Spatial Distribution of Rice Brown Planthopper, *Nilaparvata lugens*

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Abstract

The distribution pattern of rice brown planthopper (BPH), Nilaparvata lugens *Stal. was studied by taking the data of on farm trials. Observations on variance and mean revealed that the pest followed the negative binomial distribution. The dispersion parameter 'K' calculated by the proportion of zeros and also by the trial and error method conclusively proved that the distribution of rice BPH was aggregated in nature. A similar type of distribution was observed by computing the data for the tests like ÷^{2}, U and T statistics. The various indices of dispersion used in the study such as Cole's index, David and Moore's index and Morisita's index further confirmed the contagious distribution of the rice BPH.*

Keywords: Ecological studies, distribution pattern, rice pests, brown planthopper, indices of dispersion, negative binomial distribution

Introduction

Rice, the staple food of millions in Asia and in many parts of the world, is subjected to attack by more than 100 insect pests. Among them, brown planthopper (BPH), *Nilaparvata lugens* Stal. is a major pest because of its nature of infestation and also the severity of damage. In India, severe outbreaks of BPH were recorded in Kerala (Das *et al*.,1972), West Bengal (Nath and Sen, 1978) and Davangere district of Karnataka (Narasimha Kumar, 2004). Knowledge on distribution pattern of BPH is vital as it particularly affects the number of samples required for estimating the population build up and also for formulating effective pest management strategies. In view of these requirements, the present investigation was conducted to study the spatial distribution of *N. lugens* at Kolakaluru village in Guntur district of Andhra Pradesh.

Materials and methods

Data on BPH counts of on farm trials were made available from Directorate of Rice Research, Rajendranagar, Hyderabad. The data available were collected from farmers' fields at Kolakaluru village in Guntur district of Andhra Pradesh, India where cv. Mahsuri (IET 5688) of rice was grown. Five sets of sampling data were collected in *Kharif* season (i.e. field numbers 1 to 5) and two sets of data were collected in *Rabi* season (field no's 6 and 7). Sampling was done at panicle initiation stage i.e., 60 days after transplanting and 50 days after transplanting in *Kharif* and *Rabi* fields, respectively when BPH incidence usually occurs. For field numbers 1 to 7 the number of plants sampled were 130, 500, 798, 245, 250, 150 and 150, respectively. Data on predator counts were also collected for field numbers 1, 6 and 7. These are denoted as 1a, 6a and 7a, respectively.

The mean and variance from the frequency distributions were first calculated and compared to gauge the aggregation of BPH. The value of 'K' was calculated as per the formulae obtained by Southwood (1978). χ^2 test was also worked out to test the 'goodness of fit' for agreement with a negative binomial distribution. Statistic 'U' and 'T' tests and six other indices of were used to confirm the distribution pattern of Rice BPH.

Formulae for computing some of the dispersion parameters / indices:

K values from trial and error (maximum likelihood or iterative solution) method were computed by using following equation of Southwood (1978).

$$n \log e\left(1+\frac{\overline{X}}{K}\right)=\left[\frac{Ax}{K+X}\right]$$

A dispersion parameter (Kc) suggested by Elliot (1979) was calculated by moments and regression method for with and without predator cases by using the formula.

$$Kc = \frac{(\bar{X})^2 - \left(S^2 / N \right)}{S^2 - \bar{X}}$$

The χ^2 test for "goodness of fit" was tested for negative binomial distribution. The expected frequencies were compared with the observed frequencies to find out χ^2 value. U and T tests were based on a comparison of observed and expected moments (mean, variance and skewness). Evans (1953) found these tests satisfactory to accept the negative binomial as a satisfactory model. The statistic 'U' was calculated by the equation,

$$U = S^2 - [\bar{X} + (\bar{X}^2 / K)$$

and the statistic 'T' by the equation

$$T = [(fX^3 - 3XfX^2 + 2\bar{X}^2 fX) / N - S^2((2S^2 / \bar{X}) - 1]$$

Cole's index of dispersion (1946) was calculated by the formula

$$I = \frac{\Sigma X^2}{(\Sigma X)^2}$$

'K' calculated from trial and error method is usually considered as appropriate 'K' value and frequently used as an index of dispersion for confirming the distribution, the reciprocal of 'K', i.e., 1/K was also used as a measure of excess variance or clumping of individuals in a population (Elliot, 1979).

The Morisita's index of dispersion (Morisita, 1962) was worked using the following equation

$$I = n\left[\frac{\Sigma(X(X-1))}{\Sigma X \Sigma (X-1)}\right] = n\left[\frac{\Sigma(X^2) - \Sigma X}{(\Sigma X)^2 - \Sigma X}\right]$$

$$F_0 = I_\delta(\sum X - 1) + (n - \sum X)$$

Results and discussion

Finding the dispersion by using frequency distribution

Plant samples drawn for BPH infestation were formulated into frequency distribution. The variance (S^2) and the mean $(\bar{X})$ were then calculated. Table1 reveals that variance is always greater than mean for all fields i.e., field numbers 1 to 7. Thus S^2 to n $\bar{X}$ ratio was always more than unity, which indicated the BPH on the crop followed the negative binomial distribution, which is often a suitable model for invertebrate population (Anscombe, 1949; Bliss and Fisher, 1953 and Debanche, 1962). Several other insect pests have also been reported to follow a clumped or negative binomial distribution viz., Greenbugs in wheat (Elliot *et al*., 2003), cranberry fruitworm and cherry fruitworm in highbush blueberries (Nikhil and Rufus, 2002), bollworms in cotton (Beyo *et al*., 2004) and red palm weevil in coconut (Faleiro *et al*., 2002).

Confirmation of negative binomial distribution of BPH population

Estimation of dispersion perameter 'K'. The value of 'K' computed by approximation as suggested by Katti and Gurland (1962) ranged between 1.6179 to 6.0785 (Table 1) and its value from proportion of zeros was in-between 0.3246 to 3.529 (zero counts of BPH were observed in only 5 fields (i.e. field no's 1a, 2, 3, 7 and 7a)).

Lower values of the 'K' for fields (4 to 7a) indicated that distribution was highly aggregated but they did not exceed the maximum limit i.e., 8. This is in confirmity with the findings of Anscombe (1948); Bliss and Fisher (1953); Shepard and Ferrer (1990) and Reddy *et al*., (1993).

Determination of common 'K' (Kc). The calculated common 'K' values for with and without predator cases are 2.2351 and 2.4667 respectively. These values were smaller than 8 confirming negative binomial distribution (Southwood, 1978).

χ2(Chi-sqare test) for "goodness-of-fit". The computed χ2values for all the fields (Table 1) ranged from 6.9847 to 60.1155 which were less than the table value at 5 per cent level of significance. This indicated the negative binomial nature of Rice BPH. The results are in agreement with the results obtained by Reddy *et al*. (1993).

The statistics 'U' and 'T' tests. The statistic 'U' and 'T' were found to be less than the corresponding standard errors for all fields confirming the negative binomial nature of Rice BPH (Southwood, 1978). The results are in confirmity with the findings of Nath and Nag (1989) and Faleiro *et al*. (2002).

Indices of dispersion

Variance to mean ratio of index of dispersion (I). The index of dispersion (I) departed from unity (Table 2) for all fields of experimentation, indicating the contagious type of distribution pattern of Rice BPH.

Table 1. Mean and variance calculated K values for the fields 1 to 7

Field number	Sample number	Mean	Variance	K	K from Proportion of zeros	K from trial and error method	Chi-square value
1	130	10.3	48.7	2.7	--	0.4	12.4
1a	130	5.1	18.8	1.9	0.3	0.4	7.6
2	500	3.0	4.5	6.1	0.6	0.6	39.0
3	798	5.6	11.2	5.5	3.5	0.4	16.0
4	245	96.1	2969.3	3.2	--	0.2	57.6
5	250	68.6	2977.2	1.6	--	0.2	6.9
6	150	75.7	2139.7	2.8	--	0.2	60.1
6a	150	64.8	2038.2	2.1	--	0.2	52.4
7	150	91.0	3571.8	2.1	0.5	0.1	8.2
7a	150	80.5	2868.4	2.3	0.8	0.2	11.2

a - Data including predator counts; K = $(\bar{X}^2)/(S^2 - \bar{X})$

Cole's index of dispersion. The cole's index value (Table 2) for all fields of experiment was found to be greater than the value of maximum regularity and randomness confirming the contagious distribution.

David and Moore's index of dispersion

The index (David and Moore, 1954) of dispersion values (Table 2) were greater than the maximum regularity (-1) and randomness (0), confirming the aggegated nature of BPH.

Table 2. Different dispersion indices

Field number	Mean variance ratio $(S^2 / \bar{X})$	Cole's Index $I = \sum (X)^2 / (\sum X)^2$	David moore's index
1	4.7	0.011	3.7
1a	3.7	0.018	2.7
2	1.5	0.004	0.5
3	2.0	0.002	1.0
4	30.9	0.536	29.9
5	43.4	0.006	42.4
6	28.2	0.009	27.2
6a	31.4	0.010	30.4
7	39.2	0.009	38.2
7a	35.6	0.010	34.6

a - Data including predator counts; K = $(\bar{X}^2)/(S^2 - \bar{X})$

'K' of the negative binomial-an index of aggregation in the population. The observed values of dispersion parameters 'K' and its reciprocal 1/K for Rice BPH population were less than 8 and greater than zero respectively (Table 3) in present confirming the earlier findings.

Morisita's index of dispersion

Morisita's index of dispersion (I_a) values for all fields were greater than unity (1), for the BPH population (Table 3). This indicated that the clumping of the population is an important characteristic associated with the fluctuation of population density (Southwood, 1978).

Table 3. Other indices of dispersion

Field number	Accurate 'K'	'1/K'	Morisita's index (I)
1	0.4	2.6	1.4
1a	0.4	2.3	2.3
2	0.6	1.7	1.7
3	0.4	2.5	1.1
4	0.2	6.2	1.3
5	0.2	5.9	1.6
6	0.2	5.7	1.4
6a	0.2	5.6	1.5
7	0.1	6.7	1.4
7a	0.2	6.1	1.5

a - Data including predator counts; K = $(\bar{X}^2)/(S^2 - \bar{X})$

It was evident from the above study that the distribution pattern of rice brown plant hoppers was negative binomial or clumped or aggregated distribution, due to which hopper burn symptoms occur in clusters in rice fields.

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Received : 31-08-07 Accepted : 21-11-08