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INFESTATIONS BY THE BAGWORMS *Metisa plana* AND *Pteroma pendula* FOR THE PERIOD 1986-2000 IN MAJOR OIL PALM ESTATES MANAGED BY GOLDEN HOPE PLANTATION BERHAD IN PENINSULAR MALAYSIA

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ABSTRACT

Metisa plana *Walker and* Pteroma pendula *Joannis are important pests of the oil palm,* Elaeis guineensis *Jacquin, which is the primary agricultural crop in Malaysia. Although there is a history of integrated management of the bagworms, information gaps exist with regard to their incidence, biology, dispersion and population dynamics. Such new information is needed to improve the current integrated management of these pests. Analysis of historical records of bagworm infestations over 63 955 ha of oil palm in 69 estates in Peninsular Malaysia showed* M. plana *and* P. pendula *to be the primary pests. Infestations were of single or mixed species, and ranged from nil to 7811 ha* yr^{-1}*. Cumulative infestations were 18 297 ha, 4904 ha and 14 607 ha for single species of* P. pendula *and* M. plana*, and for mixed species of* P. pendula *and* M. plana*, respectively. This shows* P. pendula *to be the predominant species, and is attributed to its ability to survive very wet weather (>200 mm rain per month) and its propensity to balloon compared to* M. plana*, which is predisposed to wash-off by rain.*

Keywords: bagworms, historical data, incidence of infestation, outbreaks, oil palm.

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INTRODUCTION

Morris (1964) showed the value of historical data in population research of forest pests. From such data, the important role of climate and vegetation in determining the synchrony of oscillations in the population of the webworm, *Hyphantria cunea* Drury, was indicated. Atkinson (1999) used historical data on the incidence of the wattle bagworm, *Chaliopsis junodi* (Heylaerts), in association with meteorological records for predictive purposes. Time series analysis has been used to examine the underlying dynamics of the population. Similarly, historical data on bagworm infestations of oil palm in Malaysia have also been used for the same purpose. The last major survey was conducted by Basri *et al.* (1988) by dispatching questionnaires to a total of 1406 estates in both east and Peninsular Malaysia. Reports of outbreaks over the period 1981-1985 were requested and analysis of the returns allowed the following features of bagworm outbreaks to be deduced: frequency of incidence of bagworms on oil palm was high, and severe outbreaks could occur at any time of the year and more than once within the same area. *Metisa plana* was the most damaging species in Peninsular Malaysia while in east Malaysia it was *Mahasena corbetti*. Reports of single species outbreaks were common while mixed species outbreak could occur in both young and old palms, but the area of outbreak tends to be greater on old palms. Lastly, Basri *et al.* (1988) reported that no consistent association was noticed between outbreaks and drought duration.

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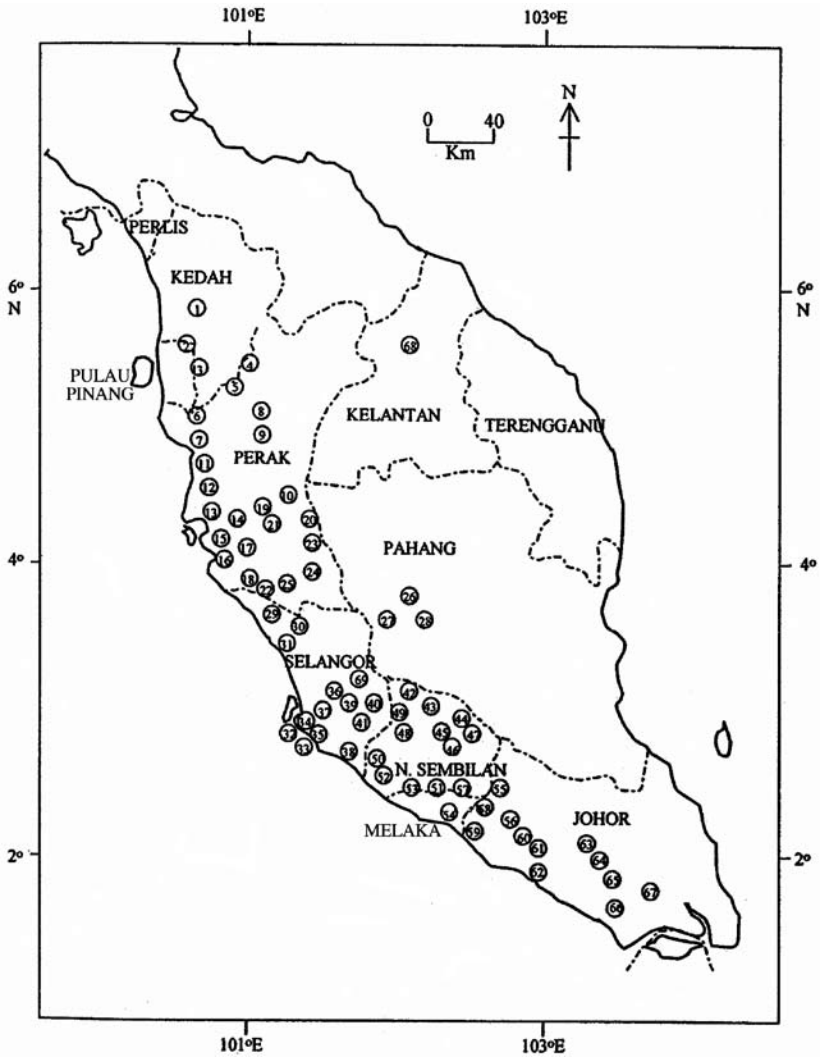
This article reports updated information on infestation for the period 1986-2000, albeit covering only 63 955 ha of oil palm in 69 estates owned or managed by Golden Hope Plantation Berhad (GHPB) in Peninsular Malaysia. In addition to studying trends, attempts were made to record any synchrony of outbreak populations.

MATERIALS AND METHODS

Historical data from estate census, feedback and advisory reports of bagworm outbreaks in GHPB oil palm plantations of Peninsular Malaysia over the period 1986-2000 were used. Altogether, 69 oil palm estates were covered in the survey. The locations of these estates are given in *Figure 1*. The information extracted is summarised as follows:

- data on frequency and species composition, host age preference for infestations and extent of infestation were interpreted in terms of number of estates and number of years each estate experienced bagworm incidence above the economic threshold (ET) as well as the total area so affected in each year. ET was set at 10 larvae per frond (Wood, 1971; Hoong and Hoh, 1992). The total yearly affected area was broken down to the proportions of area infested by *M. plana* and *P. pendula* alone and by mixed populations. Incidence of these populations on 3-7, 8-15 and >15-year-old palms were also established.
- the pattern of infestation by single and mixed species at above ET for *M. plana* and *P. pendula* were plotted against months within the years under review. The infestations were compared with rainfall patterns in an attempt to gauge the influence of rainfall on outbreaks. This was achieved by graphical comparison, correlation analysis and by calculating the percentage of single and mixed species infestations above ET for the period under review that occurred during rainfall per month^{-1} of <50, >50 <100,



Key

1. Kuala Ketil
2. Victoria
3. Somme
4. Holyrood
5. Sungai Krian
6. Jin Seng
7. Chersonese
8. Elphil
9. Strathisla
10. Kinta Kellas
11. Sungai Bruas
12. Sogomana
13. Cashwood
14. Sungai Wangi
15. Melentang
16. Bagam Datoh
17. Gough Garden
18. Flemington
19. Selaba
20. Bikam
21. Sungai Klah
22. Sungai Samak
23. Trolak
24. Cluny
25. Bedford
26. Edensor
27. Lanchang
28. Mentakab
29. Bukit Belimbing
30. Bukit Badong
31. Kuala Selangor
32. North
33. West
34. East
35. South
36. Sungai Sedu
37. Dusun Durian
38. Sepang
39. Bangi
40. Semenyih
41. Glengowrie
42. Pertang
43. Sungai Sabaling
44. Kelpin
45. St. Helier
46. Bukit Pilah
47. New Rompin
48. Sialang
49. Juasseh
50. Paroi
51. Linsum
52. Bradwall
53. Sungai Baru
54. Diamond Jubilee
55. Sungai Senarut
56. Muar River
57. Welch
58. Tangkah
59. Kundong
60. North Labis
61. Nordanal
62. Lanadron
63. Tambuku
64. Bukit Benut
65. Benut
66. Kelan
67. Bukit Lawang
68. Mengkebang
69. Kajang

Figure 1. Map of Peninsular Malaysia showing locations of the 69 oil palm estates used in the survey.

>100 <200, >200 <300, >300 <400, >400 <500 and >500 <600 mm.

- synchrony of outbreaks was gauged by the following estimate:

$$\text{No. of records of infestation occasions with the same \% synchrony} = \frac{\text{life stage (1st to 2nd instar, 3rd and above instar, or pupa)}}{\text{Total No. of records (n)}} \times 100$$

The total number of records (n) depended on the number of blocks or fields surveyed. Larger areas of infestation normally had a higher total number of records. Synchrony of outbreaks was estimated within each outbreak year for individual estates as well as for months within a year within and/or across estates. For the former, records on the life stage of the census blocks in the field or fields of the outbreak occasion were used. The latter was meant to show synchrony over a larger geographical area, and an overall estimate of the life stage of individual infestations above ET for each month of a year was used.

RESULTS

Sixteen out of 69 estates surveyed experienced bagworm infestations above ET over the 15-year period (*Table 1*). These estates were mostly located in Perak (7) and Selangor (8), with a single incidence in Johor. The majority of these estates (14) were coastal in location. The frequency of outbreaks varied from one to 10 years over the 15-year period. No outbreaks occurred from 1987 to 1989. Outbreaks occurred only in one year at Sungai Krian, Jin Seng, Chersonese, Selaba, Bikam, Sungai Samak, Sungai Sedu and Bukit Benut Estates. Outbreaks in two years were recorded in Kuala Selangor, South and Sepang Estates whereas Melentang and Dusun Durian Estates had outbreaks in three. North Estate experienced outbreaks in four years, East Estate eight and West Estate had the most frequent outbreaks, *i.e.* 10 years.

TABLE 1. SURVEYED ESTATES THAT EXPERIENCED BAGWORM INFESTATIONS ABOVE THE ECONOMIC THRESHHOLD OVER A 15-YEAR PERIOD

	Estate	Years in which infestation recorded
1.	Sungai Krian	1992
2.	Jin Seng	1998
3.	Chersonese	1998
4.	Melentang	1995, 1996, 1998
5.	Selaba	1998
6.	Bikam	2000
7.	Sungai Samak	2000
8.	Kuala Selangor	1995, 1998
9.	North	1986, 1992, 1998, 2000
10.	West	1990-1996, 1998-2000
11.	East	1992-1998, 2000
12.	South	1986, 2000
13.	Sungai Sedu	1990
14.	Sepang	1993, 1995
15.	Dusun Durian	1986, 1993, 2000
16.	Bukit Benut	1992

TABLE 2. EXTENT OF BAGWORM INFESTATIONS ABOVE THE ECONOMIC THRESHHOLD IN THE SURVEYED ESTATES

Year	Total area infested by bagworm / (ha)	Area (percentage of total)
1986	46 367	843 (1.8)
1987	48 212	0
1988	49 325	0
1989	52 657	0
1990	55 272	958 (1.7)
1991	63 341	1 140 (1.8)
1992	63 840	4 956 (7.8)
1993	65 965	5 257 (8.0)
1994	62 641	3 539 (5.7)
1995	63 473	3 767 (5.9)
1996	68 271	1 282 (1.9)
1997	66 396	861 (1.3)
1998	68 337	3 425 (5.0)
1999	63 955	3 969 (6.2)
2000	63 955	7 811 (12.2)
Cumulative	-	37 808

The extent of infestation ranged from nil to 12.2% of the total oil palm area of the 69 estates (*Table 2*). There was no clear trend of infestation with years although the maximum of 12.2% or 7811 ha occurred in the year 2000. A cumulative total of 37 808 ha of oil palm experienced infestations above ET by bagworms over 1986-2000.

Metisa plana and *P. pendula* were the only species recorded. These occurred either singly or in mixed populations. Single species *M. plana* infestations ranged from nil to 1184 ha yr^{-1} with a cumulative total of 4904 ha over the 15 years; the highest infestation being in 1998 (*Table 3*). *Pteroma pendula* infestations ranged from nil to 7639 ha yr^{-1} with a cumulative total of 18 297 ha. High *P. pendula* activity was obvious from 1998 onwards. Mixed infestations ranged from nil to 3644 ha yr^{-1}, totalling 14 607 ha. On a yearly basis, there was no consistent preference by the three infestation types for the

TABLE 3. AGE OF PALMS WITH BAGWORM INFESTATIONS ABOVE THE ECONOMIC THRESHOLD FOR THE SURVEYED ESTATES

Year	Palm age (yr) ha (%)	*P. pendula* area ha (%)	*M. plana* area ha (%)	*P. pendula* + *M. plana* area ha (%)	Cumulative area ha (%)
1986	3-7	114 (13.5)	-	-	114 (13.5)
	8-15	435 (51.7)	-	-	435 (51.7)
	>15	293 (34.7)	-	-	293 (34.7)
	Total	842			842
1990	3-7	-	-	-	-
	8-15	19 (100)	939 (100)	-	958 (100)
	>15	-	-	-	-
	Total	19	939	958	
1991	3-7	84 (17.1)	-	138 (24.1)	222 (19.5)
	8-15	234 (47.5)	56 (73.7)	257 (44.9)	547 (48.0)
	>15	174 (35.4)	20 (26.3)	177 (31.0)	371 (32.5)
	Total	492	76	572	1 140
1992	3-7	246 (50.2)	440 (45.5)	1 570 (44.9)	2 256 (45.5)
	8-15	104 (21.2)	450 (46.4)	945 (27.0) 1	499 (30.2)
	>15	140 (28.6)	77 (8.0)	985 (28.1)	1 202 (24.2)
	Total	490	967	3 500	4 957
1993	3-7	513 (52.7)	347 (54.2)	2 215 (60.8)	3 075 (58.5)
	8-15	355 (36.5)	126 (19.7)	1 160 (31.8)	1 641 (31.2)
	>15	105 (10.8)	167 (26.1)	269 (7.4)	541 (10.3)
	Total	973	640	3 644	5 257
1994	3-7	318 (39.4)	31 (26.0)	1 056 (40.4)	1 405 (39.7)
	8-15	278 (34.5)	48 (40.3)	887 (34.0)	1 213 (34.3)
	>15	211 (26.1)	40 (33.6)	670 (25.6)	921 (26.0)
	Total	807	119	2 613	3 539
1995	3-7	1 069 (61.1)	186 (100)	1 350 (73.8)	2 605 (69.2)
	8-15	456 (26.0)	-	353 (19.3)	809 (21.5)
	>15	225 (12.9)	-	127 (7.0)	352 (9.3)
	Total	1 750	186	1 830	3 766
1996	3-7	30 (8.3)	97 (51.6)	133 (18.1)	260 (20.3)
	8-15	180 (49.8)	58 (30.9)	364 (49.7)	602 (47.0)
	>15	151 (41.9)	33 (17.6)	236 (32.2)	420 (32.8)
	Total	361	188	733	1 282
1997	3-7	-	273 (62.8)	105 (24.6)	378 (43.9)
	8-15	-	132 (30.3)	321 (75.4)	453 (52.6)
	>15	-	30 (6.9)	-	30 (3.5) 861
	Total		435	426	
1998	3-7	144 (15.1)	268 (22.6)	510 (39.6)	922 (26.9)
	8-15	678 (71.1)	636 (53.7)	532 (41.30	1 846 (53.9)
	>15	131 (13.7)	280 (23.6)	246 (19.1)	657 (19.2)
	Total	953	1 184	1 288	3 425
1999	3-7	1 197 (30.2)	-	-	1 197 (30.2)
	8-15	1 824 (46.0)	-	-	1 824 (46.0)
	>15	948 (23.9)	-	-	948 (23.9)
	Total	3 969			3 969
2000	3-7	2 519 (33.0)	95 (55.6)	-	2 614 (33.5)
	8-15	3 395 (44.4)	76 (44.4)	-	3 471 (44.4)
	>15	1 725 (22.6)	-	-	1 725 (22.1)
	Total	7 639	171	-	7 810
Cumulative	3-7	6 235 (34.1)	1 737 (35.4)	7 078 (48.5)	15 050 (39.8)
	8-15	7 959 (43.5)	2 520 (51.4)	4 819 (33.0)	15 298 (40.5)
	>15	4 103 (22.4	647 (13.2)	2 710 (18.6)	7 460 (19.7)
	Total	18 297	4 904	14 607	37 808

age groups of the palms. However, considering the cumulative data over 15 years, single species *M. plana* and *P. pendula* infestations occurred the most in 8- to 15-year-old palms followed by palms of 3-7 and >15 years. Mixed species infestations, on the other hand, occurred the most in 3- to 7-year-old palms, followed by palms of 8-15 and >15 years. The cumulative area for all infestation types nevertheless indicates almost equivalent attacks on 3-7 and 8- to 15-year-old palms with markedly lower attacks on >15-year-old palms.

A comparison of the number of infestations above ET with months and years over the period under review shows no clear trend for overall single and mixed species infestations by *M. plana* and *P. pendula* (*Table 4*), mixed species infestations only (*Table 5*), and single species *P. pendula* infestations (*Table 6*). Single species *M. plana* infestations however showed a clear trend of occurring only in the first six months of the year (*Table 7*). A comparison of monthly rainfall with the above infestation types did not reveal any visual associations. This was confirmed by the failure to obtain significant differences through correlation analysis of rainfall data with incidence of infestation in the same month and two generations later.

TABLE 4. NUMBER OF INFESTATIONS ABOVE THE ECONOMIC THRESHOLD BY MONTH AND YEAR FOR ALL INFESTATIONS OF *P. pendula* AND *M. plana*

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	0	1	4	0	5	1	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	1	0	0	0	0	0	0	0	0	1
1991	0	0	3	1	3	8	2	10	0	4	4	8
1992	21	12	17	15	13	11	7	10	13	0	2	10
1993	16	14	3	9	7	6	14	10	14	6	14	16
1994	12	16	5	7	8	10	18	17	6	0	1	1
1995	7	2	0	3	2	6	9	9	16	14	10	3
1996	1	4	11	5	5	5	3	5	3	5	7	2
1997	4	2	0	4	3	0	7	4	1	5	3	2
1998	7	2	3	4	10	5	0	0	0	9	8	10
1999	0	0	19	21	11	14	6	9	9	7	19	11
2000	3	32	19	26	15	12	6	8	37	0	0	0

TABLE 5. NUMBER OF INFESTATIONS ABOVE THE ECONOMIC THRESHOLD BY MONTH AND YEAR FOR MIXED INFESTATIONS OF *P. pendula* AND *M. plana*

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	3	1	0	8	0	10	0	4	0	0
1992	16	5	13	12	11	11	7	6	13	0	1	0
1993	15	0	0	8	7	5	12	10	14	0	0	7
1994	10	12	5	7	8	6	18	9	0	0	0	1
1995	2	2	0	1	2	4	9	1	4	4	2	3
1996	0	0	0	0	5	5	3	5	3	5	7	2
1997	0	0	0	0	0	0	0	4	1	5	3	2
1998	0	0	0	0	0	0	0	0	0	9	3	0
1999	0	0	0	0	0	0	0	0	0	0	6	0
2000	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 6. NUMBER OF INFESTATIONS ABOVE THE ECONOMIC THRESHOLD BY MONTH AND YEAR FOR *P. pendula* ONLY

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	0	1	4	0	5	1	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	1
1991	0	0	0	0	3	0	0	0	0	4	4	8
1992	0	0	0	0	0	0	0	0	0	0	1	10
1993	1	0	3	0	0	1	0	4	0	6	14	9
1994	0	0	0	0	0	4	0	0	0	0	1	0
1995	5	0	0	0	0	0	0	8	6	10	8	0
1996	0	0	0	5	0	0	0	8	12	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	4	0	0	0	10	0	0	0	0	0	5	10
1999	0	0	19	21	11	14	6	9	9	7	13	11
2000	3	32	19	20	15	12	6	8	37	0	0	0

TABLE 7. NUMBER OF INFESTATIONS ABOVE THE ECONOMIC THRESHOLD BY MONTH AND YEAR FOR *M. plana* ONLY

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	1	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	2	0	0	0	0	0
1992	5	7	4	3	2	0	0	0	0	0	0	0
1993	0	14	0	1	0	0	2	0	0	0	0	0
1994	2	4	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	2	0	2	0	0	0	0	0	0
1996	1	4	11	0	0	0	0	0	0	0	0	0
1997	4	2	0	4	3	0	7	0	0	0	0	0
1998	3	2	3	4	10	5	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	6	0	0	0	0	0	0	0	0

TABLE 8. PERCENTAGE OF SINGLE AND MIXED INFESTATIONS ABOVE THE ECONOMIC THRESHOLD FROM 1986 TO 2000 WITHIN VARIOUS RANGES OF RAINFALL

Rainfall, (mm month^{-1})	*P. pendula*	*M. plana*	*P. pendula* + *M. plana*
<50	1.9	33.3	3.8
>50 to <100	7.6	50.0	17.5
>100 to <200	24.5	16.7	57.5
>200 to <300	41.5	0	17.5
>300 to <400	20.8	0	3.8
>400 to <500	1.9	0	0
>500 to <600	1.9	0	0

TABLE 9. PERCENT SYNCHRONY OF LIFE STAGES FOR TOTAL NUMBER OF RECORDS (n) OF BAGWORM INFESTATIONS

Estate	Year	% Synchrony (n)		
		P. pendula	*M. plana*	*P. pendula + M. plana*
Sungai Krian	1992	-	100 (12)	100 (4)
Jin Seng	1998	-	100 (17)	-
Chersonese	1998	-	100 (25)	100 (18)
Melentang	1995	100 (15)	-	-
	1996	100 (25)	-	-
	1998	100 (50)	-	-
Selaba	1998	-	-	100 (18)
Bikam	2000	100 (10)	-	-
Sungai Samak	2000	100 (24)	-	-
Kuala Selangor	1995	-	100 (10)	-
	1998	-	100 (35)	-
North	1986	100 (25)	-	-
	1992	-	-	95.8 (50)
	1998	-	-	100 (18)
	2000	-	100 (60)	-
West	1990	100 (15)	-	-
	1991	100 (104)	100 (6)	98.0 (148)
	1992	100 (25)	-	86.8 (387)
	1993	100 (60)	100 (36)	92.2 (184)
	1994	100 (102)	-	85.4 (171)
	1995	-	-	89.0 (145)
	1996	-	100 (13)	-
	1998	100 (48)	-	-
	1999	100 (653)	-	-
	2000	99.5 (746)	-	-
East	1992	100 (25)	100 (45)	88.8 (129)
	1993	100 (104)	100 (30)	87.9 (195)
	1994	-	100 (30)	86.2 (189)
	1995	100 (380)	-	100 (49)
	1996	-	100 (66)	79.6 (146)
	1997	-	100 (106)	84.8 (175)
	1998	-	100 (74)	-
	2000	100 (141)	-	-
South	1986	100 (24)	-	-
	2000	100 (11)	-	-
Sungai Sedu	1990	-	100 (105)	-
Sepang	1993	-	100 (16)	-
	1995	-	100 (25)	-
Dusun Durian	1986	100 (8)	-	-
	1993	100 (18)	-	-
	2000	100 (16)	-	-
Bukit Benut	1992	-	100 (132)	-

Note: % synchrony = $\frac{\text{No. of records of infestation occasions with same life stage}}{\text{Total No. of records}} \times 100$

However, plotting of percentage infestations above ET for the 15 years under review with various ranges of rainfall per month showed that single species *M. plana* infestations coincided with dry weather conditions, with 33.3% occurring in situations of <50 mm rainfall per month and 50% with >50 <100 mm rainfall (*Table 8*). With increasing rainfall, single species *P. pendula* infestations increased from 1.9% at <50 mm to 41.5% with >200 <300 mm rainfall per month. Single species *M. plana* infestations ceased at this level of rainfall and although single species *P. pendula* infestations decreased with higher rainfall, infestations of 1.9% occurred at the extremes of >400 <500 mm and >500 <600 mm rainfall per month ranges, respectively. Mixed species infestations reflected a weather preference by both species, being highest at 57.5% with >100 <200 mm rainfall per month and tapering off equally within two rainfall ranges on either side of this rainfall regime.

Analysis of the synchrony of infestations with years for individual estates shows high synchrony for single species infestations. For *P. pendula*, 99.5%-100% synchrony was recorded and 100% for *M. plana* (*Table 9*). Synchrony was more variable for the mixed species infestations, ranging from 79.6%-100% with a mode of 100, reflecting a high frequency and level of synchrony. With the within and/or across estates assessments with month and year, total synchrony was obtained with single species infestations (*Table 10*). The synchrony of mixed species infestations was variable, ranging from nil to 100%; however, this could have been amplified by the small number of records involved (*Table 11*). This suggests that the majority of assessments were meaningfully synchronous, albeit at times lower than the equivalent annual within estates assessments.

TABLE 10. TOTAL SYNCHRONY (x = 100%) OF LIFE STAGES FOR TOTAL NUMBER OF RECORDS (n) OF BAGWORM INFESTATIONS WITHIN AND/OR ACROSS ESTATES

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P. pendula												
1986	-	-	x(4)	-	x(5)	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	x(3)	-	-	-	-	-	x(4)	x(4)
1992	-	-	-	-	-	-	-	-	-	x(6)	x(14)	x(10)
1993	-	-	x(3)	-	-	-	-	-	-	-	-	x(9)
1994	-	-	-	-	-	x(4)	-	x(4)	-	-	-	-
1995	x(5)	-	-	-	-	-	-	x(8)	x(6)	x(10)	x(8)	-
1996	-	-	-	-	-	-	-	x(8)	x(12)	-	-	-
1997	-	-	-	x(5)	-	-	-	-	-	-	-	-
1998	x(4)	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	x(19)	x(21)	x(11)	x(14)	x(6)	x(9)	x(9)	x(7)	x(5)	x(10)
2000	x(3)	x(32)	x(19)	x(20)	x(15)	x(12)	x(6)	x(8)	x(37)	-	x(13)	x(11)
M. plana												
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-
1992	x(5)	x(7)	x(4)	x(3)	x(2)	-	x(2)	-	-	-	-	-
1993	-	x(14)	-	-	-	-	x(2)	-	-	-	-	-
1994	x(2)	x(4)	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	x(4)	x(11)	x(2)	-	x(2)	-	-	-	-	-	-
1997	x(4)	x(2)	-	-	-	-	-	-	-	-	-	-
1998	x(3)	x(2)	x(3)	x(4)	x(3)	x(5)	x(7)	-	-	-	-	-
1999	-	-	-	x(4)	x(10)	-	-	-	-	-	-	-
2000	-	-	-	x(6)	-	-	-	-	-	-	-	-

TABLE 11. PERCENT SYNCHRONY OF LIFE STAGES FOR TOTAL NUMBER OF RECORDS (n) OF MIXED *P. pendula* AND *M. plana* INFESTATIONS WITHIN AND/OR ACROSS ESTATES

Year/Month	1986-1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Jan	-	-	81.2(16)	86.7(15)	90(10)	50(2)	-	-	-	-	-
Feb	-	-	80(5)	-	83.3(12)	100(2)	-	-	-	-	-
Mar	-	100(3)	76.9(13)	-	60(5)	-	-	-	-	-	-
Apr	-	-	83.3(12)	75(8)	71.4(7)	-	-	-	-	-	-
May	-	-	90.9(11)	71.4(7)	75(8)	0(2)	60(5)	-	-	-	-
June	-	87.5(8)	72.7(11)	100(5)	100(6)	100(4)	80(5)	-	-	-	-
July	-	-	71.4(7)	83.3(12)	83.3(18)	44.4(9)	33.3(3)	-	-	-	-
Aug	-	80(10)	100(6)	60(10)	77.8(9)	-	60(5)	100(4)	-	-	-
Sep	-	-	84.6(13)	85.7(14)	-	100(4)	100(3)	-	-	-	-
Oct	-	50(4)	-	-	-	75(4)	100(5)	80(5)	88.9(9)	-	-
Nov	-	-	-	-	-	100(2)	71.4(7)	0(3)	33.3(3)	66.7(6)	-
Dec	-	-	-	57.1(7)	-	100(3)	100(2)	100(2)	-	-	-

DISCUSSION

The present survey covered 63 955 ha of oil palm in Peninsular Malaysia, whereas that of Basri *et al.* (1988) covered 695 630 ha for the whole of Malaysia. Nevertheless, the location and frequency of outbreaks for equivalent regions continued to follow the same pattern, *i.e.* outbreaks were concentrated in Perak and Selangor, and frequency could be singular to chronic. Basri *et al.* (1988) indicated that 5.3% of the surveyed area experienced bagworm outbreaks over a five-year period, or at an average of 1.1% of the area per year. The present study showed 59.1% infestation over 15 years or 3.9% of the area per year. Although these figures were not fully comparable owing to the differences in the total areas involved and their geographical distribution, a more extensive incidence of bagworms in the 69 estates of the present study was indicated. Infested areas were above ET, meaning that they had all been treated with pesticides. Assuming an average treatment cost of RM 14 - RM 62 ha^{-1} (Chung and Sim, 1993; Chung and Narendran, 1996), and that a conservative one round of treatment was carried out, RM 529 311-RM 2 344 090 would have at least been spent to manage the pests over the 15-year period. This did not consider the losses due to yield depression consequent to defoliation by the bagworms which could not be captured in this survey. There are thus obvious indications that bagworms are serious and costly pests of oil palm with no sign of abatement in their incidence in Peninsular Malaysia.

In the context of the extent and geographical distribution of recording, cumulative single species *P. pendula* infestations were almost four times higher than that of *M. plana*, while mixed species infestations were comparable with those of single species *P. pendula* infestations. As only infestations above ET were used, to reflect similar potential for if not intensity of damage, it was clear that *P. pendula* was the predominant and most troublesome bagworm pest of the estates surveyed. Wood (1971) reported a similar status of *P. pendula* during the initial outbreaks of bagworms in Peninsular Malaysia. *Metisa plana* only came into prominence after spraying with BSLRC insecticides. *Pteroma pendula* nevertheless continued to be the most common bagworm pest in Peninsular Malaysia in a survey carried out by the Malaysian Oil Palm Grower's Council over the period 1975-1980 (Wood, 1982). *Metisa plana* was considered the most serious pest by Basri *et al.* (1988) based on the extent of its infestations and the intensity of damage caused; however, *P. pendula* was a close second.

Basri *et al.* (1988) reported that all ages of oil palms were susceptible to bagworm attack with a slightly greater area of damage in palms of more than eight years of age. The present study shows this to be true only in single species *P. pendula* and *M. plana* infestations which had the greatest incidence in 8- to 15-year-old palms. Greatest infestations occurred in younger 3- to 7-year-old palms for mixed infestations whereas almost equivalent infestations occurred in 3- to 7-year-old and 8- to 15-year-old palms when the cumulative area of all three infestation types was considered. However, infestations were consistently lowest in palms older than 15 years. Basri *et al.* (1988) surmised that overlapping fronds of older palms increased the chances of infestation by facilitating dispersal. Siburat and Mojiun (1998) postulated that the closed canopies older palms shaded out ground vegetation and thus reduced the sources of shelter and food for the natural enemies of bagworms, and this in turn contributed to the

increase in the pest numbers. Results of the present study did not show clear support of these two theories, particularly in the light of the consistently lowest incidence of bagworms in palms more than 15 years old. Factors other than the age of palms would seem to be more important in predisposing outbreaks.

Except for single species *M. plana* infestations that followed the trend reported by Basri *et al.* (1988) that outbreaks occurred mostly in the first half of the year, no clear time-based incidence trend for the other infestation types was detected. Observations of bagworm outbreaks in Malaysia were often associated with low rainfall or drought (Syed and Shah, 1977; Basri *et al*., 1988; Hoong and Hoh, 1992); however, this association has not been statistically established. In the present study, attempts to correlate rainfall with incidence over months of each year showed no significant association. However, when comparing proportions of cumulative infestations above ET for the 15 years of survey with ranges of rainfall per month, the results show a preference by *M. plana* incidence for dry weather, and the opposite for *P. pendula*. Infestations of the latter occurred even with very high rainfall of 400-600 mm per month. This suggests a hitherto unrecognised differential in the influence of rainfall on bagworm species incidence. This same differential could also be the reason why rainfall has been reported to be unreliable in predicting outbreaks (Chung, 1998) because all bagworm species were assumed to have the same response to rainfall.

It is commonly believed that the marked seasonality of temperate regions results in insects living there often having discrete generations (Dempster, 1975), whereas in the tropics, insect generations are more likely to overlap because of more or less continuously favourable conditions (Banerjee, 1979). These generalisations could, however, be misleading as there are examples of tropical insects showing discrete and stable generations (Tothill *et al*., 1930; Bigger, 1976; Wolda, 1983). *Pteroma pendula* and *M. plana* in oil palm are further examples for which generations have been observed to be in phase (Wood, 1971, 1988; Basri and Kevan, 1995; Rhainds, 2000; Rhainds and Goh, 2000). Such synchrony was, however, believed to occur during outbreak situations, with generations overlapping during non-outbreak periods (Wood, 1988). For *M. plana* with its short adult life span, pheromone-mediated mate attraction to apterous females and coinciding emergence times for males and females have been postulated as factors promoting synchrony (Basri and Kevan, 1995; Rhainds, 2000). Present results provide further and quantified support of the synchronous nature of *P. pendula* and *M. plana* infestations, particularly in single species infestations; even in mixed species infestations, synchrony was high. Such synchrony was not only evident in infestations within estates, but also in different estates at any point in time. This suggests that besides the aforementioned factors, some other wider-acting factors could be involved. Godfray and Hassell (1987) demonstrated theoretically that the relative lengths of host and parasitoid generations could promote discrete generations in tropical insects when the natural enemies have a shorter generation time than the host. Basri *et al*. (1995) showed that the parasitoids of *M. plana* have this characteristic, and that they could thus contribute to the synchrony of bagworm generations. However, other biotic factors could be involved to synchronise infestations over several well-separated estates. As only data for infestations above ET were available, asynchrony of non-outbreak infestations could not be ascertained. However, the present study shows different results with single and mixed species infestations; thus, care should be exercised when generalising synchrony or otherwise of infestations. The present study suggests the need to conduct more detailed studies on *P. pendula* because findings on *M. plana* may not necessarily be applicable to *P. pendula*. In addition, response of each species to a similar factor, such as rainfall, had been found to be different. Although *P. pendula* is the predominant pest species, the pest status of *M. plana* is still not diminished owing to its greater damage potential and reproductive success through more efficient dispersion.

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