UNIVERSITI PUTRA MALAYSIA

ECOLOGICAL STUDIES ON *PTEROMA PENDULA* JOANNIS AND *METISA PLANA* WALKER (LEPIDOPTERA: PSYCHIDAE) TOWARDS IMPROVED INTEGRATED MANAGEMENT OF INFESTATIONS IN OIL PALM

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By

HO CHENG TUCK

Thesis Submitted to the School of Graduate Studies,
Universiti Putra Malaysia, in Fulfilment of the Requirement for the
Degree of Doctor of Philosophy

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To

Keng See and Kin Leong

for the sacrifices, support, and strength

"Though one may be overpowered,
two can defend themselves. A cord
of three strands is not quickly broken."

Ecclesiastes 4: 12

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Doctor of Philosophy

ECOLOGICAL STUDIES ON *PTEROMA PENDULA* JOANNIS AND *METISA PLANA* WALKER (LEPIDOPTERA: PSYCHIDAE) TOWARDS IMPROVED INTEGRATED MANAGEMENT OF INFESTATIONS IN OIL PALM

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

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Pteroma pendula Joannis and *Metisa plana* Walker are important pests of the oil palm *Elaeis guineensis* Jacquin, which is the primary agricultural crop of Malaysia. Although there is a history of the integrated management of the bagworms, information gaps exist with regard to their incidence, biology, dispersion and population dynamics. Work of this thesis was aimed at overcoming these deficiencies and using the new information to improve integrated management of the pests.

Analysis of historical records of bagworm infestations over 63,955 ha of oil palms in 69 estates in Peninsular Malaysia showed *P. pendula* and *M. plana* to be the primary pests. Infestations were single species or mixed and ranged from nil to 7,811 ha per year. Cumulative infestation was 18,297 ha, 4,904 ha and 14,607 ha for single species *P. pendula*, *M. plana* and mixed species *P. pendula* and *M. plana* respectively. This showed *P. pendula* to be the predominant species. This was attributed to greater intrinsic rate of population increase, r_m, and finite rate of population increase, λ, for the species as well as its ability to survive very wet weather. Lower energy requirement for completion of life cycle and likewise propensity to balloon (which otherwise predisposed wash-off by rain) were established as reasons for this.

Synchrony of *P. pendula* and *M. plana* populations within and across estates was verified. Rainfall was indicated to be the primary factor synchronizing bagworm populations, particularly over wide areas, through their deleterious effects on survivorship of the pests. Short adult life span and overlapping if not synchronous emergence of males and females, pheromone-based male attraction to apterous females, regular dispersion of populations and natural enemies were postulated as other factors.

The use of multiple colonies that facilitated destructive and non-destructive sampling together with standardizing food media provided accurate details of the life history of *P. pendula* and *M. plana*. *Pteroma pendula* was confirmed to possess four larval stages with no difference in the number of instars and pupal development time between the sexes. Life history of *M. plana* followed report by earlier workers of 5-6 larval instars for males and 6-7 for females. There was, however, no difference in pupal development time and size. Sex ratio for both species was nevertheless 1:1 and more representative r_m and λ values were obtained. The last two statistics were nevertheless superior for *P. pendula* and insects bred in the field (r_m *P. pendula* 0.06459 laboratory, 0.07327 field and λ

1.06672 laboratory, 1.07603 field cf. r_m *M. plana* 0.04783 laboratory, 0.06061 field and λ 1.04899 laboratory, 1.06248 field).

Although *P. pendula* is the predominant pest species, results of this thesis showed pest status of *M. plana* to be not diminished owing to its greater damage potential and reproductive success through more efficient dispersion.

Through polynomial regression, standardized residual and relative net precision analyses, frond 17 was established as the representative sampling unit for experimental work and 10-19 for life-table construction. Lack of interspecific association suggested these sampling units to be applicable for single and mixed infestations. The bagworms were regularly dispersed in oil palm with a general mean-variance relationship of $\log(s^2) = 1.780 + 0.821 \log(\bar{x})$.

Road dust was shown to be directly detrimental to survival of bagworms and their parasitoids. However, in tall palms, there was insufficient dust deposition in the higher fronds to inhibit bagworm survival but was sufficient for their parasitoids. This allowed bagworm proliferation on such fronds, indicating road dust to more likely encourage outbreaks in tall than short palms.

Pupa number, adult female weight and favourable demographic statistics of *P. pendula* and *M. plana* were most consistently positively correlated with leaf nitrogen levels. Negative correlation of the above parameters with leaf magnesium and calcium levels was also indicated. As oil palm cultivation

targets maintenance of optimum foliar nitrogen levels, the crop is nutritionally supportive of bagworm populations. Further investigations on verifying the role of high Mg and Ca foliar levels in suppressing bagworm reproductive potential is merited.

Life-table studies showed that except for the abiotic factor of rainfall at the first larval instar to be the key factor for *M. plana*, natural enemies were important factors causing major fluctuations in population size of *P. pendula* and *M. plana*. As the natural enemies regulate populations in concert, the manipulation of the environment towards one that would conserve if not increase numbers of natural enemies would be a more practical first line of action. Increasing diversity of vegetation within the oil palm environment with the aim of encouraging and prolonging natural enemy activity through provision of shelter and nectar could meet this need. A combination of field bioefficacy and cage efficiency experiments showed usefulness of candidate plants to be *Euphorbia heterophylla* L. ≡ *Cassia cobanensis* (Britton) Lundell > *Antigonon leptopus* Hook. & Arn. ≡ *Crotalaria zanzibarica* Benth. ≡ *Turnera subulata* J.E. Smith > *Asystasia gangetica* (L.). On consideration of bioefficacy with ease of establishment and subsequent maintenance, the best mix would be *C. cobanensis* > *A. leptopus* ≡ *T. subulata.*

A highly efficient binomial sequential sampling plan based on the regression model $\bar{x} = 46.819\ [-\log(1-P_i)]^{0.727}$ was developed. With this plan, 97% correct decisions were made with only 13 presence-absence samples for approximately 10 ha of palms, 100% correct decisions being achieved with a maximum of

136. A reliable enumeration-free census system is thus for the first time available for use in making control decisions for *P. pendula* and *M. plana* in oil palm.

The use of life-tables provided hitherto unavailable insight into the effects of insecticides commonly used against *P. pendula* and *M. plana*. Cypermethrin, a synthetic pyrethroid widely used against the pests by commercial growers, was shown to have lower direct toxicity to larvae and marked deleterious effect on natural enemies when compared with acephate and *Bacillus thuringiensis aizawai*. The last was demonstrated to be both toxic to larvae but safe against natural enemies, suggesting the biocide to be a good alternative to the use of cypermethrin and acephate. Trunk injection with methamidophos provided the best control, mode of action being high selective toxicity to pests and safety to natural enemies. The combined effect could break life cycles, explaining the frequently observed long periods of control achieved with a single injection.

The foregoing findings allowed better understanding of the anatomy of outbreaks of the two pests and thus their anticipation and pre-emption. The development of an improved census technique, avoidance of road dust, proper timing and use of target-specific insecticides in conjunction with the establishment of more effective nectariferous plants facilitate this. In addition, hitherto unavailable details of life history, demographic statistics, sampling units and experimental methodologies for the bagworms would be useful tools for future research.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KAJIAN EKOLOGI KE ATAS *PTEROMA PENDULA* JOANNIS DAN *METISA PLANA* WALKER (LEPIDOPTERA: PSYCHIDAE) UNTUK PENINGKATAN PENGURUSAN PEROSAK DI KAWASAN KELAPA SAWIT

Oleh

HO CHENG TUCK

September 2002

Pengerusi: **Profesor Khoo Khay Chong, Ph.D.**

Fakulti: **Pertanian**

Pteroma pendula Joannis dan *Metisa plana* Walker adalah perosak-perosak penting kelapa sawit *Elaeis guineensis* Jacquin yang merupakan tanaman pertanian utama di Malaysia. Walaupun sejarah pengurusan bersepadu ulat bungkus sedia wujud, masih terdapat kekurangan maklumat tentang infestasi, biologi, penyebaran dan dinamiks populasi ulat-ulat tersebut. Penyelidikan dalam tesis ini bertujuan untuk mengatasi kelemahan-kelemahan ini dan menggunakan maklumat baru yang dihasilkan untuk meningkatkan prestasi pengurusan perosak-perosak tersebut.

Analisis rekod-rekod sejarah infestasi ulat bungkus yang meliputi 63,955 ha kawasan kelapa sawit dalam 69 ladang menunjukkan bahawa *P. pendula* dan *M. plana* adalah perosak-perosak utama. Infestasi tersebut terdiri daripada spesies tunggal atau campuran dan meliputi luas kawasan antara sifar hingga 7,811 ha setahun. Infestasi kumulatif didapati sebanyak 18,297 ha, 4,904 ha dan 14,607 ha

masing-masing untuk spesies tunggal *P. pendula*, spesies tunggal *M. plana* dan spesies campuran *P. pendula* dan *M. plana*. Oleh itu, *P. pendula* ialah spesies yang dominan. Kejadian ini adalah berpunca daripada keupayaan peningkatan populasi inat, r_m, dan populasi finat, λ, yang lebih tinggi dan kebolehan spesies tersebut untuk mandiri dalam keadaan cuaca yang amat lembab. Keperluan tenaga yang rendah untuk melengkapkan kitaran hidup dan kecenderungan rendah untuk terapung dari benang sutera atau "ballooning" (dengan itu mengelakkan curahan oleh hujan) telah ditentukan sebagai faktor-faktor penyebab.

Singkroni populasi *P. pendula* dan *M. plana* telah ditentukan di dalam dan di kalangan ladang. Taburan hujan yang menjejas kemandirian perosak-perosak tersebut didapati sebagai faktor utama yang mempengaruhi singkroni populasi, terutamanya dalam kawasan yang luas.

Pteroma pendula didapati mempunyai empat peringkat larva tanpa perbezaan bilangan instar dan masa perkembangan kepompong di antara jantina. Sejarah hidup *M. plana* mengikuti laporan oleh penyelidik-penyelidik dahulu di mana bilangan instar ialah 5-6 untuk jantan dan 6-7 untuk betina. Namun, tiada perbezaan diperhatikan dari segi masa perkembangan dan saiz kepompong. Walau bagaimanapun, nisbah jantina kedua-dua spesies ialah 1:1 dan nilai-nilai r_m dan λ yang lebih mencerminkan keadaan semulajadi telah diperolehi. Namun, statistik r_m dan λ adalah lebih tinggi untuk *P. pendula* dan ulat-ulat yang dibiak di lapangan .

Walaupun *P. pendula* merupakan spesies perosak predominan, status *M. plana* sebagai perosak tidak susut disebabkan potensi kerosakannya yang lebih tinggi dan kejayaan pembiakannya melalui penyebaran yang lebih berkesan.

Pemilihan daun pelepah ke- 17 sebagai unit pensampelan untuk kerja penyelidikan dan ke- 10-19 untuk pembinaan jadual hayat telah ditentukan melalui regresi polinomial, piawai residual dan analysis ketepatan relatif bersih. Ulat bungkus didapati disebarkan serata di kawasan kelapa sawit mengikut perhubungan am purata-varian $\log (s^2) = 1.780 + 0.821 \log (\bar{x})$.

Habuk jalan secara langsung telah mengakibat kesan buruk terhadap kemandirian ulat bungkus dan parasitoidnya. Namun demikian, tidak banyak habuk jalan yang terlekat pada pelepah-pelepah bahagian atas pokok-pokok yang tinggi. Akibatnya, cuma kemandirian parasitoid sahaja terencat manakala ulat bungkus terus merebak di atas pelepah-pelepah tinggi. Dengan demikian, habuk jalan lebih berkemungkinan menggalakkan wabak ulat bungkus pada pokok-pokok yang tinggi berbanding yang rendah.

Bilangan kepompong, berat betina dewasa dan statistik demografi yang baik menunjukkan korelasi positif yang konsisten dengan aras kandungan nitrogen daun. Parameter-parameter tersebut menunjukkan korelasi negatif pula dengan aras kandungan magnesium dan kalsium daun.

Kajian jadual hayat menunjukkan bahawa musuh-musuh semulajadi merupakan faktor utama yang menyebabkan perubahan besar dalam saiz populasi *P. pendula* dan *M. plana*, melainkan faktor abiotik hujan yang menjadi faktor utama untuk *M. plana* pada peringkat instar larva pertama. Oleh sebab musuh-musuh semulajadi mengawal populasi secara bersepadu, manipulasi persekitaran kawasan kelapa sawit untuk memelihara atau meningkatkan bilangan musuh-musuh semulajadi adalah langkah tindakan pertama yang praktikal. Matlamat ini boleh dicapai dengan meningkatkan kepelbagaian tumbuhan di dalam persekitaran kawasan kelapa sawit. Ini bertujuan untuk memberi perlindungan dan nektar kepada musuh semulajadi yang seterusnya akan menggalak dan melanjutkan aktiviti hidup musuh semulajadi tersebut. Kombinasi eksperimen bioefikasi di lapangan dan kecekapan sangkar menunjukkan beberapa spesies tumbuhan yang berguna, iaitu, *Euphorbia heterophylla* L. ≡ *Cassia cobanensis* (Britton) Lundell > *Antigonon leptopus* Hook. & Arn. ≡ *Crotalaria zanzibarica* Benth. ≡ *Turnera subulata* J.E. Smith > *Asystasia gangetica* (L.).

Satu pelan pensampelan binomial berjujukan yang amat cekap berdasarkan model regresi $\bar{x} = 46.819\,[-\log(1-P_i)]^{0.727}$ telah dicipta. Dengan mengguna pelan ini, 97% keputusan betul telah diperolehi dengan hanya 13 sampel hadir-tidak hadir dalam kira-kira 10 ha kawasan kelapa sawit, di mana 100% keputusan betul diperolehi dengan maksimum 136 sampel.

Penggunaan teknik jadual hayat telah dapat memberi penjelasan yang selama ini tidak diketahui berkenaan kesan racun-racun serangga yang kerap diguna untuk mengawal *P. pendula* dan *M. plana*. Sipermetrin, satu piretroid sintetik yang banyak diguna oleh penanam komersial, telah didapati menghasilkan kesan toksik langsung yang lebih rendah terhadap larva dan kesan buruk yang nyata terhadap musuh-musuh semulajadi berbanding asefat dan *Bacillus thuringiensis aizawai*. *Bacillus thuringiensis aizawai* menunjukkan kesan toksik terhadap larva tetapi selamat untuk musuh-musuh semulajadi dan ini membayangkan biosid tersebut adalah alternatif yang baik untuk sipermetrin dan asefat. Suntikan metamidofos ke dalam batang kelapa sawit merupakan kaedah pengawalan yang paling baik di mana cara tindakannya tertumpu pada perosak tetapi mengelak dari musuh semulajadi. Gabungan kesan demikian boleh menghapuskan kitaran hidup ulat bungkus, menerangkan kejayaan pengawalan perosak dalam tempoh yang panjang dari satu suntikan.

Keputusan penyelidikan di atas menambah pemahaman mengenai anatomi dan juga jangkaan dan pengelakan perebakan *P. pendula* dan *M. plana*. Kawalan perebakan tersebut telah diselenggarakan melalui ciptaan satu kaedah bancian yang lebih efisien, pengelakan habuk jalan, penggunaan racun-racun serangga yang spesifik pada masa yang sesuai dan penubuhan tumbuh-tumbuhan bernektar yang lebih efektif. Tambahan lagi, pengetahuan baru yang diperolehi mengenai kitaran hidup, statistik demografi, unit-unit pensampelan dan metodologi eksperimen merupakan sumbangan bernilai untuk penyelidikan ulat bungkus di masa hadapan.

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> "The better work men do is always done
> under stress and at great personal cost."
> William Carlos Williams

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