Relationship of Larval Density and Instars of *Pseudaletia unipuncta* to Rice Leaf Feeding[1]

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ABSTRACT

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Larvae of *Pseudaletia unipuncta* (Haworth) (Lepidoptera: Noctuidae) in the laboratory consumed an average of 267.7 cm^2 of rice foliage over an average 24.3-day developmental period. Of the total amount consumed, 96% was eaten during the last 10 to 12 days (5th and 6th instars). Feeding damage in the field was generally found on the distal portion of rice leaves. More larvae were found in fields with a dense rice plant stand than in areas with a thinner plant stand. Defoliation of rice plants was highly correlated with larval density. The greatest number of larvae observed in the field was 0.37 larvae per plant.

The armyworm *Pseudaletia unipuncta* (Haworth) occurs as a pest on small grains, corn, and forage grasses, especially in the eastern half of North America. In California it can also be important on rice. During the early instars, larvae skeletonize tender, young leaves or the inside of leaf sheaths. Later, the larvae are less selective and remove irregular portions of the entire leaf starting from the edge, but leave the midvein intact.

There have been a number of studies of the life history and biology of the armyworm in Canada and the United States, in addition to numerous reports of pest outbreaks. Davis and Satterthwait (1916) thoroughly described development, growth, and food consumption for larvae reared on corn foliage. The biology of the armyworm in Tennessee was studied with larvae fed Johnson grass, corn, or leaves of various small grains (Breeland 1958). In Canada, Pond (1960) and Guppy (1961) examined the pest's life history on oats and other grains. A quantitative study of food consumption and growth for armyworm larvae raised on corn was done by Mukerji and Guppy (1970).

The present study investigated *P. unipuncta* larval feeding on rice plants and included leaf preference, consumption in the laboratory, and the relationship of larval density to defoliation in California rice fields.

Materials and Methods

Laboratory Studies. Rice plants of the variety M101 were used for both leaf consumption and developmental studies. They were grown in the greenhouse in plastic pots placed in water-filled trays and were transferred to the laboratory as needed. The studies were conducted at 21.7°C, 16 h light:8 h dark.

Larvae that had been reared on rice were caged on growing rice leaves to determine leaf consumption. The outlines of leaves on 2- to 4-week-old plants were traced on paper before larvae were caged over them in 73.9-ml plastic cups. Each container held either five 1st-instar larvae, three 2nd-instar larvae, two 3rd-instar larvae, one 4th-instar larva, or one 5th-instar larva. Rice was also caged with no larvae as a control to determine the amount of leaf growth. Ten containers were used for each instar and 20 for the control plants. 1st- through 4th-instar larvae were allowed to feed for 2 days to approximate total feeding in those instars. 5th-instar larvae fed for 1 day before being removed. The outline of each leaf was again traced on paper to coincide with the consumed leaf tissue. The area of each paper cutout of the leaves before and after feeding was measured with a Lambda Instruments Corp. (LI-COR) model LI-3000 portable area meter to determine the amount eaten.

Because 6th-instar larvae would consume more leaves than could be enclosed in a plastic container, they were placed on whole plants. The surface area of the leaves on each of twenty, 14-week-old plants was measured with a LI-COR LI-3000 portable area meter. One larva was placed on each of 10 plants, which were then enclsoed in separate plastic bags. Ten plants received no larvae as a control to determine the amount of plant growth during the feeding period. After a 3-day feeding period, larvae were removed and the surface area of the leaves was measured once more. Feeding throughout the instar was assumed to be near the same rate measured during the test period, and leaf consumption for a particular instar was calculated on this basis.

Larvae were reared on growing rice leaves for developmental studies. 1st- through 4th-instar larvae were caged on leaves in 73.9-ml plastic cups, and 5th- and 6th-instar larvae were enclosed in plastic petri dishes (10 by 2 cm). Fresh 4- to 8-week-old plants were supplied as necessary. Containers were examined daily, and a record of molts was kept.

Field Studies. Eight commercial fields in Butte and Glenn Counties, Calif., planted with rice varieties M7, M9, M101, or 'Calrose 76,' were selected in which armyworm damage was easily observable and larvae were present. Nine samples were taken in each field with a 0.14-m^2 hoop dropped at random. The area enclosed by the hoop was searched for lar-

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Table 1.–Duration of larval instars and rice consumption by *P. unipuncta* in the laboratory

Instar	Duration of instar (days)	Amt of leaf tissue consumed/ day (cm^2)	Amt of leaf tissue consumed/ instar (cm^2)	% of total consumed/ instar
I	3.9 ± 0.5	0.10 ± 0.04	0.39	0.15
II	3.1 ± 0.9	0.25 ± 0.06	0.78	0.29
III	3.1 ± 0.5	0.75 ± 0.16	2.33	0.87
IV	2.9 ± 0.5	2.10 ± 0.84	5.83	2.18
V	3.8 ± 1.0	15.67 ± 1.23	59.55	22.25
VI	6.3 ± 0.6	31.55 ± 14.48	198.77	74.26
Prepupa	1.2 ± 0.4	–	–	–
Total	24.3 ± 4.7	–	267.65	100.00

vae on the plants and in the water. The number of live and dead (drowned) larvae in the area was recorded, along with the number of damaged and total plants. One plant with feeding damage in each sample was removed and frozen in a plastic bag for later analysis.

The amount of defoliation was estimated for the thawed plants by assigning each leaf on a plant to a category of 0, 25, 50, 75, or 100% leaf tissue removed. The categories of all leaves of a plant were added and the total divided by the number of leaves for an estimate of overall defoliation.

The same plants were used to determine the leaf preference for feeding. The presence or absence of feeding damage for the distal and basal halves of each leaf from the oldest to yoüngest leaf on each tiller for every plant was recorded.

Results

Developmental times and the area of rice leaf tissue consumed by larvae in the laboratory are presented in Table 1. There was a rapid increase in the amount of leaf tissue consumed as a larva developed. Of the total amount consumed, 96% was eaten in the 5th and 6th instars during the last 10 to 12 days of larval feeding.

Larvae in the field tended to feed at the top of plants. Of 551 leaves that had been fed upon, significantly more had feeding damage on the distal half than on the basal half (539 vs. 156; chi-square test, $P \leq 0.001$). Only 12 leaves had feeding only on the basal half; 144 had feeding damage on the entire leaf.

On tillers of field collected plants, significantly more of the oldest leaves had been damaged than newest leaves (213 vs. 57; chi-square test, $P \leq 0.001$). Although it appears from these results that armyworm larvae prefer older leaves over younger leaves, 5th- and 6th-instar larvae fed randomly in the laboratory. Plants from the field were collected toward the end of larval development. Many of the plants which had sustained much damage on older leaves had produced new, young leaves which had not been exposed to many armyworms by the time the plants were collected.

More larvae were found in fields with a dense plant stand than in areas with a thinner stand (Fig. 1). Larvae were generally found during the day resting among tillers of plants that were very close to-

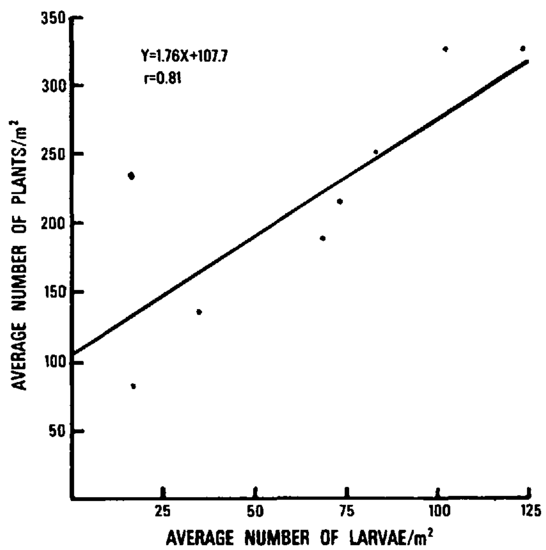

FIG. 1.—Relationship between plant density and *P. unipuncta* larval density in commercial rice fields in Butte and Glenn Counties, California, 1980.

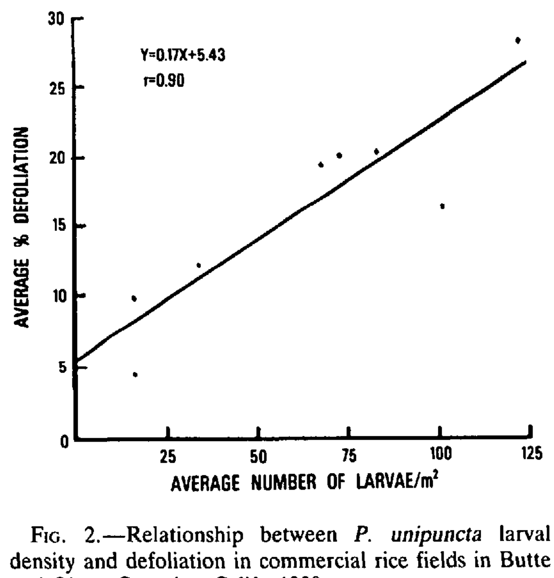

FIG. 2.—Relationship between *P. unipuncta* larval density and defoliation in commercial rice fields in Butte and Glenn Counties, Calif., 1980.

gether, regardless of plant density. The amount of defoliation in an area was highly correlated (0.001 probability interval) with the number of larvae found (Fig. 2).

Discussion

Armyworms feeding on rice foliage consumed the same total amount as Davis and Satterthwait (1916) recorded for larvae reared on corn foliage. Differences between the consumption rates within the various instars in the two studies were noted for the 1st, 5th, and 6th instars. 1st-instar larvae consumed twice as much rice as corn. In the 5th instar, larvae consumed much more rice than corn (59.55 vs. 34.87 cm^2), but in the 6th instar, larvae consumed less rice than corn (198.77 vs. 221.83 cm^2). The amount consumed in the last two instars combined was the same, with 96% of the total amount eaten during this period. The duration of instars was relatively close, except the 6th instar on corn was about 2.4 days longer. The prepupa was not included in the studies on rice, and this may account for the difference.

1st- and 2nd-instar larvae on rice plants remain in the sheath or inside furled leaves where they feed until molting. Just before, during, and after the 3rd instar, they begin to feed from the margin of the leaf inward, and in general are more easily observed. During the day, larvae rest on the lower parts of the plants, generally just above the water surface in flooded rice fields, and move up the plants at night to feed. Larvae are usually found in areas of high plant density, among closely spaced plants. Plants that are very close together provide a dense canopy that reduces light penetration. This selection of areas of low light intensity and dense foliage would be possible only if oviposition in rice fields occurred from mid- to late season. During the first four instars, larvae consume relatively small amounts of foliage, then consume the majority of what they will eat in the last 10 to 12 days of larval development. Because of their small size, cryptic behavior, and small amount of feeding, armyworms usually remain unnoticed until the late instars, when defoliation becomes visible.

The amount of leaf tissue on rice plants available for armyworms depends on plant age, variety, extent of tillering, plant spacing, plant condition, etc. The average leaf area for the 98-day-old plants used for food consumption of the 6th-instar larvae was 441.1 cm^2. The daily consumption rate of the 6th instar over the last 6 days averaged 31.55 cm^2 (Table 1). A variable number of larvae and days of feeding was used to calculate several hypothetical levels of defoliation (Fig. 3) for 6th-instar larvae at this consumption rate. Based on the regression lines of Fig. 1 and 2, 0.37 larva per plant was associated with 25% defoliation. For the 0.37 larva to have consumed 25% of the plant's leaves based on Fig. 3, they would have had to feed as 6th-instar larva for 9.5 days. However, only 7.3 days of feeding as a 6th instar would be necessary to achieve 25% defoliation if previous feeding is taken into account. This is longer than the 6.3 days larvae in the laboratory took to go through the 6th instar. Conditions in the field will not be the same as those under which development and consumption were measured. Since larval development is temperature dependent (Guppy 1969), temperature would influence daily consumption rates and the number of days spent feeding. Additionally, greenhouse grown rice plants may be shorter, take longer to mature, and if grown individually, have more tillers and leaves than fieldgrown plants. For a specific level of defoliation, the actual amount of leaf tissue removed will change with plants of different size and number of leaves. The many reasons for differences in larval consumption and plant leaf area given above preclude the fitting of a general formula to every situation, but Fig. 3 does show the potential for armyworm defoliation at varying population levels for the most damaging instar (74% of total consumption). Such information will assist in making decisions on control regarding time and larval numbers per plant when compared with data on the relationship between defoliation and rice grain yield (Rice et al. 1982).

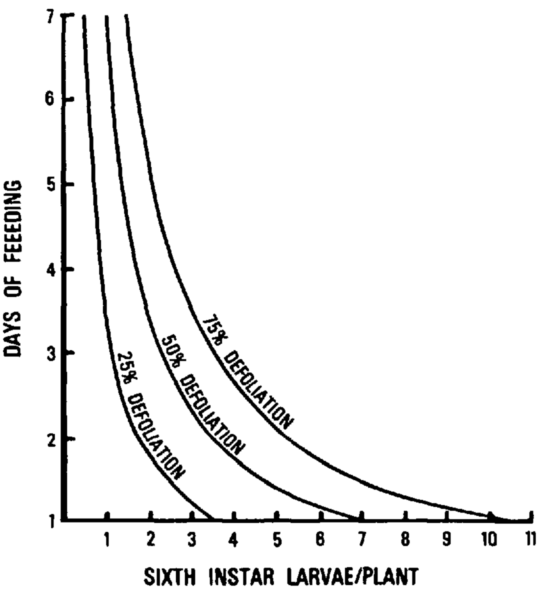

FIG. 3.—Hypothetical consumption of rice at three levels for 6th-instar *P. unipuncta* larvae.

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