Spatial Distribution of the Migrants of the Corn Delphacid, *Peregrinus maidis* (Ashmead) (Homoptera: Delphacidae) in Cornfields[1]

J. TAKARA and T. NISHIDA[2]

ABSTRACT

Spatial distribution of the migrants of the corn delphacid in plantings of corn used for silage was determined by sampling population density at sites throughout fields. By this means, migrants were found to aggregate along borders of fields. There were variations to this pattern, but the same borders were generally infested in successive plantings of the same field.

Within each field, population density decreased continuously with distance from the borders. This decline was shown to be described by the relationship $\log_e(m) = \log_e(a) + bx$, where m is the average number of migrants per plant at distance, x (in meters), from the edge, and a is the average per plant at the field edge. Calculation of b, the regression coefficient, and use of this information in pest surveillance are described.

The corn delphacid, *Peregrinus maidis* (Ashmead), is a pantropical pest of corn which is found on all continents except Europe (Nampompeth 1973). It is a serious pest in Hawaii because it transmits the maize mosaic virus and causes "hopperburn", a toxicogenic disease. In studying the movements of this insect in the agroecosystem, we have found that no corn delphacids are present in fields with newly emerged corn plants. As the plants grow older they become infested with the macropterous forms which migrate into the field. Nishida (1978) has reported that these mirgrants settle in localized areas of fields. Wolfenbarger et al. (1976) observed that maize mosaic incidence (and presumably corn delphacid numbers) decreased with distance infield from field margins. In this paper we describe in detail the spatial distribution of migrant corn delphacids, and discuss the value of this information in pest management.

MATERIALS AND METHODS

This study was conducted at a commercial silage corn farm at Kahuku, a narrow coastal plain on the north coast of Oahu. Five fields, planted at a density of 60,000 plants/ha, were used in the study. The fields, 20-40 ha, were planted and harvested continually through the year, irrigated with an overhead pivot sprinkler system, and treated before planting with carbofuran, a systemic insecticide applied to the soil.

Migrant populations were sampled in 16 plantings of the five fields during July, 1979 to October, 1980. Plantings were sampled during the fourth week of plant growth to allow sufficient time for arrival of migrant adults, but insufficient time for their progeny to attain adulthood, when they might be mistaken for migrants. Spatial pattern was determined using an index of population density, taken at each sampling location, to produce diagrams of migrant distribution patterns. The index was obtained by determining the percentage of plants infested by at least 1 corn delphacid. In addition to providing a measure of migrant abundance at the site, this index was used to estimate the average number of corn delphacids per plant by the relationship: $\log_e(m) = 0.224 + 0.0337 (P)$, where m is the average number per plant; and P, the percentage of infested plants (Fig. 1).

---

[1] Journal Series No. 2737 of the Hawaii Institute of Tropical Agriculture and Human Resources.

[2] Department of Entomology, University of Hawaii, Honolulu, Hawaii 96822.

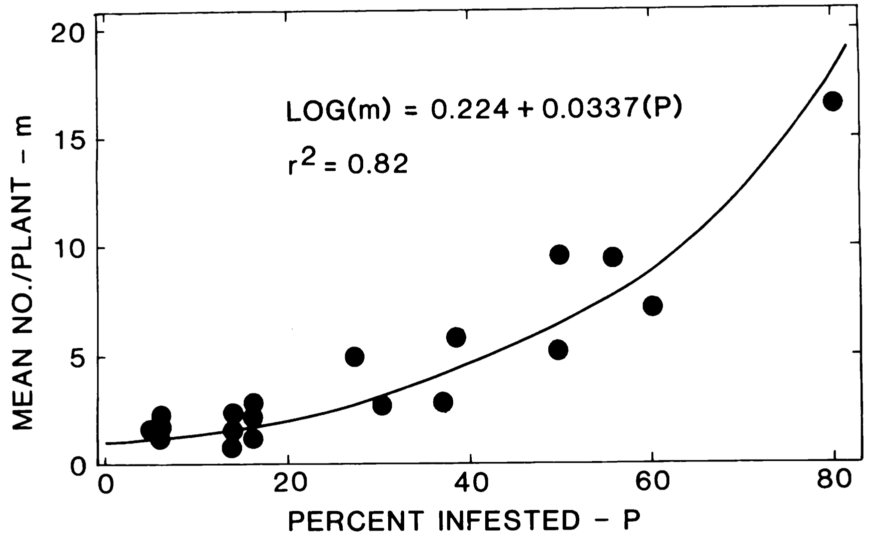

FIGURE 1. Relationship between the percentage of plants infested by migrant adult corn delphacids and the average number of adults per plant. Each data point represents counts taken on 50 plants.

Field data to calculate the percent infested values were obtained by examining plants for the presence or absence of adults. The data were taken while the sampler walked beside or astraddle a row of corn looking down on the plants. Particular attention was given the leaf whorl, where the adults congregate. Generally, 25 plants in each of 2 adjacent rows were examined and the percentage infested based on these 50 plants.

This sampling procedure was repeated at between 80 and 200 sampling sites per planting, depending on field size. In each planting studied, the first sampling site was chosen from a border location. Sampling then proceeded infield at 25 m intervals toward the field center until no migrants appeared in the samples. Sampling was then discontinued and another border sampling location, 50-60 m from the previous one, was selected. From this location, sampling again proceeded inward at 25 m intervals toward the field center until no migrants were found. This procedure was repeated until the field was sampled entirely.

Surface-relief diagrams of the spatial patterns were generated from the index values using computer program g 10638 (Taylor et al. 1971), adapted to the University of Hawaii Computing Center as program SPLOT by Bridges and Becker (1976). To use this program, each index value was located on a coordinate system describing the field area. Within the program, this information was put through an interpolation process which estimated infestation values for locations between sample sites. Both the actual and interpolated values were then plotted.

RESULTS

Border aggregation pattern

Corn delphacid infestations were detected in 12 plantings. The areas over which migrants settled in these plantings ranged from a fraction of a hectare in a partially infested planting to over 30 ha in a planting which was completely infested. The pool of potential migrants at Kahuku was apparently very large as estimates of the number of migrants in the various plantings ranged from a few thousand to over 5 million.

Among the plantings, the size and location of infestations were variable. However, distribution patterns were consistent in that migrants always settled along the borders of fields, Figs. 2 and 3. In fields in which migrant numbers were very low, infestations were found only along the extreme edge. Fields in which migrants were more numerous were infested to greater distances infield.

Variations in spatial pattern

Variations to the border aggregation pattern were observed. Four variations, presented schematically in Fig. 2 show that all observed patterns could be placed along a continuum of possible distribution patterns involving the field borders and interiors to increasing extent. Figs. 2A and 2D, for example, represent extreme patterns at Kahuku in which, on one hand, a small section of the border was infested, and on the other, the entire planting was infested. Intermediate patterns at Kahuku are represented by Fig. 2B in which several sections of the border were infested, and Fig. 2C in which the entire border was infested but the interior was not. Actual patterns in other plantings at Kahuku, which are not shown here, were intermediate between two patterns depicted in Fig. 2.

Consistency of patterns

Infestation patterns in successive plantings of each field were generally consistent. In three plantings of field 1, for example, infestations were always along the eastern border. In field 5 it was restricted to the west side. In the three other fields, both the east and west borders were infested in successive crops.

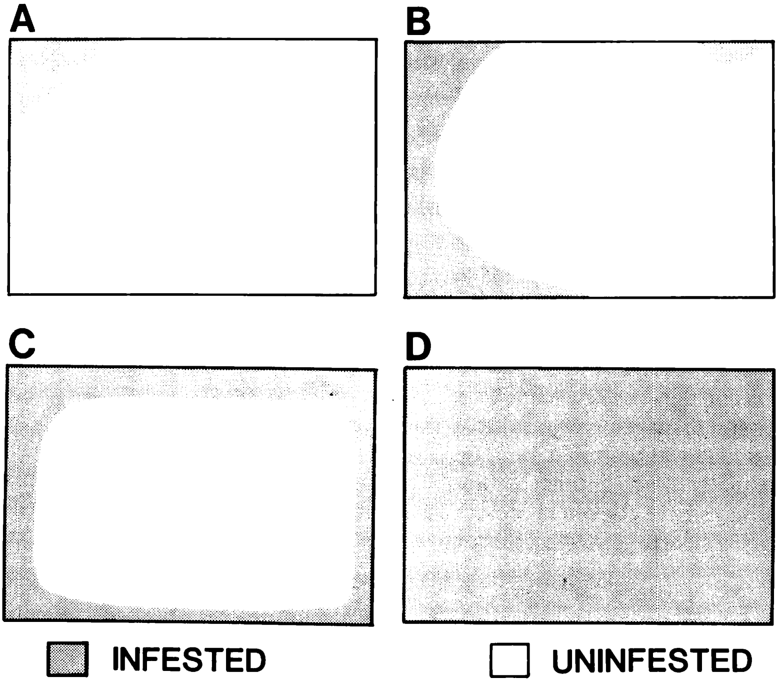

FIGURE 2. Diagrammatic representation of the range of migrant distribution patterns in cornfields at Kahuku, Oahu.

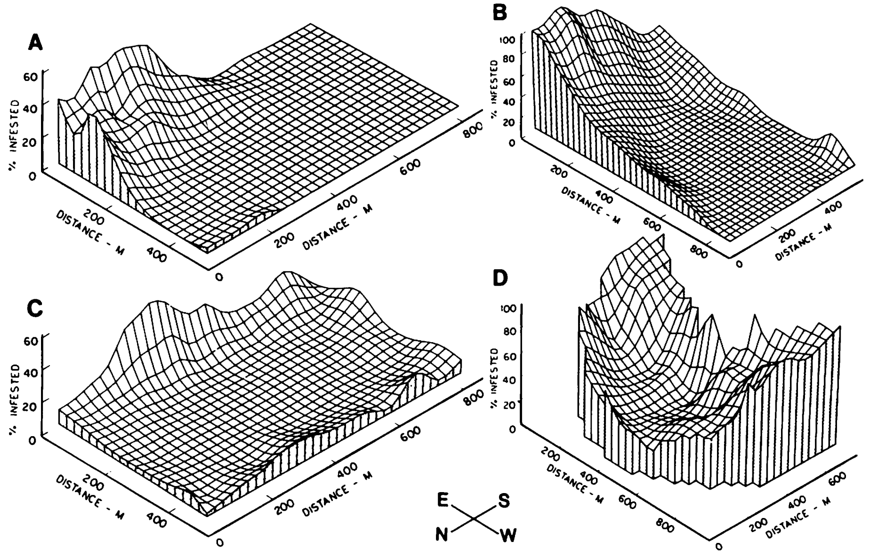

FIGURE 3. Surface-relief diagrams of migrant spatial patterns in 4 plantings at Kahuku, Oahu, plotted with the northwest corners nearest the page bottom. A - planting 1, field 4; B - planting 1, field 1; C - planting 2, field 4; D - planting 1, field 3.

Surface-relief description of patterns

To reveal quantitative patterns in the distribution of the migrants, surface-relief diagrams were generated for each infested planting by use of the computer. Fig. 3A represents a field in which the population was high only in the northeast corner of the field. A high percentage of this field was unpopulated. In Fig. 3B, population at the western edge was zero compared to 100% infestation level along parts of the eastern border. Fig. 3C shows that infestation was found at variable levels along all borders, whereas the field interiors were completely unpopulated. The pattern shown in Fig. 3D occurred in a heavily populated field. Migrants were distributed throughout the field, but numbers were highest along the east and west edges. It can be seen from these diagrams that migrants were not distributed evenly over infested areas. Not only did levels of infestation vary greatly along different borders of the same field, it also declined continuously with distance toward the field interior.

Relationship between abundance and distance from borders

For pest management purposes, a model to predict population density at locations within a field was desirable. Because migrant population density appeared to decline exponentially with distance toward the field center, and because exponential relationships have elsewhere provided adequate models of insect dispersal and distribution (Wolfenbarger 1946), the following expression was tested for fit to field data:

$$\text{Log}_e(m) = \text{Log}_e(a) + bx \qquad (1)$$

where m is population density at distance, x (in meters), from the border; a, population density at the border; and b, rate at which the logarithm of density changes with distance infield. Used in these tests were eighteen data sets in which migrants were found at least 100 meters to the field center from the north, south, east and west border sample locations of the various plantings.

The results, presented in Table 1, show that the expression explained a large proportion of the variation among data points; the coefficient of determination r^2, ranging from 0.70 to 0.98. In addition, no systematic variations were evident in plots of the residuals. Moreover, the regression coefficients, b, were less than zero in all 18 cases at the 10% significance level, a result which was consistent with the population gradients observed in the field. In the 5 cases where the value of the regression coefficient was not statistically significant at the more stringent 5% level acceptable to some, the degrees of freedom were low. This indicated that any uncertainty about the relationship was due to lack of data caused by shallow migrant penetration into the field rather than to weakness of the model. It was concluded, therefore, that the expression provided a good model describing the decline in population density with distance toward the field center.

Based upon this result it was speculated that prediction of population density in a field might be greatly simplified if the regression coefficients were constant, i.e., if the logarithm of density declined with distance infield at the same rate from all infested borders. A test of this hypothesis by covariance analysis, however, showed that the differences among the regression coefficients were statistically significant. This result showed that population density did not decline at the same rate from all infested borders, and for this reason, that the same regression coefficients are not applicable to population decline from all infested border sites.

TABLE 1. Fit of the relationship $\log_e(m) = \log_e(a) + bx$ to population density data collected from silage cornfields at Kahuku, Oahu, where m is the average number/plant at distance, x (in meters), from the border, a is population density at the border, and b is the rate at which the logarithm of population density declines with distance infield.

F/P/T[1]	$\log_e(a)$	b	df	r^2	Significance Level
3/2/W	0.58	-0.0027	5	0.72	0.0318
3/2/E	1.09	-0.0041	8	0.80	0.0012
4/2/S	0.67	-0.0043	4	0.98	0.0008
3/1/E	2.40	-0.0047	12	0.70	0.0004
2/1/W	2.30	-0.0048	10	0.78	0.0003
5/1/W	0.94	-0.0055	3	0.85	0.0780
4/2/N	0.74	-0.0059	4	0.76	0.0545
4/1/N	0.88	-0.0062	4	0.96	0.0037
3/1/N	1.80	-0.0064	4	0.77	0.0512
2/1/E	2.80	-0.0077	11	0.91	0.0001
2/1/S	1.84	-0.0088	6	0.97	0.0001
2/1/N	3.40	-0.0091	11	0.90	0.0001
1/1/N	1.23	-0.0092	4	0.95	0.0054
4/2/E	1.01	-0.0093	4	0.71	0.0708
2/3/E	1.84	-0.0126	6	0.81	0.0060
1/1/E	2.72	-0.0127	8	0.96	0.0001
3/1/S	2.66	-0.0138	3	0.92	0.0412
3/4/W	1.18	-0.0147	3	0.84	0.0819

[1] Field number/planting number/transect location.

DISCUSSION

The consistency with which migrants were distributed along certain borders in each field suggested that at Kahuku, the primary sources of migrants were other cornfields. This conclusion was based on the observation that borders with a history of heavy infestations were those which adjoined neighboring fields. This relationship was obvious when the neighboring field was mature and nearing harvest, a period when the corn delphacids migrate into succulent vegetation (Nishida 1978). Under such conditions, infestations along borders adjoining fields were generally more extensive and migrants more numerous than at other times.

Weedy marginal areas around cornfields have previously been reported as principal sources of migrants of the corn delphacid (Wolfenbarger et al. 1976; Napompeth 1973). In this regard, Namba and Higa (1971) have shown that a number of grass species are capable of sustaining corn delphacids for several generations. During the present study, reproductive populations were observed in the weedy periphery upon Johnson grass, *Sorghum halepense* (L.) Pers.; however, there appeared to be no relationship between location of the grass and spatial pattern of the migrants.

The mechanism by which border aggregations are formed and maintained is not clearly understood. Aggregation may be partially explained by the gregarious behavior exhibited by adults. Attraction of males to females, which, like the brown planthopper, *Nilaparvata lugens* (Stål), is triggered by female abdominal vibrations (Ichikawa and Ishii 1974), undoubtedly is a contributing factor. However, flight habits are likely responsible to a greater degree than other factors. The corn delphacid is not a strong flier. It stays aloft a few seconds at a time, making frequent landings, and thus moves in saltatorial fashion. It also flies at a low level, generally within a meter of the ground. These flight habits result in greater frequency of contact with border plants and are probably one of the factors responsible for border aggregations.

Spatial patterns observed in the present study are in agreement with Wolfenbarger et al. (1976) in Florida. He observed that maize mosaic disease occurs most heavily along the borders of fields. Border aggregations may not be typical of corn delphacid distribution in all situations, however. Napompeth (1973), working at Kaaawa, an area 20 km south of Kahuku, observed that migrants were dispersed throughout fields rather than aggregated along the borders. Fields at Kaaawa were much smaller than at Kahuku, and cultural practices also differed. These are factors which apparently influence spatial patterns of migrant corn delphacids.

The information presented here has value in designing pest management strategies under conditions at Kahuku. It was found that most plantings were either completely uninfested or only partially infested along localized sections of borders. Insecticide applications over the entire field are therefore unnecessary in most plantings. In plantings which were completely infested, damage was observed only along the borders of fields, where populations were highest. Little or no damage was observed in the relatively sparsely populated interiors since the corn variety planted was resistant to disease and able to tolerate migrant populations to a level at which ca. 30% of the plants were infested (Nishida 1978). For these reasons, a surveillance effort to determine when and where treatments are needed would be valuable in reducing insecticide use.

Based upon distribution patterns described herein, surveillance should be directed at the borders of fields, particularly those borders which face adjoining fields and which have a history of high infestations. Field interiors need not be scouted unless a border site is found infested. The extent of infestation can be determined by field surveys interior to that site. Alternatively, population density at any distance infield can be estimated from the line describing the decline in the logarithm of density with distance infield (eq.1). The slope, b, of this line can be estimated with population density data from as few as two sample sites, one at the border, and the other at a distance infield. Once the slope has been determined, the intercept of the line can be obtained by calculating the logarithm of density, $\log_e(a)$, obtained at the border sample site. The parameters describing the line are calculable in this way, and density at any distance infield can be predicted from them. Because density declines at different rates from different border sites, the slope value must be recalculated for each infested border site discovered. Additional work should be done on sampling error to determine the reliability of these calculations.

ACKNOWLEDGMENT

The authors gratefully acknowledge the help and cooperation given by the management and employees of Lowe Inc., without which this study would not have been possible.

REFERENCES CITED

Bridges, K.W. and **R.E. Becker. 1976.** Computer programs for ecological data processing. Dept. of Botany, University of Hawaii, Tech. Report No. 2.

Ichikawa, T. and **Ishii. 1974.** Mating signal of the brown planthopper, *Nilaparvata lugens* Stål (Homoptera: Delphacidae): Vibration of the substrate. Appl. Entomol. & Zool. 9:196-198.

Namba, R. and **S. Higa. 1971.** Host plant studies of the corn planthopper, *Peregrinus maidis* (Ashmead), in Hawaii. Proc. Hawaii. Entomol. Soc. 21:105-108.

Nampompeth, B. 1973. Ecology and population dynamics of the corn planthopper, *Peregrinus maidis* (Ashmead) (Homoptera: Delphacidae) in Hawaii. Ph.D. Thesis, University of Hawaii, Honolulu. 257 pp.

Nishida, T. 1978. Management of the corn planthopper in Hawaii. P1. Prot. Bull. F.A.O. 26:5-9.

Taylor, J., P. Richards and **R. Halstead. 1971.** Computer Routines for Surface Generation and Display, Marine Science Branch, Dept. of Energy, Mines and Resources, Ottawa. Manuscript Report No. 16.

Wolfenbarger, D.O. 1946. Dispersion of small organisms. Distance dispersion rates of bacteria, spores, seeds, pollen and insects: incidence rates of diseases and injuries. Am. Midland Nat. 35:1-152.

———, H.H. Samol and **D.H. Habeck. 1976.** Dispersal distances of the Caribbean fruit fly, corn planthopper and Cuban May beetle. Res. Pop. Ecol. Kyoto Univ. 18:118-122.