*Journal of Biological Control*, 25 (1): 51– 54, 2011


**Research Note**

# Spatial distribution of *Cheilomenes sexmaculata* (Fabricius), an important predator of bean aphid, *Aphis craccivora* Koch in green gram

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**ABSTRACT**: Field studies were conducted to study the spatial distribution of *Cheilomenes sexmaculata* (Fabricius) during summer and *kharif* seasons, 2009 at instructional cum research farm of Assam Agricultural University, Jorhat, Assam. Various indices of dispersion were used to study the distribution pattern. In both seasons, the variance to mean ratios were found to be less than unity, dispersion parameter 'k' was less than 8 and David and Moore's indices of clumping were negative. Also, Lloyd's indices of mean crowding were less than mean and indices of patchiness were less than unity, indicating positive binomial (regular) distribution of *C. sexmaculata* at both larval and adult stages.

**KEY WORDS**: Spatial distribution, green gram, *Aphis craccivora*, *Cheilomenes sexmaculata*

(Article chronicle: Received: 16.10.2010; Sent for revision: 10.11.2010; Accepted: 06.12.2010)

The cowpea aphid, *Aphis craccivora* Koch, is an important pest causing serious damage and considerable losses to green gram crop. The nymphs and adults suck the plant sap from young parts of the plant and their feeding induces wilting. The aphids were found predated by a coccinellid beetle, *Cheilomenes sexmaculata* (Fab.) in the field. Spatial distribution of the predator was studied for development of population models, for better understanding of predator–prey interactions for the management of *A. craccivora.*

Green gram variety SG–1 was grown in an area of 50m$^2$ at instructional cum research farm of Assam Agricultural University, Jorhat, Assam. Three methods of sampling, *viz.*, plant inspection method (PIM), measured row method (MRM) and quadrat method (QM) were adopted to study the spatial distribution of *C. sexmaculata*. The number of larvae and adults of the coccinellid predator were recorded. Samples were drawn at weekly intervals during summer (mid–March to mid–June, 2009) and *kharif* (mid–September to mid–December, 2009). In PIM, ten plants were randomly selected from the plot, in MRM, two samples of ½ m row length (ten plants) were randomly selected and two quadrats of size 0.35×0.35m (twelve plants) were selected at random in QM.

Various indices of dispersion were used to analyse the distribution pattern. The mean number of *C. sexmaculata* ($\bar{x}$) and the variance ($s^2$) were calculated for each date of observation in all the sampling methods. The simplest approach used was variance to mean ratio (VMR). The value of VMR is one for Poisson distribution and less than one for regular or positive binomial and more than one for aggregated or negative binomial distribution. The index of clumping of David and Moore (1954) was calculated by $I_{DM} = s^2 / \bar{x} - 1$ whose value is zero for random, positive for negative binomial and negative for positive binomial. The parameter k which is the measure of the amount of clumping was calculated by the formula given by Southwood (1978), *viz.*, $k = \frac{\bar{x}^2}{s^2 - \bar{x}}$. If k value is greater than eight (k>8), clumping is low and there is a tendency towards randomness. If k value is smaller than eight (k<8), it indicates high amount of aggregation. The concept of mean crowding is used to indicate the possible effect of mutual interference or competition among individuals, which is expected when they encounter one another.

The sample estimate of mean crowding (x*) was calculated by $x^* = \bar{x} + \left[\frac{s^2}{\bar{x}} - 1\right]$ given by Lloyd, 1967. The ratio of mean crowding to mean density (x*/ x) is called patchiness index (Lloyd, 1967) whose value is less

**Table 1. Parameters of spatial distribution of** C. sexmaculata **in summer green gram**

| Sampling date (DAS) | Crop growth stage | Sampling method | Variance to mean ratio $S^2/\overline{X}$ | | Dispersion parameter k | | Index of clumping IDM IDM | | Index of mean crowding X* | | Lloyd's index of patchiness $X^*/\overline{X}$ | | Mean colony size C* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult |
| 08.03.09 (12) | Seedling stage | PIM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| | | MRM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| | | QM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| 15.03.09 (19) | Early vegetative growth | PIM | 0.22 | 0.76 | –1.03 | –1.28 | –0.78 | –0.24 | 0.02 | 0.06 | 0.02 | 0.20 | 1.02 | 1.06 |
| | | MRM | 0.65 | 0.89 | –2.04 | –2.00 | –0.34 | –0.11 | 0.35 | 0.08 | 0.50 | 0.44 | 1.35 | 1.08 |
| | | QM | 0.36 | 0.67 | –0.23 | –1.14 | –0.64 | –0.33 | 0.26 | 0.06 | 0.29 | 0.17 | 1.26 | 1.06 |
| 22.03.09 (26) | Rapid leaf formation | PIM | 0.67 | 0.89 | –1.23 | –2.00 | –0.33 | –0.11 | 0.07 | 0.08 | 0.17 | 0.44 | 1.07 | 1.08 |
| | | MRM | 0.56 | 0.76 | –1.14 | –1.28 | –0.44 | –0.24 | 0.05 | 0.06 | 0.11 | 0.20 | 1.05 | 1.06 |
| | | QM | 0.81 | 0.56 | –3.27 | –1.14 | –0.19 | –0.44 | 0.41 | 0.05 | 0.69 | 0.11 | 1.41 | 1.05 |
| 29.03.09 (33) | Flowering | PIM | 0.09 | 0.56 | –1.21 | –1.14 | –0.91 | –0.44 | 0.19 | 0.05 | 0.17 | 0.11 | 1.19 | 1.05 |
| | | MRM | 0.44 | 0.56 | –1.79 | –1.14 | –0.56 | –0.44 | 0.44 | 0.05 | 0.44 | 0.11 | 1.44 | 1.05 |
| | | QM | 0.35 | 0.81 | –2.15 | –3.27 | –0.65 | –0.19 | 0.75 | 0.41 | 0.54 | 0.69 | 1.75 | 1.41 |
| 05.04.09 (40) | Early pod formation | PIM | 0.60 | 0.65 | –2.25 | –2.04 | –0.40 | –0.34 | 0.50 | 0.35 | 0.56 | 0.50 | 1.50 | 1.35 |
| | | MRM | 0.78 | 0.44 | –3.56 | –1.09 | –0.22 | –0.56 | 0.58 | 0.04 | 0.72 | 0.07 | 1.58 | 1.04 |
| | | QM | 0.15 | 0.22 | –1.41 | –1.03 | –0.85 | –0.78 | 0.35 | 0.02 | 0.29 | 0.03 | 1.35 | 1.02 |
| 12.04.09 (47) | Mid pod formation | PIM | 0.56 | 0.15 | –5.63 | –1.41 | –0.44 | v0.85 | 2.06 | 0.35 | 0.82 | 0.29 | 3.06 | 1.35 |
| | | MRM | 0.44 | 0.35 | –4.70 | –2.15 | –0.55 | –0.65 | 2.05 | 0.75 | 0.79 | 0.54 | 3.05 | 1.75 |
| | | QM | 0.11 | 0.09 | –2.70 | –1.21 | –0.89 | –0.91 | 1.51 | 0.19 | 0.63 | 0.17 | 2.51 | 1.19 |
| 19.04.09 (54) | Late pod formation | PIM | 0.08 | 0.11 | –4.25 | –2.25 | –0.92 | –0.89 | 2.98 | 1.11 | 0.76 | 0.56 | 3.98 | 2.11 |
| | | MRM | 0.11 | 0.10 | –4.25 | –2.40 | –0.89 | –0.90 | 2.91 | 1.40 | 0.77 | 0.60 | 3.91 | 2.40 |
| | | QM | 0.08 | 0.59 | –3.80 | –5.07 | –0.92 | –0.41 | 2.58 | 1.69 | 0.74 | 0.80 | 3.58 | 2.69 |
| 26.04.09 (61) | Maturity | PIM | 0.33 | 0.76 | –1.04 | –1.28 | –0.67 | –0.24 | 0.03 | 0.06 | 0.04 | 0.20 | 1.03 | 1.06 |
| | | MRM | 0.44 | 0.89 | –1.09 | –2.00 | –0.56 | –0.11 | 0.04 | 0.08 | 0.07 | 0.44 | 1.04 | 1.08 |
| | | QM | 0.60 | 0.76 | –2.25 | –1.28 | –0.40 | –0.24 | 0.50 | 0.06 | 0.56 | 0.20 | 1.50 | 1.06 |
| 03.05.09 (68) | Harvesting (2-3 days before harvest) | PIM | 0.89 | 0.89 | –2.00 | –2.00 | –0.11 | –0.11 | 0.08 | 0.08 | 0.44 | 0.44 | 1.08 | 1.08 |
| | | MRM | 0.76 | 0.89 | –1.28 | –2.00 | –0.24 | –0.11 | 0.06 | 0.08 | 0.20 | 0.44 | 1.06 | 1.08 |
| | | QM | 0.89 | 0.89 | –2.00 | –2.00 | –0.11 | –0.11 | 0.08 | 0.08 | 0.44 | 0.44 | 1.08 | 1.08 |

DAS = days after sowing; PIM = plant inspection method; MRM = measured row method; QM = quadrat method

**Table 2. Parameters of spatial distribution of *C. sexmaculata* in *kharif* green gram**

| Sampling date (DAS) | Crop growth stage | Sampling method | Variance to mean ratio $S^2/\overline{X}$ | | Dispersion parameter k | | Index of clumping IDM IDM | | Index of mean crowding X* | | Lloyd's index of patchiness $X^*/\overline{X}$ | | Mean colony size C* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult | Larva | Adult |
| 27.09.09 (13) | Seedling stage | PIM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| | | MRM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| | | QM | – | 0.89 | – | –2.00 | – | –0.11 | – | 0.08 | – | 0.44 | – | 1.08 |
| 04.10.09 (20) | Early vegetative growth | PIM | 0.81 | 0.67 | –3.27 | –1.23 | –0.19 | –0.33 | 0.41 | 0.07 | 0.69 | 0.17 | 1.41 | 1.07 |
| | | MRM | 0.81 | 0.76 | –3.27 | –1.28 | –0.19 | –0.24 | 0.41 | 0.06 | 0.69 | 0.20 | 1.41 | 1.06 |
| | | QM | 0.65 | 0.89 | –2.04 | –2.00 | –0.34 | –0.11 | 0.35 | 0.08 | 0.50 | 0.44 | 1.35 | 1.08 |
| 11.10.09 (27) | Rapid leaf formation | PIM | 0.89 | 0.67 | –2.00 | –1.23 | –0.11 | –0.33 | 0.08 | 0.07 | 0.44 | 0.17 | 1.08 | 1.07 |
| | | MRM | 0.76 | 0.89 | –1.28 | –2.00 | –0.24 | –0.11 | 0.06 | 0.08 | 0.20 | 0.44 | 1.06 | 1.08 |
| | | QM | 0.67 | 0.89 | –1.23 | –2.00 | –0.33 | –0.11 | 0.07 | 0.08 | 0.17 | 0.44 | 1.07 | 1.08 |
| 18.10.09 (34) | Flowering | PIM | 0.60 | 0.36 | –4.44 | –0.23 | –0.40 | –0.64 | 1.40 | 0.26 | 0.78 | 0.29 | 2.40 | 1.26 |
| | | MRM | 0.17 | 0.22 | –2.28 | –1.03 | –0.83 | –0.78 | 1.07 | 0.02 | 0.56 | 0.03 | 2.07 | 1.02 |
| | | QM | 0.53 | 0.33 | –3.61 | –1.04 | –0.47 | –0.66 | 0.28 | 0.03 | 0.16 | 0.05 | 1.28 | 1.03 |
| 25.10.09 (41) | Early pod formation | PIM | 0.33 | 0.44 | –3.00 | –1.79 | –0.67 | –0.56 | 1.33 | 0.44 | 0.67 | 0.44 | 2.33 | 1.44 |
| | | MRM | 0.10 | 0.33 | –2.40 | –3.60 | –0.90 | –0.67 | 1.40 | 0.53 | 0.60 | 0.44 | 2.40 | 1.53 |
| | | QM | 0.38 | 0.29 | –3.59 | –1.55 | –0.62 | –0.71 | 1.58 | 0.39 | 0.72 | 0.35 | 2.58 | 1.39 |
| 01.11.09 (48) | Mid pod formation | PIM | 0.06 | 0.11 | –3.39 | –2.25 | –0.94 | –0.89 | 2.26 | 1.11 | 0.71 | 0.56 | 3.36 | 2.11 |
| | | MRM | 0.21 | 0.17 | –4.16 | –2.28 | –0.79 | –0.83 | 2.51 | 1.07 | 0.76 | 0.56 | 3.51 | 2.07 |
| | | QM | 0.22 | 0.40 | –3.86 | –2.83 | –0.78 | –0.60 | 2.22 | 1.10 | 0.74 | 0.65 | 3.22 | 2.10 |
| 08.11.09 (55) | Late pod formation | PIM | 0.24 | 0.29 | –5.41 | –3.27 | –0.76 | –0.71 | 3.34 | 1.59 | 0.81 | 0.69 | 4.34 | 2.59 |
| | | MRM | 0.17 | 0.11 | –4.80 | –2.70 | –0.83 | –0.89 | 3.17 | 1.51 | 0.79 | 0.63 | 4.17 | 2.51 |
| | | QM | 0.11 | 0.47 | –4.25 | –4.70 | –0.89 | –0.53 | 2.91 | 1.97 | 0.77 | 0.79 | 3.91 | 2.97 |
| 15.11.09 (62) | Maturity | PIM | 0.50 | 0.76 | –1.60 | –1.28 | –0.50 | –0.24 | 0.30 | 0.06 | 0.38 | 0.20 | 1.30 | 1.06 |
| | | MRM | 0.33 | 0.67 | –1.04 | –1.23 | –0.66 | –0.33 | 0.03 | 0.07 | 0.05 | 0.17 | 1.03 | 1.07 |
| | | QM | 0.81 | 0.76 | –3.27 | –1.28 | –0.19 | –0.24 | 0.41 | 0.06 | 0.69 | 0.20 | 1.41 | 1.06 |
| 22.11.09 (69) | Harvesting (2-3 days before harvest) | PIM | 0.89 | 0.89 | –2.00 | –2.00 | –0.11 | –0.11 | 0.08 | 0.08 | 0.44 | 0.44 | 1.08 | 1.08 |
| | | MRM | 0.76 | 0.89 | –1.28 | –2.00 | –0.24 | –0.11 | 0.06 | 0.08 | 0.20 | 0.44 | 1.06 | 1.08 |
| | | QM | 0.89 | 0.89 | –2.00 | –2.00 | –0.11 | –0.11 | 0.08 | 0.08 | 0.44 | 0.44 | 1.08 | 1.08 |

DAS = days after sowing; PIM = plant inspection method; MRM = measured row method; QM = quadrat method than one, equal to or larger than one in regular, random and clumped distribution, respectively. The mean colony size (C*) was also calculated as given by Tanigoshi *et al.* (1975). Iwao's patchiness regression-index x* = á + â $\bar{x}$ was calculated over a range of densities (Iwao, 1972). The constant á is the intercept on the ordinate or index of basic contagion and â is the slope of the regression line when x* is regressed on the  or density contagiousness co-efficient. If á $\geq$ 0 and â $\geq$ 1, then distribution is contagious and for regular distribution á $\leq$ 0 and â $\leq$ 1. *Cheilomenes sexmaculata* larva appeared in the early vegetative growth of the crops in both the seasons till harvest. The statistical parameters used to describe dispersion behaviour of *C. sexmaculata* larva are summarized in Tables 1 and 2 for summer green gram and *kharif* green gram, respectively.

The variance to mean ratio was less than unity in all the sampling occasions indicating regular distribution. The value of dispersion parameter 'k' was less than eight. Similarly, the other statistical parameters, *i.e.*, David and Moore's index of clumping (negative value), Lloyd's index of mean crowding (<) and Lloyd's index of patchiness (<1) also revealed regular distribution. The more confirmed approach for deciding the distribution of *C. sexmaculata* larva was found with Iwao's patchiness regression. In summer, the Iwao's patchiness regressions in PIM, MRM and QM were x*=0.8821 – 0.4166, x*=0.8600 – 0.2972 and x*=0.7641 – 0.2551, respectively. In *kharif*, the Iwao's patchiness regressions were x*=0.8092 – 0.1548 in PIM, x*=0.8299 – 0.3013 in MRM and x*=0.7889 – 0.2550 in QM. In all the cases the values of á were negative and â was less than unity which confirmed the regular distribution of *C. sexmaculata* larva. The negative values of á signified that the larva had a tendency to repel each other, *i.e.*, presence of one coccinellid beetle repel the other to occupy the same area. Shukla and Pathak (1987) reported similar findings with *Coccinella septempunctata* L. feeding on corn leaf aphid, *Rhopalosiphum maidis* (Fitch). Rao *et al*. (2002) also reported similar findings with *Coccinella transversalis* feeding on green pea aphid, *Acyrthosiphon pisum* Harris. Pandey (2004) studied the spatial distribution of *A. craccivora* and its predator *Coccinella* spp. on alfalfa and recorded negative binomial distribution of aphids and positive binomial distribution of the predators.

*Cheilomenes sexmaculata* adults were recorded in the field when the crops were in seedling stage. Observing the statistical parameters for dispersion behaviour of *C. sexmaculata* adult it could be clearly concluded that it was distributed regularly in both the seasons (Tables 1 and 2). All the statistical parameters, *viz*., variance to mean ratios, dispersion parameter 'k', David and Moore's index of clumping, Lloyd's index of mean crowding and Lloyd's index of patchiness indicated regular distribution.

Further confirmation of regular distribution of *C. sexmaculata* adults was obtained from Iwao's patchiness regression (x*=0.5384–0.0883 in PIM, x*=0.6203–0.2033 in MRM and x*=0.7854–0.2477 in QM in summer season). In *kharif*, the Iwao's patchiness regressions were x*=0.6877–0.1706 in PIM, x*=0.6382–0.1500 in MRM and x*=0.7787–0.1843 in QM.

Thus, the present studies conclude that the larva and adult of *C. sexmaculata* followed positive binomial (regular) distribution suggesting uniform regulatory pressure in all parts of the field and accommodating minimum inter- and intra-specific competition. These studies are more useful in designing population models and for understanding the predator-prey interaction for successful management of *A. craccivora*.

## ACKNOWLEDGEMENT

The authors duly acknowledge Dr. D. C. Bora, Head of Department of Entomology, Assam Agricultural University, Jorhat, India, for his technical suggestion.

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