UNIVERSITI PUTRA MALAYSIA

SAMPLING TECHNIQUE FOR DETERMINING EGG DISTRIBUTION COCOA POD BORER (*CONOPORMORPHA CRAMERELLA*) (SNELLEN) (LEPIDOPTERA: GRACILLARIIDAE) AND COCOA POD PHENOLOGY

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By

NOORAZLIN MOHD ALI

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DEDICATION

To my beloved husband, Zamran Haji Hari thanks for helping me making my dreams a reality. Your sacrifices, patience, support and encouragement are truly helpful.

I am truely indebted to my father, Haji Mohd Ali Mohd Yusof and mother, Hajah Azizah Tajuddin. I really appreciate your support, inspiration and motivation. Its hard for me without your love and sacrifice. There is no other compatible parent such both of you.

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And to my inspiriting little kid, Nurin Aqilah Zamran; you understand the hardship of me and believe me dreams will be reality with Allah S.W.T permitted.

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By

NOORAZLIN BT MOHD ALI

June 2005

Chairman: **Professor Syed Tajuddin Syed Hassan, PhD**

Faculty: **Science**

An in-depth investigation on sampling of cocoa pod bore (CPB) was carried out over a 12 mounth period in 2000 at Malaysia Cocoa Board Research station at Hilir Perak, Sg Sumur Perak conducted over a period of 12 months. Several components were examined. The components examined were the most reliable and efficient sampling technique, determining distribution of CPB with respect to pod phenology, determining optimum sample size to produce sampling parameters for CPB. Generally, during low population levels, the mean population densities and their relative variations were similar for all sampling techniques. However, during high population densities, mean densities and relative variations increased. This is especially for random sampling which has been found as the most reliable sampling technique. Using two aggregation models which are widely used; Taylor's Power Law (b coefficient) CPB's egg were found to be highly aggregated. In determining optimum sample sizes, two parameters were calculated; b of Green's model and β for

Kuno's model. The Green model was suitable to produce the most efficient sampling sizes during low and high population densities. During high population densities, random sampling was the most reliable with Taylor's Power Law providing the optimum coefficients for developing optimum sample sizes.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

TEKNIK PENSAMPELAN UNTUK MENENTUKAN TABURAN ULAT PENGOREK BUAH KOKO (UPBK) (*CONOPORMORPHA CRAMERELLA*) (SNELLEN) (LEPIDOPTERA: GRACILLARIDAE DAN FENOLOGI BUAH

Oleh

NOORAZLIN BT MOHD ALI

Jun 2005

Pengerusi: **Professor Syed Tajuddin Syed Hassan, PhD**

Fakulti: **Sains**

Pada tahun 2000, satu kajian terperinci mengenai pensampelan ulat pengorek buah koko (UPBK) telah dijalankan selama 12 bulan. Terdapat beberapa komponen utama yang dikaji meliputi kaedah yang paling bersesuaian dan efektif, mengenal pasti bentuk taburan ulat pengorek buah koko (UPBK) berdasarkan fenologi buah koko, dan penentuan saiz sampel optimum untuk menghasilkan parameter pensampelan yang paling optimum. Secara umum, apabila populasi UPBK rendah, nilai min populasi dan relatif variasi yang diperolehi menyerupai bagi kaedah-keadah yang digunakan. Namun begitu, apabila populasi bertaburan tinggi kaedah rawak merupakan kaedah yang paling persis. Dengan menggunakan dua model pengelompokan yang terkenal, Hukum Kuasa Taylor dan Indeks Pengelompokan Iwao, UPBK ditemui secara meluas dalam keadaan berkelompok. Bagi penentuan saiz sampel optimum, dua bentuk model iaitu Green, b dan Kuno, β digunakan. Model Green didapati paling sesuai menghasilkan kaedah pensampelan paling

effektif pada populasi UPBK tinggi dan rendah. Apabila populasi UPBK tinggi, kaedah pensampelan secara rawak memberikan hasil yang paling berpadanan dimana Hukum Kuasa Taylor memberikan pekali optimum untuk pembentukan saiz sample paling optimum.

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Last but not least, the I gratefully acknowledge MARA sponsorship which enables me to complete this project.

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LIST OF ABBREVIATIONS

b	Taylor's index
ß	Iwao's index
° C	Celcius
et al.	others
i.e	that is
m^2	meter square
ml	mililiter
r^2	correlation coefficient of regression
RV	relative variation
RNP	relative net precision
SE	standard error
TPL	Taylor Power Law
$\bar{x}$	mean density

CHAPTER 1

INTRODUCTION

Cocoa is the third most important primary crop in Malaysia which provide RM 0.66 billion revenue to the country (MCB, 2001). The Malaysian cocoa industry has developed rapidly since late 70's with production reaching 240, 000 tons in 1990. It is the most productive crop in the world with a yield of 1 tons/ha/year (MCB, 2001). However, in 1980's the industry was beset with the problems of prolonged depressed price and the infestation of a serious pest, the cocoa pod borer, *Conopomorpha cramerella* (Snellen) (CPB).

The cocoa pod borer was first discovered in late 1970 in Tawau and subsequently found in Peninsular Malaysia in 1986. It is indigenous to South East Asia as it is known to attack Leguminosae species such as *Nephelium lappaceum* (rambutan) pulasan and *Nephelium mutabile* (pulasan) and other members of Sapindicae such as *Pometia pinnata* (kasai). The life cycle of CPB begins with the laying of eggs on pod surface especially within the primary furrow (Azhar and Long, 1993). The larva hatches, and burrows directly into the pod to feed within the placenta. The penetration into the placenta of the young pods resulted in retarded pod development and malformed beans. This poses persistent problems to the growers, which subsequent increase in production cost and reduction yield.

1.1 Problem statement

Several methods are recommended to manage CPB including frequent harvesting, bagging or sleeving, chemical treatment and the use of natural enemies and pheromones. However, the use of chemical treatment or insecticides is the most common approach to control the CPB infestation. Many estate managers make treatment decisions typically based on infestation level (Sidhu *et al.* 1987), thus setting a time lag in between the time of decision and the actual implementation of control. Assessment made during observations does not reflect the actual situation when decisions are made. In addition, the continuous use of insecticides poses environmental problems and increase in production cost (Azhar *et al.* 2001). The severity of pest infestation too has increased since many pests have become more resistant to existing insecticides (Voss, 1988, Senn *et al.* 1994). Hence, an effective timing of insecticide applications based on the population level and crop phenology is needed.

1.2 Integrated Pest Management

The Integrated Pest Management (IPM) programs in agroecosystems have shown a positive impact on rice (Hassan *et al.* 1996). Since the primary objective of IPM is to reduce losses resulting from pests in a very effective, economically and ecologically compatible way, various pest management approaches have been recommended to reduce the reliance on chemical pesticides to improve pest management decision making at the farm level (MacKay *et al.* 1993).

Sampling is an important IPM component, especially in the development and execution of quantitative studies, estimation assignments, monitoring and surveillance strategies, pest population modeling and simulation, and forecasting protocols (Hassan, 1999). The major purposes of sampling are; determining statistics of samples or parameters of population, and secondly accessing the status of the population with respect to action thresholds (Hassan, 1999). Many factors should be considered such as within plant distribution of the pest (Maisin *et al.* 1997) in order to represent population attributes for decision-making analysis whether to treats or to classify the density of the population. Besides, the choice of accurate and relevant sampling plan and dynamics should be scrutinized (Wilson and Room, 1982 ; Hassan *et al.* 1992). This helps to produce a commercial procedure with the fastest method for estimating the yield of uninfested pods based on the distribution pattern of eggs study (Azhar and Long, 1993). The contribution of phenology growth of the cocoa pod is essential in most CPB's management program (Day, 1956).

1.3 Research Objectives

The main objectives of this research were 1) to determine the most reliable sampling technique for CPB egg distribution pattern, 2) to analyse the distribution pattern of CPB with respect to the phenology of growth of the cocoa pod, 3) to determine the optimum sample sizes for population management purposes.

CHAPTER 2

LITERATURE REVIEW

2.1 The Purpose of Sampling

Sampling is an essential activity in entomological and ecological research in order to get accurate and precise estimates of species abundance where the understanding of the population's dynamics is desired (Buntin, 1994). It provides current information on the pest status to make timely decisions for management activities in integrated pest management (Gonzalez, 1971) and form a baseline population research database (Morris, 1955).

In integrated pest management (IPM), there are two main purposes in sampling i.e, sampling for density estimation and for decision-making purposes (Binns and Nyrop, 1992). Ruesink (1980) reported that the reasons for sampling are to determine whether the economic threshold has been exceeded and hence the need for control measure and secondly, to estimate the population density with some predetermined degree of reliability. An example of management purpose sampling is sequential sampling by Azhar and Long (1991, 1993), who developed the fastest method for estimating cocoa yield.

An example of the second purpose sampling is assessment of insect abundance in a particular habitat (Azhar and Hassan, 2000), where reasonably accurate determination of population density is important. Estimation of density sampling involve technical and logistic constraints which need to be addressed to provide reliable data estimates.

2.2 Sampling Concepts

2.2.1 Sample Unit and Samples

Sampling universe in statistics refers as a whole population in which samples are taken (Pedigo, 1989). In arthropod sampling, the sampling universe represents the habitat in which the population occurs (Lee, 1997). For instance, the cocoa and rice fields are the sampling universe.

The sampling unit and samples are taken within the sampling universe. The measurable entity is based on the sampling unit such as a single leaf, single fruit or whole plant. In rice ecosystem, Hassan and Rashid (1997a; 1997b) a hill was the sampling unit while Azhar and Long (1991; 1993) used a cocoa pod as the sampling unit for cocoa ecosystem, and a cocoa tree as another alternative

According to Azhar and Hassan (2000) a sampling unit should follow several criteria as listed below;