Damage and Preference of Lesser Cornstalk Borer (Lepidoptera: Pyralidae) Larvae for Peanut Pods in Different Stages of Maturity

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ABSTRACT Lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller), larvae of various ages were fed peanut, *Arachis hypogaea* L., pods in stages 1 to 6 of maturity. Larval survival and pod damage were much greater on pods in stages 1 to 3 than on pods in stages 4 to 6. Older larvae were able to damage more mature pods, but this damage was primarily external scarification without pod penetration. Preference tests showed that larvae preferred pods in stages 2 and 3 and damaged pods in stages 1 to 3 significantly more than pods in stages 4 to 6. The significance of these findings in relation to field infestations of lesser cornstalk borer larvae is discussed.

THE LESSER cornstalk borer (LCB), *Elasmopalpus lignosellus* (Zeller), is one of the most destructive insects throughout the area of the United States that produces peanuts, *Arachis hypogaea* L. (Leuck 1967, Berberet et al. 1979, Smith and Holloway 1979). It is considered a dryland insect (Luginbill and Ainslie 1917, King et al. 1961, Walton et al. 1964, French 1971), because damage occurs most often in light, sandy soil and tends to be more severe during droughty periods. Leuck (1967) and French (1971) characterized damage by this insect on peanuts; early instars feed above ground on vegetative buds, flower axils, stems, and leaves or leafy debris touching the soil surface, and later instars, especially under dry conditions, feed below the soil surface on pods and pegs. Leuck (1967) also described pod damage by the LCB as a honeycombed declivity type of scarification, usually extending lengthwise along the pod and with penetration at the peg end of the pod. Peg damage was also described and was considered the most potentially damaging to yield. In 1980, the LCB caused over $27 million in losses to Georgia peanut producers (Suber et al. 1982). During this epidemic, a second type of pod damage, scarification without pod penetration, by the LCB was noted. This observation prompted a study of LCB damage and preference in relation to the stages of peanut pod development.

Materials and Methods

The method described by Williams and Drexler (1981) for determining peanut pod maturity based on color and morphological characteristics of the mesocarp was used to classify peanut pods into six classes. Based on this classification system, peanut pods in stage 1 are in their initial development, with a smooth surface texture and a soft, watery, white mesocarp. Stage 2 pods are structurally similar to pods in stage 1, but reach their maximum physical size and develop a longitudinal vein system. As pods develop from stages 3 to 7, the mesocarp color changes from yellow to black, the mesocarp structure changes from slightly resilient to very rigid, vein development is completed, the surface texture changes from slightly rough to very rough, and the surface reticulations develop and become very distinct. The classification technique involves removal of only a small portion of the pod epidermis to expose the mesocarp and visual observation of the structural characteristics of the pod. Because minimum destruction of pod tissue is required to determine the stage of pod maturity, the method lends itself to biological investigations of the LCB and other insects which feed on peanut pods.

'Florunner' peanuts were planted on 7 May through 15 June 1982 at the Gibbs and Belflower Farms, Tift County, Ga. For evaluation, plants with pods in developmental stages 1 to 6 were pulled and brought into the laboratory. Pods were cut from the plant with the entire peg attached, classified, and rinsed for ca. 1 min in 1% sodium hypochlorate and in distilled water. Clear plastic containers (5.2 cm in diameter by 3.6 cm in height) with tops were prepared by drilling a 1.7-cm-diameter hole in the bottom of each container. Two small holes were also drilled in the top of each container to prevent water condensation. Floral Aqua Pics were used to provide the moisture required to maintain the tissue of excised pods during the experiments. The pegs of freshly excised pods were passed through the hole in the rubber cap of the Aqua Pics and were submerged in distilled water. An Aqua Pic was then inserted through the hole in the bottom of the plastic container, and sterilized sand was added to the container until it

Table 1. Survival of LCB larvae and damage to peanut pods in different stages of development

Larval age (days)	Peanut developmental stage[a]	Larval survival (%)[b]	Damaged pods (%)[b]	Damage rating[c]	Larval wt (mg)
0	1	17.0b	70.0ab	1.9a	20.9a
	2	37.0a	78.0a	1.9a	20.2a
	3	37.0a	62.0b	1.2b	16.3a
	4	5.0c	12.0c	0.2c	13.5a
	5	0.0c	0.0c	0.0c	—
	6	0.0c	0.0c	0.0c	—
5	1	4.0b	80.0a	2.4a	17.5b
	2	48.0a	64.0a	1.3b	18.0b
	3	52.0a	68.0a	1.3b	27.2a
	4	0.0b	0.0b	0.0c	—
	5	0.0b	0.0b	0.0c	—
	6	0.0b	0.0b	0.0c	—
7	1	40.0b	76.0a	2.3a	21.8ab
	2	64.0a	76.0a	1.7b	27.6a
	3	60.0ab	76.0a	1.3b	28.6a
	4	12.0c	44.0b	0.6c	11.4b
	5	8.0c	56.0ab	0.6c	19.9ab
	6	0.0c	40.0b	0.4c	—
10	1	60.0a	88.0a	2.6a	19.8b
	2	84.0a	80.0a	1.6b	27.5a
	3	60.0a	84.0a	1.4b	22.9ab
	4	28.0b	64.0a	0.8c	23.4ab
	5	20.0b	72.0a	0.8c	7.9c
	6	28.0b	88.0a	0.9c	3.6c

Means within a column for each larval age are not significantly different ($P \leq 0.05$) when followed by the same letter, by Duncan's multiple range test.
[a] Peanut developmental stages based on the description given by Williams and Drexler (1981).
[b] Percentage data converted to arc sine $\sqrt{\%}$ for analyses.
[c] Pod damage rating on a scale from 0 to 3, where 0 = no damage, 1 = external pod scarification, 2 = pod penetration, and 3 = pod consumed.

reached the top of the Aqua Pic. Each container was then infested with an LCB larva from a laboratory culture maintained as described by Chalfant (1975). The containers were capped and placed in an incubator at 26.7 ± 2°C.

Tests to measure larval survival, pod damage, and larval development on stages 1 to 6 of pod development were conducted with neonate and 5-, 7-, and 10-day-old larvae; each larval age constituted a separate test. Two tests were conducted with neonate larvae; in the first test, a single pod was provided for each stage whereas in the second, two pods of stage 1 were provided. Each test was conducted in a randomized complete block with 25 replications of each pod stage. Tests were evaluated at 12, 11, 7, and 5 days for the neonate, 5-, 7-, and 10-day-old larvae, respectively. Data were recorded on percent survival, percentage of pods damaged, and larval weight. Damaged pods were also rated on a scale from 0 to 3, where: 0 = no damage, 1 = external scarification, 2 = pod penetration, and 3 = pod consumed. Data were subjected to analysis of variance, and means were separated with Duncan's multiple range test.

Preference tests were conducted in 25-cm-diameter dishes. The bottom of the dish was divided into six equal sections for stages 1 to 6 of pod development, and three 1.7-cm-diameter holes were drilled into the bottom of the dish for each section to accommodate the Aqua Pics. Six peanuts of each stage, two per Aqua Pic, were classified and disinfected as described above and were randomly assigned to the six sections within the dish. The Aqua Pics were placed in the dish, sand was added until it covered the tops of the Aqua Pics, and 10 5-day-old LCB larvae were placed on the sand in the center of the dish. The dishes were then covered with lids and placed in an incubator at 26.7 ± 2°C. Two experiments were conducted, both in a randomized complete block design with 10 replications. After 8 days, data were collected on the number of larvae feeding on each pod stage, larval weights, percent damaged pods, and pod damage ratings. Data analyses and mean separation were conducted as in the previous tests.

Results and Discussion

The survival and larval weights for LCB larvae of different ages fed on peanut pods are presented in Table 1. Two tests were conducted with neonates but were combined because there were no significant test × stage interactions. LCB larval survival was significantly greater ($P \leq 0.05$) when fed pods in stages 1 to 3 than in stages 4 to 6, with one exception: survival of 5-day-old larvae on stage 1 pods was not significantly different from survival on pods in stages 4 to 6. Similarly, peanuts in stages 2 and 3 promoted greater survival of neonate and 5-day-old larvae than did stage 1 peanuts.

Trends for weight when larvae were fed peanut pods of different stages were not as evident as were trends for larval survival. No significant differences in larval weights were noted when peanuts

Table 2. Preference of LCB larvae for peanut pods in different stages of development

Peanut developmental stage	No. of larvae/pod[a]	Damaged pods (%)[b]	Damage rating[c]	Larval wt (mg)
1	0.42b	36.9bc	1.07ab	23.2a
2	1.47a	56.2a	1.36a	26.5a
3	1.58a	50.9ab	0.83b	23.3a
4	0.32b	19.3c	0.24c	28.4a
5	0.26b	22.9c	0.23c	26.5a
6	0.42b	24.6c	0.26c	22.9a

Means within a column, followed by the same letter, are not significantly different ($P \leq 0.05$), by Duncan's multiple range test.
[a] Peanut developmental stages based on the description given by Williams and Drexler (1981).
[b] Percentage data converted to arc sine $\sqrt{\%}$ for analysis.
[c] Pod damage rating on a scale from 0 to 3, where 0 = no damage, 1 = external pod scarification, 2 = pod penetration, and 3 = pod consumed.

were infested with neonate larvae. With 5-day-old larvae, significantly greater weights occurred when larvae fed on stage 3 pods than when they fed on pods in stages 1 or 2. Results from 7-day-old larvae were conflicting: pods in stages 2 and 3 produced significantly heavier larvae than those in stage 4, but not significantly heavier larvae than stage 5 pods. Stage 2 peanuts promoted significantly greater weight gain for 10-day-old larvae than stages 1, 5, and 6. Percent LCB-damaged pods and pod damage ratings are also presented in Table 1. The percentage of damaged pods by 0- to 7-day-old larvae was significantly greater in stages 1 to 3 than in more mature pods, with one exception. Percent damage by 10-day-old larvae was not significantly different for all pod stages. Thus, comparing 7- and 10-day-old larvae with 0- and 5-day-old larvae, the ability to damage pods in stages 4 to 6 increased with larval age at infestation.

Pod damage ratings were also greater on pods in stages 1 to 3 than on pods in stages 4 to 6. Furthermore, damage ratings were significantly greater in stage 1 than in stages 2 and 3, with the exception that neonate larvae damaged stage 1 and 2 pods equally. As before, neonate and 5-day-old larvae were essentially unable to damage more mature pods, but the ability increased with increasing larval age at infestation.

Several interesting points can be noted from the results above. First, 0- to 7-day-old larvae severely damaged stage 1 pods but were unable to survive as well as they did on pods in stages 2 or 3. The internal contents of almost 60 to 100% of the stage 1 pods were entirely consumed by larvae of these ages. Only with 5-day-old larvae did this entire consumption of stage 1 pods limit the quantity of food and affect larval weight. However, if larvae in the other tests had remained on stage 1 pods through their entire development, they would have starved or pupated without attaining maximum weight.

Second, neonate and 5-day-old larvae were unable to damage pods once structural resiliency in stage 3 pods advanced to structural rigidity in pods in stages 4 to 6. In tests with 0- and 5-day-old larvae, an average of 69.3% of the pods in stages 1 to 3 were penetrated, whereas only 2.7% of the pods in stages 4 to 6 were penetrated. Thus, once the peanut pod hardened in stage 4, early-stage larvae were unable to penetrate the pod. Older larvae often damaged mature pods, but in general the damage tended to parallel that by younger larvae; 70.7% of the pods in stages 1 to 3 were penetrated, whereas only 8% of those in stages 4 to 6 were penetrated. The increased percent damage by older larvae that fed on more mature pods was primarily pod scarification without penetration.

Data from the two preference tests were combined and presented in Table 2. Significantly ($P \leq 0.05$) more larvae were found on stage 2 and 3 pods than on pods of any other stage. Similar results were also noted for percent damaged pods and pod damage rating, i.e., pods in stages 2 and 3 were preferred for feeding more than were pods in stages 4 to 6. In general, pod damage ratings tended to follow those recorded in previous tests; i.e., stages 1, 2, and 3 were most heavily damaged, but the magnitude of damage was considerably less when only 10 larvae were given a preference of 36 peanuts on which to feed. Furthermore, no significant differences in larval weight were noted when larvae were given a preference. This lack of weight differences may be due to free access of larvae to all pod stages, and larvae may have moved from one stage pod to another during the test.

In summary, LCB larval preference and survival tend to be greater when feeding on peanut pods in the early stages of development. Once pods reach stage 4, the mesocarp develops structural rigidity, and preference, survival, and degree of damage decline. The primary damage to peanuts in stages 4 to 6 is external feeding or scarification of the exocarp. Therefore, a field infestation during early pod set and fill is potentially much more damaging than in infestation during late pod fill when the majority of the peanut pods have advanced to stage 4 or beyond. However, several researchers have shown that pod damage increases fungal contamination of the kernel, thus increasing the possibility of pod rot or *Aspergillus flavus* Link contamination and aflatoxin formation (Diener 1973). Although pod damage is not necessary for aflatoxin formation in peanuts, LCB and other insect damage increases the likelihood of *A. flavus* contamination (Dickens and Satterwhite 1973, McDonald and Harkness 1963, 1964, McDonald et al. 1964). Structural damage to peanut pods, such as LCB scarification without pod penetration, may predispose the pods to fungal invasion. Therefore, definite recommendations concerning the potential damage of an LCB infestation during late pod fill cannot be made until research has been conducted on the degree of structural damage to the peanut pod and level of fungal contamination.

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