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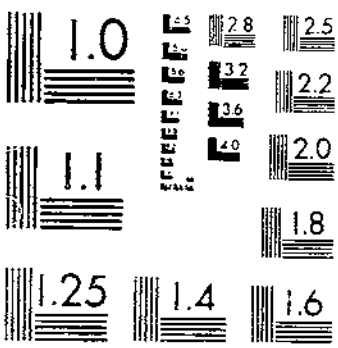

MICROCOPY RESOLUTION TEST CHART
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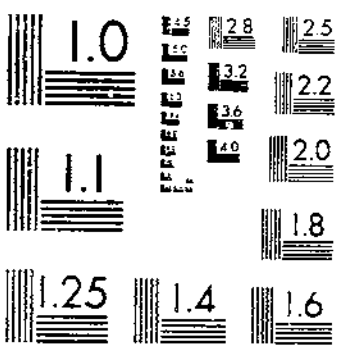

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THE LARGER SOD WEBWORM[1]

By GEORGE G. AINSLIE, *Associate Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology*

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INTRODUCTION

The larger sod webworm (*Crambus trisectus* Walker) is one of the economically important species of its genus. The adult (fig. 1, A) is a comparatively large, yellowish-gray moth with a wing expanse of an inch or more. It is widely distributed in the northern part of the United States and in southern Canada, and apparently is most abundant throughout a region extending from Ohio to Iowa. There are several cases on record where the larvae have become seriously injurious, and undoubtedly their annual toll from pastures, meadows, lawns, and cornfields is large, although impossible to estimate. In this bulletin the attempt is made to bring together all available facts concerning the larger sod webworm.

SYSTEMATIC HISTORY

Four different times has this species been described as new, twice by Walker, once in 1856 (*15, p. 119*)[2] as a noctuid under the name of *Carvanca trisecta* and again in 1863 (*16, p. 156*) as *Crambus interminellus*, both times from moths from Nova Scotia. In 1863 Zeller (*20, p. 37*) described it as *Crambus exsiccatus* from moths from Illinois, and again in 1874 (*21, p. 429*) as *Crambus biliturellus* from specimens from Vancouver Island. It has been mentioned rarely in European literature and then only incidentally as an American species.

[1] This bulletin constitutes No. 5 of the series of contributions to a knowledge of the Crambinae of North America.

[2] Italic numbers in parentheses refer to "Literature cited," p. 17.

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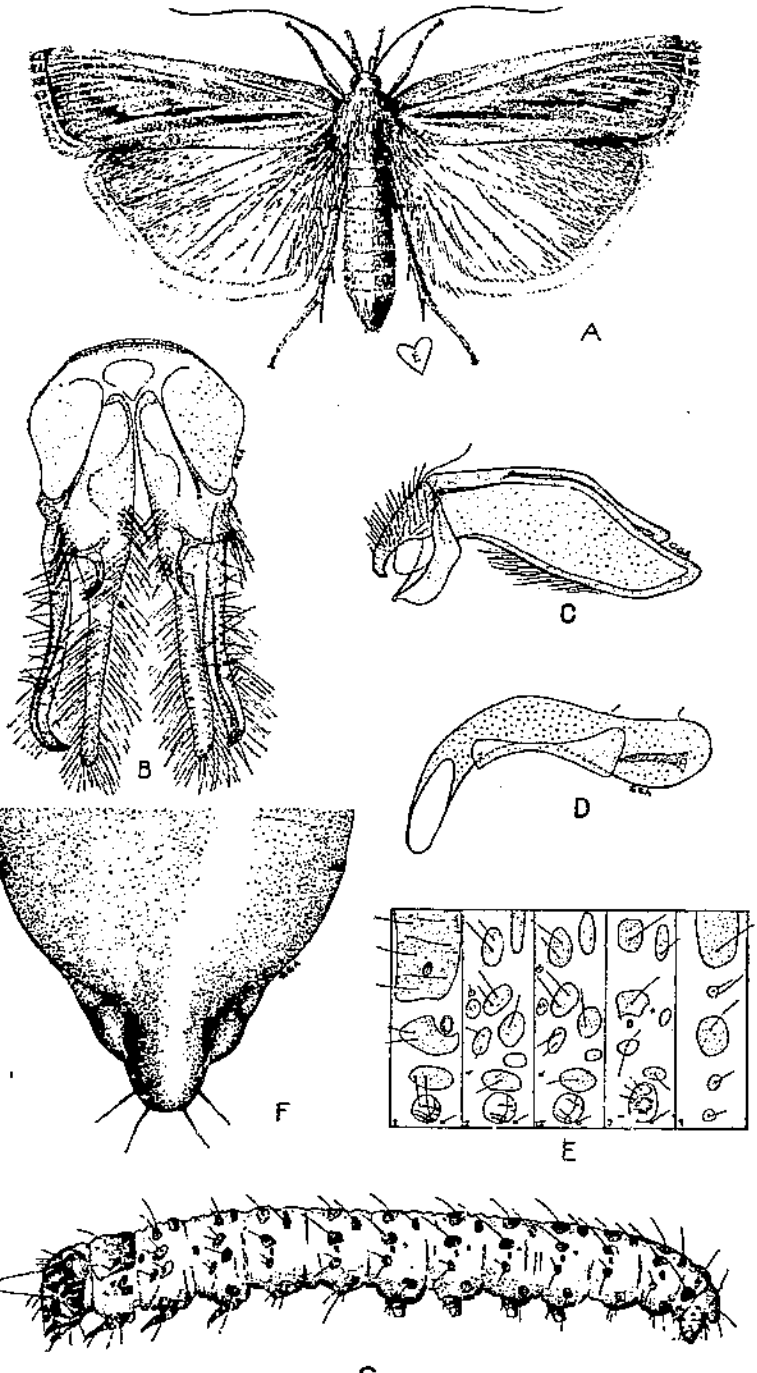

FIG. 1.—The larger sod webworm (*Crambus trisectus*): A, adult moth; B, male genitalia, harpes; C, male genitalia, tegumen, uncus, and gnathos; D, male genitalia, aedoeagus; E, setal map of larva, showing arrangement of pinacula on three thoracic and third and ninth abdominal segments; F, caudal tip of pupa, dorsal view; G, mature larva.

In a preliminary list of the American species of Crambus, Grote (*6, p. 78*) overlooked Walker's earlier descriptions and listed the species as *Crambus exsiccatus*. His lead was followed by economic writers for a decade, and Smith (*13, p. 346*), in his first list of the insects of New Jersey, accords it place under Zeller's name. The next year, however, the same author (*14, p. 86*) recognized that Zeller's *exsiccatus* and *bilituretlus* were synonymous with Walker's *interminellus* and so arranged them in his list of the Lepidoptera of North America. For the next five years both names were used rather interchangeably by economic writers. In 1895 Hampson (*7, p. 928*), after a study of Walker's types in the British Museum, decided that *interminellus* and *trisecta* were the same and placed the latter in the genus Crambus as *trisectus*. This reduced the other three names to synonyms, and, with few exceptions, all the literature on this species since the time of Hampson's paper has appeared under the name *Crambus trisectus* Walker. Thus the synonymy stands as follows:

Carvanca trisecta Walker, 1856.
Crambus interminellus Walker, 1863.
Crambus exsiccatus Zeller, 1863.
Crambus bilituretlus Zeller, 1874.
Crambus trisectus (Walker), Hampson, 1895.

DISTRIBUTION

The larger sod webworm is a North American species. Its distribution corresponds roughly to the Canadian, Transition, and Upper Austral life zones. It occurs completely across the continent in southern Canada, but nothing is known of its northern limits. East of the Mississippi, the southernmost points from which authentic records are available are Washington, D. C., and Clarksville and Kingston, Tenn. At the last point a single specimen was taken in 1918, though at Knoxville, 30 miles east, it has not been found in six seasons' collecting, and in five years' work it was not found at Nashville, a scant 30 miles south of Clarksville. A set of three specimens in the National Museum collection bears the single label "Fla.," but this is very probably incorrectly labeled. West of the Mississippi the line slopes sharply southward to include Amarillo, Tex., and Mesilla, N. Mex., only a short distance from the international boundary. Records are available from Colorado, Utah, and Washington. Whether the species occurs west of a line connecting these points remains to be seen. The accompanying map (fig. 2, A) illustrates the known distribution.

FOOD PLANTS

In rearing cages, bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomeratus*), timothy (*Phleum pratense*), and crabgrass (*Syntherisma sanguinalis*) were eaten readily by the larvæ, as were also oats, wheat, rye, barley, and corn. Johnson grass (*Sorghum halepense*), when offered, was invariably refused at first and then eaten only under necessity and by the larger larvæ. J. J. Davis notes that a larva in a rearing cage fed on the leaves of white sweet clover (*Melilotus alba*). When hungry, larvæ nibbled cowpea leaves but did

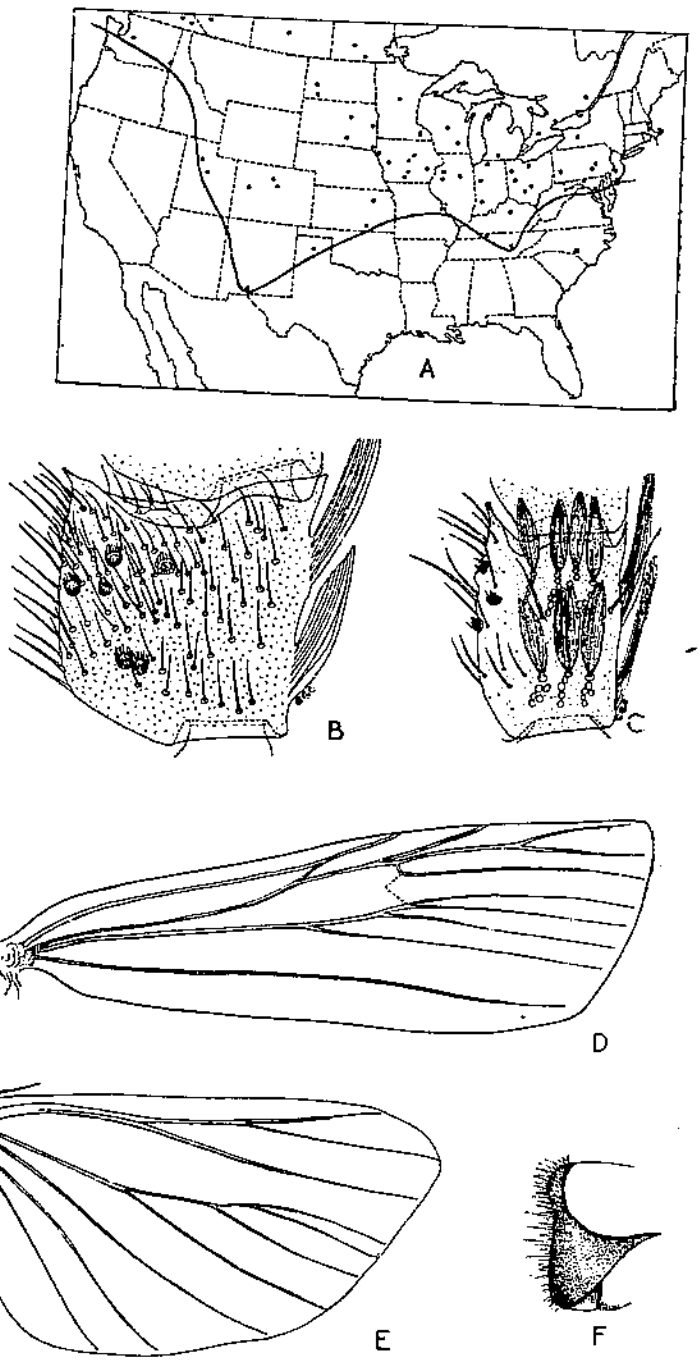

FIG. 2.—The larger sod webworm (*Crambus trisectus*): A, known distribution; B, segment (twenty-fifth) of male antenna, greatly enlarged; C, segment (twenty-fifth) of female antenna, greatly enlarged; D, venation of front wing; E, venation of hind wing; F, female genitalia, valve

not relish them. Gossard (*5, p. 207*) found the larvæ "feeding freely about the roots of clover and proved by observation that they could readily subsist on this plant without other food." This observation was corroborated by the writer, who found that, in boxes, the larvæ fed freely on red-clover leaves. Felt (*3, p. 74*) mentions that the larvæ can subsist on sheep sorrel (*Rumex acetosella*) in the absence of more suitable food. A number of larvæ were provided with several sorts of moss, and while they cut it up somewhat they did not thrive, and finally died without increasing in size. Moss was offered them because it had been found to be the chosen food of some species, especially in the early instars.

ECONOMIC HISTORY

Although one of these moths was reared in connection with the severe outbreak of *Crambus vulgivagellus* Clemens in New York State in 1881 (*9*), the first definite record of injury seems to be the statement by Forbes (*4, p. 173*) in 1886, reporting damage to corn planted on old sod land. The next year, in Iowa, it was reported so frequently and from so many different points that Osborn was led to make a rather extended study of the species, and his account (*10, p. 154–160*) is the first and only economic paper dealing at any length with it. Although it appeared to be most abundant in sod lands and grasslands, most of the reports connected it with injury to young corn. In another place (*11, p. 44*) the same writer says that in Iowa it "may be counted as among the very constant destructive species."

Webster (*17, p. 85–87*) recorded an outbreak of considerable magnitude in northern Ohio, in which this species played an important, if not the principal part. Fields of young oats and corn were completely consumed and "even meadows did not escape, and in many places were left as bare and brown as in December." Again, Gossard (*5, p. 207*) records "considerable damage * * * to young corn" by this species in northwestern Ohio in 1910. "A number of fields had to be replanted and the stand in many others was greatly thinned." In 1918 the species again reached destructive numbers in Iowa, and many pastures and meadows were completely destroyed. Many other instances of less severe injury are recorded in the literature.

The economic importance of the species can not be accurately measured by the published records. In meadows and pastures the damage may be severe enough to reduce greatly the yield and carrying capacity of the land, and yet, unless the larvæ are abundant enough completely to devastate the area, their presence may be and usually is entirely overlooked. Even injury to corn is, without doubt, often improperly ascribed to cutworms. Rearing records show that it is one of the most voracious feeders of the group, and with the proper combination of favorable climatic conditions is capable of producing severe and widespread damage.

SEASONAL HISTORY

Although the writer has not had the opportunity to follow this species throughout the year in the field, enough data are available to give a fairly complete account of the seasonal habits.

It is certain that the insect passes the winter only as a larva. Osborn (*10, p. 158*) says for Iowa that "the insect is double-brooded. * * * Moths of the spring brood appear in June; early stragglers by the 1st, the bulk of the brood from the 7th to the 15th, and late stragglers till the 1st of July. * * * The fall brood of moths appearing in August, early stragglers the 1st of the month, the bulk of the brood during the middle of the month and till the 1st of September, and late stragglers are seen till fore part of October. Moths of this brood deposit eggs for the fall and winter brood of larvæ, which larvæ mature by the latter part of May, pupating during last of May and fore part of June."

Rearing records kept by the writer show that the insect is continuously active during the warm part of the year and that the larvæ pupate without delay upon reaching maturity. Thus the number of generations in a year depends largely on the length of the growing season. For Iowa this appears to be two. It is still open to question whether the moths appearing in late September and October belong to a third generation, descendants of the moths appearing early in June, or are merely belated stragglers of the second. At Ithaca, N. Y., in 1889 (*12, p. 210, 212*), the moths were taken at lights in comparative abundance during June and the first half of July, but very few appeared after that time. In a series of trap-lantern collections made during 1915 at La Fayette, Ind., this species made its appearance first on May 12. At Hagerstown, Md., specimens were taken May 8, 1915, and Hine (*8, p. 26*) reports the earliest moths taken in central Ohio on April 26. In 1916 at La Fayette the last specimens appeared at the trap light October 13, whereas the preceding year none was taken after September 14. Between these extremes they were almost continuously present, more numerous at some times than at others, but without enough variation in abundance to permit separation into distinct generations.

Rearing records show that under optimum conditions the time from the hatching of the egg to the emergence of the adult varies between 33 and 46 days. The egg stage adds to this 6 days and the preoviposition period perhaps 3 more, making an average of about 50 days for the life cycle in summer. In cages kept at outdoor temperatures at Knoxville, Tenn., larvæ hatching August 13 developed into moths which emerged from October 13 to November 1. Moths have been taken in Nova Scotia, British Columbia, and Vancouver in August, indicating two generations in the north. It is safe to say that this species has two generations over the greater part of its range, with just the possibility of a small or partial third generation at its southern limits.

INSTAR RECORDS

In Tables 1, 2, and 3 are condensed data on the length of the various instars and stages and the quantity of food eaten. These records were made in the insectary at Nashville, Tenn., from material obtained from La Fayette, Ind. Table 1 contains records of a series of 50 larvæ which hatched July 13, and Table 2, for comparison, the combined records of two lots of larvæ, of which one hatched September 9 and the other September 18. Under outdoor conditions the larvæ in Table 2 would not have matured the same fall, but they were kept in a cool room at a somewhat milder and more uniform

temperature than prevailed outside. In the later instars the records of the larvæ about to pupate are separated from those which molted again, as the two lots can hardly be averaged together. The instar just preceding the change to the pupa is invariably the longest and during it the larva is most voracious. The third instar is the shortest. In Table 3 is shown the number of linear millimeters of bluegrass leaves of average width (about 3 mm.) consumed by the larvæ in the various instars. As shown, one larva consumed during its life bluegrass leaves totaling nearly 13 linear feet.

TABLE 1.—*Length (in days) of stages and instars of larvæ of the larger sod webworm, hatching July 18, 1915*

Stages or instars	Maximum	Minimum	Average	Number of individuals averaged
	Days	*Days*	*Days*	
Egg	5	5	5	
Larva:				
Instar 1	3	3	3	50
Instar 2	5	3	3.12	50
Instar 3	4	2	2.99	47
Instar 4	7	2	4.00	43
Instar 5	6	2	3.62	34
Instar 6	7	3	4.15	26
Instar 7, normal	9	3	5.80	5
Instar 7, prepupal	12	8	9.11	5
Instar 8, prepupal	11	10	10.66	2
Total length of larval life [1]	39	28	31.75	12
Pupa	12	9	10.31	7
Period between oviposition and emergence of adult [1]	51	38	44.71	7

[1] The maximum and minimum figures given for "Total length of larval life" and "Period between oviposition and emergence of adult" are not computed by adding together the stages and instars, but are actual records from the number of individuals under observation, as given in the last column. The averages were obtained by dividing the sum of the actual records by the number of individuals.

TABLE 2.—*Length (in days) of stages and instars of larvæ of the larger sod webworm, hatching September 9 and 18, 1914*

Stage or instar	Maximum	Minimum	Average	Number of individuals averaged
	Days	*Days*	*Days*	
Egg	8	7	7.00	
Larva:				
Instar 1	8	4	5.00	33
Instar 2	5	3	4.10	29
Instar 3	5	3	3.26	27
Instar 4	7	3	5.46	26
Instar 5	11	6	7.00	24
Instar 6, normal	14	6	9.30	20
Instar 6, prepupal	16	16	16.00	1
Instar 7, normal	19	14	16.50	2
Instar 7, prepupal	27	14	20.00	16
Instar 8, prepupal	20	20	20.00	1
Total length of larval life [1]	64	43	55.12	17
Pupa	30	19	23.25	12
Period between oviposition and emergence of adult [1]	96	71	85.75	12
Moth [2]	19	3	12.82	11

[1] The maximum and minimum figures given for "Total length of larval life" and "Period between oviposition and emergence of adult" are not computed by adding together the stages and instars but are actual records from the number of individuals under observation, as given in the last column. The averages were obtained by dividing the sum of the actual records by the number of individuals.

[2] Specimens reared in confinement. Five moths laid an average of 56.6 eggs the maximum number being 80 and the minimum 18.

TABLE 3.—*Food records (in linear millimeters) of bluegrass leaves eaten by larvae of the larger sod webworm*

Instar	Maximum	Minimum	Average	Number of individuals averaged
	Mm.	*Mm.*	*Mm.*	
1	2	2	2	9
2	4	2	3	10
3	15	6	9.83	6
4	70	15	35.50	56
5	200	37	97.50	52
6, normal	670	90	338.45	42
6, prepupal	970	970	970.00	1
7, normal	1,140	220	629.60	5
7, prepupal	2,400	600	1,457.62	24
8, prepupal	2,160	720	1,360.00	3
Total [1]	3,824	1,135	2,177.22	18

[1] The maximum and minimum totals are not computed by adding together the figures given for the several instars but are actual records from the number of individuals under observation, as given in the last column.

THE EGG

The eggs are laid during the time when the females are most active, dusk or early evening, and during the day none are produced, even when the moths are confined in the dark. The eggs are not placed by the female but are dry when released and are dropped freely while the moth is either flying or standing, as may be observed by watching the surface beneath a group of them as they flutter about a light. Osborn (*10, p. 156*) notes that in the morning the sill and floor beneath a window were thickly strewn with eggs from moths that had been seeking escape from the room during the night. Only very rarely has an egg been found in the field, for they are so small and drop so far down among the grass stems that they are almost beyond recovery, even when the moths are abundant.

DESCRIPTION OF THE EGG

Elongate-oval, bluntly rounded on the ends, one of which is slightly larger than the other; with about 18 rounded, longitudinal ribs extending nearly to the poles; transverse carinæ flat, faint, and sometimes wholly obsolete; polar areas smooth, flattened. Length, 0.4589 to 0.5648 millimeter (average 0.5181 millimeter); width, 0.3177 to 0.3652 millimeter (average 0.3377 millimeter).

The eggs are almost pure white when laid but within a few hours change to pale yellow and by the third day have deepened to a dull orange. The sixth day they darken further, and soon the dark head of the larva within can be located near one end. They hatch on the seventh day, the larva cutting a way out just to one side of the larger end of the egg and leaving the shell milky white and somewhat iridescent.

THE LARVA

The newly hatched larva is vigorous, and in a dry place without food remains active for about 24 hours. During this time it crawls constantly about. One larva was trailed with a pencil mark from the time it hatched at noon until it died at 8 o'clock the next morning. The line so made measured 54 feet and 4 inches, and on some

surface more congenial than the dry smooth paper would perhaps have been longer.

Many larvæ were reared both on potted plants and individually in tin salve boxes where they were provided with damp blotter or sand and fresh bluegrass. The instar records in Table 1 were obtained from these isolated larvæ.

When ready to feed, the young larva seeks a hiding place under or between the blades. It incloses the retreat with a few threads of loosely spun silk and begins operations by cutting a small pit in the leaf surface between the veins to, but not through, the membrane on the opposite surface. As this pit elongates into a groove the larva lies in it and protects itself above by a loose network of silk fibers. The excrement is placed systematically, first along the sides of this network and later above, and very soon a protective covering is formed through which the builder can not be seen. The groove is widened to include the intervals between three or four veins. Through the first two instars and often partly through the third, all the feeding is done by skeletonizing, only the veins and surface membrane being left. Thereafter the leaf is entirely consumed, the larva feeding in such a way that the end is cut diagonally at an angle of about 45°.

By the time the third or fourth instar is attained the larva is too large to live on a single leaf, so it constructs of silk, earth, and excrement a tube or tunnel lying on or just beneath the surface of the ground, and generally leading away from the base of the plant on which it is feeding. It feeds by cutting a leaf off near the base and drawing the end into the mouth of the retreat where it can be consumed at leisure. Thereafter the larva seldom leaves the protection of its burrow even at night. Excrement in the form of dry, green, sawdustlike frass is discharged into the distant end of the retreat, finally so filling it that the larva is forced to provide other quarters, which it does by building a second tube or tunnel from the base of the plant in another direction. As many as four or five such radiating retreats may be constructed and abandoned in turn by one larva in the course of its life. The presence of a larva is most easily recognized by the short stubs of grass blades cut at the characteristic angle of 45°. During the last instar before pupation the larvæ consume proportionately much more food than at any other time. The food records in Table 3 were obtained by giving the larvæ measured quantities of bluegrass leaves at the beginning of each instar, and at its close measuring the uneaten portions. The bluegrass leaves used averaged about 3 millimeters in width, and a skeletonized leaf was considered to be two-thirds consumed.

The newly hatched larva has a dark head and cervical plate and a pale yellow body slightly dusky at the tip. The particle of eggshell which it consumed in releasing itself from the egg passes slowly through the digestive tract as a plainly visible salmon-colored plug and is voided with the first food which passes through. In the first three instars the head is black, or nearly so; then it becomes dusky yellowish-brown, with a faint pattern in darker brown which in later instars becomes more pronounced and definite, until in the mature larva (fig. 1, G) the head is prominently marked with groups

of dark-brown, rounded spots. The body also becomes darker because of a reddish brown overcolor and finally assumes a deep-purplish hue.

The normal number of instars was not determined with certainty. Larvæ in both the seventh and eighth instars pupated, and moths of both sexes emerged from the pupæ. Judging from the results with other species, however, it is probable that the males normally pupate from the seventh instar and the females from the eighth. None of the reared larvæ exceeded eight instars, as did those of several other species.

Larvæ seem able to pass the winter at almost any age. Most of those entering winter quarters, however, are small, in from the second to the fifth instar, as the larger larvæ are able to continue feeding and emerge as adults when the less-resistant small larvæ are making preparations for winter. In preparing for the rigors of winter each larva spins tightly about itself a delicate, closely woven case of white silk, covered outwardly with earth particles. It is nearly spherical and so closely invests the tightly coiled larva that it is difficult to open the case without injuring the inmate. The case is constructed at times in the end of the feeding tunnel, at others the larva leaves its old habitation altogether and seeks a sheltered crevice beside a clod or among the grass stems. A favorite place in the cages was about the base of the lantern globe covering the plants at, or a little beneath, the surface of the earth. When tufts of grass stems are available these wintering cases are sometimes fastened among them at a little distance above the ground. At Nashville, Tenn., the larvæ formed these cases during the last half of October and remained in them until the latter part of the following April. They seemed to winter well, even though the cages were allowed to dry out completely and were exposed to every variation of temperature, occasionally as low as zero.

TABLE 4.—*Measurements of larvæ of the larger sod webworm in the various instars*

Instar	Head width			Number of individuals averaged	Total length
	Maximum	Minimum	Average		
	Mm.	*Mm.*	*Mm.*		*Mm.*
1	0.2118	0.2118	0.2118		1.0- 2.0
2	.3351	.2471	.3089	14	2.5- 3.5
3	.4042	.4236	.4554	17	3.7- 5.5
4	.7590	.5822	.6760	18	6.0- 8.5
5	1.1120	.8472	.9955	20	10.0-12.0
6	1.4473	1.1049	1.3251	4	12.0-18.0
7	1.5885	1.5356	1.5532	3	18.0-24.0
8	2.3208	2.1004	2.2151	2	24.0-28.0

DESCRIPTION OF THE LARVA

INSTAR 1

Newly hatched larva. Head deep fuscous; frontal suture, caudal margin, and ocellar area black. Cervical plate fuscous, slightly paler than head. Body pale yellow, a little dusky caudad, with a pinkish tinge due to the salmon color of the ingested eggshell, pinaculn slightly dusky. Later in the instar the pale body color becomes tinged with a reddish overcolor, especially caudad.

INSTAR 2

Head deep fuscous to black, shining. Cervical plate a little paler than head. Body covered with dark reddish-brown overcolor which is broken along the sutures, less dense ventrad, the pinacula a little darker than skin.

INSTAR 3

Head fuscous to black, shining, the paler ones with faintly darker markings. Cervical plate fuscous, paler than head, somewhat mottled. Body dark reddish brown, paler along folds, sutures, and ventrad; pinacula nearly concolorous with skin but shining and faintly rugose; skin dull; minute black cicatrices near spiracles on pedal segments of abdomen.

INSTAR 4

Head brownish yellow, clouded with smoky brown; frontal suture, ocellar area, and caudal margin black. Cervical plate fuscous, darker than head, with a rounded brown spot laterad. Body dark reddish brown, this overcolor being broken along sutures, folds, and ventrad and with short rows of small clear vacuoles along dorsolateral margin; pinacula darker than skin, rather small and widely separated.

INSTAR 5

Head brownish yellow, marked with close groups of small round dark-brown to black spots. Cervical plate dark yellowish brown, darker than head, about concolorous with the dorsal pinacula on the body, darker caudad and with narrow, pale median line. Body dark reddish brown; pinacula rather small but distinct and widely separated.

INSTAR 6

Head as in instar 5, but the markings more pronounced. Cervical plate dark brown, almost black, especially caudad, concolorous with the dark markings on the head, feebly shining. Body leather-brown, a little paler ventrad; pinacula deep chocolate-brown, semishining and faintly rugose; cicatrices on pedal segments of abdomen black, about as large as the spiracles.

INSTAR 7

Head as in instar 6. Cervical plate dusky yellow to pale fuscous, with spots much lighter than in preceding instars; greenish-yellow tinged with a rufous overcolor; pinacula bronze-brown, rather larger than heretofore, distinctly defined and well separated.

INSTAR 8

(Fig. 1, E, G.)

Head dark brownish yellow, marked with close groups of round, dark-brown spots; ocellar area, caudal margin of head, and markings on mouth parts black. Cervical plate dark fuscous, shining; a narrow pale median line, most distinct near caudal margin; an oval spot toward each extremity and a pair on caudal margin near meson. Body dull yellowish, greenish from contents; skin finely granular, glistening; pinacula chocolate-brown, distinct. On the third abdominal segment the pinaculum of seta 1 is large and suboval, with a faintly darker dash cephalomesad of the seta; of seta 2, elongate oval; of seta 3, more nearly round and distinctly emarginate for both the nearly round spiracle and the brownish cicatrix. Setæ 4 and 5 situated together on a small nearly round pinaculum; seta 5 smaller, above and a little caudad of seta 4. Seta 6 on a small, broadly oval pinaculum above base of leg; seta 7, a group of three nearly in a row on an elongate pinaculum bordering base of leg; seta 8, a very small seta close to and mesad of leg. Crochets of prolegs triordinal, forming a complete circle but a little weaker on the outer side. In addition to these pinacula there appears, on the first abdominal segment, a small naked chitinized plate directly caudad of the spiracle. At first as large as the pinaculum bearing setæ 4 and 5, it becomes smaller on each succeeding segment and finally disappears completely on segments 4 to 6. Sauranal plate dusky yellow, with groups of small dark spots.

THE COCOON AND PUPA

When at last fully fed, the larva forms in the ground, close by its system of feeding tunnels but usually entirely separate from it, a cell about the size and shape of a peanut meat. It stands vertically or at a slight angle, and its depth depends somewhat on the looseness of the earth. It is connected with the surface by a short tube or neck which at its upper end, at the ground level, is closed by an ingenious valve made of silk which can be left open or closed at will. The cocoon is rather firm, smoothly lined with soft gray silk, and outwardly covered with earth and grass particles firmly interwoven with silk. It is easily overlooked or mistaken for a solid lump of earth.

DESCRIPTION OF THE PUPA

Length, 11 millimeters; width, 3 millimeters. Two pairs of minute setæ on front near base of antennæ and another pair near ventral margin of clypeus. Lateral sutures of pilifers faint, obsolete caudad. Proportions of appendages, etc., very similar to those of *Crambus hemiochrellus* Zeller, except in the cremaster (fig. 1, F) which in this species is narrower, longer, more decidedly rounded above both laterally and distally, bears longer setæ, and has the lateral furrows much narrower and longer, extending to the lateral line. Beneath, the tip of the abdomen is gibbous laterad and sharply excavated mesad so that the ventral line of the cremaster is parallel with the axis of the body.

THE MOTH

The moths frequent grassy places, apparently without regard to their location. Felt (*2, p. 62*) states that "this species seems to prefer low, wet land," and that "the moths fly mostly at or just after dark." They are strongly attracted by lights and such moths often contain large numbers of eggs. The females come in largest numbers to light in the early evening, soon after dusk, and only rarely after 9 o'clock, whereas the males come in largest numbers somewhat after midnight. To this fact, as demonstrated by the writer (*1, p. 115*), is due the difference of opinion regarding the possibility of using trap lights as an economic measure in controlling this species and others.

The females are prolific, though none, of which there is a record, has reached the total of "over 500 eggs" predicted by Felt (*2, p. 63*). Dissections of the ovaries of freshly emerged moths show from 50 to 65 eggs and immature ova in each of the eight ovarioles, and it is probable that more develop as the mature ones are disposed of, so that the 500 mark is well within the possibilities. The average number laid by females taken in the field at various times and places was 202. One lot of 11 of these moths averaged 222. The largest number obtained from a single moth was 441. These moths were all confined individually in dry tin boxes and had probably disposed of a part of their eggs before capture. One of them lived 16 days in captivity, and the average for 35 was 6½ days, which is probably less than the normal life of a moth in the field. A single unmated moth supplied with water lived 15 days and laid 143 eggs, and when dissected 14 eggs and a few undeveloped cells were found in her ovaries. Two similar moths fed dilute honey lived 10 days each, and laid respectively 3 and 45 eggs. After death the ovaries of the first were entirely empty while the second contained about 400 mature and partly

developed eggs. It is likely that the moths normally do not feed, for the presence of food seems to result neither in increased fecundity nor in greater longevity. Only a few males were observed, and under the same conditions they lived scarcely half as long as the average female. Mating occurs very shortly after the emergence of the female from the pupa, for only 2 of 35 moths taken in the field were infertile.

DESCRIPTION OF THE MOTH

Expanse of wings, 21 to 35 millimeters. Palpi ochraceous gray, whitish within toward the base and specked with fuscous outside; head, thorax, and patagia pale ochraceous, the former whitish and the latter sometimes with a few fuscous scales. Male antennæ stout, flattened; female antennæ filiform. Forewings pale ochraceous, lighter caudad and distad, surface scattered with dark-brown to black scales, except along the fold, just behind which there is usually an elongated dark area extending from the base distad nearly half the length of the wing. At the end of this area, but above the fold, at the base of the vein Cu_2, is a dark spot marking the position of the ochraceous median line which curves evenly distad and cephalad from this point until it meets the costa a little beyond the middle. About midway between this dark spot and the end of the wing is another, somewhat elongated in a direction almost parallel with the end of the wing and indicating the subterminal line which is obsolete cephalad. Terminal line indicated by two or three dark brown or black spots at the base of the fringe toward the caudal margin. Fringe fuscous, cut by three to seven white lines, continuations of the interspaces. The forewing varies widely in the prominence of the markings, in some specimens being almost uniform ochraceous, in others with each interspace sprinkled with black scales in addition to the markings described above. Hind wings silvery white at base, shading to ochraceous or pale fuscous distad, fringes white.

GENITALIA

Female.—Valve (fig. 2, F) subquadrate, a little longer than broad, somewhat constricted at base, angles rounded, the dorsal only very slightly produced.

Male.—Body of tegumen short (fig. 1, C), flattened above, the limbs broad, acute cephalad, very lightly chitinized except for a narrow stronger margin, a row of coarse hairs near the center of ventral margin; uncus short, stout, and hooked at tip, concave bi'sute above; gnathos broad, short, deeply concave, only slightly exceeding the uncus and terminating in a minute outturned tip. Aedoeagus (fig. 1, D) tubular, a little enlarged cephalad, caudad turned strongly ventrad, only moderately chitinized and in a strip running spirally about the organ, distal opening oblique and lateral, one short, stout cornutus usually withdrawn to base of aedoeagus; anellus a lightly chitinized dumbbell-shaped plate closely subtending the aedoeagus. Harpes (fig. 1, B) with costal margin free and heavily chitinized into a long, stout, sinuous arm, somewhat more sharply curved at tip, furrowed to tip on inner side; with scattered short spines for three-fourths its length; sacculus lightly and nearly uniformly chitinized throughout, its base concave, the terminal arm or cuculius long, flat, narrow, slightly exceeding the free costa and rounded at tip, densely hairy with brush of especially long hairs about the middle of the outer margin; at the base of the free portion of the sacculus and somewhat between it and the free costa is the short, stout, curved, heavily chitinized spinelike clasp, arising from a chitinized ridge which extends to the outward margin at the base of the free costa and there ends in a chitinous shoulder bearing a tuft of slender hairs. Vinculum not conspicuous, reduced to a thickened basal margin and a small triangular plate between the bases of the sacculi. The left harpe is usually a little larger and longer than the other, and the tip of the left free costa is more decidedly curved.

SYSTEMATIC RELATIONSHIPS

Crambus trisectus is one of the most generalized forms of the genus. This is shown by its comparatively large size, its modest coloration with lack of any striking color pattern, and its simple and only slightly modified genitalia. It lies between *luteolellus* Clemens and

hemiochrellus Zeller, rather closer to the former. The male genitalia are much like those of *luteolellus*, differing mainly in that the cucullus (fig. 1, B) is more highly chitinized and more sparingly hirsute, and in the presence of a stout accessory spine or clasper at the base of and between the cucullus and the free costa. They differ also in the appearance of a short, stout, heavily chitinized internal spine or cornutus in the aedoeagus (fig. 1, D) of which there is no trace in *luteolellus* and which in *hemiochrellus* is more than double the size. In *hemiochrellus* also, the cucullus is naked and consists of a long, sharp, sinuous spine, while the clasper is absent or exists only as a rounded, spined lobe. The antennal segments of *luteolellus* and *trisectus* (fig. 2, B, C) are quite similar, while those of *hemiochrellus* show considerable increase in size and in the number of sensoria. The writer does not agree with Felt (*2, p. 83*) in his figure of and statement concerning the female genital plate (fig. 2, F), for he finds it very similar in form to those of *luteolellus* and *hemiochrellus*. The venation (fig. 2, D, E) of the three species mentioned is very similar. In all three the veins SC and R seem truly to anastomose.

NATURAL ENEMIES

The larvæ of this species are attacked by several insect parasites, and their numbers are doubtless much reduced by insectivorous birds and animals such as mice, moles, ground squirrels, and gophers; and also by predacious insects and fungous diseases.

In June, 1920, near La Fayette, Ind., there was a local but severe outbreak of webworms because of which several acres of corn had to be twice replanted before a fair stand was obtained. Two species of Crambus were concerned, *C. trisectus* and *C. mutabilis* Clemens, the former predominating to the extent of about 80 per cent of the total. Numbers of the larvæ were collected and reared by W. H. Larrimer and his assistants. From 95 of these larvæ taken in the field, 26 moths were obtained, 19 of them *C. trisectus* and 7 *C. mutabilis*. Thirty-one of the larvæ died or were lost, and the remaining 38, 40 per cent of the total, yielded parasites. Of the parasites, 34 were dipterous and belonged to two species of Tachinidae, 13 being *Phorocera claripennis* Macq., and 21 being *Exorista nigripalpis* Towns. The four remaining parasitized individuals yielded three species of hymenopterous parasites, Macrocentrus sp., 2; *Angitia obscura* Cress., 1; and a species of Cymodusa, 1. One additional species, *Orgilus detectiformis* Vier., was obtained from other larvæ collected at the same place, and reared by the writer at Knoxville, Tenn. The species of Macrocentrus (probably *M. crambivorus* Vier.) is also known as a parasite of *C. mutabilis* and is discussed in another paper in connection therewith, while the others are noted below in more detail. As most of these webworm larvæ were not specifically determined before the rearing of the parasites, it is impossible to say definitely from which host each of the parasites came, but, because of the numerical predominance of larvæ of *C. trisectus*, those not know to be otherwise connected are considered to have come from this host.

Twenty-eight flies of *Exorista nigripalpis* Towns. were reared from 28 larvæ. Of this number, 25 remained within the host until the latter had pupated and afterwards broke out and formed their

puparia inside the cocoon and close beside the pupal shell of their former host. The other three emerged from the dead larval host and pupated in the open without protection. One of these flies was reared from a larva determined as *Crambus mutabilis;* the others all came from larvæ determined as those of *C. trisectus* or specifically undetermined. None of the host larvae from which this fly was reared gave any external indication of parasitism when collected in the field. The parasitic maggots issued from the host 2 to 8 (average 4) days after pupation, and 9 to 14 (average 11) days later the flies issued from the puparia.

Phorocera claripennis Macq. is known to attack larvæ of *C. mutabilis* and is discussed at greater length in another paper. It may also attack *C. trisectus*, but definite evidence is still lacking.

One specimen of *Angitia obscura* Cress. (det. Cushman) was reared from this material, the exact specific identity of the host again being open to question. After its host had remained inactive and without feeding for nearly a week, the grub emerged and three days later transformed into a naked pupa. The adult emerged six days after pupation.

A specimen of a species of Cymodusa (perhaps *mississippiensis* Ashm.) developed from a larva, which when taken in the field, showed no evidence of parasitism. This larva fed normally for 10 days after capture and remained inactive for a similar period, then constructed a normal cocoon of silk and bits of trash and lay within it for 10 days more, whereupon a hymenopterous grub emerged and spun a dark cocoon within the cocoon of its host. Eight days later the adult Cymodusa emerged.

In one of the tin boxes containing larvæ from the La Fayette outbreak there was found, on its arrival at Knoxville, a freshly formed, golden-yellow hymenopterous cocoon. Seven days later the adult emerged and was determined by S. A. Rohwer as *Orgilus detectiformis* Vier.

Two other hymenopterous parasites have already been recorded in literature from this host, *Ephialtes aequalis* Prov. (*Pimpla annulipes* Brullé) (*19, p. 51*) and *Apanteles crambi* Weed (*18, p. 8*).

Records of the Bureau of Biological Survey reveal the common crow to be an enemy of larvæ referable to the genus Crambus. In 10 of 2,341 stomachs such larvæ were found.

CONTROL MEASURES

As with most of the other pests in this group, efforts at control must be preventive rather than remedial. When the larvæ are found injuriously abundant in a cornfield, little can be done except to replant. To keep the replants from being also attacked, the new rows should lie between the old ones, and the infested plants should be allowed to stand as long as possible so that the webworms will complete their growth on them, without turning their attention to the younger plants of the later sowing, as they are sure to do if the field is merely plowed or disked and replanted. By June 1 all the larvæ will be sufficiently mature to permit of the old injured plants being cultivated out, only the replants being left to occupy the ground. The moths emerging from these larvæ will seek grassy places and will not again trouble the corn. Poisoned baits have been tried in infested cornfields but without success.

As a preventive, land known to be infested with larvæ and intended for corn the following year should be plowed as early in the fall as possible, preferably in August or September, and kept fallow the remainder of the season and up to corn-planting time the following spring. If the fall plowing is delayed until October or November, the larvæ will have already prepared themselves for winter, and the disturbance will not seriously injure them.

In grasslands, meadows, and pastures, rotation will, of course, eliminate the trouble for the time, but where rotation is impracticable any treatment that favors the growth of the grass will decrease the proportion of injury. Ample fertilization will enable the grass to make more growth than the larvæ can consume and thus preserve the life of the plants until the larvæ are mature or until disease or natural enemies make way with them. Seldom does serious injury occur two years in succession in one locality, and the balance between these larvæ and the natural agencies which normally hold them in check is quickly reestablished. This does not mean, however, that no injury is done except in periods of abnormal abundance, for there is a constant and severe drain on the productive capacity of meadow and pasture at other times. So far, however, no practical method has been devised to reduce this loss.

SUMMARY

Crambus trisectus is one of the "close-wing" moths, the larvæ of which, known as sod webworms, cause frequent and serious damage to meadow and pasture lands and also to young corn following grass.

This species is a native of the northern part of the United States and is especially injurious throughout the section extending from Ohio to Iowa. It feeds almost exclusively on native grasses.

The moths expand from 1 to 1½ inches and are yellowish gray, with more or less conspicuous darker markings. They fly most freely about dusk and drop their eggs while flying.

The eggs hatch in about a week into lively little caterpillars which construct tubular burrows of silk and earth among the grass roots on, or just beneath, the surface of the ground. They emerge at night to feed on the grass blades and often cut them off and drag them into their burrows where they can feed at leisure.

There are two generations each year. The larvæ spend the winter among the grass roots, sealed up in tight little silk cocoons. They come out and feed ravenously through April and May, and the moths appear in May and early June. The second generation of moths appears in mid-August. Corn is attacked by the overwintering caterpillars soon after it appears above ground. The larvæ of the second generation are most injurious to grass and pasture lands in July, especially in dry seasons, when the grass is unable to recover quickly. The larvæ resulting from the second generation of moths only partially complete their growth in the fall and do little or no damage at that season. The pest is held in check naturally by insect enemies and fungous diseases.

When once present in a field it can be controlled with difficulty, and measures used against it should be preventive rather than remedial. Such measures are crop rotation, ample fertilization, and,

in the case of sod land intended for corn the following year, early fall plowing.

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