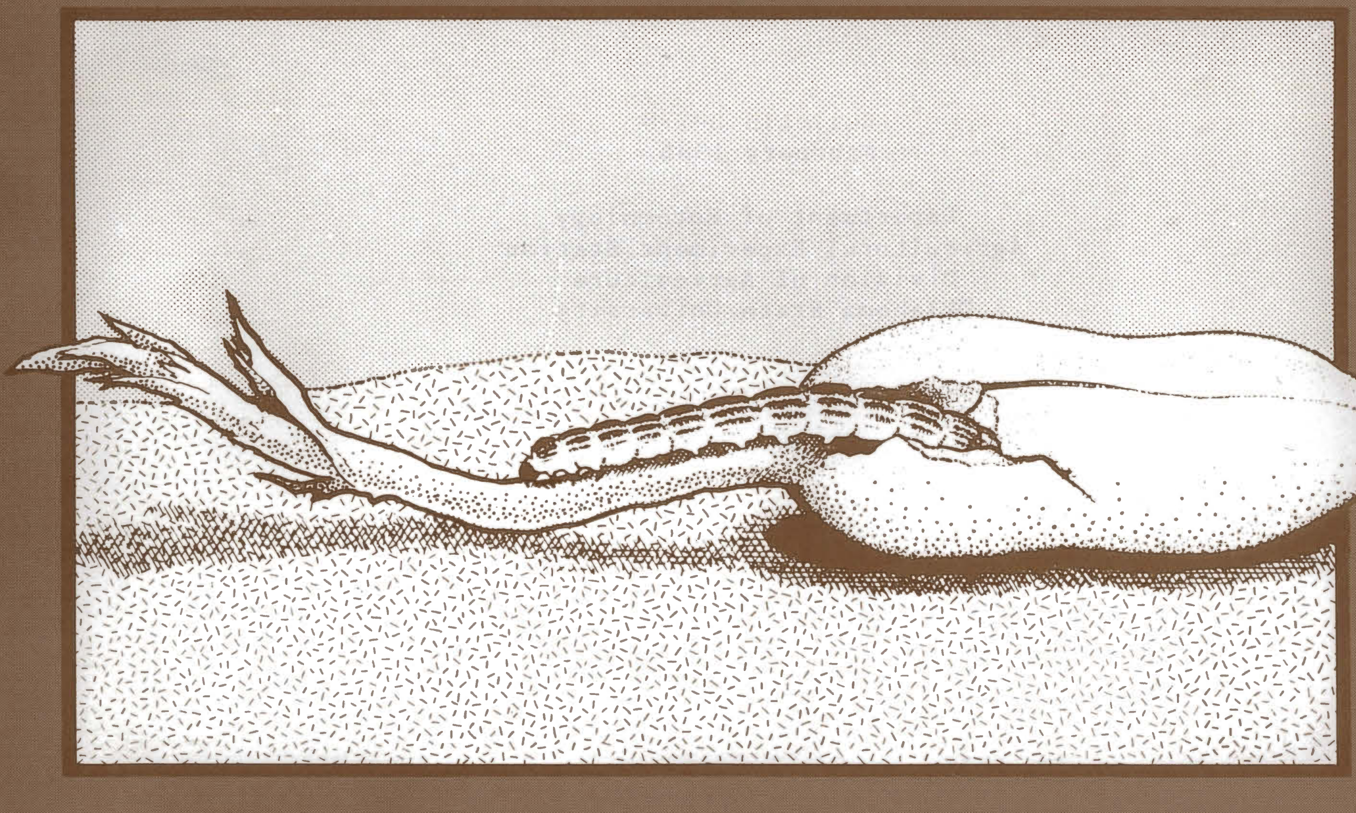
THE LESSER CORNSTALK BORER IN PEANUTS



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The Lesser Cornstalk Borer; a Key Pest of Peanuts in Oklahoma

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The lesser cornstalk borer (LCB), Elasmopalpus lignosellus (Zeller), has been reported to feed on at least 60 plant species in the United States. Among these host plants are several crop species such as corn, alfalfa, sorghum, wheat and peanuts. The LCB is regarded as a serious pest of peanuts in both southeastern (Leuck 1967) and southwestern (King et al. 1961, Walton et al. 1964) production areas of the United States. Its principal habitat during larval development is in soil where it feeds on pegs, pods and roots of the plants (Berberet et al. 1979, Leuck 1967). The LCB has been considered the most important insect pest of peanuts in Texas and Oklahoma where much of the acreage consists of nonirrigated peanuts grown on well-drained, sandy soils which are ideally suited for survival of this insect (Walton et al. 1964).

Although the LCB had been reported infesting peanuts during the 1940's, studies were not initiated for development of effective control measures until 1954 (Harding 1960). The first year that heavy LCB damage was reported in Oklahoma was 1963, and in that year research was conducted by Walton et al. (1964) on biology and control of the species. With exception of the work of these authors, little research was conducted relating to the LCB in Oklahoma until the studies described in this publication were initiated in 1972.

LIFE STAGES AND DEVELOPMENTAL STUDIES

Adult Longevity and Fecundity

The LCB adult is a grayish-brown moth with a wingspan of ca. 20 mm. Sexual dimorphism is exhibited in coloration of adults with males having much lighter forewings than females. When at rest, the wings are folded roof-like over the body. These moths remain within plant foliage during daytime hours, and if disturbed, they fly short distances in erratic, jerky patterns. Holloway and Smith (1975) observed that virtually all flight activity of LCB adults occurred in darkness under laboratory conditions. Other authors have reported that the moths mate and females oviposit during nighttime hours (Luginbill and Ainslie 1917, Stone 1968).

Cage studies of King et al. (1961) and Leuck (1966) indicated that female moths live an average of 8-10 days. These authors were in agreement that egg production averaged about 125/female. Mack and Backman (1984) studied ovipositional rates for LCB at nine temperatures and found that fecundity ranged from 39 to 119 eggs/female. The highest egg production was observed at 80-86°F.

Studies were conducted in Oklahoma from 1976-1978 on longevity and fecundity of LCB females. Adults used in these studies were obtained by rearing field collected pupae from 'Spanhoma' and 'Florunner' peanuts. The Spanhoma cultivar was developed for production in the Texas-Oklahoma area. This Spanish-type cultivar was studied in comparison with Florunner, which has been grown on progressively increasing acreage in Oklahoma since the early 1970's. Collections were made at weekly intervals throughout the growing season of each year. After emergence, individual females were paired with males in clear plastic, ovipositional chambers (10 cm dia. x 4 cm height). Humidity was maintained at 70-80% in chambers by placing a damp sponge covered by filter paper in the bottom of each. Eggs were laid on paper toweling which covered the chambers. Chambers were checked at 2 day intervals to determine if moths were living and to collect eggs for counting. Paper towels with eggs were held for 1 week prior to recounting to determine percent fertility. All studies were conducted at 78 ± 3°F and 14 hr photophase. Means were computed for female lifespan, total eggs/female and fertile eggs/female for each of three generations completed in each year. Significant differences in these variables for cultivars were determined by use of 't' tests.

Lifespans of females from Florunner peanuts ranged from 12.6 days in 1976 to 21.3 days in 1977. For those from Spanhoma, lifespans ranged from 12.8 (1976) to 20.3 days (1977). In both cultivars, moths of the first generation lived longest and lifespan in each generation decreased thereafter (Table 1). Over the 3 years, mean lifespan was 16.2 and 16.6 days in Florunner and Spanhoma, respectively. Cultivars had no significant effect on lifespan of moths. Females lived about 1 week longer than had been reported earlier (King et al. 1961, Leuck 1966).

Table 1. - Life span and fecundity of *E. lignosellus* females collected from 'Florunner' and 'Spanhoma' peanuts, 1976-1978.

	Yearly Means			Generation Means			Overall
Cultivar	1976	1977	1978	I	II	III	Means
			Life Span (Days)				
Florunner	12.6	21.3	15.3	18.7	15.7	15.4	16.2
Spanhoma	12.8	20.3	16.1	18.8	16.1	15.2	16.6
			Total Eggs/Female				
Florunner	364.6	253.6	270.6**	324.4	300.1*	274.3	297.0*
Spanhoma	359.7	300.3	370.5	352.1	368.9	299.4	340.7
			Fertile Eggs/Female				
Florunner	349.6	233.1	255.0**	316.4	283.3	251.7	280.3
Spanhoma	340.6	300.3	342.1	342.7	335.9	271.4	316.1

* Cultivar means significantly different, ($p < 0.05$), 't' test.

** Cultivar means significantly different, ($p < 0.01$), 't' test.

Table 2. - Egg production over the lifespan of LCB moths from 'Florunner' and 'Spanhoma' peanuts.

Female Age (days)	Florunner Eggs/2 days	Florunner Cum. % oviposition	Spanhoma Eggs/2 days	Spanhoma Cum % oviposition
4	45.6	14.6	50.2	13.8
6	90.0	43.5	96.7	40.4
8	70.5	66.1	86.0	63.7
10	43.1	79.9	55.4	78.9
12	20.1	86.4	28.4	86.7
14	13.7	90.8	12.6	90.2
16	13.7	95.2	16.0	94.6
18	8.0	97.8	11.0	97.7
20	3.2	98.9	3.6	98.8
>20	3.5	100.0	4.2	100.0

Egg production/female was 2-3 times greater than reported by Leuck (1966). It was even greater than that reported by Luginbill and Ainslie (1917) who found that females laid up to 342 eggs with the average being 190. It should be emphasized, however, that the values for our studies given in Table 1 were computed using only those data for moths which laid fertile eggs. Approximately 25% of the moths laid no fertile eggs. Had these been included, the eggs/female values would have been reduced. With exception of yearly means for 1976, moths from Spanhoma laid more eggs with higher fertility than those from Florunner. This may indicate that the nutritional qualities or the microhabitat provided by the Spanhoma cultivar were more favorable for the LCB. The rate of egg production over the lifespan of females was similar in the cultivars. About 80% of the eggs had been laid when moths reached 10 days of age (Table 2). Additional information relating to these studies is contained in the paper of Berberet et al. (1982).

Development of Immature Stages

Detailed descriptions of the egg, larval instars, and pupa of the LCB were prepared by Luginbill and Ainslie (1917). Eggs are oval and about 0.5 mm in diameter. Newly laid eggs are white in color and become dark red when ready to hatch. According to Leuck (1966), eggs are deposited on leaves, stems, and in soil beneath plants. Smith et al. (1981) devised a flotation method with which they could efficiently separate eggs from soil. They found that over 90% of eggs were laid in soil and most were deposited within 10 cm of peanut plants. Developmental time for eggs averaged about 3 days (King et al. 1961, Leuck 1966).

The first and second larval instars are distinctly reddish in color and feed primarily on lower leaves which are in contact with the soil. As the larvae feed, they construct small, silken tunnels covered with soil particles. The tunnels are attached to feeding sites on leaves. The third and fourth instar larvae become progressively more blue-green in color with brown transverse bands located dorsally on each segment. These instars feed on stems and often cause extensive girdling of the plant crown. They also feed on pegs and pods. According to Lynch (1984), a high proportion of the third and fourth instars are able to penetrate developing pods and feed within them. As with the smaller larvae, silken tunnels are attached to feeding sites. Fifth and sixth instar larvae are distinctly blue-green in color with brown transverse bands on the dorsum of each segment. Larvae of these instars have the greatest potential for damaging pegs and pods. Immature pods are often completely consumed. Feeding damage also results in external scarification of pods and provides points of entry for pod-rotting fungi (Lynch 1984). Although most feeding damage occurs on plant structures within 2-3 cm of the soil surface, with very dry conditions, larvae may feed on pods which are 4-6 cm deep in soil. When larvae reach the last instar, there is typically extensive webbing or tunneling attached to pegs, pods or stems where they have fed. During the summer months, larval development reportedly requires an average of 17 days (Luginbill and Ainslie 1917) to 19 days (Leuck 1966).

The pupa is pale green when newly molted and becomes progressively darker in color as the time for adult emergence nears. The average length is 8-10 mm with a diameter of 2 mm. Pupation occurs within a silken cocoon spun in the soil. An exit tube for use by the adult upon emergence extends to the soil surface giving the cocoon the appearance of a stocking. Externally, the cocoon is covered with a dense layer of soil particles. The enlarged basal area which contains the pupa may be within 1 cm of the soil surface when high moisture conditions exist. Under dry conditions in sandy soils, cocoons have been found as deep as 8-10 cm. Luginbill and Ainslie (1917) reported the average length of the pupal stadium is 10 days.

In 1977 a series of constant temperature studies were conducted in Oklahoma to determine developmental thresholds and degree day requirements for life stages of the LCB. Ten to fifteen replicates of egg, larval, and pupal stages were reared at each of four temperatures; 55 $\pm$ 2°, 65 $\pm$ 2°, 75 $\pm$ 2°, and 85 $\pm$ 2°F. Humidity was maintained at 65 $\pm$ 5% and photoperiod was 14 hr. Insects were checked at 12 hr intervals to record development.

Eggs were obtained from females which had emerged from field-collected pupae. After oviposition onto paper towels, eggs were counted and towels were cut into pieces, each with 20 eggs. A sample was incubated at each temperature for each of 15 replicates. Larvae were obtained from eggs laid in the laboratory and 15 replicates of 10 were reared for each temperature. They were reared in 17 x 63 mm

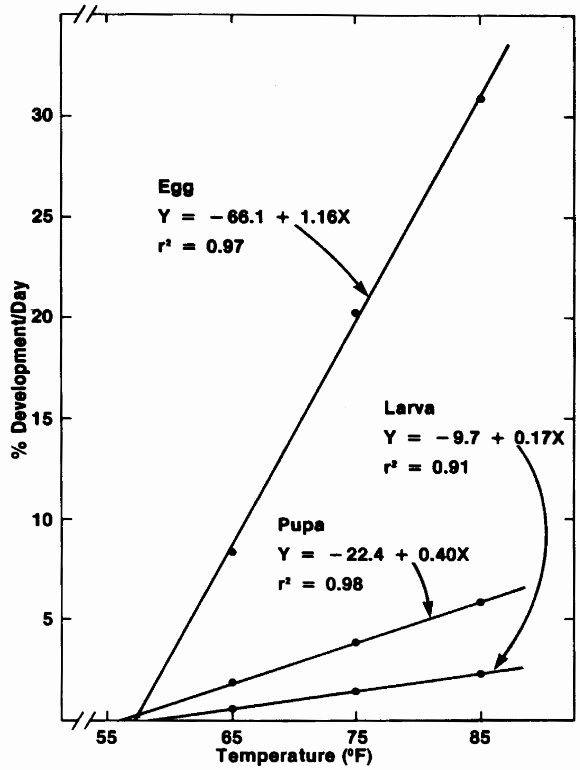

Fig. 1. - Developmental rates of immature stages of LCB.

Table 3. - Temperature requirements for development of the LCB.

Temperature (°F)	Egg		Larva		Pupa	
	Days	Degree days	Days	Degree days	Days	Degree days
55	no hatch		no pupation		no adult emergence	
65	10.0	80.0	96.9	678.3	26.8	241.2
75	5.4	97.2	36.1	613.7	13.1	248.9
85	3.0	84.0	23.4	631.8	8.5	246.5
Mean		87.1		641.3		245.5
Developmental threshold	57°		58°		56°	

vials containing a modified Vanderzant-Adkisson medium (Vanderzant et al. 1961). Pupae were obtained by rearing field collected larvae on the medium cited above. Ten replicates of 10 pupae were held in 30 ml cups for each temperature.

The relationship between developmental rate and temperature was described by a regression equation for each life stage. Equations and developmental thresholds are shown in Figure 1. Degree days required for completion of each life stage are given in Table 3. The total degree day (F) requirement for completion of a generation was ca. 1020. This included 50 degree days for the period from adult emergence until the first eggs were laid. At a daily mean temperature of 85°F, which is typical of Oklahoma in mid-summer, generation time would be about 36 days. It seems unlikely that development from egg to adult could occur in as few as 25 days as reported by King et al. (1961) and Walton et al. (1964).

POPULATION STUDIES

Seasonal Occurrence of LCB

Several authors have reported that the LCB completes three generations during the growing season in field crops (Berberet et al. 1979, Johnson 1978, Leuck 1966, Luginbill and Ainslie 1917). Leuck (1966) stated that a partial fourth generation occurred in Georgia during October. There is considerable overlapping of generations which causes difficulty in distinguishing members of each.

A sampling program was conducted in nonirrigated Spanhoma and Florunner peanuts in Marshall County from 1975 to 1978. The objective of the program was to determine the seasonal occurrence of LCB in relation to plant phenology. Also to be determined was the possibility that nutritional qualities or microhabitat provided by the prostrate, runner-type cultivar (Florunner) in comparison with the erect Spanish-type (Spanhoma) might result in different seasonal infestation levels or relative densities of life stages. Plots of 0.5 ha size of each cultivar were planted ca. June 1 of each year in a research area with uniformly sandy soil. Peanut production on sandy soil without irrigation provided a favorable habitat for the LCB.

Plants were sampled at weekly intervals from mid-June to early October. On each date a minimum of 50 plants/cultivar were removed from the soil and examined for LCB larvae. The soil around the base of each plant was sifted to locate larvae which had been dislodged and cocoons. The percentage of plants with live larvae or pupae (% infested) was computed for each cultivar. If necessary, additional plants were sampled until at least 50 LCB/cultivar had been collected. Stage of plant development (pegging, pod formation, etc.) was also recorded.

The LCB were taken to the laboratory where larvae were divided into four groups according to length; 2-4 mm, 5-8 mm, 9-12 mm, and 15-18 mm. Degree day accumulations were calculated for the period from June 1 to September 30 of each year using a threshold temperature of 57°F. Generations of LCB were separated and groups of larvae and pupae were assigned to generations based on two criteria: 1) Degree day accumulations were related to requirements for life stages and total generation time (1020 F° days) to ascertain probable beginning dates for each generation, 2) The relative numbers of larvae (in each size category) and pupae for each sampling date. This second criterion also indicated peak densities for life stages of each generation. Means for the 4 years were calculated for percent plants infested and relative incidence of larvae and pupae throughout the growing season. Graphs were prepared to illustrate these data.

Due to the similarity in seasonal occurrences and infestation levels of LCB in Spanhoma and Florunner peanuts, a single graphic presentation has been included. This figure was prepared from data for the Spanhoma cultivar. Generations of the LCB did overlap extensively in this study. Due to the fact that data from 4 years were averaged in preparing the graphs, occurrence of larvae and pupae for each generation tends to have a lengthened time frame. For a single year, periods of overlap would likely be somewhat shorter.

Larvae of the first generation were found beginning in mid-June. This is the only point in the season when collections consisted entirely of larvae (Fig. 2). Infestation levels were generally less than 30% during this generation. Feeding occurred primarily at the crown of the plant and on stems and leaves which were in contact with the soil. The first pupae were collected in early July. As larval numbers declined due to pupation, about 50% of the collections was comprised by larvae and the remainder were pupae in mid-July.

Small larvae of the second generation were first collected in mid-July. Plants were 40-50 days of age and formation of pegs and pods had begun as larval populations increased for this generation. These larvae fed primarily on fruiting structures. Over 50% of the plants of each cultivar were infested as the larval peak was reached. Pupation for the second generation began in early August and extended to September.

Small larvae of the third generation were collected in late August. By mid-September, third generation larvae comprised 80% of the LCB's collected. The infestation level reached 70-80% during September and tunneling in developing pods as well as external scarification of mature pods was extensive. Plants were 90-110 days of age as third generation larvae became numerous and damaged pods could not be replaced before harvest. In some instances, girdling of plant crowns was severe and portions of plants were killed. In September and early October, infestation levels in Florunner often exceeded those in Spanhoma. This was apparently due to the prostrate growth and greater habitat area available under the plant canopy in Florunner. Although it is not shown in Figure 2, small larvae were collected in October which probably represented the start of a fourth generation.

Due to the extended time over which LCB moths migrate into peanut fields, there is extensive overlapping of generations. Based on degree day accumulations and relative numbers of larvae and pupae throughout the season, three generations were delineated. The majority of larval feeding resulted during the period when pegging, pod formation, and pod maturation were occurring.

Spatial Patterns of LCB in Fields

Luginbill and Ainslie (1917) reported that LCB infestations in crop plants were often confined to areas with sandy soils. They cited

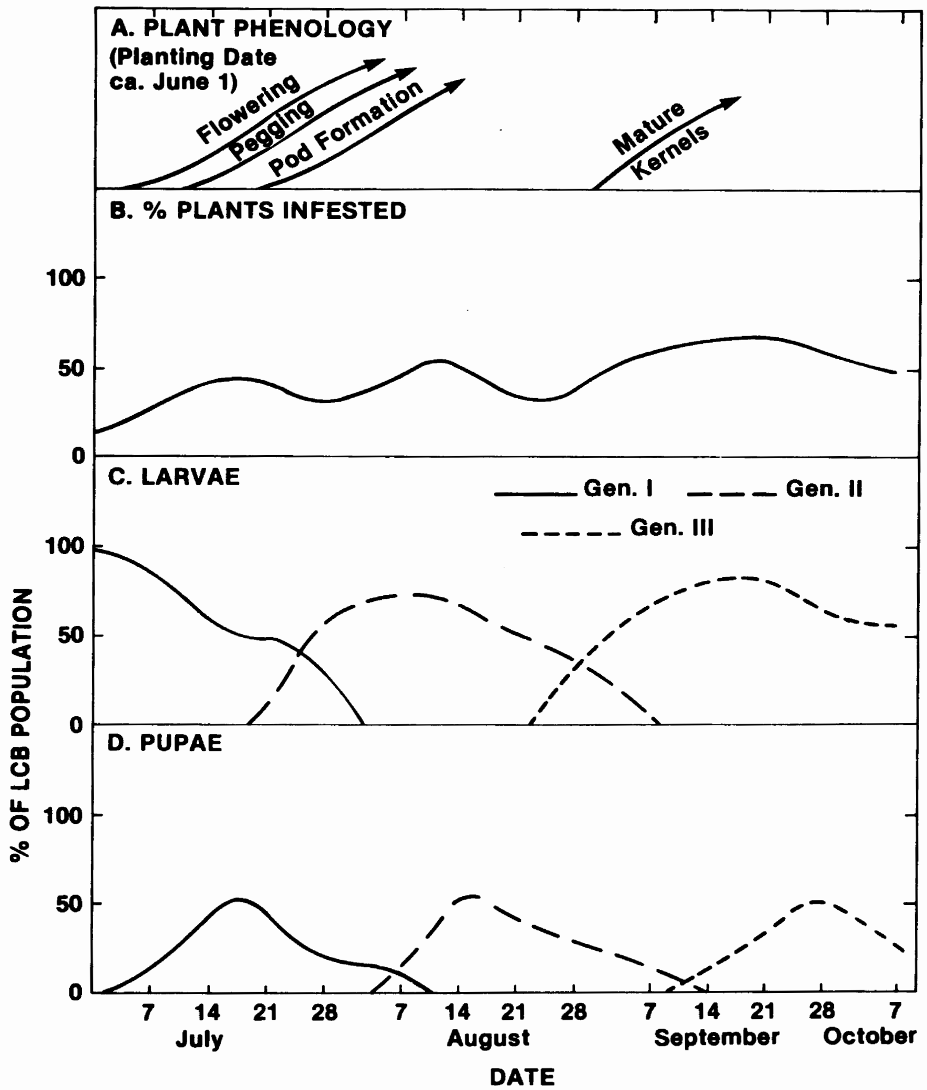

Fig. 2. - Peanut plant phenology and seasonal occurrence of LCB. (% of LCB population refers to relative numbers of larvae and pupae collected).

several instances in which crops were heavily damaged in sandy soils while suffering much less damage when grown in loam soil. Walton et al. (1964) stated that peanuts suffered much greater damage when grown in "deep sand" as compared with those grown in sandy loam or loam soils. The tendency of the LCB to occur most often in areas with sandy soil is included with scouting instructions in extension publications as well (Berberet and Pinkston 1984, Womack et al. 1981).

A sampling program was conducted over a 7 year period to determine spatial patterns for the LCB in peanut fields. Data were also taken on soil textures and plant populations to determine effects of these variables on occurrence of LCB in fields. A total of 12 fields of cooperating producers, which averaged 8-10 ha. (20-25 acres) in size, were utilized during the period from 1972 to 1978 for these studies. Nonirrigated fields were used as they were much more likely to have LCB infestations (Walton et al. 1964). Fields were located in Bryan, Hughes, and Marshall Counties of southern Oklahoma. Depending on which fields were planted in peanuts and the occurrence of LCB infestations, from three to six fields were sampled in each year. None of them had been treated with insecticides within 4 weeks prior to being sampled.

Sampling was conducted between July 15 and August 15 of each season. As adults migrated into fields and began oviposition in early June, 4-6 weeks were allowed for first generation populations to become established. As indicated in the previous section of this report, larvae of the second generation comprise a high proportion of the population in the 3-4 weeks following July 15. A stratified sampling plan was used with each field being measured and gridded for ca. 100 evenly spaced samples. For each sample, plants were pulled from 0.3 m of row and roots, pegs and pods were examined for larvae. The soil around the plants was sifted to recover larvae which had been dislodged and pupae in cocoons. Numbers of LCB (larvae and pupae) and plant counts were recorded for each sample.

A soil sample was collected from each of the 100 sites in every field for soil textural analysis. Soil classes were determined based on percentages of sand, clay, and silt particles using a standard soil textural triangle. This analysis revealed that five classes predominated in the fields including sand, loamy sand, sandy loam, loam and silt loam. This list includes a range from those with relatively large particles which drain and dry rapidly (sand) to those with a high proportion of very small particles which dry much more slowly (loam, silt loam). Analysis revealed that most fields had at least three classes of soil. Most had areas of sand and loamy sand, where over 70% of the soil particles were sand. Many also had areas of loam and/or silt loam, with as little as 40% sand particles and the remainder clay and silt.

Mean populations of LCB per sample and per plant were calculated for each field and each year of sampling. Sample variances and dispersion parameters (k values) were also calculated for each field. Additional calculations, which included all fields where the LCB was found in at least 30% of the samples were completed for each year and for the entirety of the study. These calculations included mean numbers and confidence limits (95%) for incidence of LCB by soil classes and plant densities (plants/0.3 m of row).

Mean population densities of LCB in fields ranged from 0.05 to 1.93/0.3 m of row during this study. Populations tended to be lowest during years when rainfall was abundant from June 15 through July 31 when the first LCB generation occurred. Rainfall and irrigation have been identified as important factors in limiting LCB infestations (All and Gallagher 1977, King et al. 1963). In 1973, when rainfall at National Weather Service recording stations nearest the fields averaged 12.8 cm in June and July, the population density averaged 0.55/0.3 m sample. In the following year, rainfall during this period averaged 2.7 cm and LCB populations rose to 1.23/0.3 m.

Infestation levels varied considerably within fields. Some portions of fields had several larvae and pupae per sample while in

Table 4. - Population densities (mean ± 95% CL) of LCB with varied soil textures and rainfall amounts, 1972-1978.

Year	Rainfall 6/15 to 7/31	Soil texture	Number of samples	LCB population #/0.3m of row
1973	12.8 cm	Sand	260	1.07 ± 0.20
		Loamy sand	113	0.30 ± 0.12
		Sandy loam	35	0.17 ± 0.16
		Loam	5	0
		Silt loam	1	0
1974	2.7 cm	Sand	150	1.88 ± 0.37
		Loamy sand	121	1.58 ± 0.34
		Sandy loam	83	1.50 ± 0.36
		Loam	129	0.93 ± 0.20
		Silt loam	30	0.67 ± 0.31
1972	7.6 cm	Sand	876	1.04 ± 0.11
to		Loamy sand	751	0.83 ± 0.10
1978		Sandy loam	209	0.88 ± 0.22
		Loam	153	0.84 ± 0.18
		Silt loam	34	0.61 ± 0.28

other areas none were found. Often, as high as 30-50% of samples contained no insects. In general, spatial patterns for populations were aggregated or clumped. Values of 2 or less were calculated for the dispersion parameter (k) in 22 of 25 analyses completed for fields. Values for k=2 or less are indicative of highly clumped populations which may fit the negative binomial distribution (Southwood 1978).

Table 5. - Population densities (mean ± 95% CL) of LCB with varied plant populations in nonirrigated peanuts, 1972-1978.

Plants/ 0.3 m of row	LCB population x year								
	1973			1974			1972-78		
	(N=)	#/0.3m	#/plant	(N=)	#/0.3m	#/plant	(N=)	#/0.3m	#/plant
1	45	0.71±0.28	0.71±0.28	32	0.75±0.30	0.75±0.30	205	0.77±0.15	0.77±0.15
2	71	0.97±0.38	0.48±0.19	87	1.21±0.34	0.60±0.17	400	0.91±0.14	0.45±0.07
3	87	0.83±0.26	0.26±0.09	114	1.47±0.31	0.49±0.10	462	0.89±0.13	0.30±0.04
4	78	1.23±0.37	0.31±0.11	76	1.18±0.34	0.30±0.08	332	1.05±0.17	0.26±0.04
5	51	0.88±0.38	0.14±0.07	59	1.66±0.55	0.33±0.11	239	0.97±0.20	0.19±0.04
6	33	0.24±0.20	0.04±0.04	43	1.86±0.08	0.31±0.13	159	0.84±0.26	0.14±0.05
>6	30	0.06	<0.01	81	1.81±0.47	0.22±0.06	184	0.96±0.24	0.12±0.04

Soil textures appeared to influence occurrence of LCB within fields and contributed to clumping of populations. Areas of sand or loamy sand soils usually had the greatest numbers as had been reported by Walton et al. (1964). During the season with highest rainfall (1973), populations were confined primarily to areas with well-drained, sandy soils (Table 4). Populations averaged 1.07/0.3 m in sand compared to 0.17 in sandy loam and 0 in the few loam and silt loam samples collected. It was evident that, with abundant rainfall, the most favorable habitats for LCB were found in sand. During the 1973 season, few LCB infestations were found in fields with loam and silt loam soils and the total number of samples with these soil types was just six.

In 1974, when less rainfall occurred, effects of soil texture on occurrence of LCB were less obvious. Although there were significantly more LCB in sand, the loam and silt loams soils had mean numbers of 0.93 and 0.67/0.3 m, respectively (Table 4). These were both much higher than the mean for loamy sand in 1973. In the drier weather conditions, LCB infestations were more widespread and a total of 159 samples were taken from loam and silt loam soils.

Overall analyses for 1972-1978 revealed that the highest populations were found in sand (1.04/0.3m), however, numbers in loamy sand, sandy loam and loam ranged from 0.83 to 0.88 and were not significantly lower. Nearly all samples included from loam and silt loam soils over the 7 year period were collected in the relatively dry year of 1974. In 6 of 7 years that studies were conducted, few LCB were found in areas with these soil types.

Two types of sampling data are presented in Table 5 related to LCB numbers vs. plant populations. LCB numbers/0.3 m are absolute density measures with the same habitat area for each sample. The numbers/plant (relative density) were consistently reduced as plant populations increased because there were seldom more than three or four LCB/0.3 m regardless of plant numbers.

Few instances occurred where absolute density measurements varied significantly due to changing plant populations. The most obvious instance where this did occur was in the wet season of 1973 when few insects were found with plant populations of six or more/0.3 m (Table 5). LCB populations with more than six plants/sample averaged 0.06/0.3 m compared to the highest level of 1.23 when the plant population was four/sample. The low numbers with higher plant density may have been due to slower drying of soil beneath a denser plant canopy. By contrast, the samples with highest plant densities also had the greatest numbers of LCB in the dry season of 1974. LCB populations in samples with six or more plants were significantly higher than those with one plant. Overall means for 1972-1978 were not significantly different regardless of plant densities.

It is evident from these studies that scouting recommendations for LCB which suggest checking plants in a minimum of five locations/field may not give accurate estimates of population density in many instances. Considering variability in populations which may occur due to soil texture and in some cases, due to plant densities, a more thorough scouting program should be utilized for decision-making relative to insecticide use.

Parasites of the LCB

Several researchers have conducted surveys to collect and identify parasites of the LCB. Leuck and Dupree (1965) identified four species which parasitized 35-61% of the LCB larvae in cowpeas and soybeans surveyed in southern Georgia. A member of the family Tachinidae, *Stomatomyia floridensis* (Townsend), was most abundant followed by *Chelonus (Microchelonus)* sp., *Orgilus* n. sp., and *Pristomerus pacificus melleus* Cushman. *Chelonus elasmopalpi* McComb and *Orgilus elasmopalpi* Meusebeck were the parasites of LCB larvae most commonly reported by Funderburk et al. (1984). In a survey of LCB parasites from several crops in Florida, these authors found the highest rates of parasitism in sorghum (11.3%) and lowest in peanuts (1.0%).

A survey was conducted in the three major peanut producing counties (Caddo, Bryan, and Hughes) of Oklahoma during 1972-1974. The principal objectives of the survey were to identify parasites and determine their seasonal occurrence and importance in regulating LCB populations. Collections were made in fields of peanut producers by removing plants from soil and examining pegs, pods, and roots for larvae. Soil around plants was sifted to recover larvae which had been dislodged from plants and pupae. Larvae were reared in the laboratory (75 ± 3°F) on modified Vanderzant - Adkisson medium (Vanderzant et al. 1961) in 17 x 63 mm vials plugged with cotton. Pupae were placed in 30 ml cups with cardboard lids. The insects were checked at 2 day intervals to record emergence of adult LCB or parasites.

During 1975-1978, studies were conducted in Marshall County for comparison of incidence and abundance of LCB parasites in nonirrigated Florunner vs. Spanhoma peanuts. The primary objective was to determine if the growth habits or other characteristics of the plants (prostrate vs. erect) influenced the occurrence of parasites. Collections of at least 50 LCB weekly were made from early July until October. Rearing was conducted as described above. Population densities for LCB were computed as #/m of row.

Of over 5000 LCB collected in surveys from 1972 - 1974 , only 179 were parasitized (4.8%). Seven species of primary parasites and one hyperparasite were identified (Table 6). Those which attacked larvae were somewhat more numerous than the pupal parasites. Grissell and Schauff (1981) have described three new species of *Invreia* from LCB pupae (*I. deceptor*, *I. usta*, *I. threa*). Although all specimens retrieved in Oklahoma have not been identified, it appears that most are *I. deceptor*. The principal conclusion which resulted from the surveys is that several parasitic species attack the LCB, and they provide little natural regulation of numbers and probably are not important in preventing the occurrence of economically damaging populations.

Studies of 1975-1978 showed that rates of parasitism in Florunner and Spanhoma peanuts averaged 13.2% and 12.8%, respectively (Table 6). The same species were found as had been identified in surveys, with exception of a gregarious ectoparasite, *Bracon gelechiae* Ashmead. The most common parasite of LCB larvae was *Apanteles* sp. *Invreia deceptor* was the most common parasite overall, and was responsible for mortality of over 5% of pupae in Florunner and

Table 6. - Parasitism of the LCB in Oklahoma, 1972-1978

Parasitic Species	Host* Stage	% of LCB parasitized: Surveys 1972-1974	Marshall Co. (1975-1978) Florunner	Spanhoma
Apanteles sp.	larva	0.3	2.0	2.4
Bracon gelechiae Ashmead	larva	---	0.7	0.6
Orgilus elasmopalpi Muesebeck	larva	1.6	1.4	1.0
Pristomerus spinator (F.)	larva	0.8	2.0	1.0
Stomatomyia floridensis (Townsend)	larva	0.1	---	---
Spilochalcis flavopicta (Cresson)	pupa	0.1	---	---
Spilochalcis sanguiniventris (Cresson)	pupa	0.1	---	---
Invreia sp. (primarily *I. deceptor* Grissel and Schauff)	pupa	0.8	5.4	6.4
*Perilampus fulvicornis*** Ashmead		0.1	0.1	0.1
Unidentified		0.9	1.6	1.3
Total		4.8	13.2	12.8

*Host stage which is parasitized

**Hyperparasite

6% in Spanhoma. Seasonal trends indicated that parasitism of LCB larvae was highest (13.2%) in the first generation and decreased thereafter (Table 7). Larval parasites showed no capability for responding positively to increased host population densities. By contrast, parasitism of pupae by *Invreia* sp. increased through the season to a maximum of 10% for the third generation during September. A complete description of this study is given by Berberet et al. (1979). The principal conclusions resulting from the study were: 1) the growth habits of cultivars did not influence the occurrence of LCB parasites, and 2) the parasites were not effective regulators of LCB populations.

Johnson and Smith (1981) reported for the first time that *Geron aridus* Painter (Bombyliidae) had been reared from LCB pupae. Larvae of the parasite apparently seek out LCB larvae and their development is completed after the host pupates. During 1980, a number of Bombyliid parasites were reared from pupae which were collected in Marshall County and they appear to be *G. aridus*.

Life System of LCB in Peanuts

Clark et al. (1967) described the life system as that part of the ecosystem which determines the existence, abundance, and evolution of a species population. In the life system, inherited properties of individuals in the population (in this case, the LCB) and environmental attributes (habitat provided in peanuts) serve as co-determinants of abundance for the species population. Mechanisms by which population densities are regulated include additive and subtractive processes which contribute to population increase or decrease, respectively.

There are several factors listed in figure 3 which relate to additive and subtractive processes influencing populations of LCB in peanuts. This listing does not include all such factors, however, it does have those which research findings have identified as being most important. Foremost among the additive processes is the presence of extensive habitats in soil and the capability of the LCB to utilize them. The presence of pegs and pods along with root systems of peanut plants in soil provides abundant food sources in a cryptic habitat which is not accessible to many natural enemies.

Population outbreaks of LCB occur during periods of warm, dry weather and highest numbers are typically found in sandy, well-drained soils (King et al. 1961, Leuck 1966, Luginbill and Ainslie 1917, Walton et al. 1964). Soil texture analyses conducted in fields in

Table 7. - Relative rates of parasitism of larval and pupal stages of the LCB, Marshall County, 1975 - 1978.

Generation	LCB/ m of row*	Larva		Pupa	
		# collected	% parasitism	# collected	% parasitism
1	2.0	993	13.2	428	1.7
2	7.0	2014	6.4	894	5.0
3	23.5	3013	3.1	794	10.0

* Peak population densities, larvae + pupae.

Values in table are for combined collections from 'Florunner' and 'Spanhoma' peanuts.

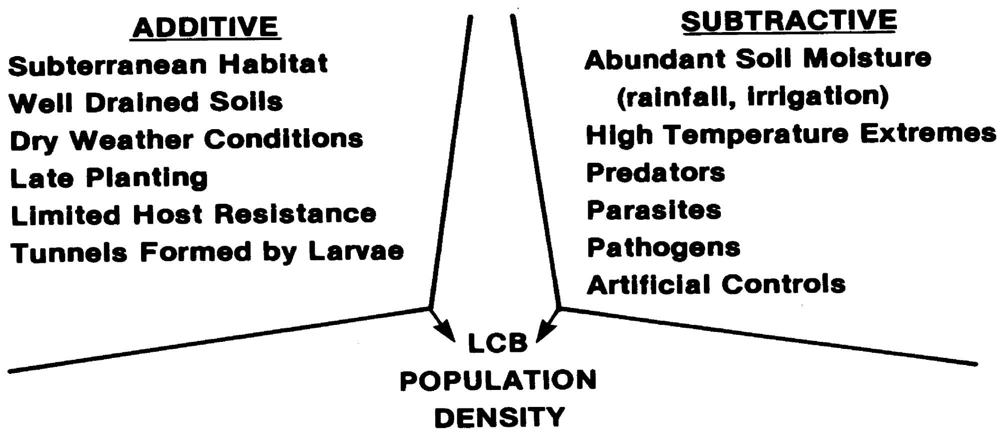

Fig. 3. - Factors related to additive and subtractive processes in the LCB life system in peanuts.

principal peanut producing counties of Oklahoma indicate that most have soils classified as sand or loamy sand which are favorable for survival of the LCB. Furthermore, rainfall frequently occurs in small amounts during the growing season and peanuts are often grown without irrigation. For example, in 1983, the nonirrigated acreage of peanuts in the state was over 11,000 hectares (27,000 acres). There is an abundant area devoted to peanut production which has favorable attributes for LCB survival.

By contrast, abiotic factors such as soil moisture may impose limitations on LCB populations or may contribute to increased numbers. All and Gallaher (1977) found that irrigation reduced the numbers of infested corn plants by 63.2% when compared with nonirrigated production areas in Georgia. A similar observation was made by Walton et al. (1964), who found reduced damage to irrigated vs. nonirrigated peanuts in Oklahoma. In three peanut fields we sampled where 15.1% of plants were infested during the relatively dry year of 1972 (rainfall from June 1 to August 15 = 12.4 cm), infestation levels dropped to 3.5% in the next season when rainfall was abundant (27.3 cm). When a combination of high moisture levels and relatively high percentages of clay or silt particles are present in soils, it was consistently observed that LCB populations were virtually eliminated.

Warm temperatures and dry conditions tend to favor survival and development of the LCB. However, we observed that when daytime temperatures regularly exceeded 95-100°F along with drought conditions, mortality of larvae occurred apparently due to desiccation. The amount of mortality appeared to be greater in Spanish than in runner peanuts, perhaps because the plant canopy provided less shading of the soil in the Spanish cultivars.

Late planting (after early May) increased damage to peanuts in Georgia because pegging and formation of harvestable peanuts then coincided with the highest incidence of LCB during August (Leuck

1967). A similar occurrence has been observed in Oklahoma when plantings are made after June 1. Larval populations in late plantings have exceeded those where planting was completed before May 15. There are two possible explanations for this: 1) Females may prefer to oviposit in fields where the plant canopy is less extensive and more soil surface is exposed, 2) It is also possible that survival of larvae is enhanced due to more rapid drying of soil after rainfall or irrigation as smaller plants provide less shade.

Several authors have reported that some peanut cultivars possess low levels of host resistance to the LCB (Leuck and Harvey 1968, Schuster et al. 1975, Smith et al. 1980). However, the levels of resistance in cultivars which have been grown extensively ('Comet', Florunner, 'Florigiant', 'NC 6', 'Spantex', 'Tamnut 74', and 'Starr') do not appear to be sufficiently high as to impose limitations on survival and development of the LCB. All of those listed had average pod damage exceeding 15% in studies of Stalker et al. (1984). In addition, two of the cultivars, Comet and Starr, served as susceptible checks in studies of Schuster et al. (1975) and Smith et al. (1980), respectively. Unless significant progress can be made in breeding for resistance, cultivation of nonresistant peanut cultivars will continue to be an additive process for LCB species populations.

As stated earlier, there are at least 15 species of parasites which attack the LCB. In addition, Johnson (1978) identified several predators including Geocoris sp. (Lygaeidae); Philophuga viridicola LeConte (Carabidae); and two Therevidae, Psilocephala acuta Adams and Furcifera rufiventris (L.W.). Various reports on effectiveness of natural enemies in regulating populations of the LCB are in agreement that mortality levels of the host are quite low. Effectiveness of these parasites and predators is undoubtedly limited by the location of LCB larvae and pupae within silken tunnels in the soil. This cryptic environment greatly reduces the chances of mortality due to most natural enemies.

Johnson (1978) also found infections in LCB larvae and pupae due to an Entomopoxvirus and a fungus, Aspergillus flavus Link, which he estimated to cause mortality of 3.7% and ca. 3%, respectively. Funderburk et al. (1984) found a granulosis virus, a fungus (Beauveria sp.) and a microsporidian causing disease in LCB larvae. The average incidence of disease produced by these agents in Florida totaled 4.4%. As in the case of the parasites and predators, the mortality caused by pathogens was quite small.

Johnson (1978) concluded from life table studies conducted in Texas that mortality of immature stages of the LCB was not density-dependent, and most regulation of populations was due to abiotic factors such as soil texture and moisture. Despite the fact that there is an abundance of natural enemies for the LCB, their importance in subtractive processes which limit LCB populations seems to be limited. It is of importance that additional studies be conducted to improve understanding of the interactions of the LCB and its physical environment in peanut fields. It is also important that research be continued for improvement of artificial measures such as host resistance and biological control, so that integrated control programs can be more effective as regulators of LCB populations.

ECONOMIC LOSSES AND CONTROL MEASURES

LCB Damage in Peanuts

Several authors have published reports which include descriptions of damage to peanuts by the LCB. The most comprehensive of these gave detailed accounts of injury to fruiting structures and related larval population densities with pecentages of damaged pegs and pods (Leuck 1967). The first studies which related infestation levels to yield reductions for use in economic threshold determinations were published by Berberet et al. (1979) and Smith and Holloway (1979).

Research was conducted in Oklahoma during 1973-1977 for determination of yield reductions due to LCB in nonirrigated Spanish peanuts. The cultivar Spanhoma was evaluated at an experimental site in Marshall County, which was selected because of its uniformly sandy soil and history of LCB infestations. The same location was used with Florunner peanuts during 1982-1983. During each season, infestation levels were adjusted with monthly applications of insecticide in which a directed spray was banded on the soil surface in the pegging zone. Carbofuran was used at rates of 2.2, 1.1 and 0.6 kg AI/ha along with untreated plots in 1973. Chlorpyrifos was used as 2.2, 1.1, 0.6, and 0.3 by AI/ha in all subsequent years. Four replications of treatments were arranged in a randomized complete block design with plot size of two rows x 100 or 150 m. Benefin or pendimethalin herbicide was used for preplant weed control, Manzeb and PCNB were applied as needed for disease control.

Twenty-five plants were sampled in each plot at weekly intervals during July through mid-September. Single plants were pulled at 4-6 m intervals in alternating rows and examined for larvae. Soil around plants was sifted to recover larvae which had been dislodged and pupae. The number of plants with live larvae or pupae (# infested) was recorded for each plot. Seasonal averages for percent infested plants were computed for each plot from results of 8-10 weeks of sampling. Entire plots were harvested at ca. 130 days postplanting and yields were computed in kg/ha.

Maximum yield for each year was estimated from averages for undamaged (2.2 kg AI/ha treatment) plots. For the Spanhoma cultivar, regression analyses were calculated to determine the relationship of infestation vs. yield and tests for parallelism were used to determine if this relationship was consistent over years. Slopes for regressions did not differ significantly ($P<0.05$) for years and a common regression was formed which combined all years. Data for just 2 years have been generated thus far for Florunner peanuts and a single regression was calculated for all data. Values used in this regression were average infestation levels for each plot vs. yield reduction (maximum yield for year - plot yield).

Average infestation levels in untreated Spanhoma peanuts ranged from 7% in 1976 to 62% in 1973 and 1975. Maximum yields for the undamaged peanuts ranged from 1506 kg/ha (1973) to 2271 kg/ha (1977). Despite the fact that infestation levels and yields varied considerably from year to year, the slopes for regressions did not differ significantly. A highly significant ($P < 0.001$) linear relationship existed between percent infested plants and yields. Year

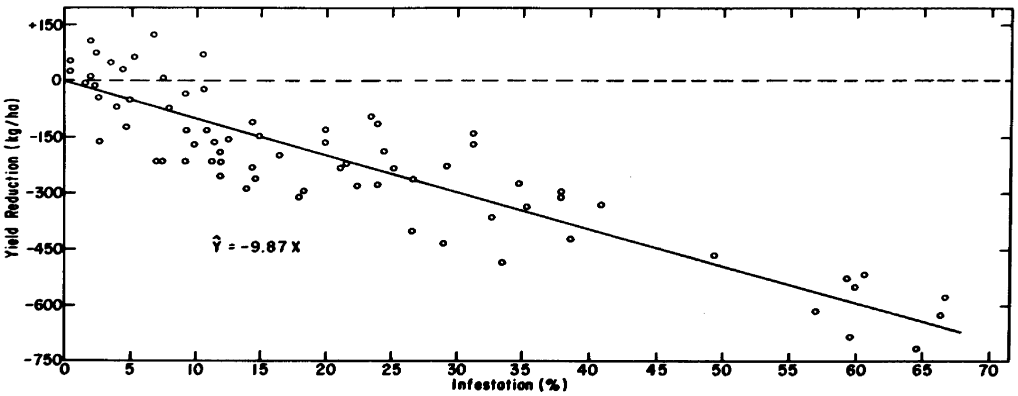

Fig. 4. - Common regression for percent infestation by LCB vs. yield reduction in Spanhoma peanuts, 1973 - 1977, (r^2 = -0.95).

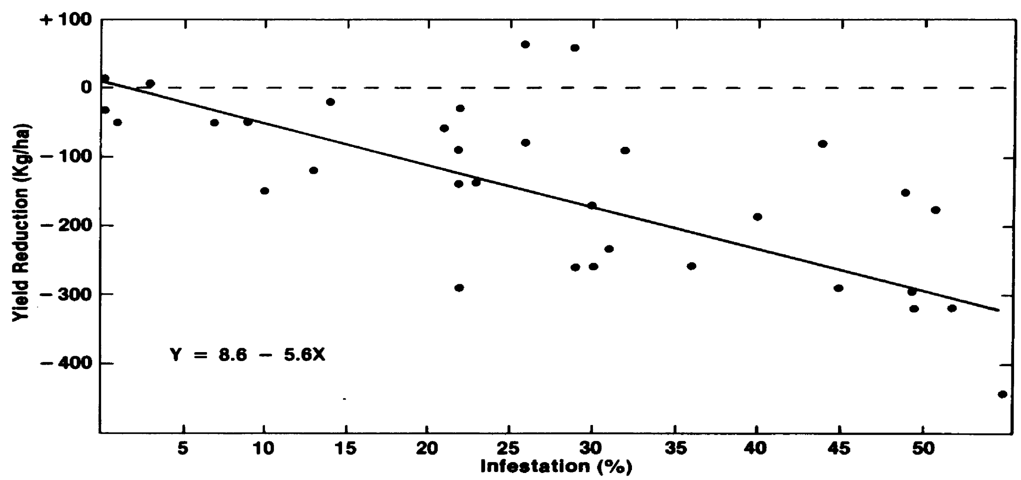

Fig. 5. - Regression for percent infestation by LCB vs. yield reduction in Florunner peanuts, 1982 - 1983, (r^2 = -0.70).

and replicate effects were removed and adjusted yield values varied around zero when percent infestation equaled zero. The common regression resulting for yield reductions had the intercept at the origin and the equation Y = -9.87X where X = percentage of plants infested and Y = kg/ha (Fig. 4). Thus, a loss of nearly 10 kg/ha (8.8 lb/acre) was sustained for each increase of 1% in infested plants. Additional discussion relating to this research is included in the publication of Berberet et al. (1979).

Average infestation levels in untreated Florunner peanuts were 47% for 1982 and 31% in 1983. Maximum yields for undamaged plots were 753 and 939 kg/ha for 1982 and 1983, respectively. Limited rainfall in both seasons resulted in low yields. The linear regression analysis of percent infestation vs. yield reduction resulted in the equation Y = 8.6 - 5.6X, where X = percentage of plants infested and Y = kg/ha (Fig. 5). The slope of this regression line was much smaller than that for Spanhoma and indicated that losses due to LCB were less severe in Florunner peanuts. However, additional data are needed for Florunner, particularly with higher rainfall amounts or irrigation, to increase the reliability of this comparison.

When combined with information on values for harvested peanuts and cost of insecticides, these estimates of percent infestation vs. yield reduction provide the required inputs for decision-making regarding insecticide applications for the LCB. Insecticide applications are not warranted unless the predicted value of crop losses exceeds current control costs.

Chemical Insecticides for LCB Control

Evaluations of insecticides for control of LCB in peanuts were first conducted in Texas during 1957-1959 (Cunningham et al. 1959, Harding 1960). These studies showed that application of granular formulations followed by irrigation or basally directed sprays in the pegging zone (nonirrigated) provided effective control and significantly reduced damage to fruiting structures by the LCB. The studies also showed the necessity of moving toxicant into the soil for effective control. Insecticides which were recommended for LCB control in Texas and Oklahoma as a result of these studies included DDT and parathion.

Additional studies were conducted beginning in 1970 to evaluate more recently developed organophosphate and carbamate insecticides for effective LCB control (Sams and Smith 1979, Smith et al. 1975). The compounds which provided adequate control included Azodrin®, Dasanit®, Dyfonate®, Furadan®, and Lorsban®. Trade names have been used to aid in rapid identification of insecticides included in this section.

Several evaluations of insecticides were conducted in Oklahoma during the period from 1972 to 1981. These studies included experiments in both irrigated and nonirrigated fields of cooperating producers in Grady and Marshall Counties. For each test, treatments were replicated four times in a randomized complete block design with two row x 150 m plots. Applications were made within 2-3 weeks after pod formation began when LCB infestation was found on at least 10% of the plants. For irrigated peanuts, granular formulations were applied in a 20-30 cm band over the row. Insecticides were watered into soil within 3 days of treatment. Spray preparations were directed onto a 20-30 cm band at the soil surface along the base of the plants in nonirrigated peanuts. Spray volume of 20 gallons/acre was applied with two nozzles/row in early morning hours when soil temperatures were relatively low.

Plots were sampled at 3 weekly intervals after treatment. For each sample, 25 plants/plot were pulled and roots, pegs and pods were examined for larvae. Soil around plants was sifted to recover larvae which had been dislodged. The number of infested plants was recorded for each plot and percent control for each treatment was calculated as percent reduction from the untreated plots. Entire plots were harvested and yield was computed as dry weight/ha. Average returns (yield savings) were calculated by subtracting the yield for untreated plots from those for the various treatments. Value of peanuts was calculated at $0.55/kg ($0.25/lb.).

Table 8. - Evaluation of insecticides for control of LCB in irrigated peanuts in Oklahoma, 1972 - 1973*.

Insecticide	AI kg/ha	# Years tested	% Average control**	Average return kg/ha	Average return $/ha***
Lorsban 10G†	2.2	2	96	587	322.85
Dasanit 15G†	1.7	1	91	620	341.00
Dyfonate 10G†	1.7	2	75	437	240.35
Furadan 10G	2.2	2	58	498	273.90
Mocap 10G	2.2	1	73	60	33.00

* One application/season.

** Calculated from 3 weekly samples after application.

*** Computed @ $0.55/kg ($0.25/lb) (costs of insecticide not subtracted).

† Registered for use against LCB in Oklahoma.

The most effective control for LCB in irrigated evaluations conducted during 1972-73 was obtained with Lorsban and Dasanit insecticides. For both of these compounds, control exceeded 90% and returns were in excess of 550 kg/ha (Table 8). Control ranged from 58% to 75% for Furadan, Dyfonate and Mocap®. Of these, the greatest yield savings (498 kg/ha) was obtained with Furadan. Lorsban (15G), Dasanit and Dyfonate granules are currently registered for LCB control in irrigated peanuts.

Results reported in Table 9 for nonirrigated peanuts are from five experiments conducted during the period from 1972-1981. Insecticides included in the table are those which were evaluated in at least two of these experiments. The most consistent compound for LCB control was Lorsban 4E. It provided 74% control @ 1.1 kg AI/ha and 91% @ 2.2 kg AI/ha. For both rates, the yield savings exceeded 250 kg/ha. Furadan 4F provided less control at 49% and 57% for the 1.1 and 2.2 kg AI/ha rates, respectively. However, Furadan consistently gave higher yield returns than were expected for the control achieved. The return for Furadan applied @ 2.2 kg AI/ha was higher than that for any other insecticide (348 kg/ha). This high yield may have resulted from reduced feeding by LCB larvae which survived the insecticide or perhaps there was some yield enhancement due to the chemical itself. Less than 50% control was obtained with Monitor®, Bolstar®, and Oftanol®. Lorsban 4E and Dasanit 6SC are

Table 9. Evaluation of insecticides for control of LCB in nonirrigated peanuts in Oklahoma 1972-1981*.

Insecticide	AI kg/ha	# Years tested	Average** % control	Average return kg/ha	Average return $/ha***
Lorsban 4E†	2.2	4	91	256	140.80
Lorsban 4E†	1.1	4	74	284	156.20
Furadan 4F	2.2	4	57	348	191.58
Furadan 4F	1.1	4	49	221	121.35
Dasanit 6SC†	1.1	3	51	206	113.34
Monitor 4WM	1.1	2	45	168	92.40
Bolstar 6EC	1.7	2	29	74	40.66
Oftanol 4EC	2.2	2	0	- 2	- 1.10

* One application/season (except 1975 - 2 applications for Lorsban, Furadan, and Dasanit).

** Calculated from 3 weekly samples after application.

*** Computed @ $0.55/kg ($0.25/lb.) (cost of insecticides not subtracted).

† Registered for use against LCB in Oklahoma.

currently registered for LCB control in nonirrigated peanuts.

Results of these evaluations are in agreement with those from Texas in showing that compounds are now available which provide effective LCB control in either irrigated or nonirrigated peanuts. It is important that application methods be utilized which insure that toxicant is moved into the soil where larvae of the LCB are found. Studies of Smith and Jackson (1975) showed that granular formulations not only provide effective LCB control in irrigated peanuts, they also cause less disruption of nontarget arthropod species than sprays. Although the disruptions to nontarget species are similar with broadcast sprays vs. basally directed sprays which have been used in nonirrigated peanuts, added efficacy of directed sprays means that fewer applications must be made. Smith and Jackson (1975) theorized that reduced numbers of applications would result in conservation of natural enemies which are important for keeping foliar pests under control.

Host Resistance to LCB

Peanuts had their origin in South America and many wild relatives of the cultivated peanut species still exist. Over the last 40 years scientists from North Carolina, Texas and Oklahoma have made collections of germplasm in South America and much of this material is being maintained for future utilization. In early studies on host resistance to LCB, Leuck and Harvey (1968) reported that some entries showed resistance in a greenhouse selection test. Leuck et al. (1967) were unable to demonstrate cultivar differences in scarification of unpenetrated pods in the field under artificial infestation of LCB's. Smith et al. (1980) reported that 81 of 490 entries evaluated in Texas showed some resistance relative to their susceptible standard 'Starr'. Stalker et al. (1984) evaluated 120 entries including cultivars and wild peanut species in North Carolina. The best 30 of these entries were retested for 4 years as prospective sources of LCB resistance.

During 1973-75, we evaluated twenty wild relatives of the cultivated peanut which were available as cuttings and 666 seed sources of cultivated peanuts obtained from either the breeding program of Oklahoma State University agronomists or the USDA Southern Regional Plant Introductions Station, Experiment, Georgia. Screening tests were conducted in a greenhouse at ca. 80°F on benches filled to a depth of 13 cm with blow sand. Plants were grown individually in plastic cylinders (20 cm high x 10.4 cm dia.) arranged in a randomized block design. The cylinders were filled with sand and set in the bench so that the top of each was 6-8 cm above the surface of the sand in the bench. Water was applied to the sand in the bench and allowed to soak into the cylinders from below and subirrigate plants. By carefully regulating watering, the sand near the tops of the cylinders (around the bases of the plants) was kept dry to provide an optimal habitat for the LCB larvae. Each seedling was infested at the two to four leaf stage, with five newly hatched LCB obtained from a colony reared by methods described earlier.

The cultivar Comet, a selection from Starr, was used as a standard in each experiment. Early tests indicated that best visual ratings could be made when one of the Comet plants on the bench had died. The death of plants did not occur until 20 to 35 days after infestation and therefore, only large larvae and pupae were recovered. In many instances we may have missed the optimum time to observe live forms and therefore, damage observations provided the best estimates of resistance. The damage rating scale used was a five point scale as follows:

1. Apparently healthy.
2. Seed leaf (terminal bud) damaged or branches missing, but plant otherwise healthy.
3. One or two branches killed.
4. Beginning to show wilt.
5. Dead or dying.

Each plant was also evaluated for the presence of LCB webbing. The material evaluated could range from 1 to 5 on the visual rating: 0 to 5 for plant webbing; and 0 to 25 for larvae and pupae present. We calculated a visual ratio by dividing the rating for each entry by the rating for Comet in the same experiment, and also calculated a survival ratio comparing the larvae and pupae present on the entry to the average number of larvae and pupae found in Comet.

Given in Table 10 are the 10 entries tested as seedlings in 1973-1975 which had the lowest ratings (highest resistance) for LCB damage as well as the four with the poorest ratings. In the 67 tests conducted to identify sources of resistance, the susceptible standard, Comet, had average ratings for visual damage of 3.6 on the five point scale and 3.7 LCB/plant. One of the wild species accessions appeared to be highly resistant when evaluated as cuttings, but when evaluated as seedlings it was susceptible. This gives indication that resistance was affected by plant age. Additional data for all entries are listed in the dissertation of Kamal (1976). We used results of the greenhouse screening as well as information of Smith et al. (1980) in selecting entries for field evaluations which were conducted during 1974-1975.

In 1974 five entries which had been shown to have LCB resistance in the greenhouse were planted in Marshall County along with the susceptible standard, Comet. The cultivars exhibited different plant types in that Comet and 'Dixie Spanish' are classified as Spanish with erect growth, whereas 'Early Runner' and Florunner are classified as Virginia types with prostrate growth. 'Virginia Bunch 67' and 'Florigiant' are classified as Virginia types but have moderately erect growth.

Each entry was planted in 12 row x 9 m plots arranged in a randomized complete block design with three replications. A split-plot arrangement was used with six rows of each main plot treated at about monthly intervals during July through September with chlorpyrifos (4E) @ 2.2 kg AI/ha and the remaining six rows of each were not treated. Maneb and PCNB were applied to all rows for control of foliar and soil-borne pathogens, respectively. Four infestation counts at 3 week intervals were completed. Ten plants per replicate from nonborder rows of each chlorpyrifos treated and untreated subplot were selected at 1 to 2 m intervals, pulled, and examined for larvae. Soil from the base of each sampled plant was sifted to recover larvae and pupae. On the final two infestation counts two plants were randomly selected from each untreated subplot in each replicate and all LCB damaged and undamaged pods and pegs were counted. Two unsampled, nonborder rows were harvested for comparisons of yield reduction percentages (treated vs. untreated) among cultivars. A 500 g sample of each cultivar from a composite of replicates was graded by the Oklahoma Federal-State Inspection Service.

Dixie Spanish, Comet, Florunner, and Florigiant were again evaluated in 1975 using the same experimental design and chlorpyrifos treatments as in the previous year. On July 31, August 14 and September 6, five plants in each replicate were sampled in rows two and five of each split-plot and numbers of larvae, pupae and empty pupal cases on the plant or in the soil under the plant were recorded. Total numbers of pods and pegs and the numbers showing feeding damage were also counted.

In 1974, significantly fewer ($P < 0.05$) treated plants of Dixie Spanish were infested with LCB than those of Comet (Table 11). No other significant differences between treated plants occurred indicating that at the level of infestation present in this test, plant morphology had no influence on effectiveness of insecticides.

Table 10. Performance of the 14 best and four worst peanut entries in greenhouse screening for seedling resistance to LCB in 1973, 1975.

Oklahoma accession number	Average visual rating*	Range of visual ratings	Plants with webbing**	Larvae and pupae present	Visual ratio***	Survival ratio***
P-1306	1.0	1-1	3	1	0.2	0.5
P-1466	1.0	1-1	3	0	0.2	0.0
P-1273	1.6	1-3	3	0	0.3	0.0
P-959	1.2	1-2	5	8	0.4	4.0
P-1260	1.8	1-3	5	1	0.4	0.2
P-1261	1.8	1-3	5	2	0.4	0.5
P-215	2.2	1-5	5	6	0.5	1.5
P-1181	2.6	2-3	5	4	0.5	2.0
P-1182	2.8	2-3	5	4	0.5	2.0
P-1187	2.5	2-3	4	1	0.5	0.5
P-1191	2.6	2-3	3	3	0.5	1.5
P-1262	2.3	1-3	3	1	0.5	0.2
P-1263	2.3	1-3	5	1	0.5	0.2
P-1337	1.8	1-3	5	1	0.5	0.3
P-129	5.0	5.5	4	5	1.6	1.3
P-1368	5.0	5-5	5	0	1.6	0.0
P-120	5.0	5-5	5	5	1.7	1.0
P-975	5.0	5-5	5	7	1.7	1.1
Comet†	3.6		4.9	3.7		

* Rating scale where 1 = healthy plant, 5 = dead plant (see text for details of rating).

** 1 = no webbing, 5 = extensive webbing.

*** Visual and survival ratings for entry divided by comparable ratings for Comet.

† Susceptable standard (values presented are means for 67 experiments).

Table 11. - Percentage of LCB infested plants, damaged pods and pegs, yield reduction, and sound mature and split kernels of peanut cultivars.

Cultivar	% plants infested Treated*	% plants infested Untreated	% damaged pods and pegs (untreated)	% yield reduction	% sound mature and split kernels Treated*	% sound mature and split kernels Untreated
Comet	9.2	57.5	30.4	44.6	71	70
Florunner	7.5	50.8	25.0	18.6	71	63
Early Runner	5.8	41.7	22.1	8.4	61	58
Virginia Bunch 67	5.0	37.8	24.8	18.7	39	38
Florigiant	4.2	35.0	26.2	15.0	59	57
Dixie Spanish	2.5	35.8	17.8	26.2	70	71
LSD P = 0.05	6.3	6.3	9.4	18.9		

* Treated with chlorpyrifos.

However, the insecticide application nozzle placements were modified to facilitate thorough coverage of lateral branches in addition to the plant bases as would normally be the case in treating Spanish peanuts. Significantly more ($P < 0.05$) untreated plants of Comet and Florunner were infested than those of all other cultivars. The difference between these two cultivars was also significant. The percentage of untreated Early Runner plants which were infested was significantly greater than that of Florigiant, but not of Virginia Bunch 67 or Dixie Spanish. Analysis of variance indicated the infestation percentages increased significantly over the 9 week sampling period. However, the cultivar by sampling date interaction was not significant ($P < 0.05$). There was significant positive correlation between infestation percentages of treated and untreated plots, indicating that the percent infestation prior to treatment influenced the posttreatment infestations.

In yield reduction percentage during 1974, Comet was significantly greater than all other cultivars except Dixie Spanish. The percentage of sound mature kernels and sound split kernels of treated subplots was greater than those of the respective untreated subplots in all cases except for Dixie Spanish, however, differences were relatively small. The average numbers of larvae collected during the 9 week sampling period from Comet plants was significantly greater ($P < 0.05$) than those from Virginia Bunch 67 or Dixie Spanish. On the basis of this experiment, the Virginia runner-type peanuts were assumed to be better able to compensate for pod loss and in some way tolerate LCB infestations. Larvae collected from Comet and Dixie Spanish were larger than those collected from the Virginia types, which indicates the possibility of antibiosis in the Virginia peanuts. However, this last observation may have been due to somewhat more favorable habitat for larvae during the warmest period of the season. Additional information relating to this study is available in the publication of Schuster et al. (1975).

The analysis of variance for the experiment conducted in 1975 had the greatest mean squares (generally significant) associated with the chlorpyrifos treatment (Table 12). Sampling dates were also significant ($P < 0.05$) for life forms (larvae and pupae) and damage observed. The cultivar x sampling time interaction was significant for pod damage only and apparently, the main effects of cultivars were independent for other comparisons. These two field experiments considered along with the study of Stalker et al. (1984) suggest that cultivar differences are difficult to demonstrate with natural infestations of LCB.

Table 12. Percentage of LCB infested plants, damaged pods and pegs, and yield reduction of four peanut cultivars evaluated in 1975.

Cultivar	% Plants Infested		% Damaged Pods**		% Damaged Pegs**		% Yield
	Treated*	Untreated	8/14	9/6	8/14	9/6	Reduction
Florigiant	9	52	5.6	21.7	23.0	34.2	23
Florunner	8	49	3.4	18.9	21.0	39.5	15
Comet	2	31	5.6	5.2	11.2	34.6	17
Dixie Spanish	2	24	5.9	5.4	11.3	25.9	11
LSD (P=0.05)	N.S.	12.5	N.S.	7.9	N.S.	N.S.	N.S.

* Treated with chlorpyrifos

** Untreated plots only

SUMMARY

As a result of research described in this publication, a great deal has been learned for inclusion of the LCB in Integrated Pest Management programs for peanuts. The life system of this pest has been described including seasonal occurrence of populations and effects of important biotic and abiotic factors in regulating these populations. The influence of LCB on yield of peanuts has been studied and described for both Spanish and runner types. Effectiveness of some types of artificial controls has been described. While additional studies are needed, the research conducted in Oklahoma to date has provided basic information for building control programs.

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REFERENCES CITED

All, J.N., and R.N. Gallaher. 1977. Detrimental impact of no-tillage corn cropping systems involving insecticides, hybrids, and irrigation on lesser cornstalk borer infestations. J. Econ. Entomol. 70:361-365.

Berberet, R.C., P.J. Cook, and D.A. Sander. 1982. Fecundity of the lesser cornstalk borer, Elasmopalpus lignosellus, from Florunner and Spanhoma peanut cultivars. Peanut Sci. 9:60-62.

Berberet, R.C., R.D. Morrison, and R.G. Wall. 1979. Yield reduction caused by the lesser cornstalk borer in nonirrigated Spanish peanuts. J. Econ. Entomol. 72:526-528.

Berberet, R.C., and K. Pinkston. 1984. Peanut insect control in Oklahoma. OSU Ext. Facts No. 7174. 4p.

Berberet, R.C., D.A. Sander, and R.G. Wall. 1979. Parasitism of the lesser cornstalk borer, Elasmopalpus lignosellus, in Florunner and Spanhoma peanuts by native hymenopterous species in Oklahoma. Peanut Sci. 6:106-109.

Clark, L.R., P.W. Geier, R.D. Hughes, and R.F. Morris. 1967. The ecology of insect populations in theory and practice. Methuen and Co. London. 232p.

Cunningham, W.N., Jr., D.R. King, and B.C. Langley. 1959. Insecticidal control of the lesser cornstalk borer on peanuts. J. Econ. Entomol. 52:329-330.

Funderburk, J.E., D.G. Boucias, D.C. Herzog, R.K. Sprenkel, and R.E. Lynch. 1984. Parasitoids and pathogens of larval lesser cornstalk borers (Lepidoptera: Pyralidae) in northern Florida. Environ. Entomol. 13-1319-1323.

Grissell, E.E., and M.E. Schauff. 1981. New nearctic Invreia (Hymenoptera: Chalcididae) from lepidopterous pests of peanut. Proc. Entomol. Soc. Wash. 83:1-12.

Harding, J.A. 1960. Control of the lesser cornstalk borer attacking peanuts. J. Econ. Entomol. 53:664-667.

Holloway, R.L., and J.W. Smith, Jr. 1975. Locomotor activity of adult lesser cornstalk borer. Ann. Entomol. Soc. Amer. 68:885-887.

Johnson, S.J. 1978. The population dynamics and natural mortality of the lesser cornstalk borer, Elasmopalpus lignosellus, in the peanut agroecosystem and the biology of selected natural parasites. Ph.D. Thesis. Texas A&M University, College Station. 112p.

Johnson, S.J., and J.W. Smith, Jr. 1981. Ecology of Elasmopalpus lignosellus parasite complex on peanuts in Texas. Ann. Entomol. Soc. Amer. 74:467-471.

Kamal, S.S. 1976. Resistance of species of Arachis to lesser cornstalk borer. Unpublished Ph.D. Thesis, Oklahoma State University, Stillwater. 85 pp.

King, D.R., J.A. Harding, and B.C. Langley. 1961. Peanut insects in Texas. Texas Agric. Exp. Sta. Misc. Publ. 550. 14p.

Leuck, D.B. 1966. Biology of the lesser cornstalk borer in south Georgia. J. Econ. Entomol. 60:1549-1551

________. 1967. Lesser cornstalk borer damage to peanut plants. J. Econ. Entomol. 58:779-780.

Leuck, D.B., and M. Dupree. 1963. Parasites of the lesser cornstalk borer. J. Econ. Entomol. 58:779-780.

Leuck, D.B., R.O. Hammons, L.W. Morgan, and J.E. Harvey. 1967. Insect preference for peanut varieties. J. Econ. Entomol. 60(6): 1546-1549.

Leuck, D.B., and J.E. Harvey. 1968. Method of laboratory screening of peanut germ plasm for resistance to the lesser cornstalk borer. J. Econ. Entomol. 61:583-584.

Luginbill, P., and G.G. Ainslie. 1917. The lesser cornstalk borer. USDA, Bureau Entomol. Bull. No. 539. 27p.

Lynch, R.E. 1984. Damage and preference of lesser cornstalk borer (Lepidoptera: Pyralidae) larvae for peanut pods in different stages of maturity. J. Econ. Entomol. 77:360-363.

Mack, T.P., and C.B. Backman. 1984. Effects of temperature and adult age on the oviposition rate of Elasmopalpus lignosellus (Zeller), the lesser cornstalk borer. Environ. Entomol. 13:966-969.

Sams, R.L., and J.W. Smith, Jr. 1979. Evaluation of insecticides for lesser cornstalk borer control on peanuts. Texas Agric. Exp. Sta. Bull. No. PR-3587. 5p.

Schuster, D.J., D.C. Peters, S.S. Kamal, and R.C. Berberet. 1975. Field comparison of peanut varieties resistant to the lesser cornstalk borer. J. Econ. Entomol. 68:704-706.

Smith, J.W., Jr., and R.L. Holloway. 1979. Lesser cornstalk borer larval density and damage to peanuts. J. Econ. Entomol. 72:535-537.

Smith, J.W., Jr., and P.W. Jackson. 1975. Effects of insecticidal placement on non-target arthropods in the peanut ecosystem. Peanut Sci. 2:87-90.

Smith, J.W., S.J. Johnson, and R.L. Sams. 1981. Spatial distribution of lesser cornstalk borer eggs in peanuts. Environ. Entomol. 10:192-193.

Smith, J.W., Jr., L. Posada, and O.D. Smith. 1980. Greenhouse screening peanut germ plasm for resistance to the lesser cornstalk borer. Peanut Sci. 7:68-71.

Smith, J.W., Jr., P.W. Jackson, R.L. Holloway, and C.E. Hoelscher. 1975. Evaluation of selected insecticides for control of the lesser cornstalk borer on Texas peanuts. Texas Agric. Exp. Stn. Bull. No. PR-3303. 16p.

Southwood, T.R.E. 1978. Ecological methods with particular reference to the study of insect populations. Chapman and Hall, New York. 524p.

Stalker, H.T., W.V. Campbell, and J.C. Wynne. 1984. Evaluation of cultivated and wild peanut species for resistance to the lesser cornstalk borer (Lepidoptera: Pyralidae). J. Econ. Entomol. 77:53-57.

Stone, K.J. 1968. Reproductive biology of the lesser cornstalk borer. I. Rearing technique. J. Econ. Entomol. 61:1712-1714.

Vandeszant, E.S., C.D. Richardson, and S.W. Fort. 1961. Rearing of the bollworm on artificial diet. J. Econ. Entomol. 55:140.

Wall, R., and R.C. Berberet. 1975. Parasitoids associated with lepidopterous pests on peanuts; Oklahoma fauna. Environ. Entomol. 4:877-882.

Walton, R.R., R.S. Matlock, and J.P. Boyd. 1964. Effect of the lesser cornstalk borer on peanuts in Oklahoma. OSU Exp. Stn. Bull. No. p-474. 10p.

Womack, H., J.C. French, F.A. Johnson, S.S. Thompson, and C.W. Swann. 1981. Peanut pest management in the Southeast. Georgia Ext. Ser. Bull. No. 850. 26p.

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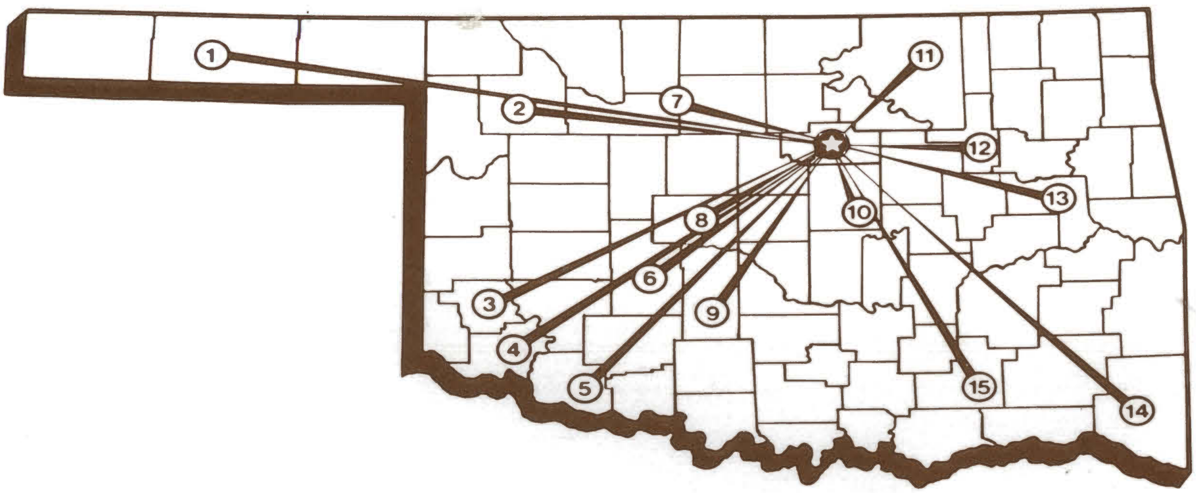

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