



**UNIVERSITI PUTRA MALAYSIA**

**SPATIAL AND TEMPORAL DISTRIBUTION OF DOLICHODERUS  
THORACICUS SMITH IN A COCOA-COCONUT AGROECOSYSTEM**

**LIEW VOON KHEONG**

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**By**

**LIEW VOON KHEONG**

**Thesis Submitted in Fulfilment of the Requirements for the Master of  
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Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Agricultural Science.

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**LIEW VOON KHEONG**

**June 1999**

**Chairman : Associate Professor Khoo Khay Chong, Ph.D.**

**Faculty : Agriculture**

Cocoa, an important crop in Malaysian agriculture is subjected to infestation by a number of insect species the most important of which is the cocoa pod borer, *Conopomorpha cramerella* Snellen. The black cocoa ant, *Dolichoderus thoracicus* is found to be effective in controlling this pest.

The abundance of nesting sites is crucial in the establishment of this ant. Coconut palms afford a great deal of nesting sites in the crown and spadices. A large number of ants also nests in artificial cocoa leaf-litter nests which basically comprises of a plastic bag (31 x 45 cm) stuffed with dry cocoa leaves. The ants also nests in the cocoa canopy, between two cocoa leaves that overlapped forming a leaf nest. The population size of the ant in the three types of nests on a per hectare basis should be compared to determined the more important nesting site. Hence the objective was to a) study the distribution of the ants in the spadices of coconut crowns, cocoa canopy and artificial cocoa leaf-litter nest b) study the effects of time and amount of cocoa leaf-litter on the size of ant population in the artificial nest and c) determine the nest site preference of *D. thoracicus* in the canopy of cocoa trees.



A sampling technique using a pipette fitted with a modified tip was developed to estimate the number of ants and its brood in various types of nests. The end of the pipette tip was cut to make an opening with a diameter of 4.2 mm. Results showed that taking seven aliquots of 3 ml per aliquot gave the best estimate for adults and total number of individuals.

Samples of all three types of nests i.e. spadices, artificial nests and cocoa leaf nests were obtained and the number of adults and brood on a per hectare basis estimated. There were significantly more ants in the artificial nests compared to the other two types of nests.

The nest site preference of the ant in relation to canopy strata was examined. The ants preferred to live in nests placed at the top and bottom strata of the canopy.

Artificial nests were set up on the cocoa trees and the change in population size of the ants in the nests over time was observed. The ants colonized the nests after two months with the population reaching a maximum of about  $20 \times 10^4$  individuals in about five months.

In another experiment, 175, 350, 525 and 700g of dry cocoa leaves were placed in plastic bags measuring 31 x 45 cm. All four treatments were placed on a cocoa tree. After five months, it was found that the bag with 350g of dry leaves had significantly more ants compared to the other three nests.

This study shows the potential of the artificial cocoa leaf-litter nest in the establishment of the black cocoa ant especially in a monococoa agroecosystem. In Malaysia where the cocoa pod borer poses a serious problem, the use of the artificial nest will help in the establishment of the ants and thus leading to the control of the most dangerous insect pest of cocoa.

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**TABURAN SEMUT HITAM *DOLICHODERUS THORACICUS* DALAM EKOSISTEM KOKO-KELAPA MENGIKUT RUANG DAN MASA**

Oleh

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Koko, suatu tanaman yang penting di Malaysia, mempunyai beberapa serangga perosak yang penting. Serangga perosak yang paling penting ialah pengorek buah koko, *Conopomorpha cramerella* Snellen. Semut hitam koko, *Dolichoderus thoracicus* dapat mengawal perosak ini.

Jumlah sarang yang mencukupi amat penting dalam penubuhan koloni semut ini. Banyak sarang dijumpai pada pokok kelapa terutamanya pada tandan kelapa. Banyak semut juga didapati hidup dalam sarang buatan yang terdiri daripada sekeping beg plastik (31 x 45 cm) yang dipenuhi dengan daun-daun kering koko. Semut ini juga bersarang dalam kanopi koko terutamanya di antara dua helai daun yang bertindih. Saiz populasi semut dalam tiga jenis sarang ini pada seunit hektar perlu dikaji dan dibanding untuk menentukan sarang yang penting. Maka, objektif kajian ini ialah a) menentukan taburan semut dalam tandan pokok kelapa b) mengkaji kesan masa



dan jumlah daun kering koko pada saiz populasi semut dalam sarang buatan dan c) menentukan kecenderungan semut hitam dalam memilih sarang yang diletak pada tiga tahap dalam kanopi pokok.

Teknik pensampelan mengganggu bilangan induk dan peringkat tidak matang dikenalpasti. Teknik ini menggunakan sebatang pipet. Hujung muncung corong pipet telah dipotong untuk membentuk satu lubang yang mempunyai jejari 4.2 mm. Didapati bahawa pengambilan tujuh alikuot pada kadar 3 ml/alikuot memberi anggaran bilangan semut yang paling tepat.

Sampel ketiga-tiga jenis sarang iaitu tandang kelapa, sarang buatan dan sarang daun, diambil dan populasi induk dan peringkat belum matang bagi sehektar dianggar. Terdapat lebih banyak semut dalam sarang buatan berbanding dengan dua jenis sarang yang lain. Perbezaan ini adalah amat ketara dan bermakna.

Sarang daun telah digantung pada bahagian atas, tengah dan bawah kanopi pokok dan didedahkan pada semut. Semut lebih memilih sarang yang diletak pada bahagian atas dan bawah kanopi pokok.

Sarang buatan digantung pada pokok dan perubahan bilangan semut yang tinggal dalam sarang dikaji mengikut masa. Sarang dihuni selepas dua bulan dan populasi semut mencapai tahap maksimum selepas lima bulan. Anggaran populasi semut adalah sebanyak  $20 \times 10^4$  individu.

Dalam kajian lain, beg plastik berukuran 31 x 45 cm diisi dengan daun koko kering dengan berat 175, 350, 525 dan 700g masing-masing. Semua rawatan digan-

tung pada satu pokok. Selepas lima bulan, didapati beg yang mengandungi 350g daun mempunyai bilangan semut yang paling banyak berbanding beg yang lain.

Kajian menunjukkan potensi sarang buatan dalam penubuhan koloni semut dalam ladang koko terutamanya dalam kawasan koko tunggal. Kebanyakan kawasan koko di Malaysia adalah koko tunggal. Kawasan-kawasan ini diancam oleh serangga perosak pengorek buah koko. Dengan adanya sarang buatan ini, semut hitam boleh ditubuhkan di kawasan koko tunggal dan ia boleh membantu dalam mengawal serangga perosak yang amat bahaya ini.

## **CHAPTER I**

### **INTRODUCTION**

#### **Importance of Cocoa to Malaysia**

Commercial cultivation of cocoa in Malaysia began in the 1960s. Since that time, increasing number of areas came under cocoa cultivation. By 1995 there was an estimated 274,000 ha of cocoa indicated in the Seventh Malaysia Plan report. The large acreage indicates the importance of cocoa to Malaysia particularly from the social and economic point of view.

From the same report, smallholders manage a large proportion of the area. Of the 274,000 ha about 54% were under smallholdings while the remainder belonged to estates. From the economic point of view, smallholders and workers in plantations depend on cocoa for their living. In the smallholder and estate sectors, cocoa is a source of income for about 130,000 families and about 45,000 workers respectively. Supporting cocoa industries such as processing, grinding and manufacturing employed many more workers.



In the Seventh Malaysia Plan report, Malaysia produced about 152,000 tonnes of dry cocoa beans in 1995. Of this amount about 30% or 50,000 metric tonnes were exported. Processing, grinding and manufacturing activities used up the remaining cocoa beans. Most of the products from these activities were exported. Hence, cocoa beans and cocoa products are a source of revenue to the country.

### **Importance of Cocoa to the Southeast Asian Region**

The two most important producers of cocoa in the Southeast Asian region are Indonesia and Malaysia (Lass, 1994). These two countries export some of their cocoa beans to the other Southeast Asian countries such as Singapore, Thailand, Philippine and Brunei. They also export their beans to countries outside the region. All of the Southeast Asian countries in varying degrees do grinding, processing and manufacturing of cocoa. Products from these activities are then exported to other parts of Asia, Europe, the Middle East and Americas. Cocoa therefore is a source of revenue for these Southeast Asian countries.

### **Problems Affecting Cocoa Production**

Insects, diseases and rodents are important pests of cocoa. Control of these pests and diseases is critical because they can cause significant loss in yield. The most important insect pests are *Helopeltis theivora* and *Conopomorpha cramerella* Snellen (CPB) (Azhar, 1995). Some important diseases are Phytophthora pod rot and vascular streak dieback (Tey et al., 1986; Jayawardena et al., 1986). Rodent pests are



squirrels and rats (Khoo and Ho, 1992). These pests and diseases cause cherelle abortion, dieback of branches and shoots, damaged roots and pods. All parts of the cocoa plant are susceptible to these pests and disease. Damage could occur at any time making control of the pests, diseases and rodents a very important field activity.

### **Management of Insect Pests**

Control of insect pests in cocoa generally depends on insecticides. This method is simple to apply, is cost effective and farmers can choose from a variety of insecticides available in the market. Chemical control is still more popular today than biological control although the latter method has had some success in the past. For example, a biological agent, *Dolichoderus thoracicus* commonly known as the black cocoa ant was used in the past in Indonesia (Giesberger, 1983). In the 1930s, there was reported that the black cocoa ant was used in over 1,400 ha of cocoa. So successful was the establishment of the ant there that planters put up notices saying ‘without the black cocoa ant there would be no cocoa’ (Giesberger, 1983). However, in spite of the effectiveness of the black cocoa ant in controlling mirids, this technology was lost through the years due to (a) doubts that the ant was directly responsible for the reduction in mirid damage (b) the advent of synthetic organic insecticides, and (c) decline in the importance of cocoa.

To be effective in the control of insect pests, insecticides should be applied properly. The insecticide should be correctly dispensed so as to obtain sufficient coverage of the cocoa tree. Large plantation companies generally have a specialized team

to devise various methods to optimize the effectiveness of the insecticide and to reduce cost. Smallholders however are at a disadvantage due to lack of resources, personnel and knowledge.

Over the last few years prior to 1997 however, prices of cocoa were low but the cost of production kept on increasing. This made the production of cocoa expensive and less viable for the large plantation companies. In addition to this problem, reports of mirid and CPB developing resistance to insecticides were beginning to appear (Dzolkhifli et al., 1986; Ho, 1994c; Lee, 1995). The problem of resistance aggravated the production of cocoa further. To further complicate the situation, consumers began demanding for pesticide free cocoa beans (Lunde, 1996). Cocoa producers therefore began searching for methods to reduce their cost of operation and also to produce pesticide free cocoa beans. Biological control appears to be the most viable option especially when there was a possible solution in the black cocoa ant.

### **Use of Black Cocoa Ant to Control Pests in Cocoa**

The use of the black cocoa ant to control *Helopeltis* in cocoa was first used by the Dutch planters in Indonesia as early as 1908 (Giesberger, 1983). This method of controlling mirids was abandoned when insecticides were introduced. Presently, efforts are being made to utilize the ant again. Researchers have found that the ant can reduce damage caused by *Conopomorpha cramerella* Snellen, *Helopeltis*, *Phytophthora* sp. and rodents (Khoo and Ho, 1992; See and Khoo, 1996).

The use of the black cocoa ant may also alleviate the problems of shortage of labor presently experienced and the inefficient application of insecticides especially in areas with steep terrain.

Considering the benefits from the use of the black cocoa ant, commercial estates were eager to exploit the usefulness of this ant. So far there have not been any success in utilizing the ant due to difficulty in establishing them over large areas of about a few hundred hectares. Various reasons for this inability to establish the ant commercially has been suggested but a systematic study will be needed to determine the real reason or reasons behind this.

### **Reasons for the Study**

Cocoa is an important crop to some section of the Malaysian population and of some industries especially those involved in the processing of cocoa and the confectioneries. For the same reason, cocoa is also important to some countries in the Southeast Asian region. The production of cocoa has unfortunately become difficult when consumers began demanding for pesticide-free cocoa products. This situation puts farmers in a difficult position especially for a crop like cocoa, which is susceptible to many pests and diseases. This difficult situation can be partly overcome if a biological control programme is to be implemented in the cocoa fields. The insect pest is the most serious at the moment. As such a biological control program to control insect pest would be most suitable. The successful establishment of the ant in a

field in Pusat Perkhidmatan Pertanian Tun Razak (PPPTR) offers hope that this type of programme can be implemented.

In PPPTR, Sungai Tekam, Jerantut, Pahang, the black cocoa ant had colonized an area of about 5 ha. The ants, which were initially collected from an area in the state of Perak, were introduced into this area in 1992. What makes this place unique was the presence of artificial cocoa leaf-litter nests. On each tree there was one nest with an abundance of ants living in it. It will be useful to study the distribution of the ants in such situation.

Many workers studying the black cocoa ant concluded that shelter is an important factor in the establishment of the ant (Khoo and Chung, 1989; Way and Khoo, 1991; and Ho and Khoo, 1994). This area in PPPTR has an abundant amount of shelter in the form of the artificial cocoa leaf-litter nest. It would be interesting therefore to see how the presence of the artificial nest affects the ant population here.

To determine the importance of the artificial nest, it was thought necessary to study the spatial distribution of the ant in this ecosystem. Such study measures the size of ant population in the artificial nests, spadices of coconut palms and cocoa trees. The study did not include the coconut fronds because of a field operation that made the sampling of coconut fronds difficult. In that field operation, dead coconut fronds were cut and stacked in rows between the coconut palms. Fronds from a few palms were then stacked together. It was then difficult to tell which palm a frond came from.

The sampling of the ants in these three nesting sites were conducted monthly for a total of 12 months because studies and observations in the past suggest that the distribution of the ant may be temporal in nature. The seasonal availability of food and reproduction was mentioned by Greenslade (1971) as the factors affecting the abundance of ants in an area. There is no study so far to show that the distribution of the black cocoa ant changes over time but it is the tendency of most biological systems. It is likely that the distribution of the black cocoa ant in this ecosystem is temporal. Hence the change in ant population sizes in the three nesting sites was also studied.

This study included an investigation on two aspects of the artificial nest. The artificial nest is basically made up of a plastic bag stuffed with cocoa leaf-litter. Nothing is known about how the quantity of leaves in the bag affects the size of the ant population living in the nest. Neither was there any information about how the ants colonize the nest over time. This study hopes to understand further the suitability of the artificial leaf-litter nests to the ants.

An investigation into the nesting sites of ants in the cocoa canopy was also thought to be a suitable addition to this study. This was because of the need to determine the suitable site on the cocoa trees in which to place the artificial nests. Locating the nest in the most suitable place on the cocoa tree could help in the establishment of the ants.

The specific objectives of this research were to:

1. study the distribution of the black cocoa ant in the spadices of the coconut crown, cocoa canopy and artificial leaf- litter nest.
2. study the effects of time and amount of cocoa leaf litter on the size of ant population in the artificial cocoa leaf-litter nest.
3. determine the nest site preference of *D. thoracicus* in the canopy of cocoa trees.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **Shelter and Ants**

Ants in general are observed to be rather adaptable and they can be found nesting in the soil, among canopies of plants and trees and among leaf litter and other plant debris on the ground (Wheeler, 1976). Some ant species construct their nests while other species use or excavate the soil to build mounds, tunnels and chambers. There are also ants that simply occupy certain plant structures (Wheeler, 1976).

The availability of shelters appears to influence the distribution of ants within an ecosystem (Doncaster, 1981). These shelters offer protection to the ant colonies from predators and from unfavorable weather and allow the colonies to develop and grow safely (Wilson, 1971).



## Shelter and the Distribution of Ants

### Abundance of Shelter

It appears that abundance of shelter affects the distribution of an ant species. In his study on the distribution of ants on Ramsey Island, South Wales, Doncaster (1981) found that one of the reason for the wide distribution of the ant *Lasius flavus* was because of an abundance of shelter. The ants could be found nesting in earth mounds or tunnels and chambers below ground and also beneath stones. This ant species appears to be able to adapt to these types of shelter while the other ant species does not appear to be able to. Earlier, Leston (1973) and Haines and Haines (1978) noticed the relationship between abundance of shelter and distribution of ants. The former observed that the ant *Crematogaster striatula* was widely distributed and was the dominant species in some cocoa areas in Ghana. Again, the observation was that the ant could adapt to many types of shelter while other ant species could not. Haines and Haines (1978) studied the infestation of *Anoplolepis longipes* on Seychelles Islands. This ant was not an indigenous species in the Seychelles. Their studies however showed them that the ant could nest in many types of shelter thus leading them to conclude that abundant of shelter and the ability of the ant to live in such shelters were important contributing factors to the spread of the ants on this island state.



## Types of Shelter and the Distribution of Ants

A species of ant may nest in the same site as another. For example *A. longipes* and *D. thoracicus* make their nests in the spadices of coconut palms (Way and Khoo, 1991). Both of these ant species also appear adaptable and can be found living in a variety of nests. *A. longipes*, for example, lives in the spadices of coconut palms or in leaf litter. The black cocoa ant, *D. thoracicus*, was found to live in more places compared to *A. longipes*. They can be found living in the spadices of coconut palms, in dry coconut fronds, in between layers of cocoa leaf litters, cocoa leaf nests which they make among the cocoa canopy and in a variety of artificial nests made from cocoa leaves and coconut fronds (Khoo and Chung, 1989; Way and Khoo, 1991; Giesberger, 1969). Other examples of ants living in a variety of nests was described by Leston (1973). He listed the various species of ants living in cocoa farms in Ghana and described the types of nests they lived in.

Leston (1973), Majer (1976a) and Doncaster (1981) observed that those species of ants that can adapt to a variety of nests are usually more widely distributed compared to those that only live in one type of nest. For example, *Lasius flavus* can build a variety of nest structures. Because of this ability to adapt, they are able to nest either at high or low densities as the dominant species or as co-dominants in a range of habitats. Although *D. thoracicus* cannot build a variety of nest structures, they are able to adapt to a variety of structures as nests. Hence they should be able to survive and be a dominant species in a territory especially when shelters are provided in abundance.