The Southwestern Corn Borer and Its Control

By R. R. Walton
and G. A. Bieberdorf

OKLAHOMA AGRICULTURAL EXPERIMENT STATION
Oklahoma A. and M. College, Stillwater
Experiment Station Bulletin No. B-321
June, 1948

CONTENTS

The Southwestern Corn Borer and Its Control

By R. R. WALTON and G. A. BIEBERDORF*
Assistant Entomologists

The southwestern corn borer** in recent years has caused considerable damage to corn in Oklahoma. Other crops are seldom badly damaged. Injury to corn varies form slight to a complete loss of the crop. The amount of injury depends on the number of borers present and the stage of growth of the plants at the time they are attacked.

The southwestern corn borer should not be confused with the European corn borer. The latter has received much more publicity, because it has been a serious pest in the northern corn belt for a long time. The southwestern borer moved into Oklahoma from the Southwest in recent years, and apparently is a native of Mexico.

Experimental work on the control of the southwestern corn borer was started by the Oklahoma Agricultural Experiment Station in 1943. This work included tests on date of planting corn, cultural methods of killing hibernating borers, use of insecticides, and preliminary studies on the resistance of varieties and hybrids to borer attack. A detailed report of the results of these tests is given in Technical Bulletin No. T-32.

THE DAMAGE AND ITS CONTROL

Control Methods.

The methods of control listed below are of value in decreasing borer damage under Oklahoma conditions, but none of them completely solves the problem. Preliminary tests with hybrids and varieties indicate that the development of a resistant strain of corn is the most promising method of reducing or preventing loss. There-

* The authors wish to express appreciation for the use of photographs belonging to the Department of Entomology of Kansas State College. These are shown in Figures 6, 9, 10, 12, 14. The map showing 1931 infestation (Figure 4) is from U. S. D. A. Technical Bulletin No. 388. Kansas information on the map on page 10 (Figure 5) is from: Walken, H. H. (1947), "Status of the southwestern corn borer in Nebraska, Kansas and Oklahoma, fall 1947"; U. S. D. A.. *Insect Pest Survey, Special Supplement* (1948. No. 1). The authors also wish to acknowledge assistance given by Drs. F. A. Fenton, R. G. Dahms and D. E. Howell of the Department of Entomology, Oklahoma Agricultural Experiment Station and Mr. C. F. Stiles, Extension Entomologist of Oklahoma. Dr. Fenton and Dahms took a portion of the data recorded in 1941, 1942 and 1943. Dr. Howell and Mr. Stiles assisted in the preparation of the manuscript.

** *Diatraea grandiosella* Dyar.

fore further research on this problem will be concentrated chiefly in an effort to breed a resistant hybrid or variety.

Substitute Sorghums for Corn. Where conditions make it practical, the borer problem can be side-stepped by growing grain sorghums instead of corn. Although sorghums may become lightly infested, borer damage is not important.

Plant Corn Early. Corn should be planted as early as conditions and previous experience will warrant. However, do not "rush the season," since damage from unfavorable growing conditions may more than offset the additional protection obtained from borer attack. The results of four date-of-planting tests, given in Table I, show that plantings made after May 1 suffer progressively increasing damage. Planting corn in June and July is very hazardous.

Plant Corn on Fertile Soil. Borer injury to corn is directly related to the stage of development of the plants at the time they are attacked. Corn on fertile soil that makes a rapid, thrifty growth suffers less damage than corn on poorer soils where early growth is slow. In Oklahoma station tests, the intensity of infestation and the amount of injury have been consistently greater on upland deep sandy soils than on heavier, more fertile bottomland. *In general, any practice that encourages thrifty plant development will decrease borer damage.*

*TABLE I.—Southwestern Corn Borer Damage in Corn Planted on Different Dates.**

Date of Planting	Stalks Infested	Stalks Lodged by Borers	"Dead-hearts" and "Dwarfs"**	Borers per Stalk	Yield per Acre
	%	%	%	no.	bu.
March 9 to April 3	83.6	8.0	1.3	2.3	23.8
April 13 to May 6	86.1	11.8	4.0	2.8	24.2
May 18 to May 20	87.5	25.0	6.5	3.1	16.3
June 18 to June 25	100.0	6.0	55.0	6.6	3.0

* These are averages for four tests made in 1943, 1944 and 1945 in Caddo, Kay and Payne counties. All tests were made with Reid Yellow Dent on deep sandy soil.

** Plants were classed as dead-heart if the terminal buds were killed by borer injury. Plants stunted by borers to the exent that they were less than one-half the height of average plants in the plot were designated as "dwarfs".

Plant a Locally Adapted Variety. Select a hybrid or variety that has proved itself adapted to your local soil and climatic conditions. For information on the performance of various varieties of corn in Oklahoma, see the most recent report of the Oklahoma Corn Performance Tests. Your county agent will have this report, or can tell you where to get it.

Preliminary tests and observations during the past two seasons show some differences in the amount of borer injury to various hybrids and varieties, but results at present do not warrant recommending specific varieties. Repeated tests must be made under varying soil and climatic conditions. The Experiment Station is now beginning extensive tests of various strains for borer resistance. Until more complete information becomes available, the safest plan is to plant locally adapted hybrids and varieties.

Harvest Early. Corn should be harvested as soon as mature. The longer infested plants stand in the field, the greater will be the number of stalks that fall or lodge as a result of the girdling activity of the borers.

Cut Stalks Close to Ground. If corn and sorghum stalks used for forage or silage are cut at or near the ground by late summer, the opportunity for borers to hibernate within the stubble is reduced.

Uproot Stubble, or Plow it Under. Where cropping practices permit and soil-blowing is not a hazard, the uprooting of stubble will reduce the overwintering population. When stubble is thrown to the soil surface, the borers in their winter quarters within the base of the stub are subjected to freezing and drying.

Listers, buzzard wing sweeps and one-way disks were effective for this purpose in station tests. Uprooting should be done as early in winter as possible—not later than early February. Stubble uprooted by February 15 or earlier had 90 to 100 percent of the borers dead, while those uprooted at later dates had progressively fewer dead borers.

Hibernating borers may also be killed by plowing stubble and stalks under to a depth of 4 inches or more. If all stalks are thoroughly covered, few, if any, moths can escape to lay eggs. Harrowing the surface makes the method more effective by sealing

cracks and crevices. Plowing should be done as early as possible, but must be done not later than early May when moths begin to emerge.

Do Not Burn Stalks. The burning of stalks after harvest will not control the southwestern corn borer. At this season, the borers are in hibernation in the stubble below the ground surface.

Control by Insectisides Not Practical. On the basis of present results, the control of borers by insecticides is not practical. In 1947, six chemicals were tested as sprays and as dusts on late corn. The materials included cryolite, Parathion, chlorinated camphene, chlordan, benzene hexachloride and DDT. The best control obtained left 68 percent of the stalks infested as compared with 86 percent infested in untreated plots.

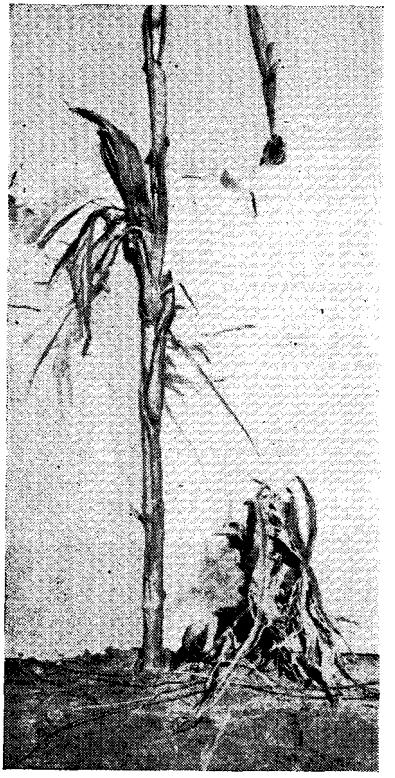

Fig. 1.—Normal and Stunted Stalk. The corn plant on the right was severely stunted because young borers killed the terminal bud during the early growth of the plant. This type of injury is often called "dead-heart." A normal stalk is shown on the left. Early-planted corn usually suffers less dead-heart injury because it has started to tassel by the time the borers first appear in June.

How the Borer Damages Corn.

Corn is the only crop seriously injured by the southwestern corn borer. Damage varies from slight injury to a complete loss of the crop, depending upon the date of planting and the intensity of infestation. Almost all parts of the plant are attacked.

Leaves. The leaves are perforated and "ragged" by the young borers; and while feeding in the plant throat they may cut across the terminal bud, produc-

Fig. 2.—Three Stunted Stalks.
The degree of stunting depends on the age of the corn plant at the time the borers attack it. Early, rapid growth helps the corn avoid such "dead-heart" injury, therefore corn has the best chance of escaping when it is planted on fertile soil and growth is rapid.

ing a dwarf plant or "dead-heart." (Figure 1). "Dead-hearts" produce little or no grain.

Stem. The next point of attack is the stem, in which the borers eat long tunnels. Several larvae tunneling in a plant before it has made its major growth will usually produce noticeable stunting of the stalk and ears (Figure 2).

Ear. The shank and shank end of the ear may be attacked. If the injury is made during the early development of the ear, growth may be retarded to produce a nubbin.

Lodging of Plants. One of the most serious losses due to borer activity is caused by the breaking over or lodging of the plants Figure 3). In late summer or early fall, borers often girdle plants by cutting a smooth ring around the inside of the stem a short distance above the ground. The plants are then broken over by their weight or the wind, greatly increasing the difficulty of harvesting.

Other Plants Attacked.

In addition to field corn, borers infest sweetcorn, popcorn, sorghums, broomcorn, Sudan grass, and Johnson grass. Damage to early planted sweetcorn is seldom severe, since the crop is harvested before the second generation of borers appears. Infestations in sorghums and broomcorn are usually light, although late-planted sorghum adjacent to heavily infested corn may be girdled and lodged to some extent. Only a very low percentage of Sudan and Johnson grass has been found infested.

Fig. 3.—Borer Attacks Cause Excessive Lodging of Corn.

Part of the loss caused by the southwestern corn borer results from "down" stalks. The borers eat tunnels in the stalk, then girdle it at the base, so a light wind will blow it over. The ears are damaged and difficult to harvest. Early harvesting helps avoid some of this loss.

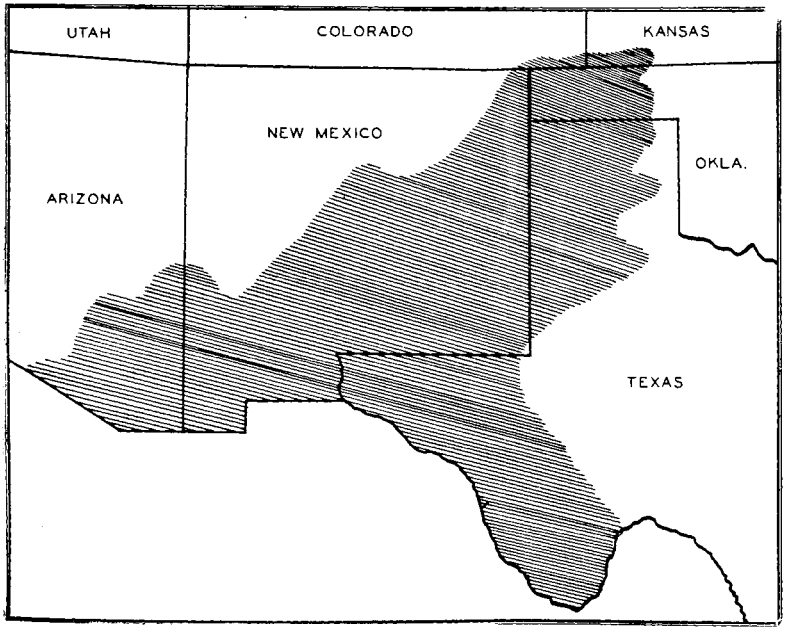

Fig. 4.—Where Southwestern Borer Was Found in Oklahoma in 1931.

The southwestern corn borer moved into Oklahoma from the west. It is not the same insect as the European corn borer which farmers battle in the Corn Belt states. This map shows the part of Oklahoma where the Southwestern borer was found in 1931. The borer can live on sorghums, but does not damage this crop seriously.

THE INSECT AND ITS HABITS

Distribution.

Until recent years the southwestern corn borer in the United States was confined to the southwestern section of the country. It is apparently a native of Mexico and probably entered the United States about 1913 (Davis *et al.* 1933).* Figure 4 shows the known distribution as of 1931. Since that time this pest has moved eastward and northward to infest a good portion of Texas and the greater part of Oklahoma and Kansas (Wilbur *et al.* 1943). Figure 5

* References to the literature cited parenthetically in this publication are cited in more detail in Technical Bulletin T-32.

shows the known areas of infestation in Oklahoma during the period 1931 to 1947. The western edge of the corn-producing section of Oklahoma was reached by 1941, when borers attacked crops in Caddo county. By 1947, the pest had invaded 65 of the 77 counties of the State, including almost all of the corn-producing area.

Description.

MOTHS.—The female moths are about two-thirds to three-fourths of an inch in length. They are a dull white to pale yellow in color, with the hind wings broader and lighter in color than the forewings. When at rest the wings are folded close to the body. The males are slightly smaller than the females and a little darker

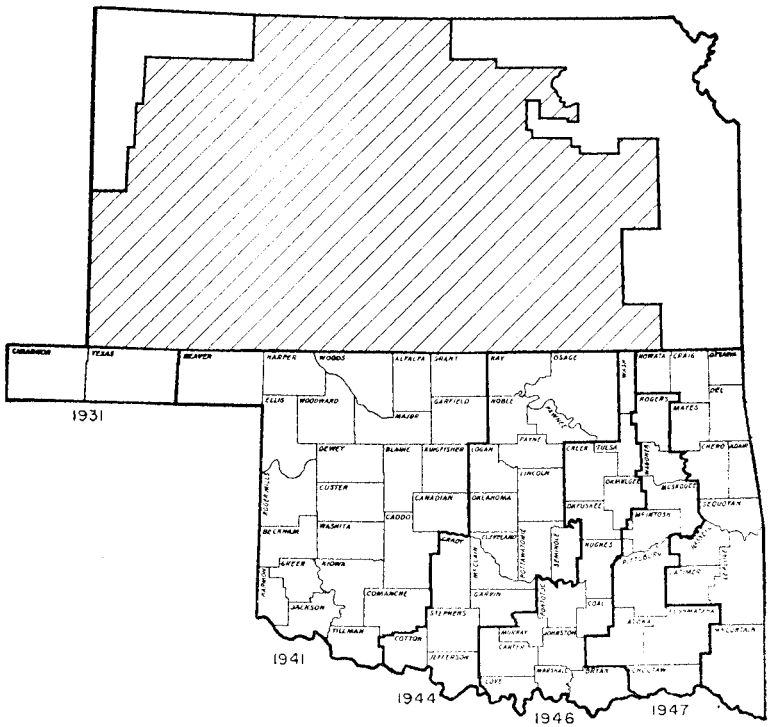

Fig. 5.—By 1947, the Borer Covered Most of Oklahoma and Kansas.

After 1931, the southwestern corn borer spread rapidly through the corn-growing sections of Oklahoma, until now it is a pest nearly everywhere this crop is produced in the State.

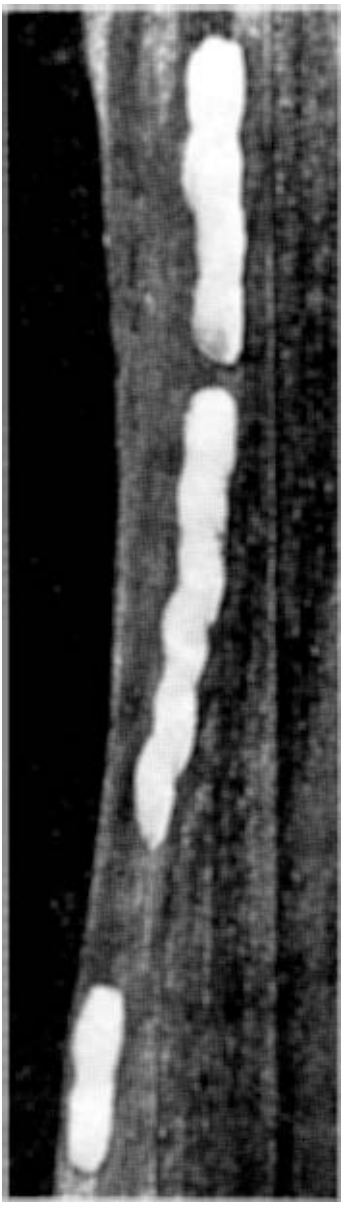

Fig. 6.—Clusters of Borer Eggs on Leaf of a Corn Plant.

in color. The moths are active at night, remaining hidden on the plant during the day, and are not likely to be noticed unless a special search is made.

EGGS.—The eggs are oval in shape, and flattened. They are white at first, and later develop three parallel orange lines across the oval. These lines give the eggs a pinkish tinge. The eggs are large enough to be seen by the naked eye but are seldom noticed unless a careful search is made. They are laid on both the upper and lower surfaces of the leaves and also on the stalks. They are found either singly or overlapping one another in chains or masses of several eggs (Figure 6).

LARVAE OR BORERS.—During the summer, larvae of the southwestern corn borer have a very conspicuous color pattern (Figure 7). The body is dull white, covered with numerous brownish-black spots that give the worm a polka-dotted appearance. The winter or hibernating borers are a uniform creamy white. Mature larvae measure 1 to 1¼ inches in length. Recently hatched larvae are very small but can be identified by closely examining them for the presence of the characteristic polka dots.

PUPAE.—The pupae are about 1 inch long, brown, and

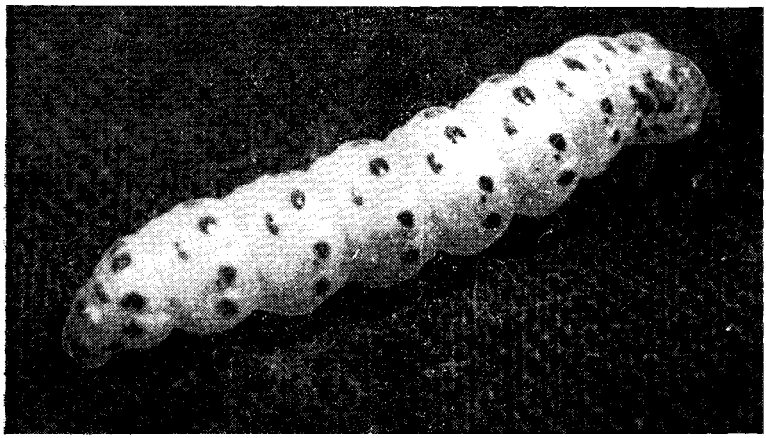

Fig. 7.—The Borer Looks Like This at Time It Tunnels Stalks.

This worm is the mature summer larvae of the southwestern corn borer. The picture is approximately 3 times actual size. At this stage in its growth, theborer has already fed on the leaves and caused stunting or "dead-heart" by killing the buds of the stalks.

cigar-shaped. They are found in tunnels within the stalks or stubble. When the moths emerge, the thin, flimsy pupal cases are left in the tunnels or protruding from the exit holes in the sides of the stalks.

Seasonal History.

Borer activity and development are closely regulated by temperature conditions. During years when the season is markedly advanced or retarded, the beginning of borer activities will be similarly regulated. For the same reason, moth emergence in the extreme southern part of Oklahoma will usually be a few days earlier than the dates given in the following paragraphs. The average seasonal history is shown in Figure 8.

NUMBER OF GENERATIONS.—There are two complete generations and a partial third each season. The third generation is generally of little economic importance, therefore the seasonal history is given for only the first and second. The life cycle of the borer in Oklahoma requires from 38 to 56 days for its completion. The approximate number of days required for the completion of each stage is as follows: egg, 5 to 6; larva, 20 to 35; pupa, 8 to 10; female moth, 5.

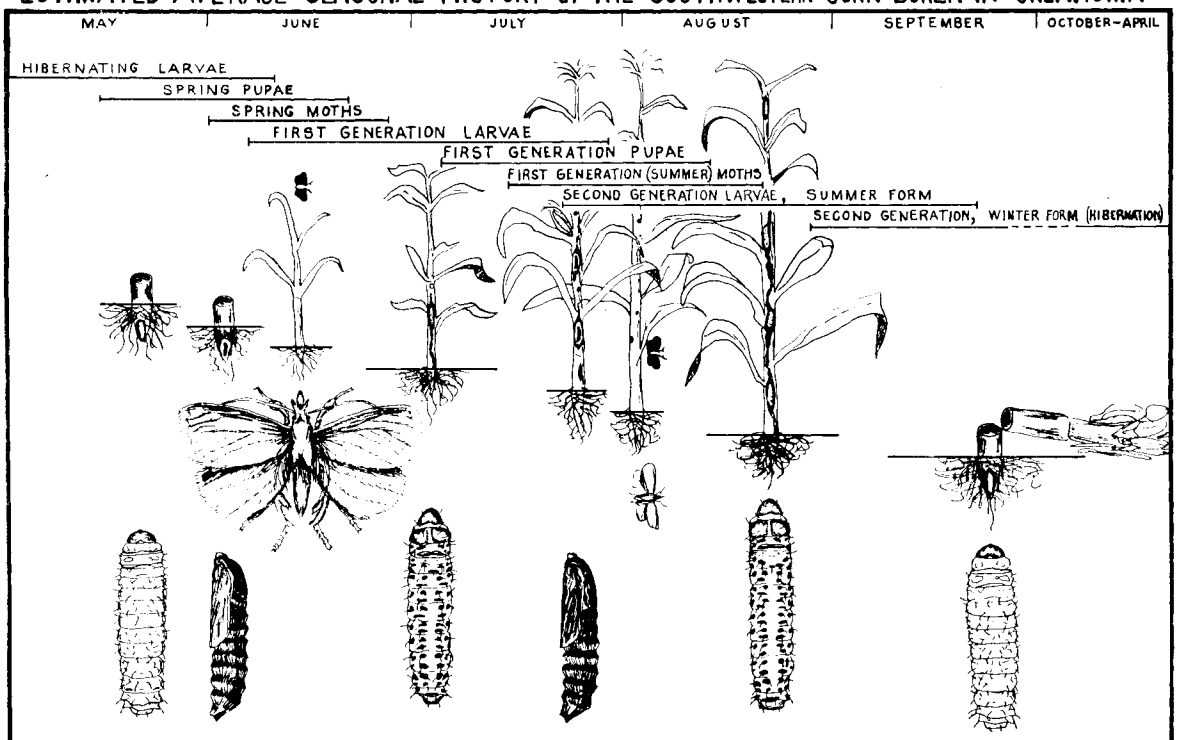

Fig. 8.—Life Cycle of the Southwestern Corn Borer in an Average Oklahoma Season.

The best chance to attack the borer comes while it is spending the winter in the underground stub of the corn stalk. Insect poisons applied during the summer have not been very effective in Station tests.

EMERGENCE OF SPRING MOTHS.—The first brood of moths emerges in late spring or early summer from the stubble of the previous year's crop. The bulk of this group appears during the month of *June*, although emergence may begin in late May and continue until early July. The egg-laying period of the spring brood corresponds closely with the period of emergence. To obtain control by plowing under stubble, treatment must be made before emergence begins.

FIRST GENERATION BORERS (LARVAE).—Borers begin to appear on plants about the *middle of June or earlier* and continue to hatch for about three weeks or a month.

FIRST GENERATION OR SUMMER MOTHS.—A very extensive brood of moths emerges from the growing plants in which the larvae have matured. Emergence begins about the *middle of July* and may continue well into August.

SECOND GENERATION BORERS.—During the *last half of July* and in *August,* corn is attacked by the second brood of borers. This generation is much greater in numbers than the first generation. Early planted corn sustains much less injury from this attack than late seeded fields.

PARTIAL THIRD GENERATION.—The great majority of the second generation borers do not pupate on reaching maturity but pass the winter in the larval stage. However, some of the larvae of this group pupate in the stalk and emerge as moths during the latter part of August and early September. These moths deposit eggs for a third generation. Usually the larvae of this generation are not very numerous nor do they do much harm.

Habits of the Insect, and Detailed Plant Injury.

SPRING MOTH EMERGENCE.—The adults or moths are nocturnal, performing the activities of emergence, mating, and egg laying at night. They usually mate the night after emerging from the old stubble. Egg laying begins the next night and may continue for three or four nights. The life of the moths is brief. The males die shortly after mating, and the females die a day or so after egg laying is completed.

EGG DEPOSITION.—The moths seem to prefer plants of intermediate size and development as a place to lay their eggs. The more mature and the very young plants receive fewer eggs. The eggs are placed on both the upper and lower surfaces of the leaves and on the stalk. The upper surface of the leaves is the preferred location. The number of eggs laid by individual females varies from less than one hundred to perhaps over four hundred.

FIRST GENERATION LARVAE.—The eggs hatch in five or six days and the tiny larvae begin to feed on the open leaves and in the whorl or throat of the plant. The larvae may feed within a leaf or eat directly through it. In the first type of feeding the green layer of the leaf is eaten out, leaving translucent areas that vary greatly in shape and size. Some of these may be long narrow strips, while others are irregular patches or mere dots. Occasionally, the leaf midribs are entered and tunneled. When the larvae eat through the leaves, small holes are produced; and if feeding is done on a rolled leaf, a horizontal row of holes will appear when the leaf unfolds. These various types of leaf feeding cause a ragged appearance in the top of the plant.

"DEAD-HEARTS" OR MALFORMED PLANTS.—Feeding on the open leaves seldom seriously affects plant development. However, as feeding tends to concentrate in the plant throat, serious injury may occur. Should one of the borers cut through the narrow neck of the growing bud, development of the plant is greatly affected. In such cases the upward growth is stopped and the plant becomes dwarfed and bushy (Figure 9). These malformed plants are sometimes called "dead-hearts" due to the plant whorl and top leaves becoming bleached or whitened. This foliage later becomes shriveled and brown. "Dead-hearts" seldom produce grain.

STALK FEEDING.—After completing about one-third of their development, the larvae move downward and tunnel in the stalk. Usually they crawl down the stalk and enter it by eating small holes through the rind. Occasionally, a larva may tunnel directly from the plant throat into the stem. For several days after the borers have entered the stalk from the side, frass or excrement may be observed protruding from the entry hole (Figure 10). The borers complete their development while eating tunnels within the stalk. These tunnels range from two or three inches to over one foot in

Fig. 9.—Typical "Dead-heart" Injury.
When young borers eat through the bud within the central whorl from which the leaves develop, the top leaves turn white. The plant is stunted and becomes a "dead-heart" as shown in Figures 1 and 2, pages 6 and 7. This plant also shows the ragged leaves left by young borers feeding on them.

length, with the average being six or seven inches. The tunnels increase in diameter as the growing borers eat upward or downward in the stalk.

INJURY FROM STALK FEEDING.—Two types of injury may result from the stalk tunneling. The plant may be retarded in development, or it may break over due to the weakening of the stalk.

Fig. 10.—Evidence Borer Is Tunneling the Stalk.

The frass indicated by the arrow is evidence that a southwestern corn borer is tunneling in the stalk.

The degree to which plant development is affected depends on the number of borers present and stage of development of the corn at the time feeding begins in the stalk. Early corn having one or two borers per stalk is seldom noticeably retarded in production. On the other hand, young plants attacked by several borers per stalk show marked stunting in plant size and pronounced reduction in yield. Even though the yield of corn may not be greatly affected, lodging may cause crop losses.

SUMMER MOTH EMERGENCE.—When the larvae have reached maturity, they change into dark brown pupae. The pupae are generally found near the lower ends of the tunnels, but they often move toward the exit holes just before emergence occurs. Empty pupal cases can be found in the tunnels or protruding from the exit holes. About ten days after the larvae change to pupae, the moths emerge and lay eggs for the second generation.

SECOND GENERATION BORERS.—The second brood of borers is much more numerous than the first generation and accordingly infests a higher percentage of the plants. In feeding habits they are similar to the first generation larvae. By this time early corn has reached or passed the silking stage and is seldom seriously retarded by the borer attack. Generally, the greatest damage sustained by early corn from this brood is the loss of grain following lodging.

PARTIAL THIRD GENERATION.—The great majority of the second generation borers do not pupate at maturity but pass the winter in the larval stage. Some of the most advanced larvae pupate in the stalk and emerge as moths during the latter part of August and early September. These moths deposit eggs for a third generation. Where late corn remains green, these larvae are active for a while during the fall.

GIRDLING OF STALKS.—Before beginning or during preparation for hibernation, borers often girdle the stalks (Figures 11 and 12). Girdling is done on the inside of the stalk and there are usually no outward signs of injury until the stalk lodges. The borer eats a smooth groove around the stalk, leaving only a thin layer of the rind intact. The groove may completely encircle the stalk, or it may extend only a portion of the way around. The point of girdling may occasionally be two or three feet above the ground but is usually in

one of the first three internodes of the stalk. The most common location is in the second internode a few inches above the ground surface. Girdled stalks occasionally fall soon after being girdled, but usually stand for some time. How long the stalks remain erect depends upon such factors as the extent of girdling, the weight of the ear, and the force of the wind.

Fig. 11.—Girdled Stalk, and Hibernating Borer in Root Stub.

Hibernating borers can be killed either by uprooting the corn stubble during the fall or winter or by plowing under the stubble and stalks before the moths come out in the spring (see pages 5 to 6).

Fig. 12.—Girdled Stalk Showing Tunnel Leading to Hibernation Cell.

If sorghum or corn is cut for silage or forage, many of the borers can be prevented from hibernating by cutting stalks at the ground surface by late summer or earlier.

HIBERNATING BORERS.—In the late summer or early fall, borers begin preparing winter quarters in the corn stubs. Generally the borers reach the stubs by crawling down the outside of the stalk and making entrance holes a short distance above the ground surface. After entering, the holes are plugged up with frass. These entrance holes can be distinguished from the other holes in the stalk by the fact that they are closed. Some hibernating borers may reach the stubs by tunneling down the inside of the stalks.

CHANGE IN COLOR OF BORERS.—Before going into hibernation, borers molt or shed their skins, resulting in a change in color design. Prior to this molt the summer form is white, covered with dark brown or black dots. The dots are not present on the winter form, its body being a uniform creamy white color.

PREPARATION OF HIBERNATION CELL.—After reaching the inside of the stubs, borers begin preparing hibernation cells (Figure 13). The base of the stalk or main root is hollowed out to its very tip. The cells are about one-fourth inch in diameter and average three

to four inches long, although they may vary from one to eight or nine inches in length. Sometimes the cells reach from the root tips to slightly above the ground, but as a general rule are in the lower three or four inches of the roots. After tunneling out the cells, the borers plug the upper parts and line the cavities with a thin sheet of silk. They then assume positions in the lower parts of the cells with their heads upward and become inactive. They usually stay in this location during the entire winter; but occasionally borers are found higher in the cells, some being at or slightly

Fig. 13.—Hibernating Larva in Winter Quarters in Corn Stub.

above the ground surface. Usually only one borer is present in a stub.

SPRING PUPATION.—In the late spring when the temperature rises the larvae become active and prepare exit openings through which the moths can escape. They then return to the lower parts of the tunnels, spin a thin cocoon about themselves, and change into brown pupae.

Insects That May Be Mistaken for Southwestern Borer.

SOUTHERN CORNSTALK BORER.—The southern cornstalk borer, *Diatraea crambidoides* (Grote), is a close relative of the southwestern corn borer and is almost identical with it. The larvae of the two species are alike in color pattern and size, and the moths differ only in certain small structural details. The southern cornstalk borer may be present in the eastern part of Oklahoma, although no positive record of it has been obtained.

Infestations of the two borers can be distinguished during the fall and winter by a certain difference in the habits of the larvae. In preparing for hibernation, the southwestern corn borers generally girdle the corn stalk. The southern cornstalk borers do not.

CORN EARWORM.—Injury by the corn earworm, *Heliothis armigera* (Hbn.), is sometimes mistaken for that of the southwestern corn borer. The larvae of both insects feed within the whorl, causing a ragged appearance of the unfurled leaves. Usually the holes made by the corn earworm are larger and more irregular than those of the borer. The corn earworm does most of its damage by attacking the ear, entering from the silk end. The southwestern corn borer sometimes attacks the shank of the ear (Figure 14) and infrequently penetrates the ear proper from this position. The earworm seldom does much damage to the stalk, sometimes making shallow grooves along its sides or occasionally cutting short tunnels directly into it. These tunnels are much larger in diameter and shorter than those made by the borer.

The larvae of the two insects can be distinguished by their color patterns. The southwestern corn borer is white with dark polka-dots, while corn earworms vary greatly in color, generally ranging from dark-brown to green and usually with longitudinal

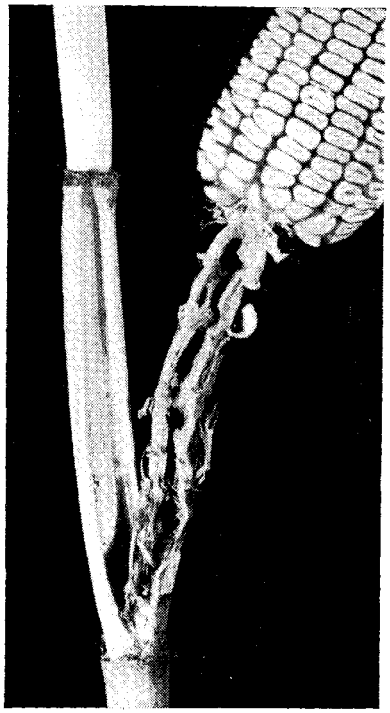

Fig. 14.—Damaged Ear Shank.

The ear shank shown here was cut away before the picture was taken, in order to show tunnels left by the borer. This ear was well developed before the injury occurred. In later corn, the damage would have dwarfed or completely destroyed the ear.

stripes of varying colors. Corn earworms pass the winter as brown pupae in the ground, while the borers hibernate in the main roots of the host plants as creamy white larvae.

FALL ARMYWORM.—The fall armyworm. *Laphygma frugiperda* (A. and S.) resembles the corn earworm in size, in its striped pattern, and to a considerable extent in its feeding habits. The fall armyworm does more tunneling in the stalk than the earworm, but its tunnels can be distinguished from those of the southwestern corn borer by the fact that they are larger in diameter and shorter.

CORN BILLBUG.—Injury by corn billbugs (*Calendra spp.*) is sometimes mistaken for that of the southwestern borer. The adult stage of a billbug is a large weevil or snout beetle. The white, legless larvae of billbugs sometimes bore in corn stalks at or near the soil surface. The holes are large and usually shallow; but they may be continued into short rough-walled tunnels. The adults frequently eat through the rolled leaves of the plant. When the leaves unfurl the injury shows up as transverse rows of holes across the leaves.