

The Distribution and Movement of Cotton Bollworm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) Larvae on Cotton

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The study determined the distribution of various instars of *Helicoverpa armigera* larvae at different growth stages of cotton under natural infestation and monitored the movement of newly hatched to fifth instar larvae in cotton plants grown in the screen house. The distribution of different instars of *H. armigera* larvae within the cotton plant was determined weekly from 30 to 93 days after plant emergence (DAE) under natural infestation. Early instar larvae were confined to succulent plant parts like growing tips and small squares. Older larvae were found in big squares and bolls. Most larvae were confined to the upper-third portion from 30 to 37 DAE, to the upper and middle-third portions from 44 to 65 DAE, and to the lower-third portion from 86 to 93 DAE.

In the screen house, after introducing newly hatched larvae of *H. armigera* on terminal buds, squares, flowers and bolls, their movement on the cotton plant was monitored daily until the fifth larval instar in the screen house. First instar larvae of *H. armigera* remained on those plant parts they were placed on. As the larvae grew older, they moved within or to lower leaf/sympodial branches and eventually to bolls situated at the lower portion of the plant. Larvae placed on terminal buds moved the longest distance followed by those placed on squares, flowers and bolls.

The distribution and movement of *H. armigera* larvae on the cotton plant were governed by the place of oviposition and the developmental stage of the plant.

Keywords: terminal buds, squares, bolls, flowers, growth stages

The cotton bollworm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae), is one of the most serious pests of cotton in the Philippines. It attacks terminal buds and fruiting structures such as squares, flowers and bolls causing a reduction in seedcotton yield of about 28 to 68 percent (Domingo and Damo, 1996).

The *H. armigera* adult lays its eggs mainly on the first leaf below the terminal of the main stem (Pascua,

1993), or on young growing leaves and small buds at the apical meristem (Mabbett et al., 1980). The eggs hatch within two to four days (Obien and James, 1988). The newly hatched larvae move from the oviposition site to other plant parts until they find a suitable feeding site (Pearson, 1958). The feeding sites of first and second instar larvae are restricted to young buds and leaves while older instar larvae feed on large buds, squares and bolls (Mabbett et al., 1980; Pearson, 1958). According to Lawton (1983), the zonation of

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larvae vertically and horizontally across the different parts of the host plant could be due to the variation in the nutritive quality of plant parts.

A knowledge on the distribution of various instars of *H. armigera* larvae and their movement at different stages of the cotton plant is very crucial in the implementation of any pest control strategy. This study then, was conducted to generate basic information which can be used in devising a sustainable pest management strategy for *H. armigera* on cotton.

Materials and Methods

Two separate experiments were conducted namely: Experiment 1 was set up to determine the distribution of *H. armigera* larvae within the cotton plant under natural infestation and experiment 2 to monitor their movement on the cotton plant grown in the screen house. The experiments were conducted at the Central Experiment Station, Cotton Research and Development Institute (now the Cotton Development Administration), Batac, Ilocos Norte, Philippines

Exp. 1. Larval distribution of *H. armigera* on the cotton plant under natural infestation

This study was conducted in two sites. In each site, cotton was planted in a 500 square meter field at a planting distance of 75 x 25 cm. The recommended production technology for cotton was followed except that insecticides were not used.

In each site, 50 plants in their seedling stage were randomly selected and tagged. These plants were taken as samples in the weekly search for the presence and distribution of *H. armigera* larvae within the plant from 30 to 93 DAE.

The location of each larva was based either in the upper-, middle- or lower-third portion of the plant. The three portions were determined after counting the number of main stem nodes for that sampling period. Plant parts where larvae were located were recorded, and the larval instar was determined. The weekly data in both sites were pooled and each week was treated as one sampling period.

Exp. 2. Movement of *H. armigera* on the cotton plant grown in the screen house

This study was conducted in a screen house (7 m X 9 m) to avoid predation and parasitization of larvae. Cotton seeds were planted at a distance of 1 m between rows and 0.5 m between hills at one plant per hill. At 70 DAE, 80 plants (20 each at terminal buds, squares, flowers and bolls) were selected and infested with one newly hatched larva of *H. armigera*. The movement of

introduced larvae was monitored daily up to the fifth instar (from day 1 to 19) and their daily location was noted as follows:

- 0 - leaf/sympodial number where larvae started or the starting point
- 1, 2, 3... - leaf/ sympodial number below the starting point of larvae
- +1, +2, +3... - leaf/ sympodial number above the starting point of larvae.

Results

Larval distribution of *H. armigera* on cotton (Exp. 1)

The distribution of different larval instars of *H. armigera* varied in relation to crop stage (Fig. 1-3). At 30 DAE, all larvae were found at the upper-third portion of the plant, 72% in terminal buds and 28% on leaves. Of the total larval population, 85% were first and 15% second instar.

At 37 DAE, most larvae (77%) were located at the upper-third portion of the plant, 54% on terminal buds, 4% on squares and 19% on leaves. The highest proportion (41%) of the larval population was first instar larva located on terminal buds. At the middle-third portion of the plant, first instar larvae were found on squares and leaves. Second and third instar larvae were found on leaves and squares at the top and the middle portion of the plant.

At 44 DAE, 56% of the larval population consisting of first and second instar larvae was found on squares at the middle portion of the plant. Thirty two percent of the larval population, mainly first instar larvae, was found on terminal buds. The same distribution was observed at 51 DAE except that the larval population on squares at the middle portion of the plant consisted dominantly of second instar larvae. At 58 and 65 DAE, the larval population was similarly concentrated on squares at the middle portion of the plant and on terminal buds. Those on the terminal buds were mostly first instar larvae. At 65 DAE, percentages of first, second, third, fourth and fifth instar larvae on squares at the middle portion of the plant were 8, 20, 22, 11 and 3 of the total population, respectively.

At 79 DAE, 67% of the larval population was located at the middle portion of the plant. The rest was found at the upper and lower third portion of the plant. Larvae were found mostly on squares at the upper-third and middle portions of the plant and on bolls at the middle and lower-third portions. The larvae on squares were mostly third instars while those on bolls were late instars.

At 86 DAE, early and late instar larvae were located on squares at upper and middle portions of the plant,

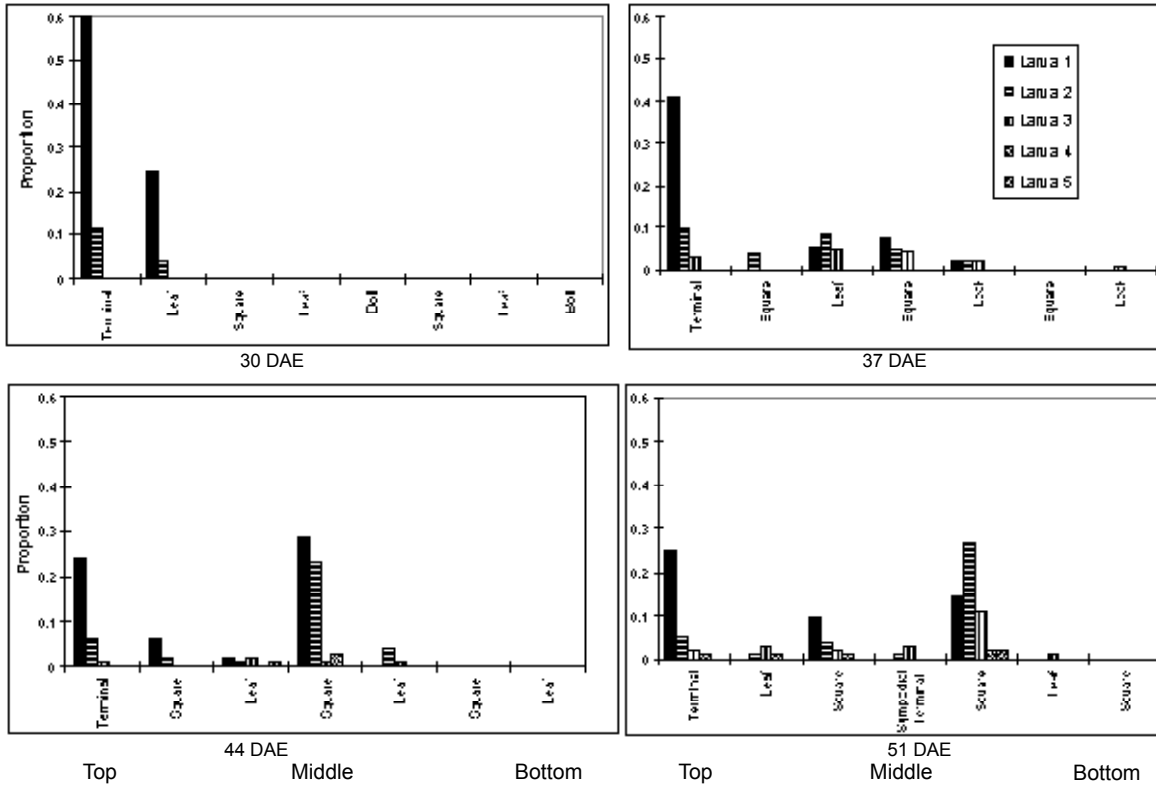


Figure 1. Distribution of larval instars of *Helicoverpa armigera* on the different parts of the cotton plant from 30 to 51

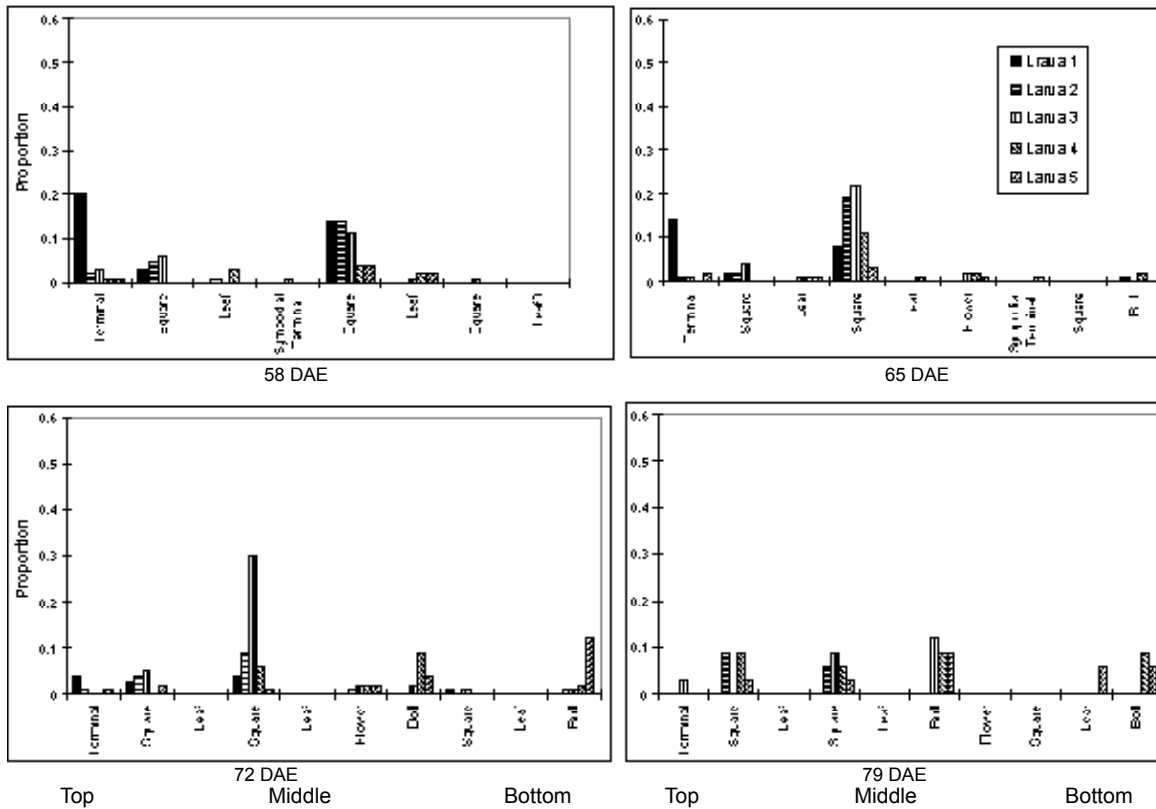


Figure 2. Distribution of larval instars of *Helicoverpa armigera* on the different parts of the cotton plant from 58 to

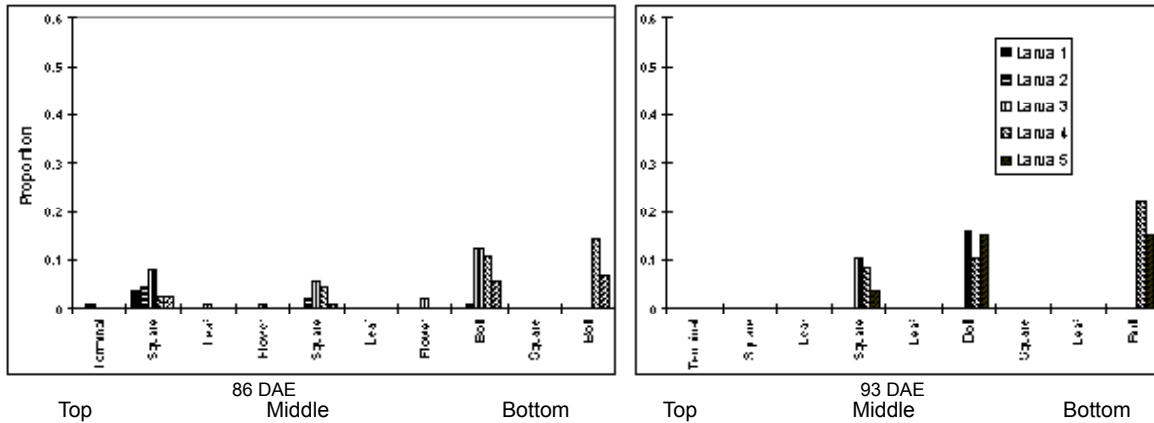


Figure 3. Distribution of larval instars of *Helicoverpa armigera* on the different parts of the cotton plant from 86 to

and accounted for 21 and 13%, respectively of total larval population. Twenty-nine percent and 22% of the total larval population were found on bolls at the middle and lower portions of the cotton plant, respectively. These larvae were in their third, fourth and fifth instar. Very few larvae were found on terminal buds, leaves and flowers during this period.

At 93 DAE, only late instar larvae were observed. They were located on the squares (23%) and bolls (42%) at the middle portion and on bolls (37%) at the lower portion of the plant.

Movement of *H. armigera* larvae on the cotton plant (Exp. 2)

Helicoverpa armigera larvae placed on terminal buds moved down further than those placed on squares, flowers and bolls. Most first instar larvae were found on those terminal buds where they had been placed on earlier. Second instar larvae moved down to the first or the second leaf below the terminal bud. Third instar larvae moved down to the third to sixth leaf/sympodial branch below the terminal bud and fed on leaves or on squares. Fourth instar larvae moved down to seventh to eighth leaf/sympodial branch below the terminal bud and fed on squares and bolls. Fifth instar larvae moved down further to the ninth and tenth leaf/sympodial branch below the terminal buds and fed on bolls (Table 1).

Helicoverpa armigera larvae placed on squares moved shorter distances than those placed on terminal buds. The longest distance covered was at day 18 when the remaining larvae moved to the sixth sympodial branch below the starting point (Table 1). Most first and second instar larvae stayed on the square where they were placed on or moved to other squares within the sympodial branch. Some larvae moved to the upper and lower sympodial branch and fed on squares. Third instar larvae moved down to the first up to third sympodial

branch from the place of infestation and fed mostly on squares. Fourth instar larvae moved down to the third up to fifth sympodial branch below the starting point and fed mostly on squares and bolls. Fifth instar larvae moved down to the fifth and sixth sympodial branch below the starting point and fed on bolls.

Helicoverpa armigera larvae placed inside newly opened flowers stayed inside. Some larvae fell on the soil with the shedding of dried petals. However, most of them remained feeding on developing bolls. Before developing bolls were totally consumed, they moved to larger bolls located within the same sympodial branch or at lower sympodial branches. They moved horizontally or vertically towards the lower portion of the plant feeding on bolls. The longest movement was at day 19 when the remaining larva moved to the seventh sympodial branch below the starting point (Table 1).

Helicoverpa armigera larvae placed on bolls exhibited the least movement, maximum three sympodial branches down at day 18. They stayed and fed outside the boll for 2 to 4 days. Then they bored inside the boll consuming it almost entirely before moving to another boll in the same or in lower sympodial branch. Most larvae stayed in a single sympodial branch for several days feeding on two or three bolls. Only one larva was observed moving to an upper sympodial branch of another plant feeding on squares, before it moved down feeding again on bolls.

Helicoverpa armigera larvae placed on squares damaged more squares than those placed on terminals, flowers and bolls (Table 2). Larvae placed on flowers and bolls damaged more bolls than those placed on squares and terminals. This is because larvae placed on squares spent 54% of their time feeding on squares while those placed on the bolls and flowers spent most of their time (98 and 74%) feeding on bolls. Larvae starting on terminals spent 28, 24 and 48% of their time feeding on terminals, squares and bolls, respectively (Table 3).

Table 1. The pattern of movements of *Helicoverpa armigera* larvae as influenced by the plant in which a newly-emerged larvae were placed.

Plant Part ¹	First instar				Second instar				Third instar				Fourth instar				Fifth instar			
	Days																			
Terminal	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
No. of larvae involved	20	20	20	20	20	20	20	19	19	19	13	11	11	11	11	11	11	10	12	
Average	0.00	0.05	0.10	1.20	1.50	1.95	2.25	2.55	3.05	3.21	3.11	3.13	3.41	3.33	3.53	3.13	3.18	3.53	3.25	
Range	0	0-1	0-1	0-4	0-5	0-7	0-7	0-12	0-12	0-12	0-12	0-12	0-12	0-12	0-12	0-12	0-12	0-12	0-12	
No. of larvae same nest ²	20	19	19	10	10	3	8	4	1	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	1	1	10	10	12	14	15	12	12	11	11	11	11	11	11	11	11	10	
No. of larvae moved up ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved up ³	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	1	1	10	2	8	3	3	2	2	2	2	2	2	2	2	2	2	0	
Square																				
No. of larvae involved	20	20	20	20	19	13	13	16	14	14	14	14	14	14	13	12	11	10	8	
Average	0.00	0.00	0.05	0.40	0.53	0.69	0.87	0.94	1.50	2.21	2.64	3.23	3.51	4.50	4.82	5.23	5.23	5.50	5.53	
Range	0	0	0	1-1	1-2	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	
No. of larvae same nest ²	20	20	19	17	9	8	2	2	0	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	0	1	2	8	9	11	9	12	12	12	12	12	12	12	11	10	8	8	
No. of larvae moved up ³	0	0	0	1	4	9	5	5	2	2	2	2	1	0	0	0	0	0	0	
No. of larvae moved up ³	0	0	0	1	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	0	1	2	9	5	9	2	5	9	9	9	9	9	9	9	9	9	0	
Flower																				
No. of larvae involved	20	20	20	19	17	14	14	12	12	12	12	12	11	9	9	7	7	4	1	
Average	0	0	0	0.15	0.65	1.53	1.71	2.25	2.53	2.33	3.23	3.53	4.21	4.81	4.82	5.00	5.00	5.25	7.00	
Range	0	0	0	0-3	0-3	0-3	1-4	1-3	1-4	1-5	1-7	1-7	1-7	2-7	2-7	3-7	3-7	4-7	7	
No. of larvae same nest ²	20	20	20	13	10	9	9	0	0	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	0	0	1	7	11	10	12	12	12	12	12	12	11	9	3	7	4	1	
No. of larvae moved up ³	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved up ³	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	0	0	1	8	4	9	2	2	2	1	1	2	1	0	1	0	1	0	
Boll																				
No. of larvae involved	20	20	19	19	15	14	14	19	19	12	11	10	10	10	9	7	8	8	4	
Average	0	0	0.16	0.21	0.23	0.93	0.94	0.25	0.53	0.53	1.00	1.10	1.10	1.10	1.10	2.43	2.50	2.70	2.50	
Range	0	0	0-2	0-2	0-2	0-3	0-3	0-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	
No. of larvae same nest ²	20	20	11	16	14	12	10	3	1	8	9	2	2	2	2	0	0	0	0	
No. of larvae moved down ³	0	0	2	2	1	0	4	5	5	7	7	3	3	3	7	7	8	8	4	
No. of larvae moved up ³	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	
No. of larvae moved up ³	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
No. of larvae moved down ³	0	0	2	1	1	1	2	1	0	2	2	1	1	0	1	2	0	1	0	

Average - average leaf/sympodial number where the larvae were located

Range - range of leaf/sympodial numbers where the larvae were located; 0 leaf/sympodial number below from where the larvae started; +1, +2, +3...-leaf/sympodial number above from where the larvae started

¹At 70 DAE a newly hatched larva was placed on the indicated plant parts

²At the starting point

³After a day

Table 2. Average number of damaged squares and bolls by *Helicoverpa armigera* during its larval development period.

Larval Origin ¹	n	Damaged Square	Damaged Boll
Terminal bud	20	3.05 ^a	2.05 ^b
Square	20	3.00 ^a	1.75 ^b
Flower	20	0.10 ^b	3.25 ^a
Boll	20	0.15 ^b	2.95 ^a

¹Placed as first instar larva on the indicated plant parts

Means marked with the same letter in a column do not significantly differ from each other at 5 % level of significance using the Duncan Multiple Range Test.

Discussion

Terminal buds and leaves were the only available plant parts for feeding at 30 and 37 DAE, and only a few small squares were available at 37 DAE. Thus, larvae concentrated at the upper-third part of the plant (Fig. 1). When squares were ready available at 44 to 65 DAE and bolls after 72 DAE, larvae were present on these fruiting bodies. Thus, the distribution of *H. armigera* larvae within the cotton plant is a function of the plant's phenological development.

Under the screen house condition, first instar larvae were restricted to plant parts where the larvae were placed. Also, Mabbett et al. (1979; 1980) found that first and second instar larvae move only short distances. This is evident on the results under natural infestation that first and second

Table 3. Average number of days a larva of *Helicoverpa armigera* feeds on different parts of the cotton

Larval Origin ¹	Plant Part								Total
	Terminal		Square		Flower		Boll		
	Days	%	Days	%	Days	%	Days	%	
Terminal bud	4.8	27.8	4.1	24.0			8.3	48.2	17.2
Square			7.8	51.4			6.6	45.6	14.4
Flower					3.0	26.4	8.5	73.9	11.5
Boll			0.2	1.7			11.4	98.3	11.6

¹Placed as first instar larva on the indicated plant parts

instar larvae were mostly located on terminal buds and on small squares at the upper and middle portion of the cotton plant (Fig. 4-6). Therefore, it is likely that the location of first and second instar larvae of *H. armigera* within the cotton plant is governed by the place of oviposition. The *H. armigera* adult lays its eggs mainly on the first leaf below the terminal of the main stem (Pascua, 1993) and on young growing leaves and small buds at the apical meristem (Mabbett et al., 1980).

Older larvae showed extensive movements within the plant going to large squares and bolls at the middle and lower part of the plant (Table 1). This is evident under the natural infestation. Most of the older larvae were at the middle and lower portions where large squares and bolls were also present. This is also in accordance with the findings of Wilson and Gutierrez (1980), and Wilson and Waite (1982).

Larvae placed on terminal buds and squares moved downward with longer distances than those placed on flowers and bolls because resources of terminal buds

and squares were quickly depleted. Those placed on flowers and bolls moved shorter distances than those placed on terminal buds and squares because more food sources were available. This indicates that as the larvae grow older, they move to the lower part of the canopy.

Implications for pest control

Early instar larvae were located at the upper-third and middle portion of the plant, feeding on young buds and small squares. As they are exposed on the periphery of the plant's canopy, they should be targets for control. Delay of control allows the larvae to grow older. They then move to squares and bolls at the lower part of the canopy. Control, then, becomes ineffective because their cryptic behavior makes them less accessible for contact insecticides.

Acknowledgments

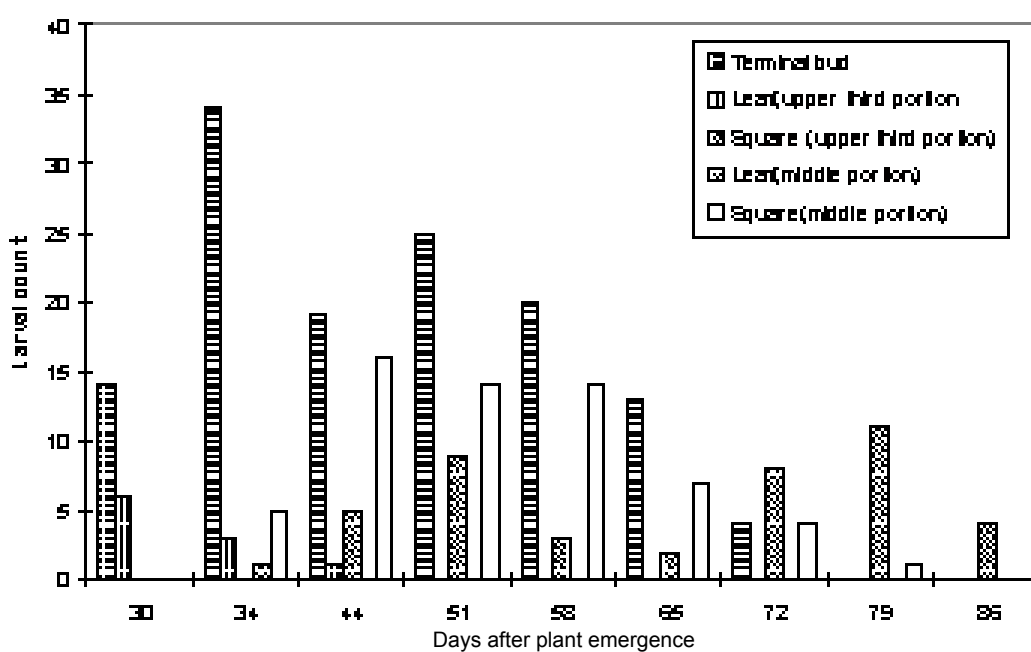


Figure 4. Distribution of first instar larvae of *H. armigera* on different plant parts of cotton in 100 sample plants.

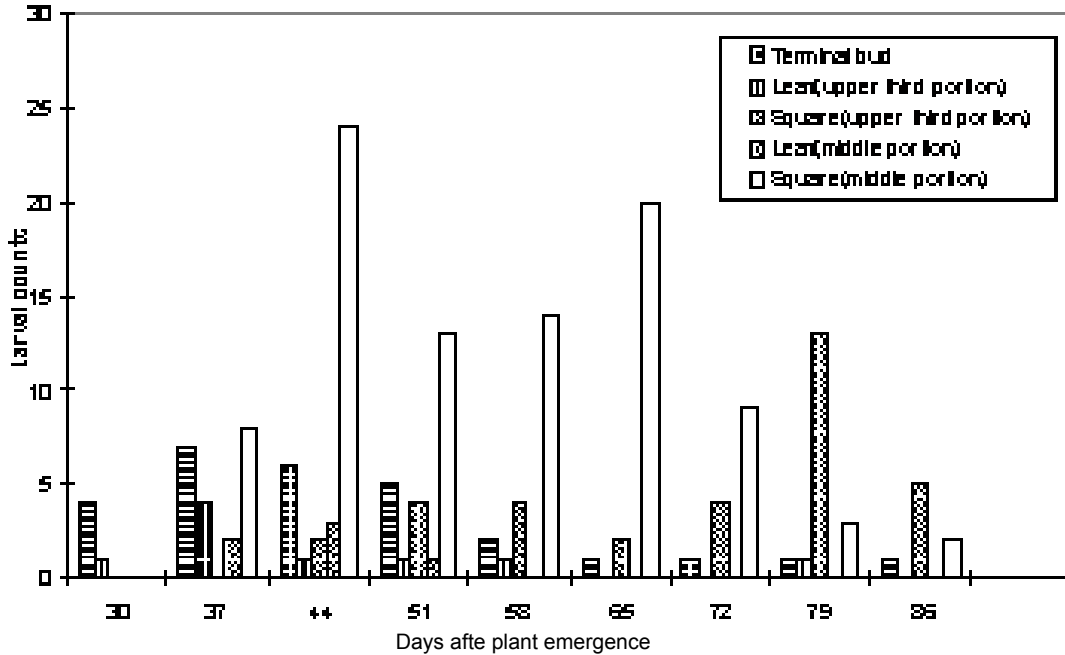


Figure 5. Distribution of second instar larvae of *H. armigera* on different plant parts of cotton plant in 100 sample plants.

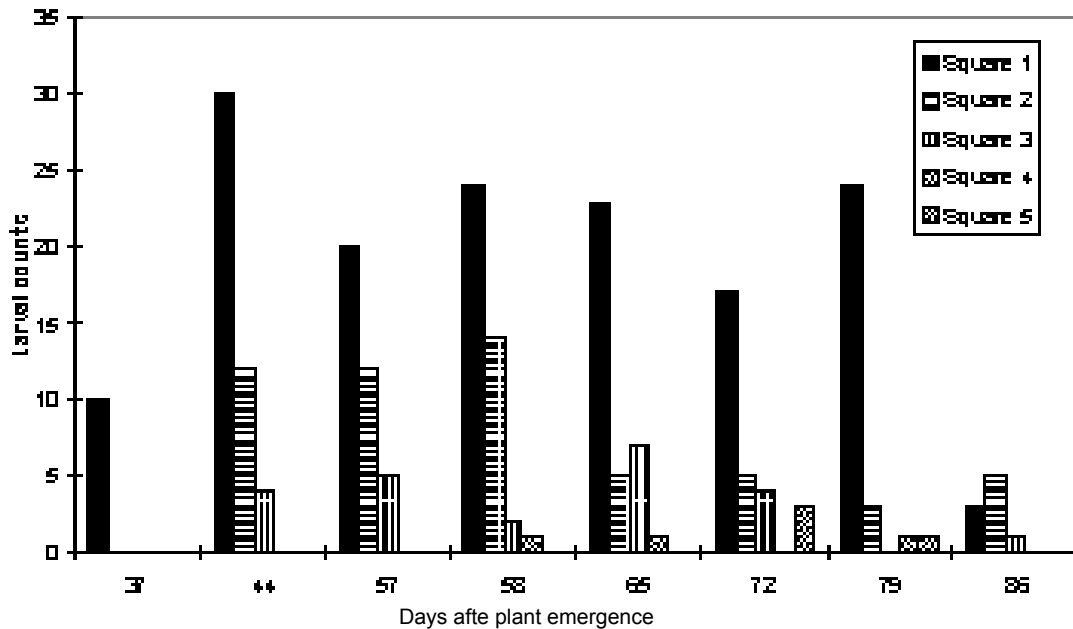


Figure 6. Distribution of first and second instar larvae of *H. armigera* on squares in sympodial branches (squares positions starts at the tip of sympodial branch).

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