ECOLOGY AND MORPHOLOGY OF HOUSEHOLD ANT, *Paratrechina longicornis* (LATREILLE, 1802) IN SOUTH EASTERN OF JOHOR

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ABSTRACT

Paratrechina longicornis is an invasive ant which may act as a predator upon pest species in plantations and agriculture farms. In spite of that, this cosmopolitan ant species is also a pest in houses (Fox *et al,* 2007) and was discovered as a mechanical carrier of pathogenic microorganisms in hospital environment in Brazil (Moreira *et al.,* 2005). The objectives of this study are to determine the occurrence, morphology and behavioural pattern activity of *P. longicornis* in built area and natural environment of Johor, the variation in the nesting preferences of *P. longicornis* occurring in wooden house and concrete houses and to compare the behavioural activity patterns and morphology of *P. longicornis* occurring in built area and natural environment of Johor. Three sites were selected, Endau-Rompin National Park, Kahang and Kg Peta as the natural environment, built and rural area respectively. No *P.longicornis* was found in the undisturbed area of Endau-Rompin National Park, 654 and 2547 individuals of *P. longicornis* were collected in Kg Peta and Kahang through manual collection. All individuals of *P. longicornis* observed all areas were black in color. Sometimes, when they were exposed to the sun, it seems to be seen as darkish brown and shiny. Variability occurs and may be dimorphic in size of the workers. The sizes of minor (2.500mm ± 0.316) and major (3.269mm ± 0.274) workers of *P. longicornis* in build area are larger than the ants found in the rural area (2.303mm ± 0.246 and 3.118mm ± 0.224 respectively. *P. longicornis* were only found nesting in two of the wooden houses and four concrete houses from 10 houses chosen in Kg Peta. From the observation made to see the behavioral pattern of activities of *P. longicornis*, in Kg. Peta, *P. longicornis* has their own nesting preferences; 1) safe and protected from weather and macroclimate such as direct sunrays, rain and wind, 2) has good thermoregulatory to heat and humidity (depends on the host material, 3)

nearest to the wide variety of food sources, 4) enough space for their nest establishment and reproduction and 5) nest must be ecologically secure. *P. longicornis* were abundant and highly adaptable to concrete house as the nesting sites were discovered mostly in the concrete houses rather than the wooden house. The peak hour of the activities of *P. longicornis* observed in Kg Peta was during night time. In Kahang (built area), activity pattern seemed to contrast to that of the Kg Peta (rural area). The activities of *P. longicornis* in were found to be affected by humidity, temperature and rain. It was observed that the activities of *P. longicornis* are closely related to the human activities that was the active period of the ant is during day time. This study provides up to date biological information of *P. longicornis* as a pest species in Malaysia and to be a good biological indicator to disturbance as it is only can be found in such area.

ABSTRAK

Paratrechina longicornis adalah merupakan semut spesies invasif yang boleh bertindak sebagai serangga perosak di ladang dan kebun pertanian. Selain itu, semut kosmopolitan ini juga merupakan serangga perosak di rumah (Fox *et al,* 2007) dan pembawa mekanikal organisma patogendalam persekitaran hospital di Brazil (Moreira *et al.,* 2005). Objektif kajian ini adalah untuk menentukan kehadiran semut, morfologi dan corak aktiviti perlakuan semut *P. longicornis* di kawasan yang dibina dan semulajadi di Johor, menentukan cici-ciri sarang *P. longicornis* yang ditemui di dalam rumah kayu dan rumah konkrit serta membandingkan corak aktiviti perlakuan dan morfologi *P. longicornis* di kawasan yang dibina dan persekitaran semulajadi di Johor. Tiga lokasi telah dipilih, Taman Negara Endau- Rompin, Kahang dan Kg Peta sebagaia alam semula jadi, yang dibina dan luar Bandar. Tiada individu *P. longicornis* ditemui di kawasan tidak terganggu Taman Negara Endau- Rompin, manakala 654 dan 2547 individu *P. longicornis* dikumpulkan dari Kg peta dan Kahang melalui kutipan manual. Semua individu *P. longicornis* diperhatikan berwarna hitam dan kelihatan perang apabila terdedah kepada cahaya matahari. Kepelbagaian dan dimorfisma mungkin berlaku dalam saiz semut pekerja. Saiz pekerja minor (2.500mm ± 0.316) dan major (3.269mm ± 0.274) di kawasan dibina adalah lebih besar daripada semut yang ditemui di kawasan luar bandar (2.303mm ± 0.246 dan 3.118mm ± 0.224 masing-masing). *P. longicornis* hanya didapati bersarang dalam dua buah rumah kayu dan empat buah rumah konkrit daripada 10 buah rumah yang dipilih di Kg Peta. Daripada permhatian yang dibuat untuk melihat pola tingkah laku aktiviti *P. longicornis* di Kg Peta, semut ini mempunyai keutamaan dalam membuat sarangnya; 1) selamat dan dilindungi dari cuaca seperti keamatan cahaya matahari, hujan dan angin, 2) mempunyai pengaliran haba dan kelembapan yang baik (bergantung baik kepada bahan binaan rumah), 3) yang terdekat dengan pelbagai sumber makanan, 4)

ruang yang mencukupi untuk pembesaran sarang dan koloni dan 5) sarang mestilah selamat dari segi ekologinya. *P. longicornis* lebih mudah beradaptasi dalam rumah konkrit kerana lebih banyak sarang mereka ditemui di rumah konkrit berbanding rumah kayu. Waktu puncak bagi aktiviti *P. longicornis* diperhatikan di Kg Peta adalah pada waktu malam. Di Kahang, (kawasan di bina), sorak aktiviti adalah bertentangan dengan Kg peta (kawasan luar bandar). Aktiviti *P. longicornis* di Kahang dipengaruhi oleh kelembapan, suhu dan hujan. Hasil pemerhatian menunjukkan bahawa aktiviti *P. longicornis* adalah berkait rapat dengan aktiviti manusia memandangkan tempoh aktif semut adalah pada waktu siang. Melalui kajian ini, maklumat terkini biologi semut *P. longicornis* sebagai spesies perosak di Malaysia dapat diketahui dan semut ini mampu menjadi penunjuk biologi untuk kawasan terganggu kerana ia hanya boleh ditemui di kawsan tersebut.

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1	m	Meter
2	mm	Milimeter
3	km	Kilometre
4	μm	Micrometer
5	m/s	Meter/second (velocity)
6	$W/m^2 K$	Thermal conductance
7	W/m K	Thermal conductivity
8	$m^2 K/W$	Thermal resistance
9	$W/m^2 K$	Thermal transmittance
10	γ	Gamma
11	(%)	Percent
12	(°C)	Degree Celcius
13	NERC	Nature and Education Research Center
14	UNSD	United Nation Statistic Division

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GLOSSARY

Antenna	a pair of segmented sensory appendages located on the head.
Clypeus	a sclerite (plate) on the lower part of the face located above the labrum.
Dimorphic	having two distinct forms; example: major and minor workers
Gaster	the remaining abdominal segments after the waist orpedicel; the enlarged part of the abdomen that is usually referred to as the abdomen, proper.
Maxillary palp	small, feeler-like structures arising from themaxilla.
Monomorphic	having only a single form; for example - ant species with all workers having the same form.
Scape	the first segment of the antenna; the elongated antennal segment that is attached to the head.
Setae	stout hair that is set in a socket in the cuticle.

CHAPTER 1

INTRODUCTION

1.1 Studies background

Ants are abundant, diverse and ecologically dominant. Ants play important function at many levels in an ecosystem. They are predators or preys, feeding on other organisms or being food for some organisms. They maybe detrivores and acclaimed organic matter decomposers. Some are mutualist; gaining from their host at the same time contributing. Many are herbivores feeding strictly on plant materials (Holldobler & Wilson, 1990). Ants also were identified as one of the most invasive pests in Malaysia after mosquitoes and cockroaches (Lee, 2002). A survey of homeowners in Penang indicated that the most common household ant species were *Pheidole* sp., *Tapinoma melanocephalum*, *Monomorium destructor* and *Paratrechina longicornis* (Lee, 2002).

Paratrechina longicornis is an invasive ant which is accidentally spread by human commerce around the world. They were so widespread and it is difficult to determine its origin. However, many believe probably

originated in southeastern Asia (Wilson & Taylor, 1967) or Africa (Smith 1965). With, this ant nowadays can be found in various part of the world such as United States (Smith, 1965), New Zealand (Harris & Abbott, 2005), Brazil (Rodrigues *et al.,* 2010), Canary Island (Espadaler & Bernal, 2003), Malaysia (Lee, 2002) and any other tropical cities worldwide. In United Arab Emirates, *P. longicornis* was recorded as one of the fifteen introduced ant species there. However, the distribution of this ant does not reach the sandy deserts of the region (Collingwood & Tigar, 1997).

1.2 Problem Statement

P. longicornis may act as a predator upon pest species in plantations and agriculture farms. In Florida, *P. longicornis* prey extensively on pest insects in soybean field (Whitcomb *et al.,* 1972) and as egg predators of coconut pest in Sri Lanka (Way *et al.,* 1989). They were abundant in disturbed rice fields in Philippines (Way *et al.,* 1998).

Beside existing in natural environment, this cosmopolitan ant species is also a pest in houses (Fox *et al.,* 2007) and was discovered as a mechanical carrier of pathogenic microorganisms in hospital environment in Brazil (Moreira *et al.,* 2005). There were nine species of bacteria isolated from *P. longicornis; K.pneumoniae pneumoniae, Serratia rubidae, Staphylococcus cohnii, Bacillus* spp, *Enterobacter agglomerans, Enterobacter cloacae, Gamella haemolysans, Gamella morbillorum and Staphylococcus aureus.* Some of these bacteria are Antibiotic-resistant type that can be linked to potentially serious problems in hospitals; *Enterobacter* tend to pose threat to children who have contracted diarrhea in hospitals, *E. cloacae* can be serious for neonates in intensive care units, *K. pneumoniae pneumoniae* are highly pathogenic and frequently fatal, *K. oxytosa* has been responsible for infant deaths in hospitals (Moreira *et al.,* 2005).

Lee, 2002 had isolated 123 bacteria and 8 fungi from the household ants include *P. longicornis*. The most common isolated bacteria and fungi were *Aeromonas hydrophila*, *Agrobacterium radiobacter*, *Aspergillus flavus* and *Aspergillus nigers*. According to Rodrigues *et al.,* (2010), a total of 137 microfungal isolates were obtained from *P. longicornis* carcasses. The results showed that the most frequent taxa found were *Aspergillus flavus* (30.7%), *Penicillium* sp. (23.4%) and *Cladosporium* sp. (18.3%). This study suggests that *P. longicornis* harbour ubiquitous soil-borne saprophytic fungi as well as insect pathogenic fungi which would be potential candidates for the biological control of urban ants.

Furthermore, there is confusion due to the size and colouration of *P. longicornis* which might lead to the taxonomic misidentification. Identification is very important to control and manage pest. Besides, there is also lack of information vital to the control and management of *P. longicornis* in rural and urban area. *P.longicornis* is so variable, considered a pest in several parts of the world and in Malaysia, and associated with many different pathogenic microorganisms. It is important that study on its morphological variability and adaptive behaviour related to housing architecture and building materials be studied.

1.3 Justification of Study

This study intends to update all biological information on *P. longicornis* which includes its morphology, behavior and interspecific communication that is not much being studied worldwide. Furthermore, no study has been done specifically on *P. longicornis* in Malaysia. The abundance and distribution will also be predicted and that will help other research on pest control and management particularly on ants.

1.4 Scope and Limit Factor

The study is conducted in three different places which are Endau-Rompin Forest Reserve, Kg. Peta and Kahang of different housing materials. It is focusing only on one household ant species, *P. longicornis*. With regard to the temperature and humidity, data will be collected near the nesting site or surface area. It is difficult to measure the humidity and temperature inside the nest because normally the size of the nest entrance was too small and advance equipment and technology need to perform this task. Rain is another limiting factor that will be taken into count when gathering the data on abundance of *P. longicornis* in different houses.

1.5 Aim and Objectives

The aim of this study is to show that building of different architecture and materials may affect the behaviour of *P. longicornis*. The objectives of this study are:

1.5.1 To determine the occurrence and morphology of *P. longicornis* occurring in built and natural environment of Johor.

1.5.2 To determine the variation in nesting preferences of *P. longicornis* occurring in wooden house and concrete houses.

1.5.3 To determine the behavioural activity patterns of *P. longicornis* occurring in built and natural environment of Johor.

1.5.4 To compare the variation in morphology and behavioural activity patterns of *P. longicornis* in built area and natural environment of Johor.

CHAPTER 2

LITERATURE REVIEW

Paratrechina longicornis falls in the Family of Formicidae and subfamily of Formicinae. Generally, Formicidae are divided into three sections; head, thorax and gaster (refer Figure 2.1). They also have a pair of antennae and a hard exoskeleton (Smith, 1965).

P. longicornis are also known as crazy ants, long horned ant and slender crazy ant (Harris & Abbott, 2005). The name crazy ant arises from its characteristic behaviour that is to scamper erratically in rapid movements when disturbed; and such do not follow their trails (Nickerson & Barbara, 2000).

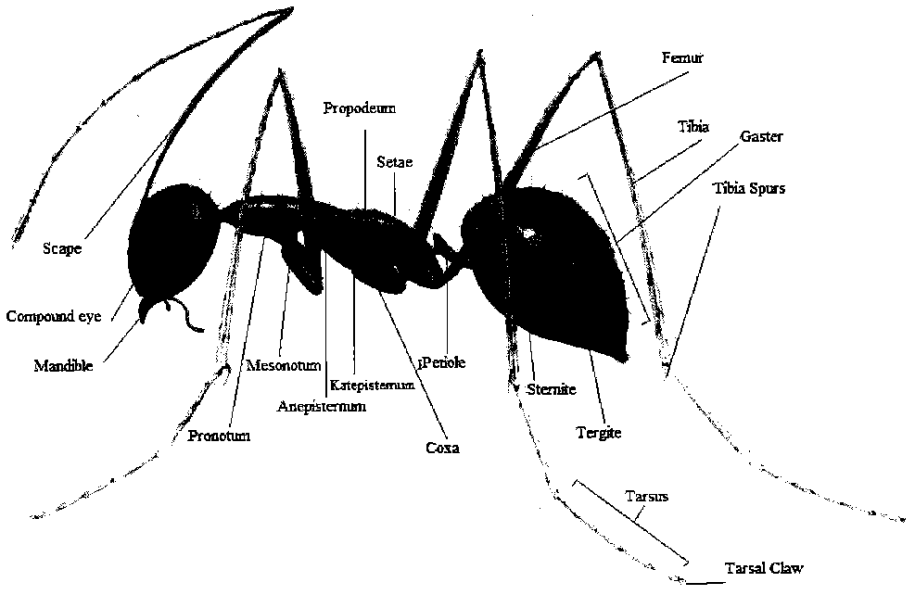

Figure 2.1: General characteristic of an ant.

2.1. Morphology

P. longicornis is known as monomorphic ant species having a size range of 2.3 to 3 mm long and a worker are brown to blackish in color with faint bluish iridescence on its body (Trager, 1984).

Smith, 1965 describes the characters of *P. longicornis* which is summarized as the following. The genus *Paratrechina* is distinguished from other genera by the extraordinarily long scape, with apex surpassing posterior border of head and at least one-half of the length of the scape. This single node ant has 12 antennal segments without a club and antenna is extremely long. The antennal fossa inserted very close to the posterior border of clypeus and the clypeus is subcarinate. Maxilary palpus is long with 6 segments (Smith, 1965).

As for the species characteristics, Nickerson & Barbara, 2000 noted the following: The head is narrow in shape with large eyes; elliptical and placed close to posterior border of the head (refer Figure 2.2). Similar to the

antennae, *P. longicornis* also has long legs with short suberects setae. The extremely erratic movement of *P. longicornis* is contributed by the slender shape of its body and the long legs they have. It is also one of the ways to recognize this ant which the researcher would like to concur with Nickerson & Barbara (2000). In addition, Smith 1965 noted that on *P. longicornis*'s body are well scattered (refer Figure. 2.3) with suberect to erect greyish or whitish setae. Scape are absent from erect or suberect setae and this character distinguishes *P. longcornis* from *P. nylanderia* (Smith, 1965).

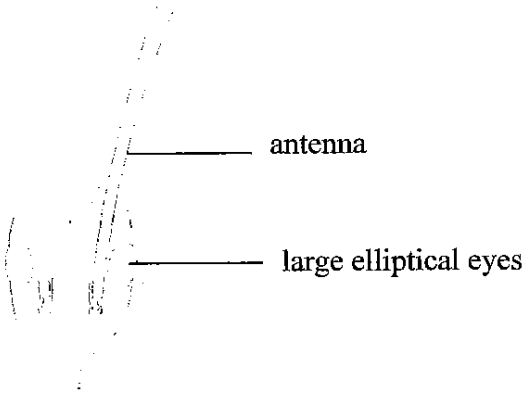

Figure 2.2: Head (dorsal view) of *P. longicornis* (Trager, 1984)

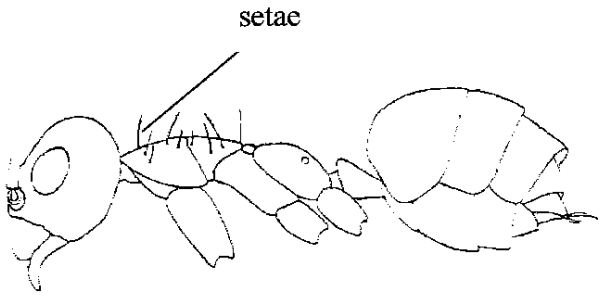

Figure 2.3: Worker (lateral view) of *P. longicornis* (Trager, 1984)

They do not have sting. However, they might bite an enemy and curve its abdomen forward to inject a formic acid secretion onto the wound. The extremely rapid movement of *P. longicornis* is contributed by slender shape of its body and the long legs they have. It is also one of the ways to recognize this ant (Nickerson & Barbara, 2000).

A more recent study by Fox *et al.,* 2007 shows that *P. longicornis* has smaller larvae, less variation in mandible morphology and presents of clear morphology of head hairs.

2.2. Life Cycle

A study by Trager as early as 1984 in Florida revealed that *P. longicornis* has a moderate to large number of colonies, up to 2000 workers and 40 queens. They have polygyne colonies with sterile workers. In warmer regions, the colonies may raise sexuals at any time of the year. However, in the seasonal climate in Florida, reproductive produced is apparently limited to the warm rainy months of May through September. The colony nest of *P. longicornis* is apparently temporary as it will move when being disturbed.

A more recent study by Fox *et al.,* 2007 shows the following: The life cycle of *P. longicornis,* starts with an egg, larval with 3 instar stages, and pupae before it develops into imago. The egg is oval, presents a transparent thin corium and being markedly separated from the embryo with length of 345± 10μm and width of 212±10μm. During first larval instar, the body is whitish, slender in shape due to the presence of short neck formed by a more pronounced first thoracic segment and the head bent ventrally. The body length and width is 445±59μm and 203.1±18μm. In the second larval instar, the shape of body is similar with the first instar however the head is slightly bent ventrally. Anus is clearly subterminal in the position and hairs are homogenously distributed over the body surface. Body length is 664.4±12.9μm and the width is 272.2±41μm. During the third larval instar, the body is dolichoderoid in shape with subterminal anus and body hairs denser over the posterior surface of the body. The size of the body is bigger in this stage with the length of 1431.6±51.3μm and width of 552.4±20.8μm. Pupae of *P. longicornis* are milky-white when young. However, the eyes are

getting black and the body gradually darkening to a deep brown as they develop into imagos. Unlike the other formicinae, there is no cocoon observed in pupae of *P. longicornis*.

As for the reproductive strategies and characteristics, Fox *et al.*, 2007 observe and describe the following: The worker in colonies will be responsible for vegetation patrol and defense. It is suggested that mating process occurred in groupings around the nest entrance. The queens will remove their wings while still callow. On the other hand, males were never observed to fly or use their wings in any way.

2.3. Behavioral Information (Foraging, Feeding and Communication)

2.3.1. Foraging

P. longicornis is known as extreme opportunist. Workers move fast in an inappropriate trail, as if lacking of sense of direction (Smith, 1965). *P. longicornis* has recorded the shortest time, 10 minutes to achieve the peak foraging activity compared to the other ants using the test arenas (Lee, 2002). This ant can forage for long distances, up to 25m from the nest.

2.3.2. Feeding

Workers of *P. longicornis* are omnivorous, feeding on live and dead insects, seeds, honeydew (Lee, 2002), household foods such as meats, grease, fruits, vegetables and liquid such as fountain syrup and soft drinks (Smith, 1965). They also function as a detrivore, which is an organism that feeds and breaks

down dead plant and animal matter, returning essential nutrients back to the ecosystem (Holldobler & Wilson, 1990). According to Norasmah *et al.*, 2006, through food preferences test, the result showed that *P. longicornis* preferred strawberry jam more compared to anchovy and egg yolk. They apparently have a seasonal preference for a high-protein diet. On the other hand, Smith 1965 noted that *P. longicornis* refuse to feed on honey and sugar.

2.3.1. Chemical communication

P. longicornis use pheromone to communicate with each other. Witte *et al.*, (2007) had found four glands in *P. longicornis* (refer Figure 2.4) as sources of pheromones with different effects; poison sac, Dufour gland, rectal and mandibular gland. Rectal gland is the one that contains trail pheromone in *P. longicornis*. It can last for 24 hours. Poison sac contains formic acid (Morgan *et al.,* 2005) does act as an attractant without inducing the aggressive and panic behaviour of *P. longicornis*. Mandibular gland contained small amounts of 2, 6-dimethylpyrazine, trimethylpyrazine, 3-ethyl-4-methylpentan-1-ol and 4, 5-dihydroxydecanoic acid γ-lactone (Morgan *et al.,* 2005). This gland is involved in alert and defensive behaviour. The Dufour gland secretion contains 2-tridecanone, followed by undecane, 2-pentadecanone and tridecane, with traces of decane, 2-dodecanone, 2-tetradecanone, ethyl phenylacetate and butyl phenylacetate (Morgan *et al.,* 2005). It is involves in alarm communication (Witte *et al.*, 2007).

There are three situation that can be described when the pheromone will be use; 1) if individuals ants are attacked and calling for help, 2) if individual ants attacks an enemy or a large prey item and need help, 3) if individuals encounters large food resource (Witte *et al.,* 2007).

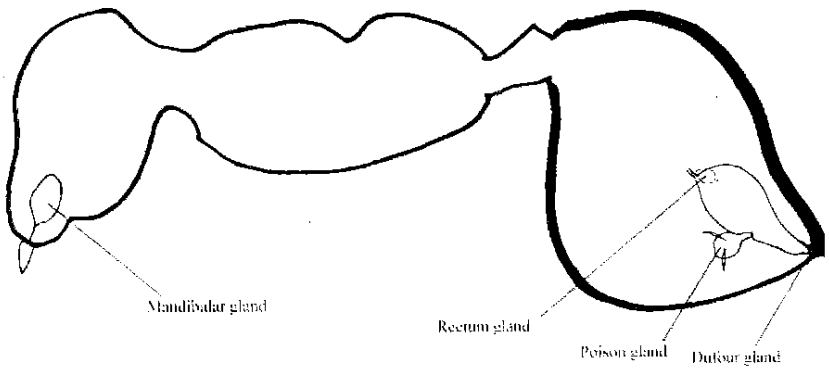

Figure 2.4: The location of different gland of ant (Gibson, 2010)

2.4. Habitat and nest sites

P. longicornis ants are highly adaptive and can live in very dry as well as moist habitats. They are always presents in both disturbed area and natural environment such as rural area (Yap & Lee, 1994), urban environment (Lee, 2002) and geothermal areas (Wetterer *et. al.,* 1999). *P. longicornis* is one of the most common ants found in buildings and would be the first species to arrive in newly disturbed habitats or new buildings (Lee, 2002). The nests can be found in dry leaf litter, and palm thatching (Trager, 1984), plant roots and cavities, under logs, in soil and also woods (Nickerson & Barbara, 2000). According to Norasmah *et al.,* (2006), *P. longicornis* also can be found building nests in cracks of wood and concrete wall of houses.

2.5. Urbanisation and disturbance

Urban area is associated with towns and cities, or happening there while urbanization is the process by which towns and cities grows bigger and more people go to live in them. According to United Nation Statistic Division (2009), an urban area is a continuously built up landmass of urban development which is also known as urban centre. It is generally the urban footprint which can be described as the lit area that can be observed from an airplane at night. Referring to the United Nation Statistic (2009), Kuala Lumpur is the only town in Malaysia that qualifies within the 100 world largest urban city, ranked as the 48th. However, Jakarta (Indonesia) is listed as the second world largest urban city, Manila listed at 5th ranked and Singapore at 65th ranked.

According to Malaysian's definition in the United Nation Statistic Division (2009), urban area is a gazetted area with 10000 or more populations. In Johor, there are 15 urban areas; Johor Bharu, Pasir Gudang, Muar, Yong Peng, Segamat, Senai, Kulai, Pontian Kecil, Mersing, Kluang, Batu Pahat, Bukit Bakri, Kota Tinggi, Tangkak and Ulu Tiram. Segamat is the nearest urban area to the Taman Negara Endau Rompin Selai with the number of 56 706 population in 2001. Meanwhile, Kahang is a sub-urban area which is the nearest to the Taman Negara Endau Rompin-Peta. Urbanisation can affect the distribution of ants (Patherine, 2005) and the behaviour as well (Holldobler & Wilson, 1990). According to Patherine (2005), declines with urbanisation, the number of ants species is declining meanwhile the abundance of ants of particular species is increases. It is because of the change of temperature, humidity, soil texture, interspecific and intraspecific competition which can affect the activity of ants.

Disturbance can be defined as changing in a community because of addition and loss of species proportion from the external factors. It can occur naturally such as due to grazing and wildfire and induced by the human such as noises, movements and development. The disturbance can also affect the activity and distribution of ants. The disturbance caused by human

development can be found everywhere in urban areas such as housing area, oil palm plantation, highways and others. Less effect of disturbance only can be found in reserve forests or tropical rainforest because the ecosystem is well maintained and far away from human activities. *Paratrechina* sp. is an opportunist ant which can be found in disturbed area and closely related to human (Joshua *et. al.*, 1996).

2.6 Housing (Definition, Types and Building Materials)

Thompson and Newmark, 1977 described house as a building which serves as a shelter and human needs, to protect from hot, rain and outside world. It is designed to provide a reasonably controlled environment with the respect to light, temperature, ventilation and sanitation. It provides a place to sleep, prepare food, and meet hygienic body functions. It can be varies in structure and design such as hut, cottage, single storey, apartment, mansion and so forth.

Thompson and Newmark, 1977 also stated that to build a house or any building, it must follow a standard approved by the experts, known as Building Code. Building Code is a standard for building construction, governing types of materials used in construction, the relation of materials used in construction, the relation of materials to design, sanitary facilities, the provision of light and air, which has been established by law in town, city or state, are usually proposed by local building contractors and labour unions. The purpose of this building code is to regulate the design and construction of buildings in a manner that safeguards the general public. It includes types of construction, function of the structure called occupancy, quality of materials, the imposed loads, allowable stresses, mechanical and electrical equipment and other requirements related to building.

According to The Department of Standards Malaysia, there are several acts and regulation of mandatory standards in construction published by the local authorities such as in the following table;

Table 2.1: Showed some of the Building Code published by the enforcement body in Malaysia according to the Department of Standards Malaysia

No.	Regulations/ Standards/Acts	Enforcement Body
1	Street, Drainage and Building Act 1974 and Uniform Building By-Laws 1984	Local government
2	Malaysian Timber Industry Board (Incorporation) Act 1973	Malaysian Timber Industry Board (MTIB)
3	Fire Services Act 1988	Fire and Rescue Department
4	Customs Act 1967 and Custom (Prohibition of Imports) (Amendment) Order 2004	Construction Industry Development Board (CIDB)

2.6.1 The construction process of building

Thompson & Newmark, 1977 stated that there are several processes in building construction. It starts with the foundation and site preparation which includes the clearing of the site and the preparation of services to the site, foundation settlement, piles and basement walls. The second process is footings. The factors that influence the type of footings are weight of

building, wall construction type and height, soil type, slope of the block, budget and drainage requirements on the block. Once the floor structure is in place, the walls are erected directly on top of the chipboard or slab. Walls act as a loading bearing support for the roof and provide space for openings such as doors and windows, and they enclose the house and seal it from weather. Walls comprise of either a structural frame and cladding or a solid masonry. The next process is roof decks, roofing and siding. When the roof, windows and doors are installed, the exterior wall and roof is clad, and the building can be secured. Lastly, to increase the comfort, healthful and safety of the building, the insulating materials and services are installed such as stormwater, electricity, sewerage, gas, air conditioner, hot water system and other needs (refer Figure 2.5).

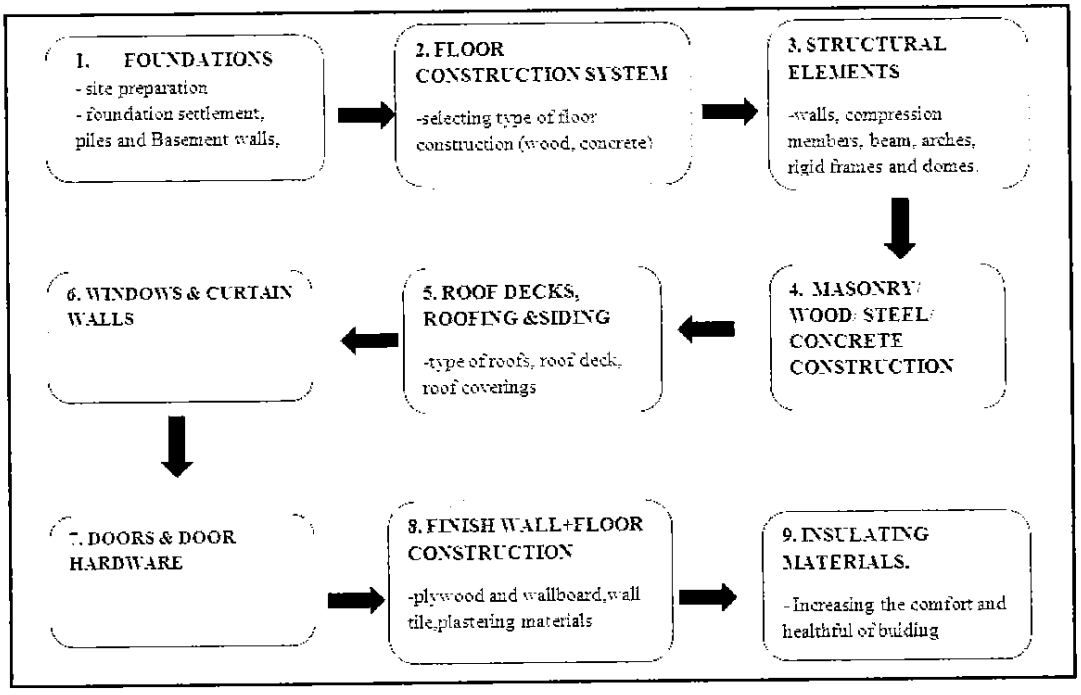

Figure 2.5: The process of building construction

2.6.2 Concrete and Wooden House

The writer believes that different types of house can affect the distribution and activity of ants. However, *P. longicornis* can be found in both types of concrete and wooden houses. There are several types of houses that can be found in Malaysia, made of different structure and materials. It does not matter whether it is big or small. The most important part is the material that has been used because different materials have different impact on moisture and temperature of the house. Some of them are entirely made of steel and concrete which is more common in urban area and the other one is house which is made of wood and sometimes with a combination of both wood and concrete. This type of house is common in less developed areas where the environment and ecosystem are being well managed and maintained naturally (pers. obs.).

The environment within the wooden house tends to be cooler. Zierls, 2005 stated that wood has the ability to absorb or exude moisture depends on the temperature and humidity as it is a natural and fibrous material. Wood reacts constantly to its surrounding that makes it popular choice by more people today. If the humidity is high, wood absorbs moisture and vice-versa if the humidity is low it emits moisture. The natural cooling and heating effect is provided by wood since it tends to adjust the weather of surrounding. To maintain the structure of house, the permanent wood foundations is being used consisting of framing wood and plywood sheathing that have been pressure treated with heavy concentration of preservative to assure it is free from decay and insect attack such as termites.

Concrete is a composite material which consists essentially of a binding medium within which are embedded particles or fragments of a relatively inert mineral filter. Concrete houses are made of the combinations of several materials; cements, aggregates, water and chemical admixtures (refer Table 4.2). There are 3 components of raw materials used in cements which are Lime (CaO), Silica (SiO2) and Alumina (Al2O3) (Oral, 2004).

According to Jackson & Dhir (1996), aggregate is used to improve both the volume stability and the durability of the resulting concrete. It is known to give significant effect on concrete behaviour such as strength, deformation, durability, toughness, hardness, volume change, porosity, relative density and chemical reactivity. Examples of aggregates are sandstone, granite, limestone, marble, basalt, alluvial and glacial. The admixtures are substances introduced into a batch of concrete, during or immediately before its mixing, in order to alter or improve the properties of the fresh or hardened concrete or both. The chemical admixtures used in concrete are accelerating admixtures such as Calcium Chloride, air-entraining admixtures such as wood resins, water reducing such as Lignosulphonic and bonding agents such as Polyvinyl Acetate.

The advantages of concrete house are it is economical, durable, energy efficient, fire resistant and as an aesthetic properties. The disadvantages are low tensile strength, low ductility, volume instability and low strength to weight ratio (Oral, 2004).

Table 2.2: The comparison of properties of Concrete and Wooden House

Concrete House	Wooden House
- Concrete house is made of the combinations of several materials; cements, aggregates, water and chemical admixtures.	- Wooden house is made of product of timber.
- Common in urban areas	- Common in less develop areas
Advantages - Cheaper building cost - Energy efficient - Aesthetic properties	Advantages - Durable - Energy efficient - Fire resistant

Disadvantages - Fire risk - Dryness and humidity cause wood to shrink - Insect damages - Fungal problems - Less strong than concrete	Disadvantages - Low tensile strength - Low ductility - Volume instability - Low strength to weight ratio
Thermal Properties - The insulation is at moderate level. - The thermal transmittance is at moderate level (Stein & Benjamin, 2000). - Thermal conductivity of hardwood is 0.18 to 0.22 W/mK (Gut & Ackerknecht, 1993).	Thermal Properties - The insulation is low - Thermal transmittance is at high level (Stein & Benjamin, 2000). - Thermal conductivity of solid cocncrete is 1.8 W/mK (Gut & Ackerknecht, 1993).

2.7 Environmental Parameters

2.7.1 Thermal Properties: Heat definition and flow

Basic components of building envelope are windows, doors, floors, walls and roofs. As the sun and daylight are admitted or redirected to the interior side through the building envelope, the energy in form of heat is also been emitted. According to Fourier Law of Heat Conduction, when there exists a temperature gradient within a body, heat energy will flow from the region of high temperature to the region of low temperature. In the conservation of the energy, the amount of the conducted heat in must be equal to the amount of the conducted heat out (Neville, 1995).

Stein & Benjamin, 2000 mentioned that heat is transmitted from one side of the walls and roof of a building to the other in the following ways; 1) By air infiltration, or leakage through cracks and other often open spaces. 2) By transmission through the walls, windows, doors and roofs. The volume of air entering a building is offset by an equal volume leaving the building. Since the temperature of the two volumes would normally be different, there is a transfer of heat with the air change.

According to Neville (1995), heat is transmitted through walls and roofs in three ways; conduction, convection and radiation. Conduction is the transmitted of heat from molecule to molecule of the wall material and to certain extent, from molecule to molecule of the air in open spaces in the wall. Convection is a process by air currents, which circulate in open spaces within the wall or roof construction and which absorb heat as they pass upward over a warm boundary surface of the air space and release heat as they pass downward over a cold boundary surface of that space. The circulation is produced by the decrease in density of air, which accompanies increase in temperature. The radiation is the process by which energy, called radiant energy, transmitted from one body or surface to another body or surface by electromagnetic waves.

In addition, according to Halid (2005), the main properties that had to be considered in building constructions and materials are reflection of the radiant heat, absorption of the radiant heat and re-emission of stored heat. The quantity of radiant heat a surface receives depends not only on the sun angle, but also to a large extent of reflectivity and absorbance.

2.7.1.1 Heat terms and symbols

Each material has a characteristic rate at which heat will flow through it and known as conductivity, designated as k. The I-P (inch pound) units of conductivity are Btu-in./h ft^2 °F; the number of British thermal units per hour (Btu/h) that flow through one square foot (ft^2) of material that is 1 in. thick,

when the temperature drop through that material is 1°F (under condition of steady heat flow). Thermal conductivity, k-value is defined in SI (System international) unit as the rate at which Watts flow through 1 square meter (m^2) of material, 1 meter thick, when the temperature drop through that material is 1K (equal to 1°C) under condition of steady heat flow. Thus, the SI unit of conductivity are W/m K (Equation 1). Thermal conductance (Equation 2), designated as C is the thermal transmission through unit area of a material per unit temperature difference between the hot and cold faces. It is expressed in W/m^2 K (Stein & Benjamin, 2000).

Equation 1:

Thermal Conductivity (k) = W/m K

Equation 2:

Thermal Conductance (C) = W/m^2 K

C = k/b where;

b is thickness of the material

Resistance, designated as R (Equation 3) tell us how effective any solid as an insulator. Insulator act as to retard the flow of heat when the heats interact with the architectural materials. In other word, insulator act inversely to conductors which encourage the heat flow due to the interaction with the materials. It is expressed as m^2 K/W (Stein & Benjamin, 2000).

Equation 3:

Thermal resistance (R-value) = m^2 K/W

R = 1/C = b/k

Thermal Transmittance or U-value (Equation 4) is defined as the quantity of heat that flows through a unit area of a building section under steady-state conditions in unit time per unit temperature difference of the air on either side of the section. It is expressed in W/m² K (Stein & Benjamin, 2000).

Equation 4:

Thermal Transmittance (U-value) = W/m² K
U = 1 / Rt where;
Rt is the total thermal resistance

2.7.2 Air Temperature

According to Monteith & Unsworth (2008), air temperature is a measure of how hot or cold the air is. Air temperature affects the growth and reproduction of plants and animals, with warmer temperatures promoting biological growth. Air temperature also affects nearly all other weather parameters. For instance, air temperature affects the rate of evaporation, relative humidity, wind speed and direction, precipitation patterns and types, such as whether it will rain, snow, or sleet. Temperature is usually expressed in degrees Fahrenheit or Celsius.

2.7.3 Relative Humidity

Humidity is a term for the amount of water vapor in the air. It commonly refers to relative humidity, expressed as a percent. Relative humidity is used to describe the amount of water vapor in a mixture of air and water vapor. It is defined as the ratio of the partial pressure of water vapor in the air-water mixture to the saturated vapor pressure of water at those conditions. The relative humidity of air depends not only on temperature but also on pressure of the system of interest (Monteith & Unsworth, 2008).

CHAPTER 3

METHODOLOGY

3.1 Study sites

This study was conducted at three sites in South eastern ofJohor (refer Figure 3.1); Taman Negara Endau-Rompin Forest Reserve, Kg Peta (part of the Endau Rompin National Park) and Kahang (refer Table 3.1).

Kg Peta is a village lives by the aboriginal people of Jakun community. It is located in Endau-Rompin National Park, adjacent to the Endau-Rompin (Peta) Visitor Complex which is 5 minutes walking from there. This indigenous people do fishing, hunting, farming and making handicrafts as their income sources. Some of them work with the Johor Park as tourist guide and planted rubber trees and oil palm to support their living. The indigenous people live in wooden house, concrete house and the combination of both materials. Before mid of 2010 when this study is conducted, there are still lack of facilities such as electricity, telephone coverage and groceries supplies. They have to go to Kahang which is 60km from Kg Peta just to buy groceries and household needs. Kahang is a suburban area, located 36km from Kluang town. It is the last stop before heading to the Endau-Rompin National Park. The main industry in Kahang is agriculture such as oil palm plantation and organic paddy field. Most of the houses in Kahang are made of concrete especially in the town area.

These study sites were chosen according to their criteria as natural environment, rural and built area. To give a brief description of the three research sites, Table 3.1 is given

Table 3.1. The descriptions of different sites of sampling in Johor.

Sites	**Description**
1) Endau-Rompin Forest Reserve 	• Represents the natural environment • Made up of pristine tropical rainforest

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