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DISTRIBUTION PATTERN OF *APHIS GOSSYPII* AND ITS COCCINELLID PREDATOR *MENOCHILUS SEXMACULATUS* IN THE CHILLI ECOSYSTEM

POLA DISTRIBUSI APHIS GOSSYPII *DAN PREDATOR KOKSINELID* MENOCHILUS SEXMACULATUS *PADA EKOSISTEM CABAI*

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INTISARI

Studi tentang pola penyebaran Aphis gossypii *Glover (Homoptera: Aphididae) predator* Menochilus sexmaculatus *Fabricius (Coleoptera: Coccinellidae) dilakukan ekosistem cabai di Kebun Percobaan Universiti Putra Malaysia. Hasil penelitian menunjuk bahwa penyebaran* M. sexmaculatus *berkorelasi positif dengan penyebaran mangsa. Penyebaran lateral dan vertikal* A. gossypii *serta* M. sexmaculatus *dikategorikan sebagai penyebaran mengelompok.*

Kata kunci: Aphis gossypii, Menochilus sexmaculatus, *distribusi*

ABSTRACT

A study on the distribution pattern of *Aphis gossypii* Glover and its coccin predator, *Menochilus sexmaculatus* Fabricius, was conducted in a chilli ecosystem at experimental field of Universiti Putra Malaysia. The study had revealed that distribution o *sexmaculatus* positively correlated with its prey distribution. The patterns of lateral vertical distribution of *A. gossypii* and *M. sexmaculatus* were categorised as a clumped patt

Key words: *Aphis gossypii, Menochilus sexmaculatus,* distribution

INTRODUCTION

Aphis gossypii Glover (Homoptera: Aphididae) (hereafter referred to as AG), has a wide range of host plant including chilli. AG is one of the most important pest of chilli in Malaysia (Salim, 1994) and *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae) (hereafter referred to as MS), is the predominant predator (Maisin *et al*., 1994) and found to be responsible in controlling populations of AG (Salim & Hussein, 1994). The predator has been reported as a good candidate for biological control of aphids (Parker *et al*., 1976; Hussein, 1991; Maisin *et al*., 19 However, a field study for describing distribution patterns of MS and its AG, has never been attempted. Sp distribution pattern of a predator and its is an essential information needed in ord analyse their relationship (Hassel & 1974). Populations of a predator and its may be distributed in a random, clump an uniform pattern (Ludwig & Reyn 1988).

The distribution of prey ha impact on the stability of the predator interactions through response of the pre to its prey distribution. The distrib patterns of AG and MS, and response of MS to the AG distribution in the chilli ecosystem were not understood. As such, the objective of the study was to determine the behavioural characteristics of MS in relation to the distribution of its prey in the chilli ecosystem.

MATERIALS AND METHODS

The study was conducted at the Experimental Field 2 at Universiti Putra Malaysia. Field reservoirs of MS were established by planting long bean as border crops around the chilli plot (30 x 20 m). The long beans, planted 25 days prior to transplanting of chilli seedlings, were intended to be a trap crop for *A. craccivora*, the prey of MS.

A total of 720 chilli seedlings var. Kulai (35 days old) were transplanted in the plot at a spacing of 100 cm between rows and 60 cm within row. Standard cultural practices were employed in growing the crops and no insecticide was applied. The plants were individually supported by a wooden stake to prevent damage from strong wind.

Reservoirs of AG were established on three aphid-infested chilli seedlings planted in each of the four borders of the chilli plot. The chilli plants inside the plot were naturally colonised by AG and MS. The study was to determine the relationship between single species of predator and prey, hence, other predators namely syrphids, chrysopids, coccinellids and spiders found in the chilli crops were hand-picked and removed. Other insect pests such as leaf feeders were also eliminated in a similar manner.

Spatial Distribution Patterns. Number of AG and MS per plant was recorded *in situ* to determine their lateral and vertical distribution patterns. The term of 'lateral distribution' is hereby defined as the distribution of AG and MS populations on chilli plants within a plot. The lateral distribution pattern was determined from the 75 to 100 sample plants. The term of 'vertical distribution' is hereby defined as the distribution of AG and MS populations on chilli leaves within a plant. The vertical distribution pattern was determined from 12 aphid- and MS-colonised plants which were taken at random beginning at 20 days after transplanting (DAT) and ending at 25 DAT when their populations were on the increase.

The spatial distribution patterns of AG and MS were determined following the procedures described by Ludwig & Reynolds (1988). These procedures dealt with the relationship between the mean and the variance of their number per sampling unit. The distribution pattern was categorised according to three criteria namely index of dispersion (ID), Green's index (GI) and dispersion parameter of the negative binomial ($\hat{k}$).

Index of dispersion (ID) was calculated using the following formula:

$$ID = \frac{s^2}{\bar{x}} \quad \text{(Ludwig \& Reynolds, 1988)} \quad [1]$$

where $\bar{x}$ was the sample mean and s^2 was the sample estimate of variance. The ID indicates random pattern when $\bar{x} = s^2$, clumped pattern when $\bar{x} > s^2$ and uniform pattern when $\bar{x} < s^2$.

Green's index (GI) was calculated using the following formula:

$$GI = \frac{(s^2 / \bar{x}) - 1}{N - 1}$$

(Ludwig & Reynolds, 1988) [2]

where N was total number of sampling units. GI = 1 indicates the maximum clumped pattern, GI = 0 indicates the random pattern and GI = -1/(n-1) indicates the maximum uniform pattern.

To estimate the $\hat{k}$ values, individuals of AG and MS were assumed to be present in discrete manner. The data were expressed as frequency distributions which consisted of the number of sampling units with 0, 1, 2 individuals, and so on. The $\hat{k}$ estimate was obtained using the following iterative equation:

$$\log_{10}(n/n_0) = \hat{k}\log_{10}[1+(\bar{x}/\hat{k})]$$

(Ludwig & Reynolds, 1988) [3]

where n was the total number of sampling units, n_0 was the number of sampling units with zero individuals, and $\bar{x}$ was the sample mean A value of $\hat{k}$ was found after the equation was balanced. The $\hat{k}$ estimate for the first iteration was obtained from:

$$k = \bar{x}^2/(s^2-\bar{x})$$

(Ludwig & Reynolds, 1988) [4]

where s^2 was the sample estimate of variance. For a sample size of <30, the fitting of the data to the negative binomial model was confirmed by chi-square test (X^2);

$$X^2 = \left(\sum_{i=1}^{n}(x_i-\bar{x})^2\right)/\bar{x} = \mathrm{ID}(N\text{-}1)$$

(Ludwig & Reynolds, 1988) [5]

where x_i was the number of individuals in the ith sampling unit and N was the total number of sampling units. For a sample size of >30, the fitting of the data to the negative binomial model was confirmed by d statistic:

$$d = \sqrt{2X^2} - \sqrt{2(N-1)-1}$$

(Ludwig & Reynolds, 1988) [6]

The null hypothesis stated that the distribution patterns were not significantly different from clumped. If the values are >1.96, there is no evidence to reject the null hypothesis or the distribution patterns are not significantly different from clumped. The ID, GI and $\hat{k}$ were computed using the programmes of NEGBINOM.BAS and POISSON.BAS developed by Ludwig and Reynolds (1988).

Response of *M. sexmaculatus* to *A. gossypii* Distribution. The MS response to the AG distribution was indicated by the relationship between their $\hat{k}$ values. Linear regression and correlation was applied to determine the influence of AG distribution to the MS distribution and the direction (positive or negative) of the correlation. The independent variable was $\hat{k}$ value of AG and the dependent variable was $\hat{k}$ value of MS. The degree of relationship was based on the values as follows (Guilford & Fruchter, 1973):

Coefficient correlation (r)	*Degree of relationship*
<0.20	: negligible relationship
0.21 to 0.40	: definite but weak relationship
0.41 to 0.70	: moderate relationship
0.71 to 0.90	: strong relationship
>0.90	: very strong relationship

The $\hat{k}$ values were very small, ranged from 0.01 to 0.61, and the data tended to proportional with the means, hence, transformation into $\sqrt{x}$ was made to ensure the data normality. The ANOVA was made to apportion variance of the regression.

RESULTS AND DISCUSSION

Spatial Distribution Patterns. The lateral distribution for AG throughout the observation dates followed the negative binomial or a clumped pattern. Table 1 shows that variance of the means for AG were much higher than those of the means. The index of dispersion (ID) values ranged from 4.51 to 1,199.72 which categorised as clumped pattern; $s^2>\bar{x}$. The values of Green Index (GI) ranged from 0.04 to 0.51 which were categorised as clumped pattern; GI = 1 is maximum clumping. These distribution patterns were also confirmed with the values of $\hat{k}$ which tended towards zero (0.001 to 0.234). In addition, the d statistics for the $\hat{k}$ ranged from 15.85 to 362.19 which were agreement with a clumped dispersion (d >1.96 and P>0.05).

Table 1. Mean density and distribution parameters for *A. gossypii* within a chilli plot

DAT	N	$\bar{x}$	s^2	ID	GI	$\hat{k}$	d	Dist.
7	100	0.09	0.41	4.51	0.4388	0.001	15.85	n.b.
10	100	0.49	5.20	10.62	0.2003	0.024	31.81	n.b.
13	100	4.02	577.98	139.51	0.3420	0.022	152.16	n.b.
16	100	20.56	4427.50	215.34	0.1043	0.056	192.45	n.b.
19	100	41.13	17167.55	417.40	0.1017	0.071	271.79	n.b.
22	100	121.02	76675.31	633.58	0.0472	0.083	308.93	n.b.
25	100	122.37	46809.40	1199.72	0.0532	0.170	281.06	n.b.
28	75	168.40	185729.10	1102.90	0.0427	0.234	238.55	n.b.
31	75	131.73	156362.10	1186.94	0.0706	0.131	362.19	n.b.
34	75	7.63	900.70	118.10	0.2051	0.097	120.08	n.b.
37	100	5.72	288.85	50.50	0.0867	0.168	85.96	n.b.
40	100	14.73	8105.70	550.28	0.3732	0.066	316.05	n.b.
43	100	1.82	30.41	16.71	0.0868	0.096	43.48	n.b.
46	100	5.79	1705.00	294.47	0.5077	0.034	227.43	n.b.
49	100	0.36	6.03	16.75	0.4501	0.012	43.56	n.b.

DAT = Days after transplanting. N: Number of sample plant. Dist.: Distribution pattern. n.b.: negative binomial (clumped pattern). $\bar{x}$: mean, s^2: variance. ID: Index of dispersion = $s^2/\bar{x}$; random pattern ($s^2 = \bar{x}$), clumped pattern ($s^2 > \bar{x}$), uniform pattern ($s^2 < \bar{x}$). GI: Green Index; the degree of clumping, GI = 0 randomness, GI = 1 maximum clumping, GI = -1/(n-1) maximum uniformity. $\hat{k}$: the dispersion parameter of negative binomial; maximum clumping $\hat{k}$ tends towards zero. d: the d statistic; $|d|<1.96$ agreement with a random dispersion, $d<-1.96$ with a regular dispersion, $d>1.96$ with a clumped dispersion (P>0.05).

The lateral distribution for MS throughout the observation dates was also described as a clumped pattern. Table 2 shows that the values of ID ranged from 1.48 to 41.19, GI ranged from 0.03 to 0.51 and $\hat{k}$ ranged from 0.004 to 0.45 with the d statistics ranged from 3.05 to 73.52. These parameters showed that in 16 to 46 DAT, the distribution for MS fitted with a clumped pattern.

Table 2. Mean density and distribution parameters for *M. sexmaculatus* within a chilli plot

DAT	N	$\bar{x}$	s^2	ID	GI	$\hat{k}$	d	Dist.
16	100	0.04	0.06	1.48	0.1582	0.059	3.05	n.b.
19	100	0.44	10.09	22.93	0.5099	0.004	53.34	n.b.
22	100	2.05	79.36	38.71	0.1849	0.027	73.52	n.b.
25	100	4.04	147.19	36.43	0.0879	0.075	70.90	n.b.
28	75	4.49	185.06	41.19	0.1196	0.108	65.95	n.b.
31	75	2.25	55.81	24.77	0.1415	0.270	48.42	n.b.
34	75	0.87	3.71	4.28	0.0513	0.331	13.05	n.b.
37	100	0.25	0.45	1.81	0.0337	0.446	4.89	n.b.
40	100	0.71	11.54	16.26	0.2179	0.034	42.70	n.b.
46	100	0.07	0.13	1.81	0.1342	0.087	4.87	n.b.

Note: The notations are as the same with Table 1.

The AG population was mostly distributed at the bottom of the chilli plant. Figure 1 shows the vertical distribution patterns for AG within a chilli plant (20 to 25 DAT). The female MS laid eggs on the leaves with high prey numbers, although some eggs were also observed laid on leaf without aphids but close to the other leaves with aphids. It can be seen in Figure 1 that the MS eggs were confined to the leaves with high number of AG.

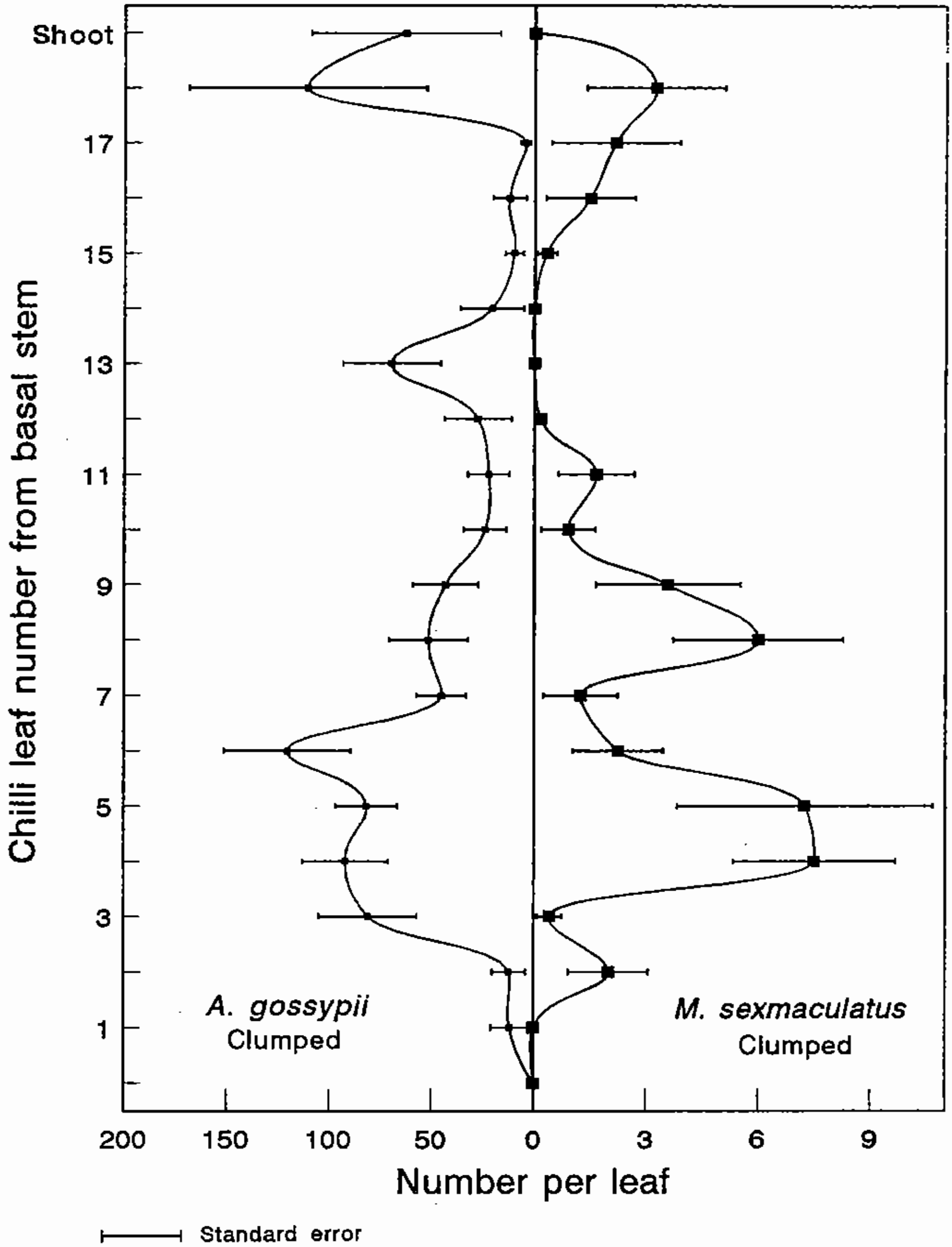

Figure 1. Distribution of *A. gossypii* and *M. sexmaculatus* (eggs) in relation to the position of the chilli leaf.

The vertical distribution for AG within chilli plant, as shown in Figure 1, followed the negative binomial or clumped pattern as indicated by ID values ranged from 4.05 to 14.93; GI values ranged from 0.0266 to 0.2732 and non-significant $\hat{k}$ values 0.12 to 0.61. Likewise, the vertical distribution for MS eggs, as shown in Figure 1, also followed the negative binomial as indicated ID values ranged from 9.93 to 32.09; GI values ranged from 0.21 to 1.00, and non-significant $\hat{k}$ values (0.01 to 0.08).

Response of *M. sexmaculatus* to *A. gossypii* Distribution. There was a tendency for MS distribution to positively correlated with AG distribution. The relationship between $\hat{k}$ values for AG (X) and MS (Y) distributed within a plot was indicated by Y = 0.0232 + 0.9619X and the correlation coefficient was not significant ($r = 0.46^{ns}$). It indicates that there was no relationship between AG distribution and MS distribution within chilli plot. On the other hand, AG distribution within a chilli plant influenced significantly the MS eggs distribution as indicated by Y = - 0.0076 + 0.3399X and a significant coefficient-correlation ($r = 0.65^{*}$, $P<0.05$). The degree of relationship was moderate (Guilford and Fruchter, 1973).

CONCLUSION

The study had revealed that the spatial distribution for both MS and AG was clumped. Positive coefficient correlation between $\hat{k}$ values of AG populations and MS egg populations indicates that MS responded positively to the AG distribution. Further research is suggested to study the implementation of pest management concept in the chilli ecosystem with exploiting the abundance of natural enemies.

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