ผลของไฟป่าที่มีต่อความหลากชนิดของมดในป่าเต็งรัง ตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน

นายคธา นุแรมรัมย์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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EFFECTS OF FOREST FIRE ON ANT DIVERSITY IN THE DRY DIPTEROCARP FOREST AT LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE

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for the Degree of Master of Science Program in Zoology
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Thesis Title	EFFECTS OF FOREST FIRE ON ANT DIVERSITY IN THE DRY DIPTEROCARP FOREST AT LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE
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คธา นุแรมรัมย์ : ผลของไฟป่าที่มีต่อความหลากชนิดของมดในป่าเต็งรัง ตำบลไหล่น่าน อำเภอเวียงสา จังหวัดน่าน. (EFFECTS OF FOREST FIRE ON ANT DIVERSITY IN THE DRY DIPTEROCARP FOREST, LAI NAN SUBDISTRICT, WIANG SA DISTRICT, NAN PROVINCE) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ.ดร.ดวงแข สิทธิเจริญชัย, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม : อ.ดร.ชัชวาล ใจซื่อกุล, 118 หน้า.

ไฟป่าเป็นภัยธรรมชาติรูปแบบหนึ่งที่ส่งผลกระทบโดยตรงต่อสิ่งมีชีวิตนานาชนิด ในฤดูแล้งป่าเต็งรังในจังหวัดน่านมักได้รับผลกระทบจากไฟป่าเป็นประจำทุกปี งานวิจัยนี้จึงมีวัตถุประสงค์เพื่อศึกษาผลของไฟป่าที่มีต่อความหลากชนิดของมดและเปรียบเทียบสังคมมดระหว่างพื้นที่ป่าเต็งรังที่ถูกไฟไหม้กับป่าเต็งรังที่ไม่ถูกไฟไหม้ โดยเก็บตัวอย่างมด 5 วิธี ได้แก่ การเก็บแบบกำหนดเวลา การใช้กับดักน้ำหวานและโปรตีน การวางกับดักหลุม การร่อนซากพืช และการร่อนดิน ดำเนินการเก็บตัวอย่างทุกเดือนตั้งแต่ เดือนมิถุนายน 2553 ถึงเดือนมิถุนายน 2554 จากการสำรวจและเก็บตัวอย่าง พบมดทั้งสิ้น 53 ชนิด ซึ่งจัดอยู่ใน 30 สกุล ใน 6 วงศ์ย่อย ได้แก่ Aenictinae, Formicinae, Ponerinae, Dolichoderinae, Pseudomyrmecinae และ Myrmicinae พบว่าพื้นที่ป่าเต็งรังที่ถูกไฟไหม้มีค่าดัชนีความหลากชนิดของมดสูงกว่าพื้นที่ป่าเต็งรังที่ไม่ถูกไฟไหม้อย่างมีนัยสำคัญทางสถิติ ($p = 0.032$) ส่วนค่าดัชนีความคล้ายคลึงกันของ 2 พื้นที่มีค่าสูงถึงร้อยละ 79 ซึ่งแสดงให้เห็นว่าสังคมมดทั้ง 2 พื้นที่มีความคล้ายคลึงกันมาก อันเป็นผลมาจากปัจจัยทางกายภาพและปัจจัยทางชีวภาพที่มีความคล้ายคลึงกัน ค่าดัชนีความเด่นของป่าที่ไม่ถูกไฟไหม้สูงกว่าป่าที่ถูกไฟไหม้อย่างมีนัยสำคัญทางสถิติ ($p=0.002$) การเปรียบเทียบความหลากชนิดของมดระหว่างฤดูกาลในพื้นที่เดียวกัน พบว่าในป่าเต็งรังที่ไม่ถูกไฟไหม้ ฤดูฝนมีค่าความหลากชนิดสูงกว่าฤดูแล้ง ส่วนป่าเต็งรังที่ถูกไฟไหม้พบว่าฤดูแล้งมีค่าสูงกว่าฤดูฝน ในป่าเต็งรังที่ไม่ถูกไฟไหม้อยู่ใกล้กับฝายเก็บน้ำจึงมีค่าดัชนีความคล้ายคลึงกันของชนิดมดระหว่างฤดูฝนกับฤดูแล้งสูงที่สุด (82.9%) ซึ่งแสดงให้เห็นว่าผลของการสร้างฝายของมนุษย์มีผลต่อรูปแบบองค์ประกอบทางชนิดของมดระหว่างฤดูกาลในแต่ละพื้นที่ศึกษา ส่วนการวิเคราะห์การแบ่งกลุ่มตามการตอบสนองต่อสภาพแวดล้อมและปฏิสัมพันธ์ของมดในแต่ละสกุล (Functional group analysis) ผลการวิเคราะห์สามารถแบ่งมดออกเป็น 7 กลุ่ม ได้แก่ dominant Dolichoderinae (DD), generalized Myrmicinae (GM), opportunists (OP), Subordinate Camponotini (SC), hot/cold/tropical-climate Specialists (H/C/TCS), cryptic species (CS), และ specialist predators (SP) จากการวิเคราะห์แสดงให้เห็นว่าทั้ง generalized Myrmicinae และ opportunist มีความเด่นในพื้นที่ที่ถูกเผา โดย generalized Myrmicinae มีรูปแบบการกระจายในวงกว้างที่สัมพันธ์กับการรบกวนสภาพแวดล้อมในขณะที่ opportunist (*Paratrechina*) เป็นกลุ่มที่ตอบสนองต่อการเปลี่ยนแปลงได้ดีจึงมีความชุกชุมสูงในพื้นที่ที่ถูกรบกวน ผลของการศึกษาด้วยวิธีการนี้ ทำให้เห็นความสำคัญของมดแต่ละชนิดที่มีต่อระบบนิเวศ อีกทั้งช่วยลดความซับซ้อนของบทบาททางนิเวศวิทยาอันเนื่องมาจากความหลากชนิดของมด และสามารถใช้เป็นเครื่องมือสำหรับการประเมินเพื่อคาดการณ์การตอบสนองของมดต่อการรบกวนจากไฟ ค่าดัชนีความเด่นในป่าเต็งรังที่ไม่ถูกไฟไหม้มีค่าสูงกว่าในพื้นที่ที่ถูกไฟไหม้ โดยพบ *Paratrechina longicornis* มีความชุกชุมสูงที่สุดในป่าเต็งรังที่ถูกไฟไหม้ ส่วนมดแดงส้ม *Oecophylla smaragdina* มีความชุกชุมในป่าเต็งรังที่ไม่ถูกไฟไหม้สูงสุด ค่าดัชนีความคล้ายคลึงกันระหว่างทั้งสองพื้นที่มีค่าสูง เนื่องจากทั้งสองพื้นที่มีความคล้ายคลึงกันในโครงสร้างสังคมพืชและแหล่งที่อยู่อาศัยย่อย ผลการศึกษาครั้งนี้แสดงให้เห็นว่าความหลากชนิดของมดในเผาป่าเต็งรังที่ถูกไฟไหม้มีการฟื้นตัวเป็นผลจากระบวนการเปลี่ยนแปลงแทนที่ทางนิเวศวิทยา

ภาควิชา ชีววิทยา ลายมือชื่อนิสิต ....

สาขาวิชา สัตววิทยา ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

ปีการศึกษา 2554 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม ....

5272237923 : MAJOR ZOOLOGY
KEYWORDS : FIRE / ANT / SPECIES DIVERSITY/ FUNCTIONAL GROUP / DIPTEROCARP FOREST

KHATHA NURAEMRAM : EFFECTS OF FOREST FIRE ON ANT DIVERSITY IN THE DRY DIPTEROCARP FOREST AT LAI NAN SUB-DISTRICT, WIANG SA DISTRICT, NAN PROVINCE. ADVISOR : ASST. PROF.DUANGKHAE SITTHICHAROENCHAI, Ph.D., CO-ADVISOR : CHATCHAWAN CHAISUEKUL, Ph.D., 118 pp.

Forest fire can have direct impacts on various organisms. Dipterocarp forests in Nan province have been consistently burned. However, the effects of the burning on ant diversity were insufficiently reported. This research investigated the effects of forest fire on ant diversity and compared ant communities between two habitats: burned and unburned dry dipterocarp forests. Ants were monthly collected from June 2010 to June 2011 using five methods: pitfall trapping, baiting, soil sifting, leaf sifting and hand sampling. The collected specimens were identified and classified into six subfamilies: Aenictinae, Formicinae, Ponerinae, Dolichoderinae, Pseudomyrmecinae and Myrmicinae. Fifty-three ant species, belonging to 30 genera, were identified. The mean of ant species diversity indices in the burned dipterocarp forest were significantly higher than unburned dipterocarp forest ($p=0.032$). The Sorensen's similarity coefficient was at 79% between the unburned and burned dipterocarp forests. The mean of dominant indices in the unburned dipterocarp forest were significantly higher than burned dipterocarp forest ($p=0.002$). In unburned dipterocarp forest, the Shanon-Weiner's species diversity index in the wet season (2.917) was higher than in the dry season (2.680), whereas in the burned dipterocarp forest, the diversity in the dry season was higher than in the wet season. The Sorensen's similarity coefficient in the species composition between wet and dry seasons was highest in the unburned dipterocarp forest (82.9%). This pattern of species composition of ant indicated that the reservoirs could affect to the variation pattern in species composition between seasons in these areas. Afterwards, the ants were classified by their functional groups as dominant Dolichoderinae (DD), generalized Myrmicinae (GM), opportunists (OP), subordinate Camponotini (SC), hot/cold/tropical climate specialists (H/C/TCS), cryptic species (CS) and Specialist Predators (SP). Functional group analysis showed that both generalized Myrmicinae and opportunists were dominated in the burned area. GM had broad distribution patterns in relation to environmental stress and disturbance while the opportunists (*Paratrechina*) were largely unspecialized and submissive species. They showed a wide habitat distribution and were most abundant in habitats under stress or disturbance where other more dominant groups were limited. This approach allowed us to emphasize the ecological role of each species, reduce the ecological complexity on ant diversity and generate a predictable assessment tool of ant responses to fire disturbance. The dominance index in the unburned area was found to be higher than that in the burned area. The dominant species found in the burned dipterocarp forest was *Odontoponera denticulata* whereas weaver ant, *Oecophylla smaragdina,* dominated in the unburned area. The high similarity index between both areas suggested the similarity in vegetation structures and microhabitats. The results reveal that ant diversity in the burned dry dipterocarp forest has been recovering which may be caused by re-colonization of ecological succession and the new habitat characteristics.

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

Natural disturbances are important events affecting community structure. Disturbances, by reducing biomass and creating variations in the availability of resources, can alter species richness and dominant species in community. If the disturbance reduces the abundance of the dominant species, by preventing the domination of limiting resources, diversity can increase (Cornell, 1978). In contrast, a reduction in diversity may be expected when the changes caused by the disturbances resulting in the elimination of species and favour the dominant species (Pickett & White, 1985). Whether diversity will increase or decrease after a disturbance depends on intrinsic characteristics of disturbances (e.g. frequency) and the characteristics of the disturbed habitat (e.g. the existence of competitive hierarchies). However, the disturbance of natural vegetation, by human activities such as agriculture and grazing livestocks, has a very significant effect on soil communities, reducing the diversity and density of these populations (Cancela da Fonseca, 1990).

Fire is the most common disturbance that can cause large scale and dramatic changes in species diversity and, therefore, has attracted considerable research effort (Whelan, 1995). In addition, fire is a major disturbance leading to numerous changes in an ecosystem because forest fire has accumulated several impacts on the environment frequent by reducing plant growth and animal habitats. Moreover, forest fire can contribute to the rising of global temperature. However, fire has long been used in Thailand for agricultural management, and underbrush clearing in forest for the case of foraging of some forest products, such as wild mushrooms. However, very little is known about the effect it has on the environment, particularly the direct impact on living organisms.

Ants are abundant and widely distributed insects that are considered important in ecosystem function as they can play a central role in ecological processes, such as nutrient cycling, seed dispersal and the population regulation of other insect (Hölldobler & Wilson, 1990; Folgarait, 1998). Furthermore, ant assemblages are frequently structured through competitive hierarchies (Hölldobler & Wilson, 1990). These reasons make ant assemblages appropriate to study the effects of disturbance on insect community structure in different habitats. One of the most common habitats prone to fire whether natural-caused or human-initiated is the dry dipterocarp forest, particularly in northern Thailand, such as in Nan province. Nevertheless, the effects of burning on ant diversity in this habitat has not been elucidated. Consequently, it is important to know whether the forest fire can affect the composition and structure of ant species in the areas.

Dry Dipterocarp forest, which the name commonly used for the characteristic forest association of the Central Indochina Dry Forests, that dominated by deciduous trees. Deciduous species of family Dipterocarpaceae (literally “Two-winged fruits”) plays important roles in ecosystem and economics of Asian forest (Corlett and Primack, 2005).The only six species of the approximately 550 dipterocarps in the world are deciduous. Four of these dipterocarps, *Shorea siamensis, S. obtusa, Dipterocarpus obtusifolius,* and *D. tuberculatus*, generally form the dominant biomass and cover in northern of Thailand. Ground fires burning through the herbaceous understory of deciduous dipterocarp forests are a common aspect of the environment, so this association is sometimes called a fire climax community. The question, therefore, is how much of this community has been formed by a history of human activities that have greatly increased the frequency of such fires. Most fires occur between December and early March, when forest conditions are driest. Dominant tree species in this formation exhibit adaptations to fire in the form of thick, corky bark to protect cambium tissues and root crowns, which readily re-sprout (Scott, 1986, cited in Sriganha and Gajaseni, 1999; Smitinand, Santisuk, and Phengklai, 1980; Newbery et al., 1992, cited in World Wildlife Fund, 2001).

The aims of this research are to investigate the effects of forest fire on ant diversity and to compare ant communities between two habitat types: burned dry dipterocarp forest and unburned dry dipterocarp forest, in Nan province. The study will provide some valuable data for both land usage planning in the burned forest and natural management in this area.

Objectives

1. To determine and compare ant species diversity between burned and unburned dry dipterocarp forests in the Chulalongkorn university forest and research station, Lai-Nan subdistrict, Wiang Sa district, Nan province.
2. To study the relationship between physical factors and the abundance of some important ants in the burned and unburned dry diptercarp forests in the Chulalongkorn university forest and research station, Lai-Nan sub-district, Wiang Sa district, Nan province.

CHAPTER II

LITERATURE REVIEW

2.1 Diversity of ants

Ants are classified in a single family, Formicidae, belonging to Order Hymenoptera (Hölldobler and Wilson, 1990). There are 23 subfamilies of ants comprising of 287 genera and approximately 12,000 described species, with a likely much larger number of species yet to be described worldwide (Bolton et al., 2006). Despite the fact that tropical forests are among the poorest surveyed areas, they still have the highest recorded species diversity, for example, approximately 2,200 species were recorded in Asia (Hölldobler and Wilson, 1990). In Thailand, there are nine recorded subfamilies: Aenictinae, Cerapachyinae, Dolichoderinae, Dorylinae, Formicinae, Leptanilliae, Myrmicinae, Ponerinae and Pseudomyrmecinae (Wiwatwittaya and Jaitrong, 2001).

The diversity of ants is very high in various localities. In wet tropical forests in eastern Madagasgar, 471 species belonging to 36 genera were found (Fisher, 2000). A survey of a primary rain forest in Kinabalu National Park, Sabah, Borneo yielded 524 species, belonging to 7 subfamilies and 73 genera (Brühl, Gunsalam, and Linsenmair, 1998), while 120 species belonging to 5 subfamilies and 49 genera were recorded in the Pasoh Forest Reserve, west Malaysia (Malsch, 2000).

Ant species diversity was studied in many parts of Thailand. Wiwatwitaya and Jaitrong (2001) reported 9 subfamilies, 73 genera and 246 species; and Phoonjumpa (2002) reported 9 subfamilies, 59 genera and 224 species in Khao Yai National Park. In Bala forest at Hala-Bala Wildlife Sanctuary, Naratiwat province, 255 species in 63 genera belonging to 8 subfamilies were found (Noon-anant, 2003). Hasin (2008) reported 9 subfamilies, 56 genera and 131 species at Sakaerat Environmental Research Station, Nakhon Ratchasima Province. Sitthicharoenchai and Chansawat (2006) reported 46 species in 18 genera belonging to 5 subfamilies in the Chulalongkorn University Forestry and Research Station at Lai-Nan Sub district, Wing Sa district, Nan province. However, most of these studies reported high diversity of ants in nature forest of Thailand. In contrast, there is limited information on ant diversity in the disturbance area.

2.2 The function of ant in ecosystem

Although the proportion of biomass that represented by ground-dwelling ants was higher in comparison with other soil macro-fauna such as termites and earthworms. In the tropics which biomass proportion varied from relatively low (0.02-5%) to high (80%)(Hölldobler and Wilson, 1990). However, in terms of population density, when at a low relative biomass, ants make a far larger contribution ranging typically from 7-53% (Lavelle and Pashanasi, 1989). One third of the entire animal biomass of Amazonia terra firme rain forest was composed of ants and termites, with each hectare of soil containing in excess of million ants and one million termites (Hölldobler and Wilson, 1990). Actually, both arboreal and ground-dwelling ants play important role in ecological function. According to the abundance of ants, niche specialization has produced a spectacular array of interactions between ants and other organisms. They play important roles in an ecosystem as preys to anteaters and humans, predators to microorganism and small insects, detritivores, mutualistic relationship with plant (ant-acacia mutualism) and some animals (ant-aphid mutualism), herbivores as a cryptic herbivory (leaf-cutter ants, they always harvest fungus by using leaves) or combinations. Their functions are usually related to species and genera which they belong to, such as generalized Myrmicinae, specialist predator and climate specialist (Alonso, 2000; Schultz and McGlynn, 2000; Andersen, 1990). In addition, they create mycorrhizal reservoirs affect nutrient immobilization, water movement, nutrient cycling, soil movement and other physical and chemical changes to soil profile (Folgarait, 1998; Philpott and Armbrecht, 2006).

2.3 Advantage for using the ants as a biological monitoring parameter to environmental change

Ants have numerous advantages over vertebrates and other arthropods in studies of landscape disturbance and species diversity (Graham et al., 2004); and these make them suitable for biodiversity and environmental monitoring studies. Ants are eusocial organisms that characterized by cooperative brood care, they also have overlapping generations of workers within their colony and a highly developed caste system (Agosti et al., 2000), which contribute towards the ants' numerical and biomass dominance, high diversity and their presence in almost every habitat throughout the world (Alonso and Agosti, 2000). Furthermore, ants, as bio-indicators of ecological niches especially soil systems, have other advantages such as a fairly good existence taxonomic knowledge for ease of identification, their relative ease of collection, stationary nesting habitats that allow them to be resample overtime and their relative sensitivity to environmental changes (Alonso and Agosti, 2000; Andersen et al., 2002). Moreover, ants are an ideal bio-indicator group for a conservation program. Amount of ant species have narrow tolerance and thus quickly respond to environmental changes. Ants' small size and reliance on relatively high temperatures make them especially sensitive to climatic and microclimatic changes. In addition, some ant colonies are long lived and have permanent nests that can be marked and revisited. Long-lived species can be monitored for the health of colony as surrounding environmental changes. In contrast, short-lived ant species may show high turnover and immediate responses to a stressed environment. Ant assemblages allow a monitoring program that is sensitive to change on a number of temporal scales (Kaspari and Major, 2000). Thus overall, as well as broadly common species, most habitats are likely to have specialized species which occur in sufficient numbers of species and abundance as to serve as suitable terrestrial indicator species of habitat quality and changes. In Thailand, Phoonjumpa (2002) reported the ant as an indicator in each plant community at Khao Yai National Park. In addition, Senthong (2003) studied the relationship between ant distribution and air quality variation in urban communities of Bangkok and stated that ants could be preliminary used to monitor air quality in urban area. Moreover, Thienthaworn (2004) reported that *Monomorium floricola, Paratrechina longicornis* and *Plagiolepis* sp.3 of AMK seemed to show the preliminary potential to be air pollution bioindicators at the area surrounding Ratchaburi Power Plant, Ratchaburi province.

2.4 Influence of the physical factors on the ant diversity

Several physical and biological factors could affect species richness and abundance of ant communities inhibiting particular environments (Ríos-Casanova, Valiente-Banuet, and Rico-Gray, 2006) because ants are small in size that make they heat up and dry out more quickly; physical factors such as temperature, solar radiation and water could play important roles in determining ant diversity (Bestemeyer, 1997). Ants, as ectotherms, are constrained to forage when they are warm enough, but not too warm. The results in which most ants forage at temperatures are greater than 10°C and cease foraging much above 40°C with an average peak foraging temperature of 30°C (Hölldobler and Wilson, 1990). These environmental conditions can limit the distribution and abundance of ants. In Bala Forest at Hala-Bala Wildlife Sanctuary, Narathiwat province, Noon-anant (2003) found that the temperature was positively correlated with number of species of *Pheidologeton*, but negatively correlated with number of species of *Acanthomyrmex, Cataulacus* and *Crematogaster*. Seasonal change influenced the number of species in genus *Aenictus, Pheidole* and *Pyramica,* with significant difference between the wet and dry seasons. In addition, Menke and Holway (2006) examined which abiotic factors determined successful expansion for the non-native species. Their research primarily focused on how levels of soil moisture and plant cover affected invasion rates. Their results revealed that soil moisture was demonstrated to influence the invasion potential of Argentine ants tremendous.

2.5 Effects of environmental stress and disturbance

Disturbance is defined as the removal of biomass, for most animals it is caused mortality. However, ants are modular organisms, and many “modules” (individual ants) can be lost without necessarily threatening the reproductive unit (the colony), in a manner analogous to the effects of herbivory on plants. Consequently, combined with protection provided by nests, especially those in the soil, habitat disturbance is often not much of a disturbance to ants at all, unless it is so severe that it causes widespread destruction of colonies. The major effects of habitat disturbance are often indirect and stress related, influencing habitat structure, microclimate and food supplies (Wilson, 2000).

2.6 Methods to estimate ant diversity and abundance

In general, ants are very easy to sample. Baiting techniques, pitfall traps, aspirators, litter sifting, Berlase-Tullgren or Winkler funnels for litter or soil core samples and hand collection with forceps or nets are among the most common methods to sample ground-dwelling ants. All these methods are easy to use, cheap and not incredibly time consuming (Hölldobler and Wilson, 1990). A comparison of the litter and soil ant fauna has showed that a combination of pitfalls, litter sifting, baiting and hand sorting increase the efficiency of species captures in comparison to any single method by itself (Majer and Delabie, 1994). The combination of methods will ensure the complete a representation of the ant fauna as can be expected. The success of any sampling protocol used alongside each method, as well as a careful interpretation of data that accounts for the limitation of the methodology (Bestemeyer et al., 2000). In fact, numerous studies have pointed out the need to use more than one method in quantifying ant diversity (Olson, 1991; Bestemeyer et al., 2000; Hashimoto, Yamane, and Mohamed, 2001).

2.7 Effect of fire on ant diversity

Fire can clarify the natural environments that affected ant community characteristics (Farji-Brener et al., 2002). In addition, fire also can decrease nest sites and food availability of ants, and modify some variations of microclimate (Farji-Brener et al., 2002). Fluctuations in animal species richness in relation to fire are perhaps best known for small mammals and birds. Changes in animal component of community certainly occur after fire, with some species disappearing, and then re-appearance of species at different times during vegetation recovery. According to Farji-Brener et al (2002), they reported that the effect of fire history on ant assemblage seemed the pattern described for vegetation cover and also depended on habitat types. In contrast, fire represented a major disturbance that reduced vegetation cover, approximately 80%. Following such changes, ant diversity was significantly reduced in burned areas. Furthermore, Castaño-Meneses and Palacios-Vargas (2003) found that extremely severe fires greatly decreased ant diversity. The most important effect of fire was the reduction of ant density and the change of species composition including trophic guilds. On the other hand, Sanders et al. (2005) stated that the effect of disturbance that caused by fire on ant assemblages depended on habitat types. Species-specific responses to habitat types and disturbance by fire were characteristically attributed. Moreover, the result insisted that assemblage composition also depended upon habitat types, but not disturbance by fire. However, ant assemblages were affected by fire and they had changed rapidly following disturbance, suggesting that ant may deserve to be good naturally bio-indicators of habitats where caused by fire disturbance and restoration management (Sanders, 2005).

2.8 Effects of fire on properties of forest soils

Fires are considered as major features of forest disruption and renovation. Many physical, chemical, mineralogical and biological soil properties could be affected by forest fires. The effects are able to indicate a result of burn severity, consists of peak temperatures and duration of the fire. Properties of forest soils that affected by fires as physical, physic-chemical and mineralogical properties, such as water repellence, the natural water repellence of soil often increases due to the formation of a continuous water-repellent layer a few centimeters under the surface. It was implied that soil permeability are decreased, therefore, the runoff and erosion are increased (Imeson et al., 1992). As soil structure stability, the structural complexity decreased because of the combustion of organic cements (Mataix-Solera and Doerr, 2004; Boyer and Miller, 1994; Badìa and Martì, 2003 cited in Certini, 1995). Bulk density was increased because of the collapse of the aggregates of organo-mineral and the voided clogging by the ash and the dispersed clay minerals; as a consequence, soil porosity and permeability decreased (Giovannini et al., 1988; Durgin and Vogelsang, 1984; Martin and Moody, 2001 cited in Certini, 2005). For particle-size distribution, is not a directly affected by forest fires, however, the increased erosion could be removed selectively the fine particle (Oswald et al., 1999; Mermutt et al., 1997). Soil pH, was increased by the heat of soil due to organic acids denaturation. Because the alkaline cations (Ca, Mg, K, Na) that bound to the organic matters were released (Macadam, 1987; Naidu and Srivasuki, 1994; Hernandez et al., 1997 cited in Certini, 2005). Mineralogical assemblage could be changed, but occurred only at temperature raised above 500 °C (Tan et al., 1986 cited in Certini, 2005). Soil color was changed because the ground was covered by a layer of black or gray ash that would be stayed until the re-colonization of plant community. As a previous studied by Ulery and Graham (1993) found that the temperature regime temporarily changed because the vegetation covers were disappeared and the ground was darkened that decreased heat refection. Furthermore, soil chemical properties as quantity and quality of organic matter were decreased suddenly after fire and changed remarkably, with a relative enrichment of the fraction more recalcitrant to biochemical attack. This is because of selective burning of fresh residues (leaves, twigs, etc.), and new formation of aromatic and highly polymerized (humic-like) compounds (Certini, 2005). Moreover, some effects of fires on biological properties of forest soil could be decreased microbial biomass but the recovery of per-fire level depended necessarily on soil moisture that caused plant re-colonization (Certini, 2005). As some previous study that conducted by Bååth et al., (1995) demonstrated that the burning also could be altered the specific composition of soil microbial community such as, decrease in basidiomycetes. In addition, the specific assemblage of mycorrhizal fungi also decreased as a result of burning (Baar et al., 1999). Typically, the direct effects of fire on soil-dwelling invertebrate are less marked than those on micro-organisms, as a result of the higher mobility of the invertebrates that enable a greater potential to escape heating by burrowing deep into the soil. However, the indirect effects of fire, particularly the reduction of litter biomass and number of species of soil dwelling invertebrates (Certini, 2005).

2.9 Effects of fires on physical factors

The physical conditions prevailing after fire are usually very different from pre-fire situation. Many of these differences will have profound implications for the recovery of the living organisms. As some published literatures that proposed by Old (1969), Knapp (1984), Mallik (1986) and Ewing and Engle (1988), provided some information in health land and grassland. In summary, these studies indicated that fire increases maximum temperatures at the soil surface, light intensity, wind speed and the vapor-pressure deficiency. According to soil temperatures, some previous studies revealed that daily soil temperatures are usually altered after fire, burned sites was generally cooler at canopy level but warmer in the soil 1 cm below the surface, with potential consequences for plant productivity, for activity of soil organisms (Ewing and Engel, 1988 cited in Whelan, 1995). These effects are caused by a combination of several factors, including the removal of shading usually provided by the vegetation, the removal of the insulative effect of litter (Ahlgren and Ahlgren, 1960; Old, 1969 cited in Whelan, 1995). In addition, the removal of all or some of the above-ground biomass by fire affects the wind profile in an area. As a previous study that proposed by Old (1969), measured wind speeds at different heights of pairies vegetation last burned at different times prior to the study. However, it is perhaps surprising that studies like this one did not appear to have been conducted in other, more complex vegetation types (Whelan, 1995). As the ecological consequences of increased wind speed after fire include more rapid desiccation of animal habitat, plant parts and soil, that greater potential for erosion and greater dispersal of some seeds (Whelan, 1995). Moreover, the moisture-holding capacity of the soil is also enhanced the amount of organic matter. Fire reduced the content of organic matter and therefore decreased the moisture-holding capacity (Neal et al., 1965 cited in Whelan, 1995).

CHAPTER III

STUDY AREAS

The study sites were in a dry diptercarp forest, located in the Chulalongkorn University Forest and Research Station, Lai-Nan subdistrict, Wiang Sa district, Nan province, northern Thailand. Two study sites were selected based on difference in the forest fire burning: (i) a natural habitat where represented by an unburned dry dipterocarp forest and (ii) a disturbed habitat that caused by fire where represented by burned dry dipterocarp forest (Fig. 3.1). Both study sites were located on the Wa river catchment, a small catchment basin of Nan river, which was one of four major watersheds in the north of Thailand. Overall area was the low level forests, settled 800 m higher above medium sea level. Boundary areas were placed between the UTM zone 47Q; N2051960-2054260 and E0688400-0690360 (Damrongrotwatthana, 2004).

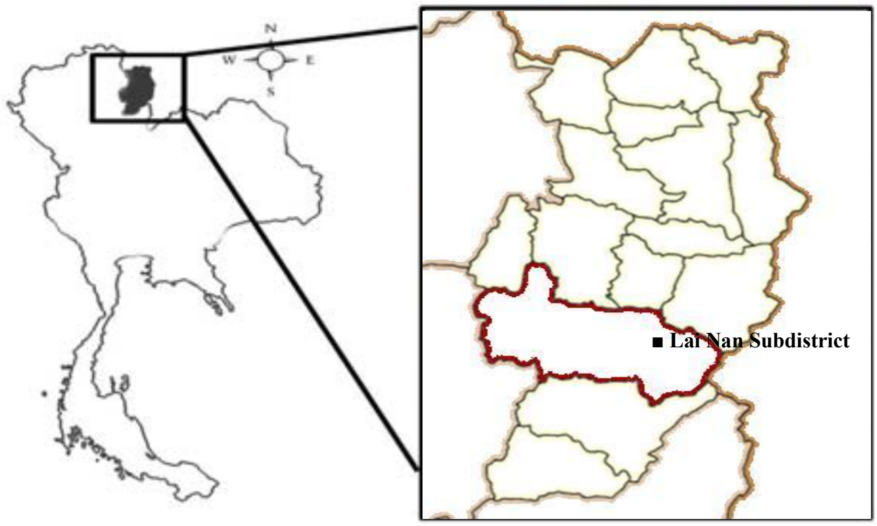


Figure 3.1 Map of Nan province, Thailand. Depicting Lai Nan sub-district, Wiang Sa district, Nan province

A. Unburned dipterocarp forest

B. Burned dipterocarp forest

Figure 3.2 The two study sites **A**. unburned dipterocarp forest, **B**. burned dipterocarp forest in Lai Nan sub-district, Wiang Sa district, Nan province

3.1 Unburned dry dipterocarp forest (Figure 3.2 A)

Most parts of the Chulalongkorn University Forest and Research Station are covered by dry dipterocarp forest. Dry dipterocarp forest, the name commonly used to characterize forest association of the Central Indochina Dry Forests, which forms an open forest or woodland community dominated by deciduous trees. Deciduous plant species of Dipterocarpaceae formed the dominant element of deciduous dipterocarp forests. Only six species of the approximately 550 dipterocarps in the world are deciduous, and all of these occur in this following formation. Four of these, such as *Shorea siamensis, S. obtusa, Dipterocarpus obtusifolius* and *D. tuberculatus,* generally form the dominant biomass and cover (Kanjanawanit, 1992; Newbery et al., 1992). As a previous studied by Damrongrojwatthana (2004) reported that there were four highest species of Dipterocarpaceae that were found in dry dipterocarp forest of Chulalongkorn University Forest and Research Station, the highest species of Dipterocarpaceae was *Shorea obtusa* (60,662 individuals), followed by *Dipterocarpus tuberculatus* (47,382 individuals), *Dipterocarpus obtusifolius* (34,424 individuals) and *Shorea siamensis* (11,042 individuals), respectively. Besides, there were other species that reported such as *Tectona grandis*, *Afzelia xylocarpa*, *Xylia xylocarpa*, *Pterocarpus macrocarpus*, *Dalbergia oliveri*, *Lagerstroemia duperreana*, *Lagerstroemia floribunda*, *Irvingia malayana*, *Hopea odorata* and *Shorea roxburghii*.

3.2 Burned dry dipterocarp forest (Figure 3.2 B)

Fire is prevalent in the dry deciduous forests of south-east Asia, the majority of fires caused by man-made (Scott, 1988). In Thailand, the 10-19% estimated extent of annual burning of dry deciduous dipterocarp forest (1984-1986 data on total estimated area burned each year; Settarak et al. 1987) is thought to be a severe under-estimate (Kanjanavanit, 1992). In Nan province, northern Thailand, most of dry dipterocarp forest, approximately 80 percent of dipterocarp area, had been commonly burned by local people. In summer (March 2010), the local people burned the dry dipterocarp forest floor and tree trunks in every year to collect weaver ant's eggs which is a famous local food, birds shooting; *Eudynamys scolopacea, Coracias benghalensis, Dicurus* sp. and animal hunting such as *Lepus peguensis, Cannomys* sp. (Damrongrotwatthana, 2004; Sitthicharoenchai and Chantarasawat, 2006). In addition, the local people not only burned for ant's eggs but also they burned for harvesting Barometer Earthstar *(Astraeus hygrometricus)* which is a famous endemic mushroom in this area. Consequently, the burning dramatically changes the tree structure and microhabitats. Effects of fire on soil color are found: in the burned dipterocarp forest, on the ground is covered by a thin layer of black or grey ash that stay until plant re-colonization. The mortality after burning of undergrowth which included herb, forbs, small shrubs and grasses was 100 %. The density of seedlings was increased after burning.

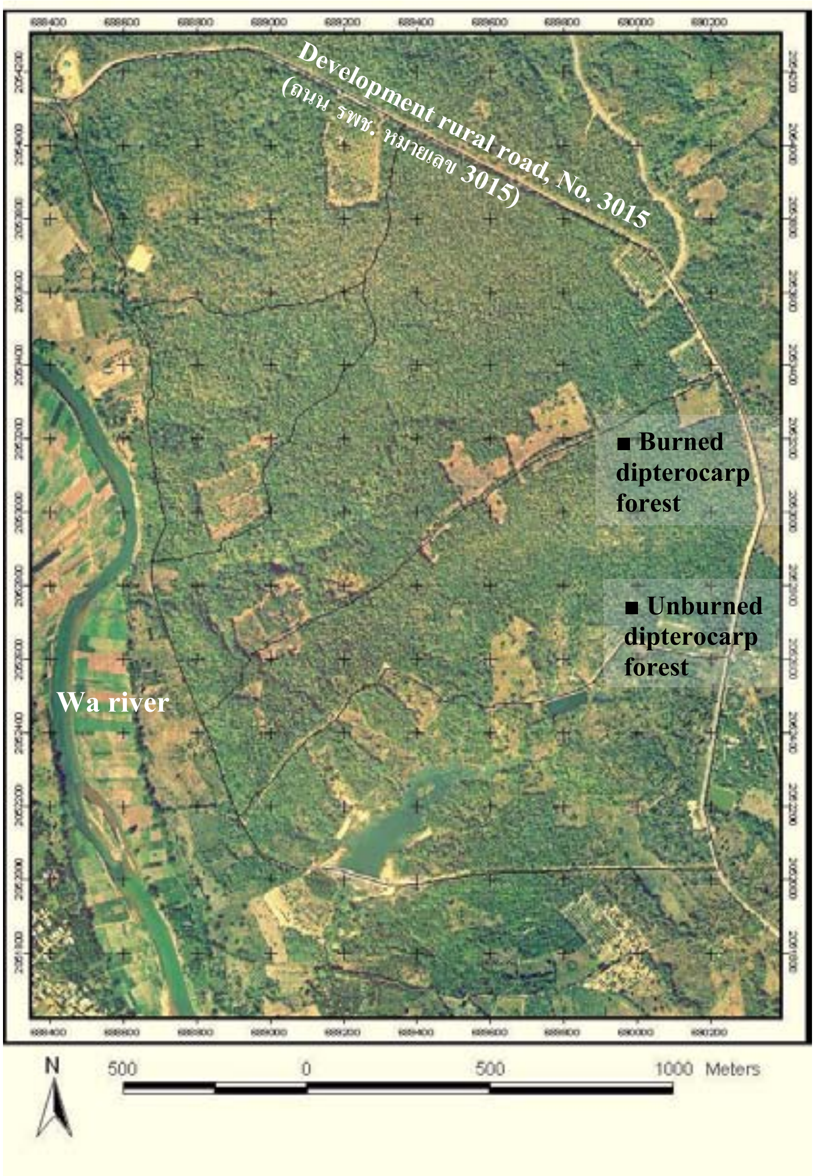


Figure 3.3 The study site map in Lai Nan sub-district, Wiang Sa district, Nan province of Thailand, depicting the two study sites sampled in 2010 – 2011: Unburned and Burned dipterocarp forests.

CHAPTER IV

ANT SPECIES DIVERSITY IN BURNED AND UNBURNED DRY DIPTEROCARP FORESTS

4.1 Introduction

Ants play important roles in the ecological functions. They have played many roles in an ecosystem as preys, predators, herbivores, detritivores and mutualists. Ant functions are related to species and genera that they have belonged to, such as generalized Myrmicinae, climate specialist and specialist predators (Alonso, 2000; Schultz and McGlynn, 2000). In addition, ants also have numerous advantages which make them as ideal species for biodiversity and environmental monitoring studies. In addition, ants are eusocial insects that contributing to numerical and biomass dominance, high diversity and also presence in almost terrestrial habitat throughout the world. Moreover, they also have several other advantages, such as well-known taxonomic information, simple collection, and their stationary colonial habits that allow them to be resample overtime. Furthermore, they are good as bio-indicators which are sensitive to environmental changes (Alonso and Agosti, 2000).

Nan is one of the northern provinces of Thailand, where is located in the remote valley of Nan river, surrounded by forest-covered mountains. Therefore, it has a high diversity of habitat types and organisms, especially insects. Insects are one of the most diversified organisms. According to all the worldwide varieties of insects on earth, ants are completely recognized. They were classified to Family Formicidae, Order

Hymenoptera, Class Insecta, which belonged to Phylum Arthropoda. These kinds of insects are very interesting not only because of their high potential worldwide distribution but also because of their important roles in global ecosystem (Agosti et al., 2000; Dunn, 2005; Hölldobler and Wilson, 1990).

The Chulalongkorn University Forest and Reseach Station where was developed by Chulalongkorn University to increase the academic opportunity for local people who lived in Nan province. Almost of these areas are composed of dry diptercarp forests where have been disturbed by many land utilization such as deforestation, mango and tamarind plantation, livestock, and forest fires.

Fire is the most common disturbances that can cause large scale and dramatic changes in species diversity and therefore has attracted considerable research effort (Whelan, 1995). In addition, fire is a major disturbance that leading to numerous changes in an ecosystem because forest fire occurrence has amount of impacts on the environment. It reduces forest area. Moreover, forest fire can cause the rising of global temperature. However, fire has long been used in Thailand for agricultural management, but very little is known about the effect it has on the environment, particularly the direct impact on living organisms, especially the ants. In the recent times, the dry dipterocarp forest in Nan province had been commonly burned, nevertheless effects of this burning on ant diversity are unknown. Consequently, it is important to know whether the forest fire can affect the composition and structure of ant species in the areas. This research investigated the effects of forest fire on ant diversity and compared ant communities between two habitat types: burned deciduous dipterocarp forest and unburned deciduous dipterocarp forest, in

Nan province. The study provided some valuable data for both land usage planning in the burned forest and natural management for conservation in the future.

4.2 Materials and Methods

4.2.1 Sampling methods

In each the two habitat types (the study site was described in Chapter III), a permanent plot of 10 x 25 m^2 was selected as a sampling area. The surveys at each site were conducted 13 months, from June 2010 to June 2011 inclusively. Five sampling methods were used to collect the ants for studying the species diversity of ants in each habitat.

4.2.1.1 Handling capture with constant time

Each permanent plot (10x25 m^2) was divided into ten small quadrats (5 x 5 m^2), and one person collected the ants for 30 minutes along the quadrat margins. The ants in each habitat were collected in three alternating time periods, in the morning, late morning and in the afternoon. The ants were intensively searched for on the bare ground, in the leaf litter, under stones, in decaying logs and under and on shrubs/herbs and from based up to 1.5 m on trees. The ants were collected by using sharpen forceps and gathered into a plastic micro-tube filled with 95% ethyl alcohol. Each tube was labeled according to its plot, study site, collecting method and collecting date. The handling capture samplings had been conducted once every month for 13 months. All alcohol-preserved specimens were brought back to an entomological laboratory in the

Department of Biology, Faculty of Science, Chulalongkorn University for identification and classification.

4.2.1.2 Sugar-protein baiting trap (modified from Bestelmeyer et al., 2000)

4.2.1.2.1 Sugar baiting trap

Each permanent plot was divided into ten smaller quadrats (5 x 5 m^2). Eighty percent sugar solution was used as the bait. Two grams of bait were placed directly at the center of a piece of cotton cloth (5 x 5 cm^2). The bait cloth was placed on each quadrat, and the ants on the cloth were gathered after 45 minutes. The ants found in the cloth piece were collected into a plastic micro-tube filled with 95% ethyl alcohol. Each of the micro-tube was labeled according to its plot, study site, collecting method and collecting date. The specimens were taken back to the laboratory, classified and counted individually. In total, there were 15 sugar baits per each study site and the bait samplings were conducted once every month for 13 months.

4.2.1.2.2 Protein baiting trap

Each permanent plot was divided into ten small quadrats (5 x 5 m^2). Canned tuna fish in mineral water was used as the bait. Two grams of bait were placed directly on the center of a piece of cotton cloth (5 x 5 cm^2). The bait cloth was placed on each quadrat, and the ants on the cloth were gathered after 45 minutes. The ants found on the cloth piece were collected into a plastic micro-tube filled with 95% ethyl alcohol. Each micro-tube was labeled according to its plot, study site, collecting method and collecting date. The specimens were taken back to the laboratory, classified and counted individually. In total, there were 15 protein baits per each study site and the baited samplings were conducted once every month for 13 months.

4.2.1.3 Pitfall trap (modified from Bestelmeyer et al., 2000)

Each permanent plot was divided into 10 small quadrats (5 x5 cm^2). In total, there were 30 quadrats per each study site. A hole was dug at the center of each quadrat. A plastic container (8 cm diameter x 12 cm height) was placed in each hole with the lip of the trap at the level of the soil surface. Petroleum gel was applied around the inner lip of trap and 2% (v/v) (alkylbenzene sulfonate Sunlight®, Unilever Thai Holding Comp.) detergent solution was poured into the trap to a depth of about two cm. The samples were collected after 24 hours and preserved in labeled plastic micro-tubes contain 95% ethyl alcohol. Each micro-tube was labeled according to its plot, study site, collecting method and collecting date. The specimens were taken back to the laboratory, classified, and counted individually. The pitfall trap samplings were conducted once every month for 13 months. Each trap was not put directly on any ant nest.

4.2.1.4 Leaf litter sifting

Each permanent plot was divided into 10 small quadrats (5 x5 cm^2). In total, there were 30 quadrats per each study site. The leaf litter was collected from within a 1 x 1 m^2 quadrat positioned at random in each selected 5 x 5 m^2 quadrat. In total, there were 30 leaf litter samples per each site. After collection, the leaf litter samples were sieved with 0.8 x 0.8 cm^2 mesh and the ants were collected using forceps and gathered into a plastic micro-tube that was filled with 95% ethyl alcohol. Each micro-tube was labeled according to its plot, study site, collecting method and collecting date. The specimens were taken back to the laboratory, classified, and counted individually. Leaf litter sifting samplings were conducted once every month for 13 months.

4.2.1.5 Soil sifting

The soil was sampled in the same sampling quadrat 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 to five cm of depth from the soil surface. The soil samples were sieved with 0.8 x 0.8 cm^2 mesh and the ants were collected using forceps and gathered into the plastic micro-tube that was filled with 95% ethyl alcohol. Each micro-tube was labeled according to its plot, study site, collecting method and collecting date. The specimens were taken back to the laboratory, classified and counted individually. Soil sifting samplings were conducted once every month for 13 months.

4.2.2 Study of physical factors

4.2.2.1 Soil physical factors

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

4.2.2.1.1 Soil moisture content (Gardner et al., 2001)

The soil moisture content was measured by incubating 50 g of soil in an oven at 105°C. 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 no change in 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:

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

4.2.2.1.2 Soil temperature

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

4.2.2.1.3 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 was immersed into the soil suspension and the changed color was compared with standard color.

4.2.2.2 Relative humidity and air temperature

The relative humidity and air temperature were measured, in the same sampling quadrat as soil moisture content were measured, by a digital thermo-hygrometer in the field.

4.2.2.3 Monthly total rainfall

The monthly total rainfall data during the study period was obtained from the meteorological station at Nan province.

4.2.3 Ant identification

The specimens were card mounted in standard from for identifying to the genera and species level. The identification was based on the keys created by Bolton (1994) and Wiwatwitaya and Jaitrong (2001). The specimens were also compared with reference collections at Ant Museum, Faculty of Forestry, Kasetsart University and Natural History Museum, Department of Biology, Faculty of Science, Chulalongkorn University. In contrast, unidentified specimens were coded based on their reference collections, for example the sp. of AMK is referred to the code of Ant Museum, Kasetsart University, the eg. Following with a number is the code of Katsuyaki Eguchi, and the sp. of CUMZ is the code of Chulalongkorn University Museum of Zoology.

4.2.4 Data analysis

The Shannon-Weiner's species diversity index (Krebs, 1999), was used to calculate the diversity of ants collected from four of the collection methods, i.e. the sugar-protein baiting trap, pitfall trap, leaf litter sifting and soil sifting, 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:

$$H' = -\sum_{i=1}^{s}(pi)(lnpi)$$

where, *H'* = Species diversity index

S = Number of species

Pi = 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 follows:

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

where, H' = Observed index of species diversity

H'_{MAX} = Maximum possible index of diversity

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

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

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

4.3 Results

4.3.1 Species richness of ant between two study sites

Across the two sites, 53 ant species and morphologically recognizable taxa from 29 genera were collected which presents a reasonably good species richness. As showed in Table 4.1, these collected ants belonged to the six subfamilies; Aenictinae, Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. The highest percentage of ant species number was Myrmicinae (45%), followed by Formicinae (23%) and Ponerinae (17%), respectively, and other families were lower than 10% (Figure 4.1). The genus *Monomorium* contained the highest species number (7), followed by the genus *Paratechina*, *Tetramorium*, *Camponotus*, *Crematogaster*, *Pheidole* and *Pachycodyla* which has 5, 4, 3, 3, and 3 species, respectively. However, some genera were found only 1 or 2 species, such as *Tetraponera*, *Oecophylla*, *Odontoponera*, *Tapinoma* and *Pheidologeton* (Table 4.1).

The total number of subfamilies, genera and species in burned dipterocarp forest were 6 subfamilies, 25 genera and 41 species, respectively but in unburned dipterocarp forest were 5 subfamilies, 25 genera and 41 species, respectively (Table 4.2).

In both areas, there was no subfamily Aenictinae found in the unburned dipterocarp forest. Myrmicinae was the subfamily that found the highest in species number in both study sites (Figure 4.2). Aenictinae was found only one species in the burned dipterocarp forest.

Some species, such as *Odontoponera denticulata*, *Oecophylla smaragdina*, *Camponotus sericeus* and *Paratechina longicornis*, were found in both sites, while other species, such as *Aenictus* sp., *Monomorium* *sechellense*, *Paratechina* sp.8 of AMK, *Polyrhachis proxima*, *Solenopsis geminata* and *Tetramorium walshi*, were found only in burned dipterocarp forest. On the other hand, some ant species, such as *Anochetus graeffei*, *Anoplolepis gracilipes*, *Pachycondyla luteipes*, *Pachycondyla astuta*, *Paratechina* sp.9 of AMK, *Philidris* sp.1 of AMK, *Ponera* sp. and *Tetramorium* sp.10 of AMK, were found in unburned dipterocarp forest (Table 4.3).

Table 4.1 The subfamily*, genera, and number of species in overall study site at Lai-Nan sub-district, Wiang Sa district, Nan province

Subfamily	Genera	Number of species
Aenictinae (2%)	*Aenictus*	1
Formicinae (23%)	*Anoplolepis*	1
	Camponotus	3
	Oecophylla	1
	Paratechina	5
	Polyrhachis	1
	Plagiolepis	1
Dolichoderinae (9%)	*Tapinoma*	1
	Technomyrmex	1
	Philidris	1
	Dolichoderus	2
Myrmicinae (45%)	*Crematogaster*	3
	Cardiocondyla	1
	Carebara	1
	Monomorium	7
	Oligomyrmex	1
	Recurvidris	2
	Pheidole	3
	Pheidologeton	1
	Solenopsis	1
	Tetramorium	4

Table 4.1 Continued

Subfamily	Genera	Number of species
Ponerinae (17%)	*Anochetus*	1
	Centromyrmex	1
	Diacamma	1
	Hypoponera	1
	Odontoponera	1
	Ponera	1
	Pachycondyla	3
Pseudomyrmex (4%)	*Tetraponera*	2
Total	30	53

*The percentages in the family column were percentages of the ant species number in each subfamily in overall study sites.

Table 4.2 The total number of subfamilies, genera, and species of ants and the species diversity (H') ,evenness indices and dominance indices in the unburned and burned dipterocarp forests at Lai Nan sub-district, Wiang Sa district, Nan province

Study sites	**Unburned area**	**Burned area**
Subfamilies	5	6
Genera	25	25
Species	41	41
H'	2.989	3.383
Evenness	0.558	0.631
Index of Dominance	0.206	0.131

Table 4.3 List of ants collected by pitfall trapping, sugar and protein baiting, leaf litter sifting, soil sifting and hand sampling from June 2010 to June 2011 in burned and unburned dry dipterocarp forests at Lai-Nan subdistrict, Wiang Sa district, Nan province.

Subfamily/species	Functional group	Site Found		Remarks (Some biology of each genus from Agosti et al., 2000)
		B	UB	
Aenictinae				
Aenictus jarujini	N/A	/		Army ants
Dolichoderinae				
Tapinoma melanocephalum	OP	/	/	Generalized foragers
Technomyrmex kraepelini	OP	/		Generalized foragers
Philidris sp.	DD		/	Foragers
Philidris sp.1 of AMK	DD	/	/	Generalized foragers
Dolichoderus thoracicus	CS			
Formicinae				
Anoplolepis gracilipes	CS		/	Foragers
Oecophylla smaragdina	TCS	/	/	Predator, tend homopterans
Paratechina longicornis	OP	/	/	Generalized foragers
Paratechina sp.4 of AMK	OP	/	/	
Paratechina sp.8 of AMK	OP	/		
Paratechina sp.9 of AMK	OP	/		
Paratechina sp.	OP	/		Generalized foragers
Polyrhachis proxima	SC	/	/	Generalized foragers
Camponotus ruflogaucus	SC	/		
Camponotus sericeue	SC	/	/	
Camponotus sp.7 of AMK	SC	/	/	Generalized foragers
Plagiolepis sp.2 of AMK	CR			
Myrmecinae				
Crematogaster rogenhoferi	GM		/	Generalized foragers, Arboreal, nest in hollow tree trunks and branches
Crematogaster sp.3 of AMK	GM		/	
Crematogaster sp.	GM	/		
Oligomyrmex sp.	CR		/	Cryptic foragers, termite thief ant
Monomorium chinense	GM, H/C/TCS	/	/	Generalized foragers, harvesters
Monomorium floricola	GM, H/C/TCS	/	/	
Monomorium destructor	GM, H/C/TCS	/	/	
Monomorium pharaonis	GM, H/C/TCS	/	/	
Monomorium sechellense	GM, H/C/TCS	/		
Monomorium sp.1 of AMK	GM, H/C/TCS	/	/	
Monomorium sp.	GM, H/C/TCS	/		
Pheidologeton diversus	CR	/	/	
Pheidole spp.	GM	/	/	Generalized and mass foragers
Pheidole planifrons	GM		/	Many seed harvesters, many omnivorous
Pheidole sp.1 of AMK	GM	/	/	
Cardiocondyla emeryi	OP	/	/	
Tetramorium sp.1	OP	/		
Tetramorium sp.10 of AMK	OP	/		Generalized foragers
Tetramorium sp.	OP		/	Generalized foragers
Tetramorium walshi	OP		/	
Solenopsis geminata	CR		/	
Recurvidris sp.	CR	/	/	
Recurvidris sp.1 of AMK	CR	/	/	

Table 4.3 Continued

Subfamily/species	Functional group	Site Found B	Site Found UB	Remarks (Some biology of each genus from Agosti et al., 2000)
Pseudomyrmecinae				
Tetraponera ruflonigra	TCS		/	Arboreal, nesting in plant cavities
Tetraponera sp.	TCS		/	
Ponerinae				
Anochetus graeffei	SP		/	Predators
Odontoponera denticulata	SP	/	/	Predators
Dicamma vagens	SP	/	/	Predators
Pachycondyla astata	SP		/	Predators
Pachycondyla luteipes	SP		/	Predators
Pachycodyla sp.	SP		/	Predators
Ponera sp.	CR		/	Predators of small arthropods
Hypoponera sp	CR		/	Generalized foragers
Centromyrmex feae	CR	/		Cryptic predators of termites

CR, Cryptic species; DD, dominant Dolichoderinae; GM, Generalized Myrmicinae; H/C/TCS, hot/cold/tropical climate specialist; OP, opportunists; SC, subordinate Camponitini; SP, specialist predators ; B, burned dipterocarp forest; UB, unburned dipterocarp forest; AMK, Ant Museum of Kasetsart University

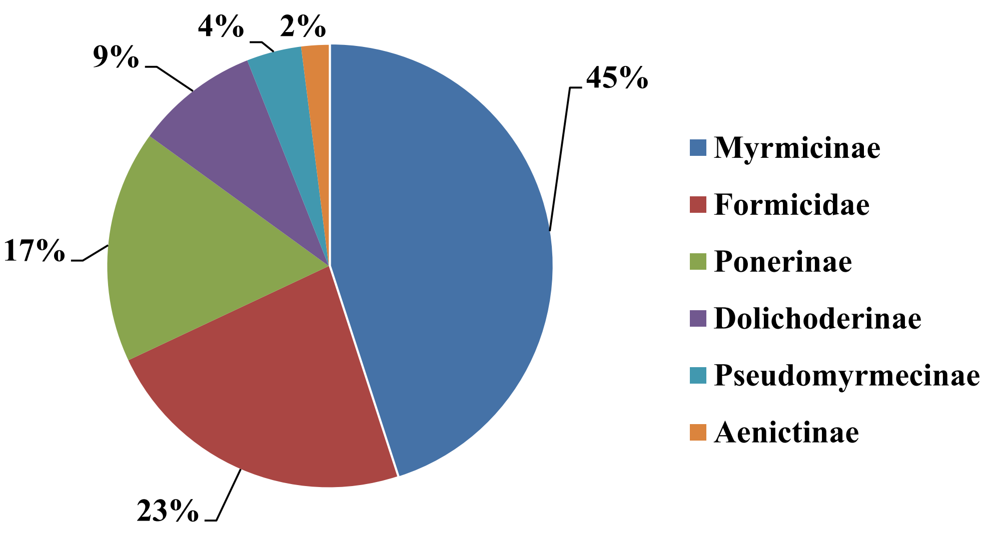


Figure 4.1 The percentage of ant species number in each subfamily in overall study sites at Lai Nan subdistrict, Wiang Sa district, Nan province

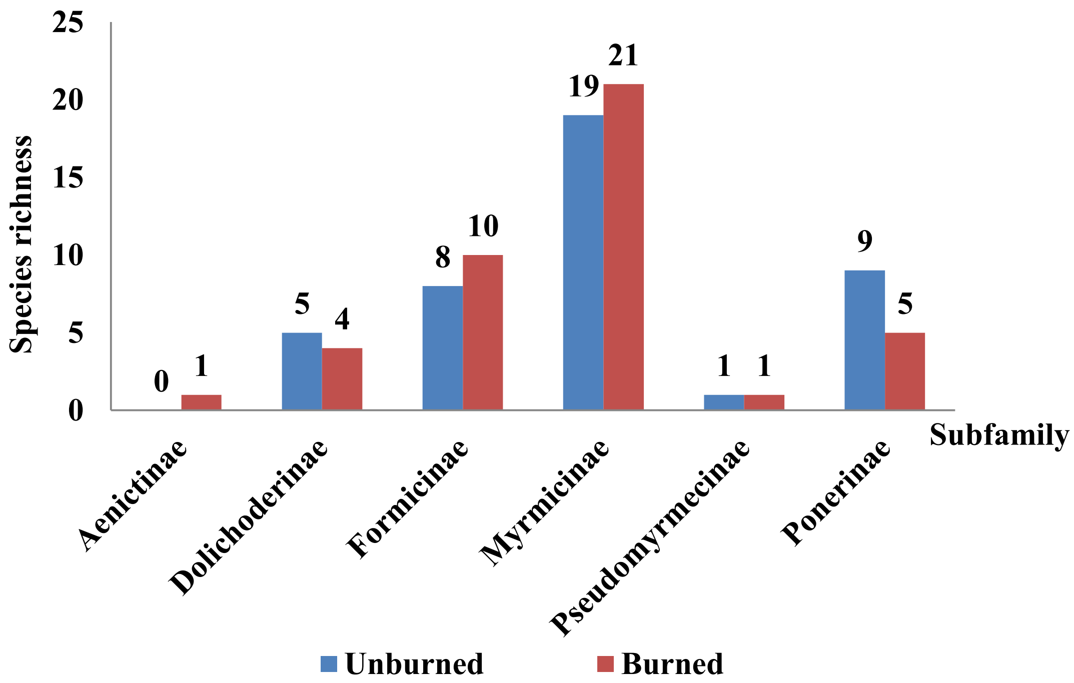


Figure 4.2 The ant species number in each subfamily between two study sites at Lai Nan subdistrict, Wiang Sa district, Nan province

4.3.2 Species diversity index between two study sites

The Shannon-Weiner's species diversity index indicated that the year-round diversity was the higher in the burned dipterocarp forest (3.383), than the unburned dipterocarp forest. Furthermore, the highest value of evenness index of ants was in burned dipterocarp forest, whereas the unburned dipterocarp forest was markedly lowers (2.989) (Table 4.2).

The mean of species diversity index of 13 months was higher in the burned dipterocarp forest (3.38 ± 0.12), than the unburned dipterocarp forest (2.99 ± 0.12). Moreover, the significant difference was also found between the burned and unburned dipterocarp forest ($p = 0.032$) (Table 4.4).

Table 4.4 The mean* of species diversity index of ants from the two sites at Lai Nan sub-district, Wiang Sa district, Nan province

Study sites	**Unburned dipterocarp forest (n=13)**	**Burned dipterocarp forest (n=13)**
Species diversity index (mean±SE)	2.99 ± 0.12[a]	3.38 ± 0.12[b]

*The mean of diversity index in each column with the different letters were significant different between the study sites by Independent t-test ($p \leq 0.05$)

4.3.3 Species similarity between sites

The species similarity between the unburned and burned dipterocarp forests, as evaluated by Sorensen's similarity coefficient, was 0.790 (Table 4.5).

Table 4.5 The Sorensen's similarity coefficient of ants from the two study sites at Lai Nan sub-district, Wiang sa district, Nan province

Study sites	Unburned dipterocarp forest	Burned dipterocarp forest
Unburned dipterocarp forest	1	-
Burned dipterocarp forest	0.790	1

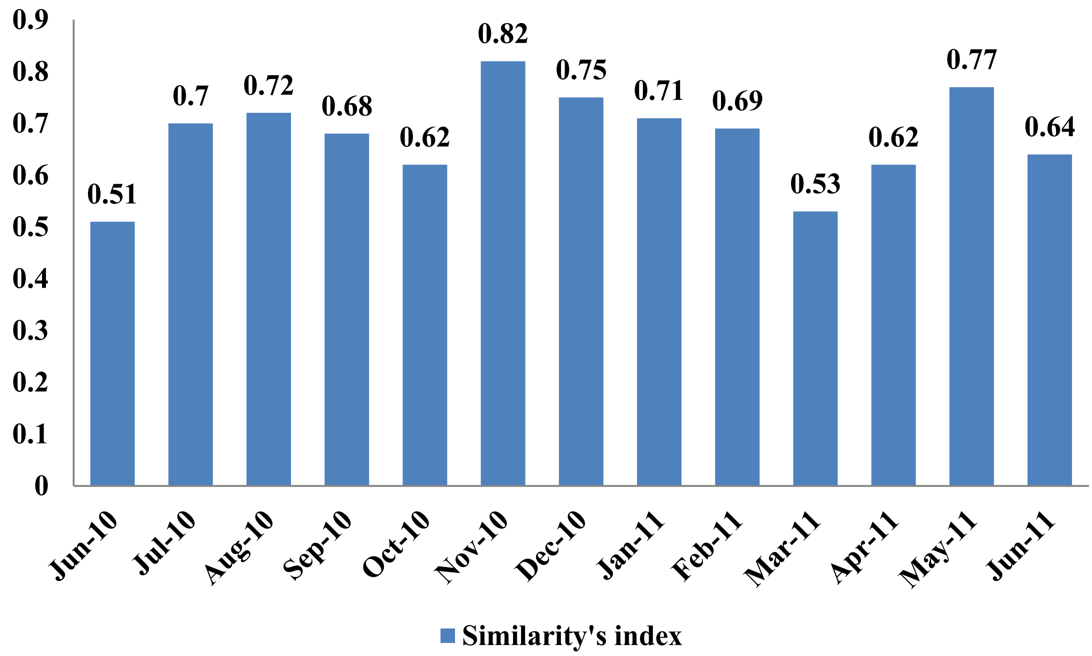


Figure 4.3 Monthly Sorensen's similarity coefficient values of ants from the two study sites at Lai Nan sub-district, Wiang Sa district, Nan province

4.4 Discussion

Even though the species diversity index in the burned dipterocarp forest was higher than the unburned dipterocarp forest, but the total number of species were equal, 41 species in either site. It may possible that the direct effects of fire on ant richness in the burned dipterocarp forest was less marked, due to the high mobility that enable them a greater potential to escape heating by burrowing deep into the soil. However, the indirect effects of fire, particularly leaf litter reduction could be effective at decreasing dramatically both total biomass and number of species of ants (Certini, 2005). In addition, the time of recovery could be predictable because it is strictly depend upon soil moisture content after burning (Neumann and Tolhurst, 1991). Moreover, season of burning is likely to influence population dynamics, not only due to fire intensity vary with season but also because some parts of a life cycle are certain to be more sensitive to fire than others. For example, eggs laid deep in the soil profile may be expected to survive a surface fire that was sufficiently intense to kill only some unfortunately workers (Whelan, 1995).

Almost all invertebrate species richness has been demonstrated to increase shortly after fire in a variety of vegetation types (O'Dowd and Gill, 1984; Andersen and Yen, 1985; Greenslade, 1997). The higher in number of ant species in burned areas compare with unburned areas in the same vegetation types also prompt to need for further investigation, particularly, diversity of microhabitats as interaction between ant communities and plant species in burned areas.

The proportion of all ant species number in each subfamily in two study sites: burned and unburned dipterocarp forest that collected from June 2010 to June 2011, supported the result from Sitthicharoenchai and Chantarasawat (2006) which reported that the subfamily Myrmicinae was the highest in species richness, followed by Formicinae and Ponerinae, respectively. This might be due to the fact that Myrmicinae is the most diversed subfamily of ant in the world (4,400 species), based on both the number of genera and species, and this subfamily occurs throughout the world in all major habitats, which has extremely wide abundances and distributions and could be found in all zoogeographic regions. Moreover, this subfamily is not commonly found only in the Indo-Australian region but also in the Oriental region including Thailand (Hölldobler and Wilson, 1990; Bolton, 1994).

Aenictinae was found less than others at only 2% in overall areas. Possibly due to there is only one genus *Aenictus* worldwide belonging to this subfamily. However, it is one of the large ant genera in the world. Presently, 149 valid species and subspecies are listed (Bolton et al., 2006). Moreover, in Thailand, there were only nine species of *Aenictus* have been referred by A List of Known Ant Species of Thailand (Formicidae: Hymenoptera) (Wiwatwitaya and Jaitrong, 2005). In addition, a newly described as a new species, *Aenictus jarujini* has been found at Huai Nam Dung National Park, Mae Hong Son province (Jaitrong and Yamane, 2010) and in this study, *A. jarujini* was recorded for the first time in dipterocarp forest, Lai Nan sub-district, Wiang sa district, Nan province, Thailand. *A. jarujini* was found under stone in a disturbed area during a hottest and dry season (Jaitrong and Yamane, 2010).

Of the 53 species that caught from the burned and unburned areas, the highest ant species abundance was *Oecophylla smaragdina*, followed by *Pheidole* spp., *Paratrechina longicornis* and *Odontoponera denticulata*, respectively. The weaver ants, *Oecophylla smaragdina* were found abundant in only unburned dipterocarp forest. Their nests were formed by typically of living leaves that bound and anchored together by using their larval silk (Hölldobler and Wilson, 1990).

This study found many of weaver ant nests hanging on the trees, particularly on *Dipterocarpus* spp. and *Shorea* spp. that supported the result from Sitthicharoenchai and Chantarasawat (2006). Furthermore, weaver ants also being an aggressive predator and territory defense, they sometimes climbed down or dropped down from their nests or tree branches onto the ground or leaf litter which not only for foraging but also defending their territory.

During the dry season, usually from November to April, local people who lived in Lai Nan sub-district, Wiang Sa district, Nan province, get in the dipterocarp forest that located in the study areas, to gather the weaver ant's eggs for food and trade. In order to get the ant eggs without any interference from the ants, the villagers will burn the dipterocarp forest floor and tree trunks to force the evacuation of weaver ant workers and then collected ant's eggs. Even in May, early in the rainy season, the weaver ants were still the dominant species that could be found everywhere in dipterocarp forest, they are swarming particularly in unburned areas. In this period they were usually very aggressive because of their breeding season (Sitthicharoenchai and Chantarasawat, 2006). It was a desirable time for mating, building nests, laying eggs and increasing their populations. These eggs were favorite food for local people (Sitthicharoenchai and Chantarasawat, 2006). On the other hand, the weaver ants, *Oecophylla smaragdina*, have been identified as an efficient bio-control agent in some horticulture crops. In tropical tree crops and forest trees, these ants help in controlling many pest species, such as caterpillars, bugs, beetles, flies and thrips. Although, the use of weaver ants as bio-control agent can be locally applicable and cost-effective, field experiments are essential (Peng et al., 1995; 2004; 2010).

The ant genus *Pheidole* was found in second-highest abundance. It has been one of the large genera which belong to family Formicinae. This genus distributes worldwide in the tropics and in the warm temperate regions. Moreover, *Pheidole* is ground dwelling ants in world tropics (Eguchi, 2001; Brown, 2000; Ward, 2000).

Paratrechina longicornis was the most abundance in burned dipterocarp forst. They are ubiquitous household pests throughout the tropics and subtropics, and also are pervasive indoor pest in temperate areas. In addition, they can be a crypto-pest, that enhancing populations of phloem-feeding hemipterans such as aphids (Wetterer, 2008). Moreover, the crazy ant *Paratrechina longicornis* is highly adaptable, living in both very dry and rather moist habitats. The crazy ant often nests some distance away from its foraging area. It nests in such places as trash, refuse, cavities in plants and trees, rotten wood, in soil under objects and also have been found under debris left standing in buildings for long periods of time (Smith, 1965). These ants can nest in a variety of locations from dry to moist environments. A crazy ant nest site can be found by looking for workers carrying food back to the nest.

Odontoponera denticulata belongs to genus *Odontoponera*, these ants were commonly found in burned dipterocarp forest in every season. They are ground-dwelling ant that dug surface ground as small holes for making their nest. They are predators, which living and foraging for small animals above the ground (Sitthicharoendhai and Chantarasawat, 2006).

Furthermore, *Odontoponera denticulata* workers were more common in burned dipterocarp forest within a few months after burning. It is possible that habitat simplification resulting from burning or the decrease in resource availability close to the nest led to increase of the foraging activity and trappability of the ant especially pitfall traps.

For this study the results showed a very high abundance and diversity of ant in burned dipterocarp forest, contrary to the unburned dipterocarp forest.

The effects of forest fire on ant diversity are idiosyncratic (Ratchford et al., 2005). As several studies have found that species richness is higher in burned areas than unburned areas (Andersen and Yen, 1985; Donnelly and Giliomee, 1985; Andersen, 1991a; York, 1994), while other study had found no any effect of fire on ant species richness (Hoffmann, 2003; Parr et al., 2004).

The data suggested that burning of diptercarp forest may have some impacts on ant communities. *Odontoponera denticulata* workers were more common in burned dipterocarp forest within a few months after burning. In contrast, weaver ant, *Oecophylla smaragdina* workers dominated in unburned dipterocarp forest, but they were absent in three months after the burning.

Furthermore, as a regeneration study by Jackson and Fox (1996) suggested that the proximity of areas under recovery to undisturbed sites may enhance a re-colonization by flora and fauna.

The burned dipterocarp forest could possess some characteristics of open habitat caused by fire and provide some benefit for “fire-favored” insect species, including pyrophilic ant species which prefer burning. Some previous studies revealed that ant responses to fire depended upon changing in habitat cover and vegetation structure. When the differences in vegetation structure between burned and unburned areas are small, the effects of fire are less pronounced. Both burned and unburned diptercarp forests were similar in ant species richness, and both areas have the high similarity index because they have similar tree structure and microhabitats. The best explanation of the pattern of high diversity of ant in burned area is the intermediate disturbance hypothesis (Connell, 1978), a mechanism that allows the maintenance of species diversity, though moderate disturbances occurring at an intermediate frequency or with intermediate intensity. It suggests that highly diverse communities are not in a state of equilibrium, but if no disturbance occurs for a very long period of time, the community will subsequently progress toward a low-diversity equilibrium community. In addition, the ecological succession is also occurring in the burned areas. However in some months, the decrease in species diversity in the burned dipterocarp forest is probably due to the dominance by competitive displacement from competitively superior species.

CHAPTER V

SPECIES DIVERSITY OF ANTS BETWEEN THE WET AND THE DRY SEASONS IN THE UNBURNED AND BURNED DRY DIPTEROCARP FORESTS

5.1 Introduction

The environmental fluctuation as a result of the effects of seasonal cycles may affect the population dynamic of ants. Activity of ants, abundance and number of colonies, could be influenced by variation of environmental factors. The food availability including soil and other above ground faunas might be more abundance in the wet season than in the dry season. In addition, ant activities are promoted to be inhibited by some kinds of physical factors, such as temperature, humidity and pH, because the activity of enzymes, hormones, and other physiological factors can be active at optimal temperature and pH. According to these reasons, it is strongly possible that the ant species diversity at spatial and temporal can be altered by changes in environmental factors that caused by seasonal variation. In the unburned and burned dipterocarp forests, the changes in seasons seem to be the major cause of environmental change. However, the study sites was similar in the vegetation structure and pattern, therefore the different in the effect of season within each study site were interested. Consequently, this chapter will be considered about the differences in ant species composition between seasons in each study site which may reveal different responses in ant species diversity due to the difference in disturbance.

This study will be provided the basis knowledge about the effects of seasonal variation on the ant species diversity that can be used to manage the negative effects of the fire disturbance in the dipterocarp forest that is important on global ecosystem in the future.

5.2 Materials and Methods

5.2.1 Sampling methods

In each of two study sites detailed in Chapter III, a permanent plot of 10 × 25 m^2 was selected as a sampling area. The surveys at each site were conducted every month, from June 2010 to June 2011 inclusive. Four sampling methods: pitfall traps, sugar-protein baits, leaf litter sifting and soil sifting were used to study the abundance of ants in each habitat as explained in Chapter IV.

5.2.2 Study of physical factors

5.2.2.1 Soil physical factors

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

5.2.2.1.1 Soil moisture content (Gardner et al., 2001)

The soil moisture content was measured as explained in Chapter IV.

5.2.2.1.2 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 paper was immersed into the soil suspension and the changed color was compared with standard color.

5.2.2.1.3 Soil temperature

The soil temperature was measured about 10 cm depth by the thermometer in the field.

5.2.2.2 Relative humidity and air temperature

The relative humidity and air temperature were measured, in the same sampling quadrat, as the soil moisture content and soil pH, were measured by the digital thermo-hygrometer in the field.

5.2.2.3 Monthly precipitation data (rainfall data)

The precipitation data all year round was obtained from the meteorological department of Thailand.

5.2.3 Ant identification

The specimen were card mounted in standard form for identifying to the subfamilies, genera and species level as explained in Chapter IV.

5.2.4 Data analysis

The species diversity and the similarity in species composition between the wet and dry seasons in each study site were determined and explained in Chapter IV

5.3 Results

5.3.1 The determination between the wet and dry seasons

The wet and dry season of this study were considered by total precipitation in each month (13 months). The months which had the total precipitation higher than 100 mm were classified as wet season (Whitmore, 1975). Consequently, the wet season in this study was from April to September and the dry season was from October to March (Figure 5.1).

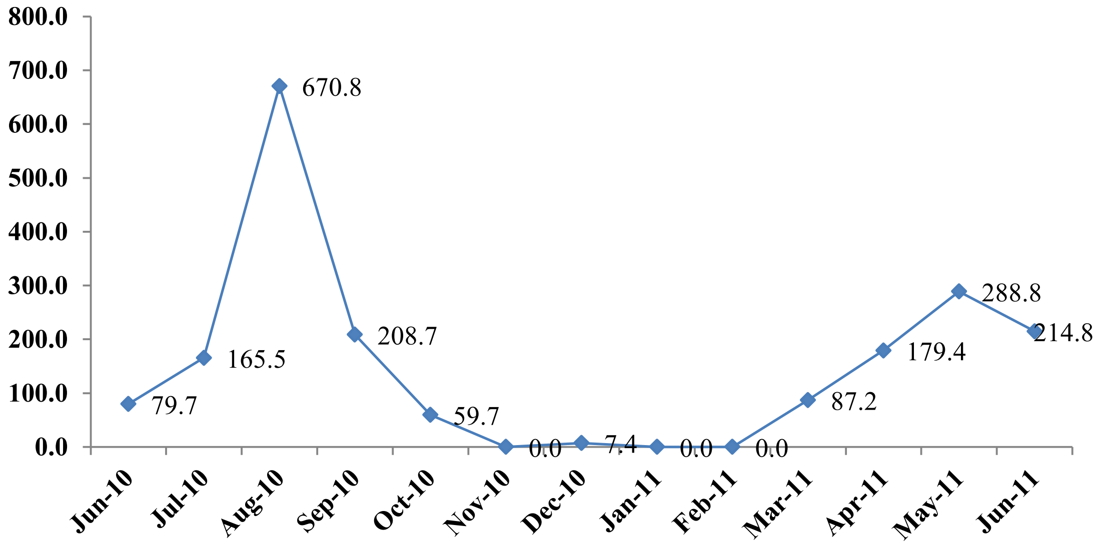


Figure 5.1 The total rainfall (mm) of each month from June 2010 to June 2011, was obtained from Department of Meteorological station, Nan province

5.3.2 Comparisons of environmental factors between the wet and dry seasons in each study site

The air temperature, soil temperature and soil moisture content were significantly higher in wet season than in dry season in both study areas, except relative humidity between two seasons in both areas were not significantly different (Table 5.1).

Table 5.1 The mean* of environmental factors comparison between the wet and the dry seasons in the two study sites at Lai Nan subdistrict, Wiang Sa district, Nan province

Environmental factors (Mean±SE)	Seasons	Unburned dipterocarp forest	Burned dipterocarp forest
Relative humidity (%)	wet	74.02 ± 2.35^{a}	74.31 ± 2.67^{a}
	dry	77.39 ± 4.39^{a}	71.64 ± 5.69^{a}
Air temperature (°C)	wet	33.84 ± 0.89^{a}	33.74 ± 0.62^{a}
	dry	26.98 ± 1.77^{b}	27.21 ± 1.36^{b}
Soil temperature (°C)	wet	27.43 ± 0.52^{a}	27.21 ± 0.52^{a}
	dry	24.63 ± 1.08^{b}	25.00 ± 0.21^{b}
Soil moisture content (%)	wet	14.44 ± 0.56^{a}	15.67 ± 0.98^{a}
	dry	6.62 ± 2.64^{b}	5.75 ± 2.50^{b}

*The mean of environmental factors in each column with the different letter were significantly different between seasons in each study site by t-test at $p = 0.05$.

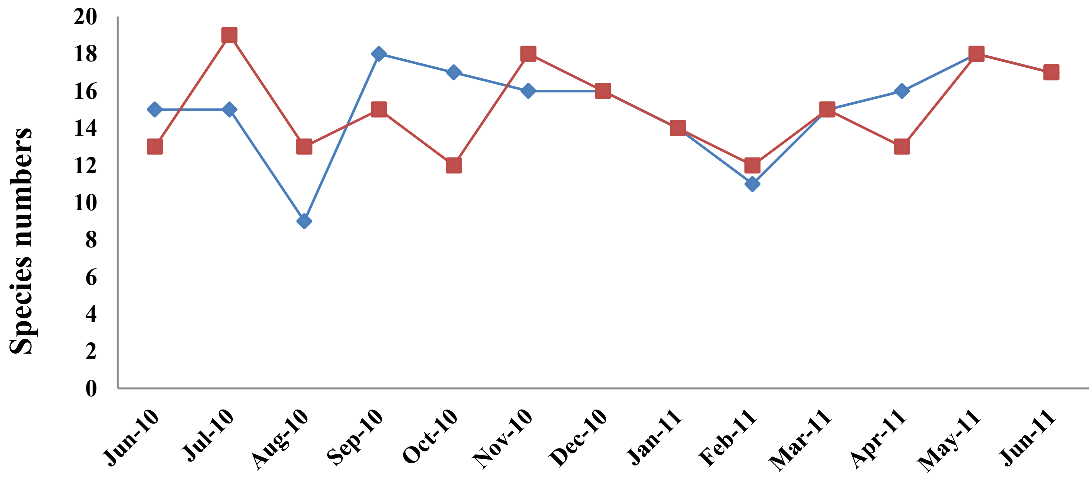
5.3.3 The species diversity between the wet and the dry seasons in each site

The highest species richness of ants was found in the burned dipterocarp forest in the wet season, followed by the unburned dipterocarp forest in the wet season. The Shannon-Wiener's species diversity indices, both during the two seasons, were highest in the burned dipterocarp forest (3.117 and 3.452) followed by the unburned dipterocarp forest (2.917 and 2.680). The species diversity indices in unburned dipterocarp forest was in the wet season than the dry season, whereas in the burned dipterocarp forest, the species diversity index in the dry season was higher than the wet season (Table 5.2).

Table 5.2 The species richness, species diversity index, and evenness index between seasons in both areas at Lai Nan sub-district, Wiang Sa district, Nan province

Study sites	Unburned		Burned	
	wet	dry	wet	dry
Species richness	34	32	37	26
Species diversity index	2.917	2.680	3.117	3.452
Evenness	0.573	0.536	0.598	0.734

In both the unburned and burned dipterocarp forests, the highest of total ant species richness was in the wet season (34 and 37 species, respectively), followed by the dry season (32 and 26 species, respectively) (Table 5.2). As showed in Figure 5.2, in the wet season (from April to September), ant species numbers were increased in both study sites and then decreased in the dry season (from October to March). Additionally, in the unburned and burned dipterocarp forests, the species richness increased when the rain began in April 2011. In the burned dipterocarp forest, the highest of ant species numbers was in July 2010, whereas the lowest of ant species numbers was in October 2010 and February 2011 and in the unburned dipterocarp forest, the highest of ant species numbers was in September 2010, but the lowest of ant species numbers was August 2010. Furthermore, the ant species numbers in the unburned and burned dipterocarp forests were continuously decreased in the dry season, from November 2010 to February 2011.



	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
UB	15	15	9	18	17	16	16	14	11	15	16	18	17
B	13	19	13	15	12	18	16	14	12	15	13	18	17

Figure 5.2 The seasonal variation of species richness of ants in each month from June 2010 to June 2011 between two study sites at Lai Nan sub-district, Wiang Sa district, Nan province

5.3.4 The species similarity between seasons in each site

The Sorensen' similarity coefficient was used to indicate the species similarity between the wet and the dry season in each study site. The highest similarity between the wet and the dry seasons in each study site was found in the unburned dipterocarp forest (0.829), followed by the burned dipterocarp forest (0.724). The similarity index between the unburned and burned dipterocarp forests was highest in the dry season (0.793), followed by the wet season (0.704) (Table 5.3).

Table 5.3 The Sorensen's similarity coefficient of ants between the wet and the dry seasons between two study sites at Lai Nan subdistrict, Wiang Sa district, Nan province

Similarity index		Unburned dipterocarp forest		Burned dipterocarp forest	
		wet	dry	wet	dry
Unburned dipterocarp	wet	1	-	-	-
forest	dry	0.829	1		-
Burned dipterocarp	wet	0.704	0.840	1	-
forest	dry	0.815	0.793	0.724	1

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

There were 23 ant species, such as *Oecophylla smaragdina*, *Paratrechina longicornis*, *Odontoponera denticulata*, *Monomorium destructor*, *Monomorium pharaonis* and *Pheidole* sp, were found in both the wet and the dry seasons and in both study sites as showed in Table 1-B Appendix B whereas some ant species were found only in the wet season or the dry season in each study site. For example, in the unburned dipterocarp forest, *Anochetus grafferi*, *Cardiocondyla emeryi*, *Crematogaster* sp.3 of AMK, *Monomorium chinense*, *Monomorium sechellense*, *Paratrechina* sp. *Pheidole* sp. of AMK, *Plagiolepis* sp.2 of AMK, *Ponera* sp. and *Recurvidris* sp. were found only in the wet season whereas *Monomorium* sp., *Pachycondyla astuta*, *Pachycondyla luteipes* and *Philidris* sp. were found only in the dry season. In the burned dipterocarp forest, many species, such as *Camponotus sericeus*, *Cardiocondyla emeryi*, *Polyrachis proxima* and *Plagiolepis* sp.2 of AMK were found only in the wet season whereas *Monomorium floricola*, *Pachycodyla astuta*, *Pachycondyla luteipes* and *Philidris* sp. were found only in the dry season. There were no more 6 ant species found only in the dry season in each study site. The ant species found only in the wet season was highest in the burned dipterocarp forest (15 species), followed by the unburned dipterocarp forest (11 species) (Figure 5.3).

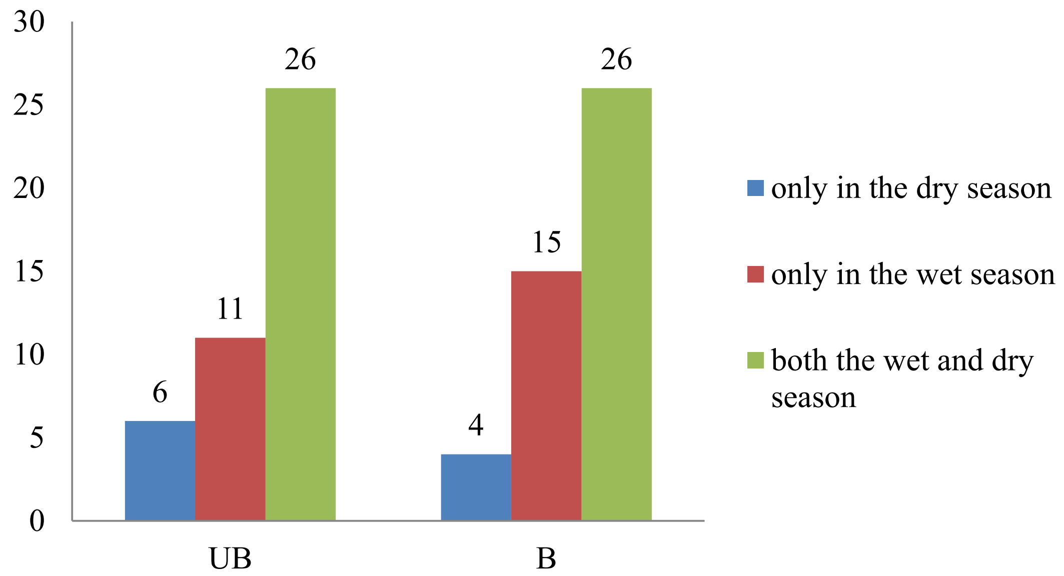


Figure 5.3 The species number of ants that was found only in the dry season, only in the wet season, and found in both seasons in each study site at Lai Nan sub-district, Wiang Sa district, Nan province

5.4 Discussion

5.4.1 The species richness of ants between the wet and the dry seasons in each study site

In both study sites, the species richness was higher in the wet season than the dry season. The highest of ant species richness was in the wet season in the burned dipterocarp forest, followed by the wet season in the unburned dipterocarp forest. This might be because of habitat availability in both sites: unburned and burned dipterocarp forests, such as leaf litter, logs, epiphytes, seed germination, seed re-sprout that supported the functional types of ant species (Andersen, 2000). Furthermore, the wet season brought about food supply that was crucial factor. In addition, resource availability such as foods was obviously critical determinant of the species abundance and distributions with specialized and generalized diets, such as seed harvesters and specialist predators (Andersen, 2000).

In dry season, the unburned and burned dipterocarp forests had low soil moisture content with the high temperature. These conditions were not suitable for ant species and their prey, therefore lower ant species numbers were found. On the other hand, in the wet season, soil moisture content was high. This condition was suitable for many soil faunas and also facilitated the growth of plants, which provided the food availability and habitat complexity. The appearance of predatory ants, such as *Anochetus grafferi*, *Ponera* sp. *Cardiocondyla emeryi* and *Recurvidris* sp. were found in this period. In addition, in the dry season, the plants in the unburned and burned dipterocarp forests shed their leaves, but almost of them also occur to the evergreen in dry season because of the irrigation. However, there was a seasonal fire that was set by local people in late March 2011 nearby the burned areas, which smoke might be disturbed the arboreal ant community. Therefore, in the unburned and burned dipterocarp forests still had some leaf litter in the dry season 2011, however the unburned dipterocarp forest had leaf litter higher than the burned dipterocarp forest, because this site was covered by the accumulated leaf litter all year round for 7 years ago, that differ from the burned dipterocarp forest, which was burned by local people since April

2010 which removed the leaf litter. The leaf litter had provided both food and nest sites for many kinds of ant species. Armbrecht et al. (2006) expected that both resources would be produced a stronger response to litter-nesting ants. Therefore, there were more leaf litter ant species that found in the unburned and burned dipterocarp forests, such as *Paratrechina* sp.9 of AMK, *Oligomyrmex* sp. and *Tapinoma melanocephalum*.

The rainfall and temperature might be important factors in tropical forest (Leving, 1983). In unburned and burned dipterocarp forest, the species richness was increased when the rain began. The highest value of total rainfall was found in August 2010 (670.8 mm) (Figure 5.1). As shown in Figure 5.2, the species richness of ants in the unburned and burned dipterocarp forests dropped off in this month. This may be due to the heavy rains which inhibit the foraging in most ant species (Levings, 1983). As a previous study reported by Bourmas (2005) revealed that the mean of rainfall period in the wet season was 20 days per month. In this study, the mean of rainfall period was 16 days ranging from 10 - 25 days in each month. These showed the impact of variation in the amount of rainfall on the ant community in the unburned and burned dipterocarp forests. In dry season, the air temperature and soil temperature were decreased in the unburned and burned dipterocarp forests. The drought condition strongly reduced foraging activity and some activities of ant species (Levings, 1983). This may be an explanation for the lower numbers of ant species in this season comparing to the wet season.

5.4.2 The species diversity index of ants between seasons in each study site

In the unburned dipterocarp forest, the Shannon-Wiener's species diversity indices were higher in the wet season than in the dry season. In contrast, in the burned dipterocarp forest, the Shannon-Wiener's species diversity indices were higher in the dry season than in the wet season. However, the species diversity index in the wet and dry seasons in the burned dipterocarp forest were higher than in the unburned dipterocarp forest. The lower species diversity index in the wet and the dry seasons of the unburned dipterocarp forest was reflected from the relative abundance of an ant species, *Oecophylla smaragdina*, which strongly high number of catches both in pitfall trapping and sugar-protein baiting (Figure 5.4). The high activity at baits of the ant may be a function of increased competition for food when the physical environment is favorable for foraging, such as after raining, but less in food source available. Food requirements might be high, depending on the pattern of brood development. In the early raining season, the weaver ant, *Oecophylla smaragdina* were also the dominant species that could be found everywhere in the dipterocarp forest, they are swarming when occupied their foods. In this period they were always aggressive because of their breeding season. It was a desirable time for mating, building their nests, laying eggs and increasing their population. Moreover, in dry season in the dipterocarp forest, some plant species were either flowering or fruiting that might provide food availability. However, the lowest in species diversity index in the dry season in the unburned dipterocarp forest. In this period, it was drought and food was scarce. In addition, it may be because of the dominance by competitive exclusion from competitively superior species such as *Oecophylla smaragdina* thus the evenness value in the dry season in the unburned dipterocarp forest was low (0.536).

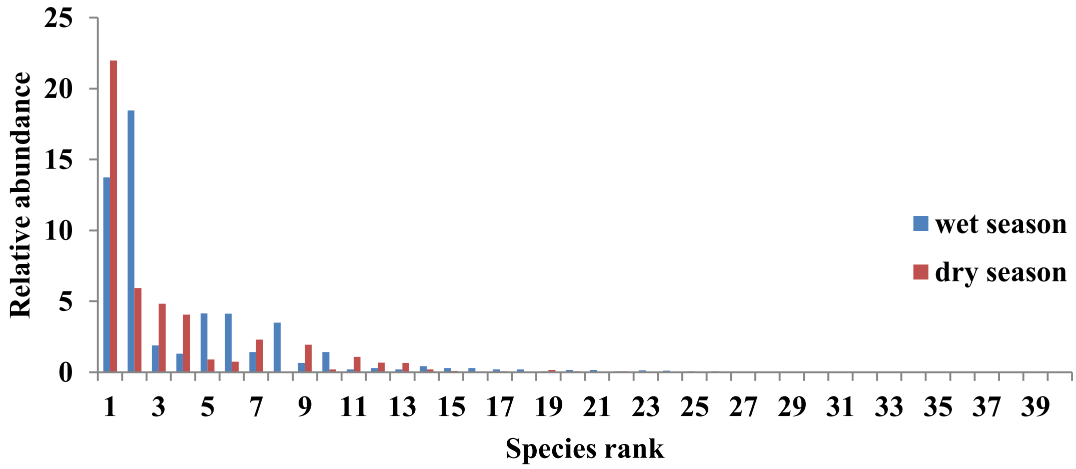


Figure 5.4 Relative abundance of ant species in the wet and dry seasons in the unburned dipterocarp forest at Lai Nan sub-district, Wiang Sa district, Nan province

The highest species diversity index in the dry season of the burned dipterocarp forest was reflected by the high relative abundance of some ant species, *Paratrechina longicornis* , *Pheidole* sp. and *Odontoponera denticulata* respectively. In dry season, these three species were dominated in abundance that caused the relatively similar of abundance to other ant species in the burned dipterocarp forest thus the evenness value in this site was high (0.734). The *Paratrechina longicornis* behavior was similar to the *Pheidole* sp. in this forest, because of their active in large number of workers. As *Odontoponera denticulata* workers, they are ground dwelling ant that forage their food on ground thus it increased their trappability, so they were found high number in pitfall traps (Figure 5.5).

In wet season, the species diversity index was lower than in the dry season that might be reflected by the high relative abundance of some ant species, *Pheidole* sp., *Paratrechina longicornis* and *Odontoponera denticulata* respectively. These species were highest in abundance that caused the distinctive difference of abundance to other ant species in the area, so the evenness value in the wet season in the burned dipterocarp forest was low (0.598). These dominant species may be a role of competition for food and nest sites when the physical environment is desirable for foraging, nesting and breeding. Therefore, it may possible the inferior species were inhibited by the superior species.

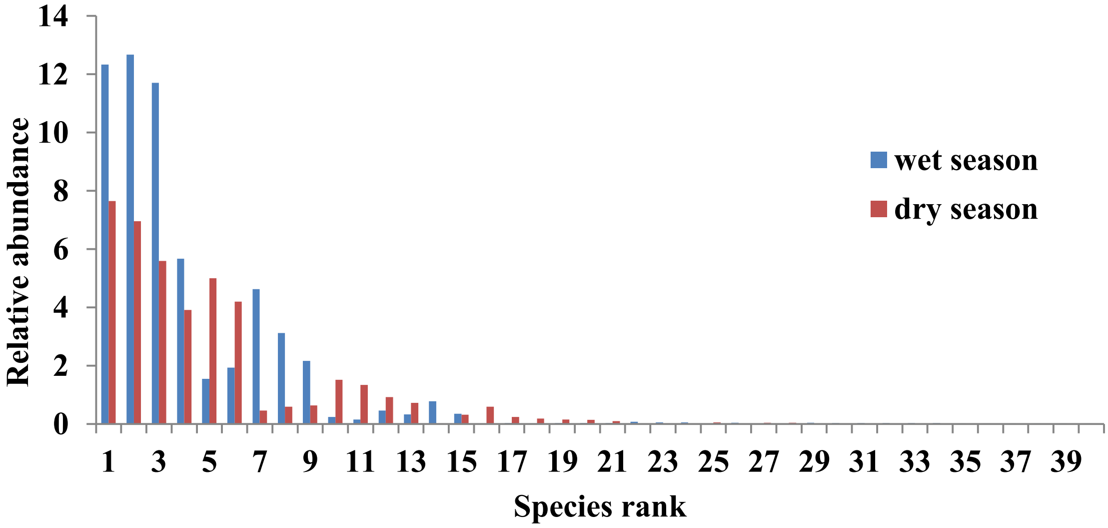
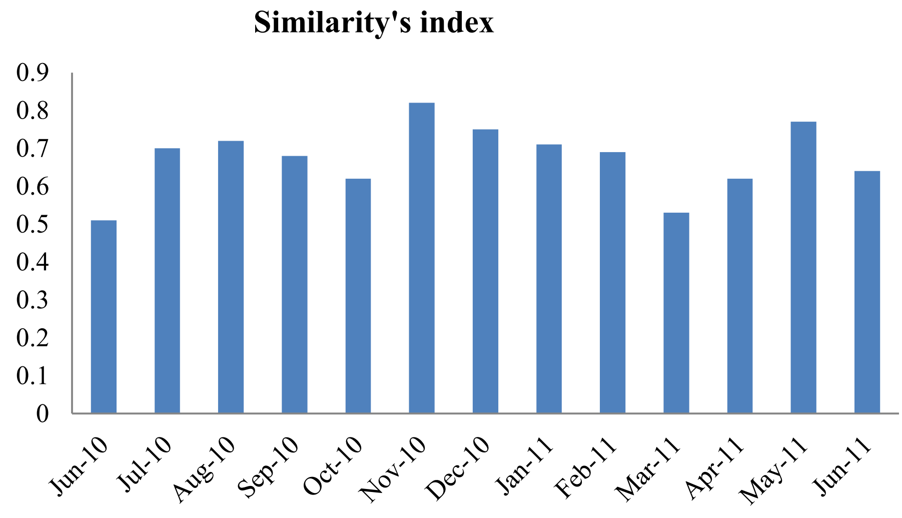


Figure 5.5 The relative abundance of ant species in the wet and dry seasons in the burned dipterocarp forest at Lai Nan sub-district, Wiang Sa district, Nan province

5.4.3 The similarity of ant species between seasons in each study site

In the unburned dipterocarp forest, the highest similarity indices in the two seasons may be due to the stability of tree structure throughout the year because the unburned dipterocarp forest rarely had been disturbed by local people. In addition, this forest located nearby the reservoir that built by Chulalongkorn university, so it was indirectly caused the water supply for the unburned dipterocarp forest all year round, especially in the dry season. These human activities made this forest had soil moisture content higher than other areas. In dry season, the various plants in the dipterocarp forest usually shed their leaves, which did not occur to the same extent with the evergreen unburned dipterocarp forest, where located nearby the reservoir. These might be possible that it was similar in biotic factors and microclimates between in the wet and dry season thus the similarity index was high (0.829). On the other hand, the similarity index between the wet and dry seasons in the burned dipterocarp forest was lower than in the unburned dipterocarp forest (0.724) because this study site was burned by local people in dry season in March to April 2010, the leaf litter and ground cover were removed from this site after burning. However, when the rain began, it was a time for improving in air quality, and leading to vegetation grows substantially. Moreover, plant community in the burned dipterocarp forest was recovered because fire triggered seed germination in *Dipterocarpus* and many plant species in dipterocarp are fire-adaptive plant, so the re-colonization in ant species and recovery of plant population in this study site could be occurred rapidly. As Figure 5.6 revealed that the similarity index continuously increased in three months (June to August 2010) after the burning in April 2010. It may be confirmed that the early process of secondary succession was occurring.



	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
Similarity's index	0.51	0.7	0.72	0.68	0.62	0.82	0.75	0.71	0.69	0.53	0.62	0.77	0.64

Figure 5.6 The species similarity index in each month between two study sites at Lai Nan subdistrict, Wiang Sa district, Nan province.

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

The 26 species found in both wet and dry seasons and in both study sites showed the capability in adaptation of these species to the environmental changes that influenced by seasonal variation in the two study sites. The important physical factors: temperature, relative humidity, soil moisture content and total rainfall were affecting on the increase and decrease or the ant population stability in the ecosystem. Moreover, these physical factors were also affected on the differences in foraging behavior of workers in each species. In addition, some ant species were reported as species-specific to temperature period, moisture, and precipitation (Andersen, 2000; Hölldobler and Wilson, 1990). However, in the unburned and burned dipterocarp forests, the proportion of number of ant species that found in both wet and dry seasons was equal. This might be indicated that in the burned dipterocarp forest, the effect of forest fire were not strongly affected on ant species richness but the variation of ant community that occurred in the dipterocarp forest may possibly depend upon not only macroclimate but also microclimate that were changed along the seasonal cycle.

CHAPTER VI

RELATIONSHIP IN ABUNDANCE OF SOME DOMINANT IMPORTANT ANTS AND SOME PHYSICAL FACTORS BETWEEN UNBURNED AND BURNED DIPTEROCARP FORESTS

6.1 Introduction

Effects of fires are disruption of natural seasonal cycles. However, seasonal variation is inherent and also a cause for other variation of abiotic factors, such as moisture and temperature, may also impose temporal changes upon ant communities (Hölldobler and Wilson, 1990). Understanding the factors that determine the distribution and abundance of organisms in their natural habitats is a major goal in ecological studies. It is widely acknowledged that community structure is affected by a myriad of abiotic and biotic factors, with relative importance of each often depending on the temporal and spatial scale of study (Levin, 1992). In addition, the study of spatio-temporal patterns is crucial not only for understanding causes of the distribution and abundance of organisms but also providing a basis for monitoring any long-term changes arising from both natural and human disturbance (Robertson et al., 1993). Moreover, in longleaf pine forest in Florida, the effects of season on ant community composition were more dominant than those fires (Izhaki et al., 2003). Although seasonal activity cycles in ants were documented (Feller, 1989; Suarez et al., 1998; Izhaki et al., 2003). Nevertheless, the activity patterns of entire ant assemblages throughout the annual cycle have largely overlooked (Fellers, 1989; Prusak, 1997; Albrecht and Gotelli, 2001). Therefore, it may be possible that there is an abundance of ants in the natural habitat which has more complexity of plant community. However, there is a limited exactly information about the abundance of ants in the disturbed habitats. Fire disturbance in dipterocarp forest might be causes the changes in vegetation cover, that bring about the variation in ants communities and some physical factor. Consequently, the effects of some physical factors on ant faunas in each study sites could be determined.

6.2 Materials and Methods

6.2.1 Sampling methods

In each of two study sites detailed in Chapter III, a permanent plot of 10 × 25 m^2 was selected as a sampling area. The surveys at each site were conducted every month, from June 2010 to June 2011 inclusive. Four sampling methods: pitfall traps, sugar-protein baits, leaf litter sifting and soil sifting were used to study the abundance of ants in each habitat as explained in Chapter IV.

6.2.2 Study of physical factors

6.2.2.1 Soil physical factors

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

6.2.2.1.1 Soil moisture content (Gardner et al., 2001)

The soil moisture content was measured as explained in Chapter IV.

6.2.2.1.2 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 paper was immersed into the soil suspension and the changed color was compared with standard color.

6.2.2.1.3 Soil temperature

The soil temperature was measured about 10 cm depth by the thermometer in the field.

6.2.2.2 Relative humidity and air temperature

The relative humidity and air temperature were measured, in the same sampling quadrat, as the soil moisture content and soil pH, were measured by the digital thermo-hygrometer in the field.

6.2.2.3 Precipitation data (rainfall data)

The precipitation data all year round was obtained from the meteorological department of Thailand.

6.2.3 Ant identification

The specimen were card mounted in standard form for identifying to the subfamilies, genera and species level as explained in Chapter IV.

6.2.4 Data analysis

The correlation coefficient was used to determine the correlation between the abundance of important ant species and some physical factors performed by SPSS and canonical correspondence analysis (CCA) was used to correlate the environmental factors with important ant species by using PC-ORE (McCune and Mefford, 1997).

6.3 Results

6.3.1 Physical factors between two study sites

The mean of all physical factors were not significantly different between two study sites ($p \leq 0.05$). All physical factors were similar between unburned and burned dipterocarp forests (Table 6.1).

Table 6.1 The mean* of some physical factors within each study site a Lai Nan sub-district, Wiang Sa district, Nan province

Physical factors	Study sites	Mean ± SE	P
Relative humidity (%)	Unburned	75.57 ± 0.23	- 0.673
	Burned	73.08 ± 10.39	
Air temperature (°C)	Unburned	30.67 ± 1.34	- 0.028
	Burned	30.72 ± 1.16	
Soil temperature (°C)	Unburned	26.13 ± 0.68	-0.068
	Burned	26.19 ± 0.43	
Soil moisture (%)	Unburned	10.83 ± 1.64	-0.105
	Burned	11.09 ± 1,87	
Soil pH	Unburned	7.00 ± 0.21	-0.114
	Burned	6.96 ± 0.22	

*The mean of physical factors in each column were performed by Independent t-test ($p \leq 0.05$)

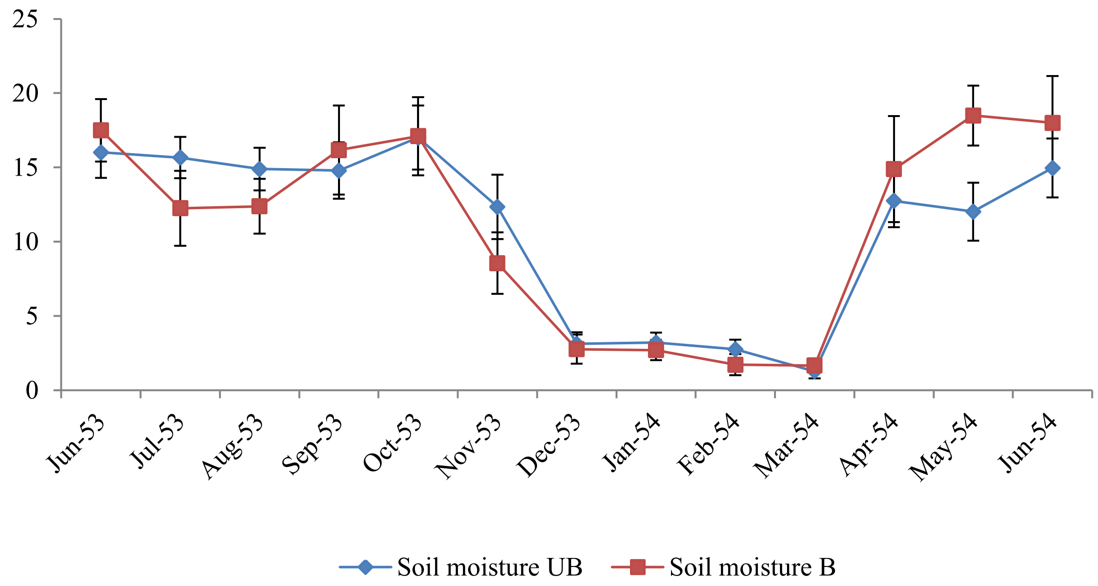


Figure 6.1A The mean of soil moisture content in each month between the unburned and burned dipterocarp forests at Lai Nan subdistrict, Wiang Sa district, Nan province

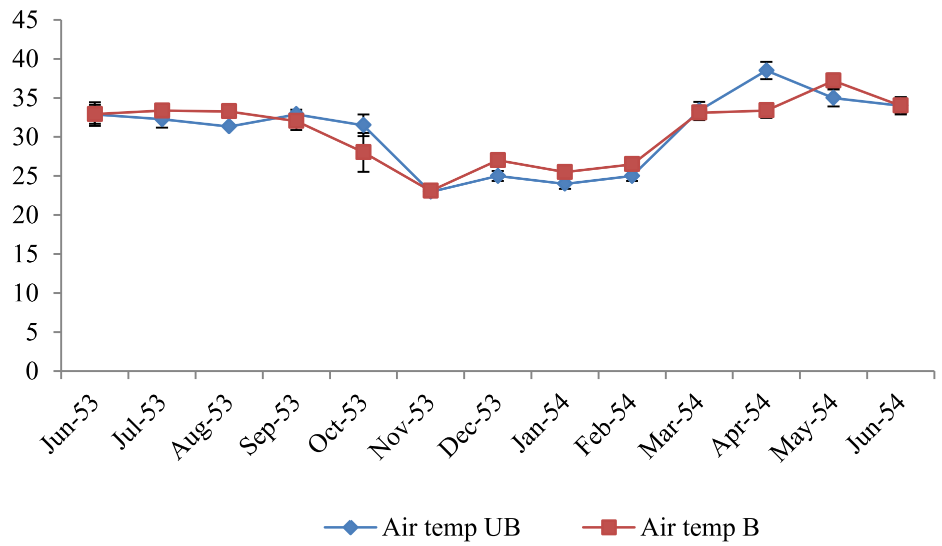


Figure 6.1B The mean of air temperature in each month between the unburned and burned dipterocarp forests at Lai Nan sub-district, Wiang Sa district, Nan province

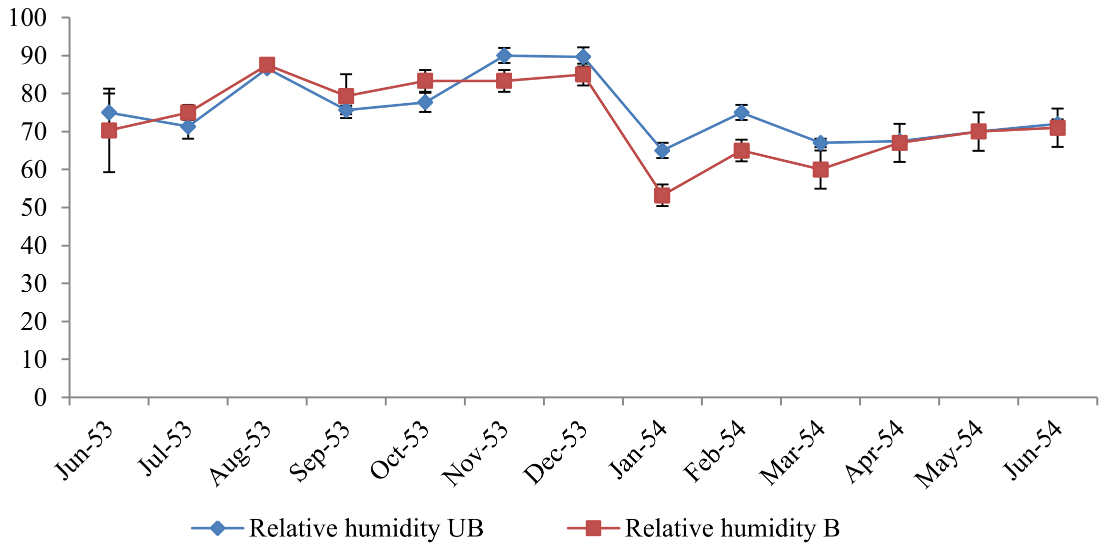


Figure 6.1C The mean of relative humidity in each month between the unburned and burned dipterocarp forests at Lai Nan sub-district, Wiang Sa district, Nan province

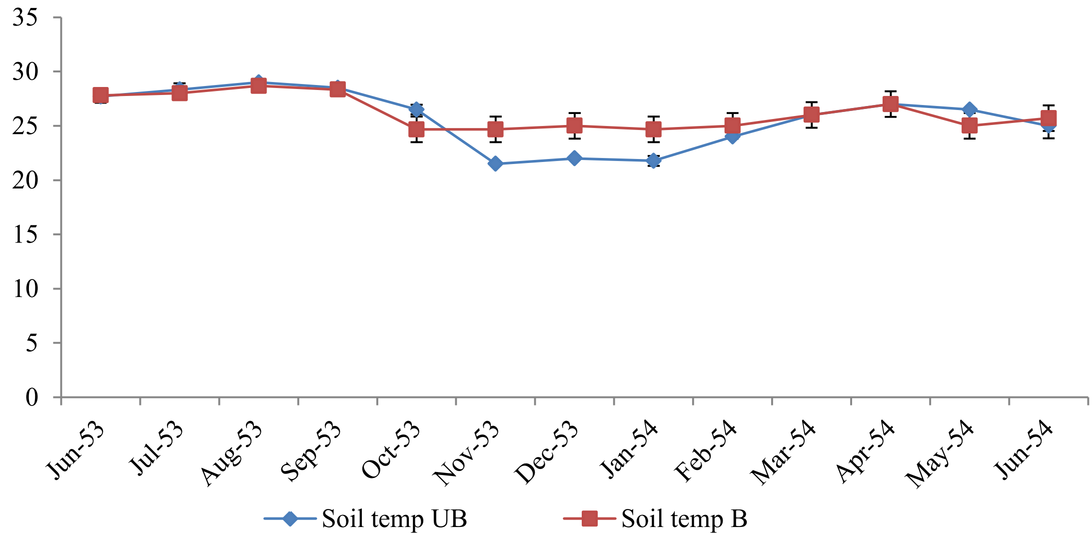


Figure 6.1D The mean of soil temperature in each month between the unburned and burned dipterocarp forests at Lai Nan sub-district, Wiang Sa district, Nan province

6.3.2 High abundant ant species in each study sites

6.3.2.1 The unburned dipterocarp forest

The total abundance of all ant species that found in the unburned dipterocarp forest was 8,222 individuals, collected by pitfall traps, sugar-protein baits, leaves litter sifting and soil sifting in overall during the study period. The unburned dipterocarp forest had communities that were numerically dominated by *Oecophylla smaragdina* (Figure 6.2 A), which accounted for 2,957 individuals of all ants in this site, followed by *Pheidole* spp. (Figure 6.2 B), *Monomorium destructor* (Figure 6.2 C) and *Odontoponera denticulata* (Figure 6.2 D).

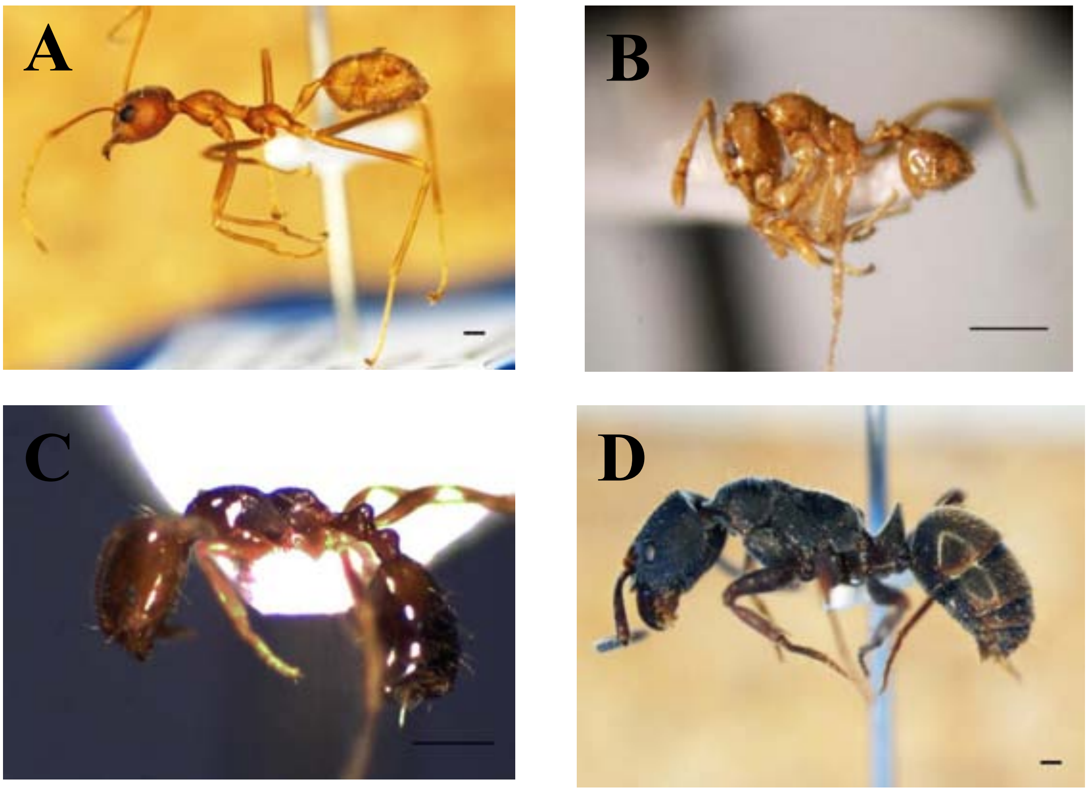


Figure 6.2 Dominant ant species in unburned dipterocarp forest, **A.** *Oecohylla smaragdina*, **B.** *Pheidole* spp., **C.** *Monomorium destructor* and **D.** *Odontoponera denticulata*, scale bars = 1 mm

6.3.2.2 Burned dipterocarp forest

The total abundance of all ant species found in the burned dipterocarp forest was 7,264 individuals collected by pitfall traps, sugar-protein baits, leaves litter sifting and soil sifting in overall study period. The burned dipterocarp forest had communities that were numerically dominated by *Paratrechina longicornis* (Figure 6.3 A), which accounted for 1,450 individuals of all ants in this site, followed by *Pheidole* spp. (Figure 6.3 B), *Monomorium destructor* (Figure 6.3 C) *Odontoponera denticulata* (Figure 6.3 D).

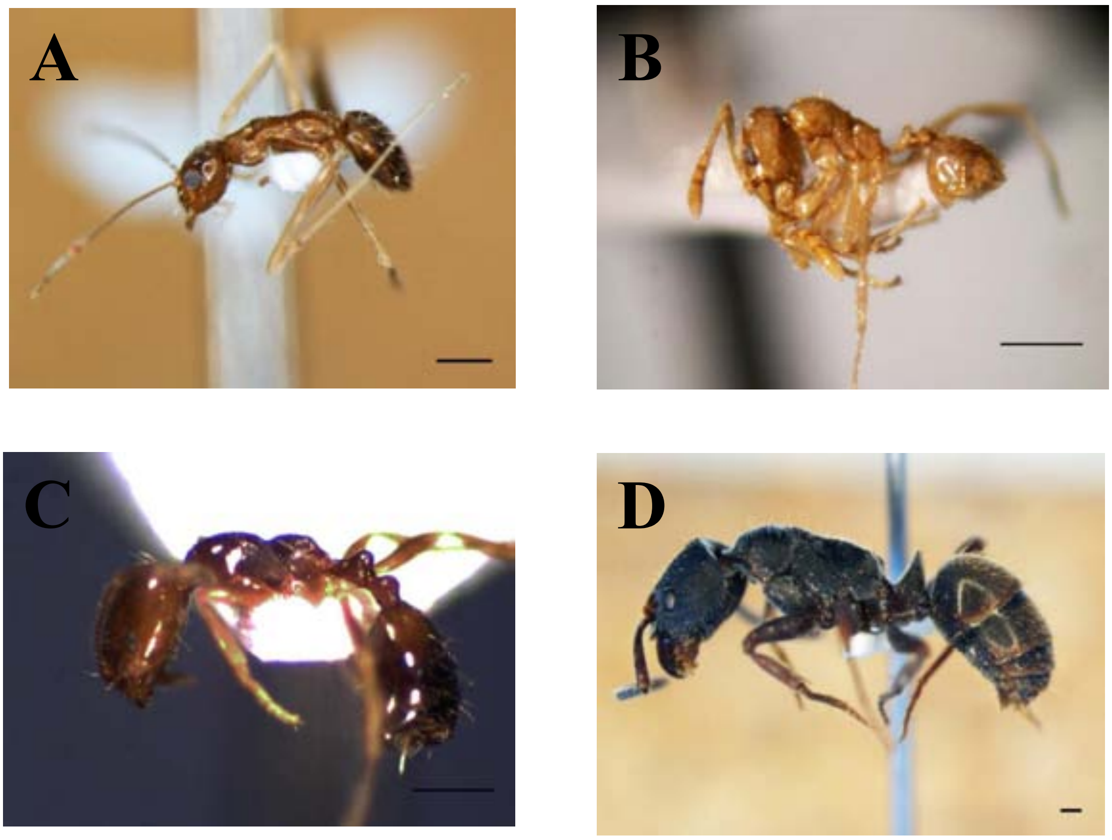


Figure 6.3 Dominant ant species in the burned dipterocarp forest **A.** *Paratrechina longicornis*, **B.** *Pheidole* spp. **C.** *Monomorium destructor* and **D.** *Odontoponera denticulata*, scale bars = 1 mm

6.3.3 The important ant species in each study site

The unburned dipterocarp forest was referred to a natural dipterocarp forest, therefore the important ant species were selected from this habitat and were used to compare to burned dipterocarp forest. The important ant species were also selected by the abundance of ants in unburned dipterocarp forest. Hence, the first four ants species with highest in abundance were selected. *Oecophylla smaragdina* had the highest abundance, followed by *Pheidole* spp., *Monomorium destructor*, and *Odontoponera denticulata* (Table 6.2). Moreover, all of them were found in both study sites throughout the year.

However, in burned dipterocarp forest, *Oecophylla smaragdina* was the fourth rank in ant abundance *Paratrechina longicornis* (1,450 individuals) and *Pheidole* spp.(1,425 individuals) were closely the first and second, respectively. The abundance of *Monomorium destructor* and *Odontoponera denticulata* in burned dipterocarp forest were found lower than unburned dipterocarp forest. *Odontoponera denticulata* was yielded 1,256 individuals, followed by *Monomorium destructor* (445 individuals) as the lowest (Table 6.2).

6.3.4 Comparison in abundance of important ant species between two study sites

The mean abundance of *Oecophylla smaragdina*, *Odontoponera denticulata* and *Paratrechina longicornis* were significantly different between unburned and burned dipterocarp forest ($p = 0.000$). The highest abundance of *Oecophylla smaragdina* caught was in the unburned

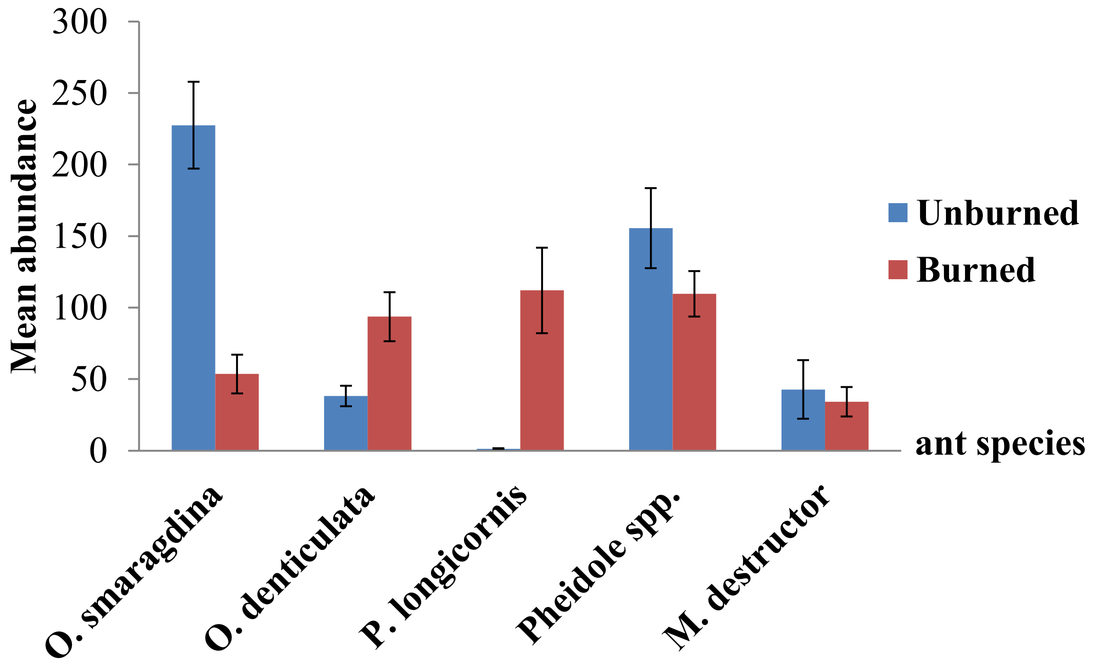


Figure 6.4 Mean abundance of important ant species in each study site at Lai Nan sub-district, Wiang Sa district, Nan province

Table 6.2 Mean* abundance of important ant species in each study site at Lai Nan sub-district, Wiang Sa district, Nan province

Important ants species	Mean abundance (±SE)	
	Unburned dipterocarp forest	Burned dipterocarp forest
Oecophylla smaragdina	227.46 ± 30.33[a]	53.54 ± 13.60[b]
Odontoponera denticulate	38.15 ± 7.12[a]	93.62 ± 17.17[b]
Paratrechina longicornis	1.17 ± 0.47[a]	112.00 ± 29.86[b]
Pheidole spp.	155.54 ± 28.05[a]	109.62 ± 16.00[a]
Monomorium destructor	42.77 ± 20.49[a]	34.23 ± 10.33[a]

*The mean abundance of important ant species with different letters were significantly different between two study sites, performed by Independent t-test ($p \leq 0.05$).

dipterocarp forest. However, *Paratrechina longicornis* was the highest abundance in the burned dipterocarp forest. Furthermore, *Paratrechina longicornis* and *Odontoponera denticulata* had significantly higher abundance in burned dipterocarp forest than unburned dipterocarp forest ($p \leq 0.05$), respectively (Table 5.2).

6.3.5 Correlation between the abundance of important ant species and some physical factors in each study site

In the unburned dipterocarp forest, the abundance of two ant species, *Pheidole* spp. and *Monomorium destructor* correlated with some physical factors. *Pheidole* spp. was positive correlated with the soil moisture content (p-value = 0.003, r = 0.758) and correlated with the soil temperature (p-value = 0.035, r = 0.586), whereas negatively correlated with the pH of soil (p-value = 0.013, r = -0.665). *Monomorium destructor* was negative correlated with the relative humidity (p-value = 0.000, r = -0.858) (Table 6.3).

In the burned dipterocarp forest, only *Pheidole* spp. was found positively correlated with the soil moisture content (p-value = 0.038, r = 0.580) (Table 6.3).

6.3.6 The relationship of important ant species and some physical factors in the study sites

The analysis of the relationship of important ant species and some physical factors: relative humidity, air temperature, soil temperature and soil moisture content was carried out by canonical correspondence analysis (CCA). The first, second and third axis had an eigenvalue of 0.111, 0.053 and 0.018 respectively. Thus the first and second axes were used for predicting the correlation between important ant species and physical factors. The ordination analysis of the important ant species-physical factors dataset showed that soil moisture content and relative humidity are good predictors of change in *Pheidole* sp. and *Monomorium destructor* in the dry dipterocarp forests (Figure 5.4).

Table 6.3 Significant correlation coefficient* between some physical factors and abundance of important ant species in each study site at Lai Nan sub-district, Wiang Sa district, Nan province

Study site	Species	Physical factor	r
Unburned dipterocarp forest	*Oecophylla smaragdina*	-	-
	Odontoponera denticulata	-	-
	Paratrechina longicornis	-	-
	Pheidole spp.	Soil moisture content	0.758
		Soil temperature	0.586
		pH of soil	-0.665
	Monomorium destructor	Relative humidity	-0.858
Burned dipterocarp forest	*Oecophylla smaragdina*	-	-
	Odontoponera denticulata	-	-
	Paratrechina longicornis	-	-
	Pheidole spp.	Soil moisture content	0.580
	Monomorium destructor	-	-

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

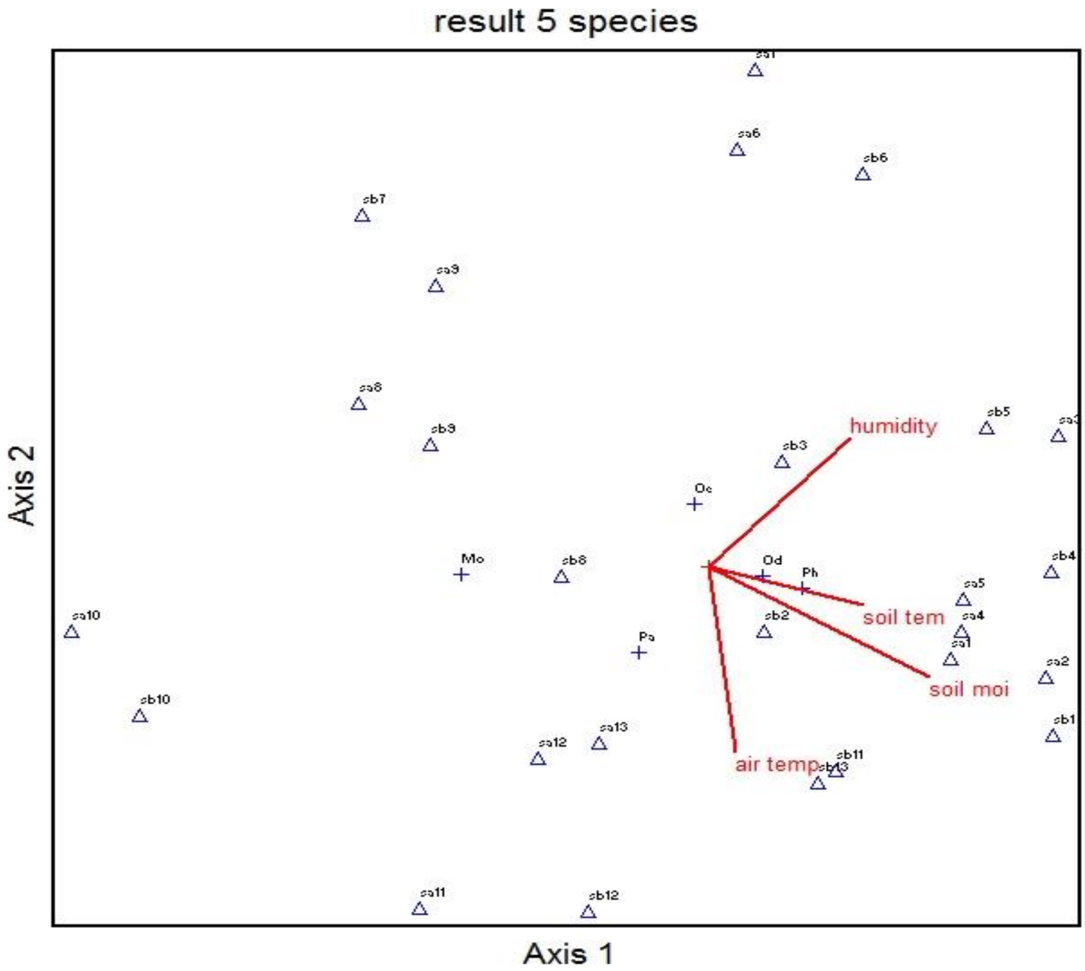


Figure 6.5 Bi-plot of a Canonical Correspondence Analysis (CCA) of important ant species. The analysis deals with 5 important ant species related to 4 factors (relative humidity, soil temperature, soil moisture content and air temperature). A positive mark indicates the optima of individual species in the two dimensional environmental space described by ordination axes 1 and 2, in which the relationships show significant differences (p-value = 0.003). Vectors show the correlations between an environmental factor and the two ordination axes, where the vector length indicates the strength of this correlation.

6.4 Discussion

6.4.1 Physical factors between the two study sites

The similar of all physical factors occurred in the unburned and burned dipterocarp forests may be because the distance between the unburned and burned dipterocarp forests was likely adjacent in global scale. In addition, these two study sites also have similar in tree structure, plant community and microhabitat, so there were no any critical different either biotic factors or abiotic factors. As a previous research in dry dipterocarp forest at Nakhonratchasima province that studied by Sunyaarch and Suraden (1989) revealed that fires could be affected on soil properties after suddenly burning. Soil moisture content decreased more than 50%, but the soil organic matter and the alkaline cations (P, K, Ca, Mg) were increased. Moreover, soil pH and Sodium were slightly increased. Furthermore, Ewing and Engel (1988) demonstrated that daily soil temperatures are usually altered after fire. Air temperature in a site can depend on whether it has been burned. The burned site was generally cooler at canopy level, but warmer in the soil 1 cm below the surface. However, these effects might be caused by combination of several factors, including the removal of shading that always provided by the vegetation, the removal of the insulative effects of litter, and the altered albedo of soil surface (Ahlgren and Ahlgren, 1969; Old, 1969; van Cleve and Viereck, 1981 cited in Whelan, 1995).

6.4.2 High abundant ant species in each two study sites

In overall areas, *Oecophylla smaragdina* was the highest in abundance. It may be because the weaver ant, *Oecophylla smaragdina*, are extremely aggressive territorial ants. They live in large arboreal colonies

(Hölldobler and Wilson, 1983) that actively forage on several trees around their nest sites. Even though, this species could be found in both burned and unburned areas. However, they were absent in a few months after burning at all, as a result of fire disturbance on their habitat. The high abundance of this species was similar to previous study in Lai Nan sub-district.

In contrast, *Paratrechina longicornis* was found in both study sites, and it had highest in abundance in burned dipterocarp forest, but it had a low in abundance in unburned dipterocarp forest. In addition, *P. longicornis*, has been called as a kind of tramp ants, which are species that commonly widely spread by human commerce and associate with human disturbance (Latreille, 1802). Although, *P. longicornis* is usually rare or absent in natural environment as well as unburned dipterocarp forest, whereas it can be found very common in disturbed and semi-natural environment (Wetterer, 2008).

Pheidole spp. is one of the prevalent ground-dwelling genus in the most species richness and abundance in the tropic (Ward, 2000). *Pheidole* was found as the secondly dominant species in each unburned and burned dipterocarp forests. Because, *Pheidole* presently comprises more than 9.5 percent of the entire known world ant fauna with over 1,100 species described worldwide (Bolton et al., 2007). Furthermore, they were classified into functional groups as generalized Myrmecinae. The ants in this group have board distribution patterns in relation to environmental stress and disturbance (Neville, 2000). Moreover, *Pheidole* spp. also play an important role in ecological function as seed harvester (Kusnezov, 1951).

Odontoponera denticulata was the third rank in abundance in burned dipterocarp forest, is ground-dwelling ant that was commonly found in burned areas, but it was found only 5% in relative abundance in unburned dipterocarp forest. This finding suggested that *Odontoponera denticulata* may prefer disturbed habitat. They usually forage their food on bare ground. Therefore, *Odontoponera denticulata* could be trapped by pitfall trap easily. Another interesting data is that the *Odontoponera denticulata* usually playing dead when threatened.

Monomorium destructor was most the third dominant species in the unburned dipterocarp forest. In burned dipterocarp forest, it was found at 6% in relative abundance. *M. destructor* was a generalist with a board diet of living and dead insects, insect eggs, nectar and seed (Bolton, 1987). They were a kind of household pests, that will feed on any food available (Smith, 1965). They also become highly abundant when occupying their food, by swarming. In order to form a large colony, they usually built their nest in soil, under log and in the leaf litter as well. It is possible that the high abundance of this species in the study was associated with the quantity of leaf litter (Torchote, 2008).

6.3.3 The comparison in abundance of important ants between two study sites

Table 5.2 showed the difference mean abundance of some important ant species between two study sites. The *Oecophylla smaragdina* was found the first highest in mean abundance in the unburned dipterocarp forest, but in the fourth rank in burned dipterocarp forest. This may be due to fire disturbance, affected their food and habitat availability. Moreover, it was possible that the decreasing in their population, because of local people, who burned and brought their eggs and larvae as food.

The mean abundance of *Paratrechina longicornis* was the highest in the burned dipterocarp forest whereas it was recorded at 2% in relative abundance. This may be due to *P. longicornis* appears to be a disturbance specialist and seemingly absent from undisturbed natural habitat, where it can occur in semi-natural vegetation (Andersen and Reichel, 1994; Clouse, 1999; Santana-Reis and Santos, 2001). The result from Andersen and Reichel (1994), Clouse (1999), Santana-Reis and Santos (2001) suggested that it may be possible that *P. longicornis* associated with disturbed areas.

6.4.4 Correlation between the abundance of important ant species and some physical factors in each study site

Only two highly abundant ant species, *Pheidole* spp. and *M. destructor*, were affected by the physical factors. The correlation of the abundance of *Pheidole* spp. and soil moisture content and soil temperature and pH of soil was different to the previous study by Watanasit (2008) which reported the negative correlation of precipitation and number individuals of *Pheidole*, and discussed that the individual numbers of *Pheidole* increases when the amount of precipitation is low. On the other hand, this study was supported to Watanasit and Phaphunnn (2000) reported that the number of *Pheidole* increased with high rainfall. This study revealed that the abundance of *Pheidole* have positively correlated with the soil moisture and soil temperature, but negatively correlated with pH of soil. It may be possible that soil moisture, soil temperature and pH of soil have an affected on *Pheidole* in unburned dipterocarp forest.

Monomorium destructor was found negatively correlated with relative humidity. This might be because in the rainy season will provide the fertility of food and habitat availability, so almost species were increased, and the competition was high. Whereas, in the dry season, most species were decreased in population that brought about the low interspecific competition, induced these generalized foragers to increase the number of workers.

However, physical factors, which reported by Pearson and Derr (1986) showed that temperature, rainfall and relative humidity influenced the distribution and abundance of arthropods on the forest floor in Peru. As a result, temperature and rainfall may affect the distribution and abundance of some species in Myrmicinae.

There was none of correlation of *Oecophylla smaragdina*, *Odontoponera denticulata* and *Paratrechina longicornis* with any physical factors, and this showed non-specific to the environment factors. In addition, on the regional and community-wide scales, ground-dwelling ant community composition has been associated with a variety of variables related to plants, including vegetation cover, vegetation composition, vegetation productivity, plant species richness, plant biomass and vegetation architecture (Izhaki et al., 2009). Moreover, it may possible that there were the other factors which associated to the abundance of these ants, such as the restoration of the plant species in dipterocarp forests along seasonal cycle all year round.

CHAPTER VII

EFFECTS OF FIRE ON ANT FUNCTIONAL GROUP IN DRY DIPTEROCARP FOREST

7.1 Introduction

Fire is not the only factor that changes in ant communities but natural seasonal cycles in abiotic factors, such as moisture and temperature, and biotic factors, such as vegetation cover, are likewise crucial (Hölldobler and Wilson, 1990). Although, seasonal activity cycles in ants have been reported as a critical condition (Lynch et al., 1980; Whitford et al., 1981; Feller, 1989). Moreover, a previous studied by Folgarait (1998) reported the effect of different disturbances on ant diversity and concluded that ant diversity typically increases after fire. However, ant diversity after fire may also decrease or remain unchanged (Majer, 1977; York, 2000; Jackson and Fox, 1996) depending upon biotic and abiotic conditions and on the time elapsed since fire (Izhaki et al., 2003).

In many important aspects, ant colonies behave more like plants than animals, and this has important implications for community structure (Andersen, 1998). Both ants and plants, they nest in fixed position, usually in ground, and resource capture is achieved through the ramification of foraging modules (Harper, 1985).

As a result of the large diversity of ants across Australia, it becomes difficult to precisely analyze the results of field assessments on ant species

(Andersen, 1990). However, the use of ant functional groups can reduce the ecological complexity, allowing analysis of ants for general trends in response to ecological function and management. Ant functional group analysis is based on global–scale responses of ants to environmental stress and disturbance that operating at the genus or sub-species level. First proposed by Greenslade (1978), the functional group approach has been reviewed and further expanded by Andersen (1995, 1997, 2000, 2003) and Hoffman and Andersen (2003) generating a predictable assessment tool of ant responses to natural disturbance. For this study, the ant species were analyzed in the terms of their functional group by using a functional group that described by Greenslade (1978) and Andersen (1990) as a framework to analyze ant species that occurred in burned and unburned dry dipterocarp forest.

At present, there is limited information about the functional group on ant community in the dry dipterocarp forest. This study will be provided the basis of knowledge of the functional group pattern on ant community in dry dipterocarp forest that maybe use as a framework for the further study and ecological management.

7.2 Materials and Methods

7.2.1 Sampling methods

In each of two study sites as described in Chapter III, a permanent plot of $10 \times 25\ m^2$ was selected as a sampling area. The surveys at each site were conducted every month, from June 2010 to June 2011 inclusive.

Four sampling methods were used to study the abundance of ants in each habitat as explained in Chapter IV.

7.2.2 Study of physical factors

7.2.2.1 Soil physical factors

Soil moisture content, soil pH, and soil temperature were measured for each of the soil sample collected from each sampling quadrat in each study site.

7.2.2.1.1 Soil moisture content (Gardner et al., 2001)

The soil moisture content was measured as explained in Chapter IV.

7.2.2.1.2 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 paper was immersed into the soil suspension and the changed color was compared with standard color.

7.2.2.1.3 Soil temperature

Soil temperature was measured at about 10 cm in depth by a thermometer in the field.

7.2.2.2 Relative humidity and air temperature

The relative humidity and air temperature were measured, in the same sampling quadrat, as the soil moisture content and soil pH, were measured by the digital thermo-hygrometer in the field.

7.2.2.3 Precipitation data (rainfall data)

The precipitation data all year round was obtained from the meteorological department of Thailand.

7.2.3 Ant identification

The specimens were card mounted in standard form for identifying to subfamilies, genera and species as explained in Chapter IV.

7.2.4 Functional group analysis

The collected ants were analyzed in terms of their functional groups. The groupings used in this study were established by Greenslade (1978) and had been subsequently refined by Andersen (1990, 1995 and 1997) as a framework. The functional grouping allows for broad-spectrum analysis of Australian ant species, as it is based on behavioral generalizations of each ant genus or species complex. There are seven ant functional groups, and their major representatives in Australia and the New World are listed in Table 7.1.

Mean of all ant populations in each functional group was analyzed, and mean were compared between two study sites by using independent t-test.

Table 7.1 The brief descriptions of functional groups which described by Greenslade (1978), Andersen (1990) and Wilson (1999) with examples of the major taxa in each group (These groups were used as a framework to analyze ant species occurrence in burned and unburned dipterocarp forests)

Functional groups	**Genus or subfamily**	**Description***
Dominant Dolichoderinae (DD)	*Iridomyrmex* *Papyrius* *Anonychomyrma*	The dominant group include ants that are competitively superior and at the top of dominance hierarchies in the most productive environments. This includes habitats where it is hot, and the environment is largely open and structurally simple
Subordinate Camponotini (SC)	*Camponotus* *Polyrhachis*	These groups of ants are found co-occurring with the Dominant Dolichoderinae, but they are competitively inferior and attempt to avoid conflict with this group, Dominant Dolichoderinae. They are generally large in size and often forage at night to reduce interaction with other ant groups.
Climate Specialist (CS)		
Hot-Climate Specialists (HCS)	*Melophorus, Meranoplus, Monomorium, Cataglyphis, Messor, Myrmecocystus, Ocymyrmex; and Pogonomyrmex*	The Hot-climate Specialists include groups of ants adapted to the hottest environments and are common in arid zones throughout Australia.
Cold-Climate Specialists (CCS)	*Monomorium, Notoncus, Myrmecorhynchus, Prolasius, Stigmacros, Formica, Lasiophanes, Temnothorax and Sternamma.*	The Cold-climate Specialists favor cooler, wetter habitats and their distribution is found around the cool temperate zones of Australia.

Table 7.1 Continued

Functional groups	**Genus or subfamily**	**Description***
Tropical-Climate Specialists (TCS)	*Mayriella, Oecophylla, Pheidologeton, Tetraponera,* Dorylinae*, Attini and* Ecitoninae	The Tropical-climate Specialists include many of the ant genera found in the northern tropical rainforests of Australia. Their distribution is centered on the humid tropics, generally where the Dominant Dolichoderinae are not abundant. Some of these genera may be behaviourally dominant, for example, the arboreal Tropical-Climate Specialist *Oecophylla*
Generalized Myrmicinae (GM)	*Monomorium, Pheidole, Crematogaster*	The ants in this functional group have broad distribution patterns in relation to environmental stress and disturbance. They are common in moderately productive environments.
Opportunist (OP)	*Rhytidoponera, Tetramorium Paratrechina, Tapinoma* Small Dolichoderinae	The ants within the opportunist group are largely unspecialized and submissive species. They have wide habitat distributions and are found most abundantly in habitats under stress or disturbance where other more dominant groups are limited.
Specialist Predator (SP)	Large Ponerinae Cerapachyinae Myrmicinae, *Anochetus, Cerapachys, Colobostruma, Epopostruma, Leptogenys, Myrmecia, Odontomachus* and *Pachycodyla*	The Specialist Predators include ants with specialized predatory diets. Many possess adaptations to the mandibles.

Table 7.1 Continued

Functional groups	Genus or subfamily	Description*
Cryptic species	Small Myrmicinae and Ponerinae, including *Hyponera* and *Solenopsis*	These are small to minute species, predominantly Mymicinae and Poneriane, that nest and forage primarily within soil, litter, and rotting logs. They are most diverse and abundance in forested habitats and are a major component of leaf litter ants in rainforest.

*The descriptions in each functional group, which described by Andersen (1988a, 1990, 1995, 1997) and Neville (2000)

7.3 Results

7.3.1 Functional groups between two study sites

The means of functional groups' population: subordinate camponotini, climate specialist and specailist predator, were significantly different between two study sites ($p \leq 0.05$), whereas dominant Dolichoderinae, cryptic species, generalized Myrmicinae and opportunist were not significantly difference. The generalized Myrmicinae was the highest in unburned dipterocarp forest, followed by climate specialist and opportunist, respectively. On the other hand, generalized Myrmicinae was also highest in burned dipterocarp forest, followed by opportunist and climate specialist, respectively (Table 7.2).

Table 7.2 The mean* abundance of functional groups within each study sites in Lai Nan sub-district, Wiang Sa district, Nan province (n=13)

Functional Groups	**Study sites**	**Mean ± SE**	**S.D**	**F**	**P**
Dominant Dolichoderinae	Unburned	19.54 ± 7.23[a]	21.10	1.61	0.125
	Burned	6.62 ± 3.47[a]			
Subordinate Camponitini	Unburned	3.08 ± 1.13[a]	38.41	-2.74	0.018
	Burned	39.85 ± 13.37[b]			
Climate Specialist	Unburned	228.92 ± 30.18[a]	119.20	4.67	0.000
	Burned	67.61 ± 16.78[b]			
Cryptic Species	Unburned	17.46 ± 10.16[a]	41.89	0.04	0.971
	Burned	16.84 ± 13.33[a]			
Gerneralized Myrmicinae	Unburned	248.46 ± 37.12[a]	111.58	1.23	0.232
	Burned	195.08 ± 22.32[a]			
Opportunist	Unburned	37.72 ± 15.08[a]	105.43	-1.98	0.060
	Burned	101.92 ± 22.69[b]			
Specialist Predator	Unburned	34.38 ± 6.09[a]	54.48	-3.45	0.003
	Burned	96.00 ± 16.74[b]			

*The mean of functional groups in each column with different letter were significantly different between two study sites, performed by Independent t-test at $p \leq 0.05$

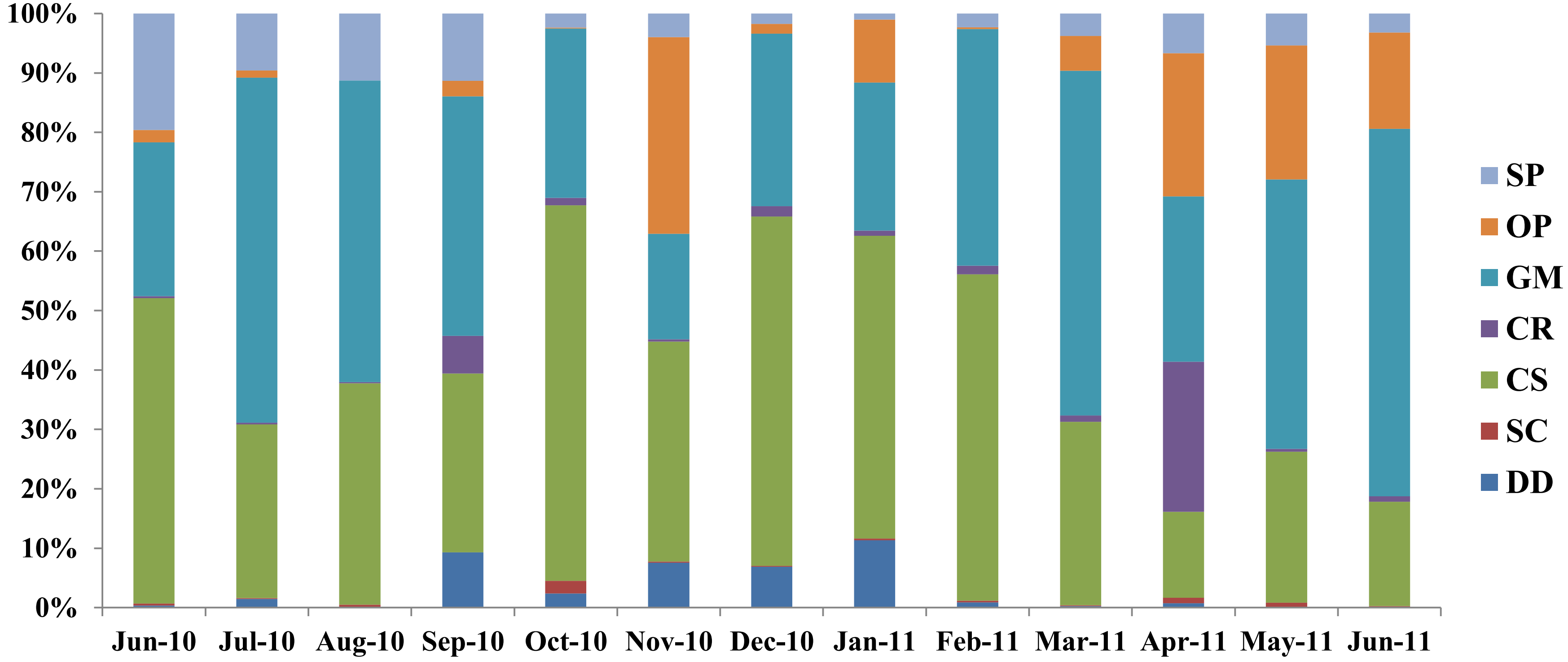


Figure 7.1A The relative abundance of ant species in each functional group according to : dominant Dolichoderinae (DD); subordinate Camponitini (SC); hot/cold/tropical climate specialist (H/C/TCS); cryptic species (CR); generalized Myrmicinae (GM); opportunist (OP); and specialist predator (SP), from June 2010 to June 2011 in the unburned dipterocarp forest.

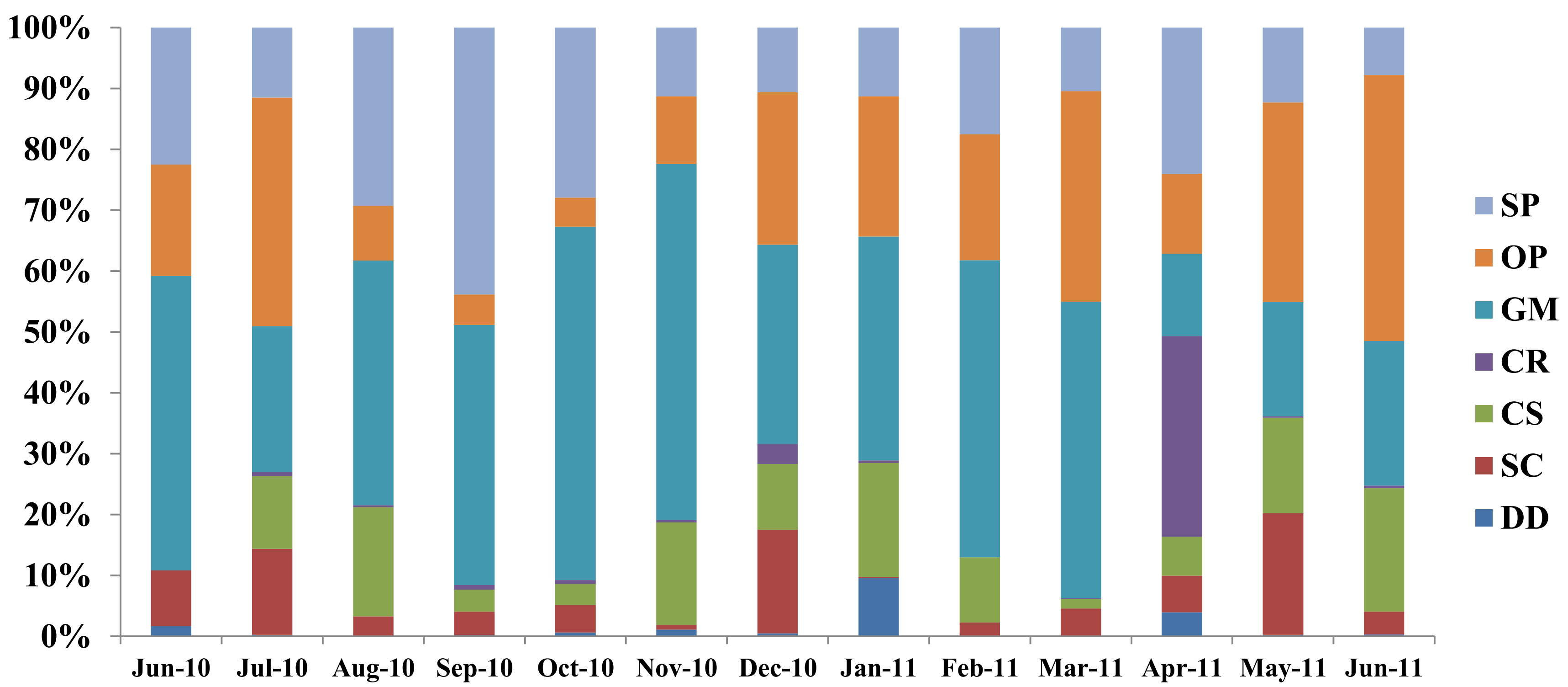


Figure 7.1B The relative abundance of ant species in each functional group according to: dominant Dolichoderinae (DD); subordinate Camponitini (SC); hot/cold/tropical climate specialist (H/C/TCS); cryptic species (CR); generalized Myrmicinae (GM); opportunist (OP); and specialist predator (SP), from June 2010 to June 2011 in the burned dipterocarp forest.

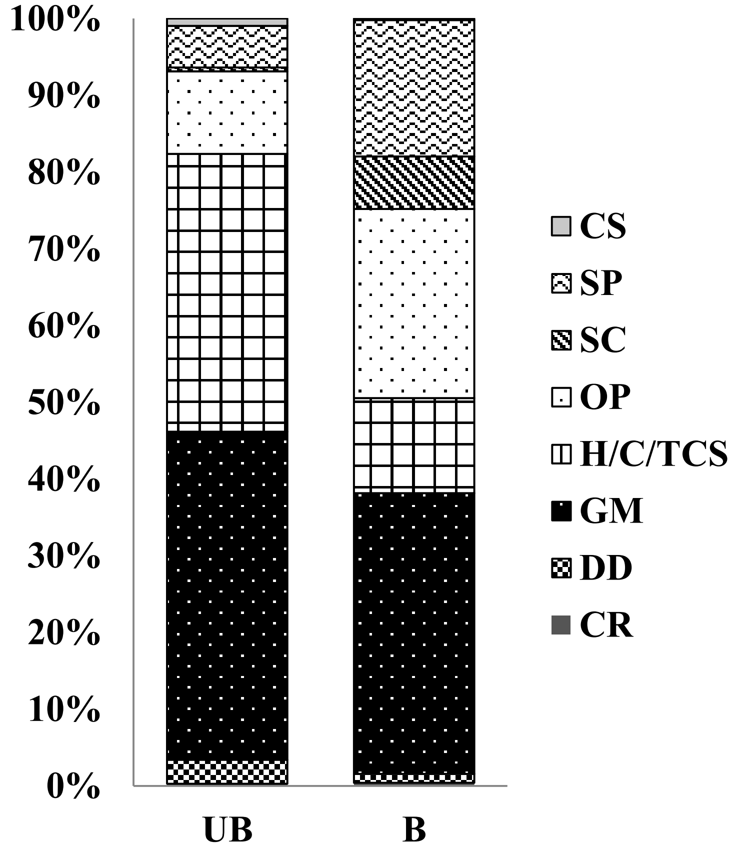


Figure 7.2 The relative abundance of ant species in each functional group according to the functional groups: dominant Dolichoderinae (DD); subordinate Camponitini (SC); hot/cold/tropical climate specialist (H/C/TCS); cryptic species (CR); generalized Myrmicinae (GM); opportunist (OP); and specialist predator (SP) for each of the unburned (UB) and burned (B) dipterocarp forest.

7.3.2 High ant functional groups in each study site

7.3.2.1 The unburned dipterocarp forest

The total abundance of all ant species found in the unburned dipterocarp forest was 8,222 individuals in overall study period. The unburned dipterocarp forest had functional groups that were numerically dominated by generalized Myrmicinae (GM), which accounted for 3,515 individuals of all functional groups in this study site, followed closely by climate specialist (CS), and opportunist (OP), respectively (Figure 7.2).

7.3.2.2 The burned dipterocarp forest

The total abundance of all ant species found in the burned dipterocarp forest was 7,259 individuals in overall study period. The burned dipterocarp forest had functional groups that were numerically dominated by Generalized Myrmicinae (GM), which accounted for 2,655 individuals of all functional groups in this study site, followed closely by Opportunist (OP), and Climate Specialist (CS), respectively (Figure 6.1).

7.3.3 The important functional groups in each study site

The unburned dipterocarp forest was referred to a natural dipterocarp forest, so the important functional groups were selected from this habitat and were used to compare to the burned dipterocarp forest. The important functional groups were also selected by the abundance of ants in each functional group in the unburned dipterocarp forest. Therefore, the four functional groups with highest in abundance were selected.

Generalized Myrmicinae (GM) was the highest in abundance, followed by climate specialist (CS), opportunist (OP) and specialist predator (SP) (Figure 7.3).

In the burned dipterocarp forest, generalized Myrmicinae (GM) was the first rank in ant abundance followed by opportunist (OP), specialist predator and climate specialist (CS) was second, third and fourth, respectively. The opportunist (OP) was yielded 1,790 individuals, followed by specialist predator (1,289 individuals) and climate specialist (CS) (Figure 7.3).

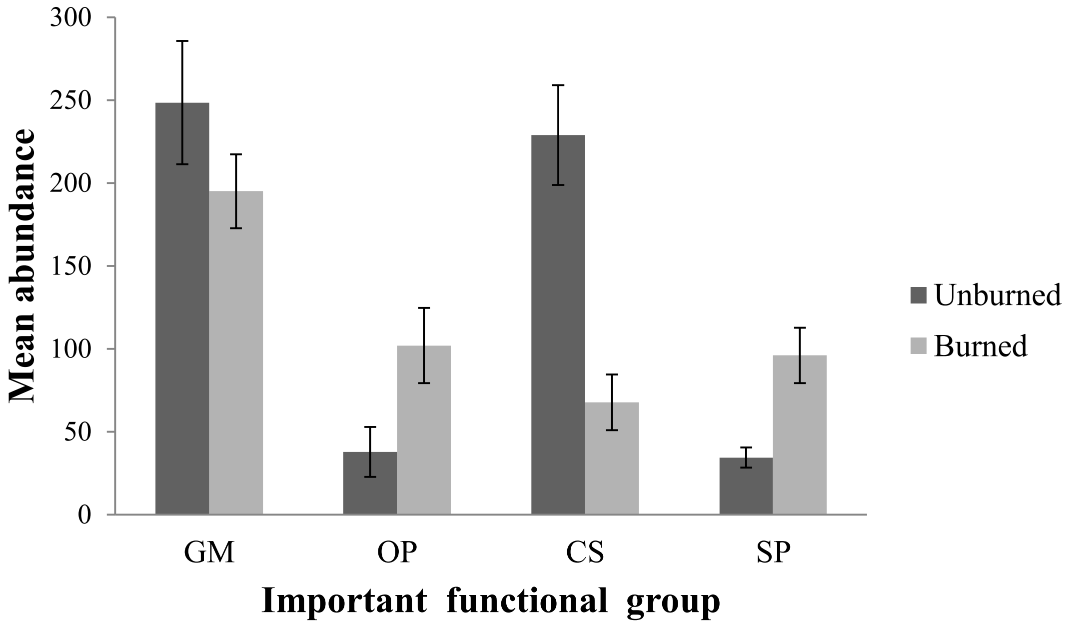


Figure 7.3 The relative abundance of important functional groups: climate specialist (CS); generalized Myrmicinae (GM); opportunist (OP); and specialist predator (SP) for each of the unburned (UB) and burned (B) dipterocarp forest.

Table 7.3 The mean* abundance of important functional groups within each study site in Lai Nan subdistrict, Wiang Sa district, Nan province

Study sites	**Functional groups (n=13)**			
	GM	**OP**	**CS**	**SP**
Unburned	248.46±37.12[a]	37.73±15.08[a]	228.92±30.18[a]	34.38±6.09[a]
Burned	195.08±22.32[a]	101.91±22.67[b]	67.62±16.78[b]	96.00±16.74[b]

*The mean of functional groups in each column with the different letters were significantly different between two study sites, performed by *Independent t-test* at $p \leq 0.05$

7.3.4 Comparison in abundance of important functional groups between two study sites

The means of abundance of Climate Specialist (CS), Specialist Predator (SP) and Opportunist (OP) were significantly different between unburned and burned dipterocarp forests ($p \leq 0.05$), except the mean abundance of Generalized Myrmecinae (GM) was not significantly different between unburned and burned dipterocarp forests. The highest abundance of Climate Specialist (CS) caught was in unburned dipterocarp forests, whereas Specialist Predator (SP) caught was the highest in burned dipterocarp forest (Table 6.3).

Table 7.4 Mean* abundance of important functional groups in each study site at Lai Nan subdistrict, Wiang Sa district, Nan province (n=13)

Important functional groups	Mean abundance (±SE)	
	Unburned	Burned
Generalized Myrmicinae (GM)	248.46 ± 37.12^{a}	195.08 ± 22.32^{a}
Climate Specialist (CS)	228.92 ± 30.18^{a}	67.62 ± 16.78^{b}
Opportunist (OP)	67.62 ± 24.38^{a}	129.00 ± 34.19^{b}
Specialist Predator (SP)	34.38 ± 6.09^{a}	96.00 ± 16.74^{b}

*The means of abundance of important functional groups with the different letters were significantly different between the study sites, which performed by *independent* t-test ($p \leq 0.05$)

7.4 Discussion

According to this study, the results revealed that opportunists *Paratrechina* were significantly dominated in the burned dipterocarp forest ($p \leq 0.05$), but they were rare in unburned areas. Aside from arboreal taxa, this study confirmed that tropical climate specialists *Oecophylla* were especially sensitive to disturbances. In specialist predators, this group comprises medium-sized to large species. They include solitary foragers, such as species of large Ponerinae, *Odontoponera* and *Pachycondyla*, which were increased in burned areas. As generalized Myrmicinae, species of *Crematogaster*, *Monomorium* and *Pheidole* are ubiquitous members of ant communities throughout the warmer regions of the world, including in unburned and burned dipterocarp forest. They are the most abundant ants with competitive tension to the others. According to Andersen (1995), the researchers considered that generalized myrmecines to be competitively subdominant ants, for the reason as firstly, they are considerably more stress tolerant than dominant dolichoderines. Secondly, whereas dominant dolichoderines typically have large territories and individuals exhibit extremely high rates of activity, territory size tends to be more restricted in generalized myrmicines, and rates of activity are more moderate. Lastly, dominant dolichoderines actively displace other ants from food source, whereas generalized myrmicines often rely more on stout defense of food sources that they have initially occupied (Andersen et al., 1991).

Consistent patterns of functional group composition can be recognized in relation to climate and vegetation (environmental stress). Functional group varies between climatic zones, and within any particular zone, varies systematically with vegetation types (Andersen, 1995; 1997). As a previous study, in monsoonal northwestern Australia, the predominant vegetation savanna, and functional group composition is similar to that in the arid zone (predominantly dominant Dolichoderines, hot climate specialist, and generalized Myrmicinae). The long-term absence of fire increases the structural complexity of the vegetation (Andersen, 1996), therefore markedly reducing insolation at the soil surface. This rapidly reduces the abundance of domonant Dolichoderines and hot climate specialists, and increases the abundance of generalized Myrmicines (Andersen, 1991).

In local patches of monsoonal rainforest, where insolation 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, 1991; Reichel and Andersen, 1996). Furthermore, in the cool-temperate southern Australia, the abundance of dolichoderines and generalized myrmicines is generally low, and opportunists and cold climate specialists are usually among the most common ants. Moreover, dominant dolichoderines and generalized myrmicines are usually only abundant in open habitats, and the relative abundances of cold climate specialists and cryptic species increase with decreasing insulation.

The ground-foraging ant faunas of different rainforest types have distinctive functional group signatures. The lowland tropics feature generalized myrmicines, particularly *Pheidole*, cryptic species, tropical climate specialists (including army and leaf cutter ants), and specialist predators. With increasing elevation or latitude, the diversity and abundance of cryptic species and particularly generalized mymicines and specialist predators decline; and tropical climate specialists are replaced by

Cold climate specialists. The faunas of cool temperate rainforests are composed almost entirely of Cold climate specialists, Cryptic species, *Hypoponera* and Opportunists, *Paratrechina* (Andersen, 1986).

Functional group composition responds predictably to habitat disturbance in temperate and semiarid regions (Andersen, 1990; Bestelmeyer and Wiens, 1996), but the effects of disturbance on functional group composition of tropical rainforest and communities have been poorly documented. For this study showed consistently with the result from Queensland by Greenslade and Greenslade (1977) indicated that a proliferation of Opportunists, species of *Paratrechina* is also characteristic response to severe disturbance in humid tropical Australia.

In any functional group analysis, there is an inevitable trade-off between generality and precision; and the board-scale predictive power of global scheme will inevitably be inadequate for a detailed understanding of the dynamics of particular communities (Andersen, 1997). However, a global ecology based on functional groups in relation to stress and disturbance provides a predictive framework for the analysis of ant community structure, integrating the roles of both abiotic and biotic factors (Dunson and Travis, 1991). It also has an important application in the use of ants as bio-indicators of environmental change (Andersen, 1990), which requires a predictive understanding of the response of ant community structure to environmental variable.

Even though functional analysis was also conducted to identify fire related trend (Thompson, 2009), which recognized the ecological rather than the taxonomic affinity of species and have been shown to be useful to study the response of ant communities to environmental stress and disturbance (Andersen 1991; Andersen 1995; Andersen, 1997; Jackson and Fox, 1996; Majer, 1983). However, these did not show any obvious trends that could be associated to fire history. As a previous studied by Thompson (2009), the study was demonstrated that functional groups did not follow predictable patterns. Therefore, it was concluded that the intermediate disturbance hypothesis may best explain the trends in ant assemblages that associated with fire. According to Connell (1978), they proposed that communities which more diverse were not in state of equilibrium, but if no disturbance occurred for long periods of time then the community would progress toward a low-diversity equilibrium community. Due to mortality of superior competitors in the latter state and diversity levels were maintained in the lesser disturbed areas by niche diversification. Moreover, the unburned sites which long-infrequent forest fire may be bring about species diversity that caused dominance by competitively superior species (Townsend et al., 1997).

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

In all of two study sites, unburned and burned dipterocarp forests, the total number of 53 and species represented quite high in these forests. Based on Shannon-Wiener's species diversity index revealed that the ant species diversity in burned dipterocarp forest was higher than the unburned dipterocarp forest. Even though the ant species diversity in the burned area was higher than the unburned area, the Sorensen's similarity coefficient indicated that the species composition between two study sites was high because they might have similar tree structure and microhabitats. It can be concluded that the burned dipterocarp forest could process some characteristics of open habitat caused by fire and provide some benefit for "fire-favored" insect species. In addition, the intermediate disturbance hypothesis is a mechanism that allows the maintenance of species diversity, when disturbance occur at an intermediate frequency or with intermediate intensity, diversity is high.

Moreover, it may possible that there were the other factors which associated to the abundance of these ants, such as restoration of plant species in dipterocarp forests along seasonal cycle all year round. Furthermore, the functional group analysis indicated that a proliferation of opportunistic species (species of *Paratrechina*) were also characteristic response to disturbance. They were significantly dominated in burned dipterocarp forest ($p \leq 0.05$) but they were rare in unburned areas.

The whole results of this research confirm that there were indirectly positive effects of forest fire on ant diversity in the dry dipterocarp forest. Some generalized species were found in both areas, while some specialized species were found dominantly in natural dipterocarp forest. If an understanding of microhabitats that used by specific ant species can be developed, along with the key trophic interactions, then the potential of using ants as terrestrial indicator species for monitoring environmental changes that caused by fire disturbance. It can be reliably and easily (low cost and time) performed comparing to some other indicator species.

However, a global ecology based on functional groups in relation to stress and disturbance provides a predictive framework for analyzing broad pattern of community composition and behavioral dominance within and between dipterocarp forest types, and the responses of dipterocarp ant communities to fire disturbance. Unfortunately, there were a few informations in functional group composition in relation to stress and fire disturbance, if these patterns are confirmed by further studies, global functional groups are a valuable tool for understanding the dynamics of dipterocarp ant communities.

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APPENDICES

APPENDIX A

Table 1-A The abundance, relative abundance, and percentage of occurrence of ant species in the unburned dipterocarp forest (common species = % relative abundance more than 5%, uncommon species = %relative abundance between 1-5%, rare species = %relative abundance less than 1%).

Species	Abundance (individual)	Relative abundance (%)	Occurrence (%)
Oecophylla smaragdina	2957	35.96	100.00
Pheidole spp.	2020	24.57	100.00
Monomorium destructor	556	6.76	92.31
Paratechina longicornis	445	5.41	76.92
Odontoponera denticulata	418	5.08	100.00
Tapinoma melanocephalum	401	4.88	100.00
Monomorium pharaonis	308	3.75	100.00
Crematogaster rogenhoferi	291	3.54	46.15
Philidris sp.1 of AMK	216	2.63	30.77
Pheidole planifrons	134	1.63	61.54
Monomorium sp.1	106	1.29	92.31
Monomorium floricola	80	0.97	30.77
Hypoponera sp.	52	0.63	92.31
Paratechina sp.4 of AMK	33	0.40	46.15
Plagiolepis sp.2 of AMK	25	0.30	7.69
Camponotus sp.7 of AMK	21	0.26	84.62
Technomyrmex kraepelini	20	0.24	38.46
Camponotus ruflogaucus	19	0.23	69.23
Pachycondyla sp.	19	0.23	61.54
Pheidologeton diversus	19	0.23	38.46
Philidris sp.	17	0.21	23.08
Monomorium chinenses	13	0.16	7.69
Recurvidris sp.1 of AMK	9	0.11	38.46
Recurvidris sp.	6	0.07	38.46
Tetramorium sp.10 of AMK	6	0.07	23.08
Oligomyrmex sp.	4	0.05	23.08
Anochetus grarfferi	3	0.04	7.69
Crematogaster sp.	3	0.04	7.69
Pachycondyla astuta	3	0.04	15.38

Table 1-A Continued

Species	Abundance (individual)	Relative abundance (%)	Occurrence (%)
Ponera sp.	3	0.04	15.38
Anoplolepis gracilipes	2	0.02	15.38
Centromyrmex feae	2	0.02	15.38
Crematogaster sp.3 of AMK	2	0.02	7.69
Dolichoderus thoracicus	2	0.02	7.69
Paratechina sp.9	2	0.02	15.38
Cardiocondyla emeryi	1	0.01	7.69
Diacamma vagens	1	0.01	23.08
Monomorium sp.	1	0.01	15.38
Pachycondyla luteipes	1	0.01	7.69
Pheidole sp.1 of AMK	1	0.01	7.69
Total	8,222	100.00	

Table 2-A The abundance, relative abundance, and percentage of occurrence of ant species in the burned dipterocarp forest (common species = % relative abundance more than 5%, uncommon species = %relative abundance between 1-5%, rare species = %relative abundance less than 1%).

Species	Abundance (individual)	Relative abundance (%)	Occurrence (%)
Paratechina longicornis	1450	19.96	92.31
Pheidole spp.	1425	19.62	92.31
Odontoponera denticulata	1256	17.29	100.00
Oecophylla smaragdina	696	9.58	92.31
Monomorium pharaonis	475	6.54	100.00
Monomorium destructor	445	6.13	100.00
Camponotus ruflogaucus	369	5.08	92.31
Tapinoma melanocephalum	269	3.70	92.31
Pheidologeton diversus	203	2.79	61.54
Camponotus sp.7	127	1.75	38.46
Pheidole planifrons	108	1.49	46.15
Monomorium sp.1	100	1.38	69.23
Philidris sp.1 of AMK	76	1.05	46.15
Paratechina sp.4	57	0.78	38.46
Crematogaster rogenhoferi	48	0.66	15.38
Monomorium floricola	43	0.59	7.69
Pachycondyla sp.	19	0.26	38.46
Recurvidris sp.1 of AMK	14	0.19	23.08
Hypoponera sp.	13	0.18	30.77
Diacamma vagens	12	0.17	46.15
Paratechina sp.8 of AMK	9	0.12	15.38
Recurvidris sp.	5	0.07	30.77
Technomyrmex kraepelini	5	0.07	38.46
Aenictus jarujini.	4	0.06	15.38
Crematogaster sp.	4	0.06	7.69
Oligomyrmex sp.	4	0.06	30.77
Cardiocondyla emeryi	3	0.04	15.38
Monomorium chinenses	3	0.04	7.69
Philidris sp.	3	0.04	7.69
Solenopsis geminata	3	0.04	7.69

Table 2-A Continued

Species	Abundance (individual)	Relative abundance (%)	Occurrence (%)
Centromyrmex feae	2	0.03	7.69
Dolichoderus thoracicus	2	0.03	15.38
Monomorium sp.	2	0.03	7.69
Paratechina sp.	2	0.03	15.38
Tetramorium sp.	2	0.03	15.38
Camponotus sericeus	1	0.01	7.69
Crematogaster sp.3 0f AMK	1	0.01	7.69
Monomorium sechellense	1	0.01	7.69
Plagiolepis sp.2 of AMK	1	0.01	7.69
Polyrhachis proxima	1	0.01	7.69
Tetramorium walshi	1	0.01	7.69
total	7,264	100	

APPENDIX B

Table 1-B List of ant species that found in the wet and dry seasons in the unburned and burned dipterocarp forests at Lai Nan subdistrict, Wiang Sa district, Nan province (W = wet season, D = dry season)

Species	Unburned sites	Burned sites
Aenictus jarujini	-	W,D
Anochetus grarfferi	W	-
Anoplolepis gracilipes	W,D	-
Camponotus ruflogaucus	W,D	W,D
Camponotus sericeus	-	W
Camponotus sp.7	W/D	W/D
Cardiocondyla emeryi	W	W
Centromyrmex feae	W/D	W/D
Crematogaster rogenhoferi	W/D	W/D
Crematogaster sp.	W	W
Crematogaster sp.3 of AMK	W	W
Diacamma vagens	D	W,D
Dolichoderus thoracicus	D	W
Hypoponera sp	W,D	W,D
Monomorium chinenses	W	W,D
Monomorium destructor	W,D	W,D
Monomorium floricola	W,D	D
Monomorium pharaonis	W,D	W,D
Monomorium sechellense	W	W
Monomorium sp.	D	W
Monomorium sp.1	W,D	W,D
Odontoponera denticulata	W,D	W,D
Oecophylla smaragdina	W,D	W,D
Oligomyrmex sp.	W,D	W,D
Pachycondyla astuta	D	D
Pachycondyla luteipes	D	D
Pachycondyla sp.	W,D	W,D
Paratechina longicornis	W,D	W,D
Paratechina sp.	W	W
Paratechina sp.4	W,D	W,D
Paratechina sp.8 of AMK	W,D	W,D
Paratechina sp.9	W,D	W,D
Pheidole planifrons	W,D	W,D
Pheidole sp of AMK	W	-
Pheidole spp.	W,D	W,D

Table 1-B Continued

Species	Unburned sites	Burned sites
Pheidologeton diversus	W,D	W,D
Philidris sp	D	D
Philidris sp.1 of AMK	W,D	W,D
Plagiolepis sp.2 of AMK	W	W
Polyrhachis proxima	-	W
Ponera sp.	W	W
Recurvidris sp.	W	W
Recurvidris sp.1 of AMK	W,D	W,D
Solenopsis geminata	-	W
Tapinoma melanocephalum	W,D	W,D
Technomyrmex kraepelini	W,D	W,D
Tetramorium sp.	-	W
Tetramorium sp.10 of AMK	W,D	-
Tetramorium walshi	-	W

BIOGRAPHY

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