



UNIVERSITI PUTRA MALAYSIA

**BAGWORM (*PTEROMA PENDULA* JOANNIS)
AND ITS CONTROL BY ENTOMOPATHOGENIC FUNGI,
(*METARHIZIUM ANISOPLIAE* METCHNIKOFF AND
PAECILOMYCES FUMOSOROSEUS WIZE)**

**CHEONG YEW LOONG
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CHEONG YEW LOONG

**Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Master Of Science**

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DEDICATION

Specially dedicated to my family members,
My dad, **Cheong Kok Seng** and mom, **Lai Soon Lan** for your patient and courage
given. Also not forgotten my brothers, **Cheong Yew Hoong** and **Cheong Yew Ken**
and sister, **Cheong Wei Pin**.

Thanks for your support and I love you all.

Also,

Specially thanks to the person that always support and advice me during the progress
of this project and thesis,

Tan Hui Sin.

Thank You to believe in me.

**“Do not think too highly of yourself, and yet,
never underestimate your ability” .**

“Still Thoughts” by Master Cheng Yen



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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(*METARHIZIUM ANISOPLIAE* METCHNIKOFF AND
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By

CHEONG YEW LOONG

September 2009

Chairman : Professor Dr. Ahmad Said Bin Sajap

Faculty : Forestry

Pteroma pendula (Joannis) was the dominant bagworm species infesting oil palm Plantation, Hutan Melintang, Lower Perak. This species had six instar stages when reared in the laboratory condition. The ratio of molting for late instar did not follow Dyar's rule. Dimorphism was observed in pupa and imago stages. Female emerged as apterous and vermiform-like, and male emerged as moth. *Pteroma pendula* had a lifespan of 50.4 ± 1.8 days in laboratory condition. Length of the cases were significantly correlated with head capsules for both male ($R^2 = 0.97$) and female ($R^2 = 0.92$) and might be useful in estimation of the instar stage in field.

Rainfall frequencies were found not significantly correlated with the outbreak of the bagworms in the study site, thus the outbreak did not influenced by rainfall. Field observation recorded the natural populations of bagworms were being controlled by predators, parasitoids and pathogenic fungi. Through systematic sampling of bagworms from the study site, the natural enemies had caused mortality to 4.85% of



the bagworm population, and this was ineffective in keeping the bagworm populations below the economic threshold level (five to ten bagworms per frond).

Two species of entomopathogenic fungi, *Metarhizium anisopliae* and *Paecilomyces fumosoroseus* had been isolated from field infected *P. pendula*. Pathogenicity tests revealed the lowest LT_{50} value at 5.72 days for *P. fumosoroseus* and 5.40 days for *M. anisopliae* at the concentration of 2×10^9 conidia ml^{-1} . The median effective concentrations (EC_{50}) were $2 \times 10^{5.10}$ conidia ml^{-1} for *P. fumosoroseus* and $2 \times 10^{5.17}$ conidia ml^{-1} for *M. anisopliae*. Conidia were prepared in Kaolinite-containing wettable powder with and without the addition of Tinopal LPW. Both substances are known to give protection against sunlight and help to prolong conidia viability. There was no differences at improving conidia viability when these formulations were tested with UVB light in the laboratory and natural sunlight at outdoor. Wettable powder formulation recorded 12-30% higher mortality on *P. pendula* when compared to the oil formulations for both fungi species.

Wettable powder formulations using both entomopathogenic fungi were applied in the field using hand sprayer and were compared to Dipel®. The results showed the wettable powder had no significant differences at causing mortality on bagworms, 5 days after treatment (DAT). Though, differences were observed on the 3rd and 7th DAT. These results suggested that the wettable powder formulation is a potential mycoinsecticide for controlling the bagworms especially at the early stages of infestation in the field.

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

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Pteroma pendula (Joannis) merupakan spesies ulat bungkus dominan yang menyerang ladang kelapa sawit di Hutan Melintang, Perak. Spesies ini mempunyai enam peringkat larva apabila diperihara di dalam makmal. Nisbah penyalinan kulit bagi larva peringkat akhir tidak mematuhi peraturan Dyar's. Dwi-morfologi diperhatikan pada peringkat kepompong dan serangga dewasa. Serangga betina menjelma dalam bentuk apterius dan vermiform, manakala serangga jantan menjelma sebagai rama-rama. *Pteroma pendula* mempunyai peringkat hidup selama 50.4 ± 1.8 hari dalam keadaan makmal. Panjang bekasnya menunjukkan hubungkait yang nyata dengan lebar kepala larva bagi kedua-dua jantan ($R^2 = 0.97$) dan betina ($R^2 = 0.92$) dan ini kemungkinan berguna dalam menjangka peringkat larva di lapangan.

Kekerapan hujan tidak menunjukkan hubungkait yang nyata dengan infestasi ulat bungkus di kawasan kajian, memberikan keputusan bahawa hujan tidak memberikan pengaruh terhadap infestasi ulat bungkus. Permerhatian di lapangan merekodkan

populasi ulat bungkus dikawal oleh musuh semulajadi iaitu pemangsa, parasitoids dan kulat pathogenik. Melalui persampelan sistematik, musuh semulajadi menyebabkan 4.85% kematian terhadap populasi ulat bungkus di ladang kelapa sawit di kawasan kajian dan ini tidak memberikan kawalan semulajadi yang efektif terhadap ulat bungkus, iaitu lima sehingga sepuluh ekor ulat per daun perepah.

Dua spesis kulat entomopathogenik, *Metarhizium anisopliae* dan *Paecilomyces fumosoroseus* diasingkan dari *P. pendula* yang dijangkiti kulat di lapangan. Kajian kepathogenan menunjukkan nilai LT_{50} terendah direkodkan 5.72 hari untuk *P. fumosoroseus* dan 5.40 hari untuk *M. anisopliae* pada kepekatan of 2×10^9 konidia ml^{-1} . Median Kepekatan efektif (EC_{50}) adalah $2 \times 10^{5.10}$ konidia ml^{-1} untuk *P. fumosoroseus* dan $2 \times 10^{5.17}$ konidia ml^{-1} untuk *M. anisopliae*. Konidia telah disediakan dalam bentuk serbuk mudah basah yang mempunyai kandungan Kaolinite dengan menambahkan atau tanpa menambahkan Tinopal LPW. Kedua-dua kandungan ini dikenali memberikan perlindungan daripada cahaya matahari dan membantu melanjutkan kemandirian konidia. Formulasi telah dikaji dengan sinaran UVB dalam makmal dan sinar cahaya matahari di luar bilik, menunjukkan kedua-dua formulasi tidak memberikan perbezaan yang nyata atas kemandirian konidia. Serbuk mudah basah merekodkan 12-30% lebih tinggi kematian terhadap ulat bungkus jika dibandingkan dengan formulasi bentuk minyak dalam ujikaji makmal.

Formulasi serbuk mudah basah menggunakan kedua-dua spesis kulat entomopathogenik telah diaplikasi di lapangan dengan menggunakan penyembur tangan dan dibandingkan dengan Dipel®. Keputusan menunjukkan serbuk mudah basah tidak mempunyai perbezaan yang nyata dalam menyebabkan kematian pada



ulat bungkus pada hari ke-5 selepas rawatan jika dibandingkan dengan Dipel®, tetapi menunjukkan perbezaan pada hari ke-3 dan ke-7 selepas rawatan dibandingkan dengan Dipel®. Keputusan ini mencadangkan bahawa serbuk mudah basah merupakan mycoinsectik yang berpotensi untuk mengawal ulat bungkus terutamanya pada awal infeksi di lapangan.

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I certify that a Thesis Examination Committee has met on 1st September 2009 to conduct the final examination of Cheong Yew Loong on his thesis entitled “Bagworm, *Pteroma Pendula* Joannis (Lepidoptera: Psychidae) and its control by Entomopathogenic Fungi, *Metarhizium Anisopliae* Metchnikoff and *Paecilomyces Fumosoroseus* Wize” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I hereby declare that the thesis is based on my original work except for the quotations and citations which has been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

CHEONG YEW LOONG

Date: 4th January 2010



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GLOSSARY OF TERMS

3A	Third anal vein of insect wing
BAL	Oil palm plantation in Sabah, sold to Golden Hope in 1996
Bt	<i>Bacillus thuringiensis</i>
CABI	Commonwealth Agriculture Bureaux International
CIBC	Commonwealth Institute of Biological Control (Now CABI)
CuP	Cubitus vein of insect wing
DAT	Day after treatment
HSD	Honestly Significant Difference
L:D	Light : Dark
MHC	Mah Hock Cheong
MPOB	Malaysia Palm Oil Board
PDA	Potato Dextrose Agar
RH	Relative Humidity
UPM	Universiti Putra Malaysia
USA	United States of America
UVB	Ultraviolet-B



CHAPTER 1

INTRODUCTION

1.1 *Pteroma pendula* as pest

Pteroma pendula (Joannis), like most bagworms is polyphagous insect and indicated by the high record of potential hosts (Khoo *et al.* 1991). Norman *et al.* (1994) state that about 31 species of shade trees and agricultural crops have been reported to be infested by *P. pendula* in Malaysia. According to Kalshoven (1981), *P. pendula* was responsible for the initial attacks but the outbreaks were restricted and usually declined due to the natural factors. This species has been reported to occur in small population with moderate damages in small areas, while *Metisa plana* was never found before 1956 (Corley and Tinker, 2003). In 1956, outbreak of *P. pendula* together with *M. plana* in certain regions in Perak State caused serious defoliation of oil palm (Wood, 1968). However, the status of *P. pendula* as major bagworm pest has been taken over by *M. plana* since 1955, after the broad spectrum persistent pesticides were applied widely in oil palm plantation (Wood, 2002). Chemical insecticide treatments might cause the resurgences of the new pest, *M. plana* (Ho, 2002). This species soon become the most economical important bagworm species in Malaysia (Kalshoven, 1981). The outbreak of *M. plana* as major pest in oil palm plantation probably due to the affect of pesticide on non target arthropods and other natural enemies, which have higher chances to contact with the pesticide due to their mobility. Since then, *P. pendula* has been recognized as the second most economical important bagworm on oil palm in Malaysia (Basri *et al.*, 1988). *Pteroma pendula* has been estimated for its threshold level on oil palm with 5 to 10 larvae per frond (Wood, 1971; Hoong and Hoh, 1992; Norman *et al.*, 1994).



A survey of the occurrence of bagworm species in Malaysia was conducted between 2000 and 2005 with total of 3880 survey forms distributed to major oil palm agencies and some independent estate, with only 44% responded (Norman and Basri, 2007). Norman and Basri (2007) also stated 49151.63ha of oil palm plantation were infested by bagworm, 67% of survey area of respondents, with *M. plana* still reported as wide distributed species in oil palm plantation follow by *P. pendula* in Peninsular Malaysia. However, this result does not indicate the dominance bagworm species as the survey was done in a limited area, representing only 9% of total distributed estate, with 5% of total oil palm plantation area in Malaysia reported to be attacked by bagworms.

1.2 History of management on bagworms using chemical applications

Chemical insecticides are one of the methods of controlling bagworms. The chemical controls of bagworms have been reported by many workers (Conway, 1966; Wood and Nesnit, 1969; Young, 1971; Hutauruk and Situmorang, 1971; Mackenzie, 1977) and they generally agreed trichlorfon was the most effective chemical insecticides against bagworm. Trichlorfon is an organophosphate insecticide and has been widely used to control cockroaches, crickets, silverfish, bedbugs, fleas, cattle grubs, flies, ticks, leafminers and leaf-hoppers (Thomas, 1986). It is a selective insecticide that it kills selected insects, but spares many or most other organisms. Trichlorfon is toxic to target insects through direct applications and by ingestion. It works both by contact and stomach poison action.

Before trichlorfon, others chemical pesticide such as endrin and dieldrin were widely used to control bagworms during 1960's in oil palm plantation (Wood, 2002). Yunus (1966) (Cited by Chung and Sim, 1991) stated that aerial spraying or ground spraying of chemical pesticide with endrin successfully controlled some early outbreaks of bagworm in Malaysia. However, spraying of a broad spectrum chemical pesticide such as dieldrin was seen to cause an increase in population of pests in oil palm plantation. This was apparently due to preferential elimination of insect natural enemies that usually keep the pests under control (Wood, 1964) (Cited by Chung and Sim, 1991). Wood (1971) showed that indiscriminate spraying of broad spectrum long residual contact insecticides, discriminating could adversely affect the agro-ecosystem that could to lead recurrent expense and catastrophic pest attacks. These organochlorines or organophosphates such as Dieldrin and Endrin kill insects, but also have high risk of killing insect natural enemies more thoroughly than the target pest (Wood, 2002). These applications effectively eliminate the pest, but it also set the scene for reoutbreak, often more intensive and widespread than that treated (Wood, 2002). Thus, integrated control programmes using selective stomach poisons (lead arsenate, trichlorfon) and trunk injection (monocrotophos, methamidophos and acephate) have been adapted and used in large scale bagworm control (Wood, 1968; Arulandi, 1971; Hutauruk and Situmorang, 1971; Wood *et al.*, 1974; Surinder, 1976; Sarjit, 1986; Nasir *et al.*, 1989; Chung, 1989; Chung, 1990).

Synthetic chemical pesticides were used widely because they often work very well for controlling pests (Hajek, 2004). However, over dependence on chemical pesticides for pest control may lead to negative effects on environment and health, and to pest resistance and resurgence. These problems may be solved through