ANT DISTRIBUTION BASED ON AIR QUALITY VARIATION IN URBAN COMMUNITY OF BANGKOK

DALAD SENTHONG

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
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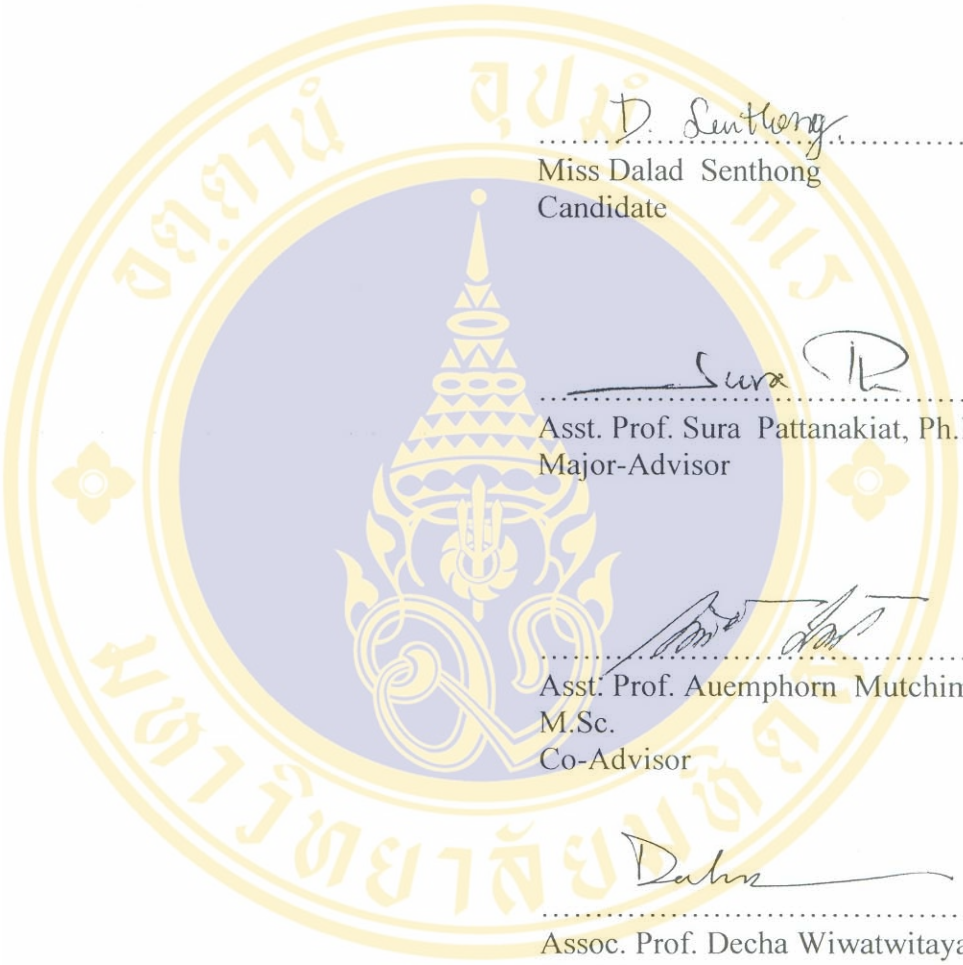

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ANT DISTRIBUTION BASED ON AIR QUALITY VARIATION IN URBAN COMMUNITY OF BANGKOK

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ABSTRACT

The objective of this survey research was to study the relationship between ant distribution and air quality variation in urban communities of Bangkok. Stratified random sampling was introduced to divide each community area into 3 types as follows: household area, commercial area and green area. Baiting and Time Unit Sampling were utilized for ant sampling between July2 002-October 2002 and December 2002-March 2003.

Seasonal change influenced the ant distribution, it revealed that the average species richness in wet and dry season were not significantly different ($P > 0.05, F=2.297$), whereas density of colony and abundance of *Pheidole bugi, Paratrechina longicornis* and *Paratrechina* sp.5 of AMKUFF were significantly different ($P<0.05, F=125.745$, 8.468, 8.234 and 6.887, respectively).

Stepwise analysis showed that ozone was positively correlated with density of colonies but negatively correlated with abundance of *P.longicornis* and *Paratrechina* sp.5 of AMKUFF. Carbon monoxide was negatively correlated with abundance of *Paratrechina* sp.5 of AMKUFF and *Tapinoma melanocephalum*. Nitrogen dioxide was positively correlated with abundance of *P.bugi*. Relative humidity was negatively correlated with abundance of *T.melanocephalum*. Furthermore, canonical correspondence analysis and TWINSPAN analysis showed parallel results that *Crematogaster monigliani* and *Cardiocondyla nuda* were positively correlated with ozone.

Results of this study can be applied by using ants to preliminarily monitor the air quality in urban areas.

KEY WORDS: ANT DISTRIBUTION / AIR POLLUTION / URBAN COMMUNITY

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ลักษณะการกระจายของมดภายใต้คุณภาพอากาศในเขตชุมชนเมืองกรุงเทพมหานคร
(ANT DISTRIBUTION BASED ON AIR QUALITY VARIATION IN URBAN COMMUNITY OF BANGKOK)

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บทคัดย่อ

การศึกษาครั้งนี้เป็นการวิจัยเชิงสำรวจ เพื่อศึกษาความสัมพันธ์ระหว่างการกระจายของมดกับคุณภาพอากาศในบริเวณชุมชนเมืองกรุงเทพมหานคร การเก็บตัวอย่างมดแบ่งออกเป็น 2 ฤดูกาล คือ ฤดูฝน (เดือนกรกฎาคม 2545-ตุลาคม 2545) และฤดูแล้ง (เดือนธันวาคม 2545-มีนาคม 2546) โดยวิธีการใช้เหยื่อล่อ ร่วมกับการกำหนดระยะเวลา ตามวิธีการสำรวจแบบ Stratified Random Sampling และสุ่มตัวอย่างด้วยวิธี line plot system โดยพื้นที่เก็บตัวอย่างในแต่ละชุมชนแบ่งเป็น 3 ลักษณะ คือ พื้นที่พักอาศัย พื้นที่ร้านค้าและร้านอาหาร และพื้นที่ที่มีต้นไม้ปกคลุมรวมถึงสนามหญ้า

ผลของฤดูกาลมีผลต่อการกระจายของมดโดย จำนวนชนิดของมดในช่วงฤดูฝนและฤดูแล้งมีค่าเฉลี่ยไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($P>0.05$, $F=2.297$) ในขณะที่ความหนาแน่นของรังความมากมายของมดชนิด *Pheidole bugi, Paratrechina longicornis* และ *Paratrechina* sp.5 of AMKUFF มีค่าเฉลี่ยแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($P<0.05$,$F=125.745$, 8.468, 8.234 และ 6.887 ตามลำดับ)

จากการทดสอบความสัมพันธ์ทางสถิติด้วยวิธี Stepwise Analysis โดยใช้ปัจจัยทางสิ่งแวดล้อม 6 ปัจจัยได้แก่ ความเข้มข้นของก๊าซซัลเฟอร์ไดออกไซด์ ก๊าซไนโตรเจนไดออกไซด์ ก๊าซโอโซน และก๊าซคาร์บอนมอนอกไซด์ อุณหภูมิ และความชื้นสัมพัทธ์ พบว่า ก๊าซโอโซนมีความสัมพันธ์เชิงบวกกับความหนาแน่นของรัง ในขณะที่มีความสัมพันธ์ในเชิงลบกับ *P.longicornis* และ *Paratrechina* sp.5 of AMKUFF ก๊าซคาร์บอนมอนอกไซด์มีความสัมพันธ์ในเชิงลบกับ *Paratrechina* sp.5 of AMKUFF และ *Tapinoma melanocephalum* ก๊าซไนโตรเจนไดออกไซด์มีความสัมพันธ์ในเชิงบวกกับ *P.bugi* ความชื้นสัมพัทธ์มีความสัมพันธ์ในเชิงลบกับ *T.melanocephalum* นอกจากนี้ผลการวิเคราะห์จาก Canonical Correspondence Analysis และ TWINSPAN Analysis มีความสอดคล้องกันโดยแสดงให้เห็นว่ามดชนิด *Crematogaster monigliani* และ *Cardiocondyla nuda* มีความสัมพันธ์ในเชิงบวกกับก๊าซโอโซน ผลที่ได้จากการวิจัยครั้งนี้สามารถเป็นแนวทางในการนำมดไปประยุกต์ใช้เป็นตัวบ่งชี้กับมลพิษทางอากาศได้

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CHAPTER I
INTRODUCTION

1.1 Background and problem statement

Since the urban areas have been expanded and developed, their ecology and environment have been also tremendous changed. The atmospheric pollution problem, especially from the transportation sector has been increased in a critical way. The levels of atmospheric pollution are continuously measured by spending quite a large amount of money in each year. Unfortunately, the measurement could not be established to cover for the hold areas to get the better result for its own effect to the urban environment. Thus, it would be approximated if the other operation could be utilized to support for this matter. The bio-indicator is expected to be one of the operation which suited support for simple monitoring and implementation.

Some kinds of animals can adapt to live in urban habitats, especially group of insects that the occurrence of species and abundance more than the others (Gilbert, 1991). For example, Czechowski (1980) reported that ants are associated with aphids occurred in the largest numbers in areas with a high traffic density, using the ants *Lasius niger* L. as an indicator of the degree of environmental pollution in a city. The study by Katayav *et.al* (1983), found that reduced number and size of ant hills (*Formica rufa*) have also reduced in heavily polluted areas. In 1993, Heliövaara and Rauno Väisänen reported that high population levels of *Aphids pomi* adjacented to a motorway.

From mentioned above, the numerous of insect species is usually reduced under the influence of urban pressure. Ants species with widespread niches dominate in urban areas. Species that succeed in colonizing are relatively free from predators and other natural enemies and can exhibit very individual-rich populations (Heliovaara and Rauno Vaisanen, 1993).

Ants have been reported as comprising a major component of biodiversity and distribute in general area and closely in ecosystem especially in tropical zones. In

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Thailand, ants were approximated between 800-1000 species (Wiwatwitaya and Rojanawong, 2001). Most of them are the forest ants, some species are found in the disturbed areas i.e., communities and industrial sectors.

In consequence of their high diversity, ant communities has proven to be a useful tool in many ways : soil health integrity, biological control in agriculture, bio-indicator in agroecosystem and be food. Furthermore, in recent years, ants were introduced to study as bio-indicator of air polluted areas. Such as the study by Hoffman (2000), ant abundance and species richness were both negatively correlated with soil SO_4 concentration, and positively correlated with distance away from mining emissions, in semi- and tropical Australia, and suggest that ants are sensitive to SO_2 emissions and appear to be good candidates as an indicator group. As Zvereva and Kozlov (2000), found that air pollution from the Severonikel nickel-copper smelter in the north-western of Russia, affects to density of wood ants. That was higher at clean site than polluted sites.

In this study, Bangkok area is chosen since it has shown a serious urban traffic pollution, beside mining site. By asking, Does ant distribution relate to air quality variation in urban community? The expected results of the study are the understanding of ant distribution in urban community and it can be use to be data base for monitoring the air quality instead advance instrument which more expensive. Moreover people can observe air quality near by their community in primary by using the ants as the bio-indicator by themselves and regard to conservation and sustainable use.

1.2 Research concept

The study of Ant Distribution Based on Air Quality Variations in Urban Community of Bangkok, independent variables are air quality characteristics that consist of Sulfur dioxide, Nitrogen dioxide, Carbon monoxide, and Ozone whereas dependent variables are species richness, abundance and diversity.

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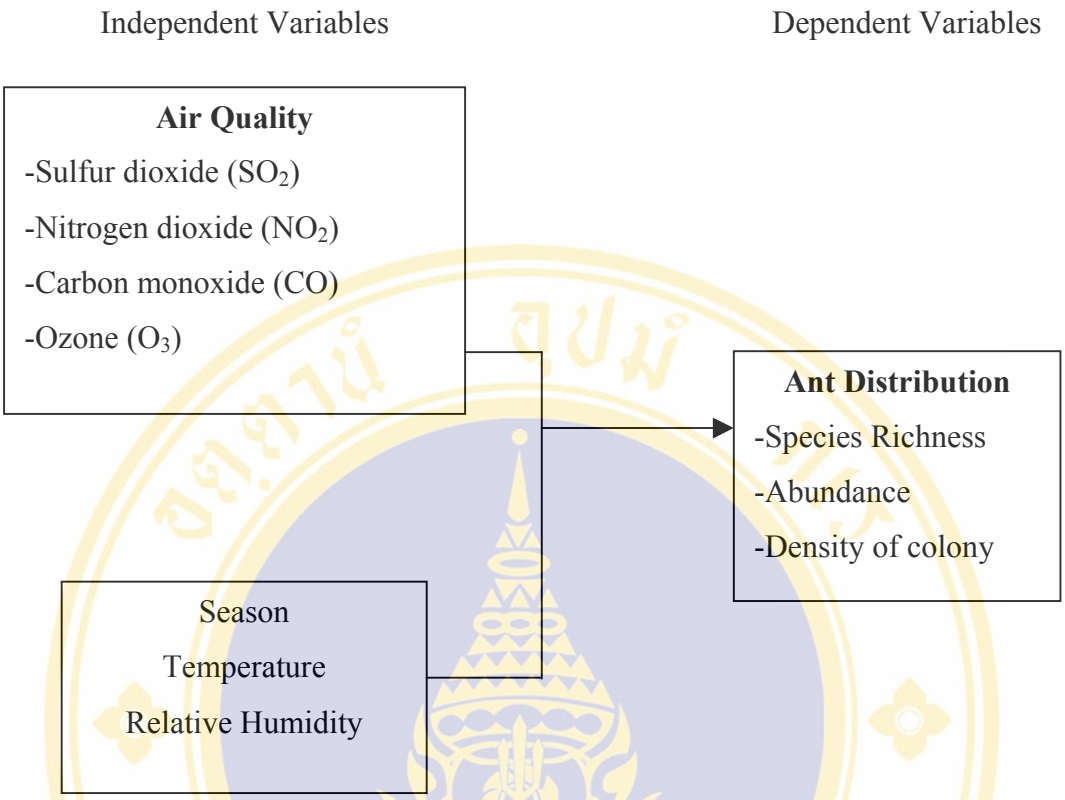

1.3 Objectives

1.3.1 To study ant distribution (species richness, abundance, density of colony) in urban community of Bangkok.

1.3.2 To study relationships between ant distribution and air quality variation in urban community of Bangkok.

1.3.3 To compare difference of ant distribution with seasons, temperature and relative humidity.

1.4 Scope of study

1.4.1 Population study are the ground-dwelling ants and ants on trees.

1.4.2 Research Variables

1) Independent variables : Sulfur dioxide, Nitrogen dioxide, Carbon monoxide and Ozone
2) Dependent variables : species richness, abundance and density of colony

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1.4.3 Research sites consist of 8 urban communities of Bangkok, namely air monitoring station of Pollution Control Department which included Dindang station, Hauy Kwang station, None Tree Vitaya station, Ratburana Post Office station, Jankasem station, National Housing Authority station, Thonburi subelectric power station and Traffic Police Residence station.

1.4.4 Duration of research

Ant sampling period is divided into 2 seasons, as wet season (July-October 2002) and dry season (December 2002 - March 2003).

1.5 Hypothesis

1.5.1 Ant distribution in term of species richness, abundance and density of colony relate to air quality.

1.5.2 Seasons, temperature and relative humidity can affect to ant distribution.

1.6 Definition of terms

1.6.1 ants mean ants that habit and dwelling on ground and trees.

1.6.2 air pollution means the pure air distributed by chemical substance or contaminated with some of gas or more and may be hazardous for subsistence of human, animals and plants.

1.7 Expected Result

1.7.1 To understand the relationship between ant distribution and air quality in urban community of Bangkok.

1.7.2 To understand ant distribution in urban community of Bangkok.

1.7.3 Be new body knowledge and data base for use ants to preliminary monitoring the air quality instead of advance instrument in urban community.

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CHAPTER II
LITERATURE REVIEW

2.1 Ant and Classification

The ants are classified as a single family, the Formicidae, within the order Hymenopotera which also includes the bees, wasps, sawflies, ichneumons, and similar forms (Hölldobler and Wilson, 1990). Eusocial vespoid acculeates with a wingless worker caste, forming perennial colonies. Head prognathous in female castes (workers and queens). Antenna with 4-12 segments in female castes, with 9-13 segments in males. Antenna geniculate between the long basal segment (scape) and the remaining funicular segment. Second abdominal segments reduced, forming a node or scale (the petiole), isolated from the alitrunk in front and the remaining abdominal segments behind. Frequently the third abdominal segment also reduced and isolated (postpetiole). Wings of alate queens deciduous, shed, after mating. Metapleural gland generally present on alitrunk, opening above the metacoxa (Bolton, 1994).

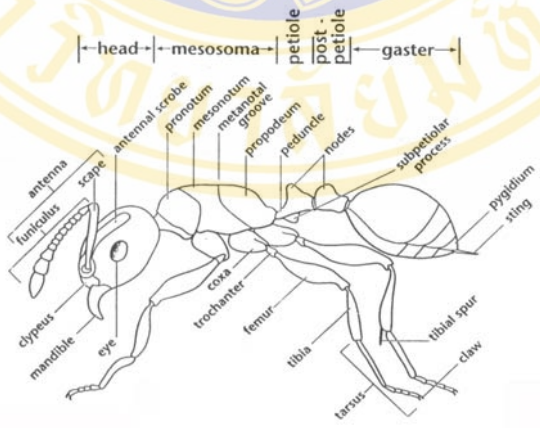

Figure 2-1 Ant in side view with the major structures labelled
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2.2 The ant niche

The ecological niche of a species describes the roles it plays in as ecosystem. The environmental factors mostly affect to ant community, three factors are important as follows:

2.2.1 The nest niche

Ant nests take a variety of forms. Some ants nest in a variety of soil types, from hard clay to loam to pure sand. While litter-nesting ants may nest in cavities in twigs or fruit, between leave, or in large, decaying logs. Some ants build nests out of chewed wood pulp. These “carton nest” are common in the tropics and may be found affixed to trees high in the canopy or in the understory, on the underside of leaves (Black, 1987).

2.2.2 The food niche

The majority of ants appear to be opportunistic foragers, taking some combination of plant exudates, seeds, and animal matter, alive of dead. Some fraction of an ant assemblage, however, is more specialized in their diets, For example, the Attini cut vegetation or collect dead insects or insect dung. This material is in turn used as a substrate on which to grow fungus, and this fungus is cultured and harvested for food. Some “ specialists” may have taxonomically narrow diets but feed on insects the are otherwise quite common (Kaspari, 2000).

2.2.3 The temporal niche

Within an ant community, subsets of species may restrict their activity to some parts of the year or day. For example, *Prenolepis imparis*, which can forage at temperature approaching 0°c, is a North American forest species commonly active in spring and fall, but rather inactive on summer (Fellers, 1989).

2.3 Factors on ant biodiversity patterns

2.3.1 Land use

In general it has been shown that agricultural practices such as heavy grazing, irrigation, drainage, fertilization, mowing, conventional tillage, ploughing and reseeding, reduce ant biodiversity and / or biomass and colony densities. Despite

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this reduction in biodiversity, ants seem to tolerate, recover, or re-invade the same areas after disturbance.

Perfecto and Snelling (1995) showed that the ant ground community is likely to suffer more reductions in biodiversity than those if the aboreal strata in coffee bushes as technological intensification increase in coffee plantation.

In western Australia, it was shown that road construction produce the greatest long term reduction in ant species alpha diversity, followed by agricultural clearing, mining, urbanization and rangeland grazing, although agricultural clearing and rangeland grazing have the greatest difference in comparison to the original diversity which characterizes the land unit (Majer and Beeston, 1996).

2.3.2 Pollution

Ants exhibit a greater resistance to pollutants in comparison to other invertebrates, especially to radioactivity and to industrial pollutants, probably due to the fact that : (1) only a ~ 10 % of ants are outside of the nest and then are exposed to these negative effects, and (2) ants can change their patterns of activity to times when exposure to pollutants is less dangerous. However, the density of ant colonies and their sizes decrease with increasing levels of pollution.

Zvereva and Kozlov (2000) studied about effects of air pollution on natural enamies of the leaf beetle, *Melasoma lapponica,* in the impact zone of the Severonikel nickel- copper smelter (Kola Peninsula, north-western Russia) and found that densities of *M. lapponica* were low at clean forest sites but higher in polluted areas. In contrast, predation on lavae by zoophagous bugs and wood ants was higher at clean sites (68.4%) than at polluted sites (32.9%). Total mortality caused by natural enemies was higher at clean sites (93.7%) than at polluted sites (79.4%) due to higher predation rates, which may partly explain increased leaf beetle density within the smelter ’s impact zone. The effects of predators in clean forests were confirmed by the extinction of adults of *M. lapponica* introduced to one of the forest sites. The data show that a decrease in predation can contribute to increased leaf beetle density and polluted sites and air pollution affects to the density of wood ants and zoophagous bugs.

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2.3.3 Climate change

Correlation between ant distribution, rainfall and temperature depend on changing conditions of temperature and humidity, may allow to predict which species can cope with changes in global temperatures and rainfall. For example, hot climate specialists should be also to tolerate increase in temperature due to the greenhouse effect.

Beside to, seasons have affected to ant diversity and ant distribution. Eungwijarnpanya *et.al* (2000) used pitfall trap to study of ants from Chantaburi province; eastern Thailand and found that species richness was significantly different in seasons, at the scale of a trap line the wet season showed higher species richness, followed by the cold, then hot seasons. However, at the larger habitat scale, the highest of species richness was 40 in the cold season, while the values were 36 and 27 for the wet and hot seasons, respectively.

2.3.4 Introductions / invasions

Exotic ants have repeatedly been shown to have negative impacts on native ant, invertebrate and vertebrate communities. Exotic ants have also shown to negatively affect restoration efforts by impeding establishment of native ant communities. When the abundance of a particular ant species is positively correlated with disturbance, this invasive species can be used as an indicator of disturbance in the area.

2.4 The important of ant

Ants are social insect which have diversity both species and abundance in vary habitats. In most terrestrial habitats they are among the leading predators of other insects and small invertebrates (Hölldobler and Wilson, 1990). Ants have the useful in many way as follows:

2.4.1 Ants as indicator of diversity

Ants are particularly appropriate for inventory and monitoring programs because most species have stationary, perennial nests with fairly restricted foraging ranges. Therefor in contrast to other insects that move frequently between

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habitats in search of food, mates, or nesting sites- ants are a more constant presence at a site and can thus be more reliably sampled and monitored (Wilson, 2000). Some ant species are specific with the habitat and high abundance, so they are easily sampled and monitored such as *Camponotus gigas* only habits in evergreen forest whereas *Oecophylla smaragdina* and *Anoplolepis gracilipes* which habit in open areas or disturbed areas only.

2.4.2 Ant as biological control in agriculture

Ants were applied to use to control pest of crops such as *Crematogaster sp.* and *A.gracilipes*, this can reduce using pesticide and help for saving money and protect the environment.

2.4.3 Ant as soil health integrity

The construction of ant nests changes the physical and chemical properties of the soil increasing its drainage and aeration through the formation of underground galleries and transforming organic matter and incorporating by food storage, aphid (Homoptera) cultivation, and the accumulation of faeces and corpses (Brain, 1978).

2.4.4 Ant as be food

In Thailand, 2 species of ant that famous to be food as *O.smaragdina* and *Cerebala sp.* (Wiwatwitaya, personal communication).

In the other hand, some ants are the cause of health problem for human. Some species are being the carrier decease to human and animals, however ants can be a nuisance more than health problems

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2.5 Field techniques for the study of ground-dwelling ants

This detailed descriptions and evaluations of eight field methods that are commonly used to study ant communities (Bestelyer *et.al*., 2000).

2.5.1 Pitfall Trapping

This method is used to estimate the abundance and species composition of ground surface active ants in an area. Traps may be plastic or glass containers that have diameter about 40-70 mm. and contain Propylene Glycol, killing agent. Traps should be placed in the ground with the lip of the trap flush with the soil or leaf litter surface or a few millimeters below the surface. The greatest advantage of pitfall traps is that they take little time to place and operate by themselves. Most epigaeic ants are well represented in pitfall traps, especially in open habitats.

2.5.2 Baiting

Baiting uses food substances to attract foraging ants to points where they may be collected or observed. This technique is commonly used to estimate the composition and richness of the active ground-foraging ant fauna, to examine ant activity and behavior patterns in studies of community structure, and to estimate the contributions of particular ant species to ecosystem processes. Baiting is the most common of the techniques used to study ant communities, no doubt because it is very simple and inexpensive and can be deployed rapidly and extensively.

2.5.3 Quadrat Sampling

In this techniques, ants are sampled directly by the investigator from within a quadrat-delimited sample are. Like pitfall trapping, this method is used to estimate the abundance and species composition of surface-active ants in an area. Quadrats are best used in open-ground situations at different times of the day or year.

2.5.4 Litter Techniques

This techniques are designed to measure the abundance and composition of ants inhabiting a volume of leaf litter, especially appropriate for use in forest and woodland habitats, where many ant species inhabit the litter layer.

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A quantity of moist leaf litter (usually all the litter and humus present under a 1 x 1 m quadrat) is collected and placed in an extraction apparatus compels mobile ants, through disturbance to the litter or through changes in microclimate, to migrate from the litter in to a collecting receptacle.

2.5.5 Colony sampling

In colony sampling, ant colonies in a defined area are identified and counted to estimate colony density and monitor changes in populations. Frequently colonies are also mapped so that demographic processes and special relationships among colonies and between colonies and environmental features may be studied. This technique detectable to the investigator in several kinds of habitats.

2.5.6 Intensive sampling

In primary goal of intensive sampling is to gather data on the total number of ants in an area by searching for and collecting all the ants within fixed plots. This approach allows precise estimation of the number of colonies and ant species per unit area. As well as estimate the total species richness of the site. This method can be used in all habitat types; it is particularly appropriate for structurally complex habitats with abundant leaf litter.

2.5.7 Direct sampling

Direct or hand sampling involves searching for and collecting ants in different miocrohabitats within an area. A favorite method of Hölldobler and Wilson (1990) in forests is to clear loose leaves from small plots to expose soil and humus and watch *th* plot for 30 minutes in order to find small or cryptic ants. Direct sampling is frequently used as a supplement to other techniques, such as pitfall trapping and may significantly argument the number of species recorded.

2.5.8 Times unit sampling (TUS)

This has been developed by Japanese myrmecologists such as Kazua Ogata and Yoko Takematsu. The sampling protocal of TUS is simple, based on the time devotes to collection. Collecting is made within 30 minutes to get as many

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species as possible. TUS adopted only hand collecting so that it is the simplest among the standardized methods (Ogata, Takematsu and Urano, 1998).

2.6 Occurrence of ant in urban areas

Some ant species can inhabit in disturbed areas which limited in habitats and food resources. Ants in subfamily and genus group which may occurrence in urban areas of Bangkok as follows: (Wiwatwitaya, personal communication)

2.6.1 Subfamily Ponerinae

1) Genus *Odontomachus*

Odontomachus workers are commonly encountered foraging on the surface of the ground both during the day and at night. They will also forage on low vegetation and on the trunks. They are generalist predators on small invertebrates, hunting singly and capturing prey with their elongate trap-line jaws. Nets are primarily in soil, either in the open or under objects but they will also occasionally nest in rotten wood on the ground.

2) Genus *Anochetus*

These ants form small nests, usually with fewer than 100 workers, in soil, in terminate nests or under logs. They are predacious on small invertebrates, using their trap – like jaws and string to capture and subdue prey. They commonly forage in leaf litter and are less frequently found in the open, especially when compared with workers of the closely related genus *Odontomachus.*

3) Genus *Diacamma*

Species of *Diacamma* nest in loose debris on the ground' s surface or less commonly in soil with a mound around the entrance. Many nests are only used for a short period before the colony moves to a new site, although nests with a single large entrance. The usual queen caste is lacking and instead mated workers produce brood.

4) Genus *Pachycondyla*

This is a large and diverse group of ants. They nest is soil either in the open or under rocks and logs, or occasionally in dense vegetation such as grass tussocks. While most are general predators or scavengers, some are specialist

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predators on termites. Some species with forage on the ground surface while others are limited to leaf or under objects on the ground. Some are also know to forage on trees at night.

5) Genus *Hypoponera*

Hypoponera can be locally abundant and is readily found under rocks and other objects on the ground, in rotten and in leaf litter. They are cryptic predators, foraging in leaf litter, and some species are known to specialise on Collembola. The males of some species are wingless and worker- like (ergatoid).

6) Genus *Leptogenys*

The nests of *Leptogenys* are found either in loose debris on the surface of the ground, or in soil. Nests on the ground surface are often used for only a short time before the colony moves to a new site, while nests in soil are occupied for longer periods. Workers are predacious and have a powerful sting. Forging occurs throughout the day and night, with workers foraging either singly or in well – formed and distinct foraging trails.

2.6.2 Subfamily Dolichoderinae

1) Genus *Tapinoma*

Tapinoma workers are often encountered foraging on low vegetation or when nests are found. They can be quite common and forage at all times of the day and night. Nest are found in a wide range of sites, including open soil, soil covered with rocks, between rocks, wood or other plant material, rotten or dead wood, plant sterns, or almost any appropriately sized preformed cavity.

2) Genus *Technomyrmex*

Technomyrmex workers are general scavengers, foraging on the ground, low vegetation and trees. They nest in the soil with or without a covering, in twigs or branches, under loose bark, and in nests constructed of plant fibres. Which are attached under leaves or to tree trunks. Workers of *Technomyrmex* commonly forage in house in search of food and water. In general they nest outdoors but will sometimes establish small nests in a suitable location indoors near a well-maintained food supply.

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3) Genus *Iridomyrmex*

Nests are located in soil, with or without covering. The above ground structure of nests varies from large mounds decorated with small pebbles and having many entrances to single, cryptic holes just large enough for individual workers to squeeze through. Most species of *Iridomymex* are general scavengers.

4) Genus *Philidris*

Species of *Philidris* form large nests containing many thousands of workers in cavities of living plants or in rotten wood above the ground. Some species are associated with plants that have special swollen stems in which the ants nest. *Philidris* workers are very aggressive when disturbed and will swarm in large numbers to attack intruders.

5) Genus *Dolichoderus*

Species of *Dolichoderus* are regularly encountered although most often in small numbers. They often forage in columns on the ground or on low vegetation and trees. Workers are general scavengers and also tend Hemiptera to collect honeydew. They nest either in the soil or arboreally, and sometimes use plant fibres to form coverings during nest construction.

6) Genus *Ochetellus*

Species of *Ochetellus* nest in open soil or under rocks, in dead wood or arboreally. Workers forage arboreally or on the ground surface, sometimes forming foraging columns, where they feed on range of small arthropods. They often forage in houses where they show a preference for fluids and sweets.

2.6.3 Subfamily Formicinae

1) Genus *Anoplolepis*

The single species of *Anoplolepis* know, to occur in Thailand, *A. gracilipes*, has been widely spread by human activities to many tropical areas. Nests of this species are primarily in the soil but may be arboreal as well. They are general predators on a range of arthropods and are known to tend Hemiptera to collect honeydew.

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2) Genus *Oecophylla*

Nest of *O.smaragdina* are always in trees or shrubs and are constructed by attaching leaves together with silk produced by their larvae. Individual colonies become very aggressive and will vigorously attack intruders. Foraging takes place both on vegetation and on the ground, and they ate predacious. Because of their large population sizes and predacious habits, these ants have been used as biological control agents.

3) Genus *Paratrechina*

Paratrechina form large colonies in open soil or under rocks or other objects, or in rotten wood on the ground. They can be locally abundant with nests easily found. Some species are known to forage primarily at night.

4) Genus *Polyrhachis*

Polyrhachis nest in open soil under rocks and logs, less commonly they nest in holes in standing trees and a few tropical species form arboreal nests made of plant fibres and larval silk. *Polyrhachis* is omnivorous and will collect nectar. Most are fairly timid and will retreat when their nests are disturbed.

5) Genus *Camponotus*

Camponotus can be expected in all habitats throughout the continent. Nests are found in a wide range of sites including in soil with or without coverings, between rocks, in wood, among the roots of plants and in twigs on standing shrubs or trees. They general scavengers and predators and will collect nectar and plant secretions and tend Hemiptera for honeydew.

2.6.4 Subfamily Myrmicinae

1) Genus *Crematogaster*

Workers are moderately aggressive and will attack when disturbed. They have well developed chemical defences and are avoided by most other ants. Nests are found in a range of sites including in soil with or without coverings, in cracks in rocks, and arboreally in truck and twigs.

2) Genus *Meranoplus*

These common ants form ground nests, with or without covering, sometimes with a mound of low dirt or a large depression around the entrance, and

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often with piles of discarded seeds or seed coats near or around the entrance. Workers are slow moving, foraging on the ground and occasionally on tree trunks, primarily during the day but also at night. When disturbed many species will retract their legs and curl their gasters under themselves to form a compact ball, and lie motionless to avoid detection.

3) Genus *Solenopsis*

These small, cryptic ants nest either in open soil or under rocks. When in open soil they sometimes have a mound of loose dirt around the nest entrance. They are also sometimes associated with the nest of other ants and termites. When nesting with other ants or termites, they act as 'thief ants', raiding the host's nests for food. Although relatively uncommon in most areas, they are sometimes locally abundant, foraging in leaf litter or on the ground.

4) Genus *Pheidologeton*

These ants form very large colonies in soil, either in the open or under wood or rocks. They are general scavengers or predators, foraging on the ground throughout the day ad night. Large numbers of workers can be attracted to baits places on the ground.

5) Genus *Monomorium*

Species of *monomorium* are very diverse in size and habits, ranging from very small generalist scavenger to large, polymorphic seed harvesters. Nests vary from small colonies under rocks to large, low mounds, and a few species nest arboreally under bark or in rotten branches. Many species form small mounds in open soil which are highly visible because of the large number of workers foraging in its vicinity. Foraging is primarily during the day, with some species limited to the hotter periods.

6) Genus *Pheidole*

Pheidole can be encountered almost everywhere and at any time. Most species form nests in the soil with a low mound of loose dirt around the entrance. These mounds are often very active with many workers carrying soil from the nest and foraging in the immediate vicinity. This can make nests highly visible. Foraging is most common on the ground and large numbers of workers can be found at highly desirable food sources such as honey baits.

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7) Genus *Tetramorium*

Within their preferred habitats these ants can be very common. They forage individually on the ground, often in large numbers, and are most active during the morning and evening hours. Nests are in soil with a simple entrance. They are general scavengers or predators and seed collecting is common in some but not all species.

2.7 Air Pollution

2.7.1 The meaning of air pollution

Stern (1976), giving a meaning of Air Pollution as the pure air was disturbed by chemical substance or contaminated with some of gas or more and may be hazardous for subsistence of human animals and plants.

Office of Environmental Policy and Planning (1997), giving a meaning as the air condition which contaminated with high quantity of contaminant into the hazardous level for human and property including with animals and plants. The various type of air contaminant such as some gas, dust, smoke and radioactive.

Environmental Health Division (1998), giving a meaning as the air condition which contaminated more quantity of toxic substance till hazardous for human, animals, plants and property both direct effect and indirect effect.

Roger (1999), giving a meaning as the presence of contaminant or pollutant substances in the air that do not disperse properly and that interfere with human healthy or welfare, or produce other harmful environmental effects.

The conclusion of all meaning of air pollution are the air condition which contaminated with concentration of toxic substance than normal situation in the continuous time and making worse for air quality till to hazard directly and indirectly for human, animals, plants and environment.

2.7.2 Source of Air Pollution

The following of 2 types of source of air pollution are: (Limpasenee *et.al*., 1993)

1) Natural air pollution

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For example, volcano, explosion, forest fire. Particles of solid, etc. Natural air pollution have less hazardous to human because the sources are far more than and amount of pollutants in the environment are less.

2) Air pollution which occurring from human ant, following as 3 types:

- Industrial air pollution as the industrial factory and other manufacturing which emits the contaminants to atmosphere. It depends on industrial type and process method.

- Air pollution from vehicles as the automobile. Particularly, the vehicles on the road which are arranged as the significant problem of Bangkok. Many vehicles are the cause of the traffic jam and emits more waste gases to the air. Following or the toxic gases with emitted from many vehicles are carbon monoxide, hydrocarbon, oxide of nitrogen and oxide of sulfur. All of that are the toxic gases for people health.

- Other source of pollution as some garbage and waste, example, garbage dump, rabbis burning or wastewater pond which make a nuisance smell.

2.8 The major air pollutants vapors and their effects

2.8.1 Sulfur Dioxide

One of the major pollutants produced from man-made source is sulfur dioxide (SO_2), much of which arises from the combustion of fossil fuels used for energy production. Industrial processes such as smelting, sulfuric acid manufacture, and petroleum refining also produce sulfur dioxide. Sulfur dioxide is a nonflammable, colorless gas that can exist in air either a gas or dissolved in water droplets. It can be tested by most people at concentrations of about 900 $\mu g/m^3$ or greater. When sulfuric acid exposed with high quantity (0.11 to 0.99 ppm in 24 hours) will be made corrosive to the respiratory tract. For the plants, it will be made chronic disease, and abnormal leafs declining and die (World Health Organization, 1976).

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2.8.2 Carbon monoxide

Carbon monoxide (CO) is one of the most widely distributed and most commonly occurring air pollutants. Atmospheric, CO is primarily produced by the incomplete combustion of carbonaceous materials used as fuels of vehicles, space heating, and industrial processing (World Health Organization, 1976). By the way, the results of air monitoring found that CO of the traffic jam area especially in rush hour period are on the severity (Limpasenee *et.al*, 1993). Carbon monoxide is a colorless. Odorless, tasteless, stable gas, slightly lighter than air; in high concentrations it can cause many physiological changes and, ultimately, after only a few hours (World Health Organization, 1976).

2.8.3 Nitric oxide and nitrogen dioxide

Nitric oxide (NO) and nitrogen dioxide (NO_2) are the most prevalent nitrogen oxide air pollutants. These pollutants are chiefly emitted from high temperature combustion process, with the major oxide on combustion emissions being NO. Nitric oxide is oxidized to in nitrogen dioxide the atmosphere. Nitric oxide is a colorless. Odorless gas that is slightly soluble in water. Nitrogen dioxide is a reddish-orange-brown gas with a characteristic pungent odor (World Health Organization, 1976).

When inhale of these gas onto body, the reaction with moisture in the respiratory tract will be made acid which damage to tissue of respiratory system damaged the color of household and made of the acid rain hazardous for plants and to be bad image too (Limpasenee *et.al*, 1993).

2.8.4 Ozone

The occurrence of adverse effects of increased concentrations of ground level ozone on human health have been widely accepted, even though it is difficult to define an overall level of impact for the whole population, as ozone peak concentrations usually occur localized. It has been noted, that people with asthmatic or similar respiratory diseases are especially sensitive to ozone concentration increases. Besides the health effects, high concentration of ground level ozone can

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seriously damage sensitive plants like agricultural crops or forest trees (Friedrich and Reis, 2000).

Besides the physiological effects of air pollutants to human and animals, ecological effects have been reported by Newman (1980) are:

1) Change in population numbers, e.g., density and diversity
2) Change in spatial distribution, e.g., dispersal, migration
3) Change in quality and quanity of habitat
4) Change in quality and quanity of food resources
5) Change in selective pressure and competitive ability
6) Change in appearance, e.g., phenotypic changes
7) Change in birth rate
8) Change in death rate
9) Behavioral change, including abnormal behavior

2.9 Principles and method of measuring air pollutants

Pollution control Department has referred the method of measuring air pollutants from World Health Organization as follows:

2.9.1 Sulfur dioxide: UV-Fluorescence method

Fluorescence emission occurs when molecules absorb radiant energy at one wavelength and re-emit part of that energy at another wavelength. In gases, fluorescence is a low pressure phenomenon, the emission being normally quenched to undetectable levels at pressures near atmospheric. However given a suitably intense monochromatic light source, the method can in principle provide the basis for selective analysis of trace gases (e.g. SO_2) which have a strong absorption band from which fluorescence emission occurs. Instruments are available for the specific measurement of SO_2 in the 0.5 to 1000 ppm range utilizing fluorescence emission. These employ a pulsed UV source which irradiates the sample gas flowing continuously through the optical cell. The fluorescence emission is detected by a photomultiplier viewing at 90˚ to the excitation beam (Roger and Robert, 1977).

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2.9.2 Carbon monoxide: Non-Dispersive Infrared Detection (NDIR) Method

Measurements are based on the absorption of infrared radiation by carbon monoxide in a non-dispersive photometer. Infrared energy from a source is passed through a cell containing the gas sample to be analyzed, and the quantitative absorption of energy by CO in the sample cell is measured by a suitable detector. The photometer is sensitized to CO by employing CO gas in either the detector or in a filter cell in the optical path, thereby limiting the measured absorption to one or more of the characteristic wavelengths at which CO strongly absorbs. Optical filters or other means may also be used to limit sensitivity of the photometer to a narrow band of interest. Various schemes may be used to provide a suitable zero reference for the photometer. The measured absorption is converted to an electrical output signal. Which is related to the concentration of CO in the measurement cell (World Health Organization, 1976).

2.9.3 Nitrogen dioxide: Chemiluminescence Method

The Chemiluminescence Method is an automated method based on the gas-phase reaction of NO with O_3 at reduced or near atmospheric pressure. Atmospheric concentrations of No2 are measured indirectly by photometrically measuring the light intensity resulting from the reaction of NO with O_3. Nitrogen dioxide is quantitatively reduced to NO by means of a converter before reacting it with O_3 to yield a measurement of NO + NO_2. After measurements of NO and NO + NO_2 are made. The NO measurement is subtracted from the NO + NO_2 measurement to yield the final NO_2 measurement. The NO and NO + NO_2 measurements may be made concurrently with dual systems or cyclically with the same system, provided the cycle time does not exceed 2 minutes (World Health Organization, 1976).

2.9.4 Ozone: Chemiluminescence Method

The Chemiluminescence Method for ozone is an automatic method based on the gas phase reaction of ethylene with O_3.Ozone reacts rapidly with excess ethylene to produce a short-lives ozonide that emits light upon decomposition. The intensity of this light is measured photometrically by a photomultiplier tube and is

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related directly to the concentration of O_3 in the air (World Health Organization, 1976).

2.10 Air quality in Bangkok

Air pollution problem in Bangkok become from 2 sources following as more automobiles, emission of toxic gas from car discharge into the air and industry which located in Bangkok and surrounding. Office of Environmental Policy and Planning (2000) reported the air quality in Bangkok as follows:

2.10.1 Air quality of general area in Bangkok

The major problem of air pollution for general area in Bangkok area between the year 1999 to 2001 which far from the road not over 50 meters and being the household area was particulate which smaller size than 10 micron but their trend were reduced (Appendix Table 1).

Although the results of total suspended particulate (TSP) monitoring average in 24 hours found that reduced in quantity since 1993 and met standard (120 $\mu g/m^3$) but in the year 1999, the trend were induced and quantity were no more over standard. Whereas the quantity of sulfur dioxide and nitrogen dioxide have met standard all years.

The quantity of carbon monoxide average in 8 hours were no more over standard (9 ppm) and have a few the number of over standard.

For the result of ozone that average in 1 hour in 1999 were found that the quantity have over standard (100 Part per billion: ppb) but in 2000, the maximum quantity was 203 ppb that higher than standard about 2.0 times at the area of Ramkamhang University (Appendix Table 2).

2.10.2 Air quality of the roadsides area in Bangkok

The results of air quality monitoring near the roadside area in Bangkok, have found the major problem were the same as generally area but more severity because living near the pollution source such as all types of vehicles and construction activities.

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Particulate matter (PM_{10}) have been the major problem, the maximum quantity which average in 24 hours was 244.4 $\mu g/m^3$ and it was increased from 1999 which had 12.8 % (Pollution Control Department, 2001).

For the result of total suspended particulate monitoring average in 24 hours found that had over standard but the trends were reduced in quantity. By the way , sulfur dioxide and ozone had standard all years. Whereas the number of over standard of nitrogen dioxide had only one time of all samples. Carbon monoxide average in 8 hours had over standard was 0.4 % in 1999. Comparing with 2000, carbon monoxide and ozone had no more over standard. For other pollutants, it have met standard (Pollution Control Department, 2001) (Appendix Table 3).

In conclusion, dust have been the major problem of air pollution in Bangkok area especially the area which nearly the roadsides. And ozone should be considered in order to increase the quantity in air in the future (Pollution Control Department, 2001).

2.11 Relevant researches

Perfecto and Vandermeer (1996) studied about microclimatic changes and the indirect loss of ant diversity in a tropical agroecosystem in Costa Rica, focusing on the ground-foraging ant community. The study site was divided to 2 characteristics, coffee farms are being transformed from vegetationally diverse shaded agroforestry systems and unshaded coffee monocultures and their hypothesis were the high-light environment and lack of leaf litter cover in the unshaded system are the determinants of the differences in ground-foraging ant diversity. Four treatments were established within the light gaps of a shaded plantation: shaded, leaf litter, shaded plus leaf litter, and a control (no shade or leaf litter added). Ants were sampled using tuna fish baits and light and temperature were measured. Shaded and leaf litter had a significant effect on the ant fauna but probably for indirect reasons having to do with species interactions. In both shade treatments, *Solenopsis geminata*, the tropical fire ant, decreased significantly while the other species increased. The possibility that the physical factor changes the nature if competitive interactions between the most abundant species is discussed.

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Vanderwoude *et.al*. (1997) studied the effects of different fire regimes on ant community structure at Bauple State Forest in 1994-1995. Three sites had been subjected to long-term burning regimes of: annual burning; periodic burning (2-3 years); and no burning. Two grids of pitfall traps were established in each compartment, and ants were sampled monthly between May 1994 and April 1995. A total of 88 species from 42 genera were recorded, with 74 species found from the annually burned site, 63 from the periodically burned site, and 43 from unburned site. The relative abundance of Eyrean (arid) taxa was particularly high (36%), and that of Bassian (cool temperate) taxa low (8%) at the annually burned site, with the reverse true for the unburned site (14% and 20% respectively). Burning frequency also affected the dominance of functional groups. The relative abundance of Dominant Dolichoderinae (species of *Iridomyrmex*) was positively related to fire frequency, while Opportunists (mostly species of *Rhytidoponera*) comprised 65% of all ants at the unburned site, but only 16% at the annually burned site.

Ogata *et.al.* (1998) compared species diversity in urban area, ant assemblages of two parks in Fukuoka city, Japan. Momochi Chuou Kouen Park (MCP) is a newly established open land, reclaimed from the sea in 1988, while Minami Kouen Park (MKP) is an old conservation area, established in 1941 and covered mainly by broad-leaved trees. A total of 31 species were found from 16 samples, each of which was collected in a 30-min time period; 17 species in MCP, 20 species in MKP. Species accumulation curves showed that obtained species number reasonably represented species diversity in true species richness is greater than that represented by samples. MCP species composition was comprised largely of tropical/subtropical elements. MCP also included higher percentage of eurychoric species and the difference in the ratio between the 2 parks would become greater in true species richness.

Peck *et.al.* (1998) assessed the potential of using ants as environmental indicators of agroecosystem condition, ants were collected from a stratified random sample of agricultural fields planted in annually harvested herbaceous crops at 90 sites in North Carolina and Virginia. The ants were identified to species and

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correlation with soil, management and crop variables were examined as the first step in developing an environmental indicator of agroecosystem condition. A total of 41 species of ants was found. Ant species assemblages were found to differ significantly between the fields and the fields margin. Ant species assemblages were correlated with soil variables, tillage practices, and insecticide use, suggesting that ants have potential as a biological indicator of agroecosystem condition.

Hoffman *et.al.* (2000) studied about responses of ant communities to dry sulfur deposition from mining emissions in semi-arid tropical Australia, with implications for the use of functional groups, forty plots were sampled, stratified at two levels : sulfur deposition zones (high, medium, low, and two control zones) and habitat (Ridge and Plain). They found that the two habitats supported distinctly different ant communities. Ant abundance was lowest in the high and medium sulfur zones on both habitats. Ant abundance and richness were bot negatively correlated with soil SO_4 concentration, and positively correlated with plant species richness and distance away from the smelters. Relative abundance and richness of Eyrean (arid adapted) taxa collectively responded positively to sulfur, and Torresian (tropical) and widespread species responded negatively. Despite large changes in species composition and abundance, there was relatively little change in the abundance of functional groups that have been widely used in studies of Australian ant communities. Ants are sensitive to SO_2 emissions and appear to be good candidates as an indicator group in this context.

In conclusion, biodiversity of ant in forest, agriculture areas or urban areas also depended on 2 factors which consist of: natural factors (such as food sources, habitats and climates) and human impacts (such as land-used change, pollution, invasions and climate change). Interestingly, few studies showed that species richness abundance and diversity related to air pollution too. So, from this review could conduced the factors and methods for study in CHAPTER III.

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CHAPTER III
MATERIALS AND METHODS

3.1 Study area

Bangkok, the center of business and technology, has rapidly population growth and the transportation is the necessary thing for people who live in Bangkok. The demand of people for transportation is high, so it make the serious problem about traffic jam, especially the areas which near the main-roadsides have more air pollution than other areas.

For the sampling area, urban communities were selected to represent for all urban communities in Bangkok which located the air monitoring station of Pollution Control Department. The throughout geography of urban communities are similarly to open areas, lots of houses and buildings, narrow roads and less the green areas.

3.2 Temperature, relative humidity and air quality data collection

The secondary data of temperature and relative humidity which were the average per day of the whole area of Bangkok were supported by Meteorological Department. Meanwhile the secondary data of air quality was supported by Air Quality and Noise Management Division, Pollution Control Department which included sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide. The measuring of these air pollutants are as follows:

1) Sulfur dioxide measuring is UV-Fluorescence
2) Nitrogen dioxide measuring is Chemiluminescence
3) Ozone measuring is Chemiluminescence
4) Carbon monoxide measuring is Non-Dispersive Detertion

The concentration of air pollutants, the average in 1 hour values of the day that collected ants in each community were investigated.

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3.3 Ants data collection

3.3.1 Sampling points

The sampling points were proposed within urban community of Bangkok which located air monitoring station of Pollution Control Department, as Klongjun community (Nation Housing Authority Station), Ratburana community (Ratburana Post Office Station), Wongwian Yai community (Thonburi subelectric power station), None Tree Vitaya community (None Tree Vitaya Station), Chockchai 4 community (Traffic Police Residence Station), Jankasem community (Jankasem Station), Dindang community (Dindang Station) and Hauy Kwang community (Huay Kwang Station) as show in Figure 3-2.

3.3.2 Materials

1) 70% Ethyl alcohol
2) 80% Honey solution (v:v)
3) Vails
4) Forcept
5) Cotton piece (3x3 cm)
6) Handlens
7) Micro-stereoscope

Figure 3-1 Materials for ant collecting at urban community of Bangkok

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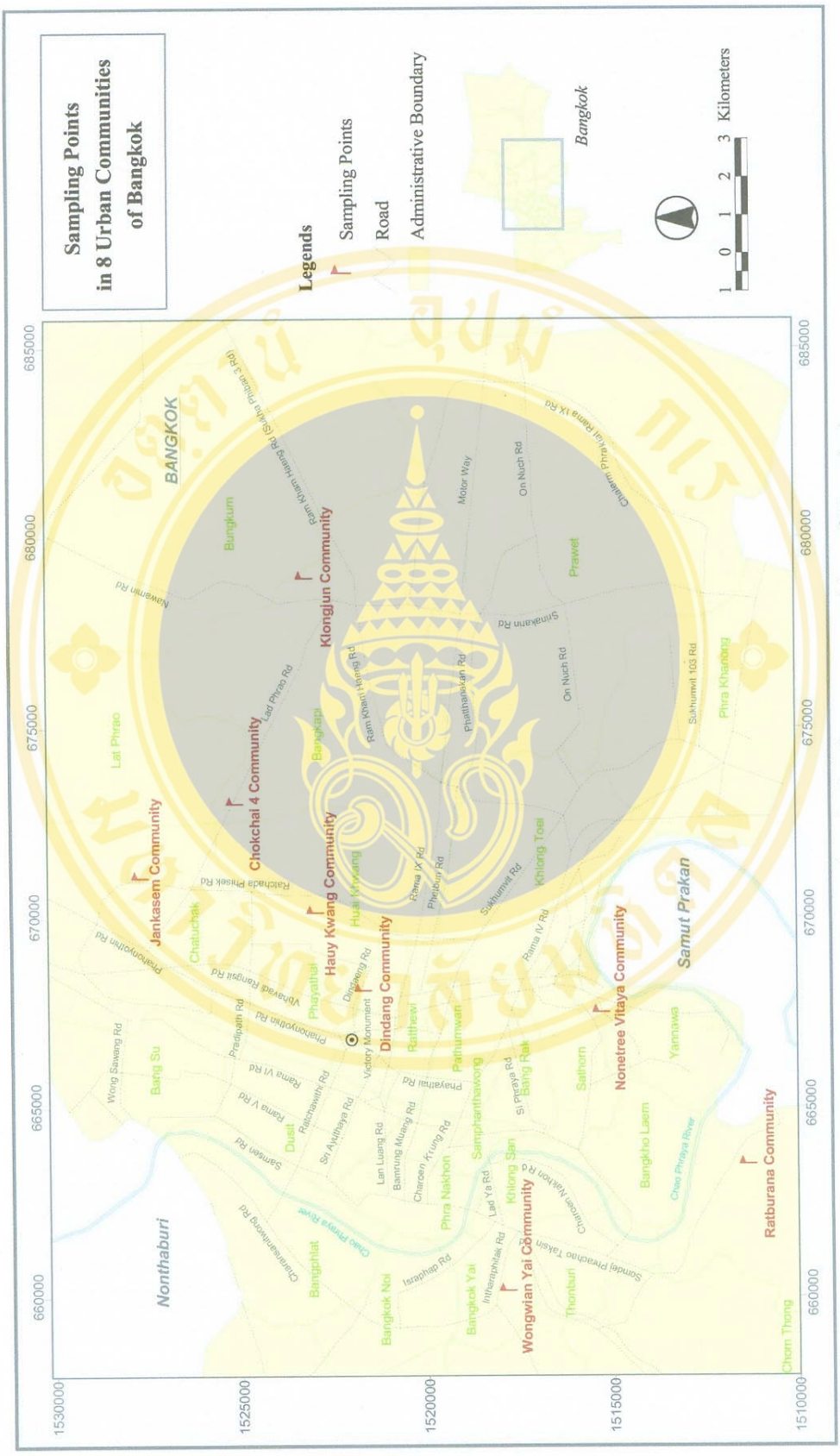

Figure 3-1 Sampling Points in 8 urban communities of Bangkok

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3.3.3 Duration of sampling

Ants sampling are divided into 2 seasons, being wet season (July-October 2002) and dry season (December 2002-March 2003).

3.3.4 Survey and sampling method

Sampling Method: Baiting and Time Unit Sampling (TUS) is chosen to use in this study which based on the time devoted to collection and these appropriate for utilized in Bangkok that mostly open areas; concrete surface and less leaf litter.

For baiting, honey solution is baited as food for ants which be accepted from ants at least occasionally observed on the preference food, compared with other type baits such as small insects and cheese. Moreover honey solution is the energy source as from the natural source; as fallen fruits, honeydew of homopterans on the shrubs and plant roots and extrafloral nectaries (Hashimoto, Yamane and Itioka, 1997). Tobin (1994) suggested that high-tempo ants (*i.e.* with rapid motion), such as *Azteca* and *Tapinoma*, usually rely exclusively on carbon-rich diets for source of energy.

Survey Method: Stratified Random Sampling is chosen to use in this study. This is simply the process of identifying areas within an overall habitat, which may be very different from each other and which need to be sampled separately. Each individual area separately sampled within the overall habitat is then called a stratum (http://www.offwell. free-online.co.uk/4howto.htm# STRATIFIED SAMPLING).

For this study, each urban community was stratified at 3 strata, consisted of (1) Green Area, (2) Commercial Area and (3) Household Area, which covered the ant habitats. Then all strata were used Line Plot System for ant sampling.

Line plot was applied to use the roads to be the bait lines for conducting the sampling plots and length for 45 m in each strata. Honey baits within each line were spaced 1 m apart. Because of covered area, baits were placed in a straight line whenever possible and conduced 1-15 of plots on the right hand of line,

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16-30 of plots on the left hand and 31-45 of plots on the right hand of line. So in each stratum, 3 lines were used with 135 plots in each community. Moreover, 2x2 m of quadrats were placed 5 m apart on the same line of honey baits for counting the colonies of ants.

Ant Sampling: Cotton pieces (3x3 cm) with 80% honey solution were placed on each line plots. Then after 30 minutes, ants were collected on cotton pieces and which around plots approximately 10 cm to preserve in 70% ethyl alcohol. In addition, the ants that found on trees in the areas were also collected and counted number of colonies in each quadrats (2x2 m) within the line plots. Finally, duration and environment around sampling areas were recorded.

3.3.5 Ant identification

The specimens were identified up to the genus and species level according to the keys by **Identification Guide to the Ant Genera of the World** (Bolton, 1994) and checked with the collected specimens in the Ant Museum of Thailand at Kasetsart University. For ants which could not be identified to species were listed as sp.1, sp.2 of AMKUFF and so on.

3.3.6 Data manipulation

1) Frequency : This value is defined as the probability of finding the species in any one area (Kreb,1985).

$$\text{Frequency} = \frac{\text{no.plots of species x X 100}}{\text{total plots of all specie}}$$

$$\text{Relative frequency} = \frac{\text{frequency of species x X 100}}{\text{sum of frequency values for all species}}$$

2) Abundance : This value is the approximated value of no. individual for each species in nom plots of species x (Kreb,1985) .

$$\text{Abundance} = \frac{\text{no. individuals of species x X 100}}{\text{no. plots of species x}}$$

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$$\text{Relative abundance} = \frac{\text{abundance of species x X 100}}{\text{sum of abundance values for all species}}$$

3) Occurrence : This value is the ratio of no. finding the species in total times of sampling.

$$\text{Occurrence} = \frac{\text{no. finding of species x X 100}}{\text{total times of sampling}}$$

4) Similarity Index or Sorensen Index : This value was based on species presence only (Spellerge, 1991). The degree of similarity in species composition between each pair of samples within a site was analyzed using Sorensen's Index which represents the proportion of total species in a sample pair which is present in both samples (Kreb, 1985).

$$C = \frac{2W \text{ x } 100}{A + B}$$

Where C = Similarity Index
W = ant species occurring in both areas
A = number of ant species in area A
B = number of ant species in area B

5) Species Diversity Index: This based on the species and abundance of species in a habitat or community. The diversity within a community was identified using Shannon-Wiener Index as the following formula (Wilson, 2000) :

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

Where H′ = Shannon Diversity Index
s = the number of species

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pi = the proportion of individuals or abundance of the ith species expressed as a proportion of total cover

ln = log base $_n$

6) Evenness Index: The calculation of equitability or evenness index was also determined of the form: (Ludwig and Reynold, 1988)

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

Where J = Equitability or evenness index

H´ = Shannon Diversity Index

H´max = ln s

3.4 TWINSPAN Analysis

TWINSPAN analysis (Two Way INdicator Species Analysis) is a type of cluster analysis. TWINSPAN program not only classify the sites but also constructs an ordered two-way table from a sites-by-species matrix that each group of sites can be characterized by a group of differential species by change the quantitative data (species abundance) of each species to the qualitative data (presence/absence) (Jongman *et.al*., 1995). For this study, PC-ORD Program version 4.0 were used.

3.5 Canonical correspondence analysis: CCA

Canonical Correspondence Analysis is a type of Canonical ordination techniques which designed to detect the patterns of variation in the species data that can be explained 'best' by the observed environmental variables. The resulting ordination diagram expresses not only a pattern of variation in species composition but also the main relations between the species and each of the environmental variables (Jongman *et.al*., 1995).The ordination diagrams of stands and species composition from CCA will be expressed in graph from with plots of points on one of

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few dimensions. The distance between the points on the graph is taken as a measure of their degree of similarity (or difference). Points, which are close together, will represent stands that are similar in species distribution; the further apart of any two points, the mire dissimilar the stands will be (Kent and Coker, 1992).

3.6 Statistical method

3.6.1 Description Statistics

Description statistics as Mean, Maximum, Minimum and Standard Error of Estimated are presented in form of graph and table.

3.6.2 Statistical analysis

Statistical analysis can contribute to this research through SPSS for Windows as follows:

1) Testing the difference of ant distribution in urban community of Bangkok by One-way ANOVA.
2) Testing the difference of ant distribution in seasons by One-way ANOVA.
3) Correlation analysis of ant distribution and air quality on urban community of Bangkok by Pearson correlation and Multiple regression analysis by stepwise method.

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CHAPTER IV
RESULTS AND DISCUSSION

4.1 Temperature and Relative Humidity of Bangkok

Temperature of Bangkok between July-October 2002 and December 2002-March 2003 was closed. The mean of temperature that highest and lowest presented in July 2002 (30.1 degree of Celsius) and January 2003 (27.3 degree of Celsius) respectively. For most of Relative humidity of Bangkok also closed. The mean of relative humidity that highest and lowest presented in July 2002 (77.8%) and October 2002 (61.4%) respectively. (Table 4-1, Figure 4-1)

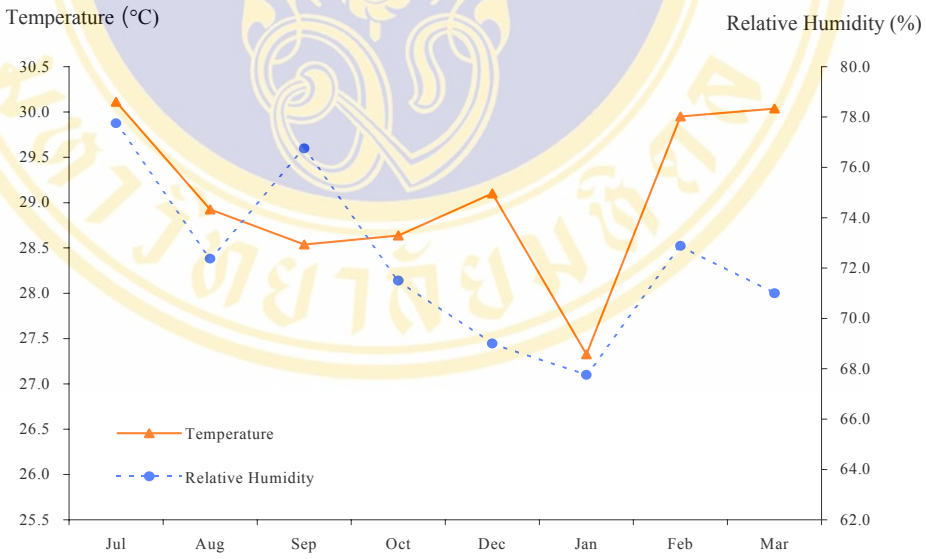

Figure 4-1 The mean of temperature and relative humidity of air in Bangkok between July-October 2002 and December 2002-March 2003

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Table 4-1: Mean of temperature and relative humidity of Bangkok (±SE) between July -October 2002 and December 2002-March 2003

Month	Temperature (°C)	Relative humidity (%)
July	30.11 (±0.24)	77.75 (±1.50)
August	28.93 (±0.32)	72.38 (±0.84)
September	28.54 (±0.31)	76.75 (±1.83)
October	28.04 (±0.29)	71.50 (±3.51)
December	29.10 (±0.25)	69.00 (±1.94)
January	27.33 (±0.30)	67.75 (±2.62)
February	29.95 (±0.26)	72.88 (±1.08)
March	30.04 (±0.39)	71.00 (±0.94)

4.2 Air Pollution

This study considered 4 types of pollutants which included sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide and investigated the average in 1 hour of each pollutant. The results are shown as follows: (Table 4-2, Figure 4-2)

4.2.1 Sulfur dioxide

The minimum and maximum of sulfur dioxide concentration were 2.38 ppb and 11.35 ppb respectively. Community which had the minimum and maximum of sulfur dioxide concentration were Jankasem and Dindang community, 3.95 ppb and 9.23 ppb respectively.

4.2.2 Nitrogen dioxide

The minimum and maximum of nitrogen dioxide concentration were 12.29 ppb and 62.53 ppb respectively. Community which had the minimum and maximum of nitrogen dioxide concentration were Klongjun and Dindang community, 21.32 ppb and 47.94 ppb respectively.

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4.2.3 Ozone

The minimum and maximum of ozone concentration were 1.05 ppb and 21.89 ppb respectively. Community which has the minimum and maximum of ozone concentration were Jankasem, 12.68 ppb and 16.05 ppb respectively.

4.2.4 Carbon monoxide

The minimum and maximum of carbon monoxide concentration were 0.29 ppm and 3.08 ppm respectively. Community which had equal in the minimum of carbon monoxide concentration were Ratburana and Klongjun community (0.77 ppm). Whereas Dindang community had the maximum of carbon monoxide concentration (2.25 ppm).

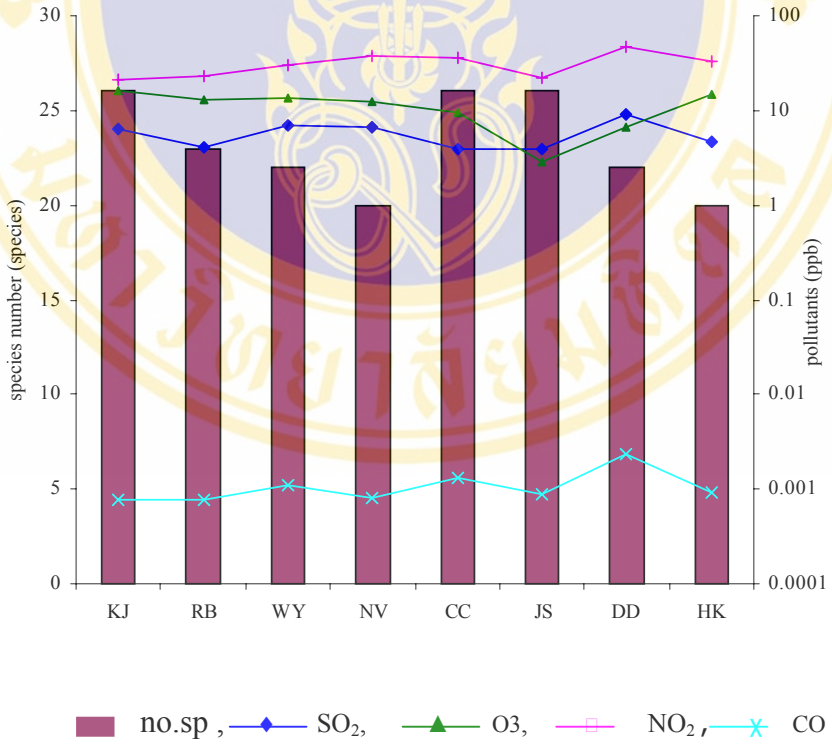

Figure 4-2 Mean concentrations of air pollutants and number of species of ants in urban community of Bangkok

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From the results showed that the overall of air quality of urban community of Bangkok was met standard. Then compared to each community found that Dindang community was clearly higher in concentration of sulfur dioxide, nitrogen dioxide and carbon monoxide than the other communities. This could be assumed that Dindang community was the lowest in air quality of urban communities.

Table 4-2: Mean concentrations of pollutants in urban community of Bangkok between July -October 2002 and December 2002-March 2003

Community	SO_2(ppb)	NO_2(ppb)	O_3(ppb)	CO(ppm)
Klongjun	6.33	21.32	16.05	0.77
Ratburana	4.12	23.08	12.68	0.77
Wongwian Yai	6.86	29.82	13.56	1.09
None Tree Vitaya	6.61	37.48	12.23	0.79
Chokchai 4	3.82	35.61	9.49	1.3
Jankasem	3.95	21.83	2.82	0.87
Diindang	9.23	47.97	6.56	2.25
Hauy Kwang	4.58	32.66	14.56	0.94

4.3 Ecological Values of ants in urban community of Bangkok

4.3.1 Species richness

The species richness of ants in urban community of Bangkok were divided into 6 subfamilies, 24 genuses and 41 species. The greatest of subfamily was Mymicinae that had 10 genus 22 species, compared with Formicinae (5genus, 9species), Ponerinae (4genus, 4species), Dolichoderinae (3genus, 3species), Pseudomyrmecinae (1genus, 2species) and Cerapachyinae (1genus, 1species) respectively. (Table 4-3)

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Table 4-3: Species number in each genus and subfamily of ants in urban community of Bangkok

Subfamily / Genus		Species number	Subfamily / Genus		Species number
Subfamily	**Myrmicinae**		Subfamily	**Formicinae**	
Genus	*Solenopsis*	4	Genus	*Paratrechina*	5
	Monomorium	4		*Anoplolepis*	1
	Tetramorium	5		*Oecophylla*	1
	Pheidole	3		*Plagiolepis*	1
	Cardiocondyla	2		*Polyrhachis*	1
	Crematogaster	3			
	Pheidologeton	1	Subfamily	**Ponerinae**	
	Oligomyrmex	1	Genus	*Anochetus*	1
	Meranoplus	1		*Leptogenys*	1
	Strumigenys	1		*Odontomachus*	1
				Pachycondyla	1
Subfamily	**Psuedomyrmecinae**				
Genus	*Tetraponera*	1	Subfamily	**Dolichderinae**	
			Genus	*Tapinoma*	1
Subfamily	**Cerapachyinae**			*Technomyrmex*	1
genus	*Cerapachys*	1		*Ochetellus*	1

For community, Klongjun, Chockchai 4 and Jankasem community showed the highest species richness member of 26 species. Ratburana community was closely to Wongwian Yai and Dindang community which were 23, 22 and 22 species respectively. Whereas None Tree Vitaya and Hauy Kwang community were less than the others, 20 species. (Table 4-4). It may due to the most area of None Tree Vitaya and Hauy Kwang community are open areas which have concrete surface and buildings. Moreover, the green areas are usually sparse and dominated by grasses. This may limited habitats and food sources for some ant species to inhabit in these communities.

4.3.2 Occurrence

Ants in urban community which contained the largest proportion in occurrence as *Solenopsis geminata, Tapinoma melanocephalum, Pheidole bugi, Paratrechina longicornis, Paratrechina* sp.5 of AMKUFF and *Monomorium pharaonis*, that were 100% of occurrence. Whereas, *Tetraponera allaborans, Tetraponera ruflonigra. Technomyrmex* sp.1 of AMKUFF, *Pachycondyla* sp.1 of AMKUFF , *Plagiolepis* sp.3

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of AMKUFF and *Strumigenys* sp.1 of AMKUFF were the least proportion of occurrence at 1.56%. (Table 4-5)

Table 4-4: Number of subfamily, genus and species of ants in urban community of Bangkok

Community	Subfamily	Genus	Species
1. Klongjun	6	16	26
2. Ratburana	4	14	23
3. Wongwian Yai	4	13	22
4. None Tree Vitaya	3	10	20
5. Chokchai 4	5	15	26
6. Jankasem	4	14	26
7. Dindang	4	11	22
8. Hauy Kwang	3	9	20

4.4.3 Relative frequency

Ants in urban communities which contained the largest proportion in relative frequency was *P.longicornis* (19.97%) and then *S.geminata, P.bugi, M.pharaonis* and *Paratrechina* sp.5 of AMKUFF were 17.91%, 16.06%, 8.76% and 6.98% of all ant species which found in communities, respectively.

Whereas the least proportion of ants in relative frequency was 0.01% which included *Cerapachys* longitarus, *Crematogaster (Orthocrema)* sp.1 of AMKUFF, *T.allaborans, T.ruflonigra, Technomyrmex* sp.1 of AMKUFF, *Leptogenys* sp.12 of AMKUFF, *Pachycondyla* sp.1 of AMKUFF, *Polyrhachis* sp.1 of AMKUFF, *Strumigenys* sp.1 of AMKUFF, *Pheidologeton diversus, Pheidole megacephalum* and *Plagiolepis* sp.3 of AMKUFF. (Table 4-5 and Figure 4-3)

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Table 4-5: Relative frequency, Relative abundance and Occurrence of ants in urban community of Bangkok

Subfamily	Genus/ Species	Relative frequency (%)	Relative abundance (%)	Occurrence (%)
Myrmicinae	*Solenopsis geminata*	17.92	31.241	100.00
	Monomorium pharaonis	8.76	12.728	100.00
	M. floricola	1.29	1.222	79.69
	M. chinense	4.22	2.784	89.06
	Monomorium sp.1 of AMKUFF	2.63	1.045	81.25
	Tetramorium smithi	1.96	1.558	68.75
	T.simillimum	2.52	1.195	89.06
	T. lanuginosum	1.85	0.272	85.94
	T.walshi	0.75	0.490	32.81
	T. bicarinatum	0.19	0.088	23.44
	Pheidole bugi	16.06	21.506	100.00
	P. fervens	0.54	1.036	1.56
	P.megacephala	0.01	0.005	3.13
	Cardiocondyla emeryi	2.79	0.199	87.50
	C. nuda	2.51	0.057	18.75
	Crematogaster (Paracrema) monigliani	0.03	0.001	7.81
	C. (Crematogaster) rogenhoferi	0.09	0.050	10.94
	C. (Orthocrema) sp.1 of AMKUFF	0.01	0.002	1.56
	Pheidologeton diversus	0.01	0.008	3.13
	Oligomyrmex sp.1 of AMKUFF	0.02	0.015	4.69
	Meranoplus bicolor	0.59	0.226	64.06
	Strumigenys sp.1 of AMKUFF	0.01	0.00025	1.56
Formicinae	*Paratrechina longicornis*	19.98	12.381	100.00
	Paratrechina sp.4 of AMKUFF	0.08	0.012	12.50
	Paratrechina sp.5 of AMKUFF	6.99	2.855	100.00
	Paratrechina sp.8 of AMKUFF	0.72	0.108	45.31
	Paratrechina sp.9 of AMKUFF	1.11	0.147	73.44
	Anoplolepis gracilipes	0.67	0.266	14.06
	Oecophylla smaragdina	1.16	0.098	48.44
	Plagiolepis sp.3 of AMKUFF	0.01	0.012	1.56
	Polyrhachis sp.1 of AMKUFF	0.05	0.00025	1.56
Ponerinae	*Anochetus graeffei*	0.01	0.003	14.06
	Leptogenys sp.12 of AMKUFF	0.09	0.0004	3.13
	Odontomachus simillimus	0.01	0.014	17.19
	Pachycondyla sp.1 of AMKUFF	0.01	0.0001	1.56
Dolichoderinae	*Tapinoma melanocephalum*	6.42	8.335	100.00
	Technomyrmex sp.1 of AMKUFF	0.01	0.0001	1.56
	Ochetellus sp.1 of AMKUFF	0.05	0.021	7.81
Psuedomyrmecinae	*Tetraponera ruflonigra*	0.01	0.0001	1.56
	T. allaborans	0.01	0.0001	1.56
Cerapachyinae	*Cerapachys longitarus*	0.01	0.001	3.13

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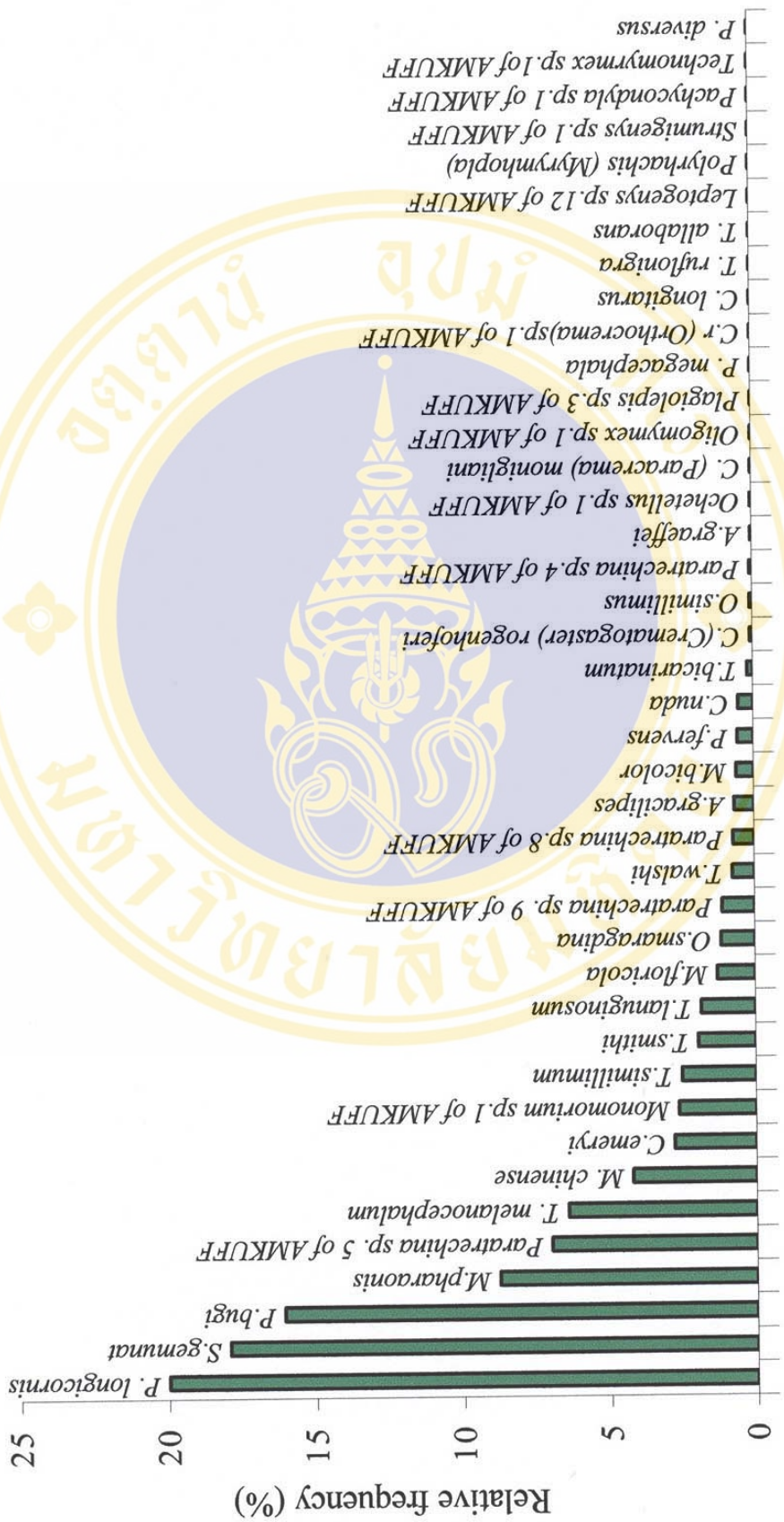

Figure 4-3 The relative frequency of ants in urban community of Bangkok between July- October 2002 and December 2002- March 2003

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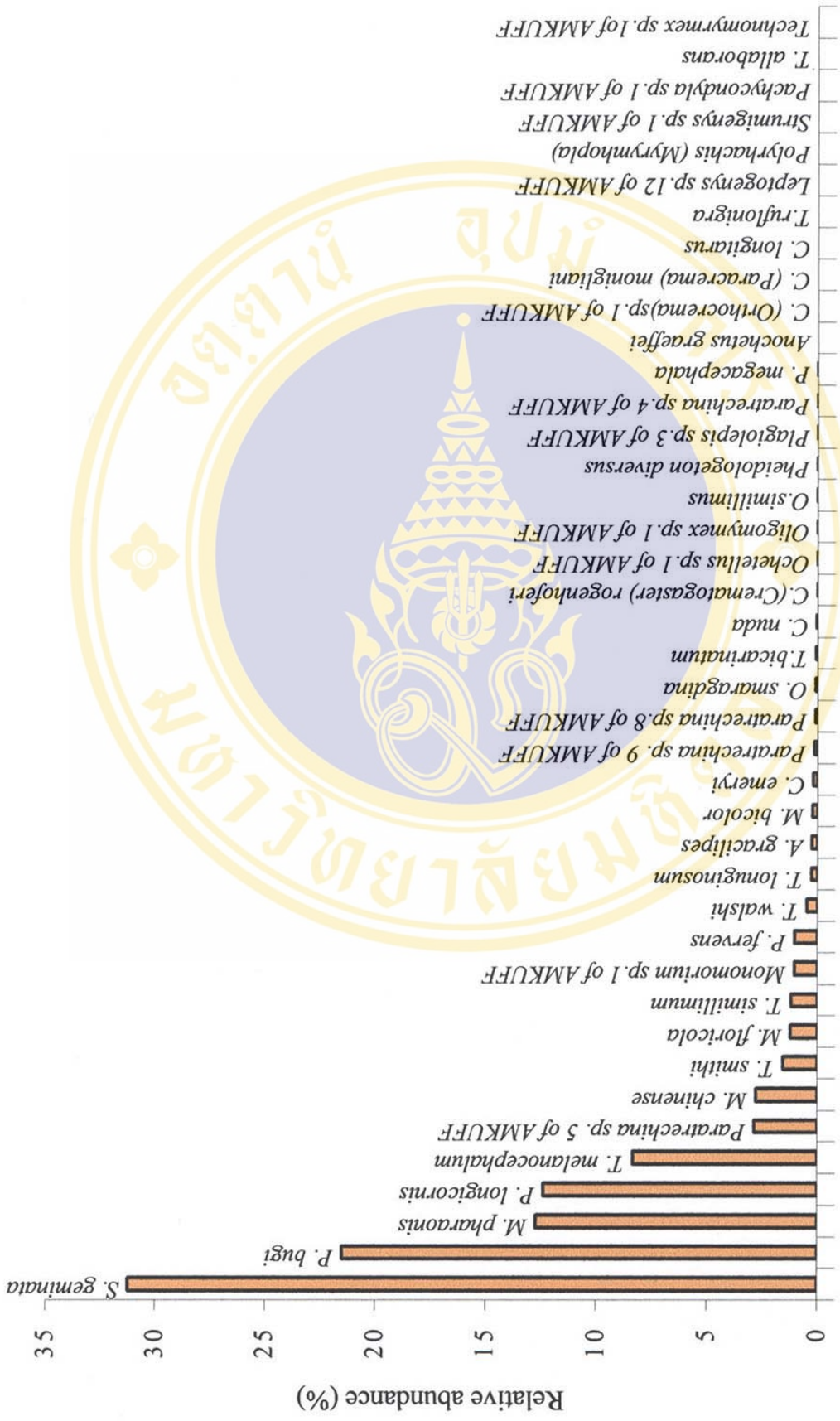

Figure 4-3 The relative abundance of ants in urban community of Bangkok between July- October 2002 and December 2002- March 2003

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4.3.4 Relative abundance

Ants in urban communities of Bangkok which contained the largest proportion in relative abundance was *S.geminata* (31.241%), followed by *P.bugi* (21.506%), *M.pharaonis* (12.728%), *P.longicornis* (12.381%) and *T.melanocephalum* (8.335%) respectively.Whereas the least proportion of ants in relative abundance was 0.0001% which included *T.allaborans, Technomyrmex* sp.1 of AMKUFF and *Pachycondyla* sp.1 of AMKUFF. (Table 4-5 and Figure 4-4)

From the results, the proportion of subfamily and species of ants were closely to the study of Ogata *et.al*. (1998) which found that ant diversity at two parks in Fukuoka city, Japan, had total of 4 subfamily 21 genus and 31 species. The largest proportion in genus and species was Mymicinae, followed by Formicinae, Ponerinae and Dolichoderinae respectively. And same as the study of Wiwatwitaya and Rojanawongse (2001), Prasityousil (2001), Phoonjumpa (2002) and Noon-anant (2003), which found that Mymicinae and Psuedomyrmecinae were the largest ant the least proportion in genus and species respectively.

Because of Myrmicinae is the greatest of subfamily of ants , based on both genus number and species number and can be found more than the others (Hölldobler and Wilson,1990; Bolton, 1994). Whereas ants of Dolichoderinae and Psuedomyrmecinae usually found on trees and tree trunks (Noon-anant, 2003), and ants of Ponerinae and Cerapachyinae are ground-dwelling ants and they are generalist predators in ecosystem (Shattuck, 1999). For this study, rarely found ants of Psuedomyrmecinae subfamily in honey baits, that may due to the accidental foraging of this ants on the ground or around the bases of trees or shrubs (Shattuck, 1999). For Cerapachyinae, had found less than the others, it may due to ants in this group are hunting singly and capturing the other ants which attacked the traps (Shattuck, 1999).

From the result of ants which had high abundance in urban communities such as *S.geminata, P.bugi, M.pharaonis, T.melanocephalum, P.longicornis* and *Paratrechina* sp.5 of AMKUFF are eurychoric species, which having a wide

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geographic distribution. They can adapted to habit in vary habitats such as ground surface, trees and buildings (Williams, 1994). This ants can rapidly change nest sites and cover the areas. In contrast, ants that had low frequency occurrence and abundance, it due to some species have limited range of food sources and habitats as some species of Pachycondyla are general predators or scavengers which limited of preys and foraging singly. So they were less frequently found the other ants which forage in large numbers (Adenson, 2000). Such some species of Crematogaster and Tetraponera are limited to host plants too (Schultz and McGlynn, 2000).

In order to ants that found on trees, such as *Solenopsis; Pheidole; Paratrechina; Tapinoma; Tetramorium* and *Monomorium*, they were the same group which found on honey baits (Appendix Table 4). It may due to most of ants in this study are generally forage and nest on the ground, moreover they have widely range of food sources and habitats. So they were occasionally found on trees too.

4.3.5 Similarity Index

From the species number of ants in urban communities, the were conducted to calculate for similarity index and compared in each communities by using Sorensen equation and the results showed in Table 4-6.

Table 4-6: Similarity index of ant in urban community of Bangkok

	KJ	RB	WY	NV	CC	JS	DD	HK
KJ	-	81.63	75.00	82.61	80.77	73.08	75.00	82.61
RB	-	-	71.11	79.07	81.63	81.63	80.00	83.72
WY	-	-	-	80.95	79.17	75.00	77.27	76.19
NV	-	-	-	-	73.91	73.91	85.71	**95.00**
CC	-	-	-	-	-	84.62	79.17	78.26
JS	-	-	-	-	-	-	**70.83**	78.26
DD	-	-	-	-	-	-	-	85.71
HK	-	-	-	-	-	-	-	-

Noted : KJ = Klongjun community, RB = Ratburana community, WY = Wongwian Yai communitiy,
NV = None Tree Vitaya community, CC = Chokchai 4 community, JS = Jankasem community,
DD = Dindang community, HK = Hauy Kwang community

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It was found that None Tree Vitaya and Hauy Kwang community shown the highest of similarity index (95%) while Dindang and Jankasem community shown the lowest of similarity index (70.83%). The similarity of ants in urban community can be divided into 5 levels, as follow:

Highest similarity	when	$80 < S \leq 100$
High similarity	when	$60 < S \leq 80$
Moderate similarity	when	$40 < S \leq 60$
Low similarity	when	$20 < S \leq 40$
Lowest similarity	when	$0 < S \leq 20$

From the similarity levels, it is indicated that the similarity of ants in urban communities of Bangkok located in the highest and high level. This could be assumed that urban communities in Bangkok were nearly distributed in number species of ants.

Then, the results of TWINSPAN analysis is shown in a two-way ordered Table (Table 4-7). The ordered of stand numbers were located vertically across the top of the table. The species numbers and abbreviated names were written down the left-hand side which the first ordered was species number 31, Tetralla (*Tetraponera allaborans*) and the last one of species number 39, Phediver (*Pheidologeton diversus*). The main block of the table presented the presence data (1) and the absence data (-). At the bottom and right hand side were the dichotomized key for stands and species respectively. Thus, species composition can be divided into 6 groups as follows:

Group A: *Tetraponera allaborans, Technomyrmex* sp.1 of AMKUFF, *Leptogenys* sp.1 of AMKUFF, *Pachycondyla* sp.1 of AMKUFF and *Polyrhachis* sp.1 of AMKUFF

Group B: *Tetramorium bicarinatum, Tetraponera ruflonigra, Pheidole megacephala, Plagiolepis* sp.3 of AMKUFF, *Cardiocondyla nuda* and *Crematogaster (Paracrema) monigliani*

Group C: *Solenopsis geminata, Tapinoma melanocephalum, Pheidole bugi, Paratrechina longicornis, Paratrechina* sp.5 of AMKUFF,

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Paratrechina sp.8 of AMKUFF, *Paratrechina* sp.9 of AMKUFF, *Monomorium pharaonis, Monomorium floricola, Monomorium chinense, Monomorium* sp.1 of AMKUFF, *Tetramorium smithi, Tetramorium simillimum, Tetramorium lanuginosum, Cardiocondyla emeryi, Oecophylla smaragdina, Meranoplus bicolor* and *Odontomachus simillimus*

Group D: *Tetramorium walshi, Anoplolepis gracilipes, Anochetus graeffei* and *Cerapachys longitarus*

Group E: *Paratrechina* sp.4 of AMKUFF, *Oligomyrmex* sp.1 of AMKUFF and *Pheidole fervens*

Group F: *Crematogaster (Crematogaster) rogenhoferi, Crematogaster (Orthocrema)* sp.1 of AMKUFF, *Ochetellus* sp.1 of AMKUFF, *Strumigenys* sp.1 of AMKUFF and *Pheidologeton diversus*

Meanwhile, the stand classification can be divided into 3 groups as follows:

Group 1: stands 1, 2 (Klongjun and Ratburana community)

Group 2: stands 3, 4, 7, 8 (Wongwian Yai, None Tree Vitaya, Dindang and Hauy Kwang community)

Group 3: stands 5, 6 (Chokchai 4 and Junkasem community)

From the two-way ordered table, it showed the difference of ant distribution in each group. It can be seen that ant species which highly distribution present in the middle part of table while the similarity of ants declined and show in the edges of table. This can be classified the ant distribution as follows:

1) High distribution : Ants in Group C
2) Moderate distribution : Ants in Group B, D and E
3) Low distribution : Ants in Group A and F

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Table 4-7: Two-way ordered table

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                12347856

 31  Tetralla   1-------   000
 33  Techsp1    1-------   000
 34  Leptsp12   -1------   000
 35  Pachysp1   -1------   000
 36  Polysp1    1-------   000
 17  Tetbica    --1111--   0010
 32  Tetraruf   --1-----   0010
 40  Pheimega   ----1---   0010
 41  Plagisp3   ----1---   0010
 19  Cardnuda   1--1-1--   0011
 24  Cremoni    1-11----   0011
  1  Solgemi    11111111   01
  2  Tapimela   11111111   01
  3  Pheibugi   11111111   01
  4  Parlongi   11111111   01
  5  Parsp5     11111111   01
  6  Parsp9     11111111   01
  7  Parsp8     11-11111   01
  9  Monophar   11111111   01
 10  Monoflor   11111111   01
 11  Monochin   11111111   01
 12  Monosp1    11111111   01
 13  Tetsmith   11111111   01
 14  Tetsimil   11111111   01
 15  Tetlongi   11111111   01
 18  Cardemer   11111111   01
 20  Oecosmar   11-11111   01
 21  Merabico   11111111   01
 28  Odonsimi   111-1-1-   01
 16  Tetwal     11---111   10
 22  Anoplong   -1-----1   10
 23  Anacgraf   111---11   10
 27  Ceralong   1-----1-   10
  8  Parsp4     --1---11   110
 29  Oligsp1    --1---11   110
 37  Pheiferv   ----1-1-   110
 25  Crerogen   -------1   111
 26  Cresp1     -------1   111
 30  Ochesp1    ------11   111
 38  Struspl    ------1-   111
 39  Phediver   -------1   111

                00000011
                001111
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From the results of TWINSPAN analysis can be explained that Group 2 of stands classification had most similarity of ant species. Because of the other groups had some ant species especially occurred in each community. When considered with the ant distribution ordered group, found that the proportion of ant species in the highly distribution groups were higher than other groups too. This may caused to the similarity indices which calculated from Sorensen equation were closed together and showed in highly similarity.

4.3.6 Species diversity index

Species diversity index based on the species and abundance of species in a community. The results showed that community which had the highest values was Ratburana community. Then were None Tree Vitaya, Jankasem, Chokchai 4, Wongwian Yai and Hauy Kwang community, respectively. (Table 4-8)

4.3.7 Evenness index

From the species diversity index of ants in communities were calculated to evenness and found that Ratburana community had the highest of evenness and then were None Tree Vitaya, Klongjun community and the latest was Hauy Kwang community. (Table 4-8)

Table 4-8: Species diversity index and Evenness index of ants in urban community of Bangkok

Community	Species diversity index	Evenness index
1. Klongjun	1.9526	0.599
2. Ratburana	2.0322	0.648
3. Wongwian Yai	1.6972	0.549
4. None Tree Vitaya	1.8809	0.628
5. Chokchai 4	1.7246	0.529
6. Jankasem	1.7516	0.538
7. Dindang	1.7303	0.560
8. Hauy Kwang	1.6393	0.547

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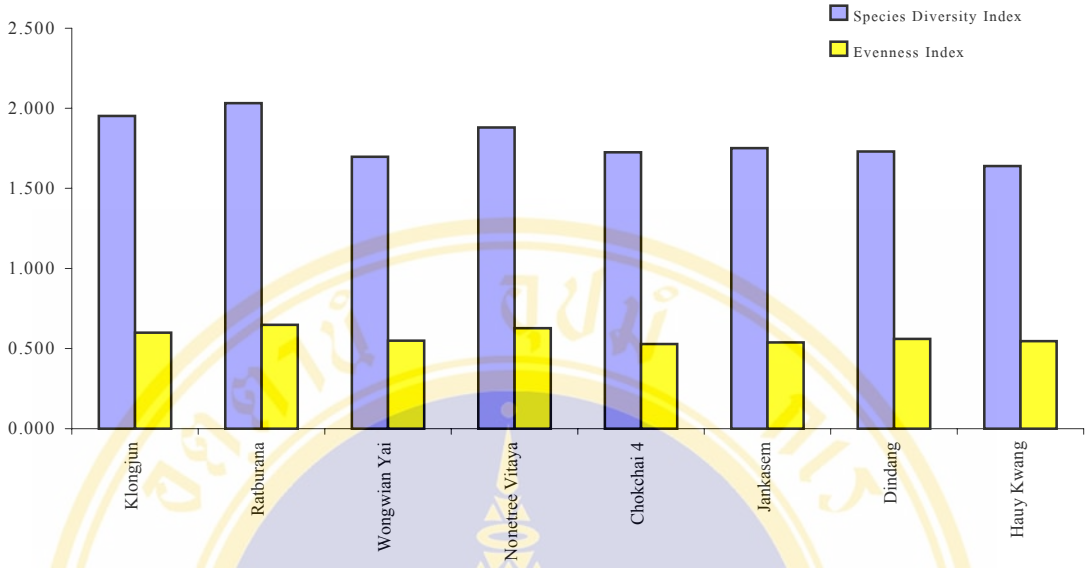

Figure 4-5 Species diversity index and Evenness index of ants in urban community of Bangkok.

This results, when considered to species diversity index and species richness of urban communities found that Klongjun, Chockchai 4 and Jankasem community had the highest of species richness whereas Ratburana community showed both the highest of species diversity index and evenness. However, the ranges of species diversity index (1.6393-2.0322) and evenness index (0.529-0.648) showed in Table 4-8 could be assumed that urban communities in Bangkok had closely species diversity of ants.

4.4 The effects of seasons to species richness, density of colony and abundance of ant

There were no significant differences found between wet and dry season for the species richness ($P>0.05$, $F=2.297$). But density of colony between 2 seasons significantly differed ($P<0.05$, $F=125.745$). (Table 4-9)

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Table 4-9: Mean (±SE) and F value of species richness, density of colony and abundance of ant between wet season (July-October 2002) and dry season (December 2002-March 2003) (* = P<0.05)

	Wet season (Jul - Oct 02)	**Dry season** (Dec 02 - Mar03)	**F values**
Species richness	15.63±0.53	16.59±0.36	2.297
Density of colony*	2.61±0.05	3.68±0.08	125.745
Abundance of ant			
S.geminata	33.24±2.27	29.32±2.58	1.304
*P.bugi**	16.02±2.12	25.93±2.58	8.468
M.pharaonis	13.40±1.92	11.73±1.69	0.427
*P.longicornis**	14.58±0.96	10.74±0.93	8.234
T.melanocephalum	8.74±1.85	8.17±1.71	0.050
Paratrechina sp.5 of AMKUFF	3.50±0.41	2.28±2.22	6.887

For the effect of seasons to abundance of ants, it was considered from ants which had a wide range of distribution (from TWINSPAN analysis) and occurrence in all times of sampling (100% of occurrence), because of these follow as using ant to be the bioindicator, these were consist of *S.geminata, P.bugi, M.pharaonis, P.longicornis, Paratrechina* sp.5 of AMKUFF and *T.melanocephalum.*

The results showed that, the mean of abundance for *P.bugi*, *P.longicornis and Paratrechina* sp.5 of AMKUFF significantly differed between wet and dry season (P<0.05, F=8.488, 8.234 and 6.887 respectively), whereas the mean of abundance of *S.geminata, M.pharaonis* and *T.melanocephalum* were not significant differences (P>0.05,F=1.304, 0.427 and 0.050 respectively).

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4.5 Relationship between environmental factors and species richness, density of colony and abundance of ants

Environmental factors for this study consist of temperature, relative humidity and air pollutants which include sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide. The relationship results were analyzed by Pearson correlation as showed in Table 4-10.

Table 4-10: Pearson coefficient of environmental factors and species richness, density of colony and abundance of ant between wet season (July-October 2002) and dry season (December 2002-March 2003) (* = P<0.05, ** = P<0.01)

	Temperature (°C)	**Relative Humidity (%)**	**SO_2**	**NO_2**	**O_3**	**CO**
Species richness	-0.165	0.096	-0.137	-0.060	0.166	-0.019
Density of colony	0.147	-0.239	-0.039	0.204	0.440**	0.027
Abundance of ants						
S.geminata	0.122	0.079	0.055	0.153	-0.075	0.257*
P.bugi	-0.163	-0.166	-0.060	-0.015	-0.027	-0.186
M.pharaonis	0.093	0.032	0.226	0.234	-0.116	0.400**
P.longicornis	-0.008	-0.037	-0.529**	-0.331**	-0.219	-0.385**
T.melanocephalum	0.044	0.090	0.081	-0.233	0.270*	-0.211
Paratrechina sp.5 of AMKUFF	-0.090	0.370**	-0.005	-0.437**	-0.160	-0.363**

4.5.1 Temperature and relative humidity

Species richness, density of colony and abundance of *S.geminata, P.bugi, M.pharaonis, P.longicornis and T.melanocephalum* were not significantly correlated with both temperature and relative humidity (P>0.05), while abundance of *Paratrechina* sp.5 of AMKUFF was positively correlated with relative humidity, significantly (P<0.01, r = 0.370). (Table 4-10)

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4.5.2 Air pollution

From the results of study found that species richness not significantly correlated with sulfur dioxide, nitrogen dioxide, ozone and carbon monoxide ($P>0.05$, $r = -0.137$, -0.060, 0.166 and -0.019 respectively). This showed that although the increasing or reducing of concentration of these air pollution, it is not effect to species richness which found in urban communities. Whereas the density of colony were significant positively correlated with ozone ($P<0.05$, $r = 0.440$). It could be explained that the higher in concentration of ozone in the air showed the higher in ant colonies ($/m^2$).

In addition, each ants had differently correlated with air pollution, sulfur dioxide was significant negatively correlated with abundance of *P.longicornis* ($P<0.01$, $r = -0.529$). It could be explained that higher in concentration of sulfur dioxide in the air showed the lower in abundance of *P.longicornis*.

Nitrogen dioxide was significant negatively correlated with abundance of *P.longicornis* and *Paratrechina* sp.5 of AMKUFF ($P<0.01$, $r = -0.331$ and -0.437 respectively). It could be explained that higher in concentration of nitrogen dioxide in the air showed the lower in abundance of *P.longicornis* and *Paratrechina* sp.5 of AMKUFF.

Ozone was significant positively correlated with abundance of *T.melanocephalum* ($P<0.01$, $r = 0.270$). It could be explained that higher in concentration of ozone in the air showed the higher in abundance of *T.melanocephalum.*

Carbon monoxide was significant positively correlated with *S.geminata* ($P <0.05$, $r = 0.257$) and *M.pharaonis* ($P<0.01$, $r = 0.400$). It could be explained that higher in concentration of carbon monoxide in the air showed the higher in abundance of *S.geminata* and *M.pharaonis.* Whereas carbon monoxide was significant negatively correlated with *P.longicornis* and *Paratrechina* sp.5 of AMKUFF ($P<0.01$, $r = -0.385$ and $–0.363$ respectively). It could be explained that higher in concentration carbon monoxide in the air showed the lower in abundance of *P.longicornis* and *Paratrechina* sp.5 of AMKUFF.

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From the results could be seen that most abundance of ants were negatively correlated with air pollution relate to the study by Hoffman *et.al.* (2000), which reported that ant abundance and species richness were both negatively correlated with soil SO_4 concentration and positively correlated with plant species richness and distance away from the smelters. As Kozlov and Zvereva (2000), found that density of wood ant and zoophagous bugs which be the predators of *M.lapponica* were higher at clean sites than polluted sites. And Adenson et.al.(2002) studied about using ants as bioindicators in land management: simplifying assessment of ant community responses, found that ant abundance and species diversity declined with increasing SO_2. In contrast Czechawski (1980) reported that *Lasius niger* L. and some aphids species occurred in the largest numbers in areas with a high traffic density. Comparably to other insects such as *Aphids*, Fluckier et.al. (1993) reported that high population levels of *Apids pomi* adjacented to a motorway.

4.6 Multiple Regression Analysis and Canonical Correspondence Analysis (CCA)

From the abundance and density of colony were employed to become dependent variable to identify the relationship of environmental variables which were the independent variables. The multiple regression analysis was then proceeded. The relation equations were form as follows:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$$

Where Y = relative abundance, density of colony

x_1 = temperature

x_2 = relative humidity

x_3 = sulfur dioxide

x_4 = nitrogen dioxide

x_5 = ozone

x_6 = carbon monoxide

The relative equations of ant distribution which considered for whole urban communities of Bangkok were shown as follows:

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1) $Y_{\text{density of colony}} = 2.592 + 0.050\ O_3$; R^2=0.194

This equation could explained that the higher in density of colony related to the higher in ozone concentrations.

2) $Y_{S.geminata} = 24.2999 + 6.373\ CO$; R^2=0.066

This equation could explained that the higher in abundance of *S.geminata* related to the higher in carbon monoxide concentrations.

3) $Y_{M.pharonis} = 7.358\ CO$; R^2=0.16

This equation could explained that the higher in abundance of *M.pharaonis* related to the higher in carbon monoxide concentrations.

4) $Y_{P.longicornis} = 23.520 - 1.367\ SO_2 - 0.221\ O_3$; R^2=0.331

This equation could explained that the higher in abundance of *P.longicornis* related to the lower in sulfur dioxide and ozone concentrations.

5) $Y_{Paratrechina\ \text{sp.5 of AMKUFF}} = 16.786 - 0.124\ NO_2 + 0.352\ SO_2 - 0.423$ temperature ; R^2=0.345

This equation could explained that the higher in abundance of *Paratrechina* sp.5 of AMKUFF related to the higher in sulfur dioxide concentrations but related to the lower in nitrogen dioxide and temperature.

6) $Y_{T.melanocephalum} = 0.625\ O_3 - 0.442\ NO_2 + 1.748\ SO_2$; R^2=0.248

This equation could explained that the higher in abundance of *T.melanocephalum* related to the higher in ozone and sulfur dioxide concentrations but related to the lower in nitrogen dioxide .

Then the relative equations of ant distribution were considered between urban communities which near the main-roadsides and the others which far from the main-roadsides. The results revealed on Table 4-11.

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Table 4-11: The relative equations of ant distribution between communities which near the main-roadsides (Community A) and communities which far from the main-roadsides (Community B)

	Community A		**Community B**	
	Relative equations	**R^2**	**Relative equations**	**R^2**
Density of colony	$Y = 2.385 + 0.077\ O_3$	0.406	$Y = 2.67 + 0.040\ O_3$	0.127
S.geminata	-	-	$Y = 43.002 - 3.392\ SO_2$	0.236
P.bugi	$Y = 0.279\ NO_2$	0.261	$Y = 2.844\ SO_2$	0.099
M.pharaonis	$Y = 11.728\ CO - 0.947\ O_3$	0.588	-	-
T.melanocephalum	Y = 113.614 - 18.405 CO - 1.003 Relative humidity	0.483	-	-
P.longicornis	$Y = 12.242 - 0.424\ O_3$	0.354	$Y = 20.958 - 1.089\ SO_2$	0.158
Paratrechina sp.5 of AMKUFF	$Y = 9.195 - 2.964\ CO - 1.56\ O_3$	0.633	$Y = 4.552 - 0.067\ NO_2$	0.123

From the table, it was indicated that ants in urban communities which near the main-roadsides were correlated with carbon monoxide and ozone concentration significantly, and could be explained as follows :

Ozone concentration was positively correlated with density of colony whereas negatively correlated with the abundance of *M.pharaonis, P.longicornis* and *Paratrechina* sp.5 of AMKUFF. Carbon monoxide concentration was positively correlated with *M.pharaonis* whereas negatively correlated with the abundance of *Paratrechina* sp.5 of AMKUFF and *T.melanocephalum*. Nitrogen dioxide concentration was positively correlated with abundance of *P.bugi*. Moreover, relative humidity was negatively correlated with abundance of *T.melanocephalum*.

For ants in urban communities which far from the main-roadsides, density of colony was positively with ozone. Abundance of *S.geminata* and *P.longicornis* were negatively correlated with sulfur dioxide, whereas *P.bugi* was positively correlated. And *Paratrechina* sp.5 of AMKUFF was negatively correlated with nitrogen dioxide.

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Then, the outputs from CCA analysis were also utilized to identify the relationship of ant abundance and environment factors. The angle and length of the line indicated the direction and strength of the relationship. The result of joint plot diagram showed in Figure 4-6

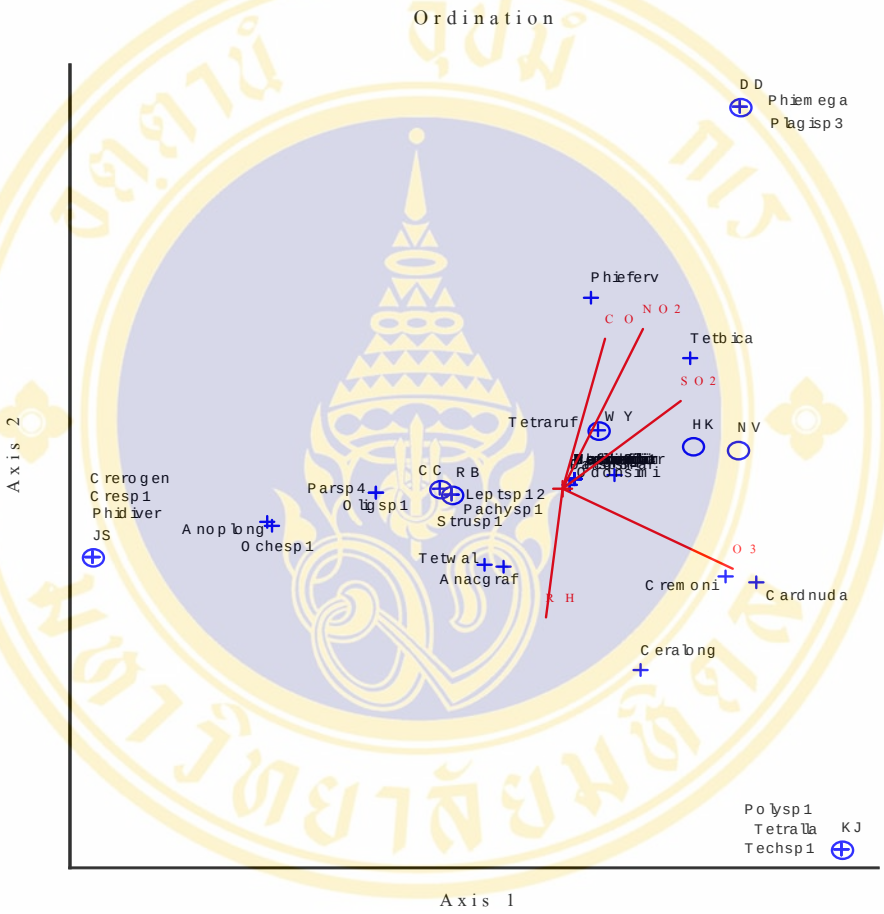

Figure 4-6 The joint plot diagram showing the relationship between a set of environmental variables and ant abundance

It can be explained that temperature, relative humidity, sulfur dioxide, nitrogen dioxide and carbon monoxide were not significantly related to the ant abundance whereas ozone was significantly related to 2 species of ants which consisted of *C.monigliani and C.nuda*. Interestingly, this diagram showed the presence of ants similarly to TWINSPAN classification that ant species which were highly distribution presented at the central of vectors as presented in the main block of

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two-way ordered table. It indicated that these ants can be highly distributed in the polluted areas when compared with the others.

From the regression analysis, the relationship for the whole urban community of Bangkok which showed in the relative equations had the low values of R^2. This indicates that the environmental variables were related to density of colony and ant abundance not clearly. It may due to this study did not consider to the ground temperature and humidity which related to ant distribution more than the temperature and relative humidity of the whole area of Bangkok. Moreover, the average of concentrations of air pollutants from 8 urban communities were so lower than the standard values as follows: the average of sulfur dioxide was 6.17 ppb (std. values =300 ppb); nitrogen dioxide was 30.46 ppb (std. values = 170 ppb); ozone was 11.0 ppb (std. values = 100 ppb) and carbon monoxide was 1.10 ppm (std. values = 30 ppm).

Meanwhile, considered between group of urban communities which near the main-roadsides and the other which far from the main-roadsides. Interestingly, R^2 values of relative equations of the first group were higher than the other. This can be assumed that increasing both ozone and carbon monoxide affected to density of colony and ant abundance significantly declined. As Anderson *et.al*. (2002) studied about ants as bioindicators in a copper and lead smelter at Mt Isa in the Australian semi-arid tropics which have the levels of soil sulphate between 1-120 ppm and revealed that ant abundance and species richness showed a significant decline with increasing sulfur dioxide. So the results of this study indicated to the significantly correlated between ant distribution and air pollution will occurred in high polluted areas.

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CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

5.1.1 The study of ant distribution based on air quality variation in urban community of Bangkok between July-October 2002 and December 2002-March 2003 found that ants which highly distributed in urban communities were *S.geminata, P.bugi, M.pharaonis, T.melanocephalum, P.longicornis and Paratrechina* sp.5 of AMKUFF.

5.1.2 For the effect of season to ant distribution, it revealed that the average of species richness in wet and dry season were not significantly different ($P>0.05$, $F=2.297$) whereas density of colony and abundance of *P.bugi, P.longicornis* and *Paratrechina* sp.5 of AMKUFF in wet and dry season were significantly different ($P<0.05$, $F=125.745$, 8.468, 8.234 and 6.887, respectively).

5.1.3 The multiple linear regression analysis showed the clearly relationship between ants and air pollution in high pollutant areas. The ants that found in communities which near the main-roadsides mostly affected from carbon monoxide and ozone concentration. While ants in urban communities which far from the main-roadsides slightly affected from sulfur dioxide. The density of colony showed positively correlated with ozone concentration.

5.1.4 In addition, the result from CCA analysis showed that ozone was a primary correlative factor and indicated that *C.nuda* and *C.monigliani* were significantly correlated with its.

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5.2 Problems of research

5.2.1 Using pesticides were a limited of ant sampling in household areas, because of it may be reduced the amount of ant populations and colonies.

5.2.2 Some flooding areas occurred in wet season, affecting to both the distorted plot of honey baits and the error of sample collections.

5.3 Recommendation

5.3.1 The period of sampling only 8 month may be not completed for ant collection. Thus, in the future sampling should annually be collected to clarify the results.

5.3.2 Mean of temperature and relative humidity were used in this study as the mean of the whole area of the Bangkok. These are not appropriate for introducing to analyze the relationship with ant distribution. For clearly results, it should be utilized the data which measured at each site both ground temperature and ground humidity.

5.3.3 This study is mostly field observation research, so some factors can not be controlled. Thus, it should be studying in the laboratory to clarify the levels of pollutants that affected to ant species.

5.3.4 Some ant species, *Paratrechina* sp.5 of AMKUFF and *M.pharaonis* have high potential to be an indicator species of urban polluted areas. Moreover, the density of colony and abundance of *C.nuda and C.monigliani* tend to be the bioindicator of the areas which have high concentrations of ozone.

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APPENDIX

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Appendix Table 1: Ambient air quality of Bangkok between 1999-2001

Air pollutans	Maximum – minimum values			Average values			Std. values
	1999*	2000**	2001**	1999*	2000**	2001**	
1.TSP (24 hr) mg/m^3	0.02-0.37	0.02-0.33	0.03-0.49	0.10	0.09	0.09	0.33
2 PM_{10} (24hr) $\mu g/m^3$	16.1-202.0	18.6-169.4	6.6-142.1	60.6	56.1	40.2	120
3. CO (1 hr) ppm	0.00-27.40	0.00-12.50	0.00-13.29	1.25	0.96	0.95	30
4. CO (8 hr)ppm	0.00-27.29	0.00-8.20	0.00-7.66	1.27	0.97	0.95	9
5. Pb (24 hr) $\mu g/m^3$	0.00-0.60	0.01-0.44	0.01-1.32	0.09	0.09	0.42	-
6. Pb (1 month)g/m^3	0.02-0.37	0.02-0.33	0.02-0.69	0.10	0.09	0.51	1.5
7. O_3 (1 hr) ppb	0.00-157.0	0.00-203.0	0.00-183.0	13.9	15.6	14.3	100
8. SO_2 (1 hr) ppb	0.00-135.0	0.00-161.0	0.00-161.0	4.8	6.7	6.2	300
9. SO_2 (24 hr) ppb	0.00-59.0	0.00-76.4	0.00-109.8	4.9	6.7	6.2	120
10.NO_2 (1 hr) ppb	0.00-158.0	0.00-136.0	0.00-164.0	22.8	22.8	22.5	170

source : *Pollution Control Department, 2000
** Pollution Control Department, 2001

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Appendix Table 2: Ambient air quality of Bangkok in 2000

Air pollutants	Values	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10	Std. values
SO_2 (1 hr) ppb	Max.	150.0	94.0	72.5	75.0	93.0	161.0	113.0	136.0	151.0	85.4	
	average	4.7	3.2	4.1	4.6	5.6	10.8	7.3	7.2	10.8	7.7	300
	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NO_2 (1 hr) ppb	Max.	127.0	135.0	125.0	126	136.0	107.0	105.0	132.0	130.0	113.0	
	average	18.8	23.9	20.9	17.7	20.3	20.2	19.4	32.1	25.0	20.2	170
	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CO (1 hr) ppm	Max.	12.5	5.3	9.1	7.0	12.2	6.5	8.3	10.13.03	5.5	12.4	
	average	1.2	0.9	0.8	1.0	1.2	0.9	0.8	1.1	0.6	1.1	30
	Min.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
O_3 (1hr) ppb	Max.			139.9	30.0	178.0	203.0	193.0	143.0	127.0	139.0	
	average	-	-	17.9	5.6	12.5	22.9	16.7	9.4	11.4	18.6	100
	Min.			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
PM 10 (24 hr) $\mu g/m^3$	Max.						131.8	143.3	156.4	145.0	169.4	
	average	-	-	-	-	-	53.6	48.3	68.6	55.8	54.0	120
	Min.						18.6	19.3	30.0	24.6	20.2	
TSP (24 hr) mg/ m^3	Max.	0.17	0.25	0.20	0.18	0.20	0.21	0.21	0.33	0.16	0.32	
	average	0.08	0.10	0.08	0.09	0.08	0.08	0.07	0.17	0.09	0.12	0.33
	Min.	0.03	0.04	0.02	0.04	0.03	0.04	0.03	0.05	0.05	0.05	
Pb (1 month) $\mu g/m^3$	Max.	0.29	0.44	0.22	0.41	0.32	0.26	0.19	0.32	0.27	1.13	
	average	0.07	0.08	0.07	0.17	0.06	0.06	0.06	0.09	0.08	0.13	1.5
	Min.	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.01	

Source : Pollution Control Department, 2001

Noted : station 1=OEP., station 2=Bansomdat jao praya, station 3= Ratburana, station 4=Meteorological Dept., station 5=Jankasem, station 6=Ramkhamheang, station 7= National Housing Authority, station 8=Hauy Kwang, station 9=None Tree Vitaya, station 10=Singharatpitayakom

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Appendix Table 3: Roadside air quality of Bangkok in year 2000

Air pollutants	Values	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Std. values
SO_2 (1 hr) ppb	Max.					69.0	85.8	120.0	
	average	-	-	-	-	7.0	9.2	11.8	300
	Min.					0.0	0.0	0.0	
NO_2 (1 hr) ppb	Max.					133.0	110.0	169.0	
	average	-	-	-	-	28.8	28.5	50.4	170
	Min.					0.0	0.0	0.0	
CO (1 hr) ppm	Max.	18.3	13.8	8.8	6.9	8.6	5.9	14.0	
	average	2.3	2.5	1.5	1.9	1.4	1.2	3.3	30
	Min.	0.0	0.0	0.0	0.1	0.0	0.0	0.0	
O_3 (1hr) ppb	Max.					90.0	136.0	85.0	
	average	-	-	-	-	8.4	10.1	4.1	100
	Min.					0.0	0.0	0.0	
PM 10 (24 hr) µg/m^3	Max.	192.4	244.4	192.2	154.7	212.8	195.5	172.5	
	average	96.3	107.5	89.0	77.1	86.5	71.1	71.1	120
	Min.	50.8	36.0	34.8	29.0	39.3	31.5	27.0	
TSP (24 hr) mg/ m^3	Max.	0.22	0.31	0.22	0.28	0.28	0.19	0.29	
	average	0.13	0.16	0.13	0.20	0.14	0.12	0.18	0.33
	Min.	0.05	0.07	0.01	0.14	0.09	0.09	0.05	
Pb (1 month) µg/m^3	Max.	0.12	0.37	0.22	0.21	0.28	0.17	0.20	
	average	0.07	0.11	0.08	0.10	0.10	0.07	0.08	1.5
	Min.	0.02	0.03	0.01	0.04	0.03	0.02	0.02	

Source : Pollution Control Department, 2001

station 1= Ministry of Natural Resources and Environment, station 2= The Department of Land Transport, station 3= Chulalongkorn Hospital, station 4= Twenty two Cycle, staion 5= Thonburi subelectric power, station 6= Traffic Police Residence and station 7= Dindang

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Appendix Table 4: Relative abundance of ants that found in urban community of Bangkok and occurrence of ant on tree

Species	Relative abundance (%)								Ants on tree
	KJ	RB	WY	NV	CC	JS	DD	HK	
1.*Solenopsis geminata*	14.708	32.325	36.828	14.490	49.782	24.460	36.340	40.996	P
2.*Tapinoma melanocephalum*	9.359	9.158	31.084	10.003	4.378	1.531	0.630	0.535	P
3.*Pheidole bugi*	36.111	13.563	11.367	36.213	14.746	37.482	13.021	9.545	P
4.*Paratrechina longicornis*	10.358	18.080	6.440	15.997	7.868	16.780	9.539	13.986	P
5.*Paratrechina* sp.5 of AMKUFF	2.995	3.180	4.222	3.546	4.337	3.014	0.609	0.934	P
6.*Paratrechina* sp.9 of AMKUFF	0.334	0.253	0.025	0.007	0.155	0.247	0.120	0.032	P
7.*Paratrechina* sp.8 of AMKUFF	0.049	0.098	0.000	0.003	0.152	0.533	0.020	0.008	P
8.*Paratrechina* sp.4 of AMKUFF	0.000	0.000	0.087	0.000	0.006	0.004	0.000	0.000	P
9.*Monomorium pharaonis*	11.302	11.431	3.445	10.892	5.537	9.606	28.692	20.923	P
10.*Monomorium floricola*	1.674	1.360	0.812	0.591	1.482	0.962	1.908	1.010	P
11.*Monomorium chinense*	0.942	0.013	0.494	4.302	1.144	1.555	3.637	10.186	P
12.*Monomorium* sp.1 of AMKUFF	2.030	2.019	0.168	0.649	0.633	1.900	0.561	0.257	
13.*Tetramorium smithi*	9.242	0.237	0.870	1.284	0.035	0.118	0.619	0.061	P
14.*Tetramorium simillimum*	0.144	0.693	3.055	1.217	0.516	0.035	2.660	1.243	P
15.*Tetramorium lanuginosum*	0.098	0.457	0.096	0.192	0.172	0.344	0.081	0.133	P
16.*Tetramorium walshi*	0.003	3.503	0.000	0.000	0.016	0.378	0.000	0.018	
17.*Tetramorium bicarinatum*	0.000	0.000	0.114	0.012	0.000	0.000	0.577	0.004	
18.*Cardiocondyla emeryi*	0.193	0.102	0.646	0.074	0.244	0.234	0.071	0.030	P
19.*Cardiocondyla nuda*	0.003	0.000	0.000	0.362	0.000	0.000	0.000	0.089	
20.*Oecophylla smaragdina*	0.092	0.445	0.000	0.083	0.123	0.113	0.002	0.005	P
21.*Meranoplus bicolor*	0.296	0.771	0.207	0.081	0.332	0.037	0.083	0.004	
22.*Anopolepis gracilipes*	0.000	2.114	0.000	0.000	0.000	0.011	0.000	0.000	P
23.*Anochetus graeffei*	0.018	0.001	0.001	0.000	0.006	0.001	0.000	0.000	
24.*Crematogaster (Paracrema) monigliani*	0.003	0.000	0.003	0.002	0.000	0.000	0.000	0.000	P
25.*Crematogaster (Crematogaster) rogenhoferi*	0.000	0.000	0.000	0.000	0.000	0.398	0.000	0.000	P
26.*Crematogaster (Orthocrema)* sp.1 of AMKUFF	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000	P
27.*Cerapachys longitarus*	0.003	0.000	0.000	0.000	0.002	0.000	0.000	0.000	P
28.*Odontomachus simillimus*	0.002	0.083	0.026	0.000	0.002	0.000	0.002	0.000	
29.*Oligomymex* sp.1 of AMKUFF	0.000	0.000	0.007	0.000	0.006	0.105	0.000	0.000	
30.*Ochetellus* sp.1 of AMKUFF	0.000	0.000	0.000	0.000	0.099	0.069	0.000	0.000	
31.*Tetraponera allaborans*	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
32.*Tetraponera ruflonigra*	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	
33.*Technomymex* sp.1 of AMKUFF	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
34.*Leptogenys* sp.12 of AMKUFF	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	
35.*Pachycondyla* sp.1 of AMKUFF	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
36.*Polyrhachis* sp.1 of AMKUFF	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
37.*Pheidole fervens*	0.000	0.000	0.000	0.000	8.198	0.000	0.091	0.000	P
38.*Strumigenys* sp.1 of AMKUFF	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	
39.*Pheidologeton diversus*	0.000	0.000	0.000	0.000	0.000	0.066	0.000	0.000	
40.*Pheidole megacephala*	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.000	
41.*Plagiolepis sp.3 of AMKUFF*	0.000	0.000	0.000	0.000	0.000	0.000	0.098	0.000	

Noted: P= Presence
KJ= Klong Jun, RB=Ratburana, WY= Wongwian Yai, NV= None Tree Vitaya,
CC= Chokchai 4, JS= Jankasem, DD= Dindang and HK=Hauy Kwang

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Appendix Figure 1: Three characteristic areas of each urban community of Bangkok

Green Area

Commercial Area

Household Area

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Appendix Figure 2: Ant species that high distribution in urban community of Bangkok

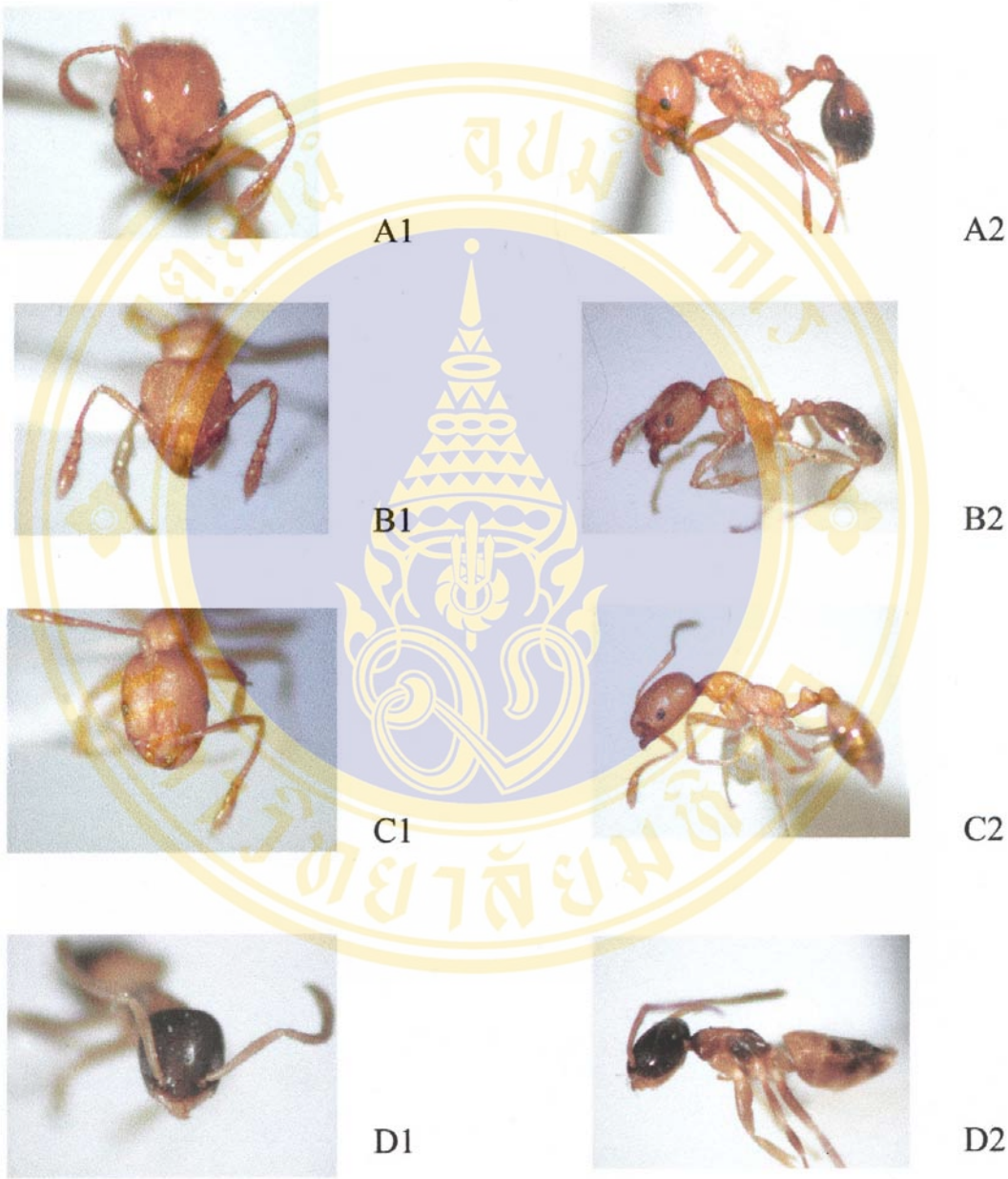

Figure A1, A2 : *Solenopsis geminata*

B1, B2 : *Pheidole bugi*

C1, C2 : *Monomorium pharaonis*

D1, D2 : *Tapinoma melanocephalu*

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Appendix Figure 2: (continued)

Figure E1, E2 : *Paratrechina longicornis*

F1, F2 : *Paratrechina sp.5 of AMKUFF*

G1, G2 : *Crematogaster (Paracrema) monigliani*

H1, H2 : *Cardiocondyla nuda*

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