Egg Distribution on Corn Plants by the Corn Earworm Moth, Heliothis Zea (Boddie)[1, 2]

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Pest management as a means of crop protection against insect pests has become an important aspect of economic entomology. At present this method of pest control is, to a great extent, still in a conceptual or evolving stage of development. Pest management strategies are developing slowly because the much needed ecological data on the pest and crop are lacking.

The corn earworm, *Heliothis zea* (Boddie) is one of the key pests of corn in Hawaii. During the past several years a number of aspects pertaining to its biology and ecology were studied in an effort to develop strategies for the control of this pest. The results obtained on the manner in which the moths distributed eggs on the corn plants are presented in this paper.

Materials and Methods

All data presented in this paper were obtained on sweet corn grown on the experimental farm of the College of Tropical Agriculture located at Waimanalo, Oahu. The variety used was H68, a new variety developed recently. Unlike most other sweet corn varieties, this one is tall. At tasselling the plants may be as tall as 215 cm. No insecticidal sprays were applied.

The corn was planted in a field 155 x 235 ft, approximately 0.8 acre. The field was divided into five blocks each with nine 155-rows of corn. Data on corn earworm eggs were taken from the middle three rows of each block. The total number of plants for the entire field was 13,000. Corn earworm eggs were counted on various parts of the plant, generally at twice a week intervals during the egg laying period. Being white and approximately 0.5 mm in diameter, corn earworm eggs were clearly visible to the naked eye in the field. Eggs prior to hatching were pale brown and those parasitized, black. Because corn was planted all year round on the experimental farm the population of the corn earworm moths was higher here than that of most commercial farms in Hawaii.

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Although a high percentage of ears developed at the same rate, there were some that developed slowly. Because of this uneven rate of development it was necessary to stratify the sampling procedure according to ear maturity. Before silking records on the number of eggs were taken on plants that had a distinct enlargement of the sheath containing the immature primary ear. After silking, the first counts were made on plants with fully elongated wet silk. Counts thereafter were made on plants with similar degree of dryness of the tip of the silk.

Temperature measurements made in the field at the time when the silk had dried showed that they were higher than expected. The air temperature in the field three feet from the ground ranged from 32.8°-33.9°C and the temperature in the silk channel, 32.0°-36.0°C. The relative humidity in the field at three feet from the ground was 43.0-47.0 percent.

The Morisita index (Morisita, 1959, 1962, 1964; Southwood, 1968) was used to measure egg dispersion and to determine whether the dispersion indices changed with time. The Morisita index is given by:

$$I_\delta = N \frac{\sum_{i=i}^{N} ni(ni-1)}{X(\Sigma X-1)} \qquad (1)$$

where N = the total number of samples, ni = number of eggs in the ith sample, and ΣX = the sum of eggs in all samples. Tests to determine whether the $I\delta$ index deviated significantly from unity were made using the following relationship:

$$F_o = \frac{I_\delta (\Sigma X-1) + N - \Sigma X}{N - 1} \qquad (2)$$

The calculated F_0 values were compared with the F values in table for the distribution of F, which are given in general statistical text books, e.g., Snedecor & Cochran (1967), using N-1 and ∞ for f_1 and f_2 degrees of freedom respectively.

Presentation of Data

Egg density in the field. The number of eggs laid by the corn earworm moth per acre of corn was determined by estimating the number of eggs laid per corn plant and multiplying it by the number of plants per acre. The average number of eggs per plant was 4.4 three days before silking, 5.1 four days after silking and 2.7 seven days after silking. With 16,250 plants per acre the instantaneous number of eggs per acre during these periods were 71,500, 82,875 and 43,875 respectively.

From an economic viewpoint the egg density during the first four days of silking is critical for it was observed that in a high percentage of ears the larvae had already bored into the silk channel within this short time. Once in the silk channel the larvae cannot be controlled by sprays. Utilizing the field data on egg deposition and using 1.9 days as the incubation period an estimate on the summation of eggs laid during the first four days of egg laying was made following the method of Southwood & Jepson (1962). During the first four days there were 155,658 eggs per acre and with 16,250 ears per acre the average number of eggs per ear was 9.6. For effective control the hatchlings from these eggs must be destroyed before their entrance into the silk channel. The dense mass of silk into which the hatchlings crawl is one of the factors that could make chemical control difficult.

Egg distribution on corn plants. Egg distribution on various parts of the corn plants was determined by counting eggs on upper leaf surface, lower leaf surface, leaf sheath, silk, husk, and tassel (Fig. 1). The data show that during the pre-silking period the eggs were found on the leaf sheath and upper leaf surface. The percentages of eggs on the leaf sheath and upper leaf surface were 69.4 and 30.6 respectively. After silking the moths tended to distribute their eggs on many parts of the plant; viz, the upper leaf surface, leaf sheath, silk, and husk. However, the number of

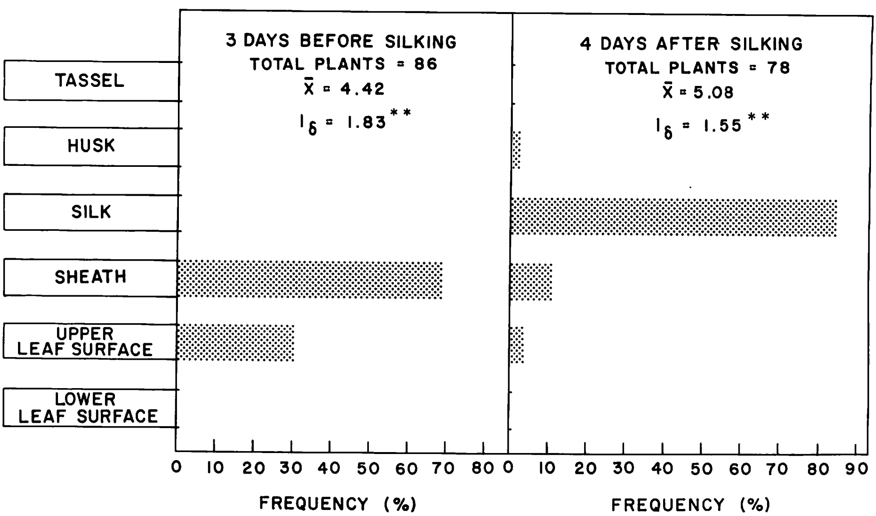

FIG. 1. Egg deposition by the corn earworm moth on various parts of the corn plant before and after the emergence of silk.

eggs laid was greatest on the silk. During the pre- and post-silking periods eggs were rarely found on the lower leaf surface and the tassel.

Data shown in Fig. 2 indicate that the distribution of eggs on various parts of the plant changed with time. There was a marked decline in the percentage of eggs laid on the leaf sheath and upper leaf surface after silking and a marked increase in the percentage of eggs laid on the silk. The increase continued up to five days after silking and thereafter remained unchanged.

Vertical and horizontal distribution of eggs. The corn earworm moths may distribute their eggs either vertically along the main axis of the plant or horizontally along the plane that extends from plant to plant within rows. The percentage of eggs counted at eight height categories, shown in Fig. 3, indicate that the vertical distribution of eggs during the pre- and post-silking periods were similar. In both instances the highest percentage of eggs was found at the 120-149 and 150-179 cm height categories. It was of interest to find that these heights corresponded to the heights at which the first and second ears of corn were produced. It was also of interest to find that this pattern of egg dispersal occurred even before the ears emerged. This observation suggests that the attractive constituents of the silk were given off by the plant in quantities detectable by the moths before the ears emerged.

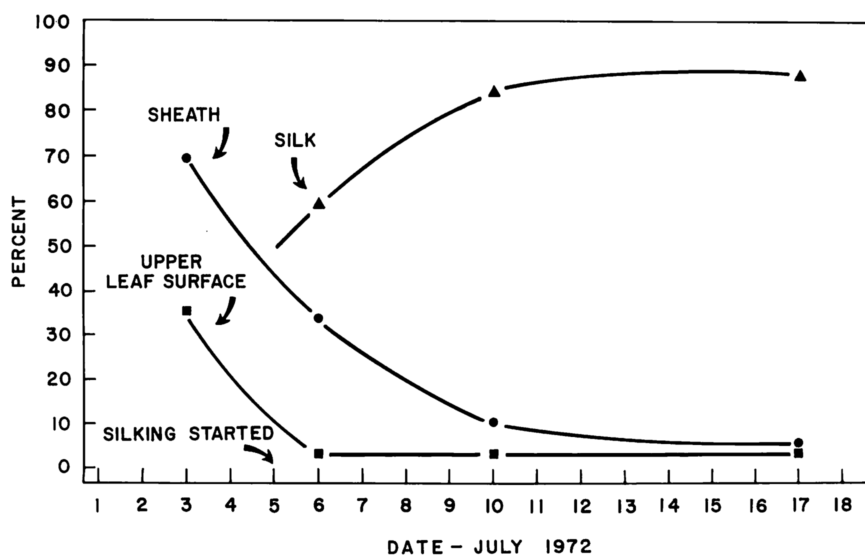

FIG. 2. Changes with time on the percentage of eggs laid by the corn earworm moth on silk, leaf sheath, and upper leaf surface.

The I_δ index was used in measuring the dispersion of eggs (Morisita, 1959, 1962, 1964; Southwood, 1968). The indices for the vertical distribution of eggs, calculated by use of equations (1) and (2) and shown in Fig. 3 and 4, are all above unity and their deviations from unity were highly significant. These deviations from unity indicate that the vertical egg distribution is not of a random (Poisson) type, but one that is of a contagious (negative binomial) type. The data presented also indicate that the I_δ values changed as the crop progressed. The I_δ value was lowest before silking and highest during the peak of the silking period. The increased I_δ values indicate that the moths tended to cluster their eggs to a greater extent during the silking period than at any other time.

Data obtained on the horizontal distribution of eggs on three sampling occasions are presented in Fig. 5. Although the range in the number of eggs varied the general shape of the frequency distribution curve of the three sampling dates was similar. Using these data and equations (1) and (2), the I_δ index was calculated. The I_δ indices, shown in Fig. 4 and 5, indicate that although all were lower than those of vertical distribution their deviations from unity were highly significant. These data again indicate that the moths deposited their eggs on the plant not at random but in a contagious manner. Unlike the I_δ indices of the vertical distribution, those of the horizontal varied little throughout the sampling period.

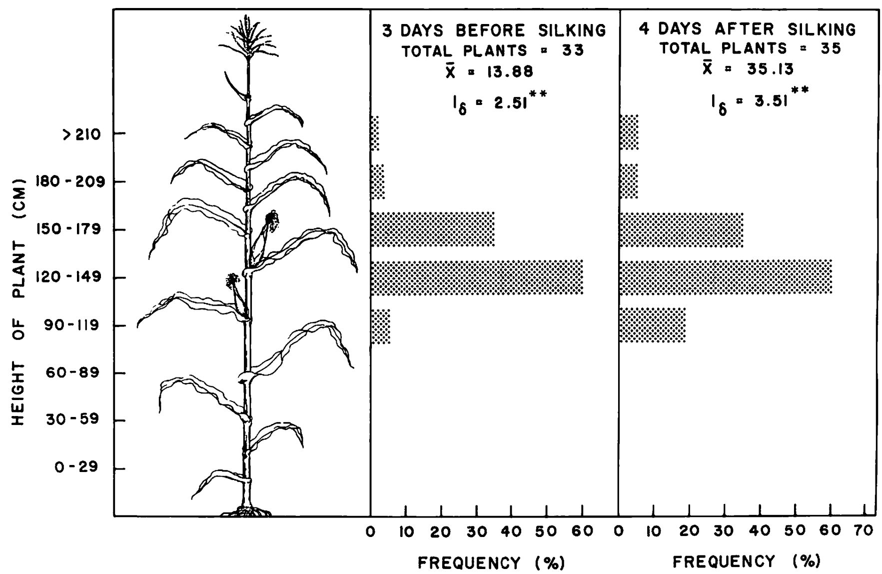

FIG. 3. Vertical distribution of the eggs of the corn earworm on corn plants before and after the emergence of silk.

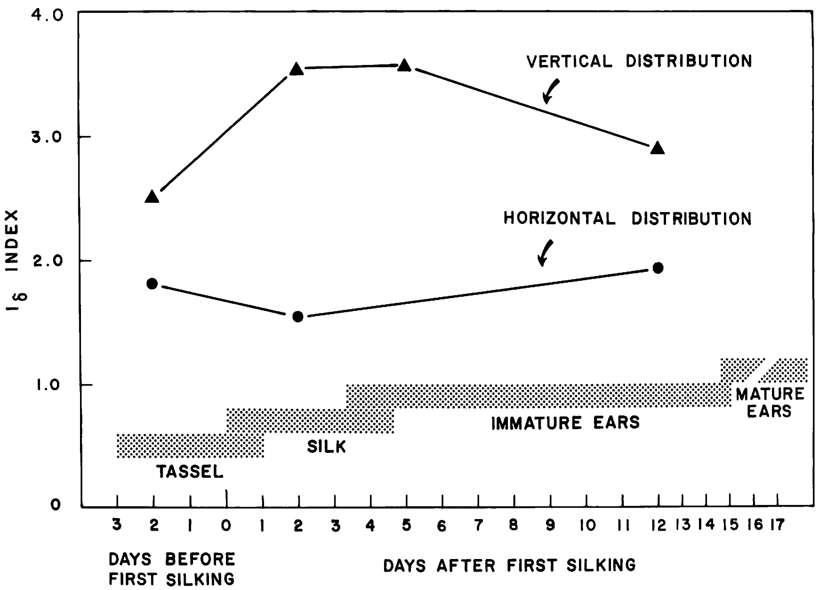

FIG. 4. The Morisita Index, I_δ, for vertical and horizontal distribution of the eggs of the corn earworm on corn plants during the pre- and post-silking periods.

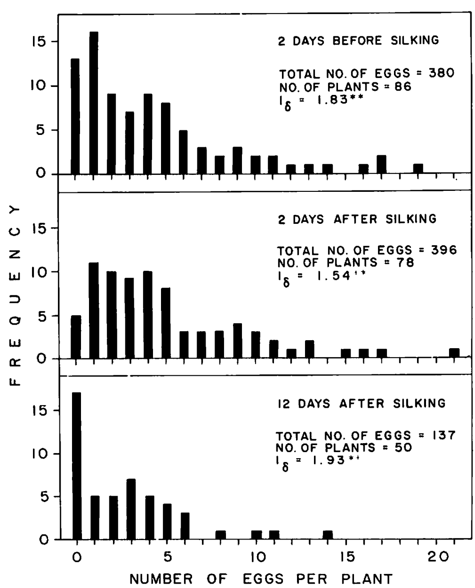

FIG. 5. Horizontal distribution of the eggs of the corn earworm on corn plants before and after the mergence of silk.

In addition to the above, I_δ index for the distribution of eggs on silk three days after silking was calculated. The value was 0.59, which was not significantly different from unity indicating that the eggs were deposited on the silk in a random or Poisson manner by the corn earworm moths at this time.

Changes in ovipositional rate with time. Data on the rate of oviposition changes with time, shown in Fig. 6, indicate considerable changes in the number of eggs laid during the maturation period of the ears. The moths began to lay eggs before tasselling in small numbers and they increased egg laying until the peak was reached at the time of maximum silking. These data indicate the marked influence of the silk on the ovipositional behavior of the moths.

Discussion

Data on distribution of eggs on the corn plant give us an indirect measure of the behavior of the moths as they move from the outside into the field. For example, it was found that the locus of egg deposition on the plant was at 99-180 cm above the ground. It is not known whether this happened because the moths preferred to fly at this height or because of some attractive principle given off by the ears at that height.

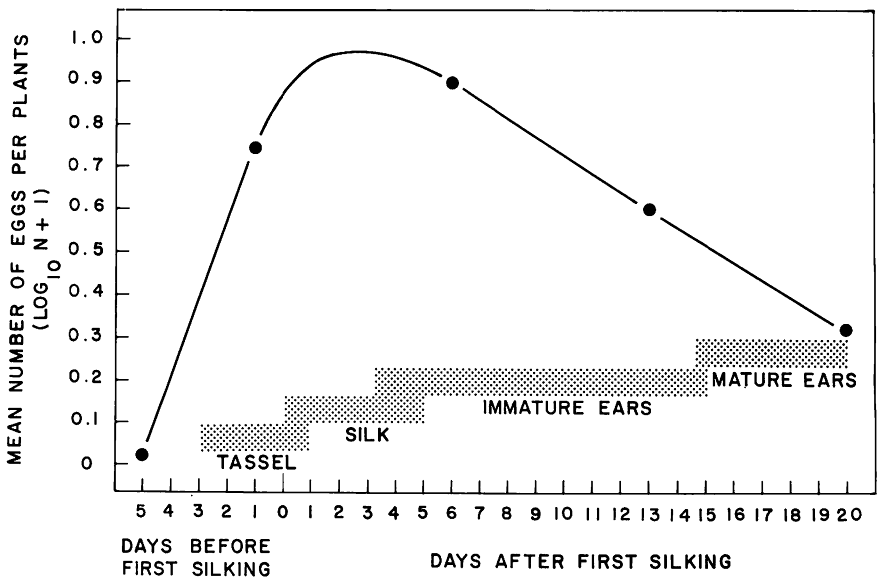

FIG. 6. Changes in the ovipositional rate of the corn earworm moth on corn plants during the pre- and post-silking periods. Data were transformed to $\log_{10}(N+1)$, where N is the number of eggs recorded.

Since all available literature indicates that the silk is attractive to the moths, the concentration of eggs at the ear-level height of the plant might be due to certain volatile silk constituents. The attractive constituents may be given off by the plant even before the emergence of the ears for it was found that the moths oviposited at the same height before the ears had emerged.

With few exceptions, the data obtained in this study on egg deposition on various parts of the plant are in agreement with those reported from elsewhere. Oatman (1966) reported the tassel infestation to be as high as 46.0 percent. Presumably this infestation resulted from oviposition on the tassel. Our results showed that the oviposition on the tassel was very small; less than 1.0 percent of the tassel contained eggs. McCallock (1920) found that 32.0 percent of the eggs were laid on the upper leaf surface, 15.0 on the stalk, and 8.9 on the tassel. These percentages are considerably higher than those obtained in this study. McCallock (1920) also reported that 30.0 percent of the eggs were found on the silk. Our results showed that the percentage of eggs on the silk exceeded 80.0 percent. These discrepancies are of interest for they could be related to such factors as varietal characteristics of the corn, level of corn earworm moth abundance, and difference in the strain of the corn earworm. The tropical strain may be different from the temperate one with respect to ovipositional behavior. Further studies should be made to determine the extent to which corn varieties influence the egg-laying behavior of the corn earworm moths.

Data obtained in this study showed the possible role of attractive substances given off by the maturing ears on the ovipositional behavior of the corn earworm moths. The localization of egg deposition on the plant in the region of the ears points to the presence of attractive substances. The data obtained also showed that the rate of egg deposition was low before tasselling, and it increased rapidly reaching a peak during the maximum silking period. Such change in the rate of egg deposition could result from either the same number of moths laying more eggs or from an increased number of gravid moths migrating into the field. It seemed in this study that the increased egg laying was due to the influx of more moths. It is conceivable that, during the development of the ears, the plants in the entire field were giving off attractive substances in the air and that the moths outside of the field were responding to them. It is also conceivable that as the concentration of the attractive substances increased with the appearance of the silk, moths from more distant areas were attracted into the corn field. Thus the increased rate of egg deposition at silking could be related to increased concentration of the attractive substances and the decreased ovipositional rate at the time of harvest could be related to decreased production of attractive substances.

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