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The Maize Billbug or Elephant Bug

(*Sphenophorus maidis* Chittn.)



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SUMMARY

1. The maize billbug, commonly known as the elephant bug, does an annual damage amounting to thousands of dollars to corn crops in south central Kansas. It is confined principally to river bottom-land.

2. The beetles have been reported in Kansas doing injury in Reno, Marion, Greenwood, Cowley, and Chautauqua Counties. They spread slowly, and because of this slow rate of distribution, crop rotation can be used effectively as a means of control.

3. The adult is a large cumbersome black beetle. It lays eggs near the base of the corn plant. The eggs hatch into grubs which burrow up and down within the heart of the plant, finally undergoing their transformation to the pupal stage in the taproot of the plant.

4. Two types of injury to the plant are found. (1) Young plants are killed or left punctured with regular rows of circular holes, by adults feeding in early spring. (2) Plants that survive this first attack are burrowed by the grubs.

5. The adult billbug is present in fields throughout the fall, winter, and the larger part of summer; eggs may be found in May, June, and sometimes July; larvæ from the first of June to the middle of September; pupæ are present from the latter half of July to the last of September.

6. The cheapest, most satisfactory, and most practicable method of control is the use of a cropping system in which corn is succeeded by some crop that is not subject to injury by this pest. In southern Kansas the best general practice has been to keep the infested fields in alfalfa for a few years, after which corn may be safely planted.

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THE MAIZE BILLBUG OR ELEPHANT BUG

(*Sphenophorus maidis* Chittn.)

WILLIAM P. HAYES

INTRODUCTION

HISTORY

The maize billbug, commonly called the elephant bug, was first reported in Kansas in 1895. (Kelly, 1911, p. 12.) At that time it was found damaging corn in Chautauqua, Cowley, and Butler Counties. Since then it has become distributed over many of the counties in southern Kansas. The beetles have been found as far north as the Kansas River, but the most damage has been confined almost entirely to corn fields in the fertile river valleys of the southern part of the State. The pest attracted considerable attention in 1911, and in 1914 a critical study of the life-history of the species was undertaken, the results of which are herewith set forth.

ECONOMIC IMPORTANCE

In regions where this beetle is abundant, it is next to impossible to raise corn successfully without control methods. The plants are attacked by both the adults and the young footless grubs. Fortunately, most of the damage is confined to fields on river and creek bottom-land. However, corn on upland has been damaged. Infested fields must be planted several times before a stand is secured and even then plants that survive are more or less stunted and seldom produce ears of any size. In places where infestation has been most serious, farmers have been compelled to follow corn by alfalfa or other crops not damaged by the beetles or grubs.

CLASSIFICATION AND COMMON NAMES

The maize billbug is known scientifically as *Sphenophorus maidis* Chittn. (Chittenden, 1905, p. 59), and until recent years has been confused with two other closely allied billbugs,

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known as *Sphenophorus pertinax* Oliv. and *Sphenophorus robustus* Horn. Some of the earlier records (Glover, 1855, p. 67, and Riley, 1882, p. 159) of damage by these forms undoubtedly pertain to the maize billbug.

In localities where it does injury to corn, the maize billbug is known to some as the elephant bug. This is due, in great part, to the fancied resemblance of the snout of the beetle to the trunk of an elephant. In other regions, this name is not common and the species is known either as the maize billbug or the corn billbug.

DISTRIBUTION

The maize billbug has been found in the following states: Alabama, Georgia, South Carolina, Texas, Oklahoma, Kansas, and, according to one writer (Chittenden, 1905, p. 61), in

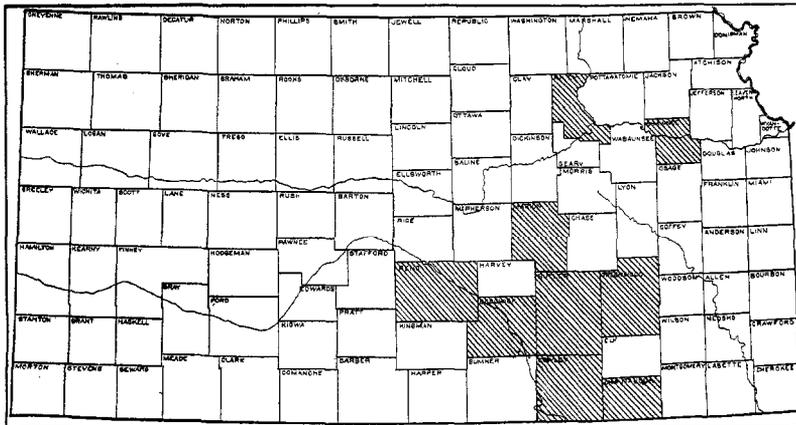


FIG. 1.—Map of Kansas showing distribution of the maize billbug

Michigan. In Kansas, it has been found in Chautauqua, Butler, Cowley, Reno, Marion, and Riley Counties. From these widely scattered reports, there seems to be no doubt that it is distributed over most of the southern states.

Since the study of this beetle was begun in 1914, it has been found or reported damaging planted corn in the following counties of Kansas: Cowley, Butler, Marion, and Greenwood. Records of the occurrence of the pest at Topeka and Wichita are found among the notes of the Department of Entomology of the Kansas Agricultural Experiment Station. The accom-

panying map (fig. 1) shows the known distribution of the species in Kansas.

The billbug is found principally along river valleys, where it does great damage to corn. (Fig. 2.) It is found doing slight injury on land known as second-bottom land and only rarely on the higher uplands. However, damage on uplands is very slight compared to the lowland ravages. The bug seems to show a preference for certain types of soil in the lowlands, since the corn on heavy gumbo soils is more seriously damaged than that on sandy soils.



FIG. 2.—Field damaged by maize billbug and, because of no crop prospects, allowed to grow to weeds. Stalks standing will produce only nubbins

MEANS OF DISPERSAL

The rate of dispersal of the maize billbug under natural conditions is very slow. Although the insect has wings it has never been observed to fly. Under artificial conditions many attempts, such as the application of intense heat, have been made to force the beetle to fly, but to no avail. Dispersion results almost entirely from the insect's ability to walk from field to field. Floods are probably a small factor of dispersal. During the 1915 season three adults were observed being carried by high waters, but as a rule, during high water the adult beetles burrow into the soil and are thus unaffected by



FIG. 3.—Corn plant showing feeding punctures of adult beetles



FIG. 4.—Corn plant showing gnarled and twisted condition of the stalk, due to feeding and egg punctures at base of plant

the water. They can live for many hours in water. A certain farmer in southern Kansas reports a field becoming infested from water coming after a heavy rain from a higher field which was heavily infested. Driftwood may sometimes play a part in the spread of this species, as it is able to carry the beetles to fields farther down the streams.

Farmers along Wild Cat Creek in Greenwood County maintain that the elephant bug was brought to their community



FIG. 5.—Corn plant showing maize billbug injury

about 1896 in cattle bedding shipped from Texas. Other southern Kansas farmers account for the introduction of the bug in their neighborhoods by similar theories.

TYPES OF INJURY

The corn plants are subject to damage from both the adult beetle and the larva, each of which causes a distinct type of injury. Punctures made by the adult while feeding (fig. 3)



FIG 6.—Infested corn roots showing a larva in burrow

kill a large number of plants soon after they break through the ground and during their early stages of growth. Corn so punctured does not show much external damage but closer examination shows the feeding holes to be large cavities gouged out underneath the narrow, external, slitlike opening. The punctures are often made in uncurled leaves, which, when they later unroll, will cause the plant to show very even rows of round holes made in the unfolded leaf. These feeding holes are made either just below or just above the surface of the

ground. Frequently, they will be found in the germinating seed and even in the tender roots. This feeding causes the plants to become twisted and distorted (figs. 4 and 5), and many, unable to withstand such treatment, are killed outright.

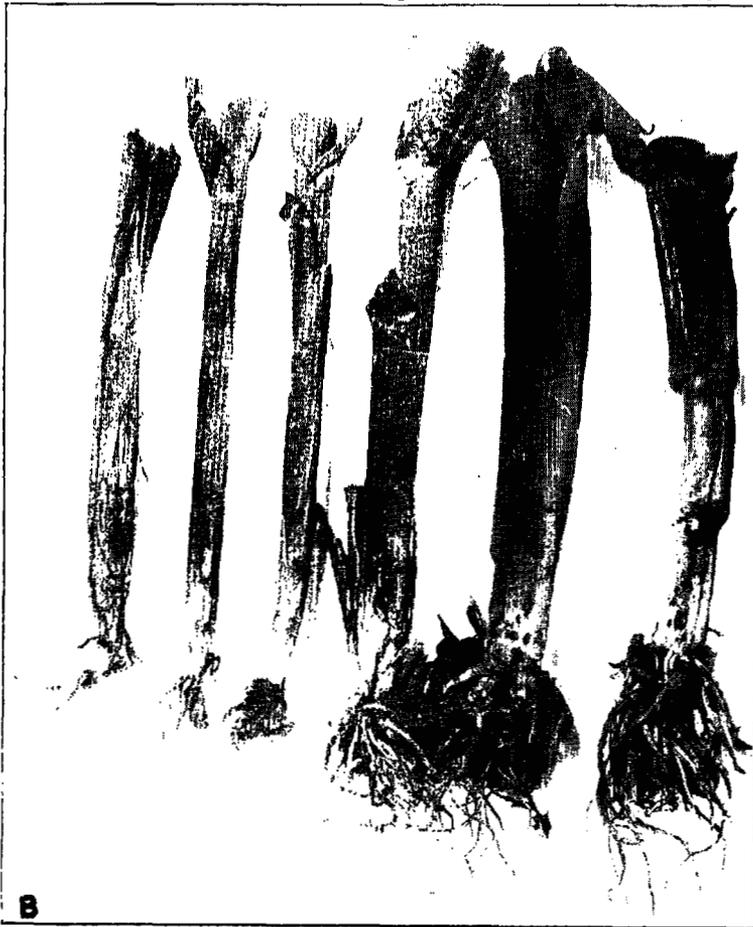


FIG. 7.—Corn root systems showing injury done by maize billbugs

Punctures similar to those found in corn are sometimes found in cane and kafir, and under certain conditions, when no other food is available, in feterita and sweet corn. Young plants are often somewhat seriously injured by adult beetles clasping their feet around the stalks and piercing the outer coverings of

the plant, making a rather deep hole where each foot has been clasped.

Plants that survive or escape injury from the feeding of the adult beetles are subject to a more severe type of damage from the feeding of the grubs or larvae. This manner of injury results as shown by figure 6.



FIG. 8.—A, Dwarfed corn plant bearing ear near surface of ground (one characteristic of billbug injury). B, Injured corn plant showing feeding position of adult beetles

The adults dig out large cavities in the plant in which to lay their eggs and from these eggs the grubs hatch and at once begin feeding and burrowing into the heart of the plant. The burrows increase in size and eventually extend from the tap-root to several inches above the surface of the soil. The grubs, thus burrowing the stalk, do not always kill the plant but cause the upper leaves to assume a pale wilted appearance and the whole plant to become gnarled and distorted. (Fig. 5.) These stalks grow slowly, sucker profusely, and seldom produce ears. The root systems of the plants are also greatly reduced in size. (Fig. 7.) Stunted plants are often found which send out small ears near the surface of the ground. (Fig. 8, A.)

FOOD PLANTS

A knowledge of the food plants of any insect is essential to its successful control. Fortunately, so far as known, this species has few natural food plants. In fact, only two have been reported—rosin plants (Hayes, 1916, p. 122) and swamp grass (Kelly, 1911, p. 15). The latter is perhaps the true natural food of this beetle, and when deprived of this source of nourishment it seeks cultivated fields. Field corn is the principal crop injured by the beetle, but at times the species will thrive on sweet corn, cane, kafir, and feterita. Upon these plants individuals have been raised to maturity, thus proving that the grubs can subsist on such food. The adults have likewise been observed feeding on the above named crops and it is within the range of probability that the species, when necessity demands, will thrive on other grain sorghums. It is not likely, however, that sorghum will be seriously damaged by this pest. The majority of the observed instances where sorghum plants were injured were cases where corn had been seriously damaged, plowed up, and the land planted to one of the sorghums.

LIFE-HISTORY

THE ADULT

Description.—The adult maize billbug (fig. 9) is a shiny black beetle with a hard outer “shell.” It is about one-half of an inch long, two-fifths as wide as long, and very robust in appearance. It has a snout or beak which curves backward and

is about one-half as long as its body. It often has a muddy appearance, due to the adhesion to the body of soil which mixes with a waxy secretion from the pores of the body.

The males are distinguished from the females by a concave excavation on the first segment of the abdomen, which is lacking in the female, and by a less rounded and nearly truncate posterior end.

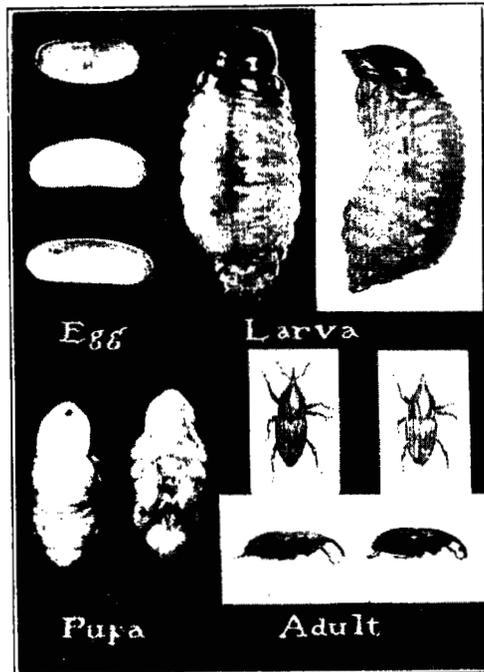


FIG. 9.—Maize billbugs in various stages of development

General Considerations.—This particular species of beetle passes through a series of changes in its development in the same way as other beetles. An egg is laid by the adult in the corn plant, from which hatches a grub or larva that feeds until full grown on the inside of the corn plant. When full grown, the larva forms a cell near the taproot and transforms to the pupal stage, during which it ceases feeding and becomes generally inactive. During this period, marked changes are undergone within the individual and it soon emerges as a full-

grown adult beetle. This sort of a life cycle gives us then four distinct changes—the egg, the larva, the pupa, and the adult.

Emergence from Pupa.—In late summer and early autumn, the beetles reach their final stages in development and begin to transform from the pupae. Emergence is accomplished after splitting the so-called pupal skin. In order to successfully remove the entire covering, the adult wriggles violently within the pupal cell, finally freeing itself. The newly emerged adult is light brown, varying from red to a whitish yellow on the abdomen and wing covers. After two or three days it darkens to a reddish black color, and later becomes entirely black.

Period of Emergence.—In some seasons, the pupæ begin to transform to adults late in July. The earliest known date is July 29. At other times, especially cooler seasons, the transformations are delayed, and in such cases, newly emerged adults cannot be found until late August or early September. This difference in time, along with other variations to be discussed later—such as variation in length of egg, larval, and pupal stages—can probably be attributed to climatic conditions in different seasons. From the author's observations, such factors as humidity and temperature play an important part in these variations.

Emergence from Stalks in Autumn.—In autumn, after becoming adults, a large number of beetles leave their pupal cells by gnawing their way out through the lower end of the cornstalk, and from our experimental observations, it is apparent that these individuals can pass the winter in the soil, under trash, or under other material offering shelter in the fields. These adults, when in the soil, compact the earth around them and form neat cells (fig. 10, A) in which they can pass the winter as do other beetles which live over the winter in the ground. Many adults, however, do not leave the stalks, but remain in the pupal cells throughout the winter.

Early Spring Activity.—When corn fields are plowed in early spring, many of the winter quarters of those beetles which have hibernated in the cornstalks are broken up and the beetles perish or are compelled to seek shelter under any objects offering favorable protection. The beetles will then hide under trash, corn shocks, or even under old haystacks in adjoining fields. A method of at least partial control by cleaning

up these places of refuge, is here suggested. In some localities, this is done by raking up and burning all the trash. About the last of April the beetles begin to emerge from these temporary



FIG. 10.—A, Cell constructed in the soil by adult beetle. B, Infested cornstalk with outer sheath torn away showing egg laid by adult female

shelters and seek food wherever it is available. Planted corn coming through the ground at this time is severely injured by the billbugs moving and feeding from plant to plant. These over-wintering adults may live through the summer and into

the fall as late as November 3, but the majority die soon after the egg-laying period ends, which is from the last of June to the first of August, depending on the character of the season,

Feeding of Adults.—The mouth parts of this beetle are located on the tip end of the long projecting beak or snout. With this snout they puncture the young corn plants just above or below the surface of the ground and feed on the leaves or heart of the plant. These punctures are later revealed by the rows of holes in the unfolded leaves. While feeding, the beetles generally hang to the plants with their heads downward (fig. 8, B), clasping the stalk with their legs; in fact, so tightly do they cling that it is hard to dislodge them.

When corn has just appeared above ground the feeding damage in most fields seems to be confined to definite areas or patches, but as these plants are killed out the beetles move to other plants and the damage spreads until it has covered most of the field. Often the beetles will feed below the surface of the soil on the roots or even the germinating seed.

Preoviposition Period.—Mating begins in the early part of May after the billbugs have fed for some time. In 1914, it was observed as early as May 10. Thirteen days later the first eggs were found. The time elapsing between mating and the time of first egg laying is known as the preoviposition period. This time varies with different individuals. It may extend from 9 or 10 days to nearly a month in some cases.

Method of Egg Deposition.—The eggs are laid in slits made by the female in plants at or near the surface of the soil. (Fig. 10, B.) Generally, these slits are made in the sheath surrounding the stalk and do not seriously affect the plants except when they are very young. The slits are made in the plant by the adult female with her beak, after which she reverses her position and deposits her egg. Upon the withdrawal of the egg-laying apparatus the slit closes and completely covers the egg. These punctures, beneath the surface, are small compared to the feeding punctures and contain, ordinarily, only one egg each. Sometimes, however, as many as three eggs can be found in a single cavity. Eggs are sometimes laid in the soil near the corn plants, but the hatching grubs find little food available there and often perish. In rearing cages, even when corn is available, eggs will sometimes be laid on the bottoms of cages

which do not contain soil, Eggs are usually laid in the cooler parts of the day.

Life of Adults.—The normal length of life of the adult beetles is a period extending from the time of their maturity in late summer or early fall to the end of their egg-laying period in June or July of the next summer. This is the longest period for any of the four life-history stages of this species. As mentioned before, under unusual conditions these beetles may survive, as observed in one instance, until November 3. In this particular case the life of this beetle, assuming that it matured the fall of the previous year, was slightly more than a year.

The adults are strong vigorous insects, having few natural enemies. For the greater part of their existence they are protected in their cells in the corn plant, in winter quarters, or under rubbish. In the spring they can withstand complete inundation for several days, by floods or heavy rains. They merely dig into the soil and come out when the water has subsided. The natural habits of these beetles in lowlands subject them frequently to these extraordinary conditions. A closely allied species known as the curlew-bug or southern corn billbug is known to be carried by tides.

THE EGG

Description.—The egg (fig. 9) of the maize billbug is nearly white when freshly laid, but as development continues it assumes a somewhat darker or yellowish tint. The surface is smooth and shiny, often appearing to have a moist film surrounding it. In shape the egg does not resemble the ordinary round insect egg, but is more elongate and more or less kidney shaped. It is about one-eighth of an inch long.

Length of Egg Stage.—The length of the egg stage varied considerably in the two years under observation. Table I shows the variation.

TABLE I.—INCUBATION PERIOD

DATE	Number eggs hatching	Minimum days	Maximum days	Average days	Remarks
1914.....	110	4	25	8.20	Dry season
1915.....	506	5	30	12.26	Wet season

From the table it will be seen that there was a variation of four days in the average length of the egg stage for the two seasons. A warm dry season, such as 1914, tends to hasten the development of the eggs and thus measurably shortens the period of incubation. A cool wet summer, such as 1915, plainly prolongs the time of development. The maximum length of this stage in 1914 was 25 days, while in 1915, one egg required 39 days to hatch. The variation in the minimum time of development was not so marked, being only one day.

Number of Eggs Laid.—Egg-laying begins about the last of May and continues, in late seasons, until the first week of August. Individual females under experimental observation, laid eggs, intermittently, over a period of 68 days. Eggs are, as a rule, not laid daily by any female. Frequently, they are deposited for two or three consecutive days followed by an intermission of a few days. Six eggs per day was the largest number to be laid by a single individual.

Eggs require moisture for hatching. This is usually furnished by the tissues of the plant. Eggs kept on damp soil hatched readily. Under laboratory conditions, they were easily incubated in moist vials or on freshly cut pieces of corn-stalk.

Fully developed eggs dissected from recently killed adults always failed to hatch. These females, at the height of the egg-laying period, were never found to contain more than six ripe and three immature eggs at one time. A few days before hatching, body segments of the growing larva can be seen through the shell. Frequently the brown coloration of the head can be seen, especially in late-hatching eggs.

THE LARVA

Description.—The larva (fig. 9) is a white plump footless grub, found normally in the heart of the corn or other infested plant. It has a small, light brown head and somewhat darker mouth parts. Toward the posterior end the body curves and enlarges, giving the whole a somewhat pear-shaped appearance. When full grown the larva is slightly over one-half of an inch long.

Habits.—In hatching the egg splits at the end containing the caudal region of the larva and along one side. By continued twisting, the young footless larva backs its way out

and finds itself surrounded by an abundance of food. At this time it is scarcely larger than the egg and is white in color, except the head, which is a chestnut brown. Frequently larvae, hatching after a short incubation period, are white with only the mandibles of a brown hue. In the latter case the whole head completely darkens soon after emerging from the shell.

The young larva at once begins to work up and down in the stalk (fig. 6), leaving the burrow behind it filled with castings. Before pupation part of these castings are used to construct a pupal cell by compacting them against the walls of the burrow near the taproot. (Fig. 11.) The larva, if head downward, reverses its position, assumes a quiescent stage for two or three days, undergoes a final moult, and pupates. Larvae under experimental observations moulted as many as five times. Three or four larvae may work in independent burrows in the same plant, a condition often found in badly infested fields. Adults, pupæ, and larvae may frequently be found in a single stalk. After becoming established in a stalk of any size, they were never observed to burrow through the tough outer covering of the plant above ground. They may do so occasionally beneath the surface.

Length of Larval Stage.—The length of the larval stage varies considerably. In 1914, on corn, it ranged from 40 to 60 days, with an average of 52.5 days. Table II shows the length of the larval stage in 1915 on different food plants.

TABLE II.—LENGTH OF LARVAL STAGE

Food	Number attempted to rear	Number matured	Maximum days	Minimum days	Average days
Maize.....	337	141	69	32	42.83
Kafir.....	47	6	68	32	47.50
Cane.....	46	12	75	39	54.83
Peterita.....	34	7	52	38	44.42
Sweet corn.....	13	3	56	43	48.00

In 1915, a much cooler season than 1914, the average length of the larval stage, on maize, was reduced from 52.5 to 42.83 days. The minimum was also lowered from 40 to 32 days and the maximum raised from 60 to 69 days. These results were obtained in an outdoor insectary and checked closely

with field observations. One larva, feeding on cane, was kept alive 123 days, but died before pupation. Although larvae were found at work in the fields as early as June 6 in 1914, they were not found until July 1 in 1915 and were present thereafter throughout July, August, and part of September.



FIG. 11.—Cornstalks split to show a pupa in its cell and an empty cell in taproot

THE PUPA

Description.—The pupa (fig. 9) varies in size from about one-half to three-fourths of an inch in length. It is somewhat oblong in shape, being slightly thicker at the middle and slightly tapering toward the rear end. The legs, snout, and wing covers are plainly visible in this stage and are folded over the lower part of the body. When freshly transformed, the pupa is creamy-white, but after a few days it assumes a yellowish tinge and gradually darkens until it is nearly the color of freshly emerged adults.

Time of Pupation.—The larva when full grown ceases feeding, assumes a quiescent or pre-pupal period, and soon transforms to the pupal stage. In 1914, the first pupa was found in a cornstalk, July 14. From this date on the pupae were present in fields until the last of September. In the cooler 1915 season, pupae were later appearing in the fields and were present until the first weeks of October.

Length of Pupal Stage.—Pupae are found in the fields during late summer and early autumn. They occur entirely in pupal cells constructed in, or near, the taproot of the infested plant, (Fig. 11.) Generally, they are found in the upright position which the grubs assume just before transformation. The length of the pupal stage, like the egg and larval stages, varied considerably in the two seasons under observation. Table III shows this variation.

TABLE III.—LENGTH OF PUPAL STAGE

YEAR	Number to pupate	Maximum days	Minimum days	Average days	Remarks
1914.....	11	13	10	11.40	Dry season
1915.....	114	30	9	13.84	Wet season

From the table it will appear that there was a variation of two days in the average length of the pupal stage for the two seasons. The maximum period of development varied from 13 to 30 days and the minimum period from 10 to 9 days for the two seasons.

SEASONAL HISTORY

Hibernation.—The majority of the maize billbug beetles pass the winter in their pupal cells within the cornstalks, but those leaving the stalks in late summer and early fall must be accounted for before winter methods of control can be thoroughly successful. Although no positive field evidence is available as to the winter homes of these migrants, experimental evidence strongly indicates that they can survive in many different situations. They have been successfully carried through the winter in the soil at various depths and under trash and rubbish.

Summer Activities.—In the spring a short time before corn-planting time, the beetles begin to issue from their winter quarters and await the appearance of the young corn plants

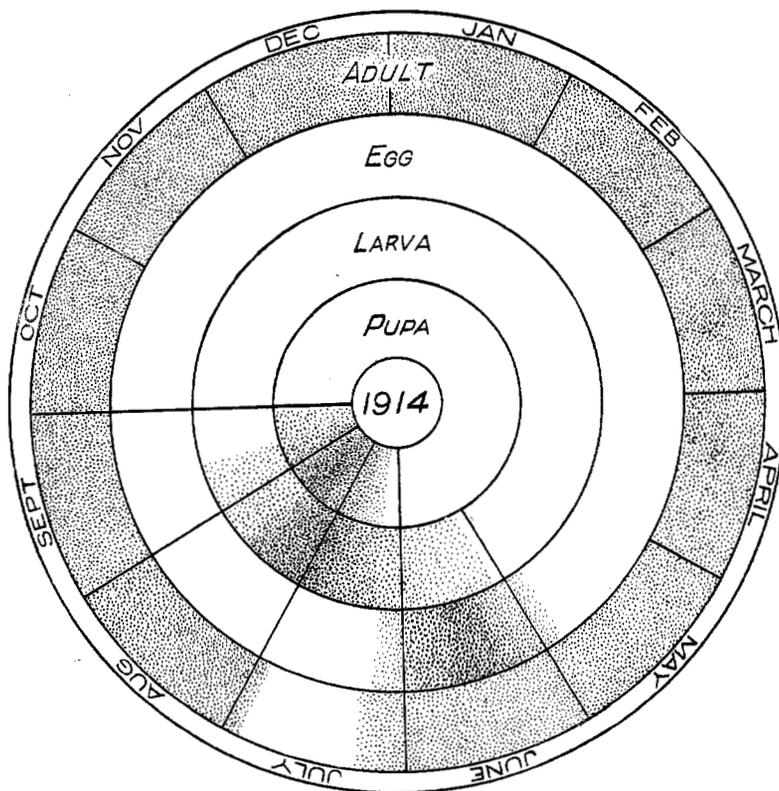


FIG. 12.—Diagram representing the seasonal appearance of the maize billbug in 1914

above ground. In many fields where corn has followed corn there is an abundance of volunteer corn which comes up early and offers favorable food for the billbugs until the regular crop is up. The beetles can be found thick in such situations. The young volunteer corn constitutes their chief food. Mating soon occurs and shortly afterward egg deposition begins.

Summing up the seasonal appearance of this billbug, we find the adults present in fields throughout the fall, winter, spring, and larger part of summer; eggs may be found in May, June, and sometimes July; larvae from the first part of June to the middle of September; pupæ are present from the latter half of July to the last of September. There is but one generation annually, though adults that have lived through the winter will sometimes be abroad after their progeny have matured. This life-history complex is illustrated by figure 12.

NATURAL ENEMIES

Unfortunately, this insect apparently has few natural enemies since, to date, none have been recorded. This scarcity may, in part, be attributed to the protection which is afforded by its habit of living the greater part of the year in the corn plant.

Near the close of the 1915 egg-laying season, four fly larvae were found living in a single egg, the only instance of apparent parasitism to come under observation. The fly larvae were not bred out but it is the author's intention to investigate this parasite further. Predaceous enemies often gain entrance to the larval burrows, especially when the taproot rots in the soil. Chief among these are ground beetles, wireworms, and ants. The following is a list of enemies found attacking the different stages:

- Attacking egg—parasitic
 - Unknown Diptera
- Attacking larva—predaceous
 - Ground beetles, adults and larvae
 - House ant (*Monomorium pharaonis* Linn.)
 - Little thief ant (*Solenopsis molesta* Say.)
- Attacking pupa—predaceous
 - Wireworms
 - Corn field ant (*Lasius niger americana* Emery)
 - House ant (*Monomorium pharaonis* Linn.)
 - Little thief ant (*Solenopsis molesta* Say)

Attacking adult—predaceous
 Ground beetles, adults
 Little thief ant (*Solenopsis molesta* Say)

CONTROL MEASURES

Fall Plowing.—Fall plowing is a fairly effective control measure. It breaks up the winter quarters of those beetles hibernating within the cornstalks and disturbs all others more or less. Ousted from their winter quarters, the probabilities are that many of the beetles will perish before finding safe protection. Especially will this be true if the plowing is done late.

Crop Rotation.—The cheapest, most satisfactory, and most practicable method of control is the use of a cropping system in which corn does not follow corn. Let corn be succeeded by some crop that is not subject to injury by this pest. In southern Kansas the best general practice has been to keep the infested fields in alfalfa for a few years, after which corn may be safely planted.

The pulling up and burning of corn stubble, as is sometimes recommended as an efficient remedy in controlling this species, is to some extent practicable in small fields. This, however, is a very laborious and impracticable task on a 60- or 80-acre field. It is not wholly effective because many beetles leave the taproot in early fall and, as yet, their winter quarters are not definitely known. Moreover, infested plants break off easily when pulled out, and often, even when the greatest care is exercised, beetles are left in the lower part of the taproot.

Swamp grass in and around infested fields should be destroyed as well as volunteer corn or sorghum. Weeds, rubbish, and trash should be cleaned up to destroy hibernation quarters.

BIBLIOGRAPHY

- (1) BLATCHLEY, W. S., and LENG, C. W.
 1916. RHYNCHOPHORA OR WEEVILS OF NORTH EASTERN AMERICA, 682 pp., 155 figs. Indianapolis, Ind.
- (2) CHITTENDEN, F. H.
 1905. ON THE SPECIES OF SPHENOPHORUS RELATED TO PERTINAX OL., WITH DESCRIPTIONS OF OTHER FORMS. *In Proc. Ent. Soc. Wash.*, v. 7, pp. 50-64.

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27

- (3) GLOVER, TOWNEND.
1855. INSECTS INJURIOUS AND BENEFICIAL TO VEGETATION. *In* Agr. Rept. Patent Office for 1854, pp. 58-84. (Reference to *Sphenophorus* sp. believed to be *maidis* by Chittenden.)
- (4) HAYES, W. P.
1916. A STUDY OF THE LIFE-HISTORY OF THE MAIZE BILLBUG. *In* Jour. Econ. Ent., v. 9, pp. 120-128, 4 pls.
- (5) KELLY, E. O. G.
1911. THE MAIZE BILLBUG. *In* U. S. Dept. Agr. Bur. of Ent. Bul. 95, Pt. II, pp. 11-22.
- (6) RILEY, C. V.
1882. INSECTS AFFECTING CORN OR MAIZE. *In* Rpt. U. S. Dept. Agr., 1881-1882, pp. 138-152. Report of Entomologist. (Reference to *S. robustus* believed to be *S. maidis* by Chittenden.)
- (7) SATTERTHWAIT, A. F.
1919. HOW TO CONTROL BILLBUGS DESTRUCTIVE TO CEREAL AND FORAGE CROPS. U. S. Dept. Agr. Farmers' Bul. 1003, 23 pp. 24 figs. Maize billbug, pp. 11-13, 5 figs.

