Indian J. Hill Farmg. 14 (2) : 48 — 52 2001

SPATIAL DYNAMICS OF CITRUS MEALYBUG *PLANOCOCCUS CITRI* RISSO AT MEDIUM HIGH ALTITUDES OF MEGHALAYA

K.Rajasekhara Rao, A. N. Shylesha and K. A. Pathak
Division of Entomology,
ICAR Research Complex for NEH Region,
Umiam, Meghalaya 793 103.

ABSTRACT

The mealybug, *Planococcus citri* Risso is one of the important insect pests of citrus in Meghalaya, India. Different regression equations were used to find the best-fit model to this pest. The result showed that *P. citri* followed a negative binomial model with an Iwao's regression equation $X^* = 2.6731 + 1.2916 \bar{X}$ ($R^2 = 0.9794$). These derivations are useful for analyzing the spatio-temporal changes in population including the density dependent and density independent processes under certain conditions.

INTRODUCTION

The insects including their different life stages feeding or resting on a crop distribute themselves in a unique manner which is specific to its own and such a phenomenon depends on the genetic characters of the insect pest and crop phenology. The knowledge of spatial distribution is vital in pest ecology because complex of biotic and abiotic factors influence the population to fluctuate according to the climate, nature of crop and abundance of natural enemies which attack them. The distribution of parasites and predators is governed by the distribution of their host preys and lastly the tritrophic relationships (Tandon and Veeresh, 1987).

The mealybug, *Planococcus citri* Risso is a regular pest of citrus apart from two dozen insects feeding on citrus (Sachan and Gangwar, 1982) which is an important pest of micropropagated citrus plants in north eastern hill region (Pathak and Rajasekhara Rao, 2000; Pathak *et. al.*, 2000). Successful management of *P. citri* depends on its distribution in space and time. The spatial distribution helps in development of population models and accordingly management measures are arrived and in particular the mode of pest management tactics.

MATERIALS AND METHODS

Ten citrus (*Citrus reticulata* Blanco) trees (10 years age) were selected and three twigs on each tree were randomly selected and tagged for the mealbug colony counts. The number of mealybug colonies was counted on all the leaves in a twig. The counts included the colonies present on both abaxial and adaxial surface of the leaves. Observations were recorded once in a month throughout the year. The data were divided into three categories synthronizing with the three flushes of citrus in NEH region. The first flush appeared in January-February, second in June-July and the third in September-October. The first two flushes are important and the last in minor. The weather during the first flush period was dry-cooler, second-humid-rainy and third-cool-winter.

Various indices of dispersion were used to analyze the *P. citri* distribution without any prior assumptionof the type of distribution. Three basic units used for fitting the distribution were mean ($\bar{X}$) variance (s^2) and the number of samples (n or N) on which the mean was based. The mean number of mealybug colonies as per their respective sampling units ($\bar{X}$) and the variance was calculated for each date of observation. The simplest approach used was Variance 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 & Moore (1954) was calculated with $I_{DM} = s^2/\bar{X} - 1$, which gave a value of zero for a random, positive value for negative binomial and negative for positive binomial. The value '*k*' of the negative binomial-a measure of the amount of clumping and often, referred to as the dispersion parameter was calculated with the method of Katti and Gurland (1962). As the values of *k* becomes larger, the distribution approaches Poisson, while fractional values of *k* indicate a distribution tending towards the logarithmic series, which occurs when $k = 0$. As the observations were recorded during different seasons of a year, and to ease the comparison, a common *k* was calculated by moment or regression method (Bliss, 1958). A further graphical test of the homogeneity of the samples was done by plotting $1/k$ against the $\bar{X}$ for each new flush.

The relationship between s^2 and $\bar{X}$ of a series of samples was done with Taylor's power law $s^2 = a\bar{X}^b$ (Taylor *et. al.*, 1978). The concept of mean crowding was used to indicate the possible effect of mutual interference or competition among individuals. The sample estimate of mean crowding (X*) was calculated by $X^* = \bar{X} + (s^2/\bar{X} - 1)$. The ratio of mean crowding to mean density ($X^*/\bar{X}$) is called patchiness (Lloyd, 1967) whose value is less than one, equal to or larger than one in under-dispersed, random and clumped distribution, respectively. The Iwao's patchiness regression-index $X^* = \alpha + \beta\bar{X}$ was also calculated over a range of densities (Iwao, 1972). The constant which is the intercept on X* axis is called the index of basic contagion. The coefficient β is related to the pattern in which *P. citri* utilizes its habitat and is called density contiguousness coefficient. The distribution with $\alpha \geq 0$ and $\beta \geq 1$ corresponds to the negative binomial series. The distribution with $\alpha = 0$ and $\beta = 1$ and $\alpha < 0$ and $\beta < 1$ corresponds to models of randomly (Poisson) and regularly (positive binomial) distributed colonies, respectively. The Mean colony size of *P. citri* per sampling unit (C*) was calculated as per Tanigoshi *et. al* (1975). The coefficient of variation (CV) was also worked out.

RESULTS AND DISCUSSION

The number of mealybug colonies per twig were less during severe winter months (December-January) when compared to the rest of the period in the year. There was a gradual growth in the mealybug population and during the second flush period the population was peak and continued upto October in the third flush. The moderately hot and humid climate in Meghalaya during the second flush period was favourable for pest build up rather than the cool and dry climates (Table 1).

Various parameters were used to study the distribution pattern of *P. citri.* Very high values of variance of *P. citri* colonies per twig above the mean number of colonies resulted in higher values of VMR. VMR was more than one during all the three flushes and ranged between 19.36 to 28.46 in the second flush indicating a highly congregated nature of *P. citri* colonies on citrus. Most commonly in such studies the variance was found to be larger than mean i.e. the distribution is contagious (Shukla and Pathak, 1987; Sekhar and Singh, 1999).

The dispersion parameter '*k*' is a measure of amount of clumping and it was ranged between 1.72 to 4.79 during the period indicating a negative binomial distribution of *P. citri* except in January. The low K_c value was low during the first flush and gradual increase during remaining two flushes indicated that the population tended to disperse at a very high density. Neither a trend nor a clustering of points was observed when the values of 1/*k* were plotted against X for each flush indicated homogeneity of samples. It further indicated that the *P citri* followed a negative binomial distribution with low K_c values.

The David & Moore Index (I_{DM}) values were all positive supporting the negative binomial distribution of *P. citri.* The extent to which mean crowding is greater than their respective mean values is called Lloyd's patchiness index. It was also found greater than unity indicating precisely the negative binomial distribution. The mean colony size of mealybug (C*) per twig was also greater than their respective means. The values of CV were all on higher side and approaching towards one indicating the negative binomial distribution of *P. citri.* It was evident from the results that the smaller the *'k'*, the larger the CV. The degree of aggregation of a population which *'k'* expresses affect the influence of natural enemies (Waters, 1959). The negative binomial was found useful in describing the pattern of predators attack on prey (Hassel, 1978).

A definite approach for arriving at the distribution model of P. citri was found with Taylor's power law and Iwao's patchiness regression equation (Table 2). The index of aggregation 'b' of power law was very high as it was >1 showing a strong contagion and in conformity with the findings of Taylor (1961). The density contagiousness coefficient β of the Iwao's patchiness regression was also >1 in all the three flushes indicating a negative binomial distribution of colonies of mealybug. When the data of three flushes was regressed the regression equation found was $X^* = 2.6731 + 1.2916\,\overline{X}$ ($R^2 = 0.9794$ and significant at 1% level). The value of α was greater than zero (2.6731) and β was greater than unity (1.2916) confirming a good fit of negative binomial distribution of citrus mealybug. The very high values of coefficient of determination (R^2) in all the three flushes and the pooled data confirmed the linearity between mean crowding and mean density over a range of different densities as per the Iwao (1968) regression equation. The negative values of α and β of Taylor's power law and Iwao's equation respectively indicated that the mealybug colonies tended towards positive binomial distribution at higher densities. It was concluded from the results that *P. citri* was highly contagious and / or clumped and followed negative binomial distribution. These studies are helpful in structuring population models, which are essential for the studies on pest outbreak and formulation of management practices.

ACKNOWLEDGEMENT

The authors are thankful to the Director, ICAR Research Complex for NEH Region, Umiam, Meghalaya for providing facilities.

REFERENCES

Bliss, C.I. (1958). The analysis of insect counts as negative binomial distribution. Proc. X Int. Cong. Ent., 2 : 1015–1032.

David, F.N. and Moore, P.G. (1954). Notes on contagious distributions in plant population. Ann. Bot. Lond. N.S., 18: 47-53.

Hassel, M.P. (1978). The Dynamics of Arthropod predator-prey systems. Princeton Monographs in Population Biology, Princeton, New Jersey.

Iwao, S. (1968). A new regression method for analyzing the aggregation pattern of animal populations. Res. Popu. Ecol., 10 : 1-20.

Iwao, S (1972). Application of the m*-m method to the analysis of spatial patterns by changing the quandrant size. Res. Popul. Ecol., 14: 97-128.

Katti, S.K. and Gurland, J. (1962). Efficiency of certain methods of estimation for the negative binomial and the Neyman type A distribution. Biometrika, 49: 215-226.

Lloyd, M. (1967). Mean crowding. J. Anim. Ecol., 36: 1-30.

Pathak, K.A., Rajasekhara Rao, K., Mishra, M., Gupta, S.G. and Yadav, D.S. (2000). Integrated management of citrus mealy bug, *Planococcus citri* Risso in micropropagated plantlets in Meghalaya. Pp 956-960. In : Hi-Tech citrus Management (Eds. Shyam Singh and S. P. Ghosh) Proceedings of International Symposim on Citriculture, 23rd to 27th November, 1999, National Research Centre on Citrus, Nagpur, India.

Pathak, K.A. and Rajasekhara Rao, K. (2000). Integrated management of major insect pests of khasi mandarin in NEH Region. pp. 803-809. Ibid.

Sachan, J. N. and Gangwar, S.K. (1982). Major insect pests of mandarin oranges. pp. 14-27. Mandarin orange decline in NEH region and its control. Technical Bulletin No. 16, ICAR Research Complex for NEH Region, Shillong, India.

Sekhar, S.M.V. and Singh, V.S. (1999). Spatial distribution pattern of Aphids infesting wheat. Indian J. Ent., 61 : 396-400.

Shukla, R.P. and Pathak, K.A. (1987). Spatial distribution of corn leaf aphid, *Rhopalosiphum maidis* (Fitch) and its predator *Coccinella septumpunctata* Linn. Indian J. Agric. Sci., 57 : 487-489.

Tandon, P.L. and Veeresh. G.K. (1987). Appropriate transformations for the counts of citrus green scale, *Coccus viridis* (Green) Coccidae: Homoptera). Insect Sci. Applic., 8: 255-257.

Tanigoshi, L. K., Browne, R.W. and Hoyt. S.C. (1975). A study on the dispersion pattern and foliage injury by *Tetranychus medinieli* (Acarina : Tetranychidae) in simple apple ecosystem. Can. Ent., 107 : 439-446.

Taylor, L.R. (1961). Aggregation, Variance and the mean. Nature, 189: 732-735.

Taylor, L.R., Woiwod, I.P. and Perry. J. N. (1978). The density dependence of spatial behaviour and the variety of randomness. J. Anim. Ecol., 47 : 383-406.

Waters, W.E. (1959). A quantitative measure of aggregations in insects. J. Econ. Ent. 52 : 1180-1184.

Table 1. Dispersion indices of distribution of Planococcus citri Risso colonies during three flushes of citrus

Month	Mean ($\bar{X}$)	VMR	*k*	I_{DM}	X*	X*/$\bar{X}$	C*	CV
I Flush								
January	03.43	01.48	7.01	0.489	03.92	1.142	04.92	0.658
February	16.06	06.33	3.00	5.339	21.40	1.332	22.40	0.628
March	32.77	17.94	1.93	16.94	49.71	1.516	50.71	0.740
April	49.00	24.14	2.11	23.14	72.14	1.472	73.14	0.701
				Kc = 2.489				
II Flush								
May	65.41	19.36	3.56	18.36	83.78	1.280	84.78	0.544
June	73.60	23.00	3.34	22.00	95.60	1.298	96.60	0.588
July	82.13	24.88	3.43	23.88	106.01	1.440	107.01	0.550
August	81.83	28.46	2.97	27.46	109.29	1.335	110.29	0.589
				Kc = 3.256				
III flush								
September	87.86	19.30	4.79	18.30	106.16	1.208	107.16	0.468
October	67.90	25.33	2.79	24.33	92.23	1.358	93.23	0.610
November	21.03	05.83	4.34	04.83	25.86	1.230	26.87	0.526
December	11.96	07.91	1.72	06.91	18.87	1.577	19.87	0.813
				Kc = 3.713				
				Kc = 3.293 (pooled data)				

Table 2. Regression parameters of the spatial distribution of *Planococcus citri* Risso

Regression	I Flush	II Flush	III Flush	Overall (Pooled)
Taylor's Power Law				
$s^2 = a\bar{X}^b$				
Sampling parameter (a)	-0.4193	-1.235	0.092	-0.1811
Aggregation parameter (b)	2.0695	2.390	1.645	1.8394
Coefficient of determination (R^2)	0.997**	0.955**	0.954**	0.979**
Iwao's Patchiness Regression				
$X^* = \alpha + \beta\bar{X}$				
Index of basic contagion (α)	-1.686	-10.26	3.250	2.6731
Density contagiousness Coefficient (β)	1.520	1.438	1.219	1.2916
Coefficient of determination (R^2)	0.998**	0.982**	0.989**	0.9794**

** Significant at 1% level