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Rat spatial distribution pattern and its relation to pod damage in a cocoa-coconut planting system

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Key words: rat, spatial distribution pattern, pod damage, cocoa-coconut planting system

Abstrak

Corak taburan ruang tikus dan hubungannya dengan kerosakan buah koko dalam sistem tanaman koko-kelapa telah dikaji di dua kawasan seluas 30 ha selama 20 bulan. Bilangan tikus, corak perlawatan, kerosakan buah dan kejadian pokok diserang, ditentukan di dalam satu grid segiempat bujur menggunakan 10 x 10 pokok koko sebagai koordinat di setiap kawasan. Jumlah tikus yang ditangkap dan ditanda dari kedua-dua kawasan masing-masing ialah 215 dan 307. Kebanyakan tikus ditangkap di jorket. Penyebaran intra-populasi dianggar mempunyai nilai K masing-masing 3.9 dan 8.7. Tidak semua koordinat dilawati dan kajian corak perlawatan menunjukkan berlakunya perkelompokan. Berdasarkan bilangan tikus yang ditangkap empat kali atau lebih, tikus jantan dan betina yang sama jumlahnya menunjukkan taburan yang berkelompok. Hanya sebilangan kecil populasi terutama tikus jantan, menunjukkan pergerakan rawak. Tiada seekor tikus pun yang menunjukkan penaburan yang berlebihan dan terkeluar daripada kawasan (hyperdispersion). Buah koko yang rosak berselerak dan tidak sama taburannya di kedua-dua kawasan tersebut. Nilai K bagi kerosakan buah di kedua-dua kawasan tersebut masing-masing ialah 1.16 dan 2.05, lebih kepada keadaan berkelompok. Keadaan pokok yang diserang juga menunjukkan perkelompokan yang rendah ke sederhana dengan nilai K 2.86 dan 3.06. Terdapat korelasi yang rendah di antara corak perlawatan dengan kerosakan buah.

Abstract

The spatial distribution pattern of rats and cocoa pod damage in a cocoa-coconut planting system was studied in two 30-ha fields for 20 months. Assessments of rat numbers, visitation patterns, pod damage and incidence of trees attacked were undertaken in a rectangular grid with 10 x 10 cocoa trees as co-ordinates in each field. The total number of animals caught and marked in the two fields were 215 and 307 respectively. A majority of the animals were caught on the jorquettes. The estimated intra-population dispersion had K values of 3.9 and 8.7 respectively. Not all co-ordinates were visited, and the visitation pattern studied showed animals to aggregate. Based on animals caught on four or more occasions, equal number of males

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and females showed clumped distribution. A few animals exhibited random movement, of which most were males. No animals showed hyperdispersion. Damaged pods were scattered and unevenly distributed in the two areas. The K values for both fields were 1.16 and 2.05 respectively, indicating clumped damage. The incidence of trees attacked also showed low to moderate clumping with K values of 2.86 and 3.06. Slight correlation was observed between visitation pattern and pod damage.

Introduction

Rats as the dominant vertebrate pest problem of cocoa in Malaysia is well documented (Han and Bose 1981; Kamarudin and Lee 1981; Lee 1982; Kamarudin et al. 1983). The extent of cocoa pod damage ranged from slight to serious (Conway 1971; Mainstone 1978; Han and Bose 1981; Lee and Arikiah 1984), and control using rat poisons to reduce rat population is frequently practised. According to Kamarudin (1983), successful field baiting depends to a large extent on correct timing and decision to bait.

Inherent to making baiting decision are pest population census and crop damage/loss estimates. Both these criteria had been the basis for most field baiting studies in cocoa (Han and Bose 1981; Lee and Kamarudin 1986) and even in oil palm (Wood 1969). Wood and Liau (1978) suggested baiting at 6-monthly intervals, these coincide with the beginning of rat population build-up. In other cases, especially in estates, baiting programmes are undertaken based on crop losses. Both techniques are laborious, unwieldy and uneconomical. Ho and Heong (1984) recommended sequential sampling, and although their method was based on sound principles of cocoa pod damage and losses, the pest population is not indicated. Similarly, the double-sampling technique was suggested by Kamarudin and Lee (1986). However, this technique would only be reliable if the assumption that the animals are randomly distributed is met. Thus, further knowledge on intra-population dispersion patterns of the pest species and the distribution pattern of pod damage would be important towards validation or improvement of the said control processes.

Materials and methods

Two cocoa-coconut fields (Field 35 and Field 36, approximately 30 ha each) in Kuala Bernam Estate were selected as the study sites. The fields were planted with semi-dwarf MAWA variety (about 8.0 m tall) at about 160 coconut palms/ha. The cocoa trees (about 3.4 m tall) were planted in twin-rows between the coconut rows at 3.0 m x 3.0 m. A rectangular grid of 10 x 10 rows of cocoa trees within the centre of each field was used for trapping of animals. In each grid, two traps were laid per trap point (one at the base and the other on a branch) with fresh coconut kernel as bait at two-tree intervals. Altogether 200 traps were laid within the grid system in each field.

Trapping of animals was done for three successive trapping nights within each month for 20 consecutive months. Rats trapped at each point were weighed, sexed, marked (ear-tagged) and released. Care was taken to ensure that released rats did not run back into the traps immediately. Assessment of damage was undertaken during every harvesting round. Pod damage was determined according to the method proposed by Kamarudin and Lee (1981) and were recorded as to their location within the 10 x 10 grid system.

The rat movement data and the damage incidences recorded were

Table 1. Cumulative damaged cocoa pods within the grid system (20-month study period)

Co-ordinates between rows	No. of damaged pods (co-ordinates within row) 1	2	3	4	5	6	7	8	9	10	Total
Field 35											
A	8	8	5	12	14	5	2	7	0	0	61
B	7	27	6	11	8	0	2	2	3	0	66
C	10	9	11	12	5	5	7	4	6	0	69
D	19	12	12	13	7	3	10	3	0	2	81
E	7	13	21	6	7	16	11	3	5	0	89
F	7	7	11	15	12	10	5	5	1	0	73
G	21	11	14	5	3	6	13	0	3	0	76
H	8	7	14	14	8	5	5	2	2	0	65
I	10	12	6	7	8	6	8	0	1	2	60
J	0	3	0	0	7	0	0	0	0	0	10
Total	97	109	100	95	79	56	63	26	21	4	650
Field 36											
A	23	9	14	23	16	11	9	20	12	9	146
B	15	21	8	12	4	11	15	17	6	1	110
C	21	9	18	8	3	4	11	10	11	0	95
D	13	14	13	20	8	7	24	12	11	4	126
E	41	43	28	19	11	5	8	15	8	0	178
F	10	10	41	16	14	6	11	9	0	0	117
G	13	16	36	12	19	7	11	31	13	3	161
H	17	13	15	20	5	9	16	15	10	10	130
I	22	18	18	6	15	2	5	6	8	2	102
J	17	24	10	22	9	11	6	30	1	0	130
Total	192	177	201	158	104	73	116	165	80	29	1 295

analysed using the negative binomial method (Cox 1976) to determine its dispersion. Since locations of rats caught within the grid system were available, recordings of animals trapped for four or more occasions were used to determine the visiting pattern of each animal following the method of Stapanian et al. (1982). The frequency of visits to co-ordinates within the spatial distribution and the spatial position of damaged pods within the grid-system were also determined and correlated.

Results

Damaged pod distribution

The distribution of damaged pods within the 10 x 10 grid system varied *(Table 1)*. Damaged pods per tree ranged from as high as 43 to no damage (a co-ordinate). Analysis of damaged pod dispersion using the negative binomial method gave K values (a measure of intensity of aggregation) of 1.16 for Field 35 and 2.05 for Field 36. Taking trees with at least one damaged pod as a measure of damage incidence sampled at monthly intervals throughout the study, none of the trees was seen to be attacked on every sampling occasion *(Table 2)*. The extent of damage incidences recorded ranged from zero to 12, with a few trees experiencing a high frequency of attack. The K values for trees with at least one damaged pod were 2.86 for Field 35 and 3.06 for Field 36.

Animal distribution

The total number of animals caught and marked throughout the 20-month study period were 215 (134 males and 81 females) in Field 35, and 307 (181 males and 126 females) in Field 36 *(Table 3)*. More males were caught as compared with females (ratio of 1.65:1 for Field 35, and 1.44:1 for Field 36). Their weights ranged from 20 g to 170 g for males, and 20 g to 144 g for females. A majority of the animals were caught on tree tops (jorquettes/branches) as compared with those on the ground. All the animals caught were *Rattus tiomanicus* (Miller).

Of the 215 animals recorded in Field 35, 52 animals (25%) were caught on four or more occasions *(Table 4)*. Similarly for the 307 animals caught in Field 36, 73 animals (24%) were caught four or more occasions. A majority of these animals showed clumped distribution (Field 35: 17 males and 21 females; Field 36: 36 males and 33 females), to random movement (13 males and one female for Field 35; three males and one female for Field 36). The number of males to females showing clumped distribution was not significantly different. In contrast, more males compared with females exhibited significant random movements ($p < 0.05$). The rat visitation pattern for co-ordinates within the grid-system was not even *(Table 5)*. Some co-ordinates had no visit while others had as high as 20 visits throughout the 20-month study. The uneven trapping distribution probably indicated the presence of both segregation and aggregation activities. Tabulation of the frequency of visits (trappings) to the number of traps showed that a majority of the traps had been visited four or more times *(Table 6)*. A negative binomial analysis of the number of visits showed that the K value for Field 35 was 3.9, and for Field 36 to be 8.71. The K values increased with the inclusion of the data from second and third trapping night for each trapping occasion.

A higher rat activity (based on the number and frequency of trapped rats) was recorded in Field 36 as compared with that of Field 35. Correlation of pod damage distribution *(Table 1)* to frequency of rat visits *(Table 3)* gave an r value of 0.260 (df = 98; $P_{0.05} = 0.197$) for Field 35 and 0.068 (df = 98; non-

Table 2. The number of cocoa trees with various damage incidences* (20-month study period)

Frequency of damage incidences	No. of cocoa trees	
	Field 35	Field 36
0	58	44
1	34	34
2	37	59
3	35	36
4	18	39
5	19	29
6	3	12
7	4	7
8	2	6
9	0	6
10	0	6
12	0	1

*trees that had at least 1 damaged pod

Table 3. Number of rats caught in two cocoa-coconut fields based on sex and trap position (20-month study period)

Field	Sex	Body wt. (g)	No. of rats caught		
			J	G	Total
35	M	85 (26–170)	103	31	134
	F	67 (20–124)	57	24	81
	Total		160	55	215
36	M	88 (20–158)	109	72	181
	F	73 (20–144)	72	54	126
	Total		181	126	307

J = jorquette
G = ground
Values in brackets indicate range of body weight

Table 4. Movement pattern for rats caught on four or more occasions (20-month study period)

Field	Movement	Sex	No.	Body wt. (g)
35	Clump	M	17	80 (26–100)
		F	21	86 (44–124)
		Total	38	
	Random	M	13	100 (56–125)
		F	1	60 –
		Total	14	
36	Clump	M	36	92 (24–140)
		F	33	75 (28–116)
		Total	69	
	Random	M	3	110 (78–132)
		F	1	98 –
		Total	4	

Values in bracket indicate range of body weight

Table 5. Frequency of rat visits to co-ordinates within the grid system (20-month study period)

Co-ordinates between rows	No. of damaged pods (co-ordinates within row) 1	2	3	4	5	6	7	8	9	10	Total
Field 35											
A	8	8	3	10	6	2	4	3	10	15	69
B	6	0	1	3	3	2	3	4	11	11	44
C	6	0	7	6	2	4	8	1	3	3	40
D	3	3	2	7	7	3	2	2	2	7	38
E	4	6	2	4	3	8	5	5	4	8	49
F	4	8	2	6	3	5	2	1	8	4	43
G	6	6	5	7	5	4	2	2	5	16	58
H	6	6	7	5	3	3	4	7	5	9	55
I	9	8	1	2	5	3	3	5	2	4	42
J	8	20	5	3	12	4	10	17	10	20	109
Total	60	65	35	53	49	38	43	47	60	97	547
Field 36											
A	10	9	1	15	5	5	15	11	6	8	85
B	10	10	13	6	4	1	0	17	2	7	60
C	9	8	6	11	3	6	4	9	6	7	69
D	7	5	9	2	8	9	5	9	8	6	68
E	15	7	10	4	10	4	1	6	4	8	69
F	3	10	1	10	10	8	8	10	3	8	71
G	6	6	8	12	9	9	8	11	8	11	88
H	8	6	8	10	7	9	10	15	8	12	93
I	12	5	1	7	9	11	10	14	5	5	79
J	15	20	3	16	11	7	8	3	12	12	107
Total	95	86	60	93	76	69	69	95	62	84	789

significant) for Field 36. The coefficient of determination R^2 were 0.066 for Field 35 and 0.005 for Field 36. Within row correlation analysis, the r values ranged from 0.043 to 0.710 and between row, the r values ranged from 0.024 to 0.964. With df = 8 and $P_{0.05} = 0.632$, the correlation was high in some cases and low in others.

Table 6. Frequency of rat visits to co-ordinates laid out in Field 35 and Field 36 (20-month study period)

Frequency of visit (x)	Field 35		Field 36	
	(f)	(fx)	(f)	(fx)
0	2	0	1	0
1	4	4	5	5
2	14	28	2	4
3	17	51	5	15
4	12	48	5	20
5	11	55	7	35
6	10	60	10	60
7	7	49	8	56
8	9	72	15	120
9	2	18	10	90
10	4	40	12	120
11	2	22	6	66
12	1	12	5	60
13	0	0	1	13
14	0	0	1	14
15	1	15	5	75
16	1	16	1	16
17	1	17	0	0
20	2	40	1	20
Total	100	547	100	789

(f) = number of co-ordinates
(fx) = activity of use

The coefficient of determination R^2 within rows ranged from 0.004 to 0.313 and between rows 0.000001 to 0.516.

Discussion

A higher proportion of the animals trapped were adults (mean body weights for males in Field 35 and Field 36 were 85 g and 88 g, and for females 67 g and 73 g respectively). The extent of pod damage in Field 36 was higher than that of Field 35. This corresponded to the abundance of animals seen in Field 36. The grid system in both the study sites were about equal in size, but the abundance of animals noted in both fields differed. Similar findings had been reported earlier by Lee (1982), Lee and Arikiah (1984) and, Lee and Kamarudin (1986). Therefore, it was inferred that population distribution of the said animals was probably dependent upon the field carrying capacity.

A larger number of animals were caught on the jorquettes as compared with that caught on the ground. This concurred with the earlier findings of Kamarudin (1983) with matured cocoa-coconut plantings, in contrast to Harrisons (1957) in shrubs and Lee (1982) for early cocoa plantings, where most of the animals were caught at ground level. The close cocoa canopy cover probably favours arboreal activity. Within the two plots, a higher proportion of the animals caught were males. This finding differed from other earlier field studies (Lee 1982; Lee and Arikiah 1984; Lee and Kamarudin 1986), where a larger proportion of the animals caught were females.

The number of males in both fields were large and the ratio of males to females showing clumped activity was almost unity, while the rest of the males exhibited random movement. There was no hyperdispersion in this study. Stapanian et al. (1982) cautioned that hyperdispersion (animals moving out of the area) would not be indicated if distances between co-ordinates were greater than the usual average distance moved. The distance between co-ordinates (9.0 m) was less than the usual average distance of 15 m traversed by rats (Kamarudin 1984), and therefore the above caution does not apply. The males exhibiting random movement were subadults and adults, suggesting that they were probably seeking to establish new homes or were displaced from their current homes.

In the determination for intra-population dispersion, Cox (1976) using the negative binomial analysis, mentioned that the K value generally lies between 0.5 and 3.0, and that the smaller the K value the greater would be the aggregation. The degree of dispersion of damaged pods (K = 1.16 for Field 35; K = 2.05 for Field 36) and incidence of trees attacked (K = 2.86 for the Field 35; K = 3.06 for Field 36) indicated higher aggregation in the former than the latter. Higher K values for damaged pods and incidence of trees attacked were noted for Field 36 as compared with Field 35 probably implied that the larger the population the less clumped the population members be.

The visitation pattern of the co-ordinates analysed using the negative binomial technique had K = 3.9 for Field 35 and K = 8.71 for Field 36 (both values were higher than the general range of K = 0.5 to 3.0) indicated that the population was disperse. It is thus postulated that the tendency for rats to clump probably occur when the population is low. If this is true then the relationship between large rat population and damaged pod distribution therefore, could be a result of only a portion of the rat population that are causing the damage. The above hypothesis is supported by the positive correlation of rat activity and pod damage to be high in some cases and low in others. Everard (1968) had noted that not all rats fed on cocoa pods. Nevertheless, the non-feeders would readily feed upon cocoa once they learned to do so.

Most cocoa-coconut plantings are of field sizes of 5–30 ha. These fields are usually subdivided into smaller blocks of about 2 ha. Currently in some estates, during harvesting all damaged pods in the respective blocks are recorded for management purposes to carry out rat-baiting. This study showed that damaged pods can vary from a low 10 to high 178. Therefore, if assessment of pod damage in blocks was taken for every 10th row, as suggested by Ho and Heong (1984), there is a greater chance of making wrong control decisions in some fields. Also the sampling method proposed by Kamarudin and Lee (1986) could not apply. Thus the decision to control would be better-off if pod damage per tree could be ascertained within the localised block since the damage incidences were clumped. In this manner, the cost of the rat control programmes probably could be reduced.

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