OVIPOSITION AND FEEDING PREFERENCES OF THE BOLLWORM ON COTTON[1]

RAIMUNDO BRAGA SOBRINHO[2], JERRY HARRIS YOUNG[3] and LINDA JOHNSON YOUNG[4]

ABSTRACT - Oviposition and feeding preferences of the bollworm, *Heliothis zea* (Boddie) on cotton, *Gossypium hirsutum* L., cultivar 'Tamcot CAMD-E', were studied. A highly significant number of eggs on terminal and leaves indicated clearly that bollworm moths exibit a high degree of preference for egg placement on these parts. Feeding sites for bollworm larvae were quite variable among instars and plant parts, except for white flowers and red flowers which were the most preferred feeding sites for all larval instars. Terminals and leaves were the second most damaged plant parts by the first instars. Large boll preferences increased from fourth to sixth instars, with a peak of damage in the fifth instar. It was concluded that egg placement may vary among plant parts. Feeding preference sites varied from instar to instar within the various cotton plant parts. Consequently, caution should be taken in common scoring practices.

Index terms: *Heliothis zea, Gossypium hirsutum,* free-choice, nochoice, plant part, egg, larvae.

PREFERÊNCIAS PARA ALIMENTAÇÃO E OVIPOSIÇÃO DA LAGARTA-DA-MAÇÃ NO ALGODOEIRO

RESUMO - Foram estudadas as preferências para a alimentação e a oviposição da lagarta-da-maçã, *Heliothis zea* (Boddie) em algodão, *Gossypium hirsutum* L., cultivar Tamcot CAMD-E. Os terminais e as folhas do algodoeiro foram as duas partes preferidas para oviposição. Houve uma variação muito grande entre o estádio da larva e a parte da planta preferida para a alimentação, embora as flores novas e velhas fossem as preferidas para alimentação por todos os estádios larvais. Os terminais e as folhas constituíram a segunda parte da planta em grau de dano por larvas de primeiro instar. Maçãs grandes tiveram a preferência de larvas do quarto ao sexto estádios com um maior dano causado por larvas do quinto estádio. Pode-se concluir que a preferência para oviposição variou entre as diferentes partes da planta. Preferência para alimentação variou entre instares dentro das diferentes partes da planta. Deste modo, cuidados devem ser tomados nas amostragem de campo.

Termos para indexação: *Heliothis zea, Gossypium hirsutum,* livre-escolha alimentar, alimento sem escolha, ovo, larva.

INTRODUCTION

Knowledge of behavior of adult and immature stages of the bollworm *Heliothis zea* (Boddie) is a prerequisite to develop an understanding of its population dynamics and biology. Literature concerning oviposition and feeding behavior of bollworms on cotton does exist but is not consistent. For example, Wilson et al. (1980) found that the largest percentages of eggs were laid on leaves. However, Farrar Junior & Bradley Junior (1985a)

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[2] Entomologist, Ph.D., EMBRAPA/Centro Nacional de Pesquisas do Algodão (CNPA), Caixa Postal 174, CEP 58100 Campina Grande, PB, Brazil.

[3] Entomologist, Ph.D., Professor, Department of Entomology. Oklahoma State University. Stillwater, Ok - 74078 U.S.A.

[4] Statistician, Ph.D., Professor, Department of Statistics. Oklahoma State University.

reported that oviposition location varied considerably from year to year. Both upper and lower surfaces of leaves were the most common sites in two years, whereas in a third, terminals were the most favored. Quaintance & Brues (1905) and Mistric Junior (1964) reported that fruiting structures had the highest percentages of eggs laid. However, Bernhardt & Phillips (1982) found the highest numbers of eggs on leaves before peak of squaring, followed by a high number on dried flowers late in the season. For *Heliothis armigera* Hubner, Parson (1940) and Beeden (1974) found the largest numbers of eggs on leaves, whereas Matthews & Tunstall (1968) reported the largest percentages were found on stems.

In relation to feeding behavior, Quaintance & Brues (1905) reported that the sequential preference for damaging cotton plant parts by the bollworm, under laboratory experiments, were flowers, squares, bolls, terminals, and leaves. However, under field conditions, bollworm larvae were found mainly on squares and small bolls. Wilson et al. (1980) observed that first and second instars caused great damage to median squares, and third, fourth, and fifth instars preferred flowers. Reese et al. (1981) found that anthers and filaments were the parts of squares most often eaten by bollworms. Parrott et al. (1978) found that tobacco budworm larvae usually spend two or three days feeding on the main stem terminals and leaves before moving to fruiting structures.

Bollworm oviposition and feeding preference sites, under laboratory experiments, have not been intensively studied. The studies presented here were undertaken, therefore, to determine the oviposition and feeding preferences of the bollworm on cotton leaves, squares, flowers, bolls, and main stem terminals, in screening cages.

MATERIALS AND METHODS

Studies on the oviposition and feeding behaviors of the bollworm on the commercial cotton cultivar "Tamcot CAMD-E" were conducted in the laboratory with temperature 26±2°C, relative humidity 55±5%, and 14:10 (L-D) photoperiod.

Oviposition studies

Two laboratory experiments were conducted to study oviposition preferences of bollworm moths on different cotton plant parts. The first experiment was carried out under free-choice conditions, i.e., all treatments and replicates were placed in big cages and infested with bollworm adults. The second experiment was conducted under no-choice conditions, i.e., only one treatment was placed in a small cage and infested with bollworm adults. A detailed description of the methodology for each experiment will be presented below.

For the free-choice study, two wood-framed screen cages, measuring 2 m x 1 m at the base, and 0.7 m in height, with a 1 mm mesh nylon screen, were used. Water-filled cups of 120 ml capacity, with a hole of 1 cm on the lid, were used to accomodate plant parts. Two similar plant parts were placed in the cup with the stems inserted through the hole into the water in order to maintain freshness. This experiment had eight replicates and five treatments in a randomized complete block design. The treatments were cotton plant parts, such as squares, flowers, bolls, leaves, and terminals. Each experimental unit consisted of five plastic cups, with two equal plant parts inserted in each cup. Each cage with four replicates were infested with five bollworm couples. They were allowed to stay in the cages for a two-day period.

For the no-choice study, wood-framed cages, measuring 0.6 m x 0.6 m at the base, and 0.5 m in height, with 1 mm mesh nylon screen, were used. In each cage, 20 plastic cups with two like plant parts each, as previously described, were infested with two bollworm pairs. They were allowed to stay in the cages for a two-day period. The treatments were the same as described in the free-choice study. This experiment was a randomized complete block design with four replicates and five treatments.

Plant parts were collected from the field and then taken to the laboratory. Each plant part and its associated stem were cut to a length of 15 cm. They were individually examined for eggs, larvae, and predators before being placed into the cups. Two days after infestation, each plant part was checked for bollworm eggs. The number of eggs on two plant parts in each cup was recorded. Data subjected to analyses of variance and means, when appropriate, were separated according to Duncan's Multiple Range Test (Duncan 1955).

Feeding studies

In these studies, 30 plastic boxes, measuring 32 cm in diameter, and 8 cm high, were used to accomodate plant parts and larvae. Each box was covered with another similar box and sealed with tape in order to avoid escapes. Plant parts were also collected from the field as described for the oviposition study.

For the first instar, eight plant parts, leaf (LF), terminal (TL), white flower (WF), red flower (RF), square with 4 mm in diameter (4s), 6 mm (6s), 8 mm (8s), and 10 mm (10s) in diameter, were randomly distributed in an equal distance in the box. The stems of the plant parts were covered with wet cotton pads in order to keep them fresh during the experiment. Each box was infested with four neonate larvae placed at the center of the box. The larvae were allowed to stay in the boxes for a period of 48 hours. After that, plant parts were checked and recorded for number of larvae found on them.

A similar procedure described above was used for the second instar. Each box was infested with two second instar-larvae, placed at the center of the box. They were also allowed to stay in the boxes for a period of 48 hours. After that, plant parts were checked for damage or lack of damage caused by larvae on plant parts.

From third to sixth instars, plant parts such as squares of 6 mm in diameter (6s), 8 mm (8s), 10 mm (10s), white flowers (WF), red flowers (RF), small bolls (<1.5 cm in diameter, SB), median bolls (>1.5 cm and <2.5, MB), and large bolls (>2.5 cm in diameter, LB) were used. Since cannibalism usually occurs with third and more advanced instars, only one larva was placed in each box. The recording procedure was the same used for the second instars, i.e., numbers and kind of plant parts damaged.

Standard analysis of variance (ANOVA) techniques were used. Graphs were prepared to illustrate numbers of plant parts damaged. Confidence intervals for the probability of plant parts damaged by each instar were developed, based on the normal approximation to the binomial distribution, according to Remington & Schork (1970).

RESULTS AND DISCUSSION

The ovipositional responses of *H. zea* to various cotton plant parts, under free-choice and no-choice experiments, are shown in (Table 1). Terminals and leaves were the most preferred sites for oviposition. Number of eggs on terminals and on leaves showed no statistical differences at 5% for both free-choice and no-choice experiments. In the free-choice study, high numbers of eggs laid on the screens of cages were observed. This had not been seen in the no-choice experiment, except for cages that contained flowers, squares, or bolls. In both experiments, there were no differences among the numbers of eggs placed on flowers, squares, and bolls. However, they were different from terminals and leaves.

In the free-choice study, a total of 239 eggs were deposited on terminals, 168 eggs on leaves, and 55, 49, and 27 on white flowers, squares and bolls, respectively. Since each treatment consisted of a row of five cups, with two equal plant parts in each, this comprised a total of 80 plant parts in the experiment for each treatment. The average number of eggs on each terminal was about three, two on leaves and less than one on the other plant parts. The highly significant F value in the oviposition tests indicated that bollworm moths prefer to lay eggs on plant parts such as leaves and terminals. Terminals and leaves

TABLE 1. Mean number of bollworm eggs on cotton plant parts in free-choice and no-choice experiments.

Plant part	Free Choice*	No Choice
Terminal	6.0 A	42.5 A
Leaf	4.2 A	39.4 A
Flower	1.4 B	11.2 B
Squares	1.2 B	15.0 B
Boll	0.7 B	5.8 B

* Means in the same column followed by same letter are not significantly different (P = 0.05).

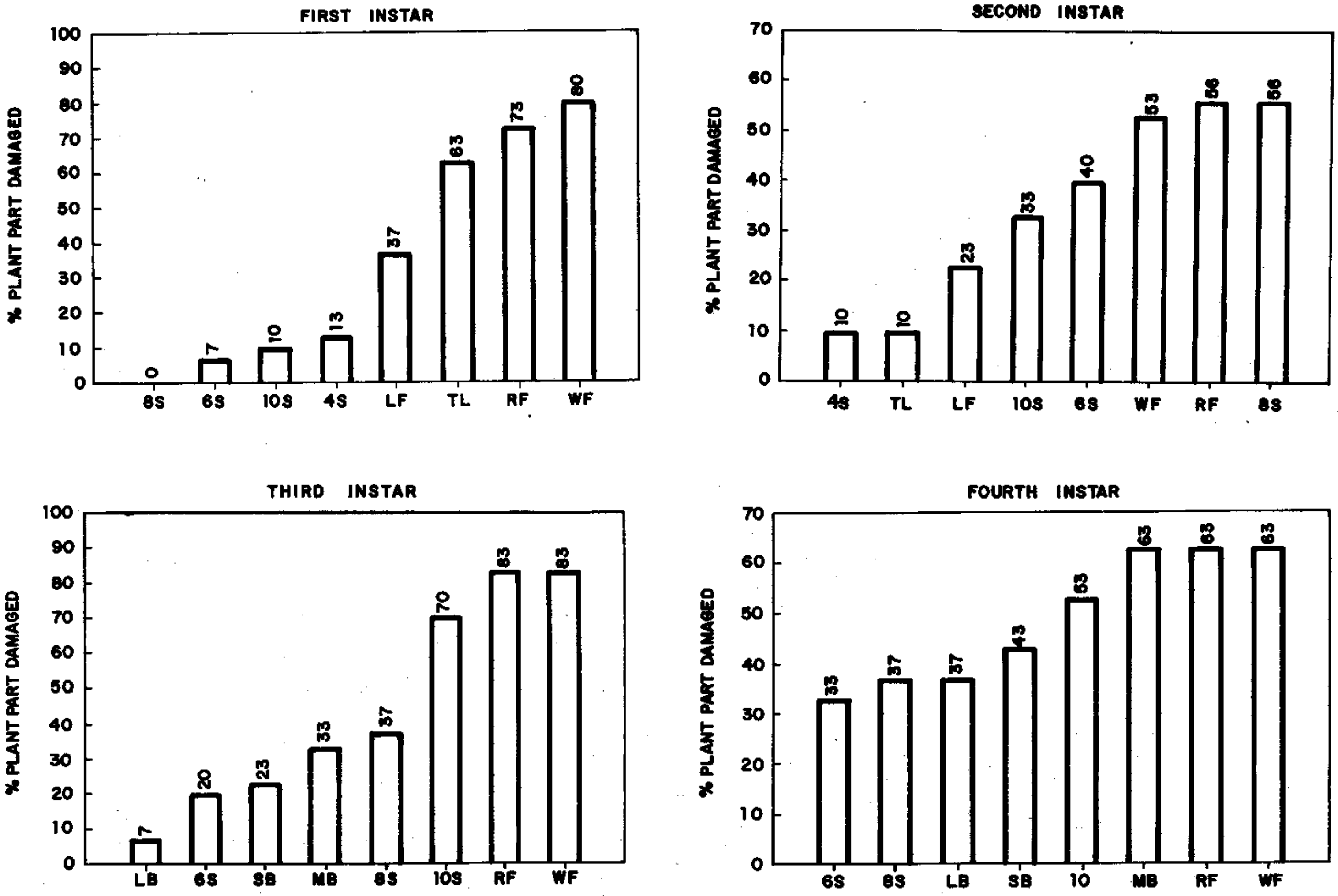
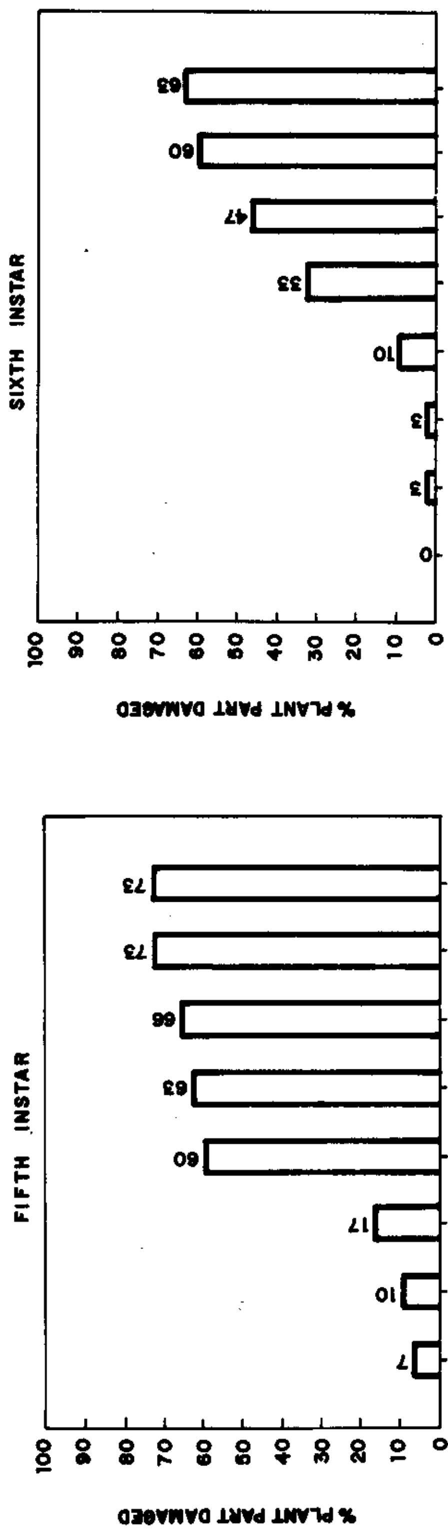


FIG. 1 to 6. Percentages of cotton plant parts damaged by Larval instars 1 to 6. 4S (Squares 4 mm in diameter); 6S (Squares 6 mm in diameter) 8S (Squares 8 mm in diameter); 10S (Squares 10 mm in diameter); SB (Small bolls); mb (Median bolls); LB (Large bolls); TL (Terminals); WF (White flowers); RF (Red flowers).



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have more tender succulent tissues with soft textured trichomes which could influence ovipositional behavior.

In the no-choice study, a total of 5,475 eggs was recorded on five types of plant parts during the experimental period. Out of that total, 2,041 were placed on terminals, 1,893 on leaves, 720 on squares, 539 on white flowers, and 282 on bolls. This experiment showed high numbers of eggs placed on the screen cages when less preferred plant parts such as squares, bolls, or flowers were tested. However, fewer eggs were observed on the screen when the plant parts were leaves or terminals.

The feeding responses of bollworm larvae to various cotton plant parts are shown in (Fig. 1 to 6). The first instar showed a high preference of WF and RF. Since first instar larvae did not cause visual damage to plant parts, the recording procedure was based on the presence of larvae. Thus, 80 and 73% of all WF and RF had at least one first instar.

From second to sixth instars, the evaluation was based on the number of plant parts damaged. The second instar damaged 56% of all 8S, RF, and 53% of all WF. Leaf, TL, and 4S were the least preferred plant parts. The damage caused by second instar was easily seen by scratches on the plant part surfaces.

Third instars caused damage to 83% of WF and RF, and 70% to 10S. Large bolls were the least preferred. This instar caused extensive damage to many plant parts in each box. Fourth instars presented a high potential of destruction by feeding on over 30% of all plant parts. Highest preferences were observed for MB, RF, WF, and 10S. Damage by fifth instars to 10S, MB, LB, RF, and WF was the greatest observed in all boxes. However, these larvae showed little indication of feeding on 6S, 8S, and SB. There was a decreasing preference for SB and a high preference for LB. This instar showed a tendency to feed mostly on large bolls.

A reduction in the feeding activity of sixth instars relative to earlier stages was clearly seen. Plant parts such as WF, RF, and LB were highly preferred. In spite of sluggish behavior, these larvae caused heavy damage, espetially to large bolls.

Confidence intervals for the probabilities of plant parts being damaged showed that the highest probabilities were observed for RF and WF in all instars. This was followed by 10S, MB, and LB (Table 2).

These studies showed that TL and LF are the most favorable places for egg deposition by bollworm. Flowers, squares, and bolls were not significantly different. There is no specific study on the oviposition behavior of the bollworm on cotton plant parts. Only one study was conducted by Farrar Júnior & Bradley Júnior (1985b) with *H. virescens*. Previous investigations did not specify terminals as oviposition sites, but considered upper or upper half of the plant as a place for oviposition. This fact has caused some misinterpretation because the upper part of a plant includes terminal, leaves, squares, bolls, and flowers. The present study strongly supports the findings by Braga Sobrinho (1988) who showed that main terminals and leaves are highly preferred places for egg deposition by bollworm moths.

There is no consistent information on larval feeding sites of *Heliothis* spp. Eleven plant parts were used as feeding sites of six larval instars. All larval instars preferred to damage WF and RF in all tests. Terminals were good feeding sites for first instars. All instars preferred to feed most heavily on the anthers of WF and RF. Most of the corolla tubes and petals were destroyed by any instar during the feeding period.

Less than 10% of all different sizes of squares were preferred by first instars. It was clear that first instars do not prefer to feed on squares to the same degree as they do on WF, RF, TL, and LF. First and second instars were found on 35% of the leaves, but damaged only 25% of them. There was an increasing preference for 10S from the second to the fifth instars, with a high decline in the sixth instars. Median bolls presented similar results, except for third instars where they were preferred to LB. The feeding preference of the bollworm larvae to cotton plant parts changed gradually from first to sixth instars. These changes were synchronized with the plant development and kind of plant structures available.

TABLE 2. Confidence interval* for probability of cotton plant parts to be damaged by six larval instars of the bollworm.

Plant Part	Instar I	II	III	IV	V	VI
4S	0.13±0.12	0.10±0.11	---	---	---	---
6S	0.10±0.11	0.40±0.18	0.20±0.14	0.33±0.17	0.07±0.10	0.0
8S	0.0	0.56±0.18	0.36±0.17	0.36±0.18	0.10±0.11	0.30±0.06
10S	0.10±0.11	0.33±0.17	0.70±0.16	0.53±0.16	0.60±0.18	0.10±0.11
LF	0.37±0.17	0.23±0.15	---	---	---	---
TL	0.63±0.17	0.10±0.11	---	---	---	---
WF	0.80±0.14	0.53±0.18	0.83±0.13	0.63±0.17	0.73±0.16	0.16±0.17
RF	0.73±0.16	0.60±0.18	0.83±0.13	0.63±0.17	0.73±0.16	0.60±0.18
SE	---	---	0.23±0.15	0.43±0.18	0.17±0.13	0.03±0.06
MB	---	---	0.33±0.17	0.63±0.17	0.63±0.17	0.33±0.17
LB	---	---	0.07±0.10	0.37±0.17	0.66±0.17	0.46±0.17

* Probability based on 30 occurrences; standard error based on normal aproximation to the binomial distribution.

CONCLUSIONS

The highly significant number of eggs on terminal and leaves indicated clearly that bollworm moths exhibit a high degree of preference for egg placement on these parts.

Feeding sites for bollworm larvae were quite variable from instar to instar and within the various cotton plant parts, except for white flowers and red flowers which were the most favorable feeding sites for all size of larvae. Terminals and leaves were the second most damaged plant parts by the first instars. Squares of all sizes were not good feeding sites for first instar larvae. Squares presented an increasing degree of preference for the second to fifth instars. Terminals had low probabilities of being damaged by second instars. Large boll preferences increased from fourth to sixth instars, with a peak of damage in the fifth instars. Median bolls presented similar results, except the high preference shown by third instars. Small bolls were comparable to median bolls in the third instars. In the fourth instars, small bolls were comparable to large bolls. In the fifth and sixth instars, small bolls had low acceptance.

From the data presented here it is clear that egg placement can vary among plant parts. Consequently, caution should be taken in common scouting practices. Feeding preference sites are quite variable. The feeding preference of the bollworm larvae to cotton plant parts changed gradually from first to sixth instars. These changes were synchronized with the plant development and kind of plant structures available.

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