CHAPTER II

LITERATURE REVIEW

Classification of ants

The ants belong to family Formicidae in the order Hymenoptera that also includes the bees, wasps, sawflies, ichneumons, and similar formed insects (Hölldober and Wilson, 1990). Eusocial vespoid acculeates with a wingless worker caste, forming perennial colonies. Head prognathous in female castes (worker and queen). Antenna with 4-12 segments in female castes, with 9-13 segments in male. Antenna geniculate between the long basal segment (scape) and the remaining funicular segments. Second abdominal segment 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).

The taxonomic hierarchy of ants

Kingdom Animalia
- Phylum Arthropoda
  - Class Insecta
    - Order Hymenoptera
      - Family Formicidae

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:

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 on cavities in twigs or fruit, between leaves, 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 understudy, on underside of leaves (Black, 1987).

2. The food niche

The majority of ants appear to be opportunistic foragers, taking some combination of plant exudates, seeds, and animal matter, alive or dead. Some fraction of an ant assemblage, however, is more specialized in their diets. For examples, the Attini cut vegetation or collect dead 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 they are otherwise quite common (Kaspari, 2000).

3. The temporal niche

In general, ants show a preference for foraging either during the day or at night. In some groups foraging will occur both period, although there may be peaks of activity with fewer foragers active during other periods. In the arid zone, the foraging activities of many species are highly dependant on temperature. Some species (for example most *Tetramorium* and some larger *Rhytidoponera*) are active only during the cool morning and evening hours, while others are active only during the hottest parts of the day (members of *Melophorus*). On cool or heavily overcast days, species which are normally seen at night may be active during the day while high-temperature loving species may remain in their nests all day.

Within an ant community, subsets of species may restrict their activities to some parts of the year. 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 in summer (Fellers, 1989).

Factor on ant biodiversity patterns

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

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

In western Australia, it was shown that road construction produced 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. Climate change

Correlation among 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 ant from Chantaburi province; eastern Thailand and found that species richness was significantly different in seasons, at the scale of a trap lone the wet season showed higher species richness, followed by 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.

3. 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 negative 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.

The important of ants

Ants are social insects which have diversity both in 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 important role in many ways as follows:

1. Ants as indicator

Ants are particularly appropriate for inventory and monitoring programs because most species have stationary, perennial nests with fairly restricted foraging ranges. Therefore, in contrast to other insects that move frequently among habitats in search for 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 habit in evergreen forest whereas *Oecophylla smaragdina* and *Anoplolepis gracillipes* habit in open area only.

Ant communities change significantly when environmental conditions are altered. As a consequence, the monitoring of ant communities has become an important component of environmental inventories. A wide range of government and non-government agencies and private companies use the monitoring of ant communities to assist them in making decisions about managing the environment.

It is well known that bush fires can cause significant damage to the environment, but properly managed fire can actually improve conditions for many plants and animals. To determine optimal fire regimes and thus protect the environment, extensive studies have been completed to determine the effects of different burning practices. Ants have proven very useful in determining the effects of fire and thus in developing management strategies which minimize its impact (Andersen,1991 & 1993 and Majer, 1990).

The monitoring of ant communities has proven to be a useful tool when determining management strategies or while evaluating the recovery of areas after severe disturbance. For example, inventories of the ants present in a mine site before disturbance have proved to be very useful in establishing the baseline conditions for successful restoration. Ants also play an important role in monitoring ecosystems and in determining priorities with regard to conservation and sustainable use.

2. Ants as biological control agent

An ancient cultured citrus ant, *Oecophylla smaragdina,* has been used in China for almost 1700 years to protect citrus fruit against damage by insect pests (Huang and Pei Yang, 1987). Moreover, many predaceous ants were applied to use as control agent of crop pests such as *Crematogaster* sp. and *Solenopsis* sp. (Rossi and Fowler, 2004), this can reduce using pesticide and help for saving money and protect the environment.

3. Ants 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 feces and corpses (Brain, 1978).

4. Ants as be food

Thai people, especially those from northern and northeastern, have a long cultural history of eating insects. Two species of ants that famous to be food as *O. smaragdina* and *Cerabara lignata*. The fresh ants, because of their rich formic acid content, are used as ingredients in salad dressing and contribute flavor in much the same way as the acetic acid in vinegar (Chen et al., 1998).

5. Ants as pests

Ants cause problems primarily when they forage in buildings for food or water and when they construct nests in buildings and gardens. When searching for food, they can be attracted to a wide range of products with different species preferring sweets, meats, fats or oils. They will also search indoors for water during dry period. When desirable items are found many species will recruit fellow nest mates to help gather the food and return it to the nest. This can result in large numbers of ants appearing over a short period of time.

Ants can be a nuisance when attempts are made to establish plants through direct seeding. Workers will forage for the newly planted seeds, removing them to their nests and causing reduced germination.

Some ants build nests in walls and foundations, or indoors in potted plants, enclosed areas, and even in cavities in toilets and sinks. In almost all cases nests are limited to pre-existing cavities or spaces between objects or in rotten wood and seldom will ants attack solid structures. Thus they generally will not cause structural damage to buildings but will take advantage of existing deterioration.

Outdoors, nesting activity can result in excavated soil being deposited in gardens and on brickwork. In most cases this causes little property damage but some species, especially species of *Aphaenogaster*, can form large numbers of chambers close to the surface. These chambers can cause soil to become soft and uneven, causing serious problems when found in golf courses or some types of pastures or crops. A few species will occasionally attack electrical wiring, apparently being attracted to either the insulation or the magnetic fields produced by the wires. In these situations extensive damage has occurred.

Ants often move nest sites when they are disturbed, or with a change in food supply. This can make control and remove of ants difficult. They may leave for short periods only to return later when a new food source is located and they can recolonize from nearby nests very quickly.

Several species of ants pose serious health threats to people who are sensitive to their stings. These ants include species of *Myrmecia* and *Odontomachus*. In extreme cases hospitalization may be required. Other species are known to carry diseases and can pose a threat in hospitals and veterinary clinics (some introduced species of *Monomorium* and the Argentine ant, *Linepthema humile*). In general ants are mainly a nuisance pest rather than a health problem.

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 (Bestelmyer et. al., 2000).

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. 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 process. 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.

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.

4. Litter techniques

These 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. 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. The apparatus compels mobile ants, through disturbance to the litter or through changes in microclimate, to migrate from the litter in to a collecting receptacle.

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 can be used to sample species of ants in an area and are detectable to the investigator in several kinds of habitats.

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.

7. Direct sampling

Direct or hand sampling involves searching for and collecting ants in different microhabitats within an area. A favorite method of Hölldobler and Wilson (1990) in forest is to clear loose leaves from small plots to expose soil and humus and watch the plot for 30 minutes in order to find small or cryptic ants. Unlike intensive sampling, in which the objective is to provide a precise estimate of colony or forager density in relatively small area, direct sampling may be spatially extensive, and the primary goal is to record the number of species inhabiting in an area. This technique is frequently used as a supplement to other techniques such as pitfall trapping and may significantly argument the number of species recorded.

8. Time unit sampling (TUS)

This has been developed by Japanese myrmecologists such as Kazua Ogata and Yoko Takematsu. The sampling protocol of TUS is simple, based on the time devotes to collection. Collecting is made within 30 minutes to get as many species of ants as possible. TUS adopted only hand collecting so that it is the simplest among the standardized methods (Ogata et al., 1998)

Specimen preparation

For short term storage, ants can be placed in 75% to 95% ethyl alcohol. They should be kept cool and in darkness, and should not be allowed to dry out. After initial collecting, the alcohol should be changed to assure that the concentration is appropriate because it can be diluted by body fluids after preserved in the first ethanol . Also, any dirt, plant materials or other debris that was collected with the ants should be removed. These materials can stain the ants if left with them for extended periods. It is especially important that the tubes should be stored in the dark to prevent colors fading and deterioration of the cuticle or integument will deteriorate over time, greatly reducing the usefulness of the material for taxonomic studies and making identifications difficult or impossible.

Pinning

For detailed study and long-term storage, ants should be point-mounted on insect pins. Pointing allows specimens to be easily manipulated while being examined with a microscope and is essential for viewing fine details such as sculpturing and pilosity. In all cases, ants, even large species such as those in the genus *Myrmecia*, should be placed on points and not directly pinned. This is because the mesosoma is relatively thin and in many species there is a flexible suture between the pronotum and mesonotum. If a pin is placed through the mesosoma the pronotum will often break away from the mesonotum, seriously damaging the specimen.

A commonly used procedure for curating ants is as follows. Field-collected specimens are transferred from the original collecting vial to a small dish and covered with alcohol. Several specimens are selected for mounting, with the exact number depending on several factors. For example, if the species is represented by only a single caste (no major or minor workers, or queens or males present) then about 6 workers should be sufficient. If, however, the species is polymorphic or queens or males are present, then representatives of all castes should be selected.

Another factor influencing the number of specimens is their size. It is desirable to place 2 or 3 workers on separate points but on the same pin. This saves space in collections, allows several specimens to be examined at the same time under the microscope, and associates polymorphic workers with each other and queens and males with workers. Because of this it is common to mount ants in sets of 3. For example, 3 workers on each of 2 pins, or a queen, male and worker on a single pin, or a major, medium and minor worker on a single pin. Large species should mounted similarly, but in sets of 2 on 3 pins. The remainder of the series can be stored in alcohol for future use.

Individual points can be either hand-cut from strips of stiff, white, high-quality, acid-free paper, or punched with a specially designed hand-punch. The use of a punch is preferable if large numbers of ants are to be mounted as it produces points quickly and of uniform size and shape. The glue used to attach ants to the points should be water-soluble to allow for later removal if needed. Stainless steel insect pins of size 2 or 3 can be used to hold the points.

Individual ants should be glued to the tip of the point with just enough glue to hold them securely but not so much that the lateral or upper surfaces are obscured. It is best to place the point so that it contacts the basal segment (coxa) of the mid- and hind legs. Specimens should be mounted upright, horizontal and with the point extending from the ant's right side. Another important procedure is to very gently position the legs so that they do not obscure the body when viewed from the side. This is one of the more difficult aspects of mounting ants but is also one of the most important as identifications will be difficult if the specimen can not be viewed clearly. Finally, the number and configuration of mandibular teeth are important characters in many groups. If possible, at least 1 of the mounted specimens should have the mandibles open so their inner margin is visible. A careful inspection of the available specimens will often reveal individuals which are in better positions for mounting. These individuals should be selected as they will help in reaching a better final result.

There are two common methods of placing ants on points. The first is to place the point on the pin and then glue the ant to the upper surface of the point. The other method is to lay the ant on its back and then glue the point (without a pin) to the underside of the ant. Once the glue has dried, the point plus ant can then be turned upright and placed on a pin. The first method works satisfactorily for small ants but generally not for larger specimens. When placed on top of a point, larger specimens tend to tilt or even fall off before the glue can dry. Because of this, the second method is preferable, especially for large specimens, and is often used for small ants as well. With this method, the tip of the point can rest on the ant while its base rests on the table or microscope until the glue dries. This minimizes tilting of the specimen and results in a higher quality preparation.

Occurrence of ants in urban areas

Some ant species can inhabit in disturbed areas where limited in habits and food resources. Ants, in subfamilies and genus groups, may occurrence in urban areas of Bangkok as follows (Dalad Senthong, 2003).

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. Nests are primary 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 sting to capture and subdue prey. They commonly forage in leaf litter and are less frequently found in the open area, especially when compare with workers of the closely related genus *Odontomachus*

3. Genus *Diacamma*

Species of *Diacamma* nest in loose debris on the ground 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 in 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 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 known to forage 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 wood and in leaf litter. They are cryptic predators, foraging in leaf litter, and some species are known to specialize 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 ground surface, 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. Foraging occurs throughout the day and night, with workers foraging singly or in well – formed and distinct foraging trails.

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 time of the day and night. Nests 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 stems, or almost any appropriately sized performed 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. Workers forage in house in search of food and water. In general they nest outdoors but sometime establish small nests in the suitable location indoors near a well-maintained food supply.

3. Genus *Iridomyrmex*

This genus nest 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 *Iridomyrmex* 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 woods 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 Homoptera to collect honeydew. They nest either in the soil or arboreally, and sometimes use plant fibres to form covering 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 house where they show a preference for fluids and sweets.

Subfamily Formicinae

1. Genus *Anoplolepis*

The single species of *Anoplolepis* is known to occur in Thailand. *A. gracillipes,* 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 wall. They are general predators on a range of arthropods and are known to tend Homoptera to collect honeydew.

2. Genus *Oecophylla*

Nests of *Oecophylla smaragdina* are always in trees or shrubs and are constructed by attaching leaves together with silk produced by their broods. Individual colonies become very aggressive and will vigorously attack intruders. Foraging takes place both on vegetation and on the ground, and they are 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, under rocks, or other objects. 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* are 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 twig on standing shrubs or trees. They general are scavengers and predators and they collect nectar and plant secretion. In addition, They also tend Homoptera for honeydew

Subfamily Myrmicinae

1. Genus *Crematogaster*

Workers are moderately aggressive and will attack when they are disturbed. They have well-developed chemical defense 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 coverings, sometimes with a mound of low dirt or a large depression around the entrance, and 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 and cryptic ants nest either in open soil or under rocks. 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. 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 and at night. Large number of workers can be attracted to baits places on the ground.

5. Genus *Monomorium*

Species of *Monomorium* are very diverse in sizes and habits, ranging from very small generalist scavengers to large polymorphic seed harvesters. Nests are 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 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 number of workers can be found at highly desirable food sources such as honey baits.

7. Genus *Tetramorium*

Within their preferred habitats these ants can be very common. They forage individually on the ground, often in large number of workers, 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.

Relevant researches

Suparoek Watanasit, Chutamat Phophuntin, and Surakrai Permkam (2000) investigated diversity of ants at Ton Nga Chang Wildlife Sanctuary, Songkhla, Thailand. Seven subfamilies of ants, including 59 genera, were found. Species richness and Shannon-Wiener diversity index were higher in the wet season than in the dry season. Seasonal change also influenced the numbers of individuals in subfamily Myrmicinae and in species *Tapinoma* 1, *Pheidologeton* 4, and *Paratopula* 1. The relationships between physical factors (temperature, rainfall, and humidity) and the numbers in subfamilies and species were examined. Temperature was negatively correlated with *Pheidole* 3 ($P<0.05$). Rainfall was positively correlated with *Pheidole* 2, *Paratopula* 2, and *Paratopula* 3 ($P<0.05$). Humidity was also positively correlated with *Camponotus* 6 ($P<0.05$).

Decha Wiwatwittaya (2001) studied on ant fauna at Doi Angkhang in several habitats. Species diversity of ants was investigated. The ants in habitats were collected. Group, species, and abundance were analyzed. The study was found that there were a total of 9 subfamilies comprise of 49 genera and 102 species. Thirty-three species were mostly found in Myrmicinae. The following subfamilies, belonging to Ponerinae and Formicinae were found 24.51% and 22.55% respectively. Genus

Polyrhachis 6.68%, *Aenictus* 5.88%, *Camponotus* 4.90%, and *Pheidole* 4.90% were mostly found in the area. *Dolichoderus thoracicus*, *Tapinoma melanocephalum*, *Paratrechina longicornis*, *Monomorium pharaonis*, and *Monomorium floricola* were always found in houses.

Decha Wiwatwittaya (2003) studied on the diversity of forest ant at Khoa Yai National Park. The study was carried out in tropical rain forest, dry evergreen forest, mixed deciduous forest, secondary forest, and savanna from January to December 2000. The study found that Khoa Yai National Park had a high diversity of forest ant species. There were a total of 9 subfamilies composed of 76 genera and 258 species. Species diversity of forest ants was highest in tropical rain forest and lowest in savanna. The numbers of forest ant species that were restricted to tropical forest, dry evergreen forest, hill evergreen forest, mixed deciduous forest, secondary forest, and savanna were 21, 21, 29, 8, 11, and 4 species, respectively. Most ant species could be categorized as moderately abundant. Forest ant species were most similar in the savanna ad in secondary forest (78.75%) and in the tropical rain forest and the dry evergreen forest (72.54%) whereas the tropical rain forest and the secondary forest (44.38%) and the tropical rain forest and the savanna (45.95%) were least similar.

Suparoek Watanasit, Saowapa Sonthichai, and Nawee Noon-anant (2003) surveyed ant fauna at Tarutao National Park, southern Thailand. Two sampling methods, hand collecting and litter sifting, were applied to ant collecting within a time limit of 30 minutes for each method. There were 3 replications of each sampling method in each study site. Five subfamilies of ants, comprising 61 species were found. The results also showed that sites had no effect on species number of ants but sampling methods differed significantly in species number of the subfamily Formicinae ($P<0.05$).

Surachai Tongjerm, Suparoek Watanasit and Decha Wiwatwittaya (2003) studied on species composition and abundance of canopy ants in Ton-Nga Chang Wildlife Sanctuary, Songkhla Province. Sixty-nine species of 22 genera from 6 subfamilies were recorded. The ant samples were classified by nesting site into 3 groups. There were 74 species, 24 species, and 20 species, nesting on tree, on ground, and unknown sites, respectively. The results of this study also showed that study site had an effect on the number of ants nesting on the ground, and seasonal change influenced species number of ant species nesting on tree whereas study site and seasonal change had no effect on ant species number of unknown sites.

Pitakpong Pompranee, Jutharat Attajarusit, and Decha Wiwatwittaya (2003) studied on species, abundance, distribution pattern and behavior of ants on sugarcane fields. Of 18 species found, 5 species named *Pheidole plagiria*, *Iridomyrmex anceps*, *Camponotus rufoglaucus*, *Paratrechina longicornis*, and *Diacamma* sp., were most abundant and played significant roles in field control of sugarcane stem borers. The distribution pattern of foraging activity of ants was mostly clumped while the nest distribution was mainly uniform. In addition, factors affecting ant foraging activity were food source, soil temperature, and light intensity.

Nawee Noon-anant, Suparoek Watanasit, and Decha Wiwatwittaya (2003) studied on the species diversity and seasonal abundance of ants in Bala forest at Hala-Bala Wildlife Sanctuary, Narathiwat province, were conducted in lowland tropical rain forest at elevation of less than 2000 meters above mean sea level. Eight subfamilies 63 genera and 255 species of ants were identified. Different times of the year and method used gave different results in term of species richness, abundance and species composition of ants. The highest number of species (133 species) was found in January 2002. It was also discovered that combination of 4 methods yielded higher number of species, genera, and subfamilies than the use of one method. The highest number of genera and species was found in Myrmicinae (26 genera 104 species), followed by Ponerinae (16 genera 74 species) and Formicinae (12 genera 47 species). The genus *Pheidole* had the highest number of species (25 species), followed by *Pachycondyla* (15 species), *Hypoponera* (13 species), *Cerapachys* (12 species) and *Camponotus* (11 species). Seasonal change influenced the number of species in the subfamily Aenictinae such as genera *Aenictus*, *Pheidole* and *Pyramica*. There were significant differences between the wet and the dry season for each of these four ant taxa. The relationships among different physical factors (rainfall, air temperature, and air humidity) and number of species varied.

Suparoek Watanasit (2003) used four sampling methods; hand collection (HC), leaf litter samples (LS), soil samples (SS), and sampling with honey baits (HB), to collect ants in a rubber plantation at Prince of Songkla University, Hat Yai, Thailand, during November - December 1999. In this study, 35 species of ants collected belong to six subfamilies: Formicinae, Myrmicinae, Aenictinae, Ponerinae, Dolichoderinae, and Pseudomyrmecinae. The results also showed that the combination of two methods (SS and LS) and the combination of three methods (SS, LS, and HC: SS, LS, and HB) yielded the highest number of ant species.

Saowapa Sonthichai (2003) collected ants by using pitfall traps from Doi Chiang Dao in Chiang Mai Province, northern Thailand. Five subfamilies; Dolichoderinae, Formicinae, Leptanillinae, Myrmicinae, and Ponerinae, 33 genera and at least 38 species of ants were found. A total of 1,313 ant specimens were collected in various forests. Seven hundred and twenty individuals and 36 species were from Pine/Hill Evergreen forest. Deciduous Bamboo forest, Lowland Evergreen forest, Summit and Dry Dipterocarp/Oak forest yielded 427, 97, 35,34 individuals and 30, 15, 8, and 10 species, respectively.

Nawee Noon-anat and Suparoek Wattanasit (2003) investigated the ants in genus *Polyrhachis* in Southern Thailand. The investigation was conducted by canopy fogging and hand collecting on lower vegetation. Nine subgenera and 78 morphospecies were found. The subgenus *Myrmhopla* had the highest number of species (33 species), followed by *Myrma* (16 species) and *Myrmatopa* (8 species). Furthermore, the vertical distribution of *Polyrhachis* was different among species. Thirty-five and 20 species were found only in lower vegetation and tree canopy respectively, while 23 species were found both in lower vegetation and tree canopy.

Weeyawat Jaitrong and Ponnarin Chumthong (2003) surveyed the ant species in Khao Ang Reu Nai Wildlife Sanctuary, Eastern Thailand, by four methods consist of honey baiting, litter sifting, hand collecting, and soil sampling. Nine subfamilies 66 genera and 214 species were found in this survey distributing in dry evergreen forest and secondary forest. The species list of ants in this wildlife sanctuary is included. Detailed information on diversity of ants is known to occur in this area, especially comparison with other site in Southeast Asia and some places in Thailand were discussed.

Beuno (1997) discussed the role of ants as pests in urban areas in Brazil. Of 2000 species described from Brazil, 20-40 were recognized as pests. These included carpenter ants of the genus Camponotus, which might damage electrical and electronic components, *Wasmannia auropunctata*, *Linepithema humile* and species of Pheidole and Crematogaster. Several species had been introduced, including *Tapinoma melanocephalum*, P*aratrechina longicornis*, *Monomorium pharaonis and Pheidole megacephala.* Ants damaged food and household possessions, they invaded food stores and electrical equipment such as refrigerators and televisions, they attached ornamental plants, and their presence could have a psychological impact on the inhabitants. The control of urban ants was difficult: the level of infestation, the species concerned and the location of the colonies must first be ascertained. The use of insecticide aerosols and powders could be environmentally damaging and might fragment and thus increased ant colonies. Toxic baits, which were transferred to the colonies by the ants themselves, were preferred.

Klotz et al. (1995) surveyed for the urban pest ants of peninsular Florida, USA. To determine the kinds of ants and types of ant problems confronted in both commercial and household pest controls. Eight species of ants identified as key pests in Florida. Of these, the most common were *Solenopsis invicta* - 14%, *Tapinoma melanocephalum* - 14%, *Paratrechina longicornis* - 14%, *Camponotus abdominalis floridanus* - 12%, *Monomorium pharaonis* - 11%, *Camponotus tortuganus* - 8 %, *Pheidole magacephala* - 7%, and *Paratrechina bourbonica* - 4%. More than 25 other species of ants, which were occasional invaders, were also collected in the survey. Customer complaints, nest locations, and treatment strategies for pest ants are also described.

Knight and Rust (1990) collected ants and obtained information from professional pest control personnel in 4 regions of California. The ants were identified and correlations with survey data were made. *Iridomyrmex humilis* was the most common ant pest (25.9%), followed by *Solenopsis xyloni* (19.33%), *Tapinoma sessile* (11.1%), and *Camponotus* spp. (9.5%). Twenty other ant taxa were also returned. *Monomorium pharaonis*, *Camoponotus* spp. and *Formica* spp. were collected from all regions. Infestions of *I. humillis*, *T. sessile* and *M. pharaonis* were collected from several different rooms within structures. *Camponotus* spp. did not infest kitchens and bathrooms as frequently as did the other common species. *I. humilis* were more difficult to control than any other species along the California coast and in densely populated areas based on the percentage of retreatments or call-backs for each species. *I. humilis* and *M. pharaonis* are extending their range within California with the former species being imported as far north as Humboldt County.

Malazemova and Maloazemov (1999) studied on ants in Yekaterrinburg, Russia. The study areas were large park forests surrounding the city, city streets, lawns, gardens, fields, wastelands, and other areas exposed to strong anthropogenic impact. Identification of the collected material revealed 21 ant species belonging to 2 subfamilies, Formicinae and Myrmicinae, and 6 genera, *Camponotus, Myrmica, Formica, Leptothorax, Lasius,* and *Monomorium*. Nineteen ant species were found in the park forest zone and 13 species in the city. Eleven species were common for these ecosystems. The highest density of ant populations was observed in moderaately moistened open habitats, medium density of nests was typical of shadowed habitats with tall grasses and the smallest number of nests were found in areas exposed to high anthropogenic pressure and high humidity. The average density of nests in the citywas almost twice that in the forest park zone. Differences were seen in the size and density of colonies, structure of populations and habits of ants. It was found that the species composition and density of ants varied depending on habitat and reached the highest values in open habitats, steppe areas and wastelands. It was concluded that the anthropisation of ants proceeds along specific pathways, and that the quantitative ratios between different dynamic groups of ants are unequal in the city. The species divergence of ant decreases along the increasing gradient of urbanization; conversely, the dominant species *Lasius niger* expands, and this accounts for the increasing abundance of ants in the city. The protective role of ant decreases there, mainly due to the disappearance of large insects belonging to the genus Formica. However, ants of the synanthropic species *Monomorium pharaonis* appeared.

Samways, Osborn, and Carliel (1997) studied about species composition and relative abundance of ground-dwelling ants at various distances from a major urban highway, in South Africa. Diversity, richness and evenness indices indicated differences between ant assemblages, with samples near to the highway (<4 m) having the highest species diversity and farthest ones (32 m) having the lowest. It appeared that the ants were influenced mostly by interspecific competition and/or distribution of food resources, especially road kills. *Pheidole megacephala* was highly dominant at all sites and was negatively associated with several species. This and other dominant species appeared to be influencing the abundance of rarer ones. Dominance and high abundance of species in the genera Pheidole, Monomorium, Tetramorium, and Paratrechina, along with the occurrence of certain grasses, indicated that the whole sampling area was disturbed.

Collingwood, Tigar, and Agosti (1997) surveyed the ant fauna of the United Arab Emirates (UAE), between February and March 1995. Samples were collected from 14 locations which included all major habitat types in the UAE. Fifteen introduced ant species (*Pachycondyla sennaarensis*, *Cardiocondyla emeryi*, *Monomorium indicum*, *M. destructor*, *Pheidole teneriffana*, *Solenopsis geminata*, *Tetramorium bicarinatum*, *Iridomyrmex anceps*, *Linepithema humile*, *Tapinoma simrothi*, *T. melanocephalum*, *Camponotus compressus*, *Paratrechina flavipes*, *P. jaegerskioeldi*, and *P. longicornis*), from 4 subfamilies were recorded. Their world and local distributions, biology, ecology and pest status are listed. Eight species were cosmopolitan, tramp species. Introduced species now account for about 20% of all ant species recorded in the UAE. It is concluded that local environment departments should develop routine monitoring programs for species which may have a harmful effect on local ecology or public health. It is suggested that *Pachycondyla sennaarensis*, *M. destructor* and *S. geminata* might be potential public health and nuisance pests.

Viswanathan and Narendra (2000) studied the effect of urbanization on the biodiversity around Bangalore, India. Ants were used as bioindicators for this study. The study revealed that *Solenopsis geminata*, *Tetramorium bicarinatum*, and *Monomorium* sp. were extremely dominant over the rest. The habitats which were least disturbed recorded the maximum diversity, while those which had numerous microhabitats had less diversity and showed extreme dominance of some species. This relative dominance of the same species of one ant over the other has pushed the lower species towards elimination in that particular habitat, which might slowly but surely lead to permanent removal of species which are very particular about their life style.

Na and Lee (2001) surveyed and found 23 common household ant species (*Monomorium pharaonis*, *Monomorium floricola*, *Monomorium destructor, Monomorium orientale, Paratrechina longicornis, Paratrechina* sp., *Anoplolepis longipes* [*Anoplolepis gracilipes*], *Tapinoma sessile*, *Tapinoma melanocephalum*, *Crematogaster* sp., *Solenopsis invicta, Solenopsis germinata, Solenopsis molesta, Tetramorium* sp., *Dolichoderus bituberculata, Camponotus* sp., *Technomyrmex albipes, Pheidole* sp., *Oecophylla smaragdina, Linepithema humile, Prenolepis imparis, Formica* sp.) from four subfamilies (Dolichoderinae, Formicinae, Myrmicinae and Ponerinae) in Penang, Malaysia. They described a morphological key to the workers of common species that were found in and around living premises.

Yamaguchi (2003) investigated how progressive urbanization influences the distribution of ant species in cities, he compared the ant species richness in urban parks of different areas and ages of Tokyo, the most intensively developed urban region in Japan, and its developing neighbor, Chiba City. A total of 43 ant species were found from 98 parks. Multiple regression analysis revealed that park area and age had a positive effect on the number of ant species in the parks and that the parks in Tokyo contained fewer species than did comparable parks in Chiba. Thus, the progression of urbanization reduces ant species richness in urban parks, most likely because it isolates the parks from the surrounding area. Next, in order to examine the relationships between the types of landform modification and the ant distribution in urban areas, he compared the ant species richness in urban parks of Chiba City among different landform types (upland + terraces, lowlands, cut and fill, banking, and reclamation). This study showed that the parks in the reclaimed lands and lowlands contained fewer ant species than did parks in other areas. The reason for this decline of ant fauna is discussed.

Ogata, Takematsu, and Urano (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 1998, 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 was 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.

Decha Wiwatwitaya, Sasithorn Hasin, and Chamaiporn Bourmas (2003) investigated ant distribution in of Bangkok among dry 2000, wet 2001, and wet 2002. Fifty-eight species were found, including Cerapachyinae (1), Dolichoderinae (8), Formicinae (10), Myrmicinae (22), Pseudomyrmecinae (3), and Ponerinae (14). The ant composition consisted of outdoors (42), indoors (10), both ones (15). Very rare species were the most relative occurrence of urban ants throughout three periods. *Tapinoma melanocephalum, Paratrechina longicornis, Monomorium pharaonis, Solenopsis geminata, Anoplolepis gracilipes* and *Oecophylla smaragdina* were commonly found over three periods. There were 8 tramp species, including *Tetramorium bicarinatum, Tetramorium simillimum,* *Monomorium pharaonis, Tapinoma melanocephalum, Anoplolepis gracilipes, Paratrechina longicornis, Solenopsis geminata,* and *Pheidole fervens. Monomorium Pharaonis, Solenopsis geminata, Camponotus (Tanaemyrmex)* sp.7 of the collections of Ant Museum Kasetsart University (AMK), and *Tetramorium bicarinatrum* were found. 1-4 household ants were mostly close species on Thai peoples' life. *Monomorium pharaonis* was the important problem for electronic industries in tropical countries.

Dalad Senthong (2003) studied the relationship between ant distribution and air quality variation in urban communities of Bangkok. Baiting and Time Unit Sampling were utilized for ant sampling between July 2002 - October 2002 and December 2002 - March 2003. Seasonal change influenced the ant distribution, it revealed that the averages of species richness in wet and dry season were not significantly different, whereas density of colony and abundance of *Pheidole bugi*, *Paratrechina longicornis* and *Paratrechina* sp.5 of AMK were significantly different. 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 AMK. Carbon monoxide was negatively correlated with abundance of *Paratrechina* sp.5 of AMK 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 ant TWINSPAN analysis showed parallel results that *Crematogaster moniglini* and *Cardiocondyla nuda* were positively correlated with ozone.