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Aggregation and Sampling Plan in three Aphidophagous Predators in a Guava Ecosystem

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ABSTRACT

Studies carried out in a guava ecosystem on three aphidophagous coccinellid predators showed that *Cheilomenes sexmaculata* (Fabricius), was spatially aggregated throughtout, while *Pseudaspidimerus circumflexa* (Motschulsky) and *Scymnus castaneus* (Sicard) had an initial random distribution which later tended to aggregation with increased mean density. However, aggregation did not seem to influence sample number with a nonsignificant correlation. Appropriate sampling plans were developed for all the three predators. At 25% precision level, the number of trees for sampling were 18, 32 and 48, respectively for the three species. A linear model was also developed to arrive at an optimum sample number for combined or individual predator estimation. As per the linear model, for example, a mean density of 2 predators/tree would require 26 trees. The sampling plans which are on sound ecological lines have relevance in biological control studies.

KEY WORDS : Aggregation, sampling, *Cheilomenes sexmaculata* *Pseudaspidimerus circumflexa*, *Scymnus castaneus*, guava

The assumption that predators occur and search at random is mathematically convenient, but biologically unrealistic. Predators tend to orient or aggregate to regions of high profitability according to Royama (1970) in his hunting model on the insectivorous bird, the great tit. Aggregation has a few implications in biological control; Firstly, predator aggregation in patches of high prey abundance provides a potentially powerful stabilizing mechanism for predator-prey interaction (Hassell, 1978; Walde and Murdoch, 1988).Secondly, because of predator aggregation, low density patches of prey become prey-refuges, also contributing to the stabilizing mechanism (Verghese, 1992). Thirdly, predator aggregation influences enumeration and field estimation, affecting sampling. Sampling plans for natural enemies are very essential for evaluating their field efficacy (DeBach *et al.*, 1976). In India, absence of ecologically based sampling plan for almost all the natural enemies is a serious lacunae in biological control programmes. Inadequate or haphazard sampling can lead to erroneous conclusions (Kuno, 1991). The objectives of this paper are to evaluate the spatial distribution of the three aphidophagous predators *viz.*, *Cheilomenes sexmaculata* (Fabricius), *Pseudaspidimerus circumflexa* (Motschulsky) and *Scymnus castaneus* (Sicard) (all Coccinellidae, Coleoptera) in a guava ecosystem and to arrive at suitable sampling plans for these predators on sound ecological lines, as these are important predators of the aphid, *Aphis gossypii* Glover (Mani and Krishnamoorthy, 1989).

MATERIALS AND METHODS

The study was conducted in a guava orchard, during 1990, on the outskirts of Bangalore. The trees were 15 years old. Population monitoring of insects in guava ecosystems between 1987 and 1989 showed that the aphidophagous predators and the aphids were abundant between March/April and June. So the present study was confined to the period between April and June.

The predators were monitored every fortnight on 10 randomly selected trees. Each tree was delineated into four quadrants of north, south, east and west. The selected trees were 'fixed' for all the fortnightly insect counts, as was done for coccinellid estimation in apple orchards by Lovei, (1991). Enumeration was done by *in situ* visual search counting, as it is better than other methods like sweep net, foliage shake and collect, etc. (Whitcomb, 1981).

The data of two fortnights grouped monthwise were subjected to spatial dispersion and sampling analyses as given in Southwood (1978). Aggregation was assessed using the parmeters variance/mean (V/M) ratio and 'k' of the negative biomial using the formula given below, which is appropriate for small mean densities.

$$k=\frac{\bar{x}^2}{s^2-\bar{x}}$$

Where $\bar{X}$ is the mean and s^2 the variance.

Sample numbers at precision levels of 10%, 20% and 25% have been calculated, as advocated by Southwood, 1978.

RESULTS AND DISCUSSION

The spatial dispersion V/M and 'k" of the three predators are presented in Table 1. V/M ratio more than unity implies aggregation, while value in the region of unity suggest random distribution (Southwood, 1978). The spatial distribution of *C.sexmaculata* was aggregated in all the three months, which was supported by the fractional 'k' values, implying contagious or clumped distribution. In *P.circumflexa,* at a lower mean density in April, there was tendency to random distribution, which however became aggregated in May and June. *S.castaneus* had uniform mean density throughtout, but showed aggregation only in June, which coincided with peak aphid density (Verghese, 1992). This is perhaps, due to aggregation to high host density (Murdoch and Stewart-Oaten, 1989).

When predators were considered in combination, the spatial distribution trend showed an increased aggregation (V/M) with increased mean density (x). This fitted linearly to the model y=0.63x + 3.94 (r=0.5831; significant at 10%).

However, this trend, may not operate at very high densities, due to mutual intraspecific interference or inter-specific competitions. The maximum number of predators per tree observed was 19. This, over a range of sampling units (quadrants) with several zeros, as to be expected in a negative binomial model, diminishes the mean density considerably.

The aggregation parameter, V/M ratio was not correlated to the number of samples (r= -0.0904: not significant) implying a non interference of aggregation pattern in sampling. This makes the development of sampling plan easier.

Table 1. Spatial dispersion parameters for the aphidophagous predators during peak season

Predators	Period (1990)	Mean (per quadrant)	Variance	V/M	k
C. sexmaculata	April	0.55	0.89	1.62	0.89
	May	0.30	0.54	1.80	0.38
	June	0.45	0.89	1.98	0.46
P. circumflexa	April	0.10	0.095	0.95	-
	May	0.50	2.16	4.32	0.15
	June	0.40	0.88	2.21	0.33
S. castaneus	April	0.20	0.17	0.84	-
	May	0.20	0.20	1.00	-
	June	0.20	0.48	2.42	0.14

Table 2. Number of sampling units for *C. sexmaculata*

Sampling months (1990)	Degree of precision (SE of % of X)		
	10%	20%	25%
April	296.53	74.13	47.44
May	600.00	150.00	96.00
June	439.51	109.88	70.32
Quadrants			
Total	1336.04	334.01	213.76
Mean	445.35	111.34	71.25
Rounded to nearest four trees	444	112	72
Number of trees	111	28	18

In Tables 2-4, the sampling units have been scaled up from quadrants to a tree, as predator density expressed in a larger universe is more useful in biological control investigations (DeBach *et al.*, 1976). Individually, for *C.sexmaculata, P.circumflexa* and *S.castaneus,* the number of trees required are 18, 32 and 48, which is an inverse trend with density as evident from the earlier model and Tables 1-4. In this situation, if a combined sampling for all the predators is envisaged, the number of trees should be taken as 48, considering the low density of *S.castaneus*. However if preliminary sampling show a higher *S.castaneus* or a combined predator mean density, then sampling 48 trees would be a waste of time and labour.

This was resolved, using another linear model combining the means of the three aphidophagous predators as x variable and number of trees at 20% and 25% precision levels as y variable. This is presented in Table 5. The number of samples (trees) is given by:

$$y=281.45\ x - 355.72$$

($r=-0.477$; significant at 5%; $df=16$)

When compared with tables 2-4, the model seemed to operate for individual predators too.

According to Bryant (1976) and Kapatos *et al.* (1977), the optimum number of samples will change in a field with time and different levels of population. Optimum sample number, therefore has to be fixed, after preliminary sampling (Southwood, 1978), following delineation of a tree into quadrants, atleast on ten trees; in apples, five trees have been found convenient (Lovei, 1991). Once optimum sample number is fixed, trees should be selected at random and fixed for subsequent monitoring. Counting should be by *in situ* canopy-search, with tree as units.

This study has shown aggregation with increased mean density to be the general pattern of spatial distribution for aphidophagous coccinellid predators in a guava ecosystem.

Table 3. Number of sampling units for *P. circumflexa*

Sampling months (1990)	Degree of precision (SE of % of X)		
	10%	20%	25%
April	950	237.5	152
May	864	216.0	138.24
June	550	137.5	88
Quadrants			
Total	2364	591	378.24
Mean	788	197	126.08
Rounded to nearest four trees	788	196	128
Number of trees	197	49	32

Table 4. Number of sampling units for *S. castaneus*

Sampling months (1990)	Degree of precision (SE of % of X)		
	10%	20%	25%
April	425	106.25	68
May	2000	500	320
June	1200	300	192
Quadrants			
Total	3625	906.25	580
Mean	1208.33	302.08	193.33
Rounded to nearest four trees	1208	300	192
Number of trees	302	75	48

Table 5. Model giving optimum number of samples for different mean densities of aphidophagous predators.

Mean		Optimum sample numbers	
per quadrant	per tree	No. of quadrants	No. of trees (20-25% precision level)
0.10	0.40	245.88	61
0.20	0.80	210.31	53
0.30	1.20	174.74	44
0.40	1.60	139.17	35
0.50	2.00	103.59	26
0.60	2.40	68.02	17
0.70	2.80	32.45	8
0.75	3.00	14.66	4
0.78	3.12	4.00	1

However, aggregation pattern does not seem to influence sample number. For combined sampling of predators a linear model developed gave the optimum sample number. This model can be used for individual predators too. The sampling plans arrived at here, is feasible and ecologically sound for reliable precision estimates for use in biological control studies.

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