	1.77±0.89 [a]
Climate Specialists (CS)	6.15±3.62 [a*]	18.31±6.91 [b*]
Cryptic Specialist (CrS)	2.31±1.08 [a*]	9.62±3.94 [b*]
Opportunist (OP)	0.08±0.08 [a*]	0.77±0.52 [b*]
Generalized Myrmicimae (GM)	10.46±4.71 [a]	13.54±5.56 [a]
Specialist Predators (SP)	0.23±0.17 [a]	0.31±0.21 [a]

* The mean of abundance in the two study sites *p*-value ≤ 0.05

7.3.3.2 High functional groups of leaf litter sifting in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 260 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Generalized Myrmicinae (GM), which accounted for 136 individuals of all functional groups in this study site and was highest in grassland (52.31%), followed by Climate Specialists (CS) (30.77%), Cryptic Specialists (11.54%) and the other functional groups in grassland less than 5%, respectively. The Dominant Dolichoderines was the lowest abundance in the functional group in grassland (Figure 7.5).

Reforestation area

The total abundance of all ant species found in grassland was 581 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 238 individuals of all functional groups in this study site and was highest in the reforestation area (40.75%), followed by Generalized Myrmicinae (GM) (30.14%), Cryptic Specialists (21.40%) and the other functional groups in a reforestation area less than 5%, respectively. The Specialists Predators was the lowest abundance in the functional group in a reforestation area (Figure 7.6).

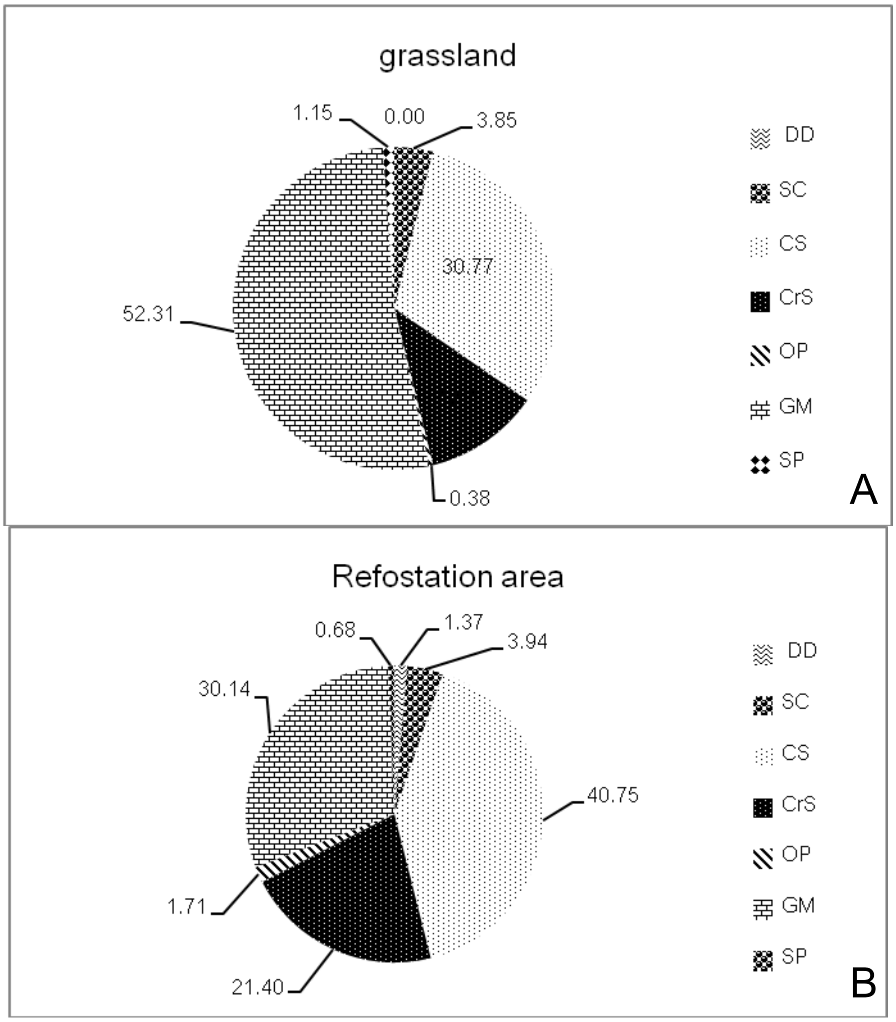

Figure 7.5 Graph showed the relative abundance of ant species in each functional group according to the functional groups about the leaf litter sifting methods : Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP), and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B).

7.3.3.3 Comparison in abundance of important functional groups in leaf litter sifting within the two study habitats

The Figure 7.7 showed the most abundance of functional groups of ant in grassland and in reforestation area. The abundance in among three functional groups, the grassland was lower than reforestation area. The highest abundance within all functional groups in grassland was Generalized Myrmicinae, followed by Climate Specialists and Cryptic Specialists, whereas in reforestation area was Cryptic Specialists, followed by Climate Specialists and Generalized Myrmicinae.

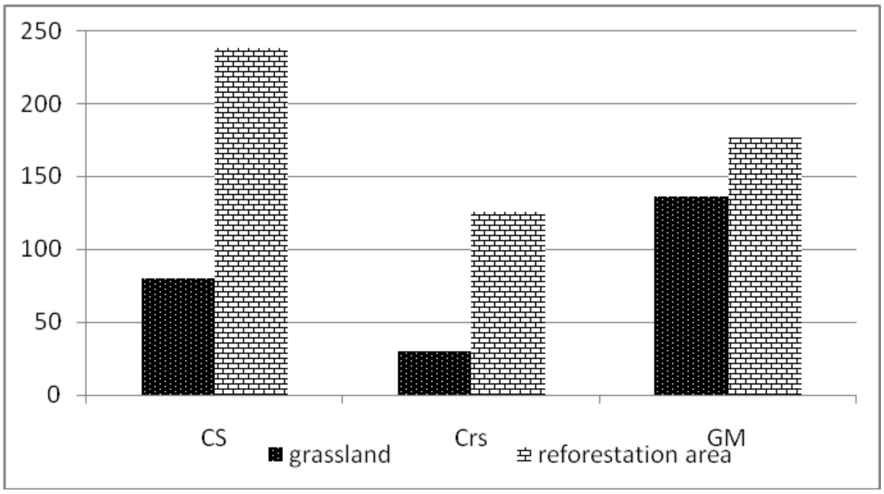

Figure 7.6 Graph showed the relative abundance of ant species of Climate Specialists (CS), Cryptic Specialists (CrS), and Generalized Myrmicinae in functional groups according to the functional groups about the leaf litter sifting method for the grassland and reforestation area.

7.3.4 Comparison functional groups of ants with soil sifting in the two study habitats

7.3.4.1 Functional groups in the two study habitats within soil sifting

The means of functional groups population were not significantly different between the two study habitats ($p \leq 0.05$), except Dominant Dolichoderines (*t*-test = 0.000, df = 24, $p \leq 0.05$) and Specialts Predators (*t*-test = 0.039, df = 24, $p \leq 0.05$) (Table 7.5).

Table 7.4 The means of functional groups in the soil sifting within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a*]	0.39±0.39 [b*]
Subordinate Camponotini (SC)	0.38±0.27 [a]	1.69±1.13 [a]
Climate Specialists (CS)	115.15±57.87 [a]	136.69±71.28 [a]
Cryptic Specialist (CrS)	112.15±57.80 [a]	135.38±71.47 [a]
Opportunist (OP)	0.00±0.00 [a]	0.00±0.00 [a]
Generalized Myrmicimae (GM)	4.92±2.19 [a]	1.77±1.11 [a]
Specialist Predators (SP)	0.00±0.00 [a]	0.23±0.23 [b]

* The mean of abundance in the two study habitats site *p*-value ≤ 0.05

7.3.4.2 High and functional groups of soil sifting in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 3,027 individuals in overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 1497 individuals of all functional groups in this study site and was highest in grassland (49.45%), followed by Cryptic Specialists (48.27%) and the other functional groups in grassland, respectively. The Dominant Dolichoderines and Specialists Predators were the lowest abundance in the functional group in grassland (Figure 7.6).

Reforestation area

The total abundance of all ant species found in grassland was 3,590 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 1,777 individuals of all functional groups in this study site and was highest in the reforestation area (49.50%), followed by Cryptic Specialists (49.03%) and the other functional groups in grassland, respectively. The Opportunist Specialists was the lowest abundance in the functional group in a reforestation area (Figure 7.7).

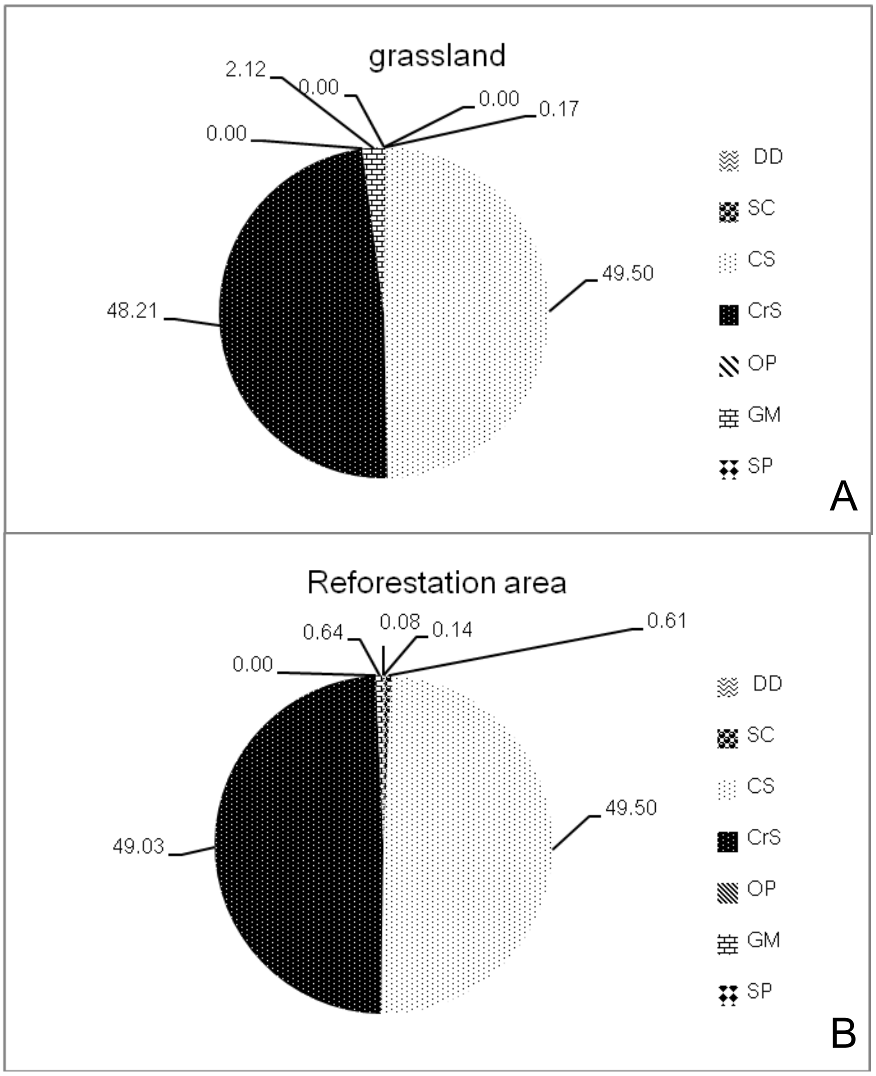

Figure 7.7 Graph showed the relative abundance of ant species in each functional group according to the functional groups about the soil sifting methods : Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP), and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B).

7.3.4.3 Comparison in abundance of important functional groups in soil sifting within the two study habitats

The Figure 7.8 showed the most abundance of functional groups of ants in grassland and in reforestation area. The abundance in the two areas in grassland was lower than in a reforestation area. The Cryptic Specialists was higher than Climate Specialists in the both areas.

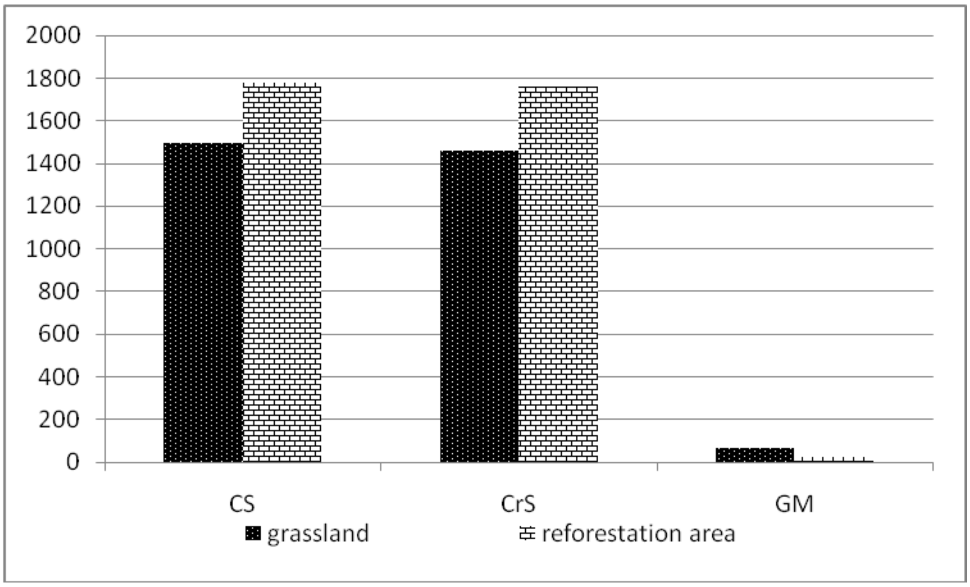

Figure 7.8 Graph showed the relative abundance of ant species of Climate Specialists (CS) and Cryptic Specialists (CrS) in functional group according to the functional groups about the soil sifting methods for the grassland and reforestation area.

7.3.5 Comparison functional groups of ants with protein bait trapping in the two study habitats

7.3.5.1 Functional groups in the two study habitats within protein baiting

The means of functional groups population were not significantly different between the two study habitats ($p \leq 0.05$), except Subordinate Camponotini (*t*-test = 0.009, df = 24, $p \leq 0.05$) and Specialts Predators (*t*-test = 0.069, df = 24, $p \leq 0.05$) (Table 7.6).

Table 7.5 The means of functional groups in the protein baiting trap within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a]	0.00±0.00 [a]
Subordinate Camponotini (SC)	35.23±9.05 [a*]	87.08±22.26 [b*]
Climate Specialists (CS)	307.62±78.95 [a]	243.38±49.98 [a]
Cryptic Specialist (CrS)	153.15±76.49 [a]	159.15±34.23 [a]
Opportunist (OP)	36.15±15.19 [a]	51.85±28.97 [a]
Generalized Myrmicimae (GM)	140.23±31.36 [a]	101.69±30.50 [a]
Specialist Predators (SP)	18.62±5.43 [a*]	27.92±10.20 [b*]

* The mean of abundance in the two study sites *p*-value ≤ 0.05

7.3.5.2 High and functional groups of protein bait trapping in the two study sites

Grassland

The total abundance of all ant species found in grassland was 8,983 individuals in overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 3,999 individuals of all functional groups in this study site and was highest in grassland (44.52%), followed by Cryptic Specialists (CrS) (22.29%), Generalized Myrmicinae (GM) (22.26%) and the other functional groups in grassland less than 7%, respectively. The Dominant Dolichoderines was the lowest abundance in the functional group in grassland (Figure 7.9).

Reforestation area

The total abundance of all ant species found in grassland was 8,724 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 3,164 individuals of all functional groups in this study site and was highest in the reforestation area (36.27%), followed by Cryptic Specialists (CrS) (23.72%), Generalized Myrmicinae (GM) (15.15%), Specialists Camponotini (12.98%) and the other functional groups in a reforestation area less than 8%, respectively. The Dominant Dolichoderines was the lowest abundance in the functional groups in a reforestation area (Figure 7.9).

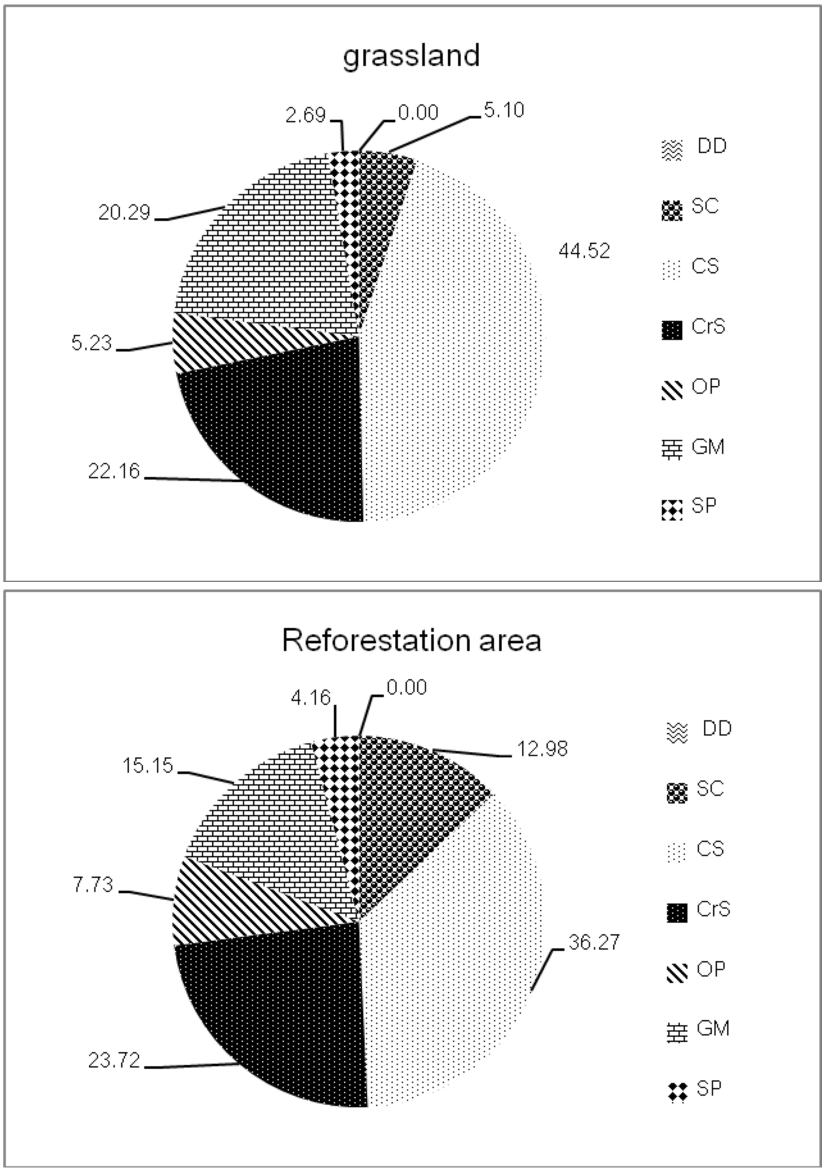

Figure 7.9 Graph showed the relative abundance of ant species in each functional group according to the functional groups about the protein bait trapping : Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP), and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B).

7.3.5.3 Comparison in abundance of important functional groups in protein bait trapping the two study habitats

The Figure 7.11 showed the most abundance of functional groups of ants in grassland and in reforestation area. The abundance in among three functional groups, the grassland was higher than reforestation area. The highest abundance within all functional groups was Cryptic Specialists, followed by Climate Specialists and Generalized Myrmicinae in the both areas.

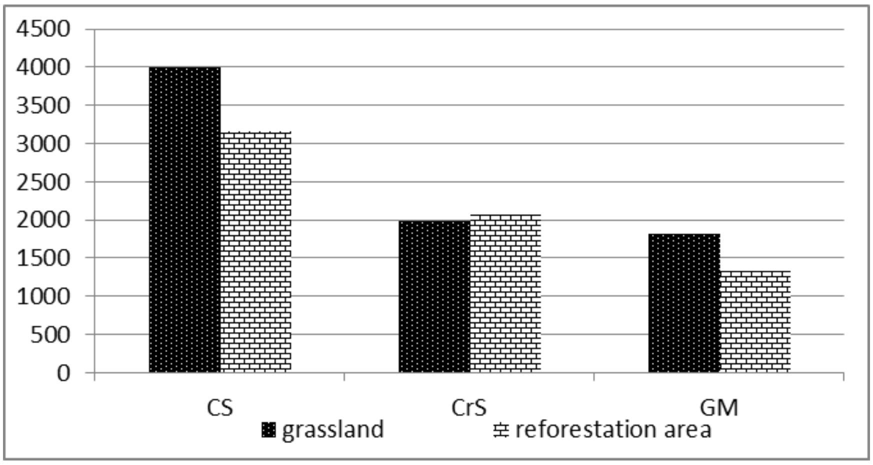

Figure 7.10 Graph showed the relative abundance of ant species of Climate Specialists (CS), Cryptic Specialists (CrS), and Generalized Myrmicinae in functional group according to the functional groups about the soil sifting method for the grassland and reforestation area.

7.3.6 Comparison functional groups of ants with sugar bait trapping in the two study habitats

7.3.6.1 Functional groups in the two study habitats within sugar baiting

The means of functional groups population were not significantly different between the two study habitats ($p \leq 0.05$) (Table 7.7).

Table 7.6 The means of functional groups in the sugar bait trapping within the two study habitats in Lai Nan subdistrict, Wiang Sa district, Nan province

Functional group	Mean of abundance of ant ± SE	
	Grassland	Reforestation area
Dominant Dolichoderines (DD)	0.00±0.00 [a]	0.00±0.00 [a]
Subordinate Camponotini (SC)	13.08±3.87 [a]	19.54±6.47 [a]
Climate Specialists (CS)	161.92±49.53 [a]	329.62±177.61 [a]
Cryptic Specialist (CrS)	122.85±49.47 [a]	312.38±186.34 [a]
Opportunist (OP)	33.00±17.08 [a]	23.38±15.84 [a]
Generalized Myrmicimae (GM)	56.69±16.00 [a]	44.08±16.87 [a]
Specialist Predators (SP)	20.85±7.68 [a]	22.54±7.34 [a]

* The mean of abundance in the two study sites p-value ≤ 0.05

7.3.6.2 High and functional groups of sugar bait trapping in the two study habitats

Grassland

The total abundance of all ant species found in grassland was 5,309 individuals in the overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 2,105 individuals of all functional groups in this study site and was highest in grassland

(39.65%), followed by Cryptic Specialists (CrS) (30.08%), Generalized Myrmicinae (GM) (13.88%) and the other functional groups in grassland less than 9%, respectively. The Dominant Dolichoderines was the lowest abundance in the functional group in grassland (Figure 7.10).

Reforestation area

The total abundance of all ant species found in grassland was 9,770 individuals in overall study period. The grassland had functional groups that were numerically dominated by Climate Specialists (CS), which accounted for 4,285 individuals of all functional groups in this study site and was highest in reforestation area (43.86%), followed by Cryptic Specialists (CrS) (41.57%), Generalized Myrmicinae (GM) (5.86%) and the other functional groups less than in reforestation area, respectively. The Dominant Dolichoderines was the lowest abundance in the functional group in reforestation area grassland (Figure 7.10).

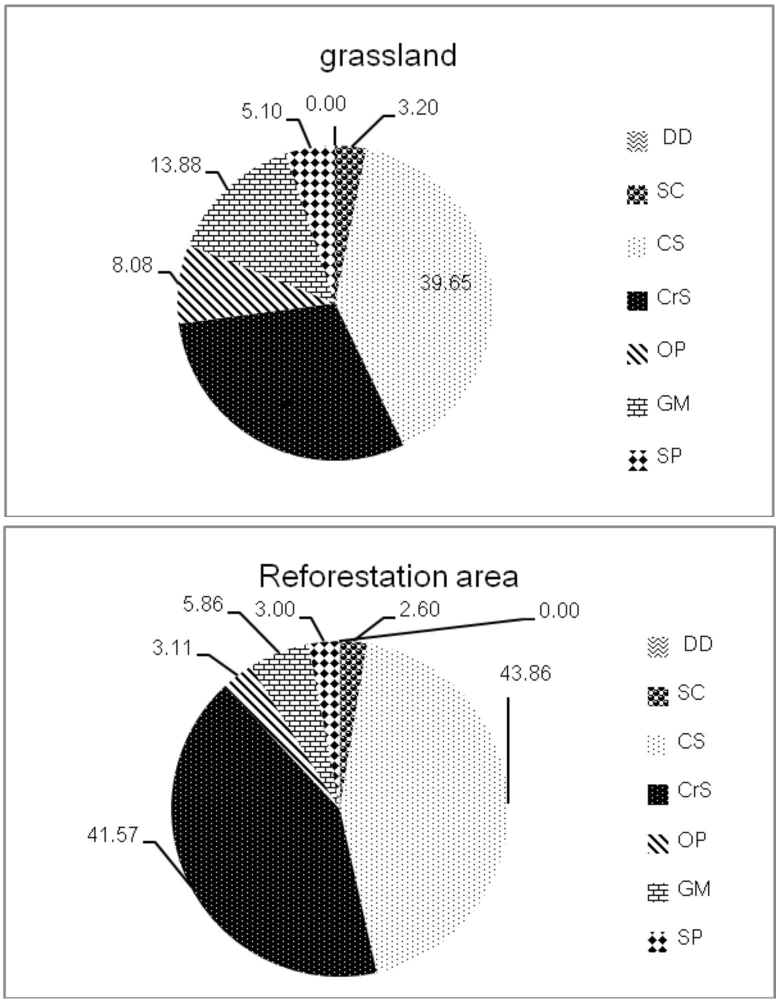

Figure 7.11 Graph showed the relative abundance of ant species in each functional group according to the functional groups about the sugar bait trapping: Dominant Dolichoderines (DD), Subordinate Camponotini (SC), Climate Specialists (CS), Cryptic Specialists (CrS), Generalized Myrmicinae (GM), Opportunist (OP), and Specialist Predator (SP) for each of the grassland (A) and reforestation area (B)

7.3.6.3 Comparison in abundance of important functional groups in sugar bait trapping within the two study habitats

The Figure 7.11 showed the most abundance of functional groups of ants in grassland and in reforestation area. The abundance in Cryptic Specialists and Climate Specialists in functional groups, the grassland was lower than reforestation area, except

Generalized Myrmicinae which was higher in grassland than reforestation area. The highest abundance within all functional groups was Cryptic Specialists, followed by Climate Specialists and Generalized Myrmicinae in the both areas.

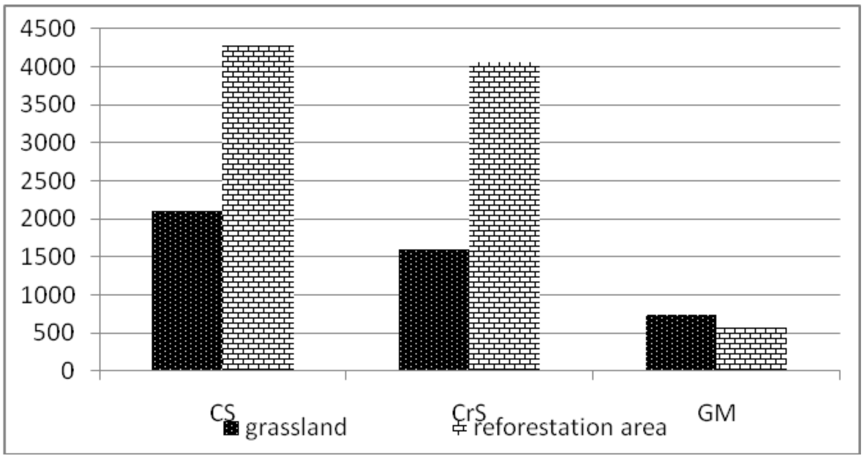

Figure 7.12 Graph showed the relative abundance of ant species of Climate Specialists (CS), Cryptic Specialists (CrS), and Generalized Myrmicinae in functional group according to the functional groups about the soil sifting methods for the grassland and reforestation area.

7.4 Discussion

The most abundant functional groups of ants in two study habitats were Climate Specialists (CS) and Cryptic Specialists (CrS). Climate Specialists was the most abundant of functional groups in reforestation area, and this was probably due to severe daily changes in temperatures between days and nights (Goudie, 2002) and the limited the species of ants that were able to establish themselves in this environment. The Cryptic species groups of ants were the second most abundance both in grassland and reforestation area. A possible reason for the dominance of Cryptic species, which live exclusively on the ground, could be that the vegetation in these ecosystems does not have the structure and complexity (Siebert, 2005) to support other groups of ants. From the result, the Dominant Dolichoderinae and Supordinate Camponotini were significantly different, showed that the both functional groups had affected on species of ants in each study habitat.

The functional groups with proportional abundance showed that both grassland and reforestation area, Climate Specialist were the highest proportion, followed by Cryptic Specialist and Generalized Myrmicinae. The three functional groups may be used to indicate on grassland because their most abundance in three groups both grassland and reforestation area.

In local patches of monsoonal rainforest, where insulation at the soil surface is even lower, Dominant Dolichoderines and Hot Climate Specialists are absent altogether; and most ants are either generalized myrmicines or opportunists (Andersen and Majer, 1992; Reichel and Andersen, 1996). Furthermore, in the cool – temperate southern Australia, the abudance of Dolichoderines and Gerneralized Myrmicines are usually only abundant in open habitats, and the relative abundance of cold Climate Specialists and Cryptic Specialists increase with decreasing insolation.

Functional group composition responds to habitat disturbance in temperate and semiarid regioons (Andersen, 1990; Bestmeyer and Weins, 1996), but effects of disturbance on functional group composition of tropical rainforest and communities have been poorly documented. The study showed consistenly with the results from Queenland by Greenslade (1997) indicated that a proliferation of Opportunists (species of Paratrechina) was also characteristic response to sever disturbance in humid tropical Australia.

The comparison in each functional group, three functional groups were most abundance in all functional groups. Climate Specialist was highest abundance in all methods, followed by Cryptic species, and Generalized Myrmicinae. The most functional groups into three groups were chose to compared in each method, in leaf litter sifting Generalized Myrmicinae was the highest groups that showed that their group could be indicate to species of ants in leaf litter method. From the study of functional group in Thailand, 3 species were found the most functional groups; Cryptic species, Generalized Myrmicinae, and Climate Specialist (Suriyapong, 2003 and Wanishsakulpong, 2007)

Therefore, the functional groups could be used to indicate groups of ants in each habitat which this study could be divided suitable groups into three groups; Climate Specialist, Cryptic species, and Generalized Myrmicinae. Generalized Myrmicinae is a functional group that could be used to indicate the ant species and their habitats by only leaf litter sifting method.

CHAPTER VIII

CONCLUSION AND RECOMMENDATION

In two study sites, grassland and reforestation area, the total of 34 ant species found represented high ant diversity in this area. Based on Shannon – Weiner's species diversity index, the reforestation area showed the highest diversity followed by the grassland. Although the higher ant species richness in reforestation area was found, the Sorensen's similarity coefficient indicated that the species composition in two study habitats was most similar ninety – two percentage between grassland and reforestation area. It can be concluded, the reforestation area can provide resource for carrying high diversity of ant species more than grassland the natural habitat.

When the ant species diversity was compared between seasons, the wet season in reforestation area was higher species richness than the other habitat because the suitable of physical factors and food sources for ants colonies in each habitat. The similarity in the ant species composition between wet and dry seasons in two study habitats were a period 0.84 -0.91 then, the two habitats were not different in both habitats. However, these indicated that the variation in ants species composition between seasons could be influenced by microhabitats in each habitat.

The functional group in two study habitats could be indicated the dominant functional groups into three groups; Climate Specialists, Cryptic Specialists, and Generalized Myrmicinae which these groups were high abundance and high number of species more than the other groups. These species also support that the human activities will be affected on the habitats and could interfere the abundance of some ant species. If an understanding of microhabitats used by specific ant species can be developed, along with the key tropic interactions, then the potential of using ants as terrestrial indicator species for monitoring environmental changes can be reliably and easily (low cost and time) performed when compares to some other indicator species.

Therefore, grassland was still the important ecosystems for specific organisms. Reforestation area will effect on diversity of ant. The studies of social structure of ants could be used as the basic knowledge for using ants as an indicator in the future and this basic data might be useful for land use planning.

REFERENCES

Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T. R. 2000. **Ants: Standard method for measuring and monitoring biodiversity**, Smithsonian Institution Press, Washington.

Alonso, L.E. 2000. Ants as indicators of diversity. In: Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (Eds). **Ants: Standard method for measuring and monitoring biodiversity**, pp. 80-88. Washington: Smithsonian Institution Press.

Alonso, L.E. and Agosti, D. 2000. Biological studies, monitoring, and ants: An overview. In: Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (Eds). **Ants: Standard method for measuring and monitoring biodiversity**, pp. 1-8. Washington : Smithsonian Institution Press.

Andersen, A.N., 1990. The use of ant communities to evaluate change in Australian terrestrial ecosystems: A review and a recipe. **Proceedings of the Ecological Society of Australia** 16: 347-357

Andersen, A. N. 1990. The use of rainforest ants: Functional groups in relation to environmental stress and disturbance. In D. Agosti, L. E. Alonso, J. D. Majer, and T. R. Schultz (eds.), **Ants: Standard method for measuring and monitoring biodiversity**, pp. 25-34. Washington: Smithsonian Institution Press.

Andersen, A.N., 1995. A classification of Australian ant communities, based on functional groups which parallel plant life-forms to stress and disturbance. **Journal of Biogeography** 22: 15-29.

Andersen, A.N., 1997. Functional groups and patterns of organisation in North American ant communities: A comparison with Australia. **Journal of Biogeography** 24: 433-460.

Andersen, A. N., Hoffmann, B. D., Muller, W. J. and Griffiths, A. D. 2002. Using ants as bioindicator in land management: simplifying assessment of ant community responses. **Journal of Applied Ecology** 39: 8- 17.

Andersen, A.N. and Majer, J.D., 2004. Ants show the way down under: invertebrates as bioindicators in land management. **Frontier in Ecology and Environment** 2: 291-298.

Bestelmeyer, B.T., Agosti, D., Alonso, L.E., Brandão, C.R.F., Brown Jr., W.L. Delabie, J.H.C., and Silvestre, R. 2000. Field techniques for study ground-dwelling ants. In Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (eds.), **Ant: Standard Method for Measuring and Monitoring Biodiversity**, pp. 122-144. Washington: Smithsonian Institution Press. 1

Bolton, B. 1994. **Identification Guide to the Ant Genera of the World.** Eagland: Harvard University Press. 222 pp.

Bolton, B. 1995. **A New General Catalogue of the Ants of the World.** Eagland: Harvard University Press. 504 pp.

Bolton, B., Alpert, G., Ward, P.S. and Naskrecki, P. 2006. **Bolton's Catalogue of Ants of the World: 1758-2005**, Cambridge: Harvard University Press.

Bourmas, C. 2005. **Species diversity of ants at Huai Khayeng, Thong Pha Phum district, Kanchanaburi Province**. Master's Thesis. Department of Forest Biology, Faculty of Forestry, Kasetsart University.

Brown Jr, W.L. 2000. Diversity of ants. In Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (eds.), **Ant: Standard Method for Measuring and Monitoring Biodiversity.** pp. 45-79. Washington: Smithsonian Institution Press.

Brühl, C.A., Gunsalam, G., and Linsenmair, K.E. 1998. Stratification of ants (Hymenoptera, Formicidae) in a primary rain forest in Sabah, Borneo. **Journal of Tropical Ecology** 14: 285-297.

Chapman, J. W. and Capco, S.R. 1951. Check List of the Ants (Hymenoptera: Formicidae) of Asia. Philippine: Office of Economic Coordination Institute of Science and Technology. 307 pp.

Connell JH. 1978. Diversity in tropical rain forests and coral reefs. **Science** 199: 1302-1310.

Corlett, R.T. and Primack R.B. 2006.Tropical rainforests: why cross-continental comparisons are needed. **Trend in ecology and evolution** 21: 104 – 110.

Damrongrojwatthana, P. 2004. **Impacts of forest disturbance on soil organic matter, soil nutrients and carbon sequestration in Nam Wa sub-watershed, Nan province.** Master's thesis. Faculty of Science, Chulalongkorn University.

Debuse, V.J.; King, J. and House A.P.N., 2007. Effect of fragmentation, habitat loss and within-patch habitat characteristics on ant assemblages in semi-arid woodlands of eastern Australia. **Landscape Ecology** 22: 731-745.

Delabie, J.H.C., Agosti, D. and Nascimento, I.C.2000. Litter ant communities of the Brazilian Atlantic rain forest region. In: Agosti, D., Majer, J.D., Alonso, L.E. and Schultz, T.R. (Eds). **Sampling ground-dwelling ants: Case studies from the world's rain forest,** pp. 1-17. Perth: Curtin University.

Delabie, J.H.C., and Silvestre, R. 2000. Field techniques for study ground-dwelling ants. In Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (eds.), **Ant: Standard Method for Measuring and Monitoring Biodiversity**. pp. 122-144. Washington: Smithsonian Institution Press.

Department of Biology, Faculty of Science, Chulalongkorn University, 2000. **General biology laboratory manual**, Bangkok: Chulalongkorn University.

Donnelly, D., and Giliomee, J.H. 1985. Community structure of epigaic ants (hymenoptera: Formicidae) in fynbos vegetation in the Jonkershoek Valley. **Journal of the Entomological Society of Southern Africa** 48: 247-257.

Eguchi, K. 2001. A revision of the Bornean species of the ant genus *Pheidole* (Insecta: Hymenoptera: Formicidae: Myrmicinae). **Troppics** 2: 1-154.

Feller, J.H. 1987. Interference and Exploitation in a quild of woodland ants. **Ecology** 69: 1466-1478.

Fisher, B.L. 2000. Ant inventories along elevational gradrients in tropical wet forests in Eastern Mardagascar. In D. Agosti, D., J. Majer, L. Alonso, and T.R. Schultz (eds.). 2000. **Sampling Ground-dwelling Ant: Case studies from the Worlds' Rain Forests.** Pp.41-49. Perth: Curtin University.

Folgarait, P.J. 1998. Ant biodiversity and its relationship to ecosystem functioning: a review. **Biodiversity and Conservation** 7: 1221-1244.

Folgarait, P.J., Gorosito, N. and Zipeto, G. 1997. **Reduction of biodiversity by Camponotus punctulatus ants mediated by human disturbance**. Association for Tropical Biology Annual Meeting. Symposium on Tropical Diversity, origins, maintenance and conservation. June 15-20, San Jose, Costa Rioca. 57 pp.

Gardner, C.M.K., Robinson, D., Blyth, K., and Cooper, J.D. 2001. Soil water content. In smith, K. A. and Mullins, C. E. (eds.), **Soil and Environmental Analysis: Physical Methods**. pp. 1-64. New York: Marcel Dekker.

Graham, J.H., et al. 2004. Habitat disturbance and the diversity and abundance of ants (Formicidae) in the southeastern Fall-Line Sandhills. **Journal of Insect Science** 4: 1-15.

Greenslade P.J.M., 1978. Ants. In: The Physical and Biological Features of Kunnoth Paddock in Central Australia (ed WA Low) pp.109-113.

Greenslade, P.J.M. and Greenslade, P., 1984. Invertebrates and environmental assessment. **Environmental Planning** 3: 13-15.

Hashimoto, Y., Yamane, S., and Mohamed, M. 2001. How to design an inventory method for ground-level ants in tropical forests. **Natural and Human Activities** 6: 25-30.

Hasin, S. 2008. **Diversity and community structure of ants at Sakaerat Environmental Research Station, Nakhon Ratchasima province**, Master's Thesis. Department of Forest Biology, Faculty of Forestry, Kasetsart University.

Hernández-Ruiz, P., Castaño-Meneses, G., and Cano-Santana. Z. 2009. Composition and Functional groups of epiedaphic ants (Hymenoptera: Formicidae) in irrigated agroecosystem and in nonagricultural area. **Pesquisa Agropecuária Brasileira**. 8: 904-910.

Hoffmann, B.D., 2000. Changes in ant species composition and community organisation along grazing gradients in semi-arid rangelands of the Northern Territory. **Rangeland Journal** 22: 171-189.

Hoffmann, B.D., and Andersen, A.N., 2003. Responses of ants to disturbance in Australia, with particular reference to functional groups. **Austral Ecology** 28: 444-464.

Hoffmann, B.D., Griffiths, A.D. and Andersen, A.N., 2000. Responses of ant communities to dry sulphur deposition from mining emissions in semi-arid tropical Australia, with implications for use of functional groups. **Austral Ecology** 25: 653-663.

Hölldobler, B. and Wilson, E. O. 1990.**The Ants**. Berlin: Springer-Verlag Berlin Heidelberg. 732 pp.

Izhaki et al., 2009. The impact of macro- vs. micro-environmental factors on the structure of ant communities inhabiting East-Mediterranean Aleppo pine forests. **Israel Journal of Entomology** 39: 129–146.

Jackson, G.P. and Fox, B.J. 1996. Comparison of regeneration following burning, clearing or mineral sand mining at Tomago, NSW:II. Succession of ant assemblages in a coastal forest. **Australian Journal of Ecology** 21: 200-216.

Jaitrong, W. and Yamane, S. 2010. The army ant *Aenictus silvestrii* and its related species in Southeast Asia, with a description of a new species (Hymenoptera: Formicidae: Aenictinae) . **Entomological Science** 13: 328-333.

Jaitrong, W. and Nabhitabhata, J. 2005. A List of known ant species of Thailand (Formicidae: Hymenoptera). **The Thailand Natural Museum Journal** 1: 9 – 54.

Kaspari, M. and Major, J.D. 2000. Using ants to monitor environmental change. In D. Agosti, D., J. Majer, L. Alonso, and T.R. Schultz (eds.). 2000. **Sampling Ground-dwelling Ant: Case studies from the Worlds' Rain Forests**. Perth: Curtin University.

King, J.R.; Andersen, A.N. and Cutter, A.D., 1998. Ants as bioindicators of habitat disturbance: validation of the functional group model for Australia's humid tropics. **Biodiversity and Conservation** 7: 1627-1638.

Krebs, C. J. 1999. **Ecological Methodology**. 2nd ed. California: Addison-Educationall Publishers. 620 pp.

Krebs, C.J. 1999. **Ecological methodology**, Addison- Educationall Publishers, California, 581 pp.

Kusnezov N. 1951. El ge´nero Pheidole en la Argentina (Hymenoptera, Formicidae). **Acta Zool. Lilloana** 12: 5–88.

Lassau, S.A. and Hochuli, D.F., 2004. Effect of habitat complexity of ant assemblages. **Ecography** 27: 157-164.

Lavelle, P. and Pashanasi, B. 1989. Soil microfauna and land management in Peruvian Amazonia (Yurimaguas, Loreto). **Pedobiologia** 33: 283-291.

Levings, S. C. 1983. Seasonal, annual, and among-site variation in the ground ant community of a deciduous tropical forest: Some cause of patchy species distributions. **Ecological Monographs** 53: 435-455.

Lynch, J.F., E.C. Balisnky, and S.G. Vail. 1980. Foraging patterns of three sympatric forest ant species, *Prenolepis impairs*, *Paratrechina melanderi*, and *Aphaenogaster rudis*. **Ecological Entomology** 5: 353-371.

Majer, J.D. 1997. The use of pitfall traps for sampling ants – a critique. **Memories of Museum Victoria** 56: 323-329.

Majer, J.D. and Delabie, J.H.C. 1994. Comparison of the ant communities of annually inundated and terra firme forests at Trombetas in the Brazilian Amazon. **Insects social** 41: 343-359.

Majer, J.D., 1983. Ants: Bioindicators of minesite rehabilitation, land-use and land conservation. **Environmental Management** 7: 375-383.

Malsh, 2000. Investigation of the diversity of leaf-litter inhabiting ants in Pasoh, Malaysia. In D. Agosti, D., J. Majer, L. Alonso, and T.R. Schultz (eds.). 2000. **Sampling**

Ground-dwelling Ant: Case studies from the Worlds' Rain Forests. Perth: Curtin University.

Nakamura, A.; Catterall, C.P.; House, A.P.N.; Kitching, R.L. and Burwell, C.J., 2007. The use of ants and other soil and litter arthropods as bio-indicators of the impacts of rainforest clearing and subsequent land use. **Journal of Insect Conservation** 11: 177-186.

Nakamura, A.; Proctor, H. and Catterall, C.P., 2003. Using soil and litter arthropods to assess the state of rainforest restoration. **Ecological Restoration and Management** 4: 20-28.

Noon-anant, N. 2003. **Species diversity and seasonal Abundance of ants in Bala Forest at Hala-Bala Wildlife Sanctuary, Narathiwat Province**. Master's Thesis Department of Biology, Faculty of Science, Prince of Songkhla University.

Odum, E.P. 1971. **Fundamentals of Ecology**. 2nd ed. London: W.B. Sauders Comp. 574 pp.

Olson, D.M. 1991. A comparison of the efficacy of litter sifting and pitfall traps for sampling leaf litter ants (Hymenoptera, Formicidae) in a tropical wet forest, Costa Rica. **Biotropica** 23(2): 166-172.

Philpott, S.M. and Armbrecht, I. 2006. Biodiversity in tropical agroforests and the ecological role of ants and ant diversity in predatory function. **Ecological Entomology** 31: 369-377.

Phoonjumpa, R. 2002. **Using ants as indicators of ant communities at Khao Yai National Park**. Master's Thesis. Department of Forest Biology, Faculty of Forestry, Kasetsart University.

Pickett, S.T.A. and P.S. White. 1985. Patch dynamics: a synthesis. In: S.T.A. Pickett and P.S. White. **The ecology of natural disturbance and patch dynamics**. pp. 371-384. New York: Academic Press.

Prusak, Z.A. 1997. **Ant fuana in three plant communities within Wekiwa Springs State Park, Florida: assessment of diversity and comparison of collecting methods** MSc Thesis, Department of Biology, University of Central Florida, U.S.A.

Read, J.L., and Andersen, A.N., 2000. The value of ants as early warning bioindicators: response to pulsed cattle grazing at an Australian arid zone locality. **Journal of Arid Environments** 45: 231-251.

Robertson, G.P., Crum, J.R., and Ellis, B.G. 1993. The spatial variability of soil resources following long-term disturbance. **Oecologia** 96: 451-456.

Schultz, T.R., and McGlynn, T.P. 2000. The Interaction of Ants with Other Organisms. In: Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (Eds). **Ants: Standard method for measuring and monitoring biodiversity**, pp. 35-44. Washington: Smithsonian Institution Press.

Senthong, D. 2003. **Ant distribution based on air quality variation in urban community of Bangkok.** Master's Thesis. Faculty of Graduate Studies, Mahidol University.

Shattuck, S. O. 1999. **Australian Ants. Their biology and identification**. Collingwood, Victoria: CSIRO Publishing. 226 pp.

Sitthicharoenchai, D and Chantarasawat, N. 2006. Ant Species Diversity in the Establishing Area for AdvancedTechnology Institute at Lai-Nan Sub-district, Wiang Sa District, Nan Province, Thailand. **The Natural History Journal of Chulalongkorn University** 6: 67-74.

Smith MR. 1965. House-infesting ants of the eastern United States; their recognition, biology, and economic importance. **USDA Technical Bulletin** 1326: 1-105.

Suarez, A., D.T. Bolger, and T.J. Case.1998. The effects of fragmentation and invasion on the native ant community in coastal southern California. **Ecology** 79(6),in Press.

Suriyapong, Y. 2003. **Study of ground dwelling ant populations and their relationship to some ecological factors in Sakaerat Environmental Research Station, Nakhon Ratchasima.** Doctoral dissertation. Institute of Science, Suranaree University of Technology.

Torchote, P., Sitthicharoenchai, D and Chantarasawat, N. 2010. Ant Species Diversity and Community Composition in Three Different Habitats: Mixed Deciduous Forest, Teak Plantation and Fruit Orchard. **The Natural History Journal of Chulalongkorn University** 10: 37-51.

Townsend CR., Scarsbrook MR., Doledec S. 1997. The intermediate disturbance hypothesis, refugia, and biodiversity in streams. **Limnology and Oceanography** 42: 938-949.

Ward, P.S. 2000. Board-scale patterns of diversity in leaf litter ant communities. In D. Agosti, D., J. Majer, L. Alonso, and T.R. Schultz (eds.). 2000. **Ants: Standard method for measuring and monitoring biodiversity**, pp. 99-121. Washington: Smithsonian Institution Press.

Watanasit, S., Tongjerm, S., and Wiwatwitaya, D. 2005. Composition of canopy ants (Hymenoptera: Formicidae) at Ton Nga Chang Wildlife Sanctuary, Songkhla Province, Thailand. Songklanakarin. **Journal of Science and Technology** 27: 665 - 673.

Wetterer, J.K. 2008. Worldwide spread of longhorn crazy ant, *Paratrechina longicornis* (Hymenoptera: Formicidae). **Myrmeological News** 11: 137-149.

Whitmore, T.C. 1975. **Tropical rain forest of the Far East, Oxford**, Clarendon Press, 352 pp.

Wilson, E.O. 1971. **The insect societies**. Cambridge: Belknap Press. Cited In: Agosti, D., Alonso, L.E., Majer, J.D. and Schultz, T.R. (Eds). **Ants: Standard method for measuring and monitoring biodiversity**, 2000, Smithsonian Institution Press, Washington, 9-24 pp.

Wiwatwitaya, D. and Jaitrong, W. 2001. **Identification guide to the ant genera of Khao Yai National Park**, Kasetsart University, Bangkok, 110 pp. (in Thai)

Yahya, B.E.B. 2000. **The use of three insect groups as biological indicators in three ecohabitats of Sabah**, School of Science and Technology, Universiti Malaysia Sabah, Malaysia, 182 pp.

York, A. 2000. Long-term effects of frequent low-intensity burning on ant communities in coastal blackbutt forests of southeastern Australia. **Austral Ecology** 25: 83-98.

Zar, J. H. 1999. **Biostatistical Analysis**. 4^{th} ed. New Jersey: Prentice hall. 830.

APPENDICES

APPENDIX A

Table 1-A The abundance, relative abundance, and percentage of occurrence of ant species in the grassland

species	Abundance (individual)	relative abundance (%)	Occurrence (%)
Pheidologeton diversus	6426	39.77	100.00
Oecophylla smaragdina	1835	11.36	100.00
Crematogaster rogenhoferi	1284	7.95	100.00
Monomorium destructor	1065	6.59	92.31
Anopholepis gracilipes	749	4.64	92.31
Odontoponera denticulata	706	4.37	92.31
Camponotus nicrobaarensis	701	4.34	100.00
Pheidologeton affinis	649	4.02	92.31
Monomorium pharoensis	441	2.73	69.23
Tapinoma melanocephalum	353	2.18	53.85
Monomorium floricola	336	2.08	46.15
Paratrechina longiconis	272	1.68	23.08
Paratrechina sp.4 of AMK	264	1.63	23.08
Crematogaster sp.6 of AMK	182	1.13	46.15
Leptogenys sp.1 of AMK	161	1.00	15.38
Cardiocondyla emeryi	140	0.87	23.08
Crematogaster sp.9 of AMK	119	0.74	38.46
Meranoplus bicolor	118	0.73	30.77
Camponotus rufograucus	114	0.71	38.46
Monomorium chinense	112	0.69	30.77
Tetraponera rufonigra	62	0.38	15.38
Polyrhachis proxima	27	0.17	7.69
Camponotus sericeus	24	0.15	15.38
Pheidole sp.1	8	0.05	61.54

species	Abundance (individual)	relative abundance (%)	Occurrence (%)
Hypoponera sp.	5	0.03	15.38
Pheidole sp.2	1	0.01	7.69
Cerapachys sp.	1	0.01	7.69
Tetramorium sp.2 of AMK	1	0.01	7.69
Solenopsis geminata	1	0.01	7.69
Plagiolepis sp.2 of AMK	1	0.01	7.69
Total	16158	100.00	

Table 2-A The abundance, relative abundance, and percentage of occurrence of ant species in the human converted area from grassland

species	Abundance (individual)	relative abundance (%)	Occurrence (%)
Pheidologeton diversus	7516	43.14	100.00
Pheidologeton affinis	2239	12.85	100.00
Camponotus nicrobaarensis	1359	7.80	100.00
Anopholepis gracilipes	1039	5.96	92.31
Odontoponera denticulata	886	5.09	100.00
Monomorium floricola	598	3.43	38.46
Meranoplus bicolor	550	3.16	46.15
Crematogaster rogenhoferi	478	2.74	92.31
Monomorium destructor	476	2.73	92.31
Monomorium chinense	376	2.16	38.46
Paratrechina sp.4 of AMK	296	1.70	30.77
Paratrechina longiconis	287	1.65	30.77
Crematogaster sp.6 of AMK	279	1.60	46.15
Tapinoma melanocephalum	260	1.49	46.15
Cardiocondyla emeryi	253	1.45	23.08
Oecophylla smaragdina	130	0.75	46.15
Crematogaster sp.9 of AMK	123	0.71	30.77
Monomorium pharoensis	111	0.64	46.15
Hypoponera sp.	71	0.41	15.38
Camponotus sericeus	27	0.15	23.08
Leptogenys sp.1 of AMK	20	0.11	15.38
Pheidole sp.1	14	0.08	76.92
Pheidole sp.2	11	0.06	84.62

Table 2-A The abundance, relative abundance, and percentage of occurrence of ant species in the human converted area from grassland

species	Abundance (individual)	relative abundance (%)	Occurrence (%)
Tetraponera rufonigra	8	0.05	15.38
Polyrhachis proxima	7	0.04	23.08
Cerapachys sp.	4	0.02	23.08
Pachycondyla rufipes	2	0.01	15.38
Pachycondyla sp.	1	0.01	7.69
Tetramorium sp.2 of AMK	1	0.01	7.69
Total	17422	100.00	

APPENDIX B

Table 1-B Correlated coefficient * between some physical factors and abundance of important ant species in grassland sites at Lai Nan subdistrict, Wiang Sa district, Nan province

Study site	Species	Physical factors	r	*p*-Value
Grassland	*Pheidologeton diversus*	Relative humidity	0.263	0.385
		Air temperature	0.389	0.189
		Soil temperature	0.389	0.189
		Soil moisture content	0.067	0.827
	Pheidologeton affinis	Relative humidity	-0.017	0.956
		Air temperature	0.378	0.203
		Soil temperature	0.378	0.203
		Soil moisture content	-0.061	0.843
	Oecophylla smaragdina	Relative humidity	-0.560	0.047*
		Air temperature	-0.387	0.192
		Soil temperature	-0.387	0.192
		Soil moisture content	-0.551	0.051
	Crematogaster rogenhoferi	Relative humidity	-0.189	0.537
		Air temperature	-0.117	0.704
		Soil temperature	-0.117	0.704
		Soil moisture content	0.185	0.545
	Camponotus nicobarensis	Relative humidity	-0.195	0.524
		Air temperature	-0.219	0.473
		Soil temperature	-0.219	0.473
		Soil moisture content	-0.658	0.014*
	Monomorium destuctor	Relative humidity	0.296	0.326
		Air temperature	0.296	0.327
		Soil temperature	0.296	0.327
		Soil moisture content	0.390	0.187
	Anopholepis gracilipes	Relative humidity	0.446	0.326
		Air temperature	0.348	0.244
		Soil temperature	0.348	0.244
		Soil moisture content	0.085	0.784

Table 2-B Correlated coefficient * between some physical factors and abundance of important ant species in human converted area from grassland sites at Lai Nan subdistrict, Wiang Sa district, Nan province

Study site	Species	Physical factors	r	*p*-Value
Reforestation area	*Pheidologeton affinis*	Relative humidity	0.170	0.578
		Air temperature	0.346	0.247
		Soil temperature	0.346	0.247
		Soil moisture content	-0.154	0.616
	Pheidologeton affinis	Relative humidity	-0.284	0.347
		Air temperature	0.379	0.202
		Soil temperature	0.379	0.202
		Soil moisture content	-0.131	0.670
	Oecophylla smaragdina	Relative humidity	-0.197	0.519
		Air temperature	-0.173	0.571
		Soil temperature	-0.173	0.571
		Soil moisture content	-0.197	0.519
	Crematogaster rogenhoferi	Relative humidity	-0.349	0.242
		Air temperature	0.061	0.844
		Soil temperature	0.061	0.844
		Soil moisture content	-	-
	Camponotus nicobarensis	Relative humidity	-0.379	0.201
		Air temperature	-0.137	0.655
		Soil temperature	-0.137	0.655
		Soil moisture content	-0.720	0.006*
	Monomorium destuctor	Relative humidity	0.107	0.727
		Air temperature	0.490	0.089*
		Soil temperature	0.490	0.089*
		Soil moisture content	0.363	0.223
	Anopholepis gracilipes	Relative humidity	0.297	0.324
		Air temperature	0.602	0.029*
		Soil temperature	0.602	0.029*
		Soil moisture content	0.006	0.986

BIOGRAPHY

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