TWENTY-SECOND REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS

ELEVENTH REPORT OF S. A. FORBES

The Gazette Press
Champaign

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INTRODUCTORY NOTE.

In accordance with present provisions for the publication of the manuscripts of this office, most of the articles of this report have already appeared, in whole or in part, as bulletins of the Agricultural Experiment Station, a fact sufficiently shown by footnotes from the titles of the separate articles. That "On the Principal Nursery Pests likely to be distributed in Trade" was printed in July, 1901, as Circular No. 36 of the Experiment Station; but the articles on "Experiments and Observations on the Use of Crude Petroleum and Pure Kerosene for the San Jose Scale", on "Experiments with Summer Washes for the San Jose Scale", on "The Canker-worm on Shade and Forest Trees", and on "The Colaspis Root-worm" have not been previously printed.

THE CORN BILL-BUGS IN ILLINOIS.*

The corn "bill-bugs" are snout-beetles of various size and color, but averaging rather large, the majority of them dull black, with the surface much marked with small pits and narrow grooves. In form they are somewhat regularly oval, with thick bodies, rounded above and beneath, and with rather long "snouts" or "beaks" of medium strength, bent downward from the front of the head. They injure and often kill young corn in spring by thrusting the beak into the stem of the plant near its base and eating out the inner tissue beneath the point of puncture. Their presence in the field is very soon made manifest by the appearance of circular or oblong holes running in rows across the blade of the leaf, each row resulting from a single thrust of the beak when the leaves were closely rolled together in the young plant. The injury done varies from insignificance up to complete destruction of practically every plant in several acres of corn and for two or three successive plantings.

In the Sixteenth Report of this office, for the years 1886–88 (but published in 1890), is an article on these insects summarizing briefly the results of observations then the most recent and the contents of previously published articles on the subject, but proposing no preventive or remedial measure except a single one for the prevention of injuries to corn by the clay-colored bill-bug, *Sphenophorus ochreus*, on newly drained and freshly broken swampy fields. This preventive measure consists merely in planting the ground broken up from the swamp grasses to some other crop than corn for the first year, flax being especially suggested.

For the ordinary injuries to corn on old ground I had at that time no definite measure to propose, but a fuller knowledge of the life histories and habits of the bill-bugs and some observations lately made in both recently subdued swamp lands and old upland

*This article was originally published in October, 1902, as Bulletin No. 79 of the State Agricultural Experiment Station.

fields have furnished a sufficient basis for a highly useful method of prevention of the worst of these injuries, and this fact has made desirable a new treatment of the subject as a whole.

Usual Conditions of Injury to Corn.

While there is in Illinois a little general and unclassifiable injury to corn by the bill-bugs, by far the greater part of it occurs under one of three conditions. If swamp lands are broken up from grass in spring and planted to corn the same year, and especially if the common reed or the club-rush or other thick-stemmed grasses with bulbous roots are common in the turf, the corn is extremely likely to be badly injured if not wholly destroyed by one of the swamp-loving species of this group. If such land is poorly cultivated, allowing these bulb-root grasses to grow up again, the injury may continue for at least another year. If an old timothy sod, either pure or mixed with some other grass, is plowed in spring and planted immediately to corn, this crop is likely to be severely injured by other and smaller species than those which attack the crop in swamps. I have known but one case of any considerable injury by these insects to a field of corn in Illinois except under one of the above conditions.

General Features of Life History.

The explanation of these facts is to be found in the life history of the various species commonest in our region, and in the food and feeding habits of the larvæ. The largest of our bill-bugs breed mainly and naturally in the bulbous roots of two or three large, grass-like swamp plants, sedges, rushes, and the like. The majority of the species of medium size live chiefly in fields of timothy, the larvæ feeding on the root bulbs of that grass; and one or two of the smallest species may feed either on timothy bulbs or on roots of blue-grass in meadows, pastures, and lawns.

So far as I know the bill-bugs pass the winter in the beetle stage, in the ground, under rubbish, or in other protected situations, and all whose life history has been at all closely observed in Illinois make their appearance in spring, chiefly in fields in which they have lived as larvæ and where they have fed on the roots of grasses the preceding year.

As the adult beetles feed in nature on the same plants as their larvæ there is little to tempt them to migrate from one field to another, and the facts lately collected in this state concerning the previous history of badly injured fields clearly indicate that the beetles pass the winter, as a rule, in the same fields in which they passed through their earlier stages, provided that these fields have been undisturbed.

General Preventive Measure.

From this it follows—and experience has amply confirmed the conclusion—that if a field of grass infested by corn bill-bugs be plowed in fall before the time of insect hibernation has begun it will be but lightly infested by them, if at all, the following year. Early fall or summer plowing of grass lands intended for corn is thus an effective measure of prevention against injury to that crop the following year.

Injury to corn by these beetles has now become so frequent and in some cases so severe, and the facts concerning the species are so little known, that a full detail of our present knowledge which bears on the subject in a practical way seems to be particularly desirable.

The Little Brown Bill-bug; the Blue-grass Bill bug.

(*Sphenophorus parvulus* Gyll.)

Sphenophorus parvulus, one of the smallest of the bill-bugs, is essentially an upland species, breeding commonly in the ordinary cultivated grasses, especially in blue-grass and timothy. It is sometimes abundant in city lawns ; it is one of the species responsible for a considerable injury to timothy meadows; and it frequently infests corn following upon the meadow grasses, although, owing to its small size, its injuries to this crop are comparatively slight except while the plant is young.

This little bill-bug is better represented in our collections than any other species, and as we have repeatedly reared it from the larva to the imago in confinement we have a comparatively full knowledge of its life history. On this account it will be convenient to treat it first in this discussion in order that it may be used as a standard of comparison for the species whose life histories are less fully known.

DISCUSSION OF LIFE HISTORY.

Occurrences of the Adult Beetle.—We have forty-one Illinios collections of the adult beetle of this species recorded, extending from March 18 to October, and representing thirteen years between 1882 and 1901. A serial account of these collections, in order of the calendar but disregarding the years, will enable us to trace the species fairly well through the season and to note the variations and transformations of its habits and its food.

Our earliest collection was made March 18, 1882, at Kappa, in Woodford county, where living beetles were found among dead leaves in woodlands, evidently still in hibernation. Next, April 7, 1897, it was collected at Urbana on blue-grass sod under boards lying where they had been placed as an attraction to cutworms seeking shelter by night. On this same date in 1882 it was obtained in a woodland lot south of Bloomington. April 14, 1897, it was collected under boards on grass at Normal, and April 16, 1887, at Edgewood, in Effingham county, in a badly damaged old timothy meadow. It was here hidden on the ground under dead vegetation, and was apparently still in its hibernation quarters. Occasional bulbs of this timothy had been hollowed out the year before in the manner characteristic of the work of *Sphenophorus* larvæ, but this injury was comparatively insignificant.

On April 17, 1894, it occurred at Urbana in a tuft of volunteer wheat, apparently having left its winter quarters at this time and resorted to the growing wheat for food. April 19, 1887, a single specimen was found under a fence rail lying on the grass, the head of it covered with mites (*Gamasidæ*) of the kind which frequently infest old beetles. This specimen was certainly not fresh, but must have hibernated as an adult. On the 24th and 25th of April, 1884, it was obtained in the course of miscellaneous entomological collections at Normal and Bloomington, in McLean county; and again on the 30th of the same month and year, in sweeping blue-grass at Normal with the insect net. In this last case, again, it had apparently begun to feed. May 4, 1892, it was brought in at Urbana from under boards, and May 6, 1887, was found at the same place on grass.

Our earliest date for an injury to corn is May 15, 1891, reported by S. P. Campbell, of Loami, Sangamon county, Ill. "These beetles," says Mr. Campbell, "insert the proboscis and each leg into the stalk and absorb all the sap, leaving small holes in the plant, weakening it very much." This injury seemed to be general in Mr. Campbell's neighborhood, as he says that "considerable interest is taken in the matter," and that "an answer to my inquiries will gratify many."

May 19, 1887, it was found at Champaign doing a very considerable injury to corn on sod. A single specimen was taken just below the surface of the soil with the beak inserted in the stalk. At Jerseyville on the 20th of May, 1891, another specimen was taken from about an inch below the surface on a stalk of corn three or four inches high, which it had injured sufficiently to cause the leaves to wilt. At Champaign May 21 and 22, 1888, it was obtained from corn plants in a field which had lately been plowed from grass. As these beetles had often been said to suck the sap of the stalks they pierce, one of these specimens was dissected to determine the nature of its food, and this was found to consist of bits of the characteristic epidermis of grass-like plants and of parallel-veined vegetation containing spiral vessels—evidence, of course, that its injuries to corn are done by biting and swallowing the substance of the plant and not by sucking the sap. This specimen was a female, well filled with fully matured eggs.

On the 24th of May, 1897, at Union Grove, Whiteside county, it was found very abundant on corn below the surface; and at Urbana, May 24, 1889, a specimen was taken from a stem of grass which it had punctured through the sheath of the second leaf from the ground. May 25, 1901, at Knoxville, in Knox county, several specimens were taken from corn growing in sod. The beetle was doing a rather serious injury throughout the field. On the 26th of May, 1885, one was taken with its beak thrust into a stalk of young corn about three inches high, the puncture being made an inch above the ground. The beetle was so engrossed with its feeding that it remained attached after the corn was pulled up and until it was forcibly picked away. On the 27th of May, 1887, a specimen was found under a board on the grass, and on the same day of the month in 1901 another was taken from young corn at Oneida, in Knox county. On the 28th of May, 1901, specimens were brought in as injuring young corn at Buda, Bureau county, and also on the 31st of that month in 1887 at Rankin, in Vermilion county.

June 7, 1884, a beetle was taken near Du Quoin with its snout inserted in a stalk of wheat close to the ground. June, 8, 14, and 16, 1882, it occurred in miscellaneous collections in McLean county; and on the 28th of June, 1900, it was seen at Griggsville, Illinois, feeding on a corn plant eighteen inches high. It was at the surface of the ground with its beak thrust far into the stalk. At the same place on the next day it was taken from timothy, many of the plants at this time being infested by the larvæ of this species. July 1 to 10, 1883, it was collected at Normal, Illinois, and on the 19th and 21st of July, 1891, it was obtained at Urbana. On the 30th of July, 1900, it appeared in a breeding-cage, reared from larvæ which had been taken in timothy bulbs at Griggsville June 26. The transformations of this lot of larvæ were not yet complete July 30, the earth containing on this date eight beetles, one pupa, and four larvæ—all alive. In August, 1892, it appeared in a breeding-cage of Professor Webster, in Ohio, bred from larvæ of that year. September 20, 1893, a specimen was found on the ground in a corn field near Urbana; and on the 24th of September, 1885, one was seen in a breeding-cage which had been stocked with larvæ from timothy bulbs at Normal July 13. The date of transformation is unknown as this breeding-cage had been neglected, no examination having been made since August 3.

September 25, 1882, a specimen was taken at Elmira, in Stark county, in the course of general collections of insects on corn. In October, 1882, it was found at Normal, the conditions not being recorded; and on the 5th of October, 1885, it was taken from a breeding-cage of timothy larvæ established July 13, but which had not been previously disturbed since August 11.

From these data it is plain that this bill-bug hibernates as a beetle in ordinary situations; that on coming out from its winter quarters it takes its first food from blue-grass, young wheat, and similar vegetation; that it transfers its attentions to corn with the first appearance of the plants, affecting that crop most generally and injuriously on timothy or blue-grass sod; that it may continue to feed on corn as late as the latter part of June, even when the plant is eighteen inches high, but that it distributes its attentions also over the grasses and grains; and that the beetles of the new generation—which begin to appear as early as August—emerge, at least in part, from their subterranean cells, and secrete themselves for hibernation as reported above.

Occurrences of Immature Stages.—Larvæ of *S. parvulus* have been noted in the course of our work at various dates from June 11 to October 22, the last a single instance of what was perhaps delayed pupation in a neglected breeding-cage. The intermediate dates are June 13, 16, 26, 27, and 28, July 4, 13, 21, and 30, and August 10. The larva taken at this last date was boring the crown of a timothy bulb on the grounds of the Experiment Station at Urbana. It was transferred to a breeding-cage, where it remained without special attention until October 22, at which time it was still feeding on the timothy. All our specimens have been taken from the root bulbs of timothy, but the larva is reported by Webster ('93) to occur occasionally in wheat, and by Bruner ('92) sometimes to infest blue-grass lawns in sufficient numbers to kill large patches of sod.

Pupæ have occurred in the course of our work on July 24 and 30, but eggs have not been seen by us at all. Webster ('92) observed oviposition as late as July 1, and inferred that the eggs are mainly laid late in May and in June.

I find in these data no definite indication of more than a single brood, unless the facts reported concerning the larva brought in

August 10 should be so interpreted. It seems to me more likely, however, that this was a belated member of the same brood as the other larvæ reared by us, and that its pupation was retarded by neglect. Our failure to find pupæ except in the middle of the season is negative evidence of the absence of a second brood. It is of course true, on the other hand, that in the absence of numerous continuous experiments in the breeding of separate individuals, no final statement can be made with respect to the number of generations.

Briefly stated, as now understood, the life history is substantially as follows: Hibernating in the imago, the beetle lays the eggs in early summer, beginning probably in May; larvæ hatch in June and doubtless for some weeks thereafter; pupation begins in July, and the final transformations to the adult, beginning late in that month, continue into August and possibly for some time thereafter.

INSTANCES OF INJURY TO CORN.

The most definite and serious case of the destruction of corn by this beetle which has come to my knowledge was reported to me by Mr Dalbey, of Taylorville, late in June, 1902.

A visit to this place made June 30 by Mr. E. S. G. Titus showed that in a field of forty acres the injury was decidedly unequal but still very general. In one part of the field nearly every stalk on several acres had been injured, while in other parts the damage varied from twenty-five to fifty per cent. of the plants. This field had been in timothy for the four preceding years, and was broken up in April, 1902, and planted almost at once to corn.

Some twenty timothy fields in this neighborhood were carefully examined, and the root bulbs in all were more or less infested by the larvæ of this bill-bug. Fields two years in timothy after corn or wheat showed ten to twenty per cent. of the plants infested, while in those three and four years old from fifty to seventy-five per cent. were more or less injured, and contained larvæ varying in size from medium to apparently full grown.

A second field of corn on timothy sod, plowed early last fall and planted at the same time as the one first mentioned, contained not a trace of bill-bug injury, although dead timothy bulbs still in the ground showed distinctly that they had been hollowed out by bill-bug larvæ. The contrast between these two fields of corn growing on old timothy sod infested with the larvæ of *Sphenophorus* the previous year, one of the fields having been plowed in April and the other in early fall, was particularly significant, and amounted, in fact, to a demonstration of the preventive effect of the fall plowing of such lands.

Sphenophorus placidus Say.

This species has been several times taken on corn in Illinois, but the most notable instance of its injuries to that crop was given me by Mr. Joseph Carter, of Rankin, Vermilion county. In a letter dated May 1, 1887, he incloses a specimen of this beetle with the statement that he found it below the surface of the ground eating into a corn plant, and that where the injured leaf appears above ground it is crossed by parallel rows of holes. He finds the beetles, he says, on every plant on an acre or two of corn, and in a letter of June 5 he adds that the beetle is destroying some five or ten acres in an eighty-acre field. The corn in this field was planted on fall plowing after oats. The ground was dry and sandy and tiled every hundred feet. Subsequently I learned that this eighty lay adjacent to an old and run-down meadow of timothy with a little redtop intermixed, and that the injured patch of corn was near this meadow. It is to be inferred from this statement that the bill-bugs had scattered out from this field of timothy to the adjacent corn in search of food.

The life history of this species is not definitely known, its immature stages never having been distinguished so far as my information goes. Our earliest collection of the beetles was made April 8, 1892, from overflowed land on a creek bottom near Urbana—evidently a hibernating specimen. The next date of its occurrence is May 21, 1888, in lately plowed sod near Champaign ; and the next, May 31, 1887, as given above. June 1, 1895, it was found injuring corn in Leroy, in McLean county ; June 5, 1887, it was still at work in the field at Rankin ; June 14, 1882, it was taken at Normal in miscellaneous collections ; June 19, at Spring Valley, from young corn ; June 30, 1888, from driftwood in a small creek near Urbana after a flooding storm ; and July 7 of the same year, from corn at Bement, Ill., where it was doing considerable injury. June 19, 1902, it came to us from northern Illinois near Savanna ; June 20, 1888, from corn fields in Whiteside county ; and August 5, 1887, from Fourth Lake, in northern Illinois, where it was taken from bulrushes along shore. So far as our data go they indicate a life history similar to that of the better-known species ; hibernation in the imago ; and an early attack on corn, with probably a midsummer breeding period of a single generation.

The Clay-colored Bill-bug.

(*Sphenophorus ochreus* Lec.)

Injury to Corn in Ford County, 1888.—My first knowledge of the habits and life history of this species began with a letter written June 21, 1888, by Mr. J. A. Montelius, of Piper City, Ford county, to Professor G. E. Morrow, Dean of the College of Agriculture at the University of Illinois. In this letter, which was accompanied by four specimens of *S. ochreus*, Mr. Montelius reported that these beetles were destroying the corn on new ground in his locality by eating into the stalk and boring to the heart of it with the effect to kill the plant. They were present in great numbers, and had destroyed a large part of the crop—some of it several plantings in succession on the same land.

Visiting these fields on the 23d of June, 1888, I found them in a swamp area which had been recently drained by a large ditch. Some of these fields had been broken up and cropped the preceding year, but most of them were planted for the first time in 1888. On the farm of Mr. Montelius, six miles north of Piper City, a field of twenty-five acres had been once destroyed, and the second planting was so badly damaged that the crop had been abandoned and the ground was being sown to millet at the time.

The injury consisted of long slit-like punctures of the stalk, beneath which the interior leaves and the stalk itself—that is to say, all the more succulent and softer parts of the plant—were irregularly but often completely eaten out. In the worst cases the plant was killed; or, if the injury was less severe, the leaves were finally marked with more or less regular oblong holes extending lengthwise of the blade but forming rows across it.

The injury thus done varied in position from a little below the surface of the ground to the middle or upper two thirds of the larger leaves. The beetles were often seen at work on young stalks, head downward, with the beak inserted its full length. They were always on the lower part of the plant from an inch above the ground to a little below it, and as many as three of them were sometimes seen on a single stalk. They were not easily alarmed, but the plant might even be cut away, if care were used, without disturbing them. Although they clung closely to the plant, they could readily be picked off by the fingers; and when thus disturbed they would feign death for a little time.

The damage in this field was heaviest near the drainage ditch, where nearly every hill was badly eaten. This ground had been broken from swamp sod that spring, and the injury was slight except where two coarse grass-like plants were abundant, the common reed, *Phragmites communis*, and the club-rush, *Scirpus fluviatilis*. An examination of these plants showed an injury to both which was precisely similar to that done to corn, but affected the wild grasses much less seriously than the cultivated plant. The injury to the reed had apparently ceased, but the club-rush in unbroken sod adjacent was still infested, the beetles being there found at the upper part of the plant piercing the terminal row of leaves and eating out the interior as in corn. None were on these wild plants growing in the plowed fields, the beetles apparently preferring the corn as food.

In a field separated from the foregoing by two or three rods of sod, and bearing now its second crop of corn, no appreciable damage had been done by these beetles, and here the reeds and rushes were wanting, having been completely killed by the second year of cultivation.

The sexes were pairing at this time, but no eggs were discovered by a careful search of punctures and excavations in all kinds of injured plants.

On another farm, occupied by Mr. Dennis, a field of fifteen acres of corn was even more seriously injured. This also had been broken up the same spring, and the reeds and rushes were very abundant in the lower ground, growing up through the sod. In such situations the corn had been completely destroyed, although replanted several times.

In still another field, two miles away, belonging to Mr. Sullivan, which had been broken from sod that spring, no damage by bill-bugs had been done, but in this field, which had been used as a pasture for several years, neither reeds nor rushes had grown.

July 27, 1888, these same farms were visited by an assistant of the office, Mr. John Marten, who found the bill-bugs still present in small numbers and injury still in progress, although evidences of fresh work were few.

In a field of a hundred and fourteen acres, belonging to Mr. Dennis, eighty acres had been sown to millet after the destruction of the corn, a pulverizer being used to prepare the ground. Here the millet had been considerably injured — the lower part of the stem punctured by the beetle and cut off with the effect to kill the plant. In parts of the field the damage thus done amounted to eighty per cent. of the yield, although the plants had rallied to some extent by throwing out new shoots from the root. Even the fox-tail grass (*Setaria*) had been similarly attacked to a small extent, and with the same result.

On the next day, July 28, a visit was made to a field of swamp land which was then being broken up for the first time. Many of the bulbs of the rushes were cut in two by the plow, and more than half of these had been excavated by the larvæ of the bill-bugs, two of which were brought to the office alive. A considerable number of adult *S. ochreus* were crawling in the furrows and over the fresh sod, and one dead bulb was found with the remains of an adult in the burrow.

Experiment with Bill-bugs on Corn.—July 3 a lot of these beetles from Piper City, sent from there June 29, were placed on hills of corn growing under large frames covered with wire gauze, the bases of which were sunk four inches in the earth. By July 5 several of these beetles had begun to feed, and on the 14th the corn was already badly eaten. On the 17th a stalk of this damaged corn was removed and critically examined, but no eggs were found. All the beetles were still alive except one male. The injuries to the corn were at this time numerous and severe, but the plants seemed rapidly growing away from them, and the beetles had moved from the base of the stalk, which had doubtless become too hard for their jaws, to the terminal leaves and other growing structures, including the young ears an inch to an inch and a half in length. The young husks had been perforated and the ears were excavated lengthwise, practically destroying them. Tassels and terminal leaves showed great recent injury, and the sheaths of leaves near the deeper punctures and excavations of the stem had often been gnawed into but not far enough to go through the sheath, the beetles having apparently found the tissues here too tough. On the 24th additional search was made for eggs on several stalks which were taken out of the earth for the purpose, but without success; neither eggs nor trace of breeding operations could be found in or about any part of the plant. The usual punctures and slits were abundant about the base of the stem, with some small discolored excavations also, but nothing else.

September 10 the remaining contents of this cage were finally overhauled, but neither live beetles, eggs, nor larvæ were found. The stalks, roots, leaves, ears, and tassels had been much injured, the tassel and the upper part of the stalk perhaps most seriously so.

The method of feeding was carefully observed by both Mr. Marten and myself. Placing itself head downward, with its stout legs embracing and firmly grasping the stalk, the beetle applies the tip of its beak straight against the surface, cutting the outer tissue with the mandibles, the action of which is distinctly audible. Gradually, with an occasional twisting motion of the head, it sinks two thirds or more of its snout into the stalk, and then, slightly rolling its head from side to side with clock-like regularity, it uses its beak as a lever to split the stalk and pry the edges of the slit apart. It pauses from time to time to eat out the soft tissues within, and by moving forward and backward and twisting to the right and left it often hollows out an interior cavity much larger than the surface injury would indicate. Then pulling the head strongly backward with the compressed beak inserted, the stalk is split upward as a boy would split a stick with a knife. In this way a slit an inch long may be made in the stalk of corn, beneath which all the softer parts have been eaten out.

Injuries in 1889.—The following year, 1889, similar and equally serious injuries were done by this beetle in the Piper City district, according to a letter received from Mr. Montelius under date of May 21. At that time forty acres of corn belonging to Mr. Towers had already been destroyed, while on the place occupied by Mr. Dennis the injury done was apparently fully as great as that of the preceding year.

A letter recently received from Mr. Montelius, dated August 8, 1902, reports that injuries by the swamp-land bill-bugs ceased with the second year, and that nothing has been seen of them during the thirteen years since. The temporary nature of their attack on newly subjugated swamp-lands is thus definitely proven.

Observations on Life History.—Other occupations made it impossible to return to this place, but late in the season the life history of the species was taken up at Urbana by observations in a swampy field where the club-rush was common.

July 2, nine specimens, two of which were copulating, were found in a large sedge, *Cyperus strigosus*, at the margins of a pond near Urbana. July 16, two eggs and larvæ which proved later to be those of this species were discovered by Mr. Marten behind the leaf sheaths and in stems of *S. fluviatilis.* Both were placed from two to four inches above the bulb, the eggs in the softer part of the stalk just inside the hard woody outer layer. One larva brought in on this day had already burrowed irregularly downward for about three inches from the place of its hatching. The following day two more eggs and another larva were found similarly placed. On the 22d of July one of these eggs had hatched and the larva from it had burrowed downward within the stem, and on the 23d two more eggs had hatched. Unfortunately no further progress was made with these specimens, both plant and larvæ having died by August 20.

July 22, three more larvæ of this bill-bug were found at Urbana in the club-rush, and August 1 several more of various sizes, from those recently hatched to one four tenths of an inch in length. One egg was also found on this same day. Two of the larvæ were in one stem. August 14, three more larvæ were brought in, practically full grown. One had burrowed completely through a small bulb of the club-rush, the channel through the bulb being continuous with that in the stalk. August 20, three other full-grown larvæ were obtained from the same swampy field, and all had burrowed downward from the place of deposit of the egg to the bulb, a distance of about three inches, and had passed out of this into a bulb of last year's growth, in which they were imbedded at the time. The plant first attacked was killed in every case. September 10 one of these bulbs was opened and a pupa found within, and on the 16th of September the pupal cavity contained an adult *S. ochreus*. On the 17th of September another beetle of this species was taken from a second of these bulbs. Three specimens were brought in August 28 in essentially the same condition as those collected August 20; that is, in each case, young larvæ hatching from the egg had burrowed downward through three or four inches of the stem and to the young bulb at its base, and had passed from this into that of last year's growth, traversing a quarter of an inch or so of earth to reach the older bulb.

Injuries in Whiteside, Adams, and Schuyler Counties.—A case similar to the foregoing, also from a district recently drained, was reported to me June 25, 1895, by M. D. John, of the "Sterling Evening Gazette," in Whiteside county. According to his statement whole fields of corn were almost completely destroyed in the vicinity of Deer Grove, sixteen miles south of Sterling, by the clay-colored bill-bug (*Sphenophorus ochreus*) together with a black species of similar size, in all probability *S. pertinax*. These bill-bugs, he says, seem to be at home in the water as well as on land. Two or three thousand acres of corn along Green River were reported to have been destroyed at this time, and most of the farmers were replanting so-called ninety-day corn, hoping still to secure a crop.

The next report of serious injury to corn by this species which has reached me came by letter dated May 24, 1901, from H. D. Hill, of Lima, Adams county, Ill., who sent a specimen of this beetle with the statement that it was destroying the young corn on his farm on bottom-lands which were originally overflowed, but which had been reclaimed and cultivated for about twelve years.

Another letter of June 25, 1902, from Rushville, Ill., written by H. E. McLaren, reports these beetles as present in the bottom-lands of a drainage district about the 24th of May, or as soon as the corn was large enough to afford them food. They made their appearance, he says, in new ground the previous year, but were still more numerous and destructive in 1902.

Extraordinary Injury to Corn in Greene County.—Under date of May 28, 1902, I received the following letter from John C. Bridgewater, of Bridgewater, Greene county, Ill.:

"I am sending you to-day about three hundred bugs which we call elephant bugs. We give them this name because of their color, the enormous size as compared with that of other pests in this section, and the trunk or bill. Their destructiveness is unparalleled, as you may judge for yourself when I say that farmers are paying five cents a dozen for them and the boys are bringing them in by the thousand. More than ten thousand have been captured and put to death in less than two days on the Hartwell ranch alone, the foreman paying five cents a dozen for every one of them. On Saturday last he was looking over the ranch and thought that he had one eighty-acre field of corn secure, but on the Tuesday following there was not enough left to plow.

"The bugs will lock their legs around a stalk of corn and run their trunk right through it as if it were a spike driven through a pine board.

"It is costing us hundreds of dollars as tribute to bug-hunting expeditions, plowing our land over and replanting where a week ago we had as good a stand as heart could wish."

Mr. Bridgewater also gives an amusing account of contests between his "elephant bugs" and young chickens, and on this point his statements are corroborated by a letter from another correspondent received in June, 1900, and accompanied by a specimen. In both cases chickens had undertaken to devour these beetles, but the latter had saved themselves by clasping their legs around the beak of the bird, and holding on so vigorously as to make it impossible for the chicken to open its mouth.

The box of beetles accompanying Mr. Bridgewater's letter were mainly *S. ochreus*, although a few *S. pertinax* were among the lot.*

In consequence of this letter I sent Mr. E. S. G. Titus to Bridgewater early in June to study the outbreak there, and again early in July. He spent the 11th and 12th of June on the Hartwell ranch, which is situated on the Illinois River at the mouth of Hurricane Creek, seven miles west of Roodhouse, in Greene county.

*See also the discussion of *S. pertinax* in the present article.

This ranch contains five thousand acres, mostly bottom-lands redeemed for cultivation by changing the course of Hurricane Creek, building eleven miles of levee, and excavating drainage ditches. One of these ditches, twenty-five feet wide and six feet deep, drains a large bottom-land lake, the bed of which forms a considerable part of the property. About 4,500 acres of this tract had been broken up, much of it in the spring of 1902, and 2,500 acres were planted to corn this year. The 500 acres not under cultivation comprise swamp-lands still unbroken, bluff-lands mainly covered with trees, and the eleven miles of ditch which drains the ranch.

Several hundred acres of the corn on this place were more or less infested, and in some of the fields the first planting was completely ruined and the second also badly eaten. Plants attacked by *S. ochreus* were usually killed, the effect of the work of *pertinax*, a smaller species, being rather to dwarf and distort the growth than to kill the plant outright.

On one ten-acre piece of corn which the manager wished especially to save, the beetles had been picked off by boys at a cost of from three to five cents a dozen, and 10,400 were brought in. In badly infested fields from one to five beetles were found on every stalk of corn. Careful search of several hundred plants failed to discover any eggs in the stalks or about the roots.

An observation of special interest was made at this place with respect to the effect of fall plowing. Owing to a temporary lack of employment for the teams on this plantation a piece of sod had been broken up the preceding fall, the remainder of the tract lying unbroken until the following spring. On this fall-plowed land, which was merely a part of an undivided field, the only injured corn was in the first two or three rows adjoining the land plowed in spring, and the harm done here was evidently due to bill-bugs which had come in from the adjacent ground.

The commonest plant on the unplowed lands was the club-rush (*Scirpus*), and this often grows in considerable quantity on cultivated land that has been broken only a year. Eggs and young larvæ, evidently those of *Sphenophorus ochreus*, were found in the bulbs of these rushes June 12, and the females were still heavy with fully developed eggs.

July 3, when this place was visited again, larvæ were still common in the bulbs, owing no doubt to continued hatching, and the average size was little if any greater than at the previous visit. Beetles also were still abundant, and as much of the corn land was now overflowed,—owing to extraordinary high water in the Illinois River,—most of the bill-bugs had been driven to the higher and drier ground. Many of them, however, were still on the rushes and on corn under water, apparently little disturbed by their submersion.

Such of the second planting of corn as had survived the bill-bug injury was in bad condition—dwarfed and much deformed in growth. One field which had been planted the third time was already practically destroyed, and the bill-bugs were still present on the corn. The crop on the field plowed in fall was in excellent condition, but considerable damage had been done in some fields which had been broken up from sod in the spring of 1901 and plowed for corn again this spring. Their condition was evidently due to insufficient cultivation last year, many rushes being left to grow with the crop. This of course kept the bill-bugs in the fields and enabled them to breed there last year.

From the general condition of this region it is to be inferred that fall plowing for two successive years with clean cultivation of the crop will afford substantially complete protection against this bill-bug injury, except as the beetles from adjacent unbroken ground may occasionally enter a corn field in search of food.

Summary of the Life History.—Our earliest collections of this beetle were made on the 21st of May, at which time the sexes were seen *in copulo*. It has been taken by us in swamps and corn fields at many later dates up to July 27, although by the 17th of that month it had practically disappeared from the corn.

Eggs were found by us June 11, but as young larvæ were present at the same time oviposition must have begun as early as the first of June. Indeed, Webster has found the eggs in Indiana late in May.* Other eggs have occurred in the course of our work, either in the field or in breeding experiments, July 4, 16, 17, 22, 23, and 30, and also August 1, thus covering an interval of about two months.

The growth of the larvæ seems to be rather slow, none of those observed by us having reached full size before the 20th of July. Other examples of the larval stage were found at intervals to August 28; and in Webster's experiments, to August 30.*

Pupæ were taken from our breeding-cages September 10; and in Webster's observations, from August 21 to 30. Imagos from our September pupæ were observed September 16 and 17, and as our experimental work was done in the open air, the plants being protected only by wire screens, no acceleration of the transformations could have taken place. Webster ('90) found adults, to-

* Webster, F. M., 1890.

gether with larvæ and pupæ, from August 21 to 30. Our collections contain no specimens of this species taken later in the year, but as no search of suitable situations has been made in localities where this bill-bug is abundant this negative evidence has no special value. It seems probable that the species is single-brooded, with a long breeding period extending through about four months, and that hibernation occurs mainly, if not altogether, in the imago stage. There is, however, nothing definite to show that the beetles emerge from their underground quarters before the spring of the following year. As other species of bill-bugs more abundant in ordinary situations but having apparently a similar life history do occur abroad in fall, it is likely that *Sphenophorus ochreus* will be found to have a similar habit.

Descriptive Notes.—A description of what was doubtless the full-grown larva of *Sphenophorus ochreus* was published by me in the Sixteenth Report of this office, page 56, but some descriptive notes made from a living half-grown specimen July 15 may assist in identification.

Length, extended in crawling, 6 mm. Head light mahogany-color, with mouth parts dark brown, almost black. First segment behind the head tinged with brown, deepest in the middle. Body thickest just back of the middle, and sloping somewhat abruptly to the tip of the abdomen, which is provided with a circlet of weak brownish bristles; the two preceding segments with similar but weaker bristles. Lateral folds, extending from the head to the tip of the abdomen, are quite distinct. The color of the skin is dirty white, and sufficiently translucent to show the brownish internal organs.

The egg of *Sphenophorus ochreus* is 3 mm. long and about half as wide, swelling somewhat after it is laid. It is at first decidedly curved, but later assumes an oval form. Color opaque white, with a faint creamy tinge. Shell transparent, shining, smooth.

SPHENOPHORUS PERTINAX OLIV.

This beetle is evidently a lowland or swamp species in great part, often breeding, like the clay-colored bill-bug, in the stems and bulbous roots of coarse semiaquatic vegetation. Dr. Kellicott reared it repeatedly to the imago several years ago in July and August from larvæ and pupæ found in New York in the common cat-tail flag, *Typha latifolia.* "The larva cuts an oblique burrow near the base of the plant, and pupates in the same.*" Dr. John

* Letter, December 3, 1888.

Hamilton has found it common in the salt marshes of New Jersey, and believes that it breeds in grasses daily wet by the tide.

In Illinois it has been most frequently collected in swampy regions or along the borders of lakes, and in corn fields has been most abundant on lands recently drained, associated there with the clay-colored bill-bug. Our Illinois collections were all made in the central and northern parts of the state, and range from April to August of several years.

The injury to corn is similar to that of the clay-colored species, but less severe owing to the smaller size of the beetle. The plant injured by *pertinax* is less frequently killed outright, but is commonly dwarfed, often becomes badly twisted as it grows, and rarely forms an ear. The beetle attacks the corn plant at the crown below the surface, and is usually nearly or quite buried in the earth. At Bridgewater, Ill., in 1902 it was about as common on corn as the larger species, but was frequently overlooked because partially concealed by its mode of feeding. In swamps it has been found on young rushes just beneath the surface, making holes in the ground like minute gopher holes to get at its food.

Parrott ('99) reports it as destructive to corn in Nebraska, the injured stalks failing to produce ears. The beetles were still at work on the corn plant July 27, and when not eating were to be found in underground burrows. In this article, published in the "Kansas Farmer" for May 11, 1899, he says that the eggs of *pertinax* were deposited June 24 to 26 in burrows about an inch under ground and touching the roots of the corn, and that these eggs were hatching July 18. His experiments satisfied him that it thrives equally well in a blue-grass sod. He assumes that it hibernates in the pupa, the evidence on that point being the receipt of specimens early in May, 1898, some of which had the peculiar pinkish color characteristic of beetles just from the pupa.*

The life history of this species seems thus not to differ materially from those of the others treated in this paper, although our data are too scanty for satisfactory generalization. Parrott's statement with regard to the breeding of the species in corn, based as it seems to be on experimental data, is of special interest, since we have no other observation of a northern species laying its eggs on the corn plant. It will be noticed that in this case the beetles were under confinement, and that no positive inference can be made as to their choice of plants for breeding in the field.

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*Letter of July 29, 1902.

SPHENOPHORUS CARIOSUS OLIV.

This bill-bug, though not common in our collections, has been taken by us in central and southern Illinois from Pekin to Cairo. It is primarily a southern species, abundant in the Gulf States and injurious to corn in South Carolina. Through the kindness of Mr. B. F. Johnson, of Champaign, I received in June, 1888, fifty living specimens of it from that state, with the information that it was there very destructive to young corn. Some of these beetles laid eggs in captivity June 4.

In Illinois it has been taken but once on corn so far as I am aware. May 1, 1891, Mr. John Marten, an assistant in my office, found a specimen of it in Urbana at the base of a very young plant, where it had gnawed a cavity in the stalk just below the surface of the ground, and kept over night in a breeding-cage it left the stalk and made its way into the seed kernel.

The imago has been found by us at various dates from April 23 to September 16. The earliest specimens, collected at Champaign April 23, 1892, were under boards and driftwood on wet ground. May 1, 1891, a single beetle was taken on very young corn at Urbana; June 30, 1888, it was obtained from a deposit of driftwood beside a creek; and July 9 of the same year, from a similar situation after a flooding rain. July 26, 1892, it was brought in from Savanna, in northern Illinois, among collections made in the Mississippi bottom; and August 16, 1891, it was found on the bank of the Ohio River near Metropolis. On the 23d of August, 1899, a number of these beetles, recently transformed, were found at Urbana, still in their underground pupal cells at the base of stalks of *Cyperus strigosus*; and, finally, September 16, 1879, it was obtained in the course of general entomological collecting from the bottoms of the Ohio River opposite Cairo, Ill. It seems thus to be essentially a lowland species, and probably breeds, like *S. ochreus*, in coarse grasses and similar vegetation of swamps and bottom-lands.

My knowledge of the life history of the species is based mainly on Mr. Marten's observations in 1889. On the 25th of July, 1889, four larvæ which proved to be those of this species were found in the stems of a large sedge (*Cyperus strigosus*) growing in a corn field near Champaign. The larvæ were just at the crown of the bulb, which they had almost completely excavated, the largest of them having, in fact, entirely cut off the stem, and lying in a cavity formed by the bases of the leaf sheaths.

On the 29th of July others were found in the same situation apparently very nearly full grown, together with some quite young which were just commencing to burrow the stalks. No evidence could be found that they passed from one stalk to another, but each apparently got its growth within a single plant. August 8 nearly all the larvæ in this field were about full grown, but no pupæ were detected; and eight days later all had apparently gained their growth, but again no pupæ were found. In several plants empty excavations were seen, and August 20 pupæ were detected at the base of the stem and in the small root bulb. They were too large for the larval cavity, which had been opened out by eating away one side, the pupal cell being completed by gnawed chips and excrement closely packed. On August 23d larvæ of various ages, together with pupæ and adults of this beetle still in their pupal cells, were brought in by Mr. Marten from stalks of *C. strigosus* in this same field. Sometimes the pupal cells were found among the fibrous roots of the plant quite outside the cavity formed by the larva in the stem, the walls of the cell being then formed of compact earth often intermingled with chips from the stem. On the 26th of August larvæ of all ages were obtained, some of them scarcely twice as large as when first hatched, and others fully prepared for pupation. Pupæ and adults were likewise found, the latter still in their underground cells which, in some cases, were still contained within the stem of the sedge, the fragments of the plant having been tightly packed together to make a compact case, so smooth within as to suggest that it had been lined by a larval secretion.

September 6, half-grown and full-sized larvæ, together with pupæ in various stages of advancement, were still to be found, and also eggs, apparently of this beetle, placed in the lower part of the outer sheath or inserted into that and the second leaf also. Small round holes were seen in the ground from which adults had apparently emerged.

From these observations it is to be inferred that the breeding period of this species is very long, the eggs being laid at intervals through many weeks. The largest larva noticed July 25 could not have hatched from the egg later than the middle of that month, and the very young of August 26 could have been at most but a few days old. Pupation and the formation of the adult by August 23 and the subsequent disappearance of imagos from the ground, together with their occurrence in the field as late as September 16, warrant us in assuming the hibernation of the imago, although it is of course possible that some observed as larvæ may have hibernated in the pupa stage. There is no evidence in these data for more than a single generation of this species in our latitude.

Description of Larva.—Head pale yellowish brown, darkened toward mouth parts, mandibles black, other mouth parts brown, body white except cervical shield, which is slightly embrowned, paler than head; spiracles pale brown, first very large, remaining eight small but gradually larger from before backward, the last, however, about twice as wide as preceding; sutural grooves very distinct below, where they are cut at the sides by about five or six longitudinal grooves, becoming fainter downwards. Several long soft hairs on head and inferior thoracic region, and some shorter, stouter ones at tip of abdomen; elsewhere, body nearly or quite naked. Form of body short and thick, gradually swollen posteriorly, segments 7–9 being thickest; anal segment with quadrate excavation above, between the last two spiracles. Tubercles beneath thorax broad, low, shining, not especially hairy.

Clypeus membranous; labrum obtusely angled in front, with two spines on the surface at about middle of antero-posterior diameter, about equally distant from each other and from the margins; two similar spines at front angles, and two other marginal ones a short distance within. Two of the inferior spines near the middle of the margin are furcate. Labium largely membranous, palpi two-jointed, basal segment a little longer than wide, terminal one slightly oval, about half as wide as the other. Ligula membranous, densely hairy in front, basal part of maxillæ bisinuate without, bearing two long hairs, one near palpus, the other at basal third; palpus two-jointed, basal joint broader than long, second small, ovate, half as wide as preceding; lobe of maxillæ semi-oval, with about ten dagger-like and furcate spines on terminal edge. Mandibles triangular, almost equilateral, acute and slightly hooked at tip, biting edge with a single triangular median tooth.

Length of larva, 15 mm.; greatest depth, 5 mm.; greatest width, 5 mm.

Additional Species.

Sphenophorus scoparius Horn, found by us but rarely on corn and grass, has occurred in our collections from June 16 to July 7, and from northern to central Illinois.

Sphenophorus sculptilis Uhler, described as *zeæ* in 1867 because of its injuries to corn, has been surprisingly rare in our collections, and has never been taken by us from the corn plant in Illinois. June 7, 1884, specimens were found on blades and heads of timothy at Du Quoin, in southern Illinois, and July 9, 1888, a single one was taken in a flood collection on the bank of a small creek at Urbana. It has appeared in our general collections from Chicago to Villa Ridge in extreme southern Illinois, and on various dates from June 7 to November 26. It is, however, doubtless locally destructive to corn in this state since it has been reported by entomologists as injurious to that crop in Massachusetts, New York, New Jersey, Delaware, Maryland, North Carolina, South Carolina, Florida, Alabama, Pennsylvania, Indiana, Ohio, Missouri, Arkansas, Iowa, and Kansas.

In most cases where definite statements have been made concerning its injuries the fact has been noted that the injured crop was growing on timothy sod.

The larvæ and pupæ have been seen by Hopkins, (W. Va.), who calls this species the timothy bill-bug, and thinks that it is one of the prime causes of the early failure of meadows. He finds the larva from June to September, and pupæ and adults from August to October. In these points of its life history it apparently agrees very well with *Sphenophorus parvulus*.

Sphenophorus robustus Horn occurs in our collections but six times, and in but two of these with a date, one in June and the other July 1. Although an abundant and destructive species in the Southern States and ranging with us to extreme northern Illinois, it is apparently too rare in this state to have any economic significance.

RECENT BIBLIOGRAPHY.

1889.

WEBSTER, F. M.—Life History of one of the Bill-bugs, *Sphenophorus ochreus* Lec. (Insect Life, Nov. 1889, Vol. 2, p, 132.)

Quotes statement of Forbes in 1888 (see '90) concerning injuries to young corn on newly drained swamp lands. Believes serious injury in several situations has been done for several years in Indiana, hundreds of acres being thus destroyed. Beetles hibernate as adults, coming forth in spring, feeding on inner parts of stems of reeds, rushes, and young corn. Eggs laid in or about roots of *Scirpus* late in May and early in June. Larvæ live within the bulbous roots, and beetles appear in August and September. Has reared adults from the egg in *Scirpus* bulbs kept in dry earth from the middle of June until the 25th of August. Infers that larvæ cannot be starved by midsummer plowing.

1890.

FORBES, S. A.—The Corn Bill-bugs (*Sphenophorus* sp.). (16th Rep. State Ent. Ill., for the Years 1887 and 1888, pp. 58–74.)

Contains an analysis of literature concerning each of the species of the genus, with description of the genus *Sphenophorus* and an analytical key to Illinois species; the original description of *S. minimus*; a description of the larvæ of *ochreus* and *parvulus*; and an account of the life histories of species so far as known, of their injuries to corn and other vegetation, of their natural enemies, and of preventive and remedial measures. It is followed by an economic bibliography of sixty-one titles, ranging from 1808 to 1888. The paper is illustrated by twenty heliotype figures of imagos on three plates.

WEBSTER, F. M.—Notes upon some Insects Affecting Corn. (Insect Life, Nov. 1890, Vol. 3, p. 159.)

Reports finding of eggs of *Sphenophorus ochreus* in stems of *Scirpus*, which eggs resemble those obtained from ovaries of females. Concludes that eggs may be deposited in stems of the plant and not always in the root.

1891.

SMITH, J. B.—Notes of the Year in New Jersey. (Insect Life, Oct. 1891, Vol. 4, p. 44.)

Reports appearance of corn bill-bug, *Sphenophorus sculptilis*, in large numbers in three New Jersey counties. Destroyed many acres of corn by drilling holes in young plants at or near the surface of the ground. The second crop, replanted after short delay, was undisturbed. The beetles were most numerous on old sod, but not confined to such land.

MCCARTHY, GERALD.—Some Injurious Insects. (Bull. 78, N. C. Agr. Exper. Station, p. 18.)

Paragraph on troublesome bill-bug or corn curculio, *Sphenophorus zeæ*. Says mature bug bites into young plants near the ground and deposits its eggs in the place bitten, the eggs soon hatching into grubs which burrow into the pith, dwarfing the plant or killing it outright. Characterizes this species as a semi-aquatic insect, and seldom troublesome except upon very wet land. Advises hand-picking, drainage, and thorough cleaning of the fields in fall.

1892.

OSBORN, HERBERT, and GOSSARD, H. A. - Corn Bill-bugs. (Bull. Iowa Agr. Exper. Station, Aug. 1892, No. 18, pp. 507-509.)

Describes injuries to corn and other crops by the clay-colored bill-bug, *Sphenophorus ochreus*, and the little brown bill-bug, *S. parvulus*. Quotes from Webster ('89) and copies his figures of *S. ochreus*. Also quotes from Forbes ('90) with respect to failure of beetles to breed in corn. Advises that bulbous roots of shrubs on recently drained land be examined, and that if larvæ of *S. ochreus* are found the ground be broken as early in summer as possible, preferably before June 1. Quotes Webster's statement ('89) concerning early plowing. Regards *S. parvulus* as likely to become a much more permanent and serious pest than the preceding. Quotes life history from Forbes ('90) and summarizes facts concerning injury to wheat and rye from Webster ('92). Says losses to corn due to this species are often serious, and quotes letter giving description of injuries to field of corn near Massena, Iowa, 1892. Damaged crop was planted on old timothy sod broken up in March. First planting taken almost entirely; second planting, finished June 17, seriously injured but not entirely destroyed. Osborn concludes that the bill-bug had developed in the timothy or perhaps in other grasses near the affected fields. Probably in most cases found largely in the immediate locality where issuing. Regards outlook for preventive measures as by no means encouraging. Suggests, however, that since worse injuries are likely to occur on land previously in grass or adjacent to such land plowing should be done as early in the previous season as possible, and that such ground should be planted late and rather heavy at first. Crop of sod corn might be raised by breaking ground first of June and planting at once.

OSBORN, HERBERT.—Notes on Injurious Insects of 1892. (Insect Life, Nov. 1892, Vol. 5, p. 112.)

Bill-bugs have for the first time caused serious injury in Iowa, *Sphenophorus parvulus* being the most wide-spread and destructive. Seems to have increased rapidly in late years, and threatens to become a very serious pest. *S. ochreus* often seen, but not likely to cause extensive damage in Iowa because of comparative scarcity of swampy land bearing rushes.

BECKWITH, M. H.—The Corn Bill-bug, *Sphenophorus sculptilis*. (5th Ann. Rep. Del. Coll. Agr. Exper. Station, p. 102.)

Describes injuries to corn. Says life history is not known. Supposes that eggs are deposited among the roots of timothy grass, and that the larva feeds upon such roots. Describes injury to corn field in Delaware observed May 20, corn being about three inches high. Experiments with London purple applied to corn, and with poisoned bunches of clover placed between the rows produced no apparent result. Cultivation of corn began May 24, and this seemed to arrest injury June 1. Scarcely any beetles could be found in corn fields, although considerable numbers were seen among the roots of timothy on a field adjoining. Believes that beetles may be driven out of field by cultivation.

WEBSTER, F. M.—Insects which Burrow in the Stems of Wheat. (Bull. 40, Ohio Agr. Exper. Station, p. 72.)

Brief article on *Sphenophorus parvulus*, here called the grain Sphenophorus. Speaks of it as doing a little injury in the larval state to wheat, oats, and barley, also having eaten the bulbous roots of timothy, and puncturing the young roots of corn. Says female lays eggs in or a little above the roots, probably late in May or in June, but oviposition had been observed as late as July 1. Larva feeds within straw until it becomes too large for its burrow, and then passes to the roots, often destroying a whole stool of the grain in this way. Pupates beside the roots, and after two or three weeks transforms to the adult. Has reared these beetles from wheat stubble in August.

BRUNER, LAWRENCE.—Report on Nebraska Insects. (Bull. 22, U. S. Div. Ent., p. 99.)

Discusses *Sphenophorus parvulus* under the name of the blue-grass weevil. Says it has been increasing quite rapidly in numbers, and is one of the commonest beetles in the city of Lincoln, Neb. Feeds on roots of common blue-grass, and in some lawns has killed large patches of sod. Beetles appear in early fall and spring. Thinks the insect is probably double brooded, but says that some of the beetles may come out in fall while the remainder may lie over the winter as pupæ. Found fully mature larvæ early in June and others in October. Damp and well-watered lawns infested as badly as those that are dry, although they do not show the injury so quickly.

SMITH, J. B.—Report of the Entomologist. (12th Ann. Rep. N. J. Agr. Exper. Station, for the Year 1891, pp. 394–395.)

Gives report of correspondents concerning injuries to corn. One says "Very much worse where there is wire-grass or quack-grass." Another says that he hears much complaint of them, confined principally to old mowing-lands. Another says the beetle is commonly known as the timothy bug, as it only seems to be bad after an old timothy sod is turned down; and still another reports it as sometimes very destructive to young corn when planted on timothy sod plowed in spring or late winter. Said also to be very injurious in Chester county, Pa. Injuries reported from May 25 to June 17. Smith says nothing is positively known concerning early stages. Reason to believe that larva lives in timothy sod. Found no eggs in punctured corn plants. Mentions use of arsenical poisons and kerosene, but is skeptical as to their value. Thinks it poor policy to replant only hills killed by the beetles, because these would be killed in turn. Recommends plowing sod for corn in fall and early winter with a view to killing out the insects living in or under the sod.

1893.

SMITH, J. B.—Report of the Entomologist. (13th Ann. Rep. N. J. Agr. Exper. Station, for the Year 1892, p. 390.)

Mentions corn bill-bug as again troublesome in some counties, frequently necessitating the replanting of corn. Injury minimized when fall plowing has been practiced. Period of injury short; replantings generally unharmed.

WEBSTER, F. M.—(Ohio Farmer, July 20, 1893, Vol. 84, p. 57.)

Reports on larva of a *Sphenophorus* sent him by a correspondent who found it in a root of growing wheat. Probably *S. parvulus.* Describes injuries by this insect to wheat and corn. Says field of corn near Jefferson, Ohio, was seriously injured by it in 1893, and refers to other corn-eating species. Says that in wheat fields the eggs, which he figures, are deposited just above the roots, but that the young, after hatching, works its way upward; and that as it gets larger it crawls down and eats its way out of the straw, finishing its growth among the roots. Often eats the underground portion of a whole stool, causing it to wither and die before the kernels have filled. Mentions occurrence in timothy, and says that injuries to corn are usually local and not frequent. Surmises that fall plowing would probably result in the diminution or prevention of the trouble, and suggests planting some other crop than corn where the occurrence of this injury is very probable. In Indiana, rye is used in this connection to advantage.

1894.

OSBORN, HERBERT.—Corn Insects, their Injuries, and how to treat them. (Bull. Iowa Agr. Exper. Station, No. 24, p. 997.)

Says clay-colored bill-bug, *Sphenophorus ochreus*, sometimes causes considerable injury to corn. Refers briefly to this species and to *S. parvulus*, discussed in previous bulletins, and mentions also *S. sculptilis*, which sometimes becomes numerous enough to eat the whole stool to the root. Refers to suggestion that sand saturated with kerosene be placed around each hill. Regards it as of doubtful value. Advises killing corn with kerosene if necessary to destroy the beetles, replanting afterwards, thus arresting their increase.

1895.

WEED, HOWARD EVARTS.—Insects Injurious to Corn. (Bull. Miss. Agr. Exper. Station, Nov. 1895, No. 35, p. 154.)

Brief note on corn bill-bugs, with copied figures. Recommends hand-picking when beetles occur in small numbers, and spraying with Paris green when on the base of the stalk if they are numerous. Says second planting of corn will be but little if at all attacked, and that when sod has been broken up in fall the beetles will do but little damage the following spring.

1898

HOPKINS, A. D.—Some Notes on Observations in West Virginia. (Bull. 17, U. S. Div. Ent., p. 45.)

Refers to *Sphenophorus sculptilis* as the timothy bill-bug, and ascribes to it considerable injury to timothy plants during past three or four years. Thinks it is one of the prime causes of early failure of meadows. Believes permanent injury can be largely prevented by liberal applications of stable manure, tobacco dust, lime, or other suitable fertilizer to the sod immediately after hay harvest. Larvæ of this species occur in June to September, and the pupæ and adults in August to October.

1899.

PARROT, PERCY J.—Bill-bugs on Corn. (Kansas Farmer, May 11, 1899, p. 314.)

Reports *Sphenophorus pertinax* as injurious to corn in Nebraska. Experiments show that it thrives equally well in blue-grass sod. Injured corn often fails to produce ears. Experiments with kerosene are mainly unsuccessful. Advises destruction of infested canes if larvæ are found in the field, rooting up and burning over corn stubble in fall to destroy pupæ, and cultivation of swamp tracts to destroy beetles. Reports deposit of eggs June 14 to 26 in the burrows of beetles about one inch below the surface of the ground and touching the corn. Eggs hatching July 18; beetles still at work July 27. When not eating, the beetles were to be found in burrows under ground, either at the base of the corn or elsewhere.

LUGGER, OTTO.—Beetles (*Coleoptera*) Injurious to our Fruit-producing Plants. (Bull. Univ. Minn. Agr. Exper. Station, Dec. 1899, No. 66, pp. 269 and 301.)

Incidental mention of *S. parvulus* as very numerous in the roots of grasses several years previous in Druid Hill Park, Baltimore, Md. Expelled from sod by application of malodorous manure followed by heavy rain. "The next day immense numbers of beetles (*S. parvulus* Gyll.) could be seen upon all the sidewalks and seats on and about the lawn; they were evidently driven out of the ground by this offensive manure." Quotes Professor Smith concerning injury to corn by bill-bugs. Corn so injured called "Frenchy" in eastern Maryland and in Virginia.

METHODS AND RESULTS OF FIELD INSECTICIDE WORK AGAINST THE SAN JOSE SCALE, 1899–1902.*

On April 11, 1899, an emergency bill was approved by Governor John R. Tanner of Illinois requiring the State Entomologist to "treat and disinfect once thoroughly," at the expense of the State, all orchard property which that officer had reason to believe had become infested with the San Jose scale before the year 1899, a fact which marked a new departure in the struggle for the control of the San Jose scale in Illinois. Unfortunately, the appropriation of $6,000 made for the expenses of this work was insufficient for its purpose, being indeed but half the sum estimated by me as necessary to give a single insecticide treatment to all the premises then known to be infested. This fact put an effectual bar upon preliminary experiments with insecticides, since it was evidently my duty to apply the appropriation at once and as far as it would go to the immediate purpose expressed in the law, that of a thorough insecticide treatment of infested premises.

Being thus limited to action on lines fixed by the existing state of our knowledge of insecticide methods, it was my first duty to make choice of the procedure which seemed most likely to enable me to exterminate the scale locally by a single treatment. This choice necessarily lay between liquid and gaseous insecticides, applied by spraying and by fumigation respectively.

The liquid insecticides well enough known at the time to make them practically available for the destruction of the San Jose scale were the whale-oil soap solution and the emulsions or mechanical mixtures of kerosene and water. Crude petroleum was then coming into use, it is true, but the results reported were too variable to entitle it to confidence as both efficient and safe. To extermin-

*This article was originally published as Bulletin No. 80 of the State Agricultural Experiment Station, under date of October, 1902.

ate the scale in orchards with a liquid insecticide required that the fluid should be so distributed as to reach every scale on every tree in quantity sufficient to kill the insect. This was obviously an impossible task, especially if we take into account the frequency with which these minute scales are secreted under bark, behind buds, etc.; and this conclusion was confirmed by two years of previous experience with the use of whale-oil soap, during which orchards and town lots at twenty-one localities in Illinois had been carefully and thoroughly treated by two of my assistants, Prof. H. E. Summers, now State Entomologist of Iowa, and Mr. R. W. Braucher, a graduate in horticulture from the University of Illinois. Subsequent inspections of the premises treated disclosed the fact that the extermination of the scale was accomplished in no case except where every visibly infested tree and shrub was destroyed, together with all adjacent vegetation to which the scale might possibly have spread.

The fumigation method had this theoretical advantage over that with the liquid spray, that an insecticide vapor set free under a close tent enveloping the infested tree would be carried by spontaneous diffusion to all parts of the inclosed space, and would thus presumably reach every particle of the infested surface and kill every scale, provided the operation were intelligently and carefully conducted. There seemed, in short, a reasonable possibility that expert fumigation would exterminate locally where the conditions were not unfavorable to thorough work, while such a result seemed clearly impossible with the liquid spray. I consequently decided to make a trial of orchard fumigation with hydrocyanic acid gas, applied after the method which had been in use for several years in the citrus orchards of the Pacific coast.

The opinion current among entomologists with respect to fumigation as an orchard method was well shown by statements of experimental results appearing at about this time, and especially by those published in August, 1898, in Bulletin 57 of the Maryland Experiment Station, and in the fall of that year in Bulletin No. 17 of the Entomological Division of the U. S. Department of Agriculture. In the first of these bulletins, entitled "A Report on the San Jose Scale in Maryland and Remedies for its Suppression and Control," Prof. W. G. Johnson, State Entomologist of Maryland, gives an account of various experiments with this insecticide gas, made in the fall of 1897 and the spring of 1898 on bearing orchard trees in Maryland. As a conclusion from experiments on fifty-three dwarf Bartlett pear-trees conducted from September 27 to October 1 by liberating gas under inclosing tents, he says (p. 86) that "the San Jose scale is entirely destroyed by the gas when used on calm, dry, sunny or cloudy days"; that "the cost of treatment, aside from the equipment, is less than that for whale-oil soap"; that "trees treated at night with very strong doses of gas do not have the foliage or dormant leaf and fruit buds affected at all, even where double the amount of gas ordinarily used is generated"; and that "trees treated in the morning before 9 a. m. and in the afternoon after 4 p. m. have the foliage very little affected by the gas." These tests were thought by him so gratifying that a meeting of those especially interested was called for a demonstration of the operation, and at a dinner served by the owner of the infested premises all the speakers "were unanimous in the opinion that the experiment was complete in every respect." In a later report on this same experiment, read August 19, 1898, at the Tenth Annual Meeting of the Association of Economic Entomologists, Professor Johnson says: *

"In order that I might report the definite and final results of these experiments, I made a careful examination of every tree in the orchard on Tuesday and Wednesday of this week. Where there were hundreds and thousands of scales breeding on the trees at this time last year not one can be found now, except upon trees under 5 feet in height and on those fumigated when the foliage was wet with dew or fog or immediately after a rain, and even on these trees the young larvæ are very few as compared with their number at this time last year. Where the fruit was much pitted and scarred by the scale last year not one has been seen upon a pear thus far this season.

"In all, the experiment is thoroughly satisfactory, in that it demonstrates by actual trial that this method can be used in our largest bearing orchards, even under the most adverse conditions, with excellent results."

Fourteen very badly infested plum-trees were also treated March 17 and 18, 1898, with hydrocyanic acid gas liberated under tents, and no living scales had been found on them three months later. "The general outcome of these experiments," says Professor Johnson,† "up to the present time, June 15, is so far satisfactory. We cannot hope to find a remedy for the San Jose scale that is more effective than hydrocyanic acid gas." Referring to this experiment again§ August 19, five months after the treatment was given, he says:

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* Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., pp. 41 and 42.

† Md. Bull. 57, p. 90.

§ Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 42.

"The gas can also be used in the spring in peach, plum, and apple orchards after the buds have begun to unfold. A block of one hundred six-year old plum-trees at Annapolis Junction was fumigated March 17 and 18, 1898, and up to the present time not a living scale has been found upon any trees, except those sprayed with 50 and 100 per cent. gasoline. The trees in this orchard were very badly infested, the most of them being so literally covered it was impossible to see the bark at any point on the trunk and larger branches.

"Other experiments were conducted in scale-infested bearing orchards in May, June, and July, the results of which cannot be finally reported at this time, except that no living scales have been found upon any of the fumigated trees."

The operations reported in the present paper can scarcely be called experiments, since they were an attempt to make practical application in the field of methods based on the experimental work and practical experience of others. Those with hydrocyanic acid gas may be taken, however, as a test of the fumigation method as applied to common orchards and fruit plantations in southern Illinois under conditions more favorable in some respects and less favorable in others than those of ordinary orchard practice. A considerable series of operations was carried on over a large territory by a single party under the direction of one foreman especially selected and carefully instructed for this work, and his management was doubtless more intelligent and exact than that of the ordinary foreman or owner of an orchard would have been. On the other hand, the conditions which he had to meet were of course much more varied than those to which any single orchardist would be subject, and the limitations of time and expense were such that the work must move steadily forward whenever at all practicable—a fact which made it impossible to choose favorable weather and to suspend operations temporarily when it was likely that the best results could not be obtained.

It has seemed to me, nevertheless, that the outcome of this campaign is well worthy of report, since it indicates with approximate fairness what can be accomplished by practical work on a large scale by the intelligent fruit grower so unfortunate as to have become the victim of the San Jose scale. Owing to the fact that these were not regarded as experimental but practical operations only, the notes of the work were not as full as I could now desire. They were, however, carefully made by competent men, and are entirely reliable so far as they go.

Experience with Orchard Fumigation.

Having decided on an extensive practical trial of orchard fumigation with hydrocyanic acid gas, I found it necessary first to provide expert advice and supervision with respect to the practical operation, with which none of my office force had any personal acquaintance, and for this purpose, after considerable correspondence, I secured the aid of Prof. Charles W. Woodworth, Assistant Professor of Entomology at the University of California and Entomologist of the California Agricultural Experiment Station. Professor Woodworth being a graduate of the University of Illinois was well known to me personally, and was particularly useful to us because he had made a special study of fumigation operations in California. He had, in fact, published an elaborate bulletin on "Orchard Fumigation,"* which was the principal reliance of economic entomologists interested, and remains to-day the best brief practical treatise on the subject.

Arriving in May, 1899, he inspected parts of our infested districts, planned our equipment and superintended its manufacture, coached our first fumigating squad, and supervised its practice work—first on the Experiment Station farm, at Urbana, and later on premises infested by the San Jose scale at Monticello, in Piatt county.

Description of Equipment.—Our tents to cover infested trees and confine the insecticide gas liberated under them were all made of eight-ounce canvas, treated in two different ways to make them impermeable to the gas. The first lot were thoroughly sized with flour paste and covered, when dry, with a thin black paint; and the second lot were saturated with boiled linseed oil and left spread out until dry. The latter method of preparation proved the more satisfactory and durable. The paint was likely to wear and crack with use, and the sizing and painting were more laborious and costly than filling with oil. The latter operation was conveniently and rapidly performed (as shown in Plate I.) by the aid of a common spray pump provided with an adjustable nozzle. Great care was necessary that the oil in the tents should be thoroughly dried out before they were folded, as otherwise they were liable to heat, with the effect to destroy the cloth if not to set up spontaneous combustion.

The fumigation outfit consisted of forty-seven tents, three pairs of lifting poles, and several sets of generators for the preparation of the gas. All except the smallest tents were flat oblong

* Bull. 122, Calif. Agr. Exper. Station.

sheets of canvas, rounded at the corners and sewed with overlapping double seams. Seven of these were 50 × 60 feet in diameter, ten were 40 × 48 feet, and twenty were 32 × 38 feet. There were also ten conical tents eleven feet in diameter at the base, used for the smallest trees. For lifting these tents into place there were two 14-foot scantlings for the smaller sheet tents, two 20-foot lifts made of 2 × 4 scantlings, spliced and reinforced, and two 30-foot masts. Each pole when in use was fitted with a pulley, through which ran a three-fourths inch rope, and was also provided with from one to three guy-ropes with which to direct its motions as the tents were being lifted and drawn into place. For trees twelve feet in height, or less, one 14-foot pole was the most convenient lift. For those between twelve and eighteen feet one 20-foot pole was commonly used unless the top of the tree was unusually broad, when two were necessary. For still larger trees the 30-foot masts were used, one or both according to the size of the tree.

Description of the Operation.—The method of handling the tents and of liberating the gas was substantially the same as that described and amply illustrated in Professor Woodworth's Bulletin 122, already referred to (pp. 20–30). Different phases and variations of the operation are illustrated in Plates II.—VI. Attempts were made at first to fumigate very large trees, even when two tents of the largest size were necessary, one being drawn over the other so as to lap upon it several feet. (See Plate V.)

In ordinary work with one pole three men were required to handle the tent, but when two poles were used a fourth man was necessary. Two others were needed for the process of fumigation, making a squad of six for the entire operation.

For peach- and apple-trees of medium size, that is, 12 to 18 feet in height with a spread of 8 to 15 feet, a squad of three men with a single 20-foot lifting pole did the work most expeditiously. The pole was leaned against the tree on the side opposite that from which the tent was to be raised, and one end of the rope running through the pulley at the top of the pole was thrown over the center of the tree and made fast to the nearest edge of the tent. The pole man then hauled the tent upward to the pulley, or at least high enough to clear the tree, and fastened his rope, took the guy-rope hanging from the top of the pole, moved forward far enough to get the necessary leverage and drew the tent over the tree, the other two men of the squad, one at each side of the tent, spreading it over the sides of the tree and adjusting it to the top. This operation is illustrated by Plate II., taken just as the men have begun to pull the tent forward over the tree. After the tent had been drawn forward far enough one tent man loosened the pulley rope and let the pole fall, the pole man detached the rope from the canvas and set the pole up at another tree, while the tent men ran a binding rope about the tent below the tree top, drew it closely, and tied the ends together. The borders of the tent were then laid close to the ground, and weighted with earth if high wind made this necessary, and the tent was carefully searched for possible leaks.

The fumigator prepared the charge according to the formula of the California Bulletin for winter treatment. He measured the circumference of the tent at its largest diameter and estimated the distance over the top from his knowledge of the length and width of the tent in use. The "acid man" measured the required amount of water and acid, poured them into the generator and held up the border of the tent while the fumigator put the generator in place near the trunk, charged it, and withdrew. He then quickly dropped the tent, seeing that it lay close to the earth, permitting no gas to escape.

The chemicals used were in the proportions indicated for a .3% gas in the table on page 28 of the California Bulletin. From the fact that the tent was usually drawn in below the head by a rope while the measurement was made round the top of the tree at its greatest diameter, the proportion of gas was in most cases considerably stronger than .3%. After charging the tent with the gas it was left to stand forty minutes, at the end of which time it was taken down and moved to another tree.

Preliminary Operation at Monticello.—Fumigation can be done while the leaves are on the trees only at night or on dark and cloudy days, and our first attempts being made in June (1899), the work was done entirely at night. The infested place nearest to my office and most convenient of access was Monticello, in Piatt county, where the San Jose scale had been found on a few town lots containing various species of fruit and ornamental trees and shrubs.

A brief operation there demonstrated at once the impracticability of satisfactory fumigation work on the miscellaneous stock of an ordinary town lot. The trees infested were of various shapes and size, some of them too large to be inclosed by a tent. Trees, shrubs, and vines were often mingled in thicket-like masses which could not be covered securely, and the various kinds of vegetation which it was necessary to treat were variously sensitive to the withering action of the gas.

After one night's work of my field party on the grounds of a prominent citizen I was summoned by telegraph both by the foreman of the fumigating squad and by the owner of the premises, and experienced no small difficulty in re-establishing cordial relations between the parties concerned. To do a thorough piece of work some destruction of small shrubbery had been necessary, and the leaves of several kinds of vines and shrubs were badly withered by the gas.

An inspection made the following year, April 14, 1900, showed an unexpectedly favorable result. On one tree heavily coated with scales many living specimens were found under a crust of the dead, but elsewhere two hours' search disclosed but three living scales. The place had been temporarily saved from serious damage by the scale, but at a cost exceeding the value of the rescued property, and the failure to exterminate was evident. No attempt has since been made by me to treat miscellaneous trees and shrubs on town lots by the fumigation method.

The trees and shrubbery on twenty-one lots in this town—all on which the San Jose scale could be found—were sprayed with a twenty per cent. soap emulsion of kerosene April 10–19, 1900.

Orchard Fumigation at Sparta. — A region of more than twenty-five square miles about Sparta, in Randolph county, was known by me to be generally infested with the San Jose scale in the fall of 1899, this and the neighborhood of Richview, in an adjoining county, being the most important infested districts discovered in Illinois up to that time. After the completion of the the annual nursery inspection of 1899, preparations were made for a general campaign with the fumigation equipment in this neighborhood, and my party took the field at Sparta October 18 under the charge of Mr. E. C. Green, with Mr. R. W. Braucher as inspector. Here it continued actively at work for the next two months, by which time it was evident that with the appropriations available it was altogether impossible to treat the infested premises of this region fully by the fumigation method, and the party was transferred to Richview, in Washington county, for work on another plan.

The Sparta district was mainly one of small farm orchards, of which only here and there one had expanded in a way to make its fruit an important part of the owner's crop. Many of the infested orchards were very old or contained some very old trees of a size to make fumigation exceedingly difficult or to put it altogether out of the question (Plate VII.). Taking one orchard with another, infested trees of every size were to be found, from those recently set out to giant survivors of the plantings of the early pioneers. The owners had often neglected their trees until it seemed a waste of public funds to attempt to save them when infested by the San Jose scale; but as the law gave me no power to condemn a tree until its value was altogether gone, I was obliged to treat such trees whether they were worth the cost of treatment or not. Osage orange hedges had become extensively infested by the scale in this district, in one instance at a distance of a quarter of a mile from the nearest orchard. Thickets of escaped fruit trees were growing beside the roads in fence corners, or by the borders of woods, and these were often more or less infested, and as the country still contained many remnants of its original forest covering there seemed a considerable probability that the scale was obscurely distributed far and wide through this forest growth.

Notwithstanding the discouraging features of the situation we made a serious attempt at fumigation here, which presently took the form, however, of a preliminary operation to show what was practicable by this method in such a place, and what must be otherwise provided for.

General Results.—From our experience at this place it soon became clear that local extermination of the scale was impracticable by fumigation, or by a single operation of any kind, unless power were given to destroy utterly everything infested which could not be cleared of the scale at once; that many of the trees were too large to fumigate, and hence could be treated only with a liquid spray; that the fumigation process in such a region was slow and extremely costly as compared with any other known; and that weather conditions often greatly diminished its efficiency by making it practically impossible to hold the gas under the tents at full strength long enough to produce the desired effect. In very windy weather no care in the management could prevent the rapid escape of the gas, as was shown by the strong smell of it on the leeward side of the tent and the absence of any such smell when the tree was uncovered; and when the weather was very cold the watery vapor from the generators condensed on the canvas and immediately froze, lining the tents with ice. In this condition they were likely to break when folded in handling, and the brittle branches of the tree breaking when the heavy tent was hauled across the top, the tents were often torn by the jagged stubs.

Furthermore, it appeared from subsequent inspections that the cases were few in which all the scales on a tree appeared to be killed, and the frequency with which scales were found alive on the lower part of the trunk, while all were seemingly dead on the remainder of the tree, showed that the insecticide gas did not diffuse equally under the tent, but tended to rise, leaving near the ground a layer of insufficiently poisoned air. As this unequal diffusion of the gas has since been demonstrated in closed rooms, — a fact now taken into account in the construction of fumigation houses,—it is evident that we have here a serious objection to the whole process of orchard fumigation for the San Jose scale. We now know that peculiar methods and special precautions are necessary to secure an equal diffusion of the gas, even in the air-tight rooms used in nursery fumigation, and with the varied conditions and rapid work of orchard fumigation it is clearly impossible to secure a uniform action even in the average case.

Details of the Work and its Results.—The following items concerning thirteen representative orchards fumigated at Sparta are taken from the field reports of the foreman and inspector.

No. 1. On the place of Alvin Blair three hundred and ninety-five trees, most of them peach, were fumigated from October 20 to November 4. They were of medium size except a few of the apple-trees, which were very large, requiring the use of two of the largest tents lapped together over one tree and tied down with ropes. The peach-trees had been severely cut back the preceding spring previous to spraying with whale-oil soap (see Plate IX.), and the sharp stubs remaining punctured the tents, thus making necessary constant inspection and frequent repair of leaks. No doubt some gas escaped and some trees were imperfectly treated. A high wind was blowing when much of the work was done, and great embarrassment was also caused by cold and rainy weather, the tents tearing easily when wet and frozen. This place was inspected September 10 of the following year (1900), and badly infested peach-trees were found scattered through the orchard, the wood of two years' growth sometimes almost incrusted. In one row which was carefully examined the scale was found on seventy-three per cent. of the trees.

No. 2. On J. W. Robinson's place one hundred and seventy-seven trees, thirty-six grape-vines, and seven shrubs were fumigated October 18–20. This place had also been sprayed with whale-oil soap early in May of the same year to check the spread of the scale. September 10, 1900, twenty-seven trees were inspected, and scales were found on twenty-one. Two of these were very badly infested, but it was surmised that these had been left without treatment on the promise of the owner to destroy them as worthless.

No. 3. The place of Mrs. J. B. Hayer was probably the one first infested in this whole region, one orchard having been completely destroyed by the owner because of injury by the scale. The trees remaining were mainly apple and pear, most of them very badly infested. One hundred and seventy trees were fumigated here November 24–27, high winds causing considerable trouble. September 12 of the following year no badly infested trees were seen, but living scales were found on thirty per cent. of the trees.

No. 4. On the place of Jefferson Porch both peach- and apple-trees were badly infested. The fumigation squad was here from November 28 to December 2, treating eighty trees of medium size. September 11 of the following year living scales were found on fifty-three per cent. of the trees, but were numerous on none.

No. 5. On the place of J. K. Blair ninety-one peach-trees were fumigated November 6 and 8, some of these badly infested and others slightly so. Twenty-eight large old apple- and peach-trees were marked for removal. Those fumigated were planted so close together that they could be treated only with great difficulty, and the canvas was badly torn in the operation. The treatment proved, however, to be unusually effective, and living scales were found September 8, 1900, on only two of the trees. A plum-tree badly infested when fumigated appeared at this time to be entirely free of living scales.

No. 6. In an orchard of several acres belonging to Sylvester Brown most of the trees were infested, some of them badly so. Many of them were large, requiring two of the largest tents to cover them. Ninety-one trees were fumigated November 8–11, and thirty-five were marked for removal, eight of them large old apple-trees. September 10, 1900, but five infested trees could be found in this orchard, and on one of the old apple-trees badly infested the preceding year not a living scale could be detected.

No. 7. November 18–23, two hundred and twelve small to medium trees were fumigated on Mr. James Davidson's place, a few apple- and two pear-trees too large to be covered by tents being left for the spraying gang. September 11, 1900, living scales were found on four of these trees, but all the others were apparently clean.

No. 8. November 23 and 24, twenty-three trees were fumigated, together with a few grape-vines, on the place of Charles Lott. Although a strong north wind made the handling of the tents unusually difficult, no living scales could be found on this place September 11, 1900, except on one apple-tree left for removal by the owner as worthless, but which he had failed to destroy.

No. 9. December 4, 1899, seventy small trees were fumigated on William Wilson's place, thirty per cent. of which were found infested by a few living scales September 11 of the following year.

No. 10. On Thomas H. Wilson's place a few trees were reported infested in a six-acre orchard of apple and peach. One hundred and twenty-six trees were fumigated here December 4 and 5, and September 11 of the following year living scales were found on ninety per cent. of them. The wind was troublesome at this place, the canvas was stiff with ice and easily torn, and lumps of frozen earth were dug up to hold the bottom of the tent in place.

No. 11. A thirty-five-acre orchard of Thomas Brown's, in which a number of infested peach-trees were found along one side, was treated December 7–16, 348 trees being fumigated here in all. These ranged from six to twenty-five feet in height, the majority requiring tents of medium size. On the 14th of December a moist snow stopped the work, which was resumed the following day in snow about a foot deep. September 12, 1900, a few scales were found on five of the trees, but the others were seemingly clear.

No. 12. On the place of Frank Blair occupied by William Blair was a badly infested young orchard and two infested hedges near by. One hundred and eighty-five trees of medium size were fumigated here November 11–15. September 8 of the following year twenty-nine of these trees were critically examined, and sixteen were found very slightly infested. The bases of the trunks of some were, however, well stocked with living scales, and sprouts growing up from near the base had thus become heavily infested.

No. 13. On the place of James A. Wood sixty trees, some of them badly infested, were fumigated December 6, and one was cut down as worthless because of the scale. A few were very large, requiring two of the largest tents to cover them. September 11, 1900, four of these trees were still badly infested, and thirty-five per cent. of them showed more or less of the scale.

Orchard Fumigation at Richview.—With the transfer from Sparta to Richview the problem of local extermination was materially simplified. The latter town is in the midst of a typical fruit district. The orchards are large and mainly well kept ; they are comparatively young and uniform and contain but few overgrown trees ; the infested district was not hopelessly large ; and the surroundings were not unfavorable to thorough work, the presence of Osage orange hedges being the most unfavorable feature.

With the advantage of two months of active field experience my party was prepared to do thorough and careful work at this place, and the instructions were to spare no labor or pains to kill every scale in every infested orchard. Hydrocyanic acid gas was used for all trees to which it was adapted, but the attempt to cover very large trees with tents was given up, such trees being severely pruned and thoroughly sprayed with kerosene emulsion diluted to contain twenty per cent. of the oil. (See Plate VIII.)

Great care was taken that the tents should be kept in perfect repair, and every part of the work was carried on under the immediate supervision of Mr. Green, foreman of the squad, or of Mr. Braucher, the inspector. The treatment was applied thoroughly, not only to all trees on which the scale could be found but to others near enough to stand in any danger of infestation. Owners of infested hedges were induced to destroy them (Plate IX.); trees very badly infested were, as a rule, cut out and burned; and, in short, nothing was omitted which would help to make the work effective and complete.

We had also at Richview the especial advantage of the countenance, aid, and influence of Mr. J. W. Stanton, Treasurer of the State Horticultural Society, himself an owner of large fruit farms, and a man whose character and experience made his judgment and advice acceptable to his entire neighborhood.

The work here began December 22, 1899, and continued to February 10, by which time all premises known to be infested had been treated, with the exception of one large apple orchard so far removed from any other fruit plantation that no danger was apprehended of an escape of the scale from it to any other property. A general inspection of this region was made after a lapse of two years, in March, 1902, all the places previously infested being then very carefully examined by Mr. R. W. Braucher, my most acute and experienced inspector.

Details of the Richview Work.—No. 1. The first place treated at Richview was an orchard of apples and peaches on the James Newcome Estate, owned at the time by J. W. Stanton and George McCoy. 2,087 trees of small to medium size were treated by fumigation between December 22 and January 4. On four of these days—December 29 and 30 and January 1 and 2—the weather was extremely cold, and fires were kept burning in the orchards to keep the water from freezing. The canvas was so stiff with ice that it was easily torn, and it was difficult to bring the skirts of the tent so close to the ground as to prevent all leakage of gas. When the tents were removed from the trees, at the end of forty minutes, no odor of the gas was perceptible during this coldest weather, although at other times it was very distinct. This work was done under the constant personal supervision of either Mr. Braucher or Mr. Green.

March 6, 1902, many trees in this orchard were badly infested, and some of them were almost completely incrusted by the scale.

No. 2. In the apple orchard of Levi Walker, a few trees along one side were found infested and also an adjoining Osage orange hedge. This place was fumigated January 8 and 9, during a January thaw following upon two days of rain. January 8 mud and water were ankle deep in that part of the orchard where the work was done The canvas became very heavy and five men were needed to handle the tents. One hundred and thirty-five trees were fumigated, ranging in height from twelve to twenty feet, and the infested Osage orange hedge was cut out about a month later. Forty-seven rods of high and heavy hedge were cut away, and the stumps were sprayed with strong kerosene emulsion.

March 7 to 12, 1902, this orchard and hedge were examined by Mr. Braucher. An occasional tree was found slighly infested with the scale in that part of the orchard fumigated two years before, and the hedge, which had grown up from the roots, was again badly infested.

No. 3. In a small orchard belonging to I. H. Jones forty-seven trees were fumigated January 10–12. One old peach-tree was destroyed, and two plum-trees were subsequently sprayed with kerosene emulsion. March 15, 1902, three trees on this place were found slightly infested with the scale.

No. 4. January 12, sixty apple- and pear-trees of medium size and smaller were fumigated in a small infested orchard belonging to Mr. James Ewing, many of them completely incrusted by the scale. March 14, 1902, only three infested trees could be found on this place, and the scale was scarce on these.

No. 5. In the orchard of George McCoy, composed of trees of medium size or larger, were a few slightly infested trees. All these were fumigated January 13, together with others around them for several rows in all directions, one hundred and thirty-eight trees in all. Owing to the discovery of a single suspicious scale on an adjoining Osage orange hedge a considerable section of the hedge was destroyed February 10. March 6, 1902, the part of this orchard treated two years before had again become slightly infested, and the adjoining hedge was reported as in bad condition from the presence of the scale.

No. 6. The orchard of Jasper Wilgus was generally and variously infested, many of the trees being in rather bad condition. Two hundred and seventy-eight small to medium trees were fumigated here on the 15th and 16th of January, two hundred peach- and apple-trees were destroyed by the owner as worthless, and one hundred and sixty-one trees too large to fumigate were sprayed with twenty per cent. kerosene emulsion January 23–26. February 9, three rods of hedge infested by the scale were removed and destroyed. This place was inspected February 28 and March 14, 1902, at which time some of the trees in that part of the orchard which had been fumigated were again badly infested, as well as a considerable length of the Osage orange hedge. On the large trees which had been sprayed with kerosene, on the other hand, only a few scales could be found.

No. 7. In a small orchard on a town lot belonging to William Edwards forty-one trees were fumigated January 17, including several reported as infested. March 1, 1902, the scale could be found only on a single tree.

No. 8. In a small infested orchard belonging to Thomas Hoke forty-six badly infested trees were fumigated January 10 to 20, and fifteen were destroyed as worthless. March 1, 1902, thirty-five of the trees were re-examined, and thirty-two of them were generally infested by the scale to an extent to require another treatment without delay.

No. 9. January 27 one hundred and seventy-two peach- and apple-trees were fumigated in an infested orchard belonging to Mrs. E. A. Glenn, and eleven trees were sprayed with 20 per cent. kerosene emulsion. According to a report of an inspection of eighty-eight of the fumigated trees made February 28 and March 1, 1902, thirty-two of these were again infested to an extent to require speedy treatment as a protection to adjacent orchards in which the scale had not been found.

No. 10. On J. Bennett's place fifteen trees were fumigated January 17, and on February 2 one large apple-tree was sprayed with kerosene emulsion. March 1, 1902, two small trees slightly infested furnished the only remaining traces of the scale.

No. 11. One hundred and thirteen trees were fumigated January 20 and 22 in an infested orchard belonging to W. H. Grove; and February 2, sixty-seven trees additional were sprayed with a twenty per cent. emulsion of kerosene. March 1, 1902, twenty-nine of these orchard trees were found infested, and also a few peach sprouts along one side of the place.

No. 12. The pear and apple orchards of J. W. Stanton were somewhat infested at this time, although they had been extensively treated with insecticide sprays since the first discovery of the scale on his premises three years before. Seven hundred and seventeen apple-trees in one corner of an infested orchard were fumigated January 22–25, and about thirty large peach-trees were removed. January 27-29 nine hundred dwarf pears were sprayed with kerosene emulsion, a part of it containing twenty per cent. of kerosene, and the remainder, by mistake of an assistant, fifty per cent. With this latter strength over one hundred trees were treated. Two years later, February 28 and March 4 and 5, 1902, all these orchards were critically examined and only a few scattering scales were found. The trees treated with a fifty per cent. emulsion had not been injured in the least. It should be said that this orchard was in excellent condition, its owner being an experienced and careful fruit grower, and everything was consequently favorable to effective work.

No. 13. January 25 and 26 thirty-five large trees were fumigated in an infested orchard of apple and peach belonging to S. D. Newcomb. March 15, 1902, Inspector Braucher reported that eighteen trees were slightly infested, but less so than two years before.

No. 14. Nineteen trees were fumigated January 26 in an infested apple orchard belonging to Edward Aplin, and some peach-trees were destroyed at the owner's request. March 14, 1902, a few slightly infested trees were found.

No. 15. January 26 nineteen trees were fumigated on Mrs. R. R. S. Vasey's place, and February 6 one very large tree was sprayed with kerosene emulsion. March 14, 1902, three slightly infested trees were found by my inspector on these premises.

No. 16. On Dr. W. Smeaton's place, in charge of L. D. Allen, sixty-seven trees, mostly peach and some of them badly infested, were fumigated January 27. This place was inspected March 12, 1902, and a few trees found slightly infested. A hedge on the place was now infested and required treatment.

No. 17. January 26 an infested tree on the place of Mrs. Simeon Shinall was fumigated, but an inspection of it March 15, 1902, showed it to be slightly infested.

Comment on the above Results.—The foregoing statements of conditions found at Sparta and at Richview are not strictly comparable with each other because the inspection at Sparta was made in September, 1900, eight or nine months after the insecticide treatment, and that at Richview was made in February and March, 1902. The Sparta region was inspected in the midst of the first growing season after the trees were treated and before the time of most rapid multiplication of the scale,—which is usually the month of October in southern Illinois,—while the Richview inspection was made after a lapse of two complete seasons of growth and multiplication.

The best results of orchard fumigation obtained by my parties are shown by the inspection reports on places 5, 6, 7, and 8 in the Sparta district, and 3, 4, 7, and 12 at Richview. In the four Sparta orchards, where 317 trees were sprayed in the fall of 1899, the scale could be found on only 11 of them in September, 1900; and in the first three Richview orchards, where 148 trees were treated, only seven proved to be infested two years later. At Sparta No. 8 a close approximation seems to have been made to a complete extermination of the scale and the same may be said of Richview No. 7, and perhaps, also, of No. 12.

The most serious obstacle to work was that offered by cold and freezing weather, as is shown especially by No. 10 at Sparta and No. 1 at Richview. High winds were less disadvantageous (see Nos. 3 and 8 of the Sparta district), and excellent results may be obtained in spite of them, as shown especially by No. 8. Neither snow nor wet weather diminished noticeably the effectiveness of the operation, as shown by No. 11 at Sparta and No. 2 at Richview. It would appear from Sparta No. 6 that large trees can be fumigated effectively by the use of two tents at once, overlapping by their edges.

In none of the cases here described was even a single orchard completely cleared of the scale,—unless possibly at Sparta No. 7,—a fact which taken in connection with the costliness of fumigation as compared with other equally if not more effective methods puts it completely out of the field for ordinary orchard work in Illinois.

Cost of Orchard Fumigation.

The expenses of our work are divisible roughly into those for exploration and inspection of the infested territory, for equipment, for transportation of the outfit and party from place to place, for supervision and general management, and for the operation of fumigation itself. All except the last of these were so largely special to our undertaking and so little like those of the ordinary owner of an orchard that they would be of little or no practical interest. For the great variety of trees on which we had to work in fumigating everything in an extensive district, we needed a greater variety and a larger number of tents than would usually be necessary in private work, and the cost of extensive inspection and that of transportation would be avoided by the orchardist working only on his own premises. The expenses of actual fumigation, however, would be about the same ordinarily as in our work, provided that the private owner had to hire all his labor but made no charge for his own services, and this item of our account will consequently be useful for comparison. It must be remembered, as explained elsewhere, that the necessity we were under to keep the party at work in good weather and bad, whenever work was at all possible, increased the average cost of fumigation per tree above what it would have been if our men could have been laid by in bad weather without expense, or could have been otherwise profitably employed.

At Sparta 2,297 trees were fumigated on seventeen different premises—an average of 135 trees at each place. 1,160 lbs. of cyanide of potassium and 290 gallons of common sulphuric acid were used in this work, at a cost of $412; and 1,700 hours of labor were required, at 10 cents an hour. The total expense was $582—an average of 25 cents a tree.

At Richview, where the trees were smaller and conditions were more favorable generally, 3,879 trees were fumigated on seventeen different places, an average of 228 trees on each. 994 lbs. of cyanide of potassium and 248 gallons of sulphuric acid were used, at a cost of $353; and the bill for labor was $113 for 1,130 hours—an average, all told, of 12 cents a tree.

Taking both places together, the cost of the mere fumigation of 6,176 trees was $1,048, or approximately 17 cents a tree. Comparisons of effectiveness and cost by this and other methods will be made later in this article, after a detail and discussion of the results of the use of the fluid insecticides.

Treatment with Whale-oil Soap.

Our experience in the treatment of many thousand trees with this well-known insecticide, prepared in the usual strength of two pounds to the gallon of water, has merely served to confirm the common conclusions with respect to it. It has proved to be very efficient for the destruction of the scale, killing practically all reached by it; has done no injury to trees or shrubs; but has proven dangerous to the fruit buds of the peach unless applied in spring after the buds begin to swell. It is much the most expensive of the sprays of which we have made use, costing at the rate of $6.50 per hundred gallons, and has also been the most inconvenient of application in cold weather. This solution is only fluid while warm, becoming of a semi-gelatinous consistency when entirely cool, and if, owing to the clogging of the nozzle, it was necessary to stop its flow for a little time, the delivery hose was sure to clog and fill if the weather was much below freezing. Our work was all done with potash soaps, but I have made no comparative tests of these and soda soaps, and have failed to find any published evidence in support of the very common preference of the former as an insecticide.

Experience with Kerosene Emulsion.

The heavy cost of the whale-oil soap solution, the annoyance and delay caused by its clogging in the delivery hose in very cold weather, and the practical certainty that a large proportion, if not all, of the fruit buds of peach-trees sprayed with it would be killed except in the comparatively small number of cases where our treatment could be applied in spring, led to the substitution for it during the winter of 1899 and 1900 of an emulsion of kerosene diluted with water and varying in actual practice to contain from 20 to 25 per cent. of kerosene.

Beginning at Sparta and Richview in January, 1900, its use was continued through February and March at Carterville and Albion, and at Monticello until April 19, by which time the season was too far advanced to permit further use of this winter spray without injury to the unfolding leaves. 5,315 trees were sprayed with it in these places and at this time. November 8 of this same year insecticide work was begun at Quincy, where a 25 per cent. kerosene emulsion was used on one large and three small orchards November 14 to December 19, and a 20 per cent. emulsion on another at New Boston, in Mercer county, December 29–31. At Barry, in Pike county, an apple orchard of 500 trees was sprayed with it, partly as an experiment, January 7–14, 1901. The mixture used there was in three different strengths, containing 20 per cent., 25 per cent., and 40 per cent. of kerosene respectively.

The orchard insecticide work of the fall of 1901 began November 25, and at first a 25 per cent. emulsion of kerosene was used for everything. December 9, however, instructions were issued to spray all peach- and plum-trees with the so-called California wash of lime, sulphur, and salt, and to use the kerosene emulsion for other trees only on sunny days, substituting whale-oil soap for it whenever the weather was dark. Finally, on February 5, 1902, my chief inspector, Mr. Green, was directed to stop the use of kerosene altogether, and to dispose of his stock on hand. This order was made in consequence of a report by Mr. Braucher, then engaged in inspecting orchards which had been treated by us in the fall and winter of the preceding year, to the effect that apple-trees had apparently been injured in November of that year in the New Boston orchard mentioned above by a 20 per cent. emulsion applied by Mr. Green.

Kerosene Emulsion at Richview.—The operations at Richview in 1900 fairly represent the cost and the results. One thousand five hundred and thirty-five trees were treated at this place at an expense of $17.65 for oil, $37.65 for labor at ten cents an hour, and

$16.73 for the hire of a horse—a total of $72.03, or an average of somewhat less than five cents a tree.* The results reported cannot be readily summarized and are consequently given in detail for several typical lots of trees.

No. 1. One hundred and fifteen apple-, pear-, and peach-trees, most of them large and old, treated with 20 per cent. emulsion January 26–29 and February 1, 1900, on the premises of Mr. G. T. Hoke—two town lots and an old orchard near by. October 8, 1900, a few living scales were found on some of the peach-trees that had been sprayed. March 11, 1902, the trees on the town lots were slightly infested, and a few scales were found on some of the orchard trees.

No. 2. Nine trees on a town lot belonging to Mr. K. Mark were treated February 1, 1900. March 11, 1902, 5 of the 9 trees were slightly infested.

No. 3. Twenty infested trees varying from medium to large belonging to Mr. Charles Miller were sprayed February 1 and 2, 1900, and March 11, 1902, scales were found on only one of these trees.

No. 4. Twelve badly infested peach-trees, small to medium in size, sprayed February 3, 1900, were found generally infested, but not heavily so, on March 22, 1902.

No. 5. Of 36 infested peach-trees belonging to Mr. John Gay, treated February 23, 1900, 20 were found infested March 3, 1902.

No. 6. February 3–6, 1900, 4 infested trees on a town lot belonging to Mr. N. F. Tate, and a large pear-tree also infested on another lot, were sprayed with 20 per cent. emulsion. A large apple-tree was destroyed at this time as practically worthless from the abundance of the scale. Two years later, March 13, 1902, all 5 of the trees sprayed were slightly infested, as were also sprouts from the root of the apple-tree destroyed.

No. 7. February 6, 1900, 12 orchard trees belonging to Mr. C. P. Cooper were sprayed, and March 12, 1902, two years later, the scale was found on 2 of these trees.

No. 8. Three large peach-trees in an orchard of Mrs. M. A. Robins were sprayed February 6, 1900, and March 17, 1902, two years later, 2 of the 3 were slightly infested.

Similar data are given for seven other premises, all pointing to

*The average cost of spraying 5,710 trees, from January, 1900, to January, 1901, at five different localities was 4½ cents a tree. The premises treated were mainly town lots, requiring frequent interruption of operations and consequently increased expense. In three orchards near Barry 1,486 trees were sprayed, and at a cost of 3.2 cents per tree.

the conclusion that trees were rarely cleared of the scale completely by this insecticide spray, but that a single treatment would serve as an efficient protection for at least two years. In several of these cases another insecticide treatment would be necessary by the end of another year at the farthest. No injury to trees of any kind was done by this twenty per cent. emulsion distributed at Richview in January and February of this year.

Experience at Carterville, Albion, and Monticello, Spring of 1900.—Beginning with March 5 and continuing to March 17, 2,272 trees, belonging to six owners, at Carterville were sprayed with a twenty per cent. emulsion with Mr. Green in charge. These trees were of mixed kinds, mainly apple, but including also plum, pear, and peach. Subsequent visits made in 1901 and 1902 showed that no injury whatever was done to any of these trees.

At Albion 674 trees were treated, mostly peach but with some apple, plum, and pear, all receiving a twenty per cent. emulsion between March 23 and 29. These trees were scattered in small lots upon twenty-four town premises. This place was repeatedly visited by inspectors and spraying parties up to the winter of 1902, and no trace of injury by the kerosene treatment was discovered.

Essentially the same statement may be made with respect to Monticello, where 843 fruit trees of various kinds, including apple, peach, and plum, were sprayed on twenty-two premises from April 10 to 19, no appreciable injury following.

Experiment with Kerosene Emulsion at Barry.—The only strict experiment with this spray made by us in the winter of 1901 was the last operation of the season—that in the apple orchard of Belah Wright, at Barry, Pike county. Five hundred trees were treated here January 7–14, 150 of them with 20 per cent. emulsion, 223 with a 25 per cent., and 127 at a strength of 40 per cent. January 7 and 8, when the 20 and 25 per cent. mixtures were applied, the weather was cloudy and rather warm. January 9 a sleety rain fell, covering the trees with ice which continued until January 14, when the 40 per cent. mixture was applied. This was a clear day with no wind.

Regarding this as an experimental test of the effects of the soap emulsion of kerosene, both on the scale and on the tree, I sent Mr. Braucher for an inspection of this orchard October 2, 1901, before beginning the fall work of the season. A general view of the orchard showed that the treatment as a whole had been very effective, but that more scales had survived in that section of the orchard treated with the 20 per cent. emulsion than in either of the other two. Two trees were found, in fact, in this part which were regarded as badly infested, and on several others scattering scales were seen. None of the trees had been noticeably injured even by the strongest spray, if exception be made of a small spot of deadened bark on a single tree which might possibly have been due to it. In the section treated with 40 per cent. of kerosene scarcely a scale escaped, and even where 25 per cent. was used the treatment was very effective.

At New Boston.—December 22, 1900, in an orchard belonging to W. Esley, near New Boston, in Mercer county, both apple- and peach-trees were found generally infested, some of the former being practically incrusted. December 24–28 this orchard was pruned and prepared for spraying by Mr. Green. December 29 and 31, 239 trees were treated with a 20 per cent. emulsion of kerosene, the 29th being very cold, clear, and bright, and the 31st cold and dull. Part of the peach-trees were pruned as a preparation for treatment and were then thoroughly sprayed, but another lot of peaches, not known to be infested, were pruned slightly or not at all previous to the insecticide spray. January 17, 1902, an inspection by Mr. Braucher showed that ten of the thirteen small peach-trees which had been pruned were dead and another badly injured, while the adjacent lot, not pruned, were not reported as injured at all. Of the 75 young apple-trees generally and badly infested which had been treated December 29, 20 were dead and 10 were badly injured, and on 26 there were still small numbers of living scales. Ten-year-old apple-trees sprayed December 31 were not injured, neither were cherry, pear, and plum sprayed at the same time.

No explanation of this extraordinary occurrence can be suggested. The oil, although bought locally, was said to be of the same brand and grade as that used elsewhere without injury, and the treatment was not peculiar in any discernible particular. On this account, even more than if a satisfactory explanation were forthcoming, the occurrence suggested caution in the use of the kerosene emulsion, and Mr. Braucher's report was followed at once, as already stated, by orders to substitute whale-oil soap for the emulsion in all our field work.

Kerosene Emulsion at Quincy.—Two other cases of apparent injury to trees by kerosene emulsion occurred in the fall of 1900 at Quincy.

No. 1. In an orchard mainly of peach-trees, belonging to Mr. Gustav Klarner, 7 trees were found October 3, 1900, infested with the San Jose scale, and were destroyed with the owner's consent November 8. Mr. Klarner wished to be sure that no scale remained on his place, and in view of the probability that other trees in the orchard were obscurely infested Mr. Green proceeded to spray all the trees, 997 in number, near enough those infested to endanger them in the least. After pruning them carefully as a means of securing a thorough distribution of the spray, he began the treatment November 14 with an emulsion containing 23 per cent. of kerosene.

The weather was unusually variable, but not cold at any time. The first day of the operation was cloudy and dull, and the second, November 15, was sunny and bright. Nothing was done on the 16th, 17th, 18th, or 20th because of rains, and only a little on the 19th, which was a damp and misty day. Spraying was resumed on the 21st and continued until the 23d, the first two of these days being bright and the last one dull.

There was nothing uncommon in this operation except that the brand of oil, purchased in the local market, was different from that ordinarily used by us elsewhere, and the emulsion was also a little stronger than the usual 20 per cent.

This orchard was inspected by Mr. Braucher between January 20 and February 17, 1902, that is fifteen months after treatment, but by this time extensive changes had been made in it by the owner, who had replaced many trees said to have been injured or killed, and had dug out a part of a large block, planting the ground to raspberries. In the part still standing 324 trees were either wanting or had been replaced by others the preceding spring. Mr. Klarner himself estimated his loss at 700 peach-trees.

No. 2. On the premises of Wm. C. Burgdorf, near Quincy, were scattered plots of mixed fruit-trees,—pear, peach, cherry, and apple,—among which Mr. Green found November 10, 1900, trees infested with the San Jose scale. Two small blocks of eighteen-year old peach-trees, 196 in all, were grubbed out by the owner of his own accord between November 12 and 21, and 248 fruit trees remaining were sprayed by Mr. Green with twenty-five per cent. kerosene emulsion November 30 and December 3. The weather was bright, with little or no wind. February 18 and 19, 1902, Mr. Braucher found that the trees treated in this orchard were either killed or injured, the peach having suffered worst. Injury to the cherry is also especially mentioned. Four or five of these trees had been grubbed out, and some others were nearly dead. The San Jose scale was detected at this time on ten peach-trees, all in one lot which had been sprayed by Mr. Green.

No. 3. On the place of August Burgdorf, at Quincy, was an orchard of fifteen-year-old apple-trees which, because of its close proximity to a badly infested tree belonging to a neighbor, Mr.

Green regarded as probably infested. Thirty-six of these trees nearest the infested tree were sprayed by him with a 25 per cent. emulsion December 4—a fair day with a light breeze—together with four other trees near by. February 18, 1902, this apple orchard was found by Mr. Braucher uninjured and apparently free from the scale, but two trees in an adjacent lot which had not been sprayed were at this time slightly infested.

No. 4. On Mr. Henry Hoffmeister's place, near Quincy, H. O. Woodworth found November 30, 1899, two apple-trees infested by the San Jose scale, and in November, 1900, Mr. Green reported three apple-trees badly infested and several peach-trees slightly so. These apple-trees and a few of the peach-trees were taken out by the owner and all the remainder were pruned by him preparatory to the application of the spray. In Mr. Green's judgment, as expressed at the time, this pruning was too severe and not according to his instructions, which he had illustrated by the sample pruning of a single tree. An emulsion containing twenty-six per cent. of kerosene was used on this place by Mr. Green December 17 to 19, the weather of the first day being dull and that of the other two days bright and fair. February 15, 1902, the trees on this place were in good condition according to Mr. Braucher's report, except for some apparent injury by the spray. It was said, however, by the tenant in charge that some of the trees sprayed had died and had been taken out.

All the orchards on the two places just described were sprayed with the same oil as that used on Mr. Klarner's place (No. 1), and the general remarks made concerning that place apply also to these.

Kerosene Emulsion. Season of 1901–02.

The fact has already been mentioned that from November 25, 1901, to December 9 of the same year a soap emulsion containing 25 per cent. of kerosene was used by our spraying parties on everything treated by them, and that from December 9 to February 5 it was applied to all trees but peach and plum, these being treated with the California wash. At the latter date its use was wholly abandoned and whale-oil soap was substituted for it, this and the California wash being the only insecticides applied during the remainder of the season.

The emulsion was used within this period on 6,536 trees at 14 different places in central and southern Illinois. The largest use of it was made at Makanda and Carterville, where it was applied to 1,975 and 1,770 trees respectively. August 15 and 16, 1902, Mr.

Titus visited these two localities under instructions to look carefully into the condition of the trees which had been treated with this kerosene spray, and according to his report no damage had been done at either place to trees of any description, while the effect on the scale was very satisfactory.

January 6–9, 1902, about 700 trees belonging to Dr. H. V. Ferrell, of Carterville, mainly apple but some of them cherry and pear, were treated with a 25 per cent. emulsion, and 130 trees, all apple but one—which was a pear tree—were sprayed at the same time on the place of Mr. J. W. Ghent. August 15, no injury from spraying could be detected in these orchards, which bore a crop of apples equal to the average crop of uninfested orchards in the neighborhood.

At Makanda 450 trees belonging to S. Y. Dickinson, mainly apple with a few cherry and plum, received the same kerosene treatment December 11–28, 1901. The apple orchard was on a steep clay slope and appeared to have suffered considerably from the drought of the preceding year, but there was no tangible evidence Aug. 16 of any injury due to the insecticide treatment applied.

On the place of Lammer Brothers, about 225 apple- and pear-trees were treated December 31 with a 25 per cent. emulsion, and owing to some apprehension of injury on the part of the owners this place was very thoroughly examined by Mr. Titus August 16. The trees were absolutely uninjured, as were also 530 apple-trees belonging to Mr. S. A. Carr, treated in the same way and examined at the same time.

Indeed the only injury done to trees by kerosene during the winter of 1901–02 of which I have been able to learn, was that to peaches on the place of Mr. Henry Archer, near Beamington, Sangamon county. A mixed orchard of 513 trees was sprayed here November 29 to December 4 with a 23 per cent. emulsion of kerosene. The orchard was variously composed of young and old trees, and included apple, pear, plum, peach, cherry and quince. The young trees sprayed—peach, cherry, and pear—were wholly uninjured, but certain old peach-trees were, with few exceptions, dead by July 12, when the place was inspected at my direction by one of my nursery inspectors, Dr. W. C. Bagley. From his report it appears that the young orchard above mentioned had been cultivated the preceding year, but that the old orchard in which the dead peach-trees stood had received but little care, not having been cultivated for several years, and that the trees of various kinds remaining in it, both those which had not been sprayed and those which had survived the treatment, were in poor and unthrifty condition. The weather of the days during which the older peach-trees were sprayed was somewhat unfavorable, with fogs, mists, and cloudy sky. No harm was done to apple or quince. A few of the pear-trees had died after being sprayed, but as the blight was prevalent on the place, their death was probably due to that disease.

An apple orchard belonging to Mr. I. N. Lowe, near Auburn, in Sangamon county, sprayed with a 25 per cent. emulsion showed no sign of injury on the 12th of the following July, and a few peach-trees on these premises treated in the same way and at the same time were also unharmed.

Field Use of the Lime, Salt, and Sulphur Wash.

From December 9, 1901, to April 15, 1902, all peach-trees receiving insecticide treatment by my field parties were sprayed with few exceptions with a mixture of lime, sulphur, and salt, known as the "California wash," and as a matter of convenience in spraying mixed orchards, some trees of other kinds received the same treatment. This wash was used on 433 different premises in 13 infested districts, but owing to occasional deficiencies in detail in operators' reports the total number of trees to which it was applied cannot be precisely given. Separate mention is made of its use, however, on 4,976 peach-trees, 463 plum, 586 apple, 111 pear, 31 quince, and various other kinds sufficient to bring the distinguishable total up to 9,000 trees.

During this period of four months of southern Illinois winter, the weather was, of course, widely various. The season was, as a whole, rather unusually favorable to insecticide work, but rains, sleets, snows, and freezing weather came frequently enough to test quite fully the general effect of the weather on the efficiency of the insecticide. Although no exact account of the results over all the great area treated can now be given, a general statement may be made that the effect has been excellent and entirely satisfactory so far as I now can judge.

To secure an exact basis for a general judgment of the outcome I sent Mr. Titus in August, 1902, to examine orchards treated with this wash the previous winter and spring, and I have his report of the results of an inspection of 25 orchards in four different localities,—Summerfield, Makanda, Albion, and Browns,—and of many town lots at the first and last of these places. Although these localities inspected formed but a small part of the number treated, they constitute a larger and more varied experiment with this wash than has hitherto been attempted anywhere east of the Pacific region, and a report of results will no doubt be appreciated at this time.

Formulæ for the California wash have varied considerably in the literature of the subject, and as it is possible that conflicting statements concerning its value may be due in part to these variations in composition, the following description of the wash used during the winter in Illinois will have its value in this connection. The mixture was made as follows: Fifteen pounds of stone lime were slaked in a kettle over a fire; fifteen pounds of sulphur were sifted or stirred in as the lime was slaking, these materials being boiled vigorously until the lime and sulphur were entirely dissolved—usually something over an hour; and fifteen pounds of salt were then put in and the whole was boiled a quarter of an hour longer. Enough hot water was added to make fifty gallons, and the mixture was sprayed while warm through a nozzle with a large cap for a coarse spray. When the material first dried on the tree it gave the bark a saffron-yellow color, which changed in twenty-four hours to a dull green and then gradually faded to a greenish gray.

The California Wash at Summerfield.—No. 1. One hundred and forty-five peach-, plum-, and pear-trees sprayed on the place of Wm. Hagemann between March 29 and April 2. Practically all of these trees were badly infested with the scale. On the 29th of March the weather was clear at first, with the temperature ranging from 48 to 66 degrees, but a hard rain fell in the afternoon with a light northwest wind. From March 31 to April 2 the weather was continuously cloudy but there was no rain; the wind, northwest and west, from brisk to high; and the temperature ranged from 36 to 62 degrees.

August 16 several peach- and pear-trees were examined on this place and one thousand scales were carefully examined, pains being taken, as in all other cases on this trip, to select the scales from all parts of the tree. Not a living scale was found on this place.

No. 2. Twenty-three slightly infested peach-trees sprayed March 22 and 24 in the orchard of Messrs. B. and A. Baer. The weather was clear on the first of these days but cloudy the second, the temperature ranging from 42 to 72 degrees. August 16 no living scales could be found.

No. 3. Twenty-four badly infested peach-trees belonging to Mrs. Mary Reibold treated the 15th and 18th of March, the first day cloudy throughout with a temperature ranging from 54 to 62 degrees, the wind at first south, changing to northwest at four o'clock, rain from noon onward. March 18, clear all day and cool, temperature from 20 to 34 degrees, with light wind. August 20, no living scale to be found.

No. 4. Eighty peach- and plum-trees on the premises of Daniel Krehbiel sprayed March 6–8 and 14–15. The weather was cloudy on all these days, and rain began on the afternoon of the last. Three thousand specimens of the scale examined August 20 and but two found alive, both partly grown. They had evidently come from an infested hedge in close proximity.

No. 5. On several town lots belonging to Mr. John Eicher 17 trees were sprayed with lime, sulphur, and salt March 10, and August 20 no living scales could be found.

No. 6. Forty trees were sprayed, a part of them with lime, sulphur, and salt, on the town property of Thomas Keith March 10. August 20 no living scale could be found.

The California Wash at Makanda.—No. 1. On the place of Mr. S. A. Carr, near Makanda, 457 peach-trees were sprayed with lime, sulphur, and salt late in December, beginning with the 24th. The weather was very bad—cold, with much sleet. August 16 no living scale could be found on these trees.

No. 2. On the place of Mr. S. Y. Dickerson, 1,743 trees treated with lime, sulphur, and salt at intervals throughout the season from January 2 to March 10 appeared wholly free from living scale August 16. In addition to a general inspection of these trees 2,000 scales were critically examined and none found alive.

No. 3. Thirty-three peach-trees were treated December 31 with the California wash in the orchard of Lammer Brothers, near Makanda, the weather being clear and the temperature about 40 degrees. August 16 no scales were found alive in this orchard where, besides a general inspection, 2,000 were examined critically.

No. 4. On the place of J. W. and J. E. Herrn 140 peach- and plum-trees sprayed with the California wash March 19 and 20, weather partly cloudy but without rain, thermometer 40 to 50 degrees. August 16 no living scale could be found.

No. 5. In the orchard of J. S. Springer about 190 peach- and plum-trees sprayed with lime, sulphur, and salt at various dates in January, February, and March. Four thousand scales critically examined by Mr. Titus August 16, but none found alive.

No. 6. One hundred and sixty-two peach-trees and seven plums treated March 24 to April 4 on the premises of W. H. Lipe. Sky cloudy throughout but no rain. No living scales found August 16 by general inspection or on a critical examination of 500 specimens.

All the orchards treated by my parties in this section were found in fine condition, although some of the worst infested trees had been lately attacked by the bark-borer, *Scolytus rugulosus*—an occurrence to be attributed to the diminished vitality of the trees due to the San Jose scale.

The California Wash at Albion.—No. 1. One hundred and fifty-seven peach-trees treated with lime, sulphur, and salt in the orchard of Hodgson Brothers, near Albion, April 5–15, the weather clear throughout. The buds were unfolding at this time, and the work was suspended at the latest date on account of the appearance of the leaves. August 21 the peach-trees sprayed were inspected, but no living scale could be found. Of a thousand scales examined none were alive.

No. 2. In the orchard of Mr. F. A. Kenyon 225 medium-sized peach-trees were sprayed March 18 to April 2. Two thousand specimens examined August 21 and two of them alive. No other living scales seen in this orchard.

No. 3. On the town lots of Anna C. Ferriman 23 peach-trees and 4 plums were sprayed April 7 and 8, the weather being fair. August 21 no living scale was found.

No. 4. On the town lots of Samuel Churchill (administrator) 37 peach-trees and 12 plums were sprayed April 5 and 7, the weather clear except for rain beginning at 3 o'clock p. m. on the 5th. Five hundred scales critically examined August 21 and no living ones found.

The California Wash at Browns.—No. 1. Three hundred and five peach-trees sprayed February 10–14 on the place of Atkinson Taylor, the weather being variable, with snow all day on the 10th and on the evening of the 11th. Four thousand scales examined August 21 and 22 on the peach-trees sprayed and none found alive.

No. 2. In the orchard of George Briggs 22 peach-trees treated with lime, sulphur, and salt February 1–5, the weather cloudy throughout. One thousand scales examined August 21 and none found alive.

No. 3. Eighty-nine peach-, apple-, pear-, and plum-trees, but mainly the first, sprayed with lime, sulphur, and salt February 25 to March 4. These trees were very large and badly infested. The weather was clear throughout except on the 4th, which was cloudy without rain. Aug. 22 no living scales could be found on the peach.

No. 4. Thirteen peach-trees sprayed with lime, sulphur, and salt on the town lot of Mary E. Marriott February 6, the weather being clear. Five hundred scales examined and three found alive. These were armored specimens, the only ones found alive at this place, although several town premises besides those mentioned above were carefully inspected.

3,931 trees in all had been sprayed with the California wash by my field parties on the premises inspected by Mr. Titus in August. Besides making a careful general examination of these trees and finding no living scales he critically scrutinized, one by one, 21, 500 individuals and found but seven of them alive. There were no crawling young, and none of these living scales had reached the age of reproduction.

General Summary.

Four insecticides have been extensively used as winter applications for the San Jose scale in our general orchard work of the past three years in Illinois; hydrocyanic acid gas, whale-oil soap, kerosene emulsion, and the California wash of lime, sulphur, and salt, the first being applied by fumigation and the others as liquid sprays.

All are efficient destroyers of the scale under favorable conditions, but the operation of fumigation is practically restricted to comparatively small trees and to comparatively mild and quiet weather. The California wash has an evident advantage in persistence of effect, which amounts to an appreciable protection of the tree against immediate reinfestation.

These four insecticides differ materially in safety, in cost, and in convenience of application. Fumigation with hydrocyanic acid gas and spraying with the California wash are perfectly safe to all trees and shrubs if applied after the old leaves have fallen and before the young leaves have put forth; whale-oil soap is likely to destroy the fruit buds of the peach if used before these have begun to swell in spring; and the kerosene emulsion in strength sufficient to insure the destruction of the scale is uncertain in its action on the more delicate kinds of trees,—the peach especially,—and on those of any kind which are in poor condition. Serious injury has occasionally been done to the peach, and in one case to apple, by an emulsion containing only 20 per cent. of kerosene, which is rather below the minimum strength at which this mixture should be used for the destruction of the scale. A twenty-five per cent. emulsion, on the other hand, is usually harmless to the apple and pear, but has proved in our work to be highly dangerous to the peach.

The cost of insecticide treatment includes the expense of the original equipment, that of the materials consumed, and that of the preparation and application of the insecticide. In respect to cost of equipment fumigation is by far the most expensive, especially if the trees to be treated are large, but the three insecticide sprays are prepared and applied by the aid of practically the same apparatus.

The cost of preparation and application is not materially different for the four insecticides under discussion, and will at any rate vary greatly in practice according to individual circumstances.

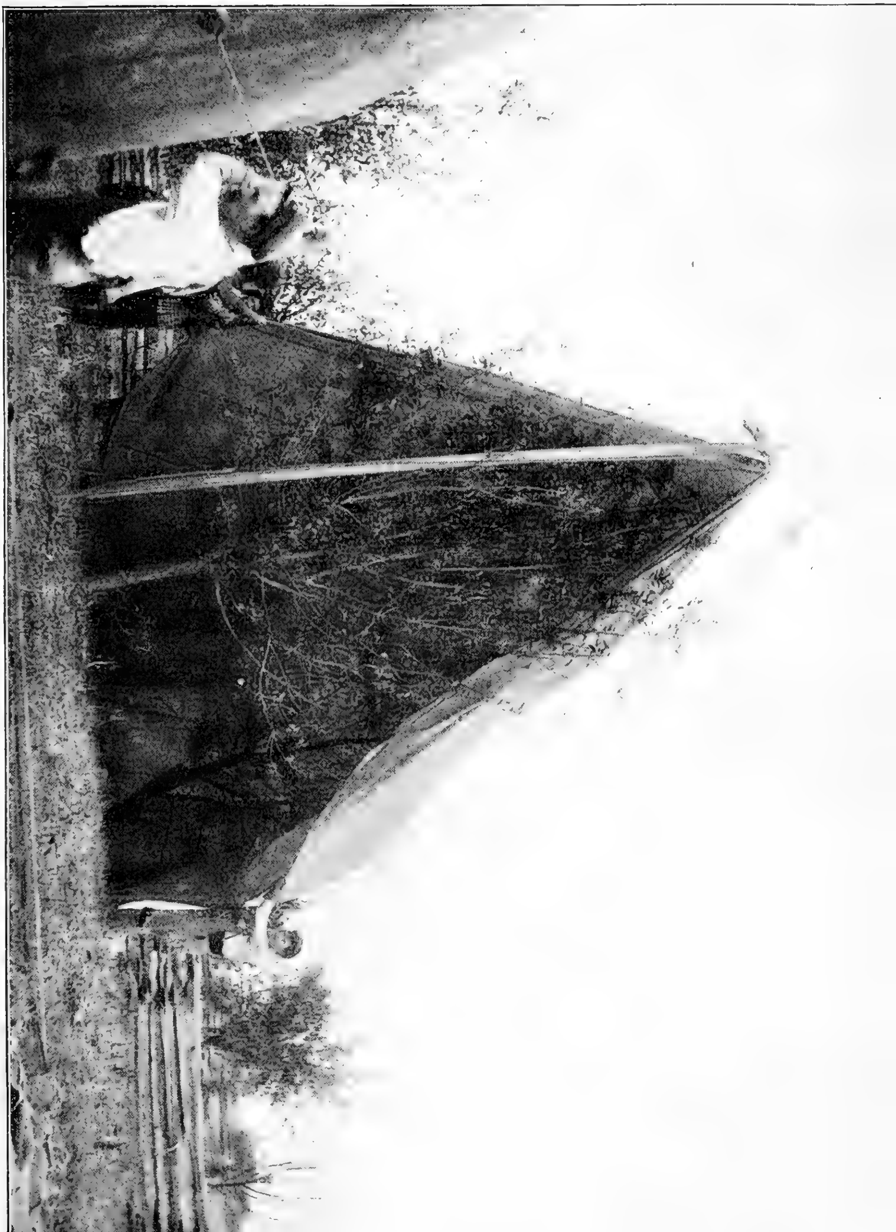
With respect to cost of materials, the fumigation process is much the most expensive. At Richview, where the trees treated were usually of medium size or less, the cost was nine cents a tree for fumigation materials, while at Sparta, where the trees averaged much larger, this cost was eighteen cents a tree. At the latter place whale-oil soap, although applied only to the largest trees as a rule, was used at a cost of seven cents a tree for the soap itself. At Carterville and Browns the average cost of lime, salt, and sulphur for the California wash was two to three cents, according to the size of the trees, while the general average per tree for kerosene emulsion as applied to over 5,000 trees was two cents each.

In convenience of application the preference belongs clearly to the kerosene emulsion and the California wash, the use of whale-oil soap being frequently embarrassed in very cold weather by the solidifying of the solution in the hose if the flow is stopped, and the operation of fumigation being a laborious and complicated one for trees above medium size.

It follows from the foregoing that of these various insecticide methods and materials the best for common use against the San Jose scale is spraying in winter with the California wash.

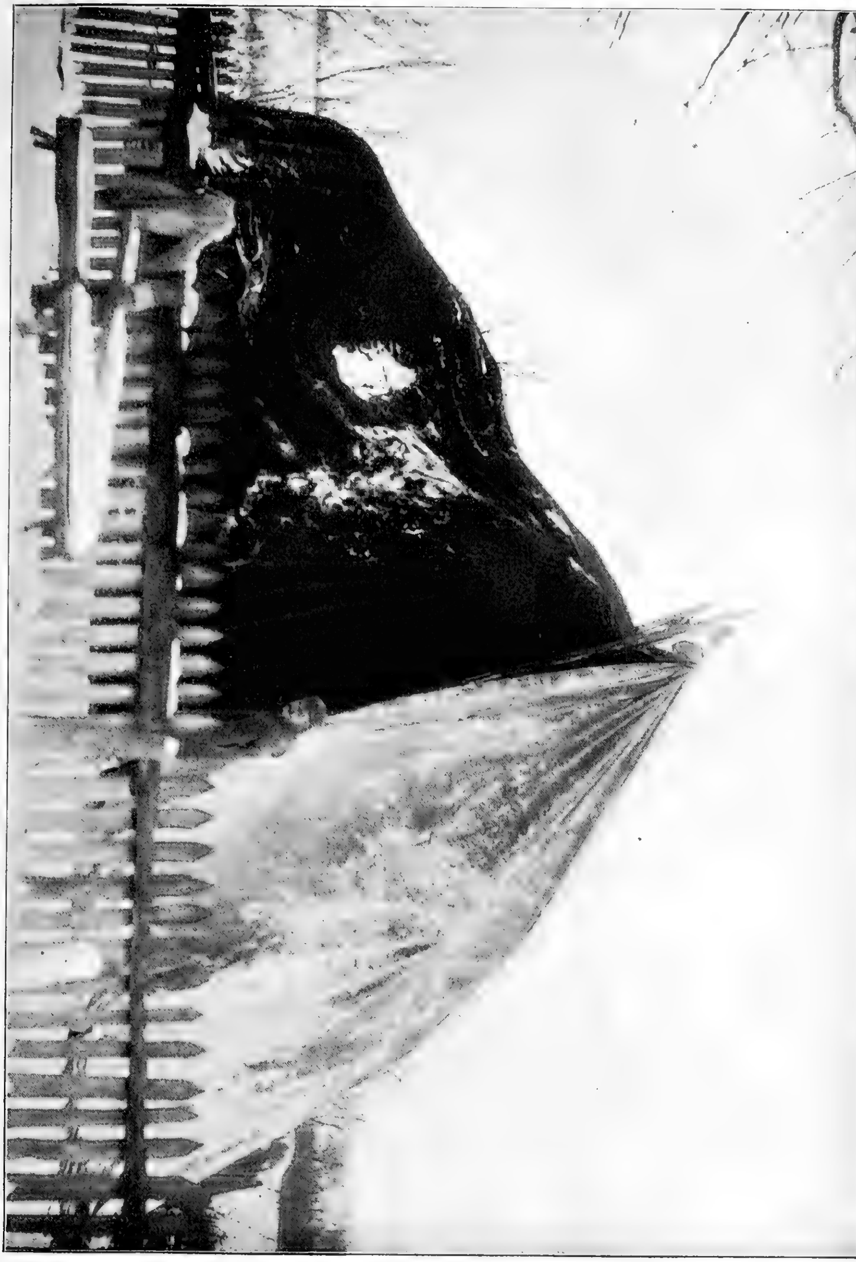
PLATE I.

OILING CANVAS FOR FUMIGATION.



SHIFTING FUMIGATION TENT WITH ONE POLE.

SHIFTING FUMIGATION TENT WITH TWO POLES IN A SNOW-STORM.



COVERING TREES WITH TWO TENTS LAPPED.

LAPPED TENTS IN PLACE, COVERING TWO TREES AT ONCE.

FUMIGATING SMALL TREES.

PLATE VII.

PEAR-TREE THIRTY-FIVE FEET HIGH INFESTED BY SAN JOSE SCALE, NEAR SPARTA, ILL.

TRIMMING AND SPRAYING PEACH-TREES.

PLATE IX.

PULLING OUT INFESTED HEDGE WITH STUMP-PULLER.

EXPERIMENTS WITH LIME AND SULPHUR WASHES FOR THE SAN JOSE SCALE.*

The "California wash" of lime, sulphur, and salt, and the "Oregon wash" of lime, sulphur, and blue vitriol, have been for many years the general reliance of the fruit growers of the Pacific Coast for protection against the San Jose scale. In a letter to me dated October 22, 1901, Prof. C W. Woodworth, of the Entomological Department of the University of California, said that "the lime, salt, and sulphur mixture is the sole dependence in this state for killing the San Jose scale," and under the same date Prof. A. B. Cordley, of the Entomological Department of the Oregon Agricultural College and Experiment Station, wrote: "With us the lime, salt, and sulphur compound is a very satisfactory remedy for the San Jose scale, and is used very extensively. In fact, this and the lime, sulphur, and blue vitriol compound are practically the only ones used for winter sprays for this insect." As early as 1889 the California wash was the only winter remedy recommended for the San Jose scale by the Secretary of the State Board of Horticulture in the Annual Report of the Board for that year; and in 1896 Prof. John B. Smith, State Entomologist of New Jersey, who visited California for a special study of the San Jose scale and its treatment there, found the lime, salt, and sulphur mixture one of the "favorite insecticides" for that scale in California and on the Pacific Coast generally.†

The introduction of these insecticides in the East has been long delayed, probably owing in large measure to unfavorable re-

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*The results of these experiments were originally published in Bulletins 71 and 72 of the State Agricultural Experiment Station, printed respectively in April and May, 1902. The first of these bulletins presented the results as apparent March 25; and the second, as shown May 12. In the present article the conclusions of Bulletin 72 have been combined with those of 71, and to this have been added the results of a later inspection made August 20. This may, consequently, be taken as a revised and enlarged edition of Bulletin 71, and a substitute for that of Bulletin 72.

†Rep. Ent. Dept. N. J. Agr. Exper. Station, 1896, p. 551.

ports of experiments made in the Atlantic states. In articles published in Bulletin 3 of the U. S. Division of Etomology, issued in 1896, and in Bulletin 30 of the same series, 1901, p. 34, the reported failure of the California wash in the East is attributed to the frequent occurrence of rains shortly after the insecticide had been applied, and chemical testimony is brought forward in support of this supposition.

USE OF CALIFORNIA AND OREGON WASHES IN ILLINOIS.

In the fall of 1901, when an appropriation of $15,000 for insecticide work on the San Jose scale became available to my office, I was embarrassed by the fact that no effective insecticide previously used by us had been found free from serious liability to injure the more tender fruit trees, or at least their fruiting buds. The peach and the plum were especially liable to serious damage by both the kerosone sprays and the whale-oil-soap solution, the first being injurious to the tree, and the second very commonly destructive to the fruit buds and, of course, to the crop of the following year. At this time I received from Professor Cordley, of Oregon, the above-mentioned letter, in which he suggested that I should give the lime, sulphur, and salt compound a thorough test in Illinois, and further said that in Oregon, where this mixture is thoroughly effective, the climate is as moist during the winter—when the spray is principally used—as in any part of the East. I had additional testimony to the same effect from a former student and assistant of mine, Mr. Fred McElfresh, who informed me, after a year's experience in entomological work at the Oregon Agricultural College, that the weather of western Oregon is very similar to that of the greater part of Illinois.

Under these conditions, I decided last fall to use the lime, salt, and sulphur mixture, standard in the Pacific states, for all our Illinois insecticide work on the peach and plum, preferring to take the risk of a possible inefficiency of the insecticide rather than the much greater one of serious injury to the orchard tree. The season seemed favorable to the treatment, and highly encouraging reports came in from the field throughout the entire winter up to early March. At this time, in order to secure more precise and comprehensive information as to the value of the Oregon and California washes, I detailed one of my office assistants, Mr. E. S. G. Titus, to carry out a series of experiments with them under various conditions and sent him to Summerfield, in St. Clair county, where he remained for three weeks, supervising the treatment of the trees, and making counts of scales and other observations of the results.

Secondary Results of the Experiments.

It was the principal object of these experiments to test the effects of rains on the two washes used, but other important results appeared in the outcome besides those immediately aimed at. Counts of dead and living scales on the check trees not treated and on the experimental trees before treatment, showed a surprising percentage of half grown scales already dead, the ratio of dead young to living scales varying on different trees and on different parts of the same tree from twenty-one per cent. to sixty-nine per cent This fact had already been observed in other localities where our insecticide work was in progress, and had, indeed, been noticed and reported as early as 1898 by another assistant of the office, Mr. E. B. Forbes, engaged in distributing to infested trees in southern Illinois the spores of a fungus parasite of the San Jose scale.

This spontaneous death of many of the scales which might have been expected to pass the winter alive, was apparently due in great measure and in both instances to a severe drouth of the preceding year. Consistently with this explanation the dead scales were most abundant on trees worst affected by the drouth, and on parts of trees to which the flow of sap would naturally be least.

Another observation of importance to the investigator was made with reference to the action of the insecticide in loosening the scales of the insects killed by it. In most cases where the application took fatal effect the scales were so far loosened from the bark that they were easily rubbed off, and might be washed away in large numbers by an ordinary rain. As a consequence, if counts were made of dead and living scales upon a tree before treatment, and again after a treatment and after a heavy rain had fallen, the ratio of living to dead might be as great in the latter case as in the former. It will be seen that by overlooking this circumstance an investigator might easily be led to very erroneous conclusions as to the effects of moisture on the insecticide.

General Features of the Experiments.

The actual effect of rains was experimentally ascertained by heavily spraying the trees with water at selected intervals after treatment with the wash, and by making careful counts of dead and living scales in each case and comparing the ratios so arrived at with those found in the beginning. The trees sprayed with each mixture were treated exactly alike except as to the subsequent application of water, and in this latter respect the different trees received very different treatment. Some, for example, were watered but once, and that the next day after the application of the insecticide wash; and others were watered daily for the seven days next following it. In order to avoid interference with the experiments by rains, which fell three times during the fortnight covered by the greater part of the experiments, some of the trees were covered by canvas tents at night and whenever rain threatened.

General Statement of Results.

Details of all forms and variations of the experiment will be given further on, but it is sufficient for this general statement to say that the general average result of a single spraying of twenty trees with lime, sulphur, and salt, as tested at the end of a week from treatment, was the destruction of 89 per cent of the scales when no water was applied within five days, and of 86 per cent. when water was used. The corresponding result of the application of lime, sulphur, and blue vitriol to fifteen trees was the destruction of 91.2 per cent. of the scales without water, and 90.7 per cent. when water was applied within the first five days. This statement, however, does not represent the final results of the experiment, for on May 12, ten weeks after the trees were sprayed, an average of 99.2 per cent. of the scales alive in the beginning were dead, and there was no perceptible difference in this respect between the lots treated with the Oregon wash and those treated with the California wash, or between those which had simply received the insecticide spray and those which had been subsequently sprayed profusely with water.

Still more conclusive and convincing is the statement of the result of an inspection of these trees made August 20, at which time 13,300 scales were examined on 23 of the trees used in the experiment, and of this number only twenty-five scales were alive. These living scales were, in fact, found only on two trees which stood close to an infested hedge which had never received any insecticide treatment, and they were only on the branches of these trees next the hedge and interlacing with it. It is scarcely too much to say, consequently, that the apparent final result was practically a complete extermination of the scale on all trees treated.

Period and Methods of the Experiments.

The experiments on which the above statement rests may be conveniently described in five lots: two with lime, sulphur, and blue vitriol; two with lime, sulphur, and salt; and one, a special experiment, with both these washes on trees covered by tents. Two of the four experiments above mentioned—one with the California wash and one with the Oregon wash—were begun March 3, and the other two (in which also both washes were used) were begun March 5. The tent experiment was begun on the 21st of the month. Almost daily observations on the lots treated were continued until March 25; that is twenty-two days for the first two lots, twenty days for the third and fourth, and five days for the lot under tents. A careful examination was made May 12, ten weeks after the first trees were sprayed, and a final inspection August 20, more than five months after the time of treatment.

The experiments consisted of a single application of the insecticide in every case, with varying subsequent treatments of the different trees with water. Frequent counts of dead and living scales were made for all of the trees, no attention being paid in these counts to old dead scales, but only to those whose size and immature character showed that they belonged to the new generation of the preceding fall. Counts of dead and living scales were made in all cases either before or shortly after the application of the insecticide spray. It was in this way ascertained that an average of about fifty per cent. of the immature scales were already dead on these trees before the insecticide was applied; and that the action of the insecticide was scarcely perceptible within the first twenty-four hours.

Experimental Trees Used.

Forty-three trees were used in all the experiments, twenty-five of them apple-trees and eighteen peach. They varied in height from twelve to eighteen feet; in spread of top from eight to twenty feet; and in diameter of trunk from four to nine inches. The average height was fourteen feet, and the average spread, thirteen. The general condition of these trees varied from "very poor" to "excellent," six of them being described as "very poor," eight as "poor," sixteen, as "fair," ten, as "good," and three, as "excellent." Some of the peach-trees were more than half dead, and many of them in such a condition that the owners were about to remove them. The dry weather of the preceding summer had killed the young growth even on otherwise healthy trees, and in some cases much of the older wood had also died from drouth. All the trees were, of course, infested with the San Jose scale, eighteen of them badly so, and the others to a medium degree.

Weather of the Period.

The weather of the experimental period was the ordinary variable weather of an Illinois March, the temperature at seven o'clock

a. m. ranging from 18° F., on the 18th, to 54°, on the 15th, and at noon, from 34°, on the 18th, to 88°, on the 25th. There was an unusual amount of wind from the southeast—on not less than fourteen days out of the twenty-two. Rain fell on six days, and a light snow on one other. The first rain, on March 7, lasted for two and a half hours, but was very light—about two gallons for each experimental tree according to Mr. Titus's estimate. The temperature at the time was 56°. On the ninth day after the beginning of the first experiment (March 11) the weather was showery, with heavy mist most of the day, the temperature 60° to 64°; and on the thirteenth day (March 15) a heavy shower of rain fell, with hail, for an hour in the afternoon, amounting to ten or twelve gallons to the tree. The 17th and 18th were cold—26° in the morning and 24° at noon on the 17th, and 18° in the morning and 24° at noon on the 18th. The wind blew strong and cold from the northwest, with a light snow on the first of these days. A slow drizzling rain fell on the 20th, beginning at about five in the afternoon and continuing through the night and all the following day.

The insecticide sprays were applied on the 3d, the 5th, and the 20th. March 3 was a partly cloudy day, with a cold raw wind from the east and northeast, the thermometer registering 30° at 7 a. m. and 40° at noon. The 5th was a clear day, with a northwest wind, fairly strong, the thermometer 30° at 7 a. m. and 45° at noon. On the 20th the wind was from the southeast, with a threat of storm which resulted in rain at five o'clock in the afternoon. The temperature was 34° at 7 a. m. and 57° at noon.

Preparation of the Insecticides.

The insecticide washes were prepared in substantially the same manner. For the California wash, fifteen pounds of stone lime were slaked in a little very hot water, fifteen pounds of ground sulphur being slowly poured in during the slaking process with constant stirring of the mixture. This was then boiled for an hour, after which fifteen pounds of salt were added and the boiling continued for fifteen minutes longer. The whole was then poured into a barrel through a strainer, and enough boiling water was added to make fifty gallons. In the preparation of the Oregon wash a pound and a quarter of blue vitriol was used instead of the salt, the crystals of the blue vitriol being dissolved in hot water and the solution added slowly to the slaking lime. The apparatus used was a Morrill and Morley pump, with twenty-five feet of hose and a twelve-foot extension rod with a double Vermorel nozzle.

The Water Sprays to test Effect of Rains.

In wetting down the trees to imitate the effects of rain, fifteen gallons of water were used to a tree, as a rule, a double amount being occasionally applied as a variation of the experiment. For a tree of the average spread of thirteen feet, fifteen gallons of water was equivalent to a rainfall of a sixth of an inch, amounting to a sharp summer shower. The washing and leaching effect of the application was, however, greater than that of a corresponding shower, since the water spray was not distributed equally over the whole area covered by the tree-top, but was made to wet the tree equally in all parts—the middle part of the tree much more freely, consequently, than the outer parts. It would doubtless be fair to say that the fifteen-gallon portion was equivalent in effect on the average experimental tree to a rainfall of a third of an inch, and the double portion, of course, to twice that amount. The time taken for the application of fifteen gallons varied, according to the weather and the size of the tree, from twenty minutes to thirty or thirty-five, and for the thirty-gallon application it was never less than an hour. The water in all cases dripped freely from the trees for some time after spraying ceased, carrying with it so much of the insecticide in solution that the drip was of about the color of the original mixture.

The applications of water were varied systematically as to number, to frequency, and to period of time between the insecticide operation and the first general wetting. Tree No. 1, for example, was wet every day for a week, commencing the next day after the California wash was applied; tree No. 2 was wet but once, and that the day after insecticide treatment; tree No 3 was sprayed on the 3d with the California wash, and with water on the 6th and every other day thereafter for three days; tree No. 6 was sprayed but once, and then with thirty gallons of water, one week after insecticide treatment.; and tree No. 9, the same, except that the water was applied at the end of two weeks. Further particulars may be obtained from the detailed accounts of the experiments.

Explanation of Tables.

The four tables in the text have been prepared to present in summary form the detailed results of the treatment for each tree as shown by successive counts of scales on selected sample twigs and branches. Against the number of each tree is placed for each date on which special observations were made, the number of scales counted and the percentage of scales killed by the insecticide up to that time. The first count shows always the percentage of scales found alive at the time of treatment. At the bottom of each table is a series of data for the entire lot of trees, corresponding in form to those in the body of the table for each tree.

Experimental Details.

First Lot of Trees. California Wash.

Nine apple-trees sprayed with lime, sulphur, and salt on the 3d day of March. Weather partly cloudy, with cold raw wind from the east-northeast, temperature 30° at 7 a. m. and 40° at noon.

Dead and living scales were first counted on these trees the following day, March 4. Although the fact was not known at the time, it became apparent later, by comparison of percentages of scales on these trees with those found on check trees and on other lots counted before insecticide treatment, that no discoverable effect of the insecticide had been produced at the time this first count was made. If any scale insects had been killed so soon, their appearance had not yet sufficiently changed to indicate the fact. The percentages found on this first day are consequently to be taken as indicating the ratio, before treatment, of dead and living scales among the young of the preceding year. One thousand three hundred and fifty such scales were counted in all, and 52 per cent. of these were alive, 48 per cent. having died from unknown causes, in most cases probably from drouth.

In determining the effect of the insecticide under the varying conditions supplied, this first count of living scales was made the starting point for the calculation of the percentages of scales killed; that is, if only 50 per cent. of the scales were found alive at the beginning of the experiment, the destruction of scales by the insecticide was figured on this 50 per cent., those dead in the beginning being of course ignored. Counts were made upon carefully selected specimen twigs or branches, the number counted each time varying from 100 to 4,000, and the totals for each tree, from 300 to 5,400. The total number of scales counted from this lot on nine trees was 24,600.

The effect of the insecticide was only gradually made manifest, and was not fully produced during the period of continuous observation which ended on the 25th of March. This fact was not understood at the time but was made apparent by the result of the visit of May 12, as shown in the last column but one of the table for Lot 1.

As these various trees were treated subsequent to the insecticide spray by an application of various amounts of water at different intervals, it will be necessary to discuss each tree separately.

LOT I. SPRAYED WITH LIME, SULPHUR, AND SALT, MARCH 3.

Tree	Scales	Mar. 4	Mar. 6	Mar. 8	Mar. 9	Mar. 10	Mar. 15	Mar. 18	Mar. 20	Mar. 22	Mar. 23	Mar. 25	May 12	Aug. 20
1	No. counted..	150	200	400	....	300	200	....	....	200	350	300	500	4000
	Per ct. alive..	40	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	75	84	....	83	74	....	....	74	78	85	100	100
2	No. counted..	150	100	....	....	....	100	....	....	100	300	100	500	2000
	Per ct. alive..	37	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	78	....	....	....	86	....	....	95	87	92	98.9	100
3	No. counted..	200	150	....	....	150	100	150	....	....	....	100	500	200
	Per ct. alive..	29	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	53	....	....	79	89	88	....	....	....	72	98.6	100
5	No. counted..	150	....	....	150	....	300	....	150	....	....	100	....	200
	Per ct. alive..	47	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	80	....	90	....	91	....	....	94	....	100
6	No. counted..	150	....	....	150	....	150	....	....	....	....	150	500	500
	Per ct. alive..	64	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	84	....	86	....	....	....	....	86	100	100
7	No. counted..	150	....	150	....	200	150	....	....	....	....	150	....	500
	Per ct. alive..	68	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	80	....	83	89	....	....	....	....	92	....	100
8	No. counted..	100	100	....	....	....	....	150	....	150	....	150	....	400
	Per ct. alive..	54	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	54	....	....	....	....	90	....	84	....	91	....	100
9	No. counted..	150	....	300	....	....	200	150	300	....	....	150	500	100
	Per ct. alive..	56	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	83	....	....	87	85	89	....	....	94	99.6	100
10	No. counted..	150	150	....	150	....	200	....	250	....	....	150	500	700
	Per ct. alive..	69	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	77	....	95	....	99	....	95	....	....	92	99.4	100
Totals	No. counted..	1350	700	850	450	650	1400	450	700	450	650	1350	3000	8600
	Per ct. alive..	52	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	67	82	86	82	87	88	92	85	83	88	99.4	100

Tree No. 1.—A tree sixteen feet high, with a nine-inch trunk and a twenty-foot top; in fair general condition, but badly infested with the San Jose scale. After insecticide treatment March 3, sprayed with fifteen gallons of water daily for seven days, from March 4 to 10 inclusive; a total application of one hundred and five gallons, equal to about half an inch of rainfall over the whole area beneath the tree-top. Rains falling as above described, added about fifteen gallons of water to this amount.

Forty per cent. of the young scales of the preceding year were alive on this tree when the treatment began. Three days after, 75 per cent. of these had been killed, and five days after, 84 per cent. The samples taken on the twelfth and nineteenth days showed an extraordinary percentage of living scales,—26 per cent. on each day,—and the average ratio of scales killed by May 12 stands at 100 per cent. August 20, four thousand scales were examined, of which all but nineteen were dead, the living scales being found only on the lower branches which penetrated an adjacent infested hedge.

Tree No. 2.—A sixteen-foot tree, with a nine-inch trunk and an eighteen-foot top; in fair general condition, but badly infested with the scale. Treated with water but once, and that on March 4, the day succeeding the application of the insecticide spray. Rainfall of course followed on the 7th, 11th, and 15th, as on all other trees of this experiment, amounting to about fifteen gallons of water additional. Thirty-seven per cent. of the scales alive at the time of treatment; 78 per cent. of these dead three days after; and 86 per cent. dead on the twelfth day. The final effect was the killing of 98.9 per cent. of the scales. August 20, two thousand scales examined were all dead.

Tree No. 3.—An eighteen-foot tree, with an eight-inch trunk and a thirteen-foot top; in good general condition, but badly infested. Water treatment three days after the insecticide application, and twice on alternate days thereafter, making forty-five gallons of water thus applied. Twenty-nine per cent of the scales alive when the treatment began; 53 per cent. of these dead on the third day and 79 per cent. on the seventh; the final destruction of scales, 98.6 per cent. Of two hundred scales examined August 20, none were alive.

Tree No. 5.—A fifteen-foot tree, with an eight-inch trunk and an eleven-foot top; in poor condition, badly infested. Sprayed with fifteen gallons of water five days after treatment, and again two days later. Forty-seven per cent. of the scales alive in the beginning; 80 per cent. of these killed by the sixth day, when the first count was made, 90 per cent. by the twelfth, and 94 per cent. by the 22d day. Of two hundred scales examined August 20, none were alive.

Tree No. 6.—A fifteen-foot tree, with an eight-inch trunk and a twelve-foot top; in poor condition, moderately infested by the San Jose scale. Treated but once with water, and this on the seventh day after the insecticide spray, when thirty gallons were applied. Sixty-four per cent. of the scales alive in the beginning; 84 per cent. of these dead by the sixth day and 86 per cent. by the twelfth; ratio of scales finally killed, 100 per cent. Of five hundred scales examined August 20, none were alive.

Tree No. 7.—An eighteen-foot tree with an eight-inch trunk and a ten-foot top; in poor general condition, moderately infested by the scale. Fifteen gallons of water on the thirteenth day after insecticide treatment, and another fifteen gallons on the fourteenth; before this, only the rainfalls already described. This tree and all the remaining trees of this lot were practically check trees with regard to the effects of the water sprays, since these were applied after the full effect of the insecticide must have been produced. Sixty-eight per cent. of the scales alive in the beginning; 80 per cent. of these dead on the fifth day, 83 per cent. on the seventh, and 92 per cent. on the twenty-first. Of five hundred scales examined August 20, none were alive.

Tree No. 8.—Seventeen feet high, with an eight-inch trunk and a twelve-foot top; in fair general condition, but badly infested with the scale. But one application of water, and that fifteen gallons on the fourteenth day after insecticide treatment. Fifty-four per cent. of scales alive in the beginning, and 54 per cent. of these dead on the third day; 90 per cent. dead on the sample representing the fifteenth day, and 91 per cent. on the twenty-first. Of four hundred scales examined August 20, none were alive.

Tree No. 9.—A sixteen-foot tree, with an eight-inch trunk and an eleven-foot top; in fair condition, but badly infested. No water (except rains) until the fourteenth day, when thirty gallons were applied. Fifty-six per cent. of the scales alive in the beginning; 83 per cent. of these dead on the fifth day and 87 per cent. on the twelfth; final effect, May 12, 99.6 per cent. destroyed. Of one hundred scales examined August 20, none were alive.

Tree No. 10.—A fifteen-foot tree, with a seven-inch trunk and a thirteen-foot top; in fair condition, moderately infested. No water was applied to this tree, and the effect of the insecticide was modified only by the natural rainfall already referred to. Sixty-nine per cent. of the scales alive in the beginning; 77 per cent of these dead on the third day and 95 per cent. on the sixth, with a final result of 99.4 per cent. destroyed by May 12. Of seven hundred scales examined August 20, none were alive.

Taking the entire group of nine trees together, without reference to differences of treatment subsequent to the insecticide spray, it appears that an average of 52 per cent. of the scales were alive in the beginning; that 67 per cent. of these were dead by the third day, 82 per cent. by the fifth, and 86 per cent. by the sixth; and that the final average effect of the treatment was the destruction of 99.4 per cent. A continued effect of the insecticide to arrest reproduction or to prevent the establishment of the young is shown by the fact that only nineteen scales out of eight thousand six hundred were found on these trees five months after treatment, and that these living scales had evidently entered the single tree on which they were found from an adjacent infested hedge.

Second Lot of Trees. California Wash.

Nine trees, partly apple and partly peach, sprayed with lime, sulphur, and salt on the 5th of March. Weather clear, with fairly

LOT II. SPRAYED WITH LIME, SULPHUR, AND SALT, MARCH 5.

Tree	Scales	Mar. 5	Mar. 7	Mar. 9	Mar. 10	Mar. 15	Mar. 18	Mar. 20	Mar. 21	Mar. 22	Mar. 23	Mar. 24	Mar. 25	May 12	Aug. 20
4	No. counted	100			200	400				200			250		200
	Per ct. alive	42													
	Per ct. killed				83	87				80			68		100
20	No. counted	200					150						100		
	Per ct. alive	47													
	Per ct. killed						92						98		
27	No. counted	200		150	300			250					200		100
	Per ct. alive	36													
	Per ct. killed			62	80			78					88		100
29	No. counted	200		200		200		200			200		150		
	Per ct. alive	42													
	Per ct. killed			80		92		87			98		93		
31	No. counted	300		200	100			250					200	500	200
	Per ct. alive	37													
	Per ct. killed			78	83			92					78	97.3	100
32	No. counted	300		300		300			200		200		300		
	Per ct. alive	44													
	Per ct. killed			69		86			79		89		87		
33	No. counted	300		200		300				200			300		
	Per ct. alive	45													
	Per ct. killed			70		80				87			95		
35	No. counted	200	200		200		300		300			200	300		
	Per ct. alive	38													
	Per ct. killed		62		90		90		99			91	97		
36	No. counted	200	300		200		200					200	200	500	200
	Per ct. alive	51													
	Per ct. killed		51		85		97					94	99	100	100
Totals	No. counted	2000	500	1050	1000	1200	650	700	500	400	400	400	2000	1000	700
	Per ct. alive	42													
	Per ct. killed		56	71	84	86	93	86	88	84	94	93	89	98.6	100

strong northwest wind; temperature, 30° at 7 a. m. and 45° at noon. In this case the dead and living scales were counted on sample twigs and branches from a part of the trees just before the application of the insecticide, and from another part on the following day. The ratios of dead to living scales were practically identical in these two lots, thus showing, as has been already remarked, that scales killed the first day, if any, do not sufficiently change in appearance within that time to suggest the fact. Subsequent counts of scales were made for this lot on thirteen later dates, the number counted, as before, ranging from one hundred to five hundred, and amounting for the lot to 11,500 specimens.

Tree No. 4.—An apple-tree, sixteen feet high, with a nine-inch trunk and a twelve-foot top; in fair condition, but badly infested by the scale. This tree received but one water treatment, and that on the 7th of March, two days after the insecticide application and on the same day as the first light fall of rain. Fifteen gallons were applied, and approximately two gallons must be added for the rainfall. Scales alive in the beginning, 42 per cent.; 83 per cent. of these dead on the sample for the fifth day, and but 68 per cent. on that for the twentieth day. August 20, two hundred scales examined, all dead.

Tree No. 20.—A peach-tree twelve feet high, with a six-inch trunk and a nine-foot spread of top; in very poor condition, though but moderately infested by the scale. No water except the natural rainfall. Forty-seven per cent. of the scales were alive in the beginning; 92 per cent. of these were dead on the thirteenth day, when the first subsequent count was made, and 98 per cent. on the sample for the twentieth day.

Tree No. 27.—An apple-tree, fifteen feet high, with an eight-inch trunk and a seventeen-foot top; in good condition, moderately infested with the scale. This tree was sprayed with water but once, and that five days after the insecticide application. Thirty-six per cent. of the scales were alive in the beginning; 62 per cent. of these were dead on the fourth day, 80 per cent. on the fifth and 88 per cent. on the twentieth. August 20, one hundred scales examined: all dead.

Tree No. 29.—An apple-tree, twelve-feet high, with a seven-inch trunk and a fifteen foot top, in bad condition, and heavily infested. Twice treated with water, once on the fifth day after the insecticide spray and once on the tenth, in each case with fifteen gallons. Forty-two per cent. of the scales alive at the beginning of the experiment; 80 per cent. of these dead on the fourth day, 92 per cent. on the tenth day, and 93 per cent. on the twentieth.

Tree No. 31.—An apple-tree, twelve feet high, with an eight-inch trunk and a nineteen-foot top; in good general condition, and moderately infested by the scale. Once treated with thirty gallons of water, on the next day after the application of the insectide spray. Thirty-seven per cent. of the scales were alive in the beginning; 78 per cent. of these were dead on the fourth day and 83 per cent. on the fifth; the final effect of the insecticide 97.3 per cent. destroyed. August 20, two hundred scales examined, all dead.

Tree No 32.—A peach-tree, twelve feet high, with a six-inch trunk and a nine-foot top; in fair general condition, but heavily infested. Treated with fifteen gallons of water a day for three days in succession, beginning the next day after the insecticide spray was applied. The second of these treatments coincided with the first day's rain. Forty-four per cent. of living scales at the beginning; 69 per cent. of these dead on the fourth day, and 87 per cent. on the twentieth, according to the sample for that day.

Tree No. 33.—A peach-tree, nine feet high, with a three-inch trunk and an eight-foot top; in good condition, moderately infested by the scale. Sprayed twice in succession with fifteen gallons a day, following immediately upon the insecticide treatment, the second application coinciding with the first day's rain. Forty-five per cent. of the scales alive at the start; 70 per cent. of these dead on the fourth day, 80 per cent. on the tenth, and 90 per cent. on the twentieth.

Tree No. 35.—A peach-tree, fifteen feet high, with a five-inch trunk and a twelve-foot top; in poor condition, and moderately infested by the scale. Treated but once with water, and that on the tenth day after the experiment began, this treatment coinciding with the third day's rain. Thirty-eight per cent. of the scales alive at the time of the application of the insecticide; 62 per cent. of these dead on the second day, 90 per cent. on the fifth, and 97 per cent. on the twentieth.

Tree No. 36.—A peach-tree, fifteen feet high, with a six-inch trunk and an eight-foot top; in poor condition, and heavily infested. Treated with water twice, once on the day following the insecticide treatment and once on the tenth day of the experiment, the last treatment coinciding with the third day of rain. Fifty-one per cent. of the scales alive in the beginning, and 51 per cent. of these dead on the second day after insecticide treatment; 85 per cent. dead on the fifth day, with a final destruction of 100 per cent. of the scales, according to the sample examined after twenty days. August 20, two hundred scales examined, all dead.

Taking this group of nine trees as a whole and averaging all statements concerning them, it appears that 42 per cent. of the scales were alive when the experiment began; and that 56 per cent. of these had been killed by the treatment by the second day thereafter, 71 per cent. by the fourth, 84 per cent. by the fifth, and 89 per cent. by the twentieth.

On the two trees examined May 12, 98.6 per cent. of the scales had been killed by the spray, and on the four trees inspected August 20, no living scales were found among the seven hundred examined.

To this lot it will be convenient to add for discussion two other trees sprayed with lime, sulphur, and salt on the 7th of March, which, it will be remembered, was the day of the first rainfall occurring in the experimental period. These trees received no water treatment, but were intended as checks on the other experiments.

Tree No. 38.—The first of these was a peach-tree, nine feet high, with a five-inch trunk and a ten-foot top. It was in excellent condition, and only moderately infested. Thirty-eight per cent. of the scales were alive on the day preceding the insecticide application, and eighteen days after the treatment 85 per cent. of these were dead.

Tree No. 39.—The second tree of this pair was also a peach-tree, about nine feet high, with a five-inch trunk and a ten-foot top, It was in excellent general condition, and moderately infested. Only 27 per cent. of the scales were alive when the experiment began; 94 per cent. of these were dead by the eighteenth day after treatment.

General Results of Experiments with Lime, Sulphur, and Salt.

An analysis of the data contained in the above descriptions of Lots 1 and 2 and in the tables of percentages for those lots enables us to distinguish two groups of trees; those which received some treatment of water within five days after the insecticide application, and those which, if treated with water at all, did not receive it until the seventh day or later.

There are eleven trees in the first group, namely, 1, 2, 3, 4, 5, 27, 29, 31, 32, 33, and 36, and nine trees in the second, namely, 6, 7, 8, 9, 10, 20, 35, 38, and 39.

The average effect of the insecticide upon the nine trees of the second group was the destruction of 92.1 per cent. of the scales by March 25, and the corresponding destruction on the eleven trees of the first group was 86.5 per cent., making a difference of 5.6 per cent., apparently due to the action of water on the insecticide when applied within five days after the original treatment. In other words and more generally stated, it may be said that in these experiments the effect of thoroughly watering the treated tree during the first five days after the experiment began, was to diminish, at first, the destructive effect of the insecticide by approximately 5.5 per cent.; but since, as will be presently shown, all differences finally disappeared, the real effect was merely to delay the action of the insecticide in a manner which proved entirely unimportant.

If we regard as a single group the twenty trees treated with the California wash, we find that 48 per cent. of the young scales of the preceding year were dead when the experiment began; that 43 per cent. of them were killed by the second day after treatment; 60 per cent. by the third; 84 per cent. by the fifth; and approximately 89 per cent. by the twentieth day. The final effect of this wash, as shown by an inspection of eight of these trees on the 12th of May, was the destruction of 99.2 per cent. of the scales alive at the beginning of the experiment.

Third Lot of Trees. Oregon Wash.

This lot of experimental trees corresponds to the first in all particulars except that the Oregon wash of lime, sulphur, and blue vitriol was used as an insecticide instead of the California wash, and that the experiment was made with seven trees instead of nine. The variations in treatment omitted in this lot correspond to those of Nos. 5 and 7 of Lot 1. All were apple-trees, growing in the same orchard as those of the first lot.

Tree No. 11.—An eighteen-foot tree, with an eight-inch trunk and a twelve-foot spread; in excellent condition, and moderately infested. Sprayed with fifteen gallons of water daily for seven days, beginning March 4, the next day after insecticide treatment. Sixty-seven per cent. of the scales alive at the beginning of the experiment; 85 per cent. of these dead on the third day, 93 per cent. on the seventh, and 98 per cent. on the twenty-second. By May 12 the percentage killed on this tree was found to be 98.8, and on August 20, out of two thousand scales examined only six were found alive, and these were on branches next an infested hedge.

Tree No. 12.—A fifteen-foot tree, with an eight-inch trunk and a twelve-foot top; in fair condition, moderately infested with the scale. Sprayed but once, with fifteen gallons of water, on the day following the insecticide treatment. Sixty-six per cent. of the scales alive in the beginning; 85 per cent. of these dead by the third day, 93 per cent. by the seventh, and 95 per cent. by the twenty-second day; the effect, May 12, the destruction of 99.4 per cent. August 20, two hundred scales were examined, and none alive.

Tree No. 13.—A twelve-foot tree, with a six-inch trunk and a thirteen-foot top; in good condition, and but moderately infested. Sprayed with water three times, beginning March 6, with intervals of one day between applications, the first rainfall coming between the first and second sprayings. Fifty-seven per cent. of the

LOT III. SPRAYED WITH LIME, SULPHUR, AND BLUE VITRIOL, MARCH 3.

Tree	Scales	Mar. 4	Mar. 6	Mar. 8	Mar. 9	Mar. 10	Mar. 15	Mar. 18	Mar. 20	Mar. 22	Mar. 23	Mar. 25	May 12	Aug. 20
11	No. counted..	300	300	....	....	150	150	....	150	....	250	150	500	2000
	Per ct. alive..	67	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	85	....	....	93	93	....	92	....	88	98	98.8	100
12	No. counted..	300	300	....	....	250	300	....	250	....	....	200	500	200
	Per ct. alive..	66	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	85	....	....	93	96	....	95	....	....	95	99.4	100
13	No. counted..	200	....	....	....	250	250	350	....	....	300	300	500	500
	Per ct. alive..	57	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	....	89	94	95	....	....	96	98	98.9	100
14	No. counted..	300	....	150	....	150	....	....	200	....	100	150	500	100
	Per ct. alive..	49	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	83	....	96	....	....	93	....	84	96	99.6	100
15	No. counted..	300	....	150	....	200	150	100	....	....	....	250	....	....
	Per ct. alive..	61	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	87	....	80	81	97	....	....	....	98	....	....
16	No. counted...	300	....	300	....	....	300	....	300	....	400	300	500	100
	Per ct. alive..	48	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	81	....	....	92	....	93	....	94	95	99.6	100
17	No. counted..	300	200	....	150	....	300	....	150	....	....	150	....	....
	Per ct. alive..	41	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	68	....	76	....	95	....	90	....	....	99	....	....
Totals	No. counted..	2100	800	600	150	1000	1450	450	1050	....	1050	1500	2500	2900
	Per ct. alive..	56	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	79	84	76	90	92	96	93	....	90	97	99.3	100

scales alive in the beginning; 89 per cent of these dead on the seventh day, when the first subsequent count was made, 94 per cent. on the twelfth, and 98 per cent. on the twenty-second; effect, May 12, the destruction of 98.9 per cent. August 20, five hundred scales examined, none alive.

Tree No. 14.—This tree was thirteen feet high, with a six-inch trunk and a sixteen-foot top. It was in good condition, but badly infested by the scale. It was treated but once with water, thirty gallons being applied seven days after the insecticide, agreeing in this respect with No. 6 of Lot 1. Forty-nine per cent. of the scales were alive in the beginning. Eighty-three per cent. of

LOT IV. SPRAYED WITH LIME, SULPHUR, AND BLUE VITRIOL, MARCH 5.

Tree	Scales	Mar. 5	Mar. 7	Mar. 9	Mar. 10	Mar. 15	Mar. 18	Mar. 20	Mar. 21	Mar. 22	Mar. 23	Mar. 25	May 12	Aug. 20
	No. counted..	300	200	....	300	400	....	300	....	....	200	200	500	200
18	Per ct. alive..	47	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	15	....	83	89	....	87	....	....	91	87	98 3	100
	No. counted..	100	100	....	100	150	150	....	....	....	....	200	....	....
21	Per ct. alive..	31	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	90	98	96	....	....	....	....	97	....	....
	No. counted..	300	....	....	300	....	300	....	200	....	150	200	....	....
22	Per ct. alive..	44	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	88	....	90	....	98	....	94	98	....	....
	No. counted..	300	....	300	....	....	200	....	....	300	....	300	....	100
23	Per ct. alive..	49	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	65	....	....	88	....	....	92	....	88	....	100
	No. counted..	200	200	....	200	....	150	....	....	200	....	200	500	200
24	Per ct. alive..	42	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	38	....	92	....	92	....	....	90	....	96	99	100
	No. counted..	300	200	200	200	....	....	300	....	....	300	200	....	....
26	Per ct. alive..	33	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	35	68	84	....	....	93	....	....	97	87	....	....
	No. counted..	250	....	....	150	200	....	200	....	....	....	200	500	300
28	Per ct. alive..	58	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	76	91	....	99	....	....	....	83	98.6	100
	No. counted..	200	....	....	300	....	200	....	200	....	300	300	500	200
30	Per ct. alive..	44	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	....	....	92	....	86	....	83	....	93	92	100	100
	No. counted..	1950	700	500	1550	750	1000	800	400	500	950	1800	2000	1000
Totals	Per ct. alive..	44	....	....	....	....	....	....	....	....	....	....	....	....
	Per ct. killed..	....	22	66	86	93	90	93	91	91	94	91	99	100

these had been killed by the fifth day, and, according to the sample count made, 96 per cent. by the twenty-second day. By May 12, the percentage of destruction was 99.6. August 20, one hundred scales examined; none alive.

Tree No. 15.—A thirteen-foot tree, with a six-inch trunk and an eighteen-foot top; in fair condition, but badly infested by the scale. This tree received no treatment with water until March 17, when 15 gallons were applied—fourteen days after the application of the insecticide. Tree No. 8 of Lot 1 is the companion tree. Sixty-one per cent. of the scales on No. 15 were alive in the beginning; 87 per cent. of these were dead on the fifth day; and 98 per cent. on the twenty-second day.

Tree No. 16.—A fifteen-foot tree, with an eight-inch trunk and a fifteen-foot top; in fair condition, but badly infested. This tree received no water treatment until the fourteenth day, when thirty gallons were applied. Forty-eight per cent. of the scales alive March 4; 81 per cent. of these dead on the fifth day, 92 per cent. on the twelfth, 95 per cent. on the twenty-second day, with a final average of 99.6 per cent. destroyed by May 12. The corresponding tree of the other lot is No. 9. August 20, one hundred scales examined; none alive.

Tree No. 17.—An eighteen-foot tree, with a nine-inch trunk and an eighteen-foot top; in poor condition, and badly infested. A check tree, receiving no water treatment, the effect of the insecticide being consequently modified only by the three rains described. Forty-one per cent. of the scales alive in the beginning; 68 per cent. of these dead in three days, 95 per cent. in twelve, and 99 per cent. in twenty-two days.

Fourth Lot of Trees. Oregon Wash.

This lot is essentially a duplicate of Lot 2 except with respect to the insecticide treatment, which was identical with that of Lot 3, and also with respect to the number of trees made use of, which was eight in this lot and nine in Lot 2. All variations of experiments with Lot 2 are represented in Lot 4 with the exception of that for No. 29.

Tree No. 18.—A sixteen-foot apple-tree, with a nine-inch trunk and a twenty-foot top; in fair general condition, but badly infested by the scale. Treated, like No. 4 of Lot 2, with a single application of fifteen gallons of water on the second day after the experiment, coinciding with the first shower of rain. Forty-seven per cent. of the scales alive when the insecticide was applied; 15 per cent. of these dead on the second day, 83 per cent. on the fifth, and 87 per cent. on the twentieth day. By May 12, 98.3 per cent. of the scales on this tree had been killed. August 20, two hundred scales examined; none alive.

Tree No. 21.—A fifteen-foot peach-tree, with an eight-inch trunk and an eighteen-foot top; in good condition, and but modererately infested. This received the same water treatment as No. 27 of Lot 2, namely, one application of fifteen gallons of water on the fifth day after the insecticide. Thirty-one per cent. of the scales were alive in the beginning. None of them appeared to have been killed on the second day thereafter, but 90 per cent. of these were dead on the fifth day, and 97 per cent. on the twentieth day.

Tree No. 22.—A peach-tree, thirteen-feet high with a six-inch trunk and a twelve-foot spread; in poor condition, though but moderately infested. Treated but once, and that on the tenth day after the insecticide application, fifteen gallons of water being used. The corresponding tree of the second lot was No. 35. Forty-four per cent. of the scales alive in the beginning; 88 per cent. of these dead on the fifth day, 90 per cent. on the thirteenth, and 98 per cent. on the twentieth day.

Tree No. 23.—A fifteen-foot apple-tree, with an eight-inch trunk and a fifteen-foot top; in poor condition, moderately infested. This, like 32, treated with three daily water sprays of fifteen gallons each on three days immediately following the insecticide treatment—a duplicate in this respect of No. 32 of the second lot. Forty-nine per cent. of the scales alive in the beginning; 65 per cent. of these dead on the fourth day and 88 per cent. on the thirteenth, and 88 per cent. again on the twentieth day. August 20, one hundred scales examined; none alive.

Tree No. 24.—A sixteen-foot peach-tree, with a six-inch trunk and a nine-foot top; in fair condition, moderately infested. Treated on two successive days, immediately following the insecticide application, with fifteen gallons of water on each day, the second of these treatments coinciding with the first day of rain. Forty-two per cent. of the scales alive in the beginning; 38 per cent. of these dead on the second day, 92 per cent. on the fifth, and 96 per cent. on the twentieth, the final result being the destruction of 95 per cent. of the scales. May 12, 99 per cent. of the scales on this tree had been killed. August 20, two hundred scales were examined; none alive.

Tree No. 26.—A twelve-foot peach-tree, with a six inch trunk and an eleven-foot top; in very poor condition, though but moderately infested. Treated, like No. 36 of the second lot, with fifteen gallons of water on the day following the insecticide application, and another fifteen gallons on the ninth day thereafter, that is, the 15th day of March. This last treatment coincided with the third rainfall. Thirty-three per cent of the scales alive at first; 35 per cent. of these dead on the second day, 68 per cent. on the fourth, 84 per cent. on the fifth, and 87 per cent. on the twentieth—when the last count was made.

Tree No. 28.—A fourteen-foot peach-tree, with a five-inch trunk and a ten-foot top; in very poor condition, though but moderately infested with the scale. This tree was reserved as a check upon the experiment, without water treatment of any kind, comparing in this respect with No. 20 of Lot 2. Fifty-eight per cent. of the scales were alive on it in the beginning; 76 per cent. of these were dead on the fifth day, and 83 per cent. on the twentieth. May 12, the ratio of destruction on this tree was 98.6 per cent. August 20, three hundred scales were examined; none alive.

Tree No. 30.—A twelve-foot apple-tree, with an eight-inch trunk and a fourteen-foot top; in good condition, and but moderately infested. Treated but once with water, that is with thirty gallons on the next day after the application of the insecticide. Forty-four per cent. of the scales alive in the beginning; 92 per cent. of these found dead on the sample examined on the fifth day after treatment, and the same ratio on the twentieth day. May 12, the ratio of destruction on this tree was 100 per cent. August 20, two hundred scales examined; none alive.

The Tent Experiment.

All the preceding experiments were intended to test the effect of artificial applications of water on the action of the two insecticides, these applications being made in a way to simulate the effects of rainfall. They were interfered with slightly by the three periods of light rain, the effects of which could not be clearly separated from those of the artificial treatment.

With a view to a test of the effects of rainfall, a small experiment was undertaken in which two trees—one treated with the California wash and the other with the Oregon wash—were covered with heavy canvas during the night and whenever rain threatened by day. Two other trees were similarly treated and left at all times exposed, and still two more, selected because of their close correspondence to the experimental trees, were reserved without treatment, as checks. This experiment was begun March 20. The trees selected (the only ones remaining available) were peach-trees on high ground and light soil, heavily infested, and in very poor condition. The drouth of the preceding season had affected them very seriously, the young wood being largely killed, and only 29 per cent. of the young scales on them being still alive.

The weather was favorable to the experiment. The insecticides were applied on the afternoon of March 20, and a slow fine rain began at 5 p. m. of the same day and continued until nine o'clock and for an unknown time into the night. Rain fell in a continuous drizzle, broken by showers, the whole of the following day, March 21, to an amount estimated by Mr. Titus at more than thirty gallons per tree.

The temperature of the 20th was 34° at 7 a. m. and 57° at noon; that of the 21st was 44° at 7 a. m. and 52° at noon, the wind from the southeast both days. Observations on this experiment continued only until the 25th, but counts of the scales were made daily up to that time—3,000 scales for the four experimental trees, and 2,050, for the two checks.

In this small experiment no differences of any significance were made out in the action of the insecticides, the total general effect being the destruction of approximately 95 per cent. of the scales at the end of five days, and variations from this average in the individual trees being too slight to take into account. So far as any conclusion can be drawn from an experiment on so small a scale, we can only infer that a rainfall such as described, occurring at the time of the insecticide treatment, would have no appreciable effect on the action of either of the washes.

Effects of Rain and Water Sprays in washing off Dead Scales.

Noticing that many scales were loosened and washed away after insecticide treatment of the trees, Mr. Titus made some careful counts from day to day of selected lots of scales on the experimental trees to determine the circumstances and the ratio of their diminution in numbers. Selecting, for example, a definite part of a branch, counting a hundred scales on it when the insecticide was applied and marking the area occupied by them, he counted them each day thereafter for several days, and thus arrived at an exact conclusion as to the effect of the fluid applications and the incidental rains. Thus, on No. 1, 300 scales counted March 3 were reduced to 188 by March 15—a loss of 37 per cent. On No. 11, 400 scales were reduced in the same time to 223—a loss of 44 per cent. Both these trees, it will be remembered, were sprayed with the insecticide March 3, and daily thereafter for one week with fifteen gallons of water. On No. 3, 100 scales were reduced in eight days to 72—a loss of 28 per cent., this tree having been three times sprayed, with fifteen gallons of water each time. On No. 6, sprayed once with thirty gallons, the loss was 25 per cent. in eight days; and on No.

14, receiving the same treatment except that the insecticide used was the Oregon instead of the California wash, the loss for the same period was 11 per cent. No. 21, sprayed also but once, with 15 gallons of water, lost 20 per cent. of its scales in seven days; No. 42, exposed to rains for a day and a night, lost in five days 11 per cent. of its scales; and No. 43, similarly exposed, lost 15 per cent.

The check trees 40 and 41, on the other hand, kept without treatment of any kind, lost within five days but four scales out of five hundred counted.

It was further apparent from observations made in the field that a brief but hard and dashing rain would detach many more scales than a light rain longer continued, and that a fine misty rain did not loosen the scales at all.

Practical Conclusions.

The foregoing described observations and experiments go to show that both the Oregon wash of lime, sulphur, and blue vitriol, and the California wash of lime, sulphur, and salt, prepared as described on page 72, are extremely valuable insecticides for winter use in Illinois for the destruction of the San Jose scale; that their effect is produced gradually, and is not altogether complete within a period of three weeks; and that frequent rains will not noticeably diminish their final action even when these come within the first five days after the insecticide treatment.

Both washes are entirely harmless to any leafless tree, and hence may be freely used in winter (but in winter only) for all kinds of trees, shrubs, and vines. Although the effect of these two washes as shown by an inspection made ten weeks after the application, was practically the same—each destroying by that time about 99.2 per cent. of the scales alive at the beginning of the experiment, there is considerable evidence in my data that the Oregon wash acts a little more promptly than the California wash, as shown, for example, by a comparison of effects at the end of a three weeks' period. At this time 88.5 per cent. of the scales had been killed by the California wash and 94.5 per cent. by the Oregon wash, a difference of 6 per cent. in favor of the latter; and if the comparison be limited to those trees which were not sprayed with water in the earlier days of the experiment, we find that the corresponding ratios are 90 per cent. of destruction for the California wash and 95 per cent. for the Oregon wash.

A comparison of the insecticide effect of these washes with that of the well-known whale-oil soap solution, two pounds to the gallon, shows that there is a slight difference in favor of the lime and sulphur washes, the ratios of living scales at the end of ten weeks being a little more than twice as great for the whale-oil soap as for the other insecticides. These ratios were, however, so small in both cases (39 scales out of 5,000 for the soap, and 35 out of 9,000 for the washes) that this difference need hardly be taken into account.

The cost of the lime and sulphur washes is less than one fifth that of the whale-oil soap, amounting to $1.12 per hundred gallons for the former in our experiments, and to $6.50 for the latter. The quantity of the washes actually used in the Summerfield experiments averaged five gallons per tree, at a cost of five and a half cents. This is about the same as the average cost of treatment with the kerosene emulsion, and but a little more than one third the cost per tree of treatment with whale-oil soap. Over the emulsion, the western washes have the inestimable advantage that they never injure the tree; and compared with whale-oil soap they are not only much cheaper and slightly more effective, but they are also to be preferred because they leave the fruit buds uninjured—even those of the peach—at whatever time of the winter they are applied.

It is possible that their use may be still fur ther cheapened by experiments showing the precise amount necessary to produce the full effect--a point not covered by our work at Summerfield, where both washes were used more freely, perhaps, than is necessary in practical work.

EXPERIMENTS AND OBSERVATIONS ON THE USE OF CRUDE PETROLEUM AND PURE KEROSENE FOR THE SAN JOSE SCALE.

At Carterville, Ill.

For the purpose of contributing to a knowledge of the values of these insecticides, and also as a basis for recommendations to Illinois fruit growers, I provided early in 1902 for a small series of careful experiments to be made at Carterville, on trees infested by the San Jose scale. The insecticide sprays were applied March 12 and 15 by the field entomologist of the office, Mr. E. S. G. Titus, and the results were tested by inspections made by him April 29 and June 15 of the same year. It was a part of my object to show the best that these insecticides could do under ordinarily favorable conditions, and I consequently chose for the experiment a time commonly regarded as most favorable to their use, that during which danger of injury to the most sensitive kinds of trees is at a minimum. The fruit-buds of all the trees treated were much swollen at the date of the experiment in southern Illinois, but neither these nor the leaf buds had as yet begun to open.

The materials used were crude petroleum (an Ohio oil of 36½° specific gravity by the Beaumé test) and common kerosene—bought from the Standard Oil Company and flashing at 143° to 145°. A Morrill & Morley pump was used in the experiment, with a heavy ⅝-inch hose, a 12-foot bamboo rod, and a Caswell nozzle. The spraying was very carefully done under the immediate supervision of Mr. Titus, and the smallest possible amount of the oils was used that would thoroughly coat the tree. On one peach- and one pear-tree, however, a heavy but very fine spray was applied. None of the trees were sprayed sufficiently to cause them to drip.

The weather of the time was fair and sunny throughout.

Fifty-two trees were sprayed in all—thirty-one with kerosene and twenty-one with crude oil. They were in two orchards, one belonging to Mr. R. H. H. Hampton, a half-mile east of Carterville, and the other to Mr. A. D. McNeill, three and a quarter miles northeast of the same town. The Hampton orchard was on a very adhesive yellow clay, originally in jack oak (*Quercus obtusiloba*), and a part of it was practically new land. The orchard of Mr. McNeill was on higher ground, and had been in cultivation for many years.

The trees chosen for the experiment were apple, cherry, pear, and peach, the apple and peach predominating. Only a part of them were infested by the San Jose scale, the others being sprayed as a test of the effect of the insecticide on the tree. Thirty-one trees were treated with pure kerosene,--nine of them apple-trees, seventeen peach, two cherry, and three pear,--and twenty-one were treated with the crude oil—ten of them apple, seven peach, one cherry, and three pear. The trees were very unequal in size, ranging from five to fifteen feet in height, and from two to thirteen feet in diameter of top. They were also quite unequal in condition, two of them being partially dead, two described as very poor, seven as poor, sixteen as fair, and twenty-five as good. But seventeen of the trees were infested with the scale; eight of them apple-trees and nine peach. The degree of infestation varied from slight to bad, the greater part of the trees being only moderately infested.

June 15 no living scales could be found on any of these trees except on three apple-trees originally badly infested, two of which had been treated with kerosene and one with crude petroleum; and on these, living specimens were reported as rare. No injury whatever was done by either insecticide to apple-, pear-, or cherry-trees, the peach being the only kind injuriously affected.

Of the twenty-four peach-trees, only four escaped all injury. Three of these had been sprayed with kerosene and one with crude petroleum. Five of the twenty-four trees were dead by June 15, (two, however, having been partly dead in the beginning); nine suffered a slight or temporary injury; and the tops of six were badly damaged, mainly by the killing of the terminal twigs. Eleven of these twenty-four peach-trees were only two years old and none of these youngs trees were injured permanently or seriously. Those reported damaged at the first inspection, April 29, had fully recovered and thrown out a vigorous growth of young wood by the 15th of June, with the exception of a single tree which still showed injury to the upper terminal twigs. Several of the older trees, on the other hand, which appeared uninjured April 29, were found badly damaged on the second visit.

They were evidently more slowly but more seriously affected by the spray than the younger and more vigorous trees.

By August 20, when a final inspection of these trees was made, all except the peach were still in good condition, and many were bearing excellent crops. Four of the peach-trees slightly injured in the beginning had rallied completely and showed no trace of the treatment, and thirteen were now dead or nearly so.

So far as this experiment goes it may be held to show that apple-, pear-, and cherry-trees may be safely treated with either pure kerosene or crude petroleum—the latter of rather light specific gravity—provided the application is made after spring conditions are well established and the fruit-buds have begun to swell, and provided also that care is taken not to apply the spray more freely than is necessary fairly to coat the surface of the bark. Both insecticides were very effective, killing very nearly every scale on the infested trees. The peach, on the other hand, was endangered by both applications even under the favorable conditions indicated, very young trees suffering somewhat but recovering promptly, while older ones were either injured slightly or seriously, or, in a few cases, killed outright.

The McNeill orchard was badly infested with canker-worms, but it was noticed April 29 that the bark of all trees which had been sprayed with crude petroleum was coated with a gummy black residue,—the non-volatile portion of the oil,— and that all trees in this condition were entirely free from canker-worms. The bark of a tree sprayed with kerosene, on the other hand, was perfectly clean, and on this the canker-worms were abundant. From this it would seem that the gummy coating left by the crude petroleum is an effective protection against these insects.

At Catawba Island, Ohio.

The above conclusion with reference to the danger of the use of crude oil for the peach, even under favorable spring conditions, is notably confirmed by a report made to me by Inspector E. C. Green, of my office, of a visit made late in May, 1902, to the Catawba Island district, in northern Ohio, where about three car-loads of crude oil had been used in March and April of this year. Of 40,398 trees examined by him 3,237 had been killed, 2,878 were dead in the top, 6,232 others had been seriously injured, and 21,603 slightly so, only 6,448 remaining without injury. Or, stated in ratios, 16 per cent. were unhurt, 54 per cent. were slightly injured and 15 per cent. seriously so, 7 per cent.

were killed as to the top, and 8 per cent. were killed outright.

The oil used was from Pennsylvania and known as "Scio" oil, but the particulars as to its specific gravity were not obtained. In all cases but one the pure oil had been used. In this exceptional instance a 26 per cent. mechanical mixture of crude oil and water had been applied to 8,700 trees with the effect to injure practically all of them. The injury was slight in all except about one hundred trees, fifty of which were killed as to the top, and fifty more were wholly dead The slighter injuries in this case took the form of the killing of an occasional branch, as if the oil had acted unevenly.

One owner, who had been favorably impressed with the results of the use of crude oil in 1901, applied it very thoroughly this year, using twelve barrels on 3,000 trees. He sprayed in April, from four directions, following the changes of the wind, but some trees were finished by spraying against the wind because a favorable change did not occur. At the time of the inspection 75 of these trees were dead, and 1,000 were killed to the trunk, making it necessary to grow new heads.

In another instance eight barrels of oil were used on 2,000 trees, the operation being intrusted to an ordinary hired man. Nine hundred of these trees were dead or worthless when examined, and 500 more were practically dead to the trunk, requiring the tops to be renewed. This orchard was sprayed in March and April, from two directions, with the wind.

In still another, seven barrels were sprayed on 2,500 trees from two directions, each time with the wind, each tree receiving a little over a pint of the oil in all. Only about 500 of these trees were slightly injured, and the remainder were in good condition except that many living scales were left, the spray apparently not having reached all parts of the bark.

"The general impression," says Mr. Green, "among those who have used the oil is that the smallest part over what is needed to dampen the surface of the wood is likely to cause serious injury or the death of the tree. The inquirer is told to use the finest Caswell nozzle and, holding this four feet from the branches to be sprayed, to allow the mist to drift with the wind through the head of the tree. When the wind changes the other side of the tree may be treated in like manner, but any attempt, even on a quiet day, to treat a tree completely at one time is almost certain to cause disastrous results. One is further cautioned to start work on the windward side of an orchard, so that a tree once treated will not get the drift from a tree subsequently treated on the windward side. It is further advised not to hold the nozzle near a branch, or to pause at any one place, for in such cases death to the branch usually results.

"To the casual observer it would seem that the people who have used crude oil devote so much of their attention to the niceties of spraying, in order to prevent injury to trees, that the original cause for treatment, the scale, is almost forgotten. Except in one orchard very little thorough work was seen, and I should think it probable that not over 50 per cent. of the scale insects on treated orchards throughout the Island had been destroyed."

EXPERIMENTS WITH SUMMER WASHES FOR THE SAN JOSE SCALE.

July 12 and 13, 1902, an experiment with two summer washes for the San Jose scale was tried in southern Illinois by my field assistant, Mr. E. S. G. Titus, the results of which were learned by an inspection made August 15. The insecticides used were a kerosene emulsion with whale-oil soap, containing ten per cent. of kerosene; and a mixture of soda, potash, sulphur, and whale-oil soap known as the "Los Angeles Co. Wash No. 5."

In the preparation of the latter three pounds of sulphur and one pound each of caustic potash and caustic soda were boiled for an hour in two gallons of water. At the same time a solution of twenty pounds of whale-oil soap was made by boiling, and at the end of the hour, the materials being all dissolved, they were mixed, boiled fifteen minutes longer, and then diluted with one hundred gallons of hot water and used at once, while hot.

Fifty-eight trees infested with the San Jose scale were thoroughly sprayed with this wash, forty-nine of them apple and nine of them peach. The Morrill and Morley pump was used with a single Vermorel nozzle. The weather was clear and extremely hot and dry. The apple-trees were nearly all heavily infested. Several of them were almost completely incrusted with the scales, which extended out to the small limbs not more than a quarter of an inch in diameter, and were plentifully distributed over the fruit. The peach-trees were little infested, or not at all, and were sprayed mainly to test the effect of the application on the tree.

With a view to determining the condition of the insects at the time, 7,900 scales on ten trees were critically examined, and from eighty-seven to ninety-nine per cent. of them were found alive, the average for the lot being ninety-five per cent.

August 15 a great many scales on these trees were found to have been killed, the larger proportion apparently on trees slightly infested. The vast majority were, however, still alive, and crawling young were numerous on the smaller branches, leaves, and fruit of those most heavily incrusted. The wash had apparently taken effect only on the crawling young, together with a small percentage of those most recently fixed. The older insects seemed to have been uninjured, and reproduction had gone on unchecked, the young scales establishing themselves upon the tree without seeming hindrance from the treatment given.

Four trees, two apple and two peach, sprayed at the same time with a ten per cent. kerosene and soap emulsion, were found July 12 in practically the same condition as those treated with the caustic wash, except that fewer of the scales had been killed.

It appears from this experiment that these summer washes, thoroughly applied, will destroy only the young scales, and will thus serve at best as a slight and temporary check upon the increase and spread of the pest. No injurious effect was shown on any of the trees with the exception of a slight burning of a few of the leaves by the Los Angeles wash—just enough to show that it could not have been safely used in any greater strength.

ON THE PRINCIPAL NURSERY PESTS LIKELY TO BE DISTRIBUTED IN TRADE.

The State of Illinois has now undertaken by legislative enactment to prevent, so far as reasonably practicable, the introduction, maintenance, and spread in this state of the fungus and insect parasites of fruit and ornamental trees and shrubs ; and as an important feature of this program of state control a system of nursery inspection has been established substantially identical with that now maintained in many other American states. It is the object of this inspection to insure as fully as possible the freedom of nursery stock, as delivered to customers, from injurious insect and fungus pests likely to continue as a cause of loss or damage in the orchard or on the premises of the purchaser.

A distinction must be made in practice between those insects and fungous diseases injurious to the property of the nurseryman, but from their nature not likely to be conveyed by the dormant tree stripped of its leaves, and those which continue on the affected tree or shrub through the winter in a condition to revive and spread with the renewal of growth after transplantation. The nursery inspection is made under our law primarily for the protection of customers of nurserymen, and only secondarily for the benefit of the nurserymen themselves; and on this account, first and most careful attention is naturally given by our horticultural inspectors to those pests which are capable of being distributed through the nursery trade. A slight and seemingly insignificant appearance of an insect or fungus of this description in the nursery rows may be far more important from the inspector's point of view than an extraordinary outbreak of some other form highly injurious in the nursery itself, but left behind when the stock is shipped.

It is greatly to the interest of the nurseryman that he should be able to detect and recognize on their first appearance all those injuries and diseases which by conveyance to his customers must seriously affect his trade, and which, by rendering his premises liable to an official quarantine, may embarrass his operations at a critical time. To meet this requirement I have prepared the following brief paper, which is a re-statement merely of the essential facts concerning the most important nursery pests likely to occur in Illinois nurseries and to spread abroad in spring or fall in the course of the regular nursery trade. Although written primarily for nurserymen, it may be found useful also to purchasers of nursery stock as an aid to an intelligent inspection of their own purchases, and as a means of protection against injury through the unnoticed admission to their premises of dangerous fungus and insect pests.

In making a choice of subjects for this purpose I have had the advantage of the results of several years' nursery inspection in this state, and have naturally given prominence to those diseases and pests commonest and most dangerous in Illinois nurseries at the present time. I have, however, further included under this discussion a small number of both fungus and insect species hitherto unknown to the nurserymen of this state, but liable to appear here at any time.

About thirty pests of the nursery have been selected for treatment, and these are nearly equally divided between insects and fungi. The most important insect species of this list are the San Jose scale, the woolly aphis, the peach-borer, and the pear-leaf mite causing the "blister" of that leaf; and the most important fungous diseases are the blight of the pear and apple, the crown-gall, the root-rot, the apple-scab, and anthracnose of the raspberry and blackberry. These and the less important forms of disease and insect injury may be distinguished with little difficulty by a careful study of specimens in connection with the brief descriptions following.

Classification and Description of the Insect and Fungus Pests of the Nursery most Important to the Nursery Trade.

Injurious to the Roots.

1. *The Woolly Aphis* (p. 106).

Attacks the apple. Forms irregular knots or swellings of various sizes on the roots, most numerous on the larger roots and near their origin. These outgrowths are smooth and soft when fresh, but become hard and rough when dry. Roots more or less covered with whitish collections of small sluggish insects, giving them a moldy look, these insects often appearing above ground, especially upon knots, scars, or other roughened surfaces of trunks and branches. Winters on roots as an inactive or dormant insect, and on the bark as an egg.

2. *The Black Peach-Aphis* (p. 107).

A short, broad, shining brownish-black aphis, infesting the roots of the peach and plum, and appearing also on the twigs, buds, and leaves. Winters as a developed insect on the roots.

3. *The Crown-gall* (p. 110).

A conspicuous wrinkled or roughened knot with a wart-like surface, growing most commonly from the crown of the tree or its vicinity. Especially likely to start from a grafting scar or other place of injury. Sometimes also borne by the larger roots or appearing on the trunk above ground. Affects nearly all deciduous fruits, including the apple, peach, apricot, pear, raspberry, blackberry, cherry, plum, grape, and quince. Believed to be contagious, and is often fatal, especially to young trees. Not certainly the same disease, however, on all of these kinds of fruits.

4. *The Root-rot* (p. 111).

A destructive, contagious, and incurable disease of the roots of trees, due to certain toadstool fungi, and resulting in the death and decay of the roots and the gradual destruction of the tree. Strings and sheets of white fungous growth between the bark and wood of the dead root, and black threads or cords of fungus mycelium running over the surface of the roots and through the dirt. Toadstools spring from the base of the trunk of badly affected trees, and masses of gum also exude about the crown. Commonest on old woodlands.

Injurious to the Bark or Wood.

5. *The Woolly Aphis* (p. 106).

(See above under No. 1).

6. *Scale Insects* or *Bark-lice* (p. 112).

Minute inactive insects, in most species concealed beneath thin, nearly structureless scales which adhere to the surface of bark or leaf. Colors varying, according to kind, from snow-white to gray or dark brown or even sooty black, and form likewise varying from circular to oval or linear. Some species wintering as eggs under the dry scale, and others as developed but dormant insects partly or fully grown. Various species infest practically all varieties of trees and shrubs.

7. *The Peach-tree Borer* (p. 121).

A yellowish white, grub-like caterpillar, about an inch long, with dark head and neck and eight pairs of legs. Mines the bark and sap-wood of the peach, plum, apricot, and cherry, commonly within a foot or so of the ground, causing profuse exudations of gum. Winters beneath the bark under ground or within the exuded gummy mass.

8. *Pear-blight, Apple-blight, Fire-blight, Twig-blight* (p. 124).

A contagious disease of the pear, apple, and quince, caused by bacteria multiplying within the living substance of the tree. Young growth dies rapidly, beginning at the tips of the twigs, the leaves and bark soon becoming first reddish and then almost inky black and drying up. Continues dormant in the diseased tissues through the winter, and may revive and spread in spring.

9. *Black-knot* (p. 125).

A contagious fungous disease of the plum and the cherry, producing rough, hard, sooty-black warts or knots on the twigs or branches, often extending for several inches along one side.

10. *Peach Fruit-spot* (p. 127).

A fruit disease of the peach, apricot, cherry, and plum due to the fungus *Cladosporium carpophilum.* Affects also the twigs of nursery stock, producing there purple blotches on the bark which may crack open when the attack is severe. Conveyed from tree to tree and from twig to fruit. Also attacks the leaves, producing small holes. On the fruit makes dull brown or black spots, which may run together, sometimes covering the surface of the peach. The diseased skin often cracks, admitting spores of the rot fungus.

11. *Anthracnose of Raspberry* (p 126).

A fungous disease of the raspberry and blackberry, producing small purple spots on the bark, which become gray with a purple rim as they expand. Spreads to leaf-stem and leaves. Dormant on old canes in winter.

INJURIOUS TO THE LEAF OR BUD.

12. *Plant-lice*, or *Aphides* (pp. 127–129).

Small sluggish insects, clustered in great numbers on the under surface of leaves. Most abundant on the younger growth. The greater part wingless, but most kinds with a varying percentage of winged individuals intermingled. Often much visited by ants. Many species, infesting nearly all kinds of plants. Cause curling of leaves and dwarfing of the season's growth. Usually pass the winter in the egg on buds and twigs, hatching in early spring.

13. *The Apple Leaf-crumpler* (p. 129).

Found in winter as a half-grown caterpillar in clusters of dead leaves webbed together and fastened to twigs of apple-trees. Protected by a slender, crooked, leathery tube within this leaf cluster. Comes out in spring and feeds upon the leaves, the buds, and even the bark of the youngest growth. Commonest on the apple, but found also on the plum, cherry, peach, and quince.

14. *The Pear-leaf Blister* (p. 132).

Black blister-like spots on the pear leaf, reddish or green when young, an eighth of an inch or more in diameter. Thickly sprinkling the surface when abundant, or running together to cover nearly the whole leaf. Caused by a minute four-legged mite, which winters under the bud-scales and infests the young leaves as they put forth in spring.

15. *The Tent-caterpillar* (p. 134).

In winter, a thick belt of eggs encircling the twig in a way to form a spindle-shaped mass three quarters of an inch in length. In June, a colony of dark caterpillars, two inches long when full grown, marked with blue, yellow, and black along the sides. A close, tent-like web spun as a shelter and retreat across the forks of branches in spring and enlarged as the growth of the colony requires.

16. *The Bag-worm* (p. 135).

In winter, soft, oval, sack-like bodies, one to one and a half inches long, more or less covered with a layer of leaves. Pointed at both ends and fastened to the twig or branch by one of them. Many of these bags contain masses of eggs, which hatch in May or June. Young caterpillars form for themselves a portable case, enlarged as they grow, and feed on the leaves of fruit and ornamental trees in nurseries and orchards. Much the commonest on evergreens, but sometimes injurious to the apple and other fruits.

17. *The Tussock-moth* (p. 136).

A beautiful small caterpillar, strikingly ornamented with long black tufts of hair from both ends of the body, and with four short pad-like brushes from the back, behind the coral-red head. Winters as a mass of eggs attached to a gray cocoon and concealed in one or more dead leaves fastened to a twig of apple, plum, willow, or other fruit or ornamental tree,

18. *The Apple-scab* (p. 137).

A disease of the leaves and fruit produced by the scab fungus (*Fusicladium dendriticum*). First appearing in early spring on the leaves in the form of soot-colored spots with indefinite margins and of various sizes. Causes holes in the leaf, these deadened blotches breaking through and dropping out; or the whole leaf may blacken, curl up, and fall. Appears also on the fruit, causing a black crust or scab. Common in nurseries, especially on the older trees. Affects apples of all kinds.

19. *The Pear-blight* (p. 124).

(See above under No. 8.)

20. *The Leaf-spots.*

Discolored spots and blotches on leaves, due to various fungus species and affecting various trees. Injurious in the nursery and carried over the winter either on dead leaves or on the bark of twigs.

Winter Forms and Appearances of the Principal Nursery Pests.

As nursery stock is prepared for shipment only during the dormant season of vegetable and insect life, the winter location and condition of the pests and parasites of the nursery is of special importance to both buyer and seller in the nursery trade. Only those insects and fungi which pass the dormant season on the tree or shrub are likely to be delivered with the stock, and the form or state in which they appear at that time must determine the methods of inspection, of prevention, and of remedy.

The parasites of tree and shrub which infest the root are usually to be found there dormant in winter, but alive throughout the year: the woolly aphis, the black peach-aphis, the crown-gall, and the root-rot are examples. Those on or in the bark are either the eggs of such insects as bark-lice or plant-lice; or living stages of the former, like the San Jose scale; or dormant stages of fungus parasites, such as the black-knot, the leaf-spots, and the apple-scab. In or beneath the bark or wood living borers may sometimes be found inactive through the winter; and fastened to the twigs are bunches of eggs, like those of the tent-caterpillar, the bag-worm, or the tussock-moth; or partly grown insects hidden in curious nests—the apple leaf-crumpler for example.

The following synoptical descriptions of these objects will serve for their identification in winter, as found on the tree.

1. Tufts of dead leaves or similar objects fastened by webbing to twigs or branches.

A tough, slender, leathery tube within the cluster of dead leaves and containing a small, dark, living caterpillar. (Fig. 16.) *The apple leaf-crumpler.*

A grayish empty cocoon within, with a thick patch of white eggs upon it which are cemented together to form a grayish smooth mass. (Fig. 25.) *The tussock-moth.*

A soft bag, an inch or more in length, pointed at both ends, and fastened by one to a branch or twig. Contains a mass of several hundred globular eggs. (Fig. 22.) *The bag-worm.*

2. Naked insects' eggs on the branches, twigs, or buds.

    Forming a spindle-shaped girdle around the twig, about three fourths of an inch long, composed of cylindrical eggs attached by one end and imbedded in a brownish cement. (Fig. 20.) *The tent-caterpillar.*

    Minute, slender, oval, shining jet-black eggs, fastened singly to the twigs and buds. *Plant-lice (Aphides).*

3. Thin, scale-like objects, fastened to the bark; usually small, and white, gray, or dark. Some kinds with a mass of minute eggs beneath; others with a small, living but motionless insect. Also soft, lump-like, smooth, motionless bodies on the bark, more or less hemispherical in form. (Fig. 5–12.) *Scale insects or bark-lice (Coccidæ).*

4. White, grub-like caterpillars, about an inch long or less, with dark heads. Buried in the bark or sap-wood of the peach at or below the surface of the ground, or sometimes, when young, in masses of exuded gum. *The peach-tree borer.*

5. Living insects on the roots.

    Forming whitish, mold-like patches on apple roots; the latter much deformed by knots, galls, or tubercles of various size. (Fig. 1, 3, 4.) *The woolly aphis.*

    Small sluggish, wingless black insects, naked on the roots of peach or plum. (Fig. 2.) *The black peach-aphis.*

6. Forming knots or galls on the surface of root, trunk, or branch.

    Rough, warty black knots and tumors on twigs and branches of the plum, chiefly along one side. (Fig. 14.) *The black knot.*

    Thick, rough, warty outgrowths from the crown of the tree or shrub, or sometimes from the larger roots near the trunk. (Fig. 1; Fig. 4, 1, 2.) *The crown-gall.*

    Irregular gall-like thickenings of the roots or outgrowths from them; often very numerous. The roots themslves deformed and contorted. (Fig. 1, 3, 4.) *The woolly aphis.*

7. Trees of unhealthy look; often with gummy exudations and clusters of toadstools about the base of the trunk. Some of the roots dead, with sheets or bands of a white leathery growth, smelling like mushrooms, between the bark and wood of the dead root. *The root-rot.*

8. Discolored specks, spots, or blotches on the bark, especially that of the younger growth.

    Irregular gray blotches with purple edges on the blackberry and raspberry. *Anthracnose.*

    Blackish or purplish spots on the young twigs. Various *leaf-spots* or the *apple-scab.*

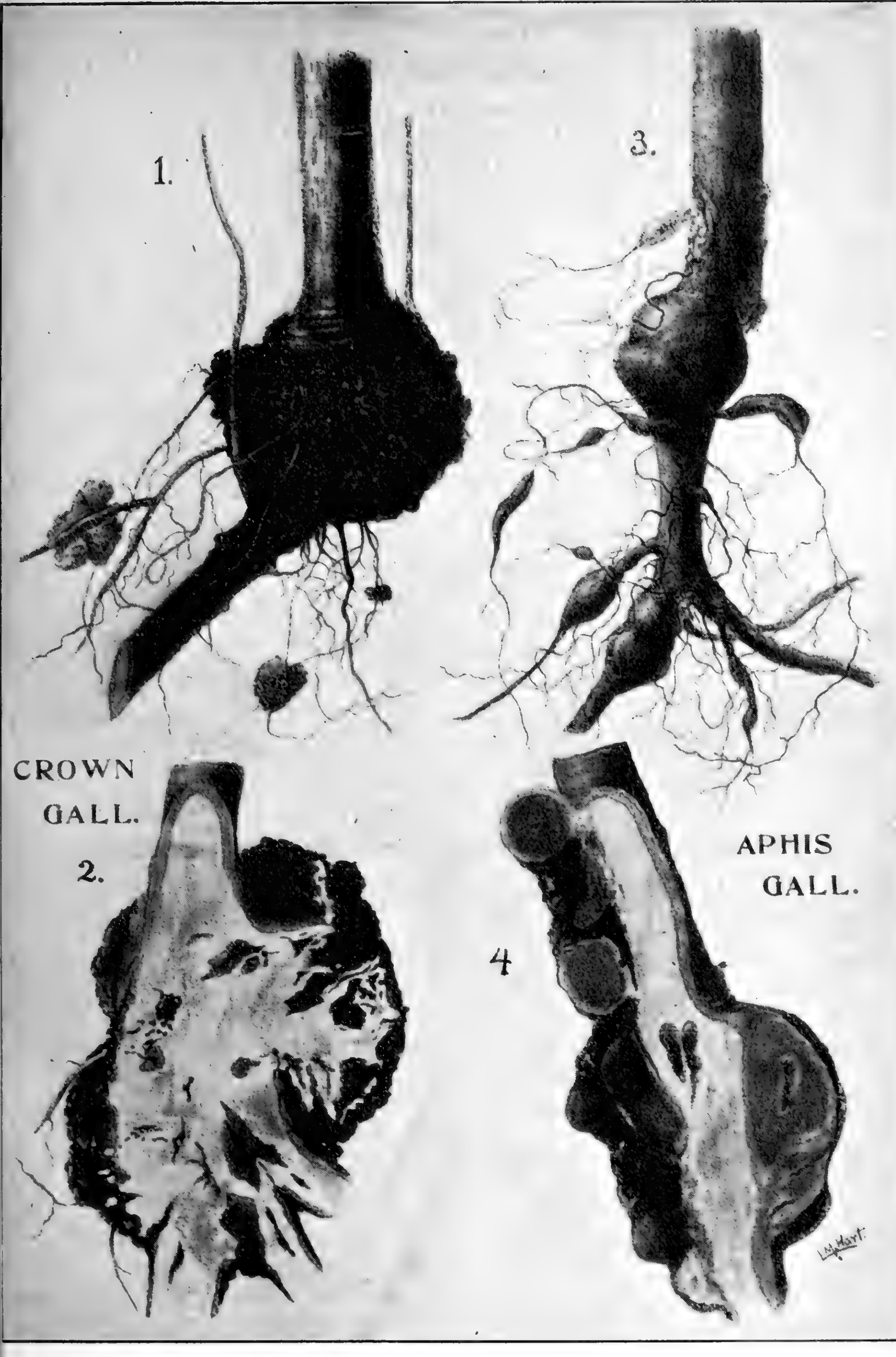

Fig. 1. The WOOLLY APHIS and the CROWN-GALL. (Original.)

DESCRIPTION AND DISCUSSION OF SPECIES.

The Woolly Aphis.

(*Schizoneura lanigera.*)

This insect is especially injurious to young apple-trees, first in the nursery and then in the orchard. It is most abundant and does its principal damage on the roots of the trees, but spreads also to the bark above ground, where it is particularly likely to appear on the young sprouts which start up from the root of an injured or unhealthy tree. Where abundant it forms bluish-white cottony patches, not unlike some kinds of mold, which on careful examination are seen to consist of a crowd or layer of minute sluggish insects, their bodies covered with a cottony coating which gives the general effect described. They are usually most abundant on the roots, but sometimes appear above ground also on the bark of the trunk or branches. On the exposed parts of the tree they are most likely to be noticed about the collar and at the forks of the principal branches, or wherever an injury to the bark has left a scar. When trees in a nursery or young orchard have a sickly look—the leaves dull and yellowish—and are not growing well, the presence of this insect on their roots may be suspected even though there may be no appearance of it on the bark above ground. If the roots of such an infested tree be examined they will commonly be found distorted and deformed with hard knot-like enlargements, many of them almost dead, or even in course of decomposition. (Fig. 1, 3, 4.) These gall-like growths occur on roots of all sizes to a depth of a foot or more beneath the surface. Unless the tree is so far gone that the insects have deserted it, they will commonly be found upon these injured roots at all seasons of the year.

The apple is the only tree liable to attack by this insect, the current supposition that it may live on the roots of forest trees being an error due to confusion of injury by the woolly aphis with that by the root-rot. As it lives underground at all seasons of the year it comes to infest more or less generally the soil itself, although this may be cleared of it by a few months' thorough cultivation sufficient to destroy effectively all living apple roots. Like many other plant-lice, the woolly aphis multiplies throughout the greater part of the year by the birth of living young from generations of wingless females only, but in October or November winged females appear somewhat abundantly, and, flying freely, especially before the wind, distribute the species widely. From these descend in the same autumn a generation of males and females, the latter of which eventually lay each a single winter egg.

This is commonly placed within a crevice of the bark, and hatching in spring gives rise to a new colony. There may be more or less migration back and forth from the groups above ground to those on the roots at almost any time of the summer and fall.

This insect is universally distributed and extremely common both in orchards and nurseries, becoming evidently more so to the southward. Being highly injurious to young trees it is a difficult pest to deal with in the nursery trade. It probably cannot be wholly eradicated from an infested nursery, and perhaps can never be completely and permanently kept out of a new plantation. Fortunately trees a few years old, once well established, commonly suffer but little from its presence, and our preventive and remedial measures must consequently be directed to the preservation of young stock. No tree whose roots are visibly injured by the woolly aphis should be allowed to go from a nursery, and none in the least infested by it should be sent out until the roots have been freed from it by an insecticide application.

The simplest method of destruction of the aphis on the roots is dipping for a few seconds in water kept heated to 130°-150° Fahr. Where heat cannot be conveniently maintained kerosene emulsion, diluted to contain about ten per cent. of kerosene, may be substituted. In the nursery, seedlings or graftings may be protected by using tobacco dust freely in the trenches in which they are planted, or by sprinkling tobacco dust in a shallow furrow along each side of the nursery row as closely as possible to the tree, and afterwards covering loosely with earth. Infested trees should not be sent out from the nursery except after fumigation with hydrocyanic acid gas or after dipping the roots in hot water or in kerosene emulsion. Trees with aphis galls or knots on the roots should be thrown out and burned. Those which have been longest in the nursery are commonly the worst infested. Culls kept from year to year are, in most parts of the state, certain to be mere nurseries for the multiplication of these and other destructive insects. In preserving overgrown trees in the hope of making a cheap sale, the nurseryman usually "saves the penny and loses the pound."

The Black Peach-Aphis.

(*Aphis prunicola.*)

The Illinois nursery inspectors have not yet reported the occurrence on peach nursery stock in this state of the black aphis of the peach—a species highly injurious and indeed seriously destructive to young nursery trees in some of the eastern states, and practically certain to appear sooner or later in Illinois. In fact it may be already present in our peach orchards, since no especial attention has lately been given to peach insects in this state.

As it passes the winter upon the roots of infested trees it is extremely likely to be transmitted in the nursery trade. and it has been frequently reported to have been introduced into new districts by this means. Slingerland mentions, for example, a New York orchardist who brought the black peach-aphis into his orchard by replacing trees which had died by young trees from an infested Delaware nursery. As far back as 1892 it was very common throughout the great peach-growing districts of New Jersey, Delaware, Maryland, and Virginia, ranking in destructiveness next to the disease known as peach-yellows. Nearly one hundred thousand trees were killed in a single nursery in one of these states within two or three weeks in 1890, while many other large nurseries were badly affected and some entirely destroyed.

The presence of this peach aphis upon the roots is indicated, according to Slingerland, by a stunting or dwarfing of the young trees such that those three or four years old have sometimes made scarcely any growth. The leaves are light green or yellowish, more or less rolled at the margin, and often spotted with red and purple from the effects of fungi. If the aphis becomes very abundant the tree dies outright, and another set in its place takes the same fatal course. Certain parts of the orchard may thus come

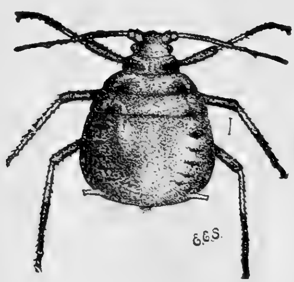

Fig. 2. The Black Peach-Aphis, wingless female.

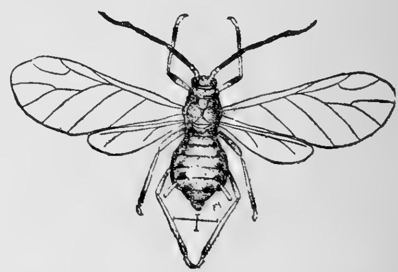

Fig. 3. The Black Peach-Aphis, winged female.

to be regarded as "dead spots," owing to the continuance of the black aphis in the earth. The principal injury is done underground, but some times the insect will appear in great numbers upon the twigs and leaves, causing the usual curling of the foliage and dwarfing of the terminal growth.

It occurs in two forms, one wingless (Fig. 2) and the other provided with large transparent wings (Fig. 3). The wingless insect is

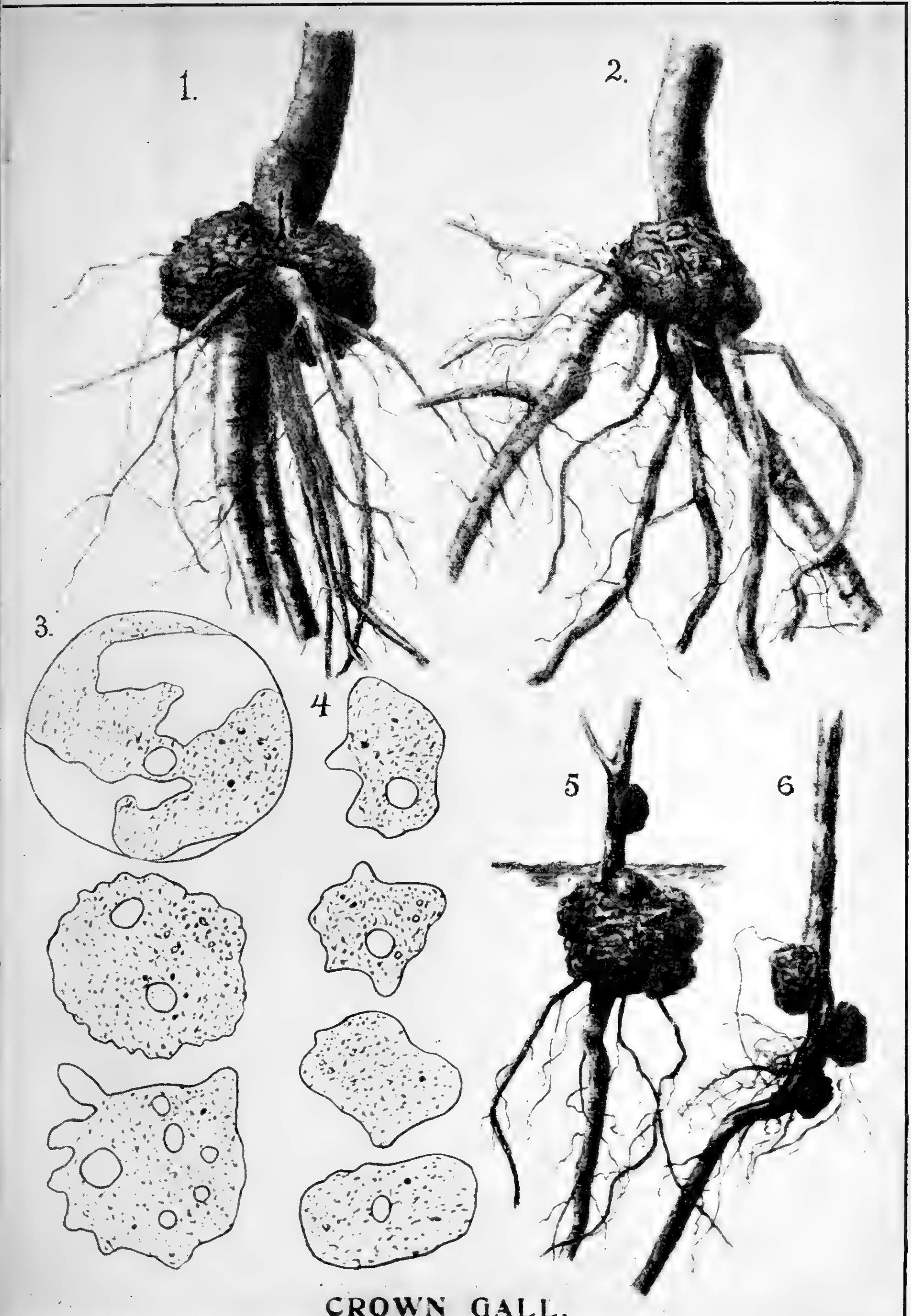

Fig. 4. CROWN-GALL: 1, 2, on peach; 3, 4, two of the amœboid germs causing crown-gall, with successive figures showing constant change of form, drawn at intervals of two and one minutes respectively; 5, 6, crown-galls produced by artificial infection of almond seedlings, the first by inserting bits of galls into slits in the bark, the latter by mixing the bits with the sand in which it was planted.

nearly a tenth of an inch in length and of a shining brownish-black color, with yellowish bands upon the legs. It is short and broad for a plant-louse, and very broadly rounded behind. The winged louse is of the same shining black color but is more slender than the form just described, with the abdomen less rounded at the tip. Several generations succeed each other during the season, the young being brought forth alive.

If this aphis should make its appearance in the nursery no peach stock should be sent out without careful fumigation, unless it should chance to be more convenient to dip the roots in kerosene emulsion diluted to contain about 5 per cent. of kerosene. Of course ground from which peach-trees infested by the aphis have been dug should not be set to peaches again, but should be used for some other stock. As the insect is not known to attack injuriously any other kind of tree, although it has been found on the plum, the resulting inconvenience will be slight.

The Crown-gall.

This is a dark, rough, abruptly protruding tumor (Fig. 1, 1, 2; Fig. 4), growing most commonly from the crown of the tree, and varying in size from that of a pea to that of the fist, or larger—the latter usually on old and long-infested trees. A badly affected tree is likely to show signs of starvation, its growth ceasing and its foliage having a sickly yellow look. Young trees often perish from this disease, which is certainly contagious in some forms and perhaps in all, and even large orchard trees may die and finally break off at the base of the trunk.

Although much the most common about the crown, just below the surface of the ground, this gall frequently grows on the larger roots, and is sometimes seen exposed upon the trunk. Appearing at first as a simple small lump or tubercle, it may so extend its growth as to girdle the trunk with its large wart-like excresences. Young galls while still fresh have at first the color of the root from which they grow, but later darken from the accumulation of dead bark on their surfaces. They are at first, while very small, softer than the healthy tissue of the root, but harden with age, and their inner structure becomes irregular and confused. On old galls, soft, white, growing points appear here and there in early spring, which, enlarging rapidly, become gradually darker and harder, and by fall take on the general apearance of the older growth.

There is much evidence that the crown-gall of the peach, apricot, and almond is a contagious disease due to a minute parasitic organism (*Dendrophagus globosus* Toumey) belonging to a peculiar group of fungi known as the "slime molds," but this conclusion has not yet been fully verified for the apple, the pear, the raspberry, or indeed for any other of the numerous kinds of fruiting and ornamental trees and shrubs on which similar wart-like growths have been observed.

Until experimental work now in progress has been carried so far as to warrant conclusions on this point, the crown-gall of the apple, now extremely common in many nurseries of the Mississippi valley, can be regarded only as a suspicious object, and not certainly as a dangerous one. But the careful nurseryman, jealous of his business reputation, will not send out even suspected material, and in doubtful cases will give his customers the benefit of the doubt. On this account I strongly advise that no stock of any kind showing galls of this sort on crown, roots, or trunk should be placed on the market. All trees growing in close contact with those thus affected should have their roots dipped in the Bordeaux mixture as a precautionary disinfectant, and the ground on which the stock so diseased has grown should be temporarily used for some other purpose than that of raising nursery trees.

The Root-rot.

This is a fungous disease of the roots of many kinds of trees, frequent and destructive in orchards, particularly in those growing on old forest land. It is not common in nurseries, but has been found by us in here and there one, and sometimes establishes itself as a permanent pest. Probably all varieties of fruit trees are liable to its attack, many forest trees being also subject to it. A badly infested tree suffers the general effects of the loss of the roots, and hence has a starved and enfeebled look. Often a mass of gum, mixed with scales of the bark, will collect about the base of the trunk. The affected roots, including many of the largest ones, die and rapidly decay, a fungous growth appearing between the bark and the wood in the form of a white irregular layer or coarse network, with a mushroom-like smell. Blackish cords or strands of a similar substance often spread over the surface or run through the earth from root to root.

The fruiting bodies of these rotten-root fungi are umbrella-shaped mushrooms—*Armillaria mellea*, *Clitocybe parasitica*, etc., some of which, at least, are, edible species—which spring in a dense cluster from the base of the trunk. They seem to be primarily fungi of rotten wood and often grow profusely around old oak stumps, continuing until the wood is thoroughly rotted away. They spread from dead and decaying wood to the living roots of trees, and may thus continue indefinitely in the ground.

Soil on which trees affected by this disease have grown should of course be abandoned for nursery or orchard purposes, and old forest land should be avoided for the growth of nursery stock until it has been cultivated long enough in some other crop to insure the practical disappearance of rotten wood and of fungi growing therefrom. No treatment of this disease can be expected to serve any useful purpose in the nursery, but an affected tree should be at once destroyed as valueless.

The Scale Insects.

(*Coccidæ.*)

The scale insects, or bark-lice, are on the whole much the most important nursery insects from our point of view; the most likely, that is, to infest the nursery in a way and at a time to make it probable that they will be conveyed on nursery stock to its purchaser. All here treated are capable of noteworthy injury to young trees, and one, the notorious San Jose Scale, is the most dangerous and destructive insect pest of the nursery. Most of them have an outward appearance so little like that of other insects that one not correctly informed in advance would never surmise that they were insects at all, but there is nevertheless a family resemblance among them such that one to whom the peculiarities of two or three prominent kinds have been pointed out will usually recognize most others. A few, however, are so small and otherwise inconspicuous that they are very little likely to be detected by the ordinary observer unless they become so abundant as to produce a notable effect on the health of the infested tree.

The greater part of them are nearly or quite motionless when full grown, remaining fixed to the bark, or in some cases to the leaf, like inanimate objects, most of them completely concealed beneath a delicate scale, a waxy secretion from the insect's surface. For a short time after birth they have considerable power of active locomotion, of which they make use to distribute themselves over the surface of the plant and to find a suitable point of attachment. Having selected this, their long and threadlike beaks are pushed deep into the living tissue of the tree, from which they proceed to suck the sap.

The greater part of them hatch from eggs laid by the female under the scale which conceals her body, and remain there, under its protection, after the parent has died and dried away. In a few species, however, the young are brought forth alive—in the San Jose scale almost always, and at least occasionally in one or two similar kinds.

One of the insects treated in this paper, the so-called peach Lecanium, remains exposed upon the surface throughout its life, secreting no scale. It has the appearance of a stationary lump-like mass upon the bark, and may be easily crushed and detached.

For the purposes of this economic discussion the scale insects may be divided into two groups, according to their mode of hibernation; those which pass the winter as living, developed insects, fully or partly grown, and those which winter in the egg. Of course, the state or stage in which the winter is passed is the same as that in which they go out in the nursery trade, and the fact that these two groups require separate insecticide treatment makes it particularly important that they should be clearly distinguished. The developed insect can be readily and certainly killed by a thorough fumigation process in which hydrocyanic acid gas is the destructive agent. This insecticide has no effect on the egg, and bark-lice which winter in the egg stage must be treated with a fluid insecticide—commonly whale-oil soap or kerosene emulsion. To make this treatment certainly effective it must be applied to the insect before the eggs are laid, preferably while it is still quite young.

The most destructive nursery scales which hibernate as eggs are the scurfy scale, the oyster-shell scale, the common elm scale, and the rose or raspberry scale, the last wintering in the egg to the north and partly grown to the south. Those which hibernate in a developed state are the San Jose scale, the Putnam scale, the Forbes scale, the walnut scale, the peach Diaspis, the peach Lecanium, and the rose scale in part, as just explained.

The San Jose Scale and its Allies

First and most important of the scale insects which winter partly or fully grown, and which may be destroyed by fumigation of nursery stock, is a group of four very similar kinds of which the San Jose scale (Fig. 5) is by far the most injurious. The others of the group are the Forbes scale (Fig. 6), the Putnam scale, and the walnut scale (Fig. 7), as mentioned above. Although these four species can be distinguished from one another by the entomological expert with perfect certainty, they are so unusually similar in general appearance, even under examination by the aid of a good hand-glass, that no reliance can be placed upon the distinctions of the untrained observer. Indeed the experienced entomologist is often driven, in individual cases, to the compound microscope and to the use of minute characters exhibited only by specimens especially prepared for microscopic examination. On the other hand, the four scales of this group may be recognized by any one as different and distinct from the other common scales.

a *b*

Fig. 5. The San Jose Scale: *a*, natural size; *b*, magnified. (Howard, U. S. Dept. Agriculture.)

In this San Jose group the point at which the young scale was evidently first formed and from which it has grown is near the center, and is marked by a minute nipple surrounded by a groove-like ring. This mark is not so evident on the older scales, but on the young it may be readily seen with an ordinary magnifier. From this starting point the scale grows by additions all around until, in the older females, it may become as broad as the head of a pin.

It must not be inferred from the foregoing statements that the scales of this group, similar as they are in appearance, are by any means equally important to the nurseryman. The San Jose scale is one of the most destructive general fruit insects known to entomology. The Forbes scale is of minor economic importance, occasionally becoming injurious to here and there a fruit tree, but under ordinary circumstances scarcely deserving of serious notice. The Putnam scale is not a general fruit scale. It has appeared in destructive numbers on the currant, but is found mainly on ornamental trees such as the ash, beech, hackberry, linden, and maple. It has been reported from the peach but it is not known to be destructive to that fruit. The walnut scale is of still less practical importance, occurring in nurseries in numbers to do injury, so far as we have seen in Illinois, only on a few ornamental trees. It has been elsewhere noticed, however, upon pear, cherry, apple, apricot and plum, and may become generally destructive.

Fig. 6. The Forbes Scale: *a*, natural size on cherry twig; *b*, female scale; *c*, male scale.

A little close and careful observation and the recollection of one or two peculiarities of habit will enable the fruit grower to distinguish these four scales one from another in the majority of cases, but for positive certainty in their recognition it is necessary to refer specimens to an entomological expert. In the Forbes scale the ring-and-nipple mark in the center is usually snow-white or nearly so, while in the San Jose scale it is almost always sooty black. The former, moreover, rarely becomes so abundant on the tree as the San Jose scale usually does. It is commonest perhaps on the cherry, and hence has been sometimes called the cherry scale, while the San Jose scale may be equally abundant on the apple, peach, pear, cherry, and plum. The Forbes and Putnam scales can scarcely be told apart by the appearance of the scale-like covering, but the latter is commonly found on shade trees and occurs on but few of the fruits, and then rarely in any abundance. The final distinction between all these scales is found in the microscopic characters of the body of the insect beneath the waxy covering, and consequently cannot be resorted to by the ordinary observer.

The fact that these ring-and-nipple scales are not easily distinguished from each other, and that without expert help the San Jose scale itself may be readily confused with any one of the other, relatively harmless, kinds, makes it necessary in winter nursery work that the nurseryman should take extraordinary precautionary measures whenever *any one* of these scales is found on his stock. Whatever may be his own opinion as to the species detected, specimens should be sent at once to the office of the Entomologist for critical study and precise determination. If they should unfortunately prove to be of the San Jose species, the case becomes one for legal requirement, under instructions from the State Entomologist's office; but even if they prove to be one of the relatively harmless species, they are likely to be the cause of grave suspicion to any customer who may chance to be superficially acquainted with the characters of the San Jose scale. It is my opinion, consequently, that a complete extermination in the nursery of this entire group of scales is the only sensible program. It must be admitted, however, that stock infested with the relatively harmless Forbes or Putnam scales may be made fit for market by thorough spraying with a solution of whale-oil soap, made by boiling two pounds of the potash soap in two gallons of water until the whole is dissolved. The mixture should be strained to exclude grit and applied while hot, since on cooling it becomes too thick to spray. It must be applied with thoroughness to every part of an infested tree, including all the surfaces of every branch and twig.

An almost equally effective application is the kerosene emulsion, diluted to contain fifteen per cent. of kerosene and applied when the leaves are off the trees. To make this emulsion, dissolve eight pounds of hard soap (or five quarts of soft soap) in ten gallons of soft water and heat to boiling. Put ten gallons of kerosene into the barrel in which the spray pump stands. Strain the boiling soap-water into the barrel and start the pump. By means of a short hose with a reducing nozzle the soap solution and oil should be pumped forcibly back into the barrel. Ten minutes of thus forcing the hot material back into itself will convert it into a creamy mixture, such that if it is left to stand in a cold glass the oil will not come to the top. This is the stock kerosene emulsion, and when diluted with about forty-five gallons of water it is ready for use. When the dilution water is added the pumping should be repeated to facilitate thorough mixing.

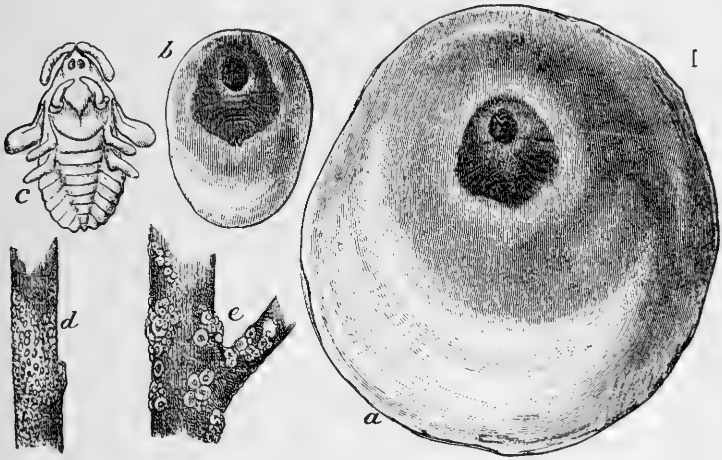

FIG. 7. THE WALNUT SCALE: *a*, *b*, female and male scales enlarged; *c*, male pupa; *d*, *e*, male and female scales, natural size. (Howard, U. S. Dept. Agriculture.)

A cheaper and more efficient insecticide method for these scales is fumigation with hydrocyanic acid gas. For this an air-tight inclosure is necessary, and in the nursery business this will usually take the form of a fumigation house specially prepared for the treatment of nursery stock. The precise method of procedure in this case will be furnished on application to this office.

ADDITIONAL NURSERY SCALES WINTERING PARTLY OR FULLY GROWN.

Besides this group of four of what we may call the *ring-and-nipple* scales, two peach scales are to be treated, when they occur in the nursery, by the most summary processes. The peach Diaspis, unknown as yet in Illinois, is circular in the female, and very elongate in the male, with a rib or keel running lengthwise down the center. The female is gray and not readily distinguished, being frequently almost covered over by the outside bark of the twig. The male scale is white and more conspicuous. The female hibernates full grown, and the eggs are deposited early in May, hatching about the middle of that month. This is a very injurious scale, and Illinois peach-growers should watch carefully for its advent and take prompt measures for its destruction if it appears.

The peach Lecanium (*L. nigrofasciatum*) has come to me frequuently of late, on both peaches and plums, as a very conspicuous, almost hemispherical, motionless insect clustered thickly upon the twigs of infested trees. Its general color is red, usually quite dark, with blackish spots and bands occupying a large part of the surface. Sometimes the whole scale is black with the exception of a reddish middle stripe. The surface is shining and smooth, or nearly so. The scale is a sixth to an eighth of an inch in length, and a little narrower, the outline being slightly oval. I have no exact knowledge of the amount of injury which this scale is likely to cause, but from its size and its abundance on specimen twigs sent several times to my office I judge that it may prove to be a decidedly injurious species.

Common Nursery Scales wintering in the Egg.

The Scurfy Scale

(*Chionaspis furfura.*)

The female of the scurfy scale (Fig. 8) is a flat, oval, or nearly circular, white or grayish white scale, beneath which in winter and spring a cluster of minute maroon-colored eggs may be found. Their color is due to their contents, and when one of these scales is crushed a reddish fluid exudes. This alone would serve to distinguish it from others occurring at this season on the apple or the pear.

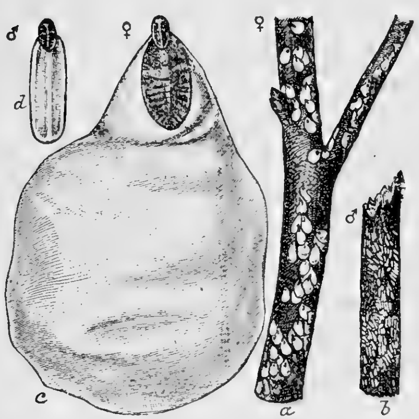

Fig. 8. The Scurfy Scale: *a*, *b*, female and male scales, natural size; *c*, *d*, same enlarged. (Howard, U. S. Dept. Agriculture.)

The male scale differs by its smaller size and elongated narrow form, by its whiter color, and by the presence of a ridge or rib running longitudinally down the middle.

The scurfy scale is almost universally distributed in Illinois orchards, and is very common in a small way in nurseries as well. Many of the better ones are wholly free from it, but perhaps most of them contain it in discoverable numbers. It is not seriously injurious to thrifty trees, except where it becomes decidedly abundant, and the efforts of the nurseryman should be addressed, for the present at least, to the reduction of its numbers and to the exclusion of the scale from new grounds rather than to its complete extermination on his premises. Stock badly infested by it should be thrown aside, and care should be exercised in establishing new plantations that they are not adjacent to infested trees. As it spreads only by the locomotion of its minute young, aided rarely by nesting birds, and as its active period is limited to a very few days after hatching, it does not readily spread to any considerable distance, and a new plantation can be kept free from it if some thought is given to the matter in the beginning.

The Oyster-shell Scale.

(*Mytilaspis pomorum.*)

The scale generally known by the above common name is so called because of its whimsical resemblance to half an oyster-shell. (Fig. 9.) It is about a sixth of an inch long, brownish, or grayish, colored about like the bark of a tree, not flattened like the scurfy scale, but convex from side to side, and two or three times as long as wide. The eggs under the scale — to be found to the number of a hundred or more at all times of the winter and early spring — are white or yellowish, and not red like those of the scurfy scale.

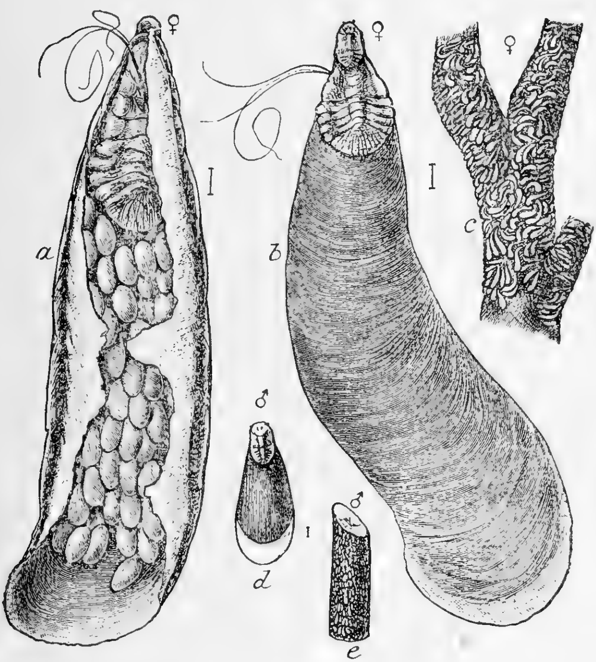

Fig. 9. The Oyster-shell Scale: *a*, female scale, under side, showing the insect and its eggs within; *b*, same, from above; *c*, same, natural size; *d*, *e*, male scale, enlarged and exact size. (Howard, U. S. Dept. of Agriculture.)

It is less generally distributed in Illinois than the scurfy scale, and is, on the whole, somewhat more injurious when it becomes abundant. It is relatively rare in nurseries except on overgrown and neglected stock. Trees infested by this scale should not be sent out by the nurseryman, but should be unhesitatingly destroyed.

THE GRAPE SCALE.

(*Aspidiotus uvæ.*)

This is an occasional pest, rarely injuring the grape seriously, but appearing now and then in a vineyard in a way to call for effective treatment. It infests especially the lower part of the vine, from the ground to the second year's growth, and accumulates in crevices and under loose pieces of bark. When abundant it comes to cover the surface with a continuous crust resembling a coat of whitewash, and in that case it weakens the vine and may cause its death. (Fig. 10 and 11.)

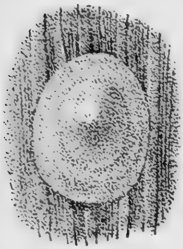

Fig. 10. THE GRAPE SCALE; female scale on bark.

The female scale is flat and nearly circular, about a fifteenth of an inch in length, pale yellowish brown or dingy white. When a scale has been removed a conspicuous white speck upon the bark marks its former position. As it winters in the egg this species cannot be destroyed by fumigation, but may best be treated, where treatment is necessary, with kerosene emulsion or whale-oil soap. The eggs begin to hatch about the middle of May, and an insecticide spray may be applied to advantage late in that month or early in June.

FIG. 11. THE GRAPE SCALE, natural size.

THE ROSE SCALE, OR RASPBERRY SCALE.

(*Aulacaspis rosæ.*)

The rose scale (Fig.12) is not by any means limited to the rose but thrives equally well on a considerable number of rosaceous plants, including especially the raspberry and the blackberry, of which it is the common scale.

It is circular, snowy white, and very readily recognized by the striking contrast between its color and the green or reddish brown of the twigs and branches on which it grows. It is often sent to my office by raspberry-growers, and has occasionally been reported by my nursery inspectors as occurring on raspberry and blackberry plants in the nursery. It is not often a serious pest, especially if old canes are regularly cleared out of the rows when they are done growing or early in the following year,

It winters in the egg as far north as New Jersey, but in the latitude of Washington some of the eggs hatch in the fall, the young hibernating partly grown, while in the extreme south, as in Florida, this form of hibernation as an immature insect is the general rule.

Fig. 12. THE ROSE SCALE: *a*, *b*, female and male scales enlarged. (Comstock, U. S. Dept. of Agriculture.)

Fumigation cannot be depended upon in Illinois to free infested plants, but the principal reliance must be placed on the destruction of all old canes and a rejection of those younger plants which show the presence of the scale.

THE PEACH-TREE BORER.

(*Sanninoidea exitiosa.*)

The peach-tree borer (Fig. 13, 14) is well and widely known as one of the most destructive insects infesting the tree in the orchard, but it is too little regarded by nurserymen as a pest of serious importance to their trade. Our own observation of its abundance in nurseries tends, however, to support the statements of Professor

Slingerland, made in the most important article on this insect which has hitherto been published*

Discussing the methods of its spread he says that "the borer probably never leaves the tree upon which it is hatched from the egg laid on the bark, but spends nearly eleven months of its yearly life cycle on or in the tree. It can thus be easily transported for long distances on infested trees, and this is doubtless the way in which it usually reaches new localities. In the spring and fall, when the trees are usually transported, many of the borers are quite small and easily escape casual observation. As large peach-trees are rarely moved, the growers of nursery stock are most responsible for the introduction of the insect into new localities."

It has been found in the roots of the smallest stock taken from the nursery, and has been noticed on many nursery trees shipped from one state to another, both in the eastern states and in California. Mr. V. H. Lowe, of the Geneva Experiment Station, said in 1897 that it was a common thing to find many young peach-trees in the packing-shed, waiting to be shipped, which were infested by borers; and Slingerland adds, "It is doubtful if there is a peach nursery to-day east of the Rocky Mountains that is not more or less infested with the peach-tree borer. It is one of the most serious of the insect pests that are now being sent out by nurserymen. When it once gets a foothold in an orchard or locality it may slowly spread from orchard to orchard by the movements of the adult insects or moths which fly readily but apparently not for very long distances. Peach- plum- prune- apricot- or cherry-trees from a nursery should always be carefully examined for borers before setting them, especially as young trees are often killed by girdling just beneath the bark under ground. Indeed every borer weakens the tree more or less, the damage done depending much on the age of the tree and the kind of care it has received."

In the Illinois nursery inspection of 1900 these borers were noticed in thirty-seven nurseries out of eighty in which peach stock is specially mentioned. Remembering the fact that these nursery trees were inspected while standing in the rows, and that the occurence of small borers was doubtless often passed without detection, we are safe in saying that over half the nurseries growing peaches are more or less infested by this borer. The cases reported were not by any means limited to the oldest trees, but included seedlings, yearlings, and two-year-olds, and also trees in the packing-shed ready for shipment. The ratio of injured trees

*Bulletin 176, Cornell University Agricultural Experiment Station, December, 1899.

ranged from 2 per cent. to 95 per cent. In most of the infested nurseries the amount of injury was estimated at from 5 per cent. to 10 per cent.

Injury to the peach by this borer is always followed by a free exudation of a thick and sticky fluid at the point of injury. This becomes mixed with pieces of bark and the excrement of the borers, and dries away to form a more or less brittle gum, usually most abundant about the base of the tree, at which point the attack is commonly concentrated. As found in the tree these insects resemble grubs, but when closely examined are at once seen to be caterpillars instead. Each is about an inch long when full grown, very light yellow except the head and the top of the "neck," both of which are brown with smooth and shining surfaces, the former dark reddish, and the latter very light. There are the usual three pairs of jointed legs on the segments next behind the head, and additional to these the soft legs, or so-called prolegs of a caterpillar, with rows of small black hooks at the tip. There are five pairs of these prolegs on segments 6 to 9 behind the head and on the last.

Fig. 13. The Peach-tree Borer, adult males and females. (Slingerland.)

The importance of the peach-tree borer from our present point of view is due to the fact that it passes the winter in the active borer stage within the infested tree, and is consequently certain to be shipped to the customer if such a tree is overlooked.

Its size at hibernation will depend in part upon the latitude, larvæ in the Southern states passing the winter nearly full grown, while to the north most are less than half that size. In favorable seasons, that is when the fall is late and winter frosts are long postponed, the size of the hibernating larvæ is of course increased. The winter is usually spent either in burrows just beneath the bark and below the surface of the soil, or imbedded in gum outside the bark at or near the surface of the ground. The smaller borers, according to Slingerland, will be found, as a rule, in the latter situation and the larger ones beneath the bark. In spring they begin to eat, mining the bark and sap-wood, and commonly confining their injuries to the trunk and roots a little way underground. In the Northern states their principal injury may be done in spring, while the farther south we go the more generally their destructive work is finished in the fall. When mature the caterpillar makes a cocoon, which is usually attached to the outside of the bark near the ground, and within this undergoes the transformation common to insects of its kind, coming out as a peculiar clear-winged moth in June and July, or, in the extreme southern part of the state, even as early as May. Eggs are laid quite promptly on the trunk of the tree, usually within a foot or two of the ground—the greater part of them within six or eight inches of it. They are stuck to the bark, one in a place, by a gummy secretion deposited with the egg.

It is probably impracticable to protect nursery stock from attack while this insect is abundant in the vicinity either upon trees standing in the nursery or in orchards adjacent. It is particularly likely to infest overgrown nursery stock, and on this account, if for no other reason, such trees should be destroyed. Whenever the owner of peach nursery stock controls peach orchards in the neighborhood he should of course see to it that these trees are annually inspected and treated as may be necessary to prevent the multiplication of this insect to an extent likely to cause an invasion of his nursery. If nursery trees become infested they should of course be destroyed as dug, and the entire block should be completely cleared of peach-trees and planted to something not subject to attack by this borer.

Pear-blight, Apple-blight, Twig-blight, Fire-blight.

This is a true contagious disease, caused by bacteria (*Bacillus amylovorus*) which infest the cells of the plant, multiplying in the sap and serving as germs to convey the disease to healthy trees.

It is best known and most destructive as a pear disease, but is also common and wide-spread in the apple orchard. It affects likewise the quince, the mountain-ash, the raspberry, the blackberry, and some other rosaceous plants.

Its characteristic symptom is a sudden dying and blackening of the newer growth of twigs and leaves, beginning generally at or near the tips and thence extending downward. The dead twigs and leaves presently become almost inky black, and remain conspicuous among the green and healthy leaves during much of the growing season. The disease extends rapidly at times, especially in the pear, but sometimes more slowly. Insects assist in its dissemination, especially when the trees are in bloom. Its bacterial germ remains dormant over winter in some of the affected trees, and starts again the following spring. It is mainly an orchard disease, but occurs occasionally in nurseries, particularly where these grow adjacent to affected orchards. If it appears in the nursery infected trees should be promptly cut out and destroyed, as no fungicide or other artificial treatment will serve to check its progress.

The Black-knot.

This is a fungous disease of the branches of plum- and cherry-trees, appearing first in the form of a thickening or swelling of the twig, which becomes thicker on one side than on the other, and here the distended bark presently breaks and a spongy mass grows out. This generally develops into large sooty-black wart-like growths, with slightly granular surface broken by deep fissures running mostly crosswise of the mass (Fig. 14). The fungus parasite causing this disease is technically known as *Plowrightia morbosa*.

"Since the knot generally occupies only one side of the limb, it does not entirely check the life processes, and the limb beyond continues to grow and put forth leaves. It is only where the knot extends completely around the twig or branch that the part beyond is killed at once. When the knots are abundant trees may be killed in a couple of year, and indeed whole orchards may in the course of a few years become so infested as to be worthless, although the injured trees may survive in a feeble way for a longer period."

Fig. 14. The Black-knot. (Garman.)

* H. Garman, Kentucky Bulletin No. 80.

All varieties of the plum and both tame and wild cherries are attacked by this disease, the common bird-cherry and the native choke-cherry being particularly subject to it. It is spread from tree to tree by means of minute spores light enough to be carried by the wind. It is consequently of great importance that in every affected tree, whether tame or wild, the disease be promptly exterminated. Where it becomes generally distributed it is one of the most destructive of all the diseases of the plum, and has obliterated plum culture over extensive districts in the East. It does not affect the tree generally and does not, indeed, extend far beyond the ends of the knots. "Hence by cutting of all affected parts it can be kept from extending, except as it appears at newly infected centers. When a tree is badly infected about the main branches it is often best to remove and burn the entire tree to prevent the disease spreading." Ordinarily it is sufficient to cut off diseased branches a short distance below the last knot, and this may be done at any time of the year. The cut surface should be washed with Bordeaux mixture, and the diseased wood should in every case be burned, since it has been amply shown that spores may develop on it to reinfect the trees.

Anthracnose of Raspberry.

A fungous disease of the bark of the raspberry, blackberry, and other closely related plants. "Appears on the canes at or near the ground as very small purple spots which spread and soon acquire a grayish-white center and finally grow to a large size, then with a clearly defined purple rim; often uniting and covering much of the bark; spreads to the petioles of the leaves when abundant and eventually to the leaves themselves, occasionally even to the fruit; spots often a quarter of an inch in diameter; not penetrating the wood to any distance; surface opaque, slightly ribbed longitudinally when old and assuming a scab-like character; when at an advanced stage splitting and admitting water so as to cause rot to extend into the underlying wood. Due to a well-known fungus (*Glœosporium venetum*) which causes the scab-spots by attacking the bark, in which it remains dormant over winter. Young shoots attacked by spores as soon as they appear in spring, and most of the growth and development take place during the growing season. Attack results in dwarfing growth and reducing quality and yield of berries. When very bad, berries may shrivel up about time of picking, and not infrequently the canes themselves die when the disease is of long standing. Black raspberries especially subject to it, in some cases to such an extent that whole plantations are ruined. Anthracnose must not be confounded with black spots due to attacks of pear-blight Bacillus, such spots sometimes occurring among spots due to attacks of the anthracnose fungus."

"This disease is certain to be sent out of the nursery on canes of raspberry and blackberry if it is present there. It is highly important, therefore, that our nurserymen keep a close watch on their stock to prevent its becoming established; and if by chance it is introduced, to get rid of it promptly. It can be exterminated. It is only necessary to burn all trimmings and to remove and burn old canes when they cease growing, rake up all leaves and burn them, and spray with Bordeaux mixture as soon as the young shoots push out in spring, following this up by two or three later sprayings with the same preparation. * * * No diseased canes should be sent out by the nurseryman.

"The buyer is advised to examine any plants he may receive, and if any of the characteristic blotches appear the whole lot should be dipped in Bordeaux mixture before planting, the plants being observed closely when they begin to grow and applications of Bordeaux mixture be made with a sprayer if any appearance of the anthracnose is witnessed.

"It is so serious a matter to get the disease established on a place that one may well hesitate about setting out plants that are in anywise affected."*

PEACH FRUIT-SPOT, PLUM-SCAB, CHERRY-SCAB

This is a fungous disease which attacks the fruit of the peach, apricot, cherry, and plum, and also the leaves and twigs of the peach. Remaining dormant upon the latter during the winter season, it is capable of being transmitted with diseased peach stock in spring. On the young twigs it produces purple blotches, in which the bark sometimes splits, as does also the skin of the fruit when affected by the same disease.

It checks the growth of young trees, but is mainly injurious to the orchardist by its subsequent infection of the fruit when the trees begin to bear. Peach-trees exhibiting this disease should not be sent out by the nurseryman, but should be destroyed as harmful to the nursery trade.

THE APPLE-LEAF APHIS.

(*Aphis mali*, etc.)

Two kindred species of apple aphis or plant-louse commonly infest the leaves of this tree in the nursery and in the orchard,

*H. Garman, Kentucky Bulletin No. 80.

doing a similar injury by similar methods, but differing especially in life history. For the purposes of this article they need not be particularly distinguished, since the treatment of nursery stock must be the same for both.

If apple stock has been infested by the leaf aphis the preceding year, the fact will be shown at shipping time, in fall or spring, by the presence on the tips of the twigs of minute, slender, oval, shining jet-black eggs fastened, perhaps in considerable numbers, to the bud scales or the surface of the bark, or lodged in crevices and on roughened places. These eggs will hatch in early spring, and the young will commence at once to suck the sap from the unfolding leaves, arresting their growth and causing them to curl. Considerable injury may thus be done to the young tree, preventing the tree growth of the twigs and making a scrubby thickly tufted tip to each infested branch. The tree is thus prevented from making a suitable season's growth, and its market value is greatly reduced.

The plant-lice themselves are small sluggish green insects, thickly clustered on the buds and the under sides of the leaves, and often attended by ants, which run actively up and down infested trees, visiting colonies of the plant-lice for the purpose of lapping up the sweetish fluids which they give forth. Several generations of these plant-lice are produced during a single season, of which two are peculiar—the first and the last of the year. The first generation is the only one which hatches from an egg; all are females, and none of them have wings. The succeeding generations are born alive. All except the last are composed of females only, and many individuals of these generations may have wings and a considerable power of flight. The last generation of the year contains both sexes, which pair, produce eggs, and perish. The two species above referred to differ in the fact that the first mentioned, *Aphis mali*, spends the entire season on the apple, while the second leaves the tree with the appearance of the third generation, resorting to grasses and grains, and returning to the apple only in autumn to produce the egg-laying generation, the last one of the year.

It is practically impossible to destroy the eggs of the plant-louse, and to keep nursery stock free from it. The insects must be destroyed in fall while they are on the trees but before the eggs are laid. This period will vary according to season and latitude, being of course the later the farther south one goes and the longer the summer season lasts. In the latitude of central Illinois most of the eggs are laid in September and October.

A suitable insecticide measure is a thorough spraying with kerosene emulsion diluted to contain five or six per cent. of kerosene, or with one pound of whale-oil soap dissolved in six gallons of water, or with a tobacco decoction made by soaking a pound of tobacco in two gallons of water. Considerable force must be used to bring the spray in contact with all the insects, and many of them will usually escape at best.

As a prevention of injury to young trees in the nursery rows the same applications should be made in early spring, commencing when the hatching of the eggs is well under way. This process begins with the first swelling of the buds, and an examination of the tips of the twigs at this time will be sufficient to indicate the precise time when the spraying had best be done.

THE CHERRY APHIS.

(*Myzus cerasi.*)

This is a black plant-louse (Fig. 15) occurring on the cherry in early spring as soon as the leaves are fairly started. It hatches from eggs left on the twigs and buds the preceding fall. It continues to multiply throughout the year, being usually most abundant, however, in spring and in fall. If it occurs in fall on nursery stock which is to be marketed that season, it should be killed by spraying in September or early October, before the eggs have been laid.

Fig. 15. THE CHERRY APHIS, wingless and winged individuals. (Weed.)

THE LEAF-CRUMPLER.

(*Mineola indiginella.*)

This insect (Fig. 16) is particularly injurious to nursery stock and young orchard trees, owing to the fact that it hibernates upon the infested tree as a half-grown larva and attacks the young leaf and the bud of leaf and blossom in early spring, thus often arresting the growth of the branch or tree by destroying the terminal bud. Owing to its early attack, it may do an injury far out of proportion to its numbers. It is so secreted and protected upon the young nursery tree that it is certain to be sent with it whether the latter be shipped in fall or in spring.

The presence of this insect is most easily recognized in winter, when the trees are bare, by the presence of clusters of brown shriveled or crumpled and partly eaten leaves, fastened together and anchored to the trees by means of silken threads (Fig. 17). If one of these ragged masses is pulled apart, in the center of it will be found a crooked leathery tube shaped like an irregular horn, and within this again, a small reddish brown caterpillar with a dark brown head. In spring, a badly infested tree will have its leaves more or less eaten and fastened together in bunches, the leaf-crumpler being commonly secreted within the bunch.

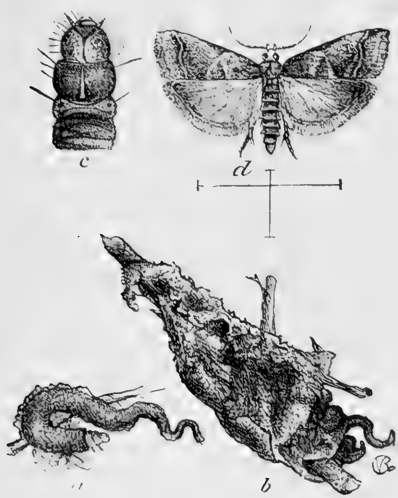

Fig. 16. THE LEAF-CRUMPLER: *a*, tube of larva; *b*, cluster of tubes and leaves, *c*, head end of larva; *d*, adult moth.

This caterpillar may be found on apple, plum, cherry, peach, and quince. The destruction of the terminal bud of course stops direct growth, and results in the formation of a mass of lateral branches from the twig, giving the young tree a stunted and scrubby look, which injures it for sale as a nursery tree, and retards its growth and diminishes its vigor in the orchard. When very abundant the young caterpillar may not only attack the leaves and swelling buds, but eat the young fruit and gnaw away the tender bark and growing twigs. The injury is done mainly at night.

It reaches its growth from the middle to the latter part of May, being at this time about half an inch in length and entirely green. It goes through the pupa stage in its larval nest, and the small grayish moths appear in June and July, laying their eggs almost at once. These hatch in about a week, and the small brown caterpillars begin at once to feed upon the younger leaves. Each presently makes a tube or case about its body by spinning a silk thread and weaving in with this particles of its own excrement and other debris. The horn-shaped case, open at one end and tapering to a point at the other, is neatly lined with silk. It is lengthened as the larva grows, by addition to the open end, and thus is considerably longer than the caterpillar when this is full grown.

Of course a nursery tree should never be sent out with these webbed nests upon its bark. By a little attention when the trees are dug and stored the nests may be easily picked off. The insect often becomes destructively numerous in the nursery rows, doing serious damage to the stock. In that case it may be destroyed at small expense by sending boys through the nursery rows after the leaves have fallen, with instructions to pick off and collect every clinging tuft of leaves or rubbish. They should then be thrown upon the ground at some little distance from any fruit tree to insure the death of the caterpillar without destroying the parasites by which many of them will be infested. A cheap and effective remedy is the spraying of the infested trees in early spring, just as the young leaves appear and before the blossoms open. Experiment has shown that a single spray of Paris green and lime (one pound of each to

Fig. 17. The Leaf-crumpler; tube clusters in winter, containing living larvæ. (Stedman.)

one hundred and fifty gallons of water) applied at this season may destroy practically all leaf-crumplers in time to prevent noticeable damage by them.

THE PEAR-LEAF BLISTER.*

(*Eriophyes pyri.*)

This is a blemish of the pear-leaf, appearing first as reddish blister-like spots an eighth of an inch or more in diameter (Fig. 18), and gradually changing, through green, to black corky spots (Fig. 19), often so abundant as to destroy the larger part of the affected tissue of the leaves. It is caused by minute four-legged mites which live within the substance of the leaf and pass the winter in the bud scales at or near the ends of the twigs. In this situation they are of course certain to be sold with the tree, and delivered alive to the customer.

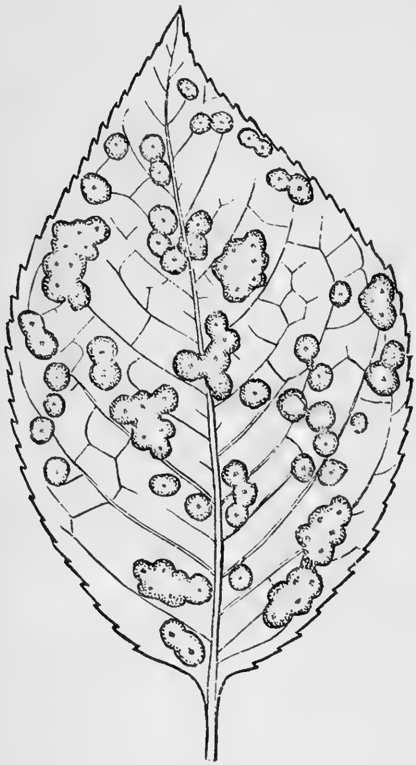

Fig. 18. THE PEAR-LEAF BLISTER; earlier stage (spots reddish).

They may be destroyed by a thorough spraying with kerosene emulsion diluted to contain about ten per cent. of kerosene.

The leaves of an infested tree are likely to show the presence of this disease before they fully open in spring. In this earliest stage red blister-like spots appear on the young leaf, brightest on the upper surface. Later they change through green to brown, becoming finally dark brown or black, reaching this last condition about the middle of June and continuing then unchanged until the fall of the leaf. These black spots are dead and dried and often unite to form large blotches, sometimes covering the greater part of the leaf. The new growth of the summer is likely

*For a full, illustrated paper on this injury see especially an article by Professor M. V. Slingerland in Bulletin 61 of the Cornell University Agricultural Experiment Station, December, 1893 pp. 317-328.

to be attacked by the disease, which passes then through the same series of stages described. If the under side of a diseased leaf be examined with a hand-lens, a minute round hole may be seen in the center of each discolored spot, and this leads into a chamber within the thickness of the leaf, in which live the mites that produce the disease.

The discolorations and appearances of injury above described are due entirely to the work of a microscopic mite, about one six-hundredth of an inch in length, belonging to the genus *Eriophyes*, peculiar in its long and almost worm-like body and in the possession of only two pairs of legs, placed close together near the front end. These minute creatures, which pass the winter between the bud scales, move to the young leaves even before these unfold, go through the epidermis on the under side, and feed upon the cellular tissue of the interior of the leaf. The destruction of substance and disturbance of growth thus caused, give rise to a thickening of the leaf, forming what is commonly called a gall, and finally cause the death of the injured tissue. As the leaves ripen and dry the mites escape through the openings of the galls and take refuge in the buds, where as many as fifteen or twenty may often be found under a single scale.

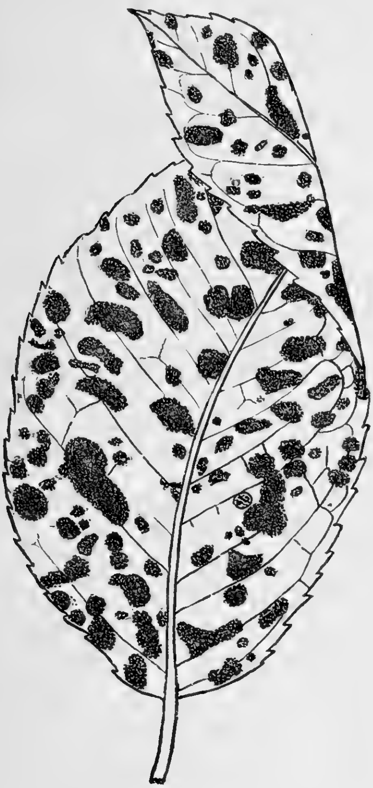

Fig. 19. The Pear-leaf Blister; later stage (spots dark brown).

It is often difficult to find a perfectly clean leaf on a badly infested tree, and often more than half the leaf substance may be killed by midsummer. Badly injured trees shed their leaves sooner than others, and "without its leaves the tree cannot store up the necessary food in its winter buds to insure a healthy vigorous tree and a full crop the next season."—(Slingerland.)

The progress of the disease can be arrested only by the destruction of the mites. This may be accomplished where there are but few infested leaves by picking or cutting them off and burning them—an operation best done in early spring. A wholesale method of destruction and an effective one is a very thorough spraying of the infested tree in winter with kerosene emulsion diluted with from five to seven parts of water. The tree should be sprayed thoroughly from every side, especial care being taken to reach the terminal buds, for this is where the mites are the most numerous. The same result may be obtained by dipping the trees in a kerosene emulsion after they are dug from the nursery rows.

The Tent-caterpillar.

(*Clisiocampa americana.*)

The twigs of nursery trees are sometimes encircled here and there with a thick belt or girdle of cylindrical eggs placed side by side with the broad end outward, and covered with a gummy coating (Fig. 20) which serves to protect them from the weather. The mass thus formed is usually about three quarters of an inch in length and something over a quarter of an inch in thickness, but narrows towards the end in a way to give it the look of a brown thickening of the twig itself. These are the eggs of the tent-caterpillar, two hundred or three hundred in a bunch. They are deposited usually in July, and are consequently to be found at any time during the late summer, fall, or the following winter. In early spring the

Fig. 20. The Tent-caterpillar; egg-mass on twig as seen in winter.

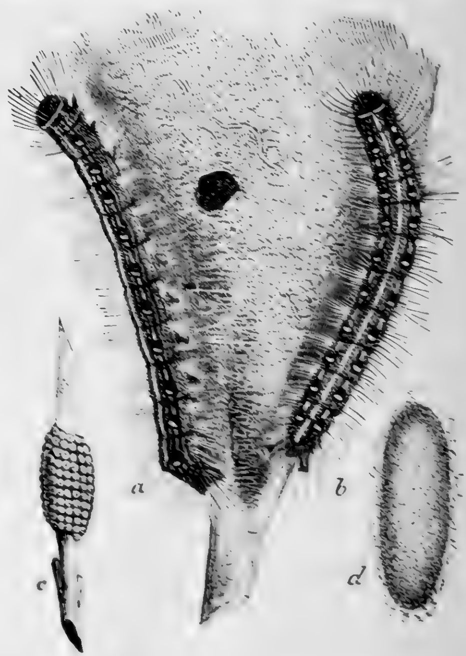

Fig. 21. The Tent-caterpillar: *a*, *b*, larvæ on nest; *c*, egg-mass with gummy covering removed; *d*, cocoon.

young caterpillars emerge from these imbedded eggs at a date corresponding closely to the opening of the buds on the apple or the pear. Soon they begin to spin sheet-like webs across the forks of the branches (Fig. 21), and as they grow they gradually make in this way a tent or nest, an irregularly conical, close-spun, whitish web, to which the colony resorts at night, and which serves them at all times for shelter and concealment. This tent does not inclose the leaves to any considerable extent, but the caterpillars come out from it to feed. They are very voracious, and rapidly strip the leaves from a tree. In June they are about two inches long (Fig. 21, *a*, *b*), with black head, the body rather dark, with a pale line along the middle of the back, and marks of blue, yellow, and black along the sides. The egg-masses, commonest on the apple, are quite conspicuous on the bare tree, and may be readily destroyed by cutting. The caterpillars are subject to arsenical poisons sprayed upon the leaves, but should not, of course, be permitted to hatch.

The Bag-worm.

(*Thyridopteryx ephemeræformis.*)

During the winter, oval, soft, sack-like bodies (Fig. 22, *c*), an inch or more in length, pointed at both ends and attached by one to a twig, may often be seen in orchards and on ornamental trees, and occasionally in nurseries also which have been infested earlier in the year. These are the egg-masses of the bag-worm, or basket-worm as it is sometimes called. Such as are empty have formerly contained the male insect (Fig. 22, *d*), escaped from its chrysalis (Fig. 22, *b*) the previous year. The eggs hatch in May and June, and the young caterpillars begin at once to feed. They presently make for themselves a silken covering (Fig. 22, *g*)

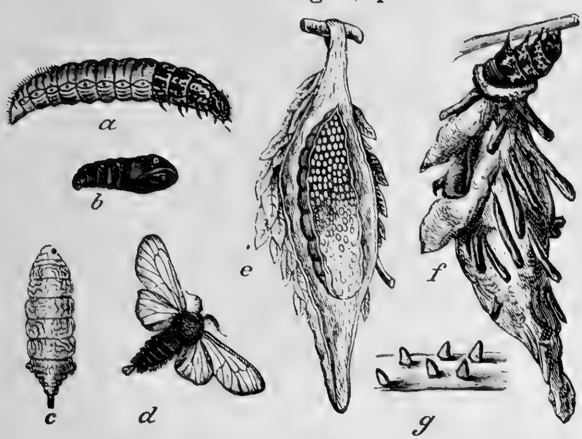

Fig. 22. The Bag-worm: *a*, larva removed from case; *b*, chrysalis; *c*, adult female taken from case; *d*, adult male; *e*, cross-section of bag and female within, latter full of eggs; *f*, bag and larva from evergreen; very young larvæ in their cases.

to which they fasten fragments of leaves, thus forming small portable cases (Fig. 23, 24, 22 *f*). As they hatch in large numbers from a single egg-case they may become very abundant on a tree and do it serious injury. It is unlikely that any careful nursery-

Fig. 23. THE BAG-WORM; young larvæ at work, and one of the cases enlarged.

Fig. 24. THE BAG-WORM; completed case of larva, from apple.

man will send out on his trees such conspicuous masses of insect eggs. They should, of course, be picked off and destroyed, if an earlier insecticide operation, such as spraying with Paris green, has not killed the caterpillars before they cease to feed.

THE TUSSOCK-MOTH.

(*Notolophus leucostigma.*)

This notorious shade-tree pest is injurious also to the apple, but it is mainly known for its injuries to ornamental trees in towns. In the winter, masses of eggs of this insect may be found fastened here and there, with a dead leaf or a cluster of such leaves, to the branch of a tree and attached to an empty gray cocoon (Fig. 25). A single cluster may contain from three hundred to five hundred white,

Fig. 25. THE TUSSOCK-MOTH; cocoon of female and frothy egg-mass laid by her upon it.

nearly globular eggs, placed in three or four layers, stuck together and imbedded in a gelatinous substance which gives the mass a grayish white surface and a convex form. The eggs hatch about the middle of May, and the young caterpillars begin at once to devour the leaves of the tree on which they are placed (Fig. 26). A careful nurseryman will always strip from the twigs of his trees, before shipping, any suspicious object of this sort, and the caterpillars can be poisoned with the usual arsenical sprays.

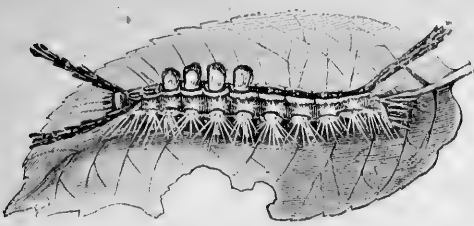

Fig. 26. THE TUSSOCK-MOTH, larva.

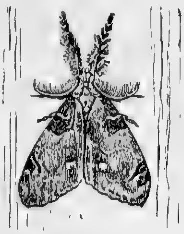

Fig. 27. THE TUSSOCK-MOTH, male.

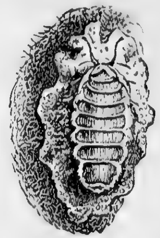

Fig. 28. THE TUSSOCK-MOTH, female.

THE APPLE-SCAB.

This is a fungous disease of the leaf and fruit of the apple, occurring throughout the state wherever this fruit is grown. The technical name of the fungus producing it is *Fusicladium dendriticum*. "It forms soot-colored spots with indefinite outlines, generally on the upper side of the leaves (Fig. 29). These spots vary from an eighth to half an inch in diameter, often fusing and occupying most of the surface, then causing the leaf to blacken, curl up, and fall; the deadened part sometimes falls out, leaving holes; the growth sometimes follows the veins, and thus assumes a branched form. Petioles and young growth of twigs are attacked. Fruit stems are occasionally injured so that young apples fall. Spots also appear on growing fruit, producing there what is known as scab, or black spot. (Fig. 30.)

"It attacks both young and old trees, being especially prevalent in nurseries among trees that have been left in the rows after they are too old to sell, and have thus become crowded and, it may also be, weedy. Some varieties are more subject to it than others, but crowded trees and those on low or badly drained soil are liable to it without much regard to variety. Its injury to the foliage consists in reducing the size of the leaves, in causing them to fall prematurely, and thus checking growth and preventing proper ripening of the wood and maturing of the buds."*

Fig. 29. THE APPLE-SCAB on the leaves.

A disease so abundant and so wide-spread as the apple-scab probably cannot at present be wholly kept out of either orchard or nursery, but it is nevertheless bad policy to distribute its germs with nursery trees if this can be prevented. It would probably be sufficient for practical purposes if nursery trees badly infested with this scab or blight were withheld from market and destroyed.

Fig. 30. TAE APPLE-SCAB on apples.

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*H. Garman, Kentucky Bulletin No. 80.

THE CANKER-WORM ON SHADE AND FOREST TREES.

At Jacksonville, Illinois.

At a session of the State Farmers' Institute held in Jacksonville, Ill., February 19–22, 1901, information was given me by Mr. H. S. Weston, Principal of the Jacksonville High School, from which I inferred that the canker-worm had done considerable injury to elm-trees in that city the preceding year, and this surmise was supported by additional information sent me February 25 by Dr. F. C. Winslow, Superintendent of the State Insane Asylum at that place. Mr. Weston kindly promised to watch for the adult insects that spring, and to give me notice if they appeared, and I received from him in consequence the following letter, dated March 19:

"I send you by mail specimens of the moth which I suppose is the parent of the worm which has destroyed our fine elms. The warm sun began to bring them out of the ground last Sunday, the seventeenth. They make for the nearest tree, and are now to be found hidden away in the crevices of the bark. Whether the moths fly into the trees or crawl up I do not know. At any rate the eggs are deposited on the twigs, I suppose, where the young worms hatch just at the time the first foliage appears. This they completely destroy when present in sufficient numbers."

The insects sent were the male moth of the canker-worm, and in my acknowledgment of March 22 I advised Mr. Weston that the trees might be protected at that season by surrounding the trunks with an adhesive band which should prevent the females from ascending the trees, but that if this were not done the only alternative would be spraying the foliage of the trees with arsenical poisons in May, after all the eggs were hatched. This advice being published in the local papers, many citizens applied a band of gas-tar to the trunks of their trees, after smoothing away the bark in a belt about twelve inches wide and about five feet from the ground. This was done in most cases late in March or early in April, and many thousand adults, both male and female, were caught in this band of tar, sometimes over a thousand females on a single tree.

In many cases the outer bark was scraped away too thoroughly, making wounds from which the sap flowed for several weeks. The gas-tar soon dried over in the sun, and many moths then crossed the belt, and later the heat of the sun caused it to run down the trunks.

This and similar applications, although made to many trees, were not used extensively enough to remove the danger of serious and possibly permanent injury to many hundreds of the magnificent elms for which Jacksonville is noted, and April 30 an assistant of my office, Mr. E. C. Green, was sent to that town with instructions to inspect the trees, to advise with the citizens, and to report upon the conditions found, with a view to such emergency measures as might prove necessary. Many egg-masses of the canker-worm were at this time scattered over the trees, and thousands of the small caterpillars, from an eighth to a quarter of an inch long, were already feeding on the slightly opened buds.

As a result of Mr. Green's visit and his interviews with prominent citizens I received May 1 a telegram from W. L. Fay, of the "Jacksonville Journal," asking me to send a spraying machine and men to spray the elm-trees at Jacksonville with a suitable insecticide, and offering to meet all expenses of the treatment. I also received a letter of the same date from Dr. Winslow, of the Insane Asylum, to the same general effect, saying that more than a hundred elm-trees on the Asylum lawn were in danger, and that the superintendents of the other state institutions at Jacksonville, and the citizens generally, desired to take the necessary steps to protect their trees.

The machine sprayer belonging to the office being at the repair shop at the time, I sent, in accordance with these requests, three orchard sprayers, with Mr. Green in charge, with the understanding that the necessary labor should be supplied at Jacksonville and that the expenses of the work, including the assistant's salary while engaged upon it, should be met by those interested at Jacksonville. This condition, which I was obliged to make owing to the fact that the appropriations of the office were not available for work of this description, was promptly accepted, the equipments were shipped, and May 6 Mr. Green returned to Jacksonville and made arrangements for systematic operations on the city streets and on the grounds of the state asylums.

A very severe hail-storm which swept the city May 5 seemed to have greatly reduced the number of canker-worms on the trees, knocking off all but very small ones, and so checking the injury for the time being. The leaves of the infested trees were, however, already badly riddled, and serious damage was certain to occur. May 8 and 9 the larger worms, half to three quarters of an inch in length, which had been knocked off the trees, were found on the trunks and larger limbs, evidently making their way back to the foliage. Only very small canker-worms could at this time be found on the leaves, so small, indeed, as to show that eggs must still be hatching.

Spraying began May 9, workmen being sent up into the trees by means of forty-foot extension ladders furnished by the fire department, and then climbing far enough to reach the outer branches with their spray. The work was laborious, difficult, and somewhat dangerous, but it was nevertheless continued with very good success until May 23, after which date the caterpillars had nearly all got their growth and disappeared, and the operation was suspended for the season.

The insecticide used was that known as arsenite of lime, a solution of common arsenic in lime-water. Twenty pounds of arsenic and 10 pounds of lime were boiled in about 20 gallons of water until dissolved,—commonly for an hour or more,—and this stock solution was diluted to contain a pound of arsenic to 300 gallons. The large sixty-foot elms required about 10 pounds of arsenic each. Twelve-foot bamboo rods were used in distributing the spray, with a Vermorel or Bordeaux nozzle at the end. The effect of the spray was very quickly seen in the dead and dying worms which fell from the trees, littering the sidewalks and grounds, where they were greedily devoured by sparrows and appropriated also by ants and other insects.

One hundred and ninety-nine trees were treated in all, varying in height from 20 to 80 feet, and averaging about 60 feet. The cost of the arsenic used was $2.50; that of the labor employed was about $99; and the other expenses involved were $65,—making the cost approximately 84 cents per tree.

Only a small part of the infested trees were covered by this operation, and many of those not reached by our parties were nearly defoliated by the end of May.

It was apparent October 2, when a visit was made to Jacksonville for an inspection of the elms, that most of the trees had supported the canker-worm attack without serious injury, only one being noticed which had apparently been killed by them. Others somewhat heavily attacked had made no terminal growth of twigs or branches, but had thrown out lateral twigs along the branches, from adventitious buds. Trees which had been sprayed were without exception in excellent condition, and those which had been but lightly infested showed little or no injury.

Notwithstanding the treatment, enormous numbers of the canker-worms had gone into the earth at the end of May for their pupation, and were certain to emerge as adults the following spring to renew the attack on the trees. With a view to setting on foot early preventive measures, Mr. E. S. G. Titus was sent from the office to Jacksonville January 22, 1902, bearing letters to the superintendents of the state institutions there, and to citizens prominent in the operations of the preceding year. He was instructed to describe and demonstrate a method of banding the trees which should prevent the females from ascending the trunks, and to assist in organizing and supervising volunteer work so far as might be necessary. Previous experiments, made on the state university campus at Urbana, had served to test various devices, and as a result it was decided to recommend the use of printers' ink, made a little more fluent by the addition of oil and spread in a thick layer upon a belt of paper tied around the tree.

The following is the full procedure used at Jacksonville. First, a strip of cheap cotton batting, not glazed, 2 or 3 inches wide, was laid around the trunk of a tree at the proper distance from the ground, and over this a 4 to 6-inch strip of tarred paper was lightly tied around the middle with ordinary wrapping twine. Upon this paper belt was spread, with a flat trowel or a wooden paddle, a layer a fourth of an inch thick of cheap printers' ink which had been mixed with a small amount of railroad car-wheel oil—just enough to make it easy to spread. It was the special purpose of this addition of oil to make the ink more sticky in cool weather. If the surface of the tar belt becomes slightly hardened by exposure so as to permit an insect to cross it, it may be made sticky again by brushing it with a little of the same kind of oil.

The mixture was spread on a paper band mainly to keep it off the bark. So applied, the unsightly band could readily be removed when the canker-worm season was over, whereas, if applied to the trunk directly it would have remained for many months to disfigure the trees. It is, furthermore, a practice of doubtful prudence to apply any substance to the bark of a tree with the expectation of leaving it there a considerable time, especially to a tree which is the product of a generation or two of growth, and which is likely to continue, if properly cared for, as a comfort and delight to many generations to come.

The cotton batting beneath the paper strip was necessary to keep the canker-worm moths from crawling up behind the paper where the roughness of the bark would give them passageway.

On the grounds of the Institution for the Deaf and Dumb were approximately four hundred trees to be banded, the diameter varying from fourteen inches to three and a half feet. Fifty of the trees were of this largest size, but the greater part of the four hundred averaged two to two and a half feet through. The cost of the operation on these trees was kindly given us by the officials as follows:

222 lbs. printers' ink, at 5c.	$11.10
7 rolls of tarred paper	7.50
103 rolls cotton batting	4.90
10 lbs. twine	1.00
Car-wheel oil	.25
9 days' labor at $1.50	13.50

Total cost, $38.25, or approximately 10 cents a tree.

Inquiry made by Mr. Titus in January, 1902, brought out the fact that the canker-worms were first seen at Jacksonville in 1899, on the county fair grounds, a half-mile west of the Institution for the Deaf and Dumb. Their progress from this place carried them to the eastward of this institution in 1900, and by 1901 they had reached the city square, three quarters of a mile farther east, and the grounds of the Insane Asylum still farther to the east and south.

At Decatur, Illinois.

In consequence of reports of injury to elms at Decatur, Illinois, a visit was made to that place by Mr. Titus May 22, 1902. In Fairview Park he found the leaves of the elms badly eaten by canker-worms, though the trees were not defoliated. The custodian of the park reported that this was the second season of this injury, little having been seen in 1901 and that not on all the trees. In 1902, however, practically none of the five hundred elm-trees in the park were free from attack.

These elms varied in size from 15-inch trunks to 2½ feet in diameter. The elms elsewhere in the city seemed also to have been infested locally, but not seriously or very generally so as yet.

Measures to protect the elms will doubtless be taken in this town next year, at least in the public parks.

In the Sangamon Forests.

On the the 23d of May a trip was made by Mr. Titus to a woodland area of several hundred acres lying along the Sangamon River in the Calamus Lake district, a few miles from Niantic, in Macon county, reports having come to me of an injury to elms in this region apparently attributable to the canker-worm. As soon as this forest came in sight, when still three miles away, deadened spots could be seen in the woods where groups of elms had been defoliated. In these places all except the youngest elms had been completely stripped of their leaves, evidently by canker-worms, of which a few indeed could still be found. The red-haw (*Cratægus*) and the wild cherry were similarly injured, apparently by the same insect.

Several of the larger elms seemed to be dead, doubtless owing to their defoliation for a year or more preceding. Young leaves had started after the first crop had been eaten away, but had died and dried up and were still hanging to the trees. The orchards in this vicinity were also generally infested, and defoliated elms and orchard trees were seen at intervals all along the way from Niantic to Decatur, a distance of twelve miles.

The preservation of these forest elms will call for measures similar to those used at Jacksonville, but here the treatment may be simplified by merely plastering the printers' ink directly on the tree either with or without a smoothing of the surface by the scraping away of the outer bark. These woodland trees being less valuable than those in town, and the continued smearing of the trunk being a matter of indifference, a careful process of banding, desirable in streets, would be unnecessary here.

THE COLASPIS ROOT-WORM.

(*Colaspis brunnea* Fabr.)

The Colaspis root worm is the grub or larva of an insect long known as injurious to horticulture in its adult stage, eating the leaves of the grape, strawberry, apple, pear, and other fruiting plants, and as a larva feeding on the roots of strawberries. The beetle has been known in horticultural entomology as the grape-vine Colaspis (Riley), and in consequence of its injuries to strawberry roots the larva has been called the strawberry root-worm (Forbes). We have had no reason until quite lately to include this species in the list of the insect pests of agriculture, although minor injuries done by the beetle to clover, buckwheat, beans, potatoes, beets, etc., have been noted and reported by entomologists; but the discovery in June, 1900, that the larva is capable of doing great damage to young corn by the destruction of its roots has made this insect an object of considerable interest to the general farmer.

Injuries to Corn.

Our first knowledge of this feature of its feeding habits is due to an inquiry, accompanied by specimens of the larva, addressed to me in June, 1900, by Mr. John T. Watkins, a farmer living near Griggsville, in Pike county, in the west-central part of the state. In consequence of his letter two visits were made to his neighborhood by an office assistant, Mr. E. B. Forbes, on the 23d and 28th of June, 1900. From Mr. Forbes's notes it appears that parts of several corn fields near Pittsfield, lying in various directions from town, from the southwest to the northeast, were more or less damaged, and that a few of them were in decidedly bad condition. In the first field visited, for example, the corn did not average over eighteen inches high, although in adjacent fields on similar soil it would reach to the waist. Many injured plants were not more than six or eight inches high, and the lower leaves of these were dry and brown. In another field the height of the uninjured corn was about five feet, but in large irregular spots—some of them two or three acres in extent—the average height was not more than a foot and a half. The lower leaves were partially dried and the tips of others were fading and drying up. In all these injured spots the roots had been gnawed or eaten, and the root-worms were found sometimes as many as a dozen or eighteen in a hill. In much the greater number of cases these injured fields were on relatively high and rolling land, usually, indeed, on the tops of hills where the soil was light and the growth of the plant comparatively slow; and in most cases these fields were all in corn for the first year after sod. Two instances were observed, however, of the occurrence of this this root-worm in fields which had been in corn the year before.

It was difficult to judge of the precise amount of injury to be attributed to the root-worms owing to the fact that they were so frequently associated with other insects affecting the general vigor of the plant in a similar manner. White grubs and wire-worms were common in some of these fields, and the corn root-aphis (*Aphis maidiradicis*) was seemingly more injurious at the time than any other insect pest.

The actual injury to the roots seems to be somewhat characteristic and not likely to be mistaken for that of any other insect. The tap-root was certain to be damaged if any harm at all had been done, the soft outer tissue of the root being eaten away down one side in an irregular line which sometimes took a more or less winding course. Usually only the surface tissue was gnawed off, but in other cases spots were eaten out to the middle of the root. The larva never cuts the root off or eats it up wholly, as does the white grub, and never burrows inside of it like the common corn root-worm.

General Appearance of the Insect.

As seen in the field in June this root-worm (Fig. 32) is a small, thick, soft, and fleshy grub, an eighth of an inch in length when grown, with the head white or reddish or brown according to the time since the last molt. The head is hard and smooth, and the top or back of the first segment of the body immediately behind the head —the one bearing the first pair of legs—is smooth and leathery and of the same color as the head, the rest of the body being soft and wrinkled crosswise. The only insects likely to occur in the same situation for which this root-worm might be mistaken are very young white grubs; and these are very readily distinguished by their more slender form, but especially by the fact that the leathery shield behind the head is wanting in the white grub, the first segment being soft and wrinkled like the others.

Fig. 31. Adult beetle, the short line at the left indicating the natural size.

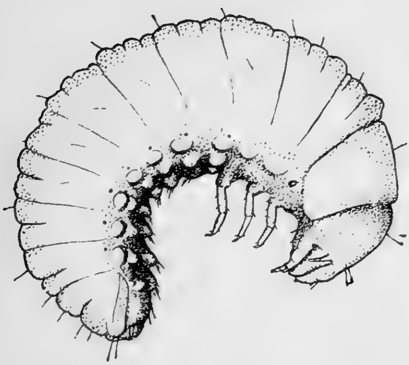

Fig. 32. Larva, greatly enlarged.

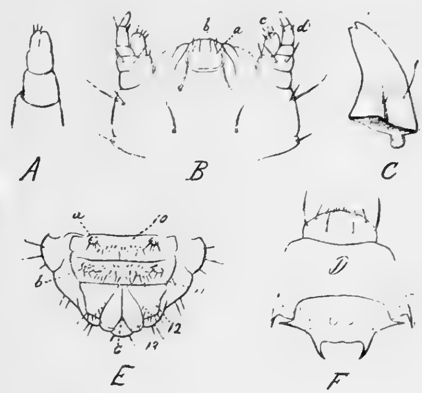

Fig. 33. Larval and pupal structures: *A*, antenna of larva; *B*, labium and maxilla of larva; *C*, mandible of larva; *D*, labrum of larva; *E*, end of larval abdomen; *F*, end of pupal abdomen.

THE COLASPIS ROOT-WORM.

Injuries to other Crops.

As a larva or root-worm this insect has hitherto been found feeding on the roots of strawberry only, but the field studies of Mr. Ernest B. Forbes already mentioned show that it feeds freely and perhaps primarily on the roots of timothy (*Phleum pratense*), infesting other crops most frequently when they follow timothy sod. He found it also at work on June grass (*Poa compressa*) and Mexican dropseed (*Muhlenbergia mexicana*), and occasionally on clover roots. In some timothy meadows it was so abundant that one or more of the larvæ were turned up with every spadeful of the soil, but a similar search in fields of blue-grass was withont result. So far as we can judge from these observations it seems that only somewhat thick and fleshy roots are likely to be eaten by it, but a systematic search would doubtless discover it on the roots of other plants than those here mentioned. These injuries to roots have amounted to little or nothing, so far as known, except in strawberry patches.

In the adult or beetle stage this insect has been found feeding upon the leaves and other organs of a considerable list of widely unlike plants, including clover, beans, buckwheat, beets, dock (*Rumex*), grape, pear, strawberry, tick-trefoil (*Desmodium*), and New Jersey tea (*Ceanothus*). It has also been reported to eat the leaves of the potato and the silks of corn. One of my field assistants, Mr. E. S. G. Titus, has this year found it feeding in early July in southern Illinois on the cow-pea, the musk-melon, and the apple, in the last instance seriously injuring the foliage of a single tree. In most cases the damage done by the beetle has been of little importance, but it is occasionally serious to the leaves of strawberries and grapes. Our examples of the injury to apple and grape show that it eats irregular elongate holes quite through the leaf.

Distribution and Life History.

This insect ranges from Nebraska to the Atlantic states and Canada. It is evidently single brooded, but its state of hibernation has not been positively ascertained. The eggs are laid in summer and fall, and the larvæ have been found by me half grown in southern Illinois May 19. It begins to pupate in June, and lives as a beetle during the summer months. In this stage it ranges in our collections from June 22 to September 14, but is most abundant in July and August. We have not found it at all in winter, even in situations where it had been previously present in large numbers.

Description.

The egg has been described by Chittenden* as "elliptical, nearly two and a half times as long as wide, not perceptibly flattened at any point, just perceptibly narrower and less rounded usually at one end than at the other, and stramineous in color. The surface is perfectly smooth, without visible sculpture and moderately shining. Length, 0.5—.54 mm.; width, 0.21—0.23 mm."

The larva is 3 4 mm. long by half as wide, white except the head and first segment, which are usually pale yellowish brown The first segment is of firmer consistency than the others, leathery and smooth above, and as long as the two following together. The head is smooth somewhat flattened in front, with a few slender scattered hairs. The mandibles are curved and rather narrow, the width being about two thirds the length. They are broad and blunt at the tip, where they are more or less clearly notched, sometimes with one notch and sometimes with two. The under side of the body is transversely ridged, one ridge to each segment, and at each end of each ridge are two prominent tubercles, forming lateral rows, bearing strong spine-like hairs. (Fig. 32.)

The pupæ are 3.5 mm. long by 2.5 mm. wide, white except the eyes and mandibles, which show red and black respectively when the pupæ are matured. The last segment terminates in two simple hooks, the points of which curve towards each other, and in front of these hooks are two pairs of lateral spines, the first of which project directly outwards.

Conclusion.

It is possible that this beetle may become generally and continuously destructive to corn, although its serious injuries so far as known at present have been limited to a single neighborhood in western Illinois. The wide variety of plants to which the beetle may resort for food and the general distribution and abundance of some of these, the abundance also of its larval food in the roots of timothy grass and corn, and the absence, so far as known, of any unusual checks on the multiplication of the species, are all conditions favorable to its maintenance in greatly increased numbers. In the present imperfect state of our knowledge of its habits, of its food preferences, and of its life history, it is impossible to discuss satisfactorily the subject of preventive or remedial measures.

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TWENTY-THIRD REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS

TWELFTH REPORT OF S. A. FORBES

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INTRODUCTORY NOTE.

In the Eighteenth Report of the State Entomologist of Illinois—the seventh of the present writer—was published the first part of a monograph of insect injuries to Indian corn, treating of injuries to the planted seed and to the roots. The present report is in continuation of the foregoing, and relates to injuries to those parts of the corn plant which are exposed above ground. Both divisions of this text have been made to include a discussion of more than the strictly injurious species, this second part especially giving practically equal attention to the corn insects generally, whether of present economic importance or not. I have, however, divided them into "the more important," "the less important," and "the unimportant" species, and have treated those notably injurious in a strictly practical manner with a minimum of technical discussion.

In preparing this paper for publication I have of course drawn freely on all sources of information known to me, but owing to the large number of species included it has been impossible to give in so brief and comprehensive a paper my authorities in detail, or even to distinguish new matter from old, or contributions of this office from those made by numerous other workers in this field. I have, however, compensated for this deficiency as well as I could by printing a list of the species discussed, with fairly full bibliographical references to the economic literature of each.

I am under unusual obligations to Mr. C. A. Hart for aid in the collation and organization of the material for this report and in the preparation of manuscript, especially that on the more technical parts of the subject. Most of the figures originating in this office—several of which are here printed for the first time—are from drawings made by Mrs. L. M. (Hart) Green; and the responsibility of seeing the report through the press has fallen mainly upon Miss M. J. Snyder, for many years Secretary of the State Laboratory of Natural History and proof-reader in my entomological office. I am indebted for many of the illustrations here used to Dr. L. O. Howard, Professor F. L. Washburn, Mr. Wm. Beutenmüller, Professor M. V. Slingerland, Dr. A. T. Neale, Professor John B. Smith, Director C. E. Thorne, and Dr. W. E. Britton.

S. A. FORBES,
Illinois State Entomologist.

A MONOGRAPH

OF

INSECT INJURIES TO INDIAN CORN

PART II

THE MORE IMPORTANT INSECT INJURIES TO INDIAN CORN.

The Illinois State Entomologist is by law required to investigate "the entomology of Illinois," and particularly to study "the history of the insects injurious to the products of the horticulturists and agriculturists of the state," and to prepare "reports of his researches and discoveries in entomology for publication by the state." While the main end of his studies should thus be economic, the whole subject of the entomology of Illinois is nevertheless open to his investigation and report. The advancement of entomology as a science and the adaptation of entomological knowledge to educational uses, if not his duty, are clearly within the general field of his privilege. I have accordingly, in the preparation of this report taken into especial account the rapidly rising interest in nature study as a useful feature of the work of the elementary school, and I have availed myself of the opportunity to incorporate into the present discussion much matter of little or no economic interest, but worthy of presentation, nevertheless, as material of value to the public school teacher in search of information concerning the commoner objects of his neighborhood.

The corn plant is so conspicuous a feature in the agriculture, and hence in the civilization, of Illinois that it must always be an attractive subject of study to the youth of the state, and suitable in a multitude of cases for use in the public schools. Like most of the larger and more abundant plants, it draws to itself a considerable assemblage of insects which find in it various attractions and advantages contributing to their maintenance or their pleasure, and which thus, by their common interest in this one great plant, come to form a kind of associate group, the group of the *corn insects*. Very few of them are peculiar to the corn plant alone, since nearly all of them are equally or even more strongly attracted to other plants as well. Many of them, indeed, belong to a considerable number of such plant-insect groups, visiting or living on many other plant species, cultivated and wild.

Not one of them is immediately beneficial to the corn plant itself, although a considerable number, parasitic or predaceous on other insects, are indirectly beneficial to it by relieving it to some extent from the attacks of insect enemies. Several of them do no appreciable harm at any time; others are injurious only under special conditions more or less rare; and still others are injurious to it whenever and wherever they occur. Their common interest in this one plant of course brings these insects also into important relations to each other, like those which influence any local assemblage of animals — those of a pond, of a grove, or of a barnyard, for example — and make of them a related group instead of a mutually indifferent assemblage.

It is the object of the present report to discuss this entire group of corn insects, to the end that the teacher and student, of whatever grade, may find in this paper a clue to the whole system of insect life of which the corn plant is the center. The study here presented may thus stand as in many respects a type or example of the relations of a plant to its insect visitants. While in this treatment the economic features of the system will receive full attention, this will not be to the exclusion of features of scientific or educational interest merely; but to avoid encumbering the more important economic matter with details and discussions of secondary interest, the paper is divided into sections, based on the economic relation.

Divisions of the Corn Insect Group.

The entire assemblage of corn insects is much too large and complicated for convenient discussion as a whole, and it may consequently best be divided into subordinate groups, some corresponding to the different organs and structures of the corn plant itself, others to different stages of its growth, and still others to the previous history of the land on which the corn is grown or to the situation of the field with respect to other and adjacent crops. There is, for example, a small group of insects which become abundant in corn fields only where corn is grown on the same ground year after year — the corn root-worm is an instance — while others, like the wireworms, infest corn injuriously only when this follows within a year or two upon grass, and others, like the stalk-borer, may invade corn only from grass-lands outside. The corn root-aphis makes its main attack on the crop while the plant is young, and the leaf-aphis usually does not appear until the crop is well advanced, and continues in rapidly increasing numbers until frosty weather checks its multiplication.

Among the groups corresponding to the different parts and organs of the growing plant the most definite distinction is between those especially adapted to a life under ground, and those which never enter the earth in search of food. The white-grubs, wireworms, corn root-worms, seed-corn maggots, and root-lice are on one side of this dividing line, and the chinch-bug, army-worm, corn-worm, leaf-louse, and a host of additional species are on the other. Among the subterranean corn insects we may distinguish a few which feed only on the softened seed in the earth; others confined to the living roots; other root insects which may extend their injuries to the underground part of the stalk; and still others which may also eat the seed.

While the relations of the injurious species of corn insects to the plant thus differ widely, making it possible to divide the species according to these relations, groups so formed are by no means as definite and sharply limited as those in a classification based on form and structure, but they overlap and intermingle variously, and may even undergo radical change with the lapse of time — a change corresponding to a change of habit in a species with the changing conditions around it. This is merely saying in other words that the actions, behavior, habits, and preferences of insects are more flexible and variable and far more readily adaptable than such of their structures as are used in their classification.

Adaptations and Reactions of the Corn Plant to its Insect Visitants.

There is little in the structure or the life history of the corn plant to suggest any special adaptation to its insect visitants — no lure to insects capable of service to it, or special apparatus of defense against those especially liable to injure it. The fertilization of its seed is fully provided for without reference to the agency of insects, and would be as well accomplished if none of them ever carried pollen from the tassel of one plant to the silk of another. Hence the plant secretes no honey and has no floral odor or colored bloom. It has no armature of spines or bristly hairs to embarrass the movements of insects over its surface or to defend against their attack the softer and more succulent foliage at its growing tip. It secretes no viscid fluids to entangle them, and forms no chemical poisons or distasteful compounds in its tissues to destroy or repel them. The cuticle of its leaf is neither hardened nor thickened by special deposits; its anthers are neither protected nor concealed; and its delicate styles — the silks at the tip of the ear — are as fully exposed as if they were the least essential of its organs. Minute sucking insects are able at all times to pierce its roots and its leaves with their flexible beaks, and with the single exception of its fruit there is no part of it which is not freely accessible at any time to any hungry enemy. Only the kernel, which was lightly covered in the wild corn plant by a single chaffy scale or glume, has become, in the long course of development, securely inclosed beneath a thick coat of husks, impenetrable by nearly all insects; and we may perhaps reasonably infer that among the possible injuries against which this conspicuous protective structure defends the soft young kernel those of insects are to be taken into account

There are also, of course, many insect species, even among those which habitually frequent the plant, which are unable to appropriate certain parts of its substance to their use, but this is because of the absence of adaptation on their part and not because of any special defensive adaptation on the side of the plant. The adult or beetle of the corn root-worm (*Diabrotica longicornis*) is an example. The larva of this insect feeds only on the roots of corn, and the beetles consequently all make their first appearance for the year in corn fields, and find their food at first on the corn plant. Owing, however, to the weakness of their jaws they are unable to eat the leaves of corn, and feed only on the fallen pollen and the young silks just growing out from the husks. Later, as the pollen disappears and the silk dries up, they are driven to other plants, or even compelled to leave the field entirely in search of food, and hence are found at that time on clover heads and on the flowers of thistles and ragweed and other late-blooming plants.

Thus we may say that with the exception of the ear the whole plant lies open and free to insect depredation, and that it is able to maintain itself in the midst of its entomological dependents only by virtue of its unusual power of vigorous, rapid, and superabundant growth. Like every other plant which is normally subject to a regular drain upon its substance from insect injury, it must grow a surplus necessary for no other purpose than to appease its enemies; and this, in a favorable season, the corn plant does with an energetic profusion unexampled among our cultivated plants. Insects, indeed, grow rapidly as a rule, but soon reach their full size. Many species multiply with great rapidity, but even these the corn plant will outgrow, if given a fair chance, provided they are limited to corn itself for food.

The great injuries to corn by insects are done by species which come into it from other and earlier crops; insects which are in the full tide of their multiplication, or perhaps at their maximum number for the season, while the corn plant is still small and young. It is not the corn root-aphis which injures corn most seriously, although confined to the corn plant and endowed with a power of multiplication scarcely surpassed among insects; it is the chinch-bug, which breaks into the field of young corn from adjoining wheat or oats, where it has already increased a hundred-fold since spring began; it is the army-worm or the cutworms, or the wireworms, or the white-grubs, which began and got most of their growth in grass, and now, by their numbers and voracity, overwhelm the young corn before the time of its most rapid growth has arrived. Practically limited to this vigor of growth as a means of escape from insect attack, anything which checks or retards its growth for a considerable time has, of course, the effect to increase insect injury. Thus, a cold and backward spring after corn-planting increases injury to the seed and the young plant by wireworms, seed-corn maggots, and the corn root-aphis; and a midsummer drouth greatly increases the effect, if not the amount, of injury by chinch-bugs, white-grubs, and the corn root-worm.

General Effects of Insect Injury.

With few exceptions, the effects of injury to corn by insects, where they do not amount to a total destruction of the plant, may be compared to the effects of simple starvation. Anything which lessens the store of food laid up in the corn kernel for use in germination and early growth, or damages seriously the roots or the leaves, or draws away the sap before it has served its purpose in the plant, practically amounts to a diminution of the available food supply. An impoverished soil, very dry weather, the sapping of the cells and vessels of the plant by sucking insects, destruction of any considerable part of its roots, and the deadening or destruction of any large percentage of its leafage, all have similar consequences, which may be classed as starvation effects, and when two or more of them coincide, each serves, of course, to intensify the effects of the others.

One common result of these starvation injuries to corn is the failure of the plant to form the ear; the stalk itself, perhaps, making a fairly vigorous growth, but remaining barren, and hence useless except for fodder. Injury to the roots, if continuous and severe, has, however, another effect, of a more special character, in so weakening the hold of the plant on the earth that the stalk readily falls after it has become top-heavy with growth, and is not able to rise again. This happens after soaking rains have softened the ground, especially if accompanied by heavy winds. It is sometimes a consequence of the destruction of the roots by the corn root-worm and the white-grubs, and is sometimes due to chinch-bugs, which, by sucking the sap from the base of the stem, prevent the formation of the strong "brace-roots" — the upper circle of roots — put forth during the last stages of the growth of the stalk. Actual loss of roots sometimes also delays the development of the plant, acting in this respect like an unusually cool summer. Thus, a field infested by grubs or root-worms may remain green after uninjured fields are practically ripe. Such backward fields are especially exposed to injury by frosts, and hence are likely to yield an unusual amount of soft corn.

Besides this class of general injuries, which diminish the vitality and lessen the size or delay the growth of the whole plant, there remain only the more local injury to the ear, caused almost wholly by the caterpillar known as the corn root-worm, and the damage done to the ear in the crib or to the kernel in the bin by the weevils and other insects of similar habit. With respect to their economic mischief, there is probably little to choose between those insects which, by destroying or weakening the plant, prevent the development of the ear or diminish its size and those which destroy the mature product. One deprives the farmer of the reward of his labors and investments as completely as the other.

General Measures of Prevention and Remedy.

From what has been said above with respect to the starvation effect of most insect injuries it follows that any management which helps to maintain and strengthen the plant by furnishing it better or more abundant food will lessen, or perhaps wholly prevent, losses from insect injury which must otherwise be serious or complete. A strong, rich soil, well cultivated, well watered, and well drained, may grow a good crop notwithstanding an amount of infestation by chinch-bugs, root-lice, root-worms, and white-grubs which would be fatal on poor or poorly managed land. The good corn farmer may thus escape with a profitable yield under insect attacks which will leave his less intelligent or less careful brother in debt after his crop is harvested. This is not merely because the vigorous plant will easily support an amount of injury under which the unthrifty one will suffer or succumb. It is an established fact that many insects themselves will not thrive as well or multiply as rapidly on a vigorous, quickly growing plant as on one in feeble condition.

More special measures are a proper rotation of crops, such that corn shall not be exposed to injury by insects which have bred on the same ground the preceding year, either in other crops or in corn itself; timely plowing, to forestall the breeding of insects by destroying them or their food; timely planting, with reference to the period of the greatest abundance or greatest activity of certain species; and the use of barriers against the movement of certain destructive species into the corn from fields adjacent, combined with insecticide measures against hordes or companies of destructive insects, which if left to themselves will work great and immediate harm.

Insect Injuries to Different Parts of the Corn Plant.

To the Leaves.—That the abundant, conspicuous, and easily accessible foliage of the corn plant should attract a large number of hungry insects and suffer more from their attentions than any other part, is naturally to be expected, since, as a consequence of its gradual and long-continued growth, it offers for consumption during many months the most succulent and nourishing food which the plant produces.

More than one hundred species of insects, representing all of the orders injurious to corn, have, in fact, been found feeding on the leaves. The most important differences in their injuries are due to differences in the mouth-parts of the insects — whether sucking or biting — and the principal differences subordinate to these are due to differences in size, number, and feeding habits of the insects concerned.

A sucking insect, merely piercing the tissue with the delicate bristle-like structures of its beak and withdrawing from the adjacent parts the more fluid portions of the cell contents, may, if very small, drain and deaden only a few neighboring cells, thus causing a minute discolored speck, insignificant unless these injuries are very numerous. Such are the injuries done by leaf-hoppers and other minute sucking species of active habit, each deadened speck evidently representing a single meal of the insect, which moves to another point, or perhaps to another plant, for its next. Plant-lice, on the other hand, which change their location with difficulty and reluctance, each remaining, as a rule, about where it was born, accumulate in patches or colonies as they multiply, and, closely occupying a larger surface, so concentrate their injury as to do much more serious damage. If injuries of this sort are greatly multiplied, as by multitudes of the chinch-bugs, the whole leaf is killed outright.

Gnawing and biting insects differ similarly with respect to the magnitude and seriousness of their injuries. Some of the small size with feeble biting organs merely gnaw away the more superficial and softer parts of the leaf, leaving the vein structures untouched, and causing discolored specks not unlike those due to leaf-hoppers; somewhat larger kinds make small holes through the leaf like pin-pricks or shot-holes; and still larger ones, such as grasshoppers, eat away the edge of the leaf or gnaw large and irregular holes through it, avoiding nothing but the heavy midrib and the stronger veins. Grasshoppers sometimes strip the whole leaf to the midrib, and eat away all but the tougher and thicker part of this.

Curious parallel rows of precisely similar holes, running across the corn leaf, are made by the corn bill-bugs, which thrust their stiff snouts, or "bills," into the young plant where its leaves are rolled together, and eat out the interior by means of minute jaws borne at the tip of the snout.

To the Stalk. — The stalk of the plant is injured by the loss of sap drained away by sucking insects, of which the chinch-bug is the most destructive; by a mining of its interior by caterpillars, like the stalk-borers, which enter it from the outside; by the punctures and feedings of the corn bill-bugs, which sink their beaks into its substance and eat out its soft interior tissue; and by the gnawing of a few large beetles (*Ligyrus*, *Allorhina*, etc.), which eat out large cavities in its side. It is similarly gnawed and irregularly eaten, when young, by sod web-worms; it is cut off at or near the ground by cutworms, and in rare instances by ants (*Pogonomyrmex barbatus*); and devoured, with the rest of the young plant, by army-worms and garden web-worms. Under ground it may be gnawed out or eaten through from side to side by wireworms, or irregularly mined by the small, soft-bodied larva known as the southern corn root-worm (*Diabrotica 12-punctata*).

To the Ear. — Injuries to the ear are of two principal kinds: the kernels may be eaten beneath the husk by a large green or striped caterpillar which bores in from the outside and feeds irregularly about, fouling the ear with its excrement; or the silks may be gnawed away from the tip of the cob at a time to interfere with the process of fertilization, and thus to blight the kernel. Small damage is also done by various beetles, caterpillars, and grasshoppers, which gnaw away the kernels at the tip of the ear where these are exposed by the opening of the husks. This injury, however, is mainly confined to ears upon the ground or to those which have been previously visited by birds. Sometimes the husks are largely eaten away by grasshoppers, together with the softer parts of the young ear itself.

Injuries to Corn by the Different Orders of Insects.

Hymenoptera: Bees, Wasps, Ants, etc. — With the exception of a small bee (*Halictus lerouxii*) frequently seen gathering corn pollen from the silk, leaves, and husks, but responsible for neither injury nor benefit to the plant, various kinds of ants are the only insects of this order which occur frequently in fields of corn.

Ants are among the most active, observant, and capable of all insects. Their restless and wide-ranging habits bring them into acquaintance with every variety of objects in their neighborhood, and little escapes their notice or their appropriation which can in any way be converted to their support. The abundance of certain species in corn fields in spring, shown especially by their burrows in and near the hills of corn, is a matter of common observation. Even in fall after frost, or during the warmest days of an open winter, these enterprising rangers may be seen climbing over the dead stalks or coursing irregularly about upon the bare earth; and many of them pass the winter in burrows or nests among the corn roots, where they are turned out in the spring plowing with eggs and larvæ in their possession.

A few corn-field ants are directly injurious to corn by hollowing out the softened and sprouting kernels in the earth, thus either preventing its germination, killing the young shoot, or weakening it by appropriating the stored food necessary to its earliest growth. The common house-ant has been once or twice reported to gnaw the young corn leaf and drink the sap exuding from the wounds thus made. One species of Southern leaf-cutting ant bites out pieces of the corn leaf, which it carries away to its underground burrows, and certain other ants are found occasionally about the tips of the green ear feeding on kernels which have been injured previously by other insects or by birds.

Direct injuries of this class are, on the whole, economically insignificant, but a few kinds of ants are capable of an indirect injury to corn which often becomes extremely serious. By the care and assistance given to plant-lice, or aphides, which infest the roots and leaves of corn, they greatly extend and increase the injury done by these insects which they have in charge. This injury is mainly due to ants which live in corn fields throughout the year, reinforced, as they are, by newcomers from adjacent grass-lands in early spring. In their underground nests in the field they collect in fall the eggs of the corn root-aphis, and in spring they place the young hatching from these eggs on the roots of suitable food-plants. As these grow and multiply, the ants transfer them from one plant to another as necessity may arise, devoting themselves to their welfare with a constancy and patience, due not to charity, as it might seem, but to an enlightened regard for their own best interests. Throughout nearly the whole season, indeed, these ants are dependent on their helpless charges for food, which they find in the abundant fluids given off by the plant-lice as these suck the sap from the growing plant.

To the ant the plant-lice are living automatic pumps, constantly drawing from the tissues of the plant excessive quantities of sap, abstracting from this only a part of its food material as it passes through their bodies, and giving it forth again in condition to serve a second time for the support of insect life. A similar benefit is derived by other species of ants from the corn leaf-aphis, but this insect is only slightly injurious to corn, and the ants are less essential to it. Nothing is known, for example, to indicate that the eggs of the leaf-aphis are cared for by ants, and, indeed, no eggs of this species have ever been found.

With the exception, therefore, of the various species of ants which attend the corn root-louse in the earth, injuries to corn by these insects may be practically ignored as insignificant, and at worst as not serious enough to require or warrant attempts at measures of prevention.

Diptera: Flies and Gnats. — Among the multitudes of two-winged flies, or *Diptera,* only a few are found frequently on or about the corn plant, and scarcely one of these is likely to do it any serious injury. The winged insects themselves are never injurious to corn, all the harm done by these insects to this plant being through their larvæ or maggots only. When corn has followed upon clover, the roots of the young plant have rarely been injured by the large, dirty-looking, grub-like larvæ of one or two of the crane-flies (*Tipulidæ*); the planted seed is sometimes eaten to some extent by the small seed-corn maggot (*Pegomyia fusciceps*); the leaves are occasionally mined in a very small way by two or three mining maggots (*Diastata* and *Ceratomyza dorsalis*); and the larva of a Syrphus fly, which commonly feeds on the fallen pollen lodged in the tassel or at the tip of the ear or at the base of the leaf, is reported sometimes to puncture the leaf for the sake of the sap. Other Syrphus larvæ doubtless compensate fully for these small injuries by feeding on the corn leaf-aphis, of which they are very fond.

The sole measure of prevention suggested by these facts relates to the so-called meadow maggots, the tipulid larvæ mentioned above. These insects are found in injurious numbers only in meadow-lands where they have hatched from eggs laid in grass or clover, and corn should not be planted on sod which was badly infested by these the preceding year.

Lepidoptera: Butterflies, Moths, and Caterpillars.—Caterpillars of about fifty-six species have been collected or reported from the corn plant, feeding on the stalk, the leaf, and the ear, or in some cases devouring the young plant entire. The principal injurious groups are the cutworms, the grass-worms, the army-worm, the web-worms, the stalk-borers, and the so-called corn-worm, which penetrates the husks and mines in the grain beneath. Of these, the cutworms, the army-worm, and the corn-worm are by far the most destructive. A few other caterpillars (*Hadena* and *Prodenia*), allied to the cutworms but having a different habit, are much less injurious.

Some seventeen species of cutworms have been taken in corn, all of similar habit with respect to corn, but very considerably different in life history—a fact which has an important bearing on measures for their control.

The stalk-borers, which penetrate the stalk and burrow within it, are the common species of that name (*Papaipema nitela*), the spindle-worm (*Achatodes zeæ*), the southern corn-stalk-worm or sugar-cane borer (*Diatræa saccharalis*), the smaller corn-stalk-borer (*Elasmopalpus lignosellus*)—also essentially a southern species—and a caterpillar (*Helotropha reniformis*)—a northern species which does not injure corn in Illinois, but which has been known to destroy it in Michigan by burrowing along the center of the young stalk. In fact, only the common stalk-borer is commonly abundant enough in Illinois to rise to economic importance.

The grass-worm (*Laphygma frugiperda*) is a pest of common occurrence, but is ordinarily economically insignificant. Occasionally it multiplies in here and there a place in a way to cause serious mischief, although it has but once been found by us (in 1889) notably destructive to corn.

The army-worm does not breed in corn fields, and is rarely found there except when its numbers force it to migrate, but then it often lays the field absolutely bare by devouring every plant to the ground. The turf web-worms (*Crambus*) are sometimes very destructive locally in Illinois to young corn after grass, and the garden web-worms (*Loxostege*) are even more injurious in the west-central states. The corn-worm (*Helio-*

this armiger), called also the cotton boll-worm in the South, is very generally and seriously injurious to corn in the ear.

The only groups of these caterpillars against which it is practicable or necessary to use special measures of protection in Illinois are the army-worm, the cutworms, the web-worms, and the stalk-borers, injuries by other species being either too trivial or too infrequent to warrant special precautions, or, like those of the corn-worm (*Heliothis armiger*), uncontrollable by any measures as yet devised and tested. Cutworms, web-worms, and stalk-borers may be virtually prevented from doing serious damage to corn by a proper arrangement and rotation of crops, and by an intelligent selection of times and methods of handling and plowing grass-lands previous to planting them to corn. The army-worm must be excluded from the field by barriers to its progress when it is on the march, and destroyed as it collects before such obstacles. A fuller discussion of these various measures will be found in connection with the special articles on the groups themselves.

Coleoptera: Beetles. — Approximately ninety species of beetles have been identified as corn insects in either the larval or adult stages, a few of them in both. Not more than one third of these species, however, need be mentioned in a merely economic list, and if we do not attempt to distinguish for economic purposes between the different kinds of white grubs and of wireworms which infest corn under ground, the list so reduced will contain less than a dozen names.

The habits of the adult beetle and those of its larva are in most cases so widely different that instances are few in which we find both stages of the same insect infesting corn, and there is not a single case known to me in which a *similar injury* is done to corn by both. The beetle larvæ injurious to corn all live under ground, and their injuries, consequently, are confined to the planted seed, the roots, and the underground part of the stalk. The adult beetles, on the other hand, may eat any part of the plant, from the seed and roots to the silk and kernels of the ear.

By far the most serious injuries due to beetles are done by their larvæ, especially by those known as wireworms, white-grubs, and corn root-worms. The only injuries by the adults themselves deserving to be classed with these, are those due to the so-called bill-bugs of the genus *Sphenophorus*.

Besides these major enemies, whose attacks are largely preventable, there is a swarm of minor or occasional enemies against which it is both useless and needless to contend. Several of the ground-beetles (*Carabidæ*), for example, eat the kernel from the tip of the ear, and one small abundant species (*Agonoderus pallipes*) has occasionally done considerable harm by devouring the seed and the roots of the young plant.

Several small species of the family *Phalacridæ*, and others of the *Nitidulidæ*, similarly infest the ear, and the larva of one of them, *Ips*

4-guttatus, has once or twice been known to eat the planted seed. Two or three of the small dung-beetles and some of the leaf-chafers do similar injuries to the kernel on the ear or in the ground. A number of the latter group occasionally injure the young plant by devouring the leaves or eating into the stalks. Larvæ of two of the short-horned borers (*Prionus*) have been reported as rarely injurious to the roots of corn, and a considerable number of the plant-beetles, flea-beetles, and the like (*Chrysomelidæ*), are variously destructive to practically all parts of the plant.

The wireworms, white-grubs, and bill-bugs are all primarily grass insects (the first and third much more strictly so, however, than the second), and their attacks, consequently, may be forestalled wholly or in great part by a proper management of the land with respect to rotation, and especially by using care in changing the crop from grass to corn. The corn root-worm, on the other hand, is a corn insect only, and its mischief may be promptly and completely arrested in any case arising, by planting corn on land not in that crop the preceding year.

Hemiptera: True Bugs. — Although not less than forty-five recognized species of bugs have been found sucking the sap from some part of the corn plant in the field, to say nothing of several others which have not been exactly identified, only one of this long list is a corn pest of the first class, but this (the chinch-bug) is, on the whole, by far the most destructive insect enemy of this plant in America.

The false chinch-bug (*Nysius angustatus*) has occasionally injured corn severely in our territory, making its way into the field from infested wheat adjoining, and the tarnished plant-bug (*Lygus pratensis*) has rarely been found responsible for noticeable injury. The corn root-aphis (*Aphis maidiradicis*) is capable of killing young corn by sucking the sap from its roots, but more frequently it merely retards the growth of the plant in spring, or perhaps permanently dwarfs it by this early drain on its vitality. The corn leaf-aphis (*Aphis maidis*) may kill some of the older leaves later in the season, but although it often continues to increase in numbers until frost checks its multiplication, it can rarely be said to diminish sensibly the amount or to impair the quality of the crop. Otherwise, the various sucking insects which are found on the corn plant obtain from the leaf, the stalk, the tassel, the silk, the husk, or sometimes from the soft young kernels exposed at the tip of the ear, an amount of liquid food too small to affect the growth of so vigorous a plant.

Special preventive measures are necessary or profitable, as a rule, only against the chinch-bug, and will be discussed in connection with that insect, although injuries by minor species may be reduced by clean culture, by the destruction of winter harborage for insects, and by a few other general measures characteristic of intelligent and careful agriculture.

Orthoptera: Grasshoppers, Locusts, and Crickets. — About twenty-five species of *Orthoptera* have been noticed as common in corn fields, the larger number and the only destructive species belonging to the so-called short-horned grasshoppers (*Acrididæ*). Like very many other insect visitants to the corn field, these *Acrididæ* are normal grass insects, and go into the corn in numbers sufficient to attract attention only when their usual food threatens to fail, and their injuries are consequently confined at first to the edges of fields adjoining pastures and meadows. The great migrating grasshopper of the Western Plains is, of course, an exception to this statement, and an occasional migrant swarm of certain Illinois species imitates with some success the practices of this western insect, settling upon a field like a flock of birds, and doing a general injury.

The ordinary grasshopper attack on corn is rarely made by the young, and is consequently postponed, as a rule, until late summer or early fall, when the corn is practically full grown and the insects are able to fly. Where the injury is severe the leaves are eaten away to the tough midrib, the husks are gnawed from the ear, and the latter, if still young, is itself devoured, little but bare stalks remaining about the edges of the fields. Fourteen species of short-horned grasshoppers are on our list of those injuring corn in this way.

The long-horned grasshoppers (*Locustidæ*), including the meadow grasshoppers, climbing crickets, and the like, are not uncommon in corn fields, but they are only slightly injurious to that plant. One of them, *Orchelimum vulgare*, has occasionally been seen to eat the leaves, silk, husks, and grain, and many other species sometimes gnaw away a few kernels from the tip of the ear. Several kinds of these insects frequently lay their eggs in the slender part of the corn-stalk, in or below the tassel of the ripened plant, but their food consists mainly of pollen, fungi, plant-lice, etc., and indicates no injury to corn.

Two of the common crickets (*Gryllus pennsylvanicus* and *Nemobius fasciatus*) sometimes injure the ripened ear, especially where there are many fallen stalks in the field, by creeping in beneath the husks and gnawing off the surfaces of the kernels.

The only possible protection to corn against grasshoppers is the destruction of these insects before they leave the grass-lands adjoining, or when they first enter the corn field. Once generally distributed in the fields, practically nothing can be done to arrest the injury. For their destruction in pastures and meadows, some one of the methods must be chosen which has been found effective against these insects in the West. These are, generally speaking, the plowing in fall of ground heavily stocked with grasshoppers' eggs, or plowing, even in summer, for the destruction of the young, the burning over of grass-lands after the young have hatched, the collection of the egg masses where these have been abundantly deposited, poisoning heavily the outer rows of corn with arsenic or Paris green, distributing along the edges of the field quantities of poisoned horse-droppings, the so-called Criddle mixture, and catching the insects in meadows and pastures by the use of the "hopper-dozer." The most important of these procedures will be more fully discussed on another page.

Neuroptera: Dragon-flies, Lace-wings, etc. — No insect injurious to corn belongs to the order *Neuroptera*, which, in fact, need be mentioned in this connection only to say that the occasional abundance in corn fields of the delicate and interesting lace-wing fly (*Chrysopa*) is to be connected with the occurrence of plant-lice there, upon which both larval and adult lace-wings feed. The winged insects we have found in corn fields eating the spores of fungi, the surface hairs of the leaf, and other delicate vegetable tissues.

Acari: Mites. — The mites commonly known as the red spiders (*Tetranychus bimaculatus* and *T. modestus*) have been rarely found injurious to the young corn leaf, causing a rusty or brownish discoloration. This injury to corn seems to have been too rare, however, o be worthy of special attention, although the wide-spread distribution and destructive capacity of these insects suggest the possibility that they may be responsible for greater injury to this plant than has been attributed to them.

Myraipoda. — Several species of millipeds and centipeds are occasionally encountered in corn fields doing a slight and infrequent injury only, by gnawing into the kernels beneath the husks. They are most likely to injure ears which touch the ground, but sometimes climb the stalk as much as two or three feet.

The Corn Insects Grouped according to their Economic Importance.

The number of insects infesting corn is so very large, and the proportion of them which are seriously injurious to that crop is comparatively so small, that it is necessary, for practical reasons, to separate the important insects from the remainder in this discussion. I have consequently divided the entire list of corn insects into three groups, according to their economic importance, placing in the first group of "the more important corn insects" those which do so serious an injury to the crop that every corn grower should know the principal facts concerning them as an essential part of his knowledge of farming; in the second group, of "the less important" insects, those which are sometimes definitely injurious but ordinarily do no great harm; and in the third group, of "unimportant" insects, those which do little or no injury to corn as a farm crop.

and which may, consequently, be practically ignored by the farmer as insignificant.

I have thought it best that the first group should be made as small as is reasonable and safe, and have placed no species in it which there was not positive reason to consider as a destructive corn pest. The second group, on the other hand, I have made to include all of the other species which are known to have any tangible economic significance whatever.

The first group may be said to contain those species concerning which every practical corn farmer should know the essential facts; the second group, those additional species which should be familiarly known to the economic entomologist; and the third group, those which are of interest chiefly to the general entomologist — the student of entomological ecology — who wishes an exhaustive knowledge of the entomology of the corn plant.

Notwithstanding this distinction, it should be remembered that negative knowledge is sometimes little less valuable than positive; that it may sometimes be as interesting, and even as important, for a farmer to know that a species appearing for the first time in his fields is not definitely injurious as it is to recognize it at once as an insect enemy. The more he can learn, consequently, of the great association of corn insects treated in this report, the better prepared he will be to handle his crop intelligently under all conditions.

It must, of course, be admitted that the dividing lines between these groups are more or less arbitrary, and at best but poorly defined, the division between the first and second being especially hard to establish. An insect may be highly important to corn culture at some times and in some parts of the country, and of little or no importance elsewhere and ordinarily, and differences of judgment will unavoidably arise as to the group in which a given species should be placed. The history of economic entomology makes it also virtually sure that certain species now properly placed in one of the less important groups will require hereafter to be transferred to a more important one, and the group division here proposed may, on this account, become more or less inaccurate in course of time.

The reverse proposition is, however, much less likely to be true. It will rarely occur that a species once recognized as seriously destructive to corn will drop to an inferior place on the list. It sometimes happens, indeed, that an alien insect species is much more numerous and destructive for a few years following upon its first appearance in the country than it ever is again, but, as a matter of fact, no single corn insect of any considerable importance is such an alien species — has come into the country, that is to say, since corn became an important American crop.

It is possible, also, that the normal progress of agriculture may make virtually universal farming practices which will serve as permanent preventives of injury by certain insects which have previously done great harm. If, for example, it should become the general rule to raise corn on the same ground for only two or three years at a time, injuries by the corn root-worm would apparently be reduced to insignificance. No such event has anywhere occurred in this country, however, and the rule of economic entomology has thus far been "once an enemy always an enemy," the list of insect pests increasing from time to time, but never diminishing.

Discussion of Species.

In the remainder of this report I give all pertinent facts of any importance known to me concerning the corn insects which frequent that part of the plant which grows above the surface of the ground, exclusive, however, of those which infest the grain or the fodder after these have been removed from the field. In order to make this treatise virtually complete for the corn insects as a group, I have made references on page 69 to a previous article on injuries to the seeds and roots of Indian corn, published in my Seventh Report as State Entomologist — the Eighteenth of the office series — and also, in briefer form, in Bulletin 44 of the State Agricultural Experiment Station. The above-mentioned Eighteenth Report may be found in volume 31 of the Transactions of the Illinois State Department of Agriculture, where it is printed as an appendix.

ECONOMIC GROUP 1.

(The more important insects: those seriously injurious to the crop, either as locally and occasionally destructive or as widely and frequently harmful.)

Insects Injurious to the Plant above Ground.
Synopsis of Injuries.

The plant cut off when young at or near the surface of the ground by a whitish, grayish, or blackish caterpillar frequently found in the earth near the injured plant................................ ....Cutworms (*Agrotis*, *Hadena*, etc.). 17

The stalk of the young plant eaten into or irregularly gnawed off. The leaves also irregularly eaten. A small, spotted, reddish caterpillar found under ground near the base of the plant in a small mass of earth held together by a web.................. .... Sod Web-worms or Root Web-worms (*Crambus*). 36

The stalk of the young plant penetrated by a round hole which is more or less plugged by excrement. The interior of the stalk irregularly eaten out by a striped burrowing caterpillar........ ....The Stalk-borer (*Papaipema nitela*). 44

The entire plant more or less completely eaten, the leaves first and then the stalk, in June and early July, by hordes of traveling striped caterpillars commonly coming into the field from one side..................The Army-worm (*Leucania unipuncta*). 47

The stalk punctured and slit, the leaves perforated by round or oblong holes arranged in parallel transverse rows. Hard-shelled, oval, black or clay-colored snout-beetles often found, head downward, on the stalk near the ground or a little beneath the surface......................Corn Bill-bugs (*Sphenophorus*). 52

Plant wilted or sickly, leaf-edges and lower leaves turned yellow or brown, many small red or dusky, or blackish and whitish bugs behind the leaf sheaths of the corn, or clustered on outer surface of the stalk............The Chinch-bug (*Blissus leucopterus*). 57

The leaves of the plant variously eaten, sometimes stripped to the midrib, about the borders of the field, in late summer or fall. The silks and husks also more or less eaten away.............. ....Grasshoppers (*Acrididæ*). 64

The husk of the ear perforated by a round hole with the excrement exuding, the corn mined beneath by a brownish, or greenish, striped caterpillar.............................. ....The Ear-worm or Corn-worm (*Heliothis armiger*). 67

THE CORN CUTWORMS.

Hadena devastatrix Brace.
H. arctica Boisd.
Agrotis ypsilon Rott.
Peridroma margaritosa saucia Hübn.
Noctua c-nigrum Linn.
Feltia subgothica Haw.
F. jaculifera Guen.
F. gladiaria Morr.
Nephelodes minians Guen.
Hadena lignicolor Guen.
Noctua clandestina Harr.
Feltia annexa Tr.
Euxoa messoria Harr.
E. tessellata Harr.
E. ochrogaster Guen.
Mamestra renigera Steph.

The caterpillars commonly known as "cutworms" destroy the young corn plant by eating the leaves, gnawing into the stalks, and cutting off the plant close to the ground at night, often dragging the severed part into their holes near by. They hide by day under clods, or by burying themselves a little distance in the earth, where they may be easily found curled up into a close spiral or a circular disk. They are thick, soft-bodied, rather sluggish caterpillars, with nearly smooth skins, varying in color from whitish to dark brown, variously marked, in many cases with longitudinal stripes, and often with dark dashes and blotches additional. They are most destructive in corn following on grass or clover, but sometimes come into the field from meadow or pasture lands adjoining, when the outer rows of corn, of course, suffer worst. Where they are very numerous it is virtually impossible to obtain a stand of corn until the period of their active injuries is passed. Many of them, when they become so numerous on any spot as to overtax their food supply, move out of the overpopulated field in companies not unlike those of the notorious army-worm. The latter belongs, indeed, to the cutworm family, and when only ordinarily common lives and feeds; generally speaking, like the cutworms of this list.

Most of the species pass the winter partly grown, and are consequently prepared to make their attack on corn as soon as it shows above ground. They enter the earth for their transformations when full grown, at times varying for the different species, most of them in late June or early July. They change in the earth to leathery, brown pupæ, from which grayish or brownish night-flying moths -- the adults of the species — emerge later in the season, and, laying their eggs in grass-lands, perish before the winter. The young hatching from these eggs live on the roots of grasses until cold weather, doing no noticeable injury, as a rule, during this fall period.

The greater part of them develop, in our latitude, only a single generation each year, but a few of the most destructive species are two- or three- brooded. This fact seems to make little difference, however, from the economic point of view, except as the single-brooded species are less able than the others to take prompt advantage, by their rate of increase, of specially favorable conditions of location, crop, or weather of the season.

Injury to corn by cutworms is best prevented by midsummer or early fall plowing of grass-lands to be planted to corn; by pasturing pigs on grass or clover lands to be plowed up for corn; by distributing, by the aid of a seed-drill, a line of dry bran or middlings, poisoned by mixing in Paris green at the rate of a pound of the poison to thirty pounds of the food-stuff, or by scattering poisoned food in spring along the borders of corn fields next to grass; and by replanting when corn is killed by them, postponing this step, however, until the cutworm injury has practically ceased for the season. The earlier the preceding year grass-lands to be planted to corn are plowed, the less will be the probability that the cutworm moths will have laid their eggs thereon, and the less, consequently, will be the danger of injury by cutworms the following year.

The points in the life history of the various cutworms essential to successful management are thus the time when the greater part of the eggs are laid for the hibernating brood of the caterpillars, and the time when this hibernating brood gets its growth in spring, ceases its injuries, and goes into the ground for its change to the pupa state. The first date shows when the ground should be plowed for corn in fall; and the second, when it may safely be planted or replanted to corn in spring.

Cutworms entering the corn field from pastures or meadows adjoining, may be effectively and cheaply poisoned by placing along the edges of the field fresh clover or other succulent vegetation which has been cut after spraying thoroughly with Paris green stirred up in water at the rate of a pound to fifty gallons.

The sixteen species whose names are placed at the head of this section have all been found injuring corn — only the first nine of them, however, notably harmful to that crop in Illinois.

The Glassy Cutworm.

Hadena devastatrix Brace.

This is a translucent, whitish caterpillar (Fig. 1), slightly tinted with bluish green, without body spots or blotches, the head red or red-brown, and the neck-shield brownish. Its appearance has been quite aptly characterized as midway between that of a white-grub and a common cutworm. It is quite similar to the yellow-headed cutworm next described, from which it is most readily distinguished by its darker head and neck-shield, and the lighter color of its body.

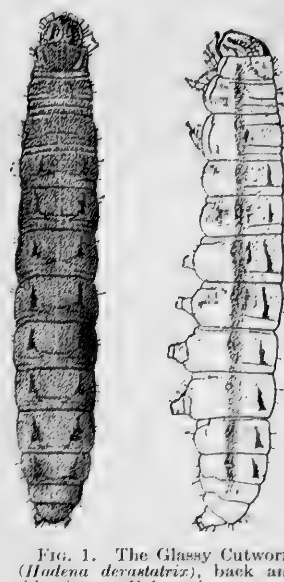


Fig. 1. The Glassy Cutworm (*Hadena devastatrix*), back and side views. Enlarged.

In view of the destructive nature of its attacks, its wide-spread range and great abundance, and the numerous published reports of serious injury to crops, this cutworm may be properly regarded as the most serious pest of its kind to corn and grass. It is rarely seen above ground, but works mainly in a burrow beneath the surface, feeding principally at night, eating off the roots close to the base of the stem, or cutting off the latter under ground.

We have found it very destructive to corn in Peoria and Henry counties, and frequently occurring in corn hills in various parts of the state. A. J. Cook reports it as injurious to corn in Michigan; Lintner, in New York; and Harvey, in Maine. Gillette pronounces it the most abundant and destructive cutworm in corn and grass in Iowa; Smith reports it as one of the most destructive of its kind in New Jersey; and Fletcher finds it injurious in Manitoba. It frequently becomes so numerous in meadows as to be notably injurious to grass. In

Ohio, for example, twenty acres out of thirty of a timothy meadow were so injured by this cutworm that the grass became dry enough to burn. In mixed fields of timothy and clover they have completely destroyed the timothy, leaving the clover unharmed. In Indiana a large area in each of three timothy fields, amounting to fifty acres in all, was totally destroyed. There was an evident migration of the cutworms in this case out of the low lands in which they originated. They have destroyed lawns in Fargo, North Dakota, and in Glencoe, near Chicago. In Canada it was found necessary to plow up several fields of winter wheat which were destroyed by them in spring, and fields of oats were seriously injured and replanted. A piece of sod land in Ohio badly infested by these cutworms was broken up in winter and planted to seedling peaches, but in the following spring thirty-five per cent. of these young trees were cut off two or three inches above the roots. Lugger says that they are very destructive to strawberry plants in Minnesota, cutting away the crown and causing the plant to wilt away. They have also injured strawberry plants in the Southern States and garden vegetables in Mississippi.

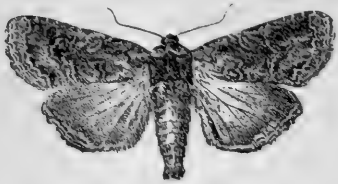


FIG. 2. The Glassy Cutworm (*Hadena devastatrix*), adult. Natural size.

Besides these farm crops they may feed upon almost any kind of herbaceous plants, including cabbages, beans, radishes, hollyhocks, and lettuce. They evidently develop mainly in grass-lands, especially in low ground, and do their most serious injury to crops following upon grass.

The species is found in the United States from the Atlantic to the Pacific, and also in Canada and in Europe. It is least abundant in the extreme South.

It appears to be single-brooded. The eggs are laid in the latter part of the season, mostly, according to Gillette, after August 1, and hatch before cold weather, the larvæ making their destructive attack in the latitude of central Illinois in the following May and the first half of June. They change to the pupa in the ground in June or the early part of July, occasionally as late as August. The moths (Fig. 2) begin to appear in June, become very abundant in August, and may remain until October. Garman found, November 25, a single cutworm of this species, which reached the moth stage the following April.

From this it follows that grass-lands must be plowed in August if they are to remain free from the eggs of this cutworm moth, and that corn planted late in June will probably remain uninjured by the cutworm itself.

The Yellow-headed Cutworm.

Hadena arctica Boisd.

It is very similar in appearance to the glassy cutworm just described, but may be distinguished by the fact that its body is pale smoky gray while the head and neck-shield are both tawny yellow. It is without stripes, spots, or other body colors. It is so similar to the preceding species that it has often been confused with it, and it is consequently impossible to separate published statements concerning injuries due to the two. It lives usually about two inches under ground, cutting off the roots of grasses, grains, and corn, and the stems below the surface.

It is frequent, but not very common, in Illinois, and is widely distributed northward in Canada, Labrador, Vancouver, and in subarctic America and Europe generally. It occurs as far south as New Mexico and is generally wide-spread east of the Rocky Mountains. In 1895 the moths were so abundant in western Ontario as to be a general nuisance, filling lamps and windows and soiling curtains and clothes. In the following season these cutworms did great damage to fields of oats, wheat, and corn, many of the fields being plowed up and replanted. Cook has also found it injurious to corn in Michigan. In New York, Fitch observed that these cutworms would finish first any living grass remaining in the corn field, but would then attack the crop itself.

Besides grasses and cereal crops, they feed on various herbaceous plants, such as cabbage, spinach, and lettuce, and on succulent shoots, like those of roses and currants.

This cutworm lives longer in the stage of destructive activity than many of the other species, often continuing its injuries beyond the middle of June, and even into July. It pupates in June or July, and the moths begin to appear late in June, becoming commonest in July and early August and lasting until September. Eggs have been deposited as early as June 13.

The Greasy Cutworm.

Agrotis ypsilon Rott.

This is a common, wide-spread, and destructive cutworm, injurious to garden vegetables and to fruits as well as to corn. When full grown (Fig. 3) it is about an inch and a half in length, of an almost uniform dark, greasy gray, with a faint dorsal stripe of dull, dirty yellow. Beneath, it is an obscure greenish yellow.

This is a typical cutworm in its feeding habits, and is one of the commonest of its kind in corn. It feeds also on grass, asparagus, cotton, tobacco, tomato, cabbage, potato, spinach, squash, beans, beets, apple, grape, and strawberries, but has not been reported as injurious to clover or as breeding in fields of that crop.

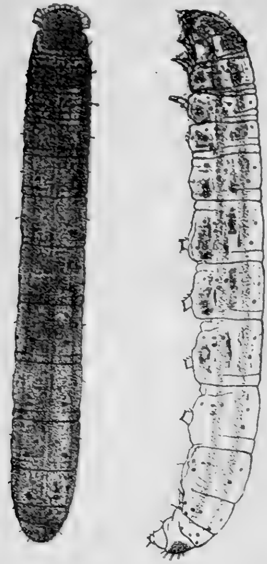


FIG. 3. The Greasy Cutworm (*Agrotis ypsilon*), back and side views. Enlarged.

It is found throughout the United States and, indeed, throughout the world, ranging to the northward as far as Manitoba and Hudson Bay, to the south as far as Uruguay and New Zealand, and the Cape of Good Hope in Africa. It occurs in India, Ceylon, and China, and is a common European species also.

While destructively abundant at times and in especially favorable situations, it is not, so far as we know, subject to periods of very extraordinary increase. It is much parasitized, when abundant, by dipterous and hymenopterous parasites, and these must serve as a severe and ready check upon its multiplication.

This cutworm is apparently, but not certainly, single-brooded. It passes the winter mainly as a caterpillar, in various stages of growth; begins to feed, of course, as soon as spring revives it; and continues more or less injurious well through June, and sometimes even into July. The destructive activity of this cutworm usually reaches its height in the latter half of May and in early June, and then declines gradually through the first half of July. A few of the larvæ cease feeding, however, in May, and complete their changes to the adult stage (Fig. 4) during that month, but the transformations of the greater part of the hibernating generation occur in June. Egg-laying begins, according to our observations, in July, the new generation sometimes beginning to hatch in the grass within a fortnight of the disappearance of the last of the cutworms of the preceding year. This species may consequently be found in the cutworm stage at practically all times and seasons. Pupæ found in our breeding-cages on the 8th of June gave the moths in four weeks, and eggs laid July 3 hatched in twenty-two days.

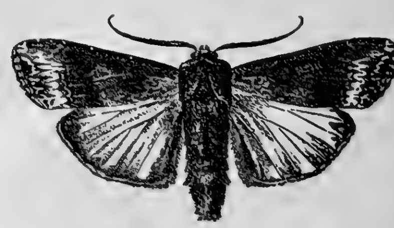


FIG. 4. The Greasy Cutworm (*Agrotis ypsilon*), adult. Natural size.

Beginning early in July, the laying of eggs doubtless continues through August, and possibly into September also. The moths have been most frequently found by us in July and August, with only occasional occurrences in September, the latest on our notes for central Illinois being September 20.

Breeding almost wholly in grass-lands, its injuries to corn are to be apprehended only where this crop follows upon grass, or where the corn field adjoins a pasture or meadow. In the former case the injury may be generally distributed throughout the field, but in the latter it will be limited chiefly to the side next to grass. It continues its injuries so late in spring that it is difficult for the corn grower to escape it by late planting, and even the first replanting of injured fields may fall a sacrifice to it; but plantings made as late as the first or second week in June will be practically safe from serious injury by it. On the other hand, the early date at which the moth begins to lay her eggs lessens the value of fall plowing as a preventive measure. Probably pasturing of infested fields of grass by pigs in fall, before breaking up for corn, is the best general preventive measure available in ordinary practice.

The Variegated Cutworm.

Peridroma margaritosa saucia Hübn.

(*Agrotis saucia.*)

This cutworm, when fully grown, is about an inch and three quarters long, and is easily recognized by its conspicuous markings. (Fig. 5, *b, c, d;* Fig. 6.) The general effect of its ground-color is grayish or brownish — usually variable, however, being light or dark as its surroundings expose it more or less to the light, those on trees or bushes being darker than those feeding near the ground on broad-leaved herbs. It is most easily distinguished, when of average color, by a row of four to six pale dots extending from the neck half way or more down the back, and a velvety spot on the segment next to the last, sharply defined behind, but shading gradually forward into the dark

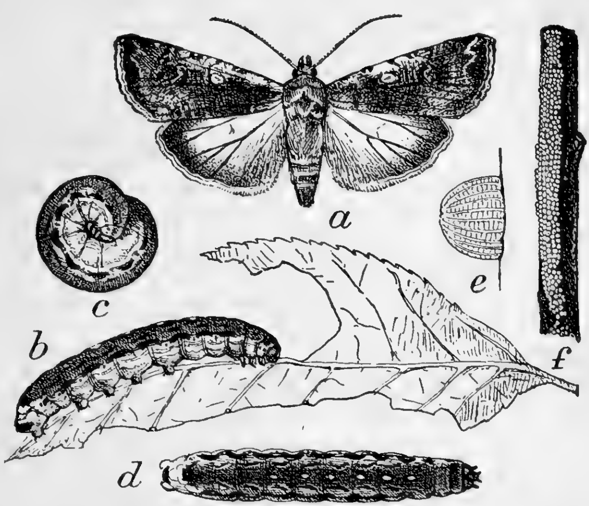


Fig. 5. The Variegated Cutworm (*Peridroma margaritosa saucia*): *a*, adult; *b, c, d*, larvœ; *e, f*, eggs. Figure *e* greatly enlarged; others natural size. (Howard, U. S. Dept. of Agriculture.)

ground-color of the back. The freshly hatched caterpillars are greenish, with black heads.

This is a very common species, but is peculiar in its habits. It climbs plants freely at night to feed, even ascending bushes and fruit-trees, and devouring any succulent tissue which it finds, including bud, fruit, flower, leaf, stalk, and root of the plant. It occurs frequently in corn fields, although not ordinarily common there. When very abundant it sometimes migrates in hordes like the army-worm, in search of food, and under such circumstances has been known to destroy hundreds of acres of young corn in a comparatively short time. It is pre-eminently a garden pest, however, being particularly destructive to fruits, vegetables, and flowers rather than to grain, crops, weeds, and wild plants. A remarkable outbreak of this cutworm occurred in the year 1900 in the United States and Canada, especially in the states of the Pacific coast. Enormous damage was done by it, particularly to fruit and vegetable crops. A full account of this occurrence will be found in Bulletin 29, N. S., U. S. Division of Entomology, and in Bulletin 47 of the Experiment Station of Washington state. Among its leading food plants are cabbage, tomatoes, potatoes, clover, onions, peas, beets, and carnations.

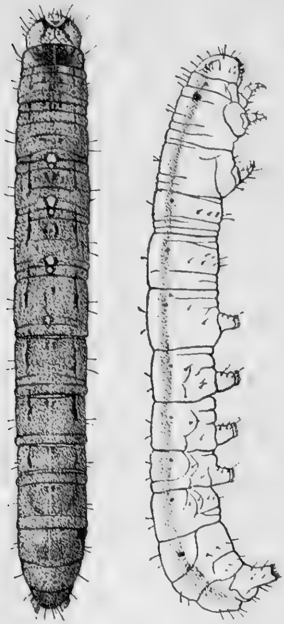


FIG. 6. The Variegated Cutworm (*Peridroma margaritosa saucia*), back and side views. Enlarged.

It occurs throughout nearly the whole of the New World, and also in western and southern Europe, northern Africa, and Asia Minor.

The seasonal history of this species is not yet well understood. It has been seen in winter as larva, as pupa, and as adult, and entomologists differ, consequently, in their statements as to its normal hibernating stage and the number of its broods. It agrees with most of the species, however, in the fact that it is destructively active in early spring, becoming most injurious in May and early June, pupating in June, and beginning to produce moths (Fig. 5, *a*) abundantly in the latter part of that month. The data which we have suggest at least two broods in a year, but there is nothing conclusive upon that point. Eggs (Fig. 5, *e*, *f*) of this species were sent to us March 27 on an apple twig from Vandalia, and others were sent us April 17 from Hardin county, in southern Illinois, which were just hatching when received. The young cutworms were kept on clover until May 26 by which time they had reached an average length of about one inch, being, in other words, at this date somewhat more than half grown. Female moths, on the other hand, confined in a breeding-cage with blue-grass July 10, had given origin six days later to freshly hatched larvæ, with which the cage was swarming at the time. Unfortunately, these presently died — probably because the food plant offered them was unsuitable. Other entomologists have several times secured and hatched the eggs of this species in the latter half of the season. In 1900, cutworms of this species — probably of the second brood — began to appear early in July, reached their greatest abundance about July 25, and had disappeared by the end of the following month. The advent of winter commonly finds individuals in every stage of growth, and moths, larvæ, and doubtless pupæ also may pass the winter successfully. We once found four larvæ in early December under boards and weeds in grass and corn. Two of these were about a third of an inch in length, and the others were approximately an inch and a quarter. Two full-grown larvæ were also found January 14 and 24.

Fortunately, this cutworm is not ordinarily sufficiently injurious in corn fields to require special precautions except when it moves in companies from its breeding grounds, and then it may be dealt with like the army-worm, by measures to be described in the article on that species.

The Spotted Cutworm.

Noctua c-nigrum Linn.

The spotted cutworm is a common species, injurious in Europe as well as in America, especially to garden vegetables, which it seems to prefer to grasses and grains. It has occasionally injured Indian corn in various states, and, like the species just discussed, is liable to travel in companies when it becomes very numerous. Under these circumstances it might require the especial attention of the corn grower. It is on record also as injuring wheat in January and in March. (Webster.)

It may be recognized (Fig. 7) by two rows of triangular black spots, one on each side of the back, with the narrow angle to the front, largest and darkest on the posterior segments of the body, and fading out before they reach the head. The general color of the caterpillar is pale brownish or ashy gray, and it is about an inch and a half long when of full size.

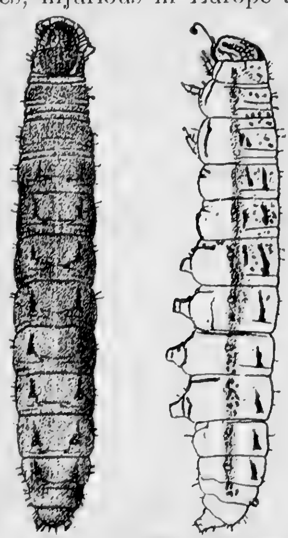


Fig. 7. The Spotted Cutworm (*Noctua c-nigrum*), back and side views. Enlarged.

It hibernates as a cutworm nearly full grown, and pupates quite early, in central Illinois late in April and early in May: consequently, if injuries to corn are due to this species they will soon cease, and the first replanting will commonly escape unharmed. Moths (Fig. 8) from pupæ formed in April and early May have appeared in our breeding experiments during the latter part of May and the first half of June, and, proceeding without much delay to deposit their eggs, they gave origin to a second brood of cutworms which became fairly well grown about the middle of July. This generation is not often found in the corn field, and does no injury there worth noticing. The moths from this second brood have appeared in our breeding-cages from late July to the middle of August. They continue alive in the fields throughout September, and lay their eggs in grass for the hibernating brood of the cutworms.

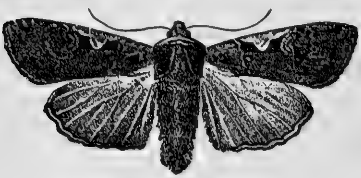


Fig. 8. The Spotted Cutworm (*Noctua c-nigrum*), adult. Natural size.

Early fall plowing of infested grass-lands may thus be expected to take effect on this cutworm by preventing the laying of many of the eggs, and by causing the starvation of many of the young which may already have hatched.

The Dingy Cutworm.
Feltia subgothica Haw.

The Western Striped Cutworm.
Feltia jaculifera Guen.

(*Agrotis tricosa, A. herilis.*)

The dingy and the striped cutworms are remarkably alike in both appearance and habits, and may well be treated together. The former (Fig. 9) is dingy gray, and easily recognized by the dusky band on each side of the back, obliquely notched on the inner border like the edge of a serrated leaf. The broad dorsal space between these bands is a buffy gray. There are also a well-marked light band along each side of the body, and dorsal and lateral pale lines rather feebly marked.

The western striped cutworm is very closely similar to the preceding, perhaps indistinguishable in the caterpillar stage. Riley says, indeed, that it is more dingy than *subgothica*, with less conspicuous lines, and with a more decided buff tint to the dorsal band. These differences are, however, within the range of ordinary variation, and the species can apparently be distinguished with cer-

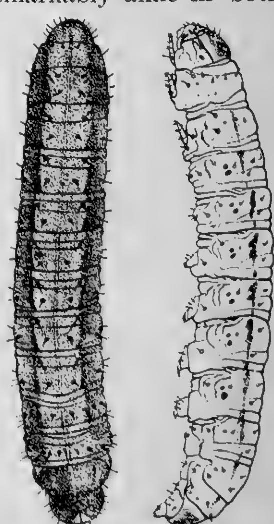


Fig. 9. The Dingy Cutworm (*Feltia subgothica*), back and side views. Enlarged.

tainty only by breeding to the adult. The young larvæ are much darker at first, sometimes nearly black.

The dingy cutworm is one of the commonest species, especially in corn, where it shares with the greasy cutworm the principal injury to that crop. Indeed, there is some reason to believe that the moth may lay her eggs in fall among the succulent weeds in the corn field, particularly when a severe drouth has made the pasture and meadow lands less inviting. In accordance with this supposition these cutworms have not infrequently been found in early spring generally distributed through corn on old corn ground. Stedman speaks of it in Missouri as the most destructive cutworm in wheat. In our breeding-cages it has evidently preferred clover to blue-grass. It is especially fond of early vegetables, including melons, cabbage, tomatoes, beans, peas, sweet potatoes, turnips, lettuce, celery, and strawberry plants. It occasionally climbs fruit-trees and shrubs to devour their buds and leaves.

The striped cutworm is also decidedly destructive to corn, according to Webster, one field in Indiana being completely ruined by it in 1895. Similar injuries were noticed in the same year in Missouri, Kentucky, Tennessee, and southern Ohio. It was the most abundant cutworm in southern Illinois in the outbreak of 1887, and, next to *gladiaria*, the commonest and most destructive throughout the state during that of 1888. It did much harm to corn in these years, but was especially injurious to clover, for which it had an evident preference, and to the meadow grasses. It frequently migrates when abundant in search of food, but without the concerted movement of the true army-worm.

Both of these species are generally distributed throughout the United States and Canada east of the Rocky Mountains. The dingy cutworm is also found on the Pacific coast, and we have specimens of the moth from Montana, Wyoming, and Utah. The striped species occurs in British Columbia.

There is but one brood of the dingy cutworm each year. Moths have been taken throughout July, August, and September, but much the most abundantly in the latter part of August. Eggs are quickly deposited, and hatch in about a week. The caterpillars grow slowly, and hibernate when quite small. Those taken by us in January, February, and March averaged less than half an inch in length, but when warm weather comes they grow apace, and in May become nearly full grown. In June they cease feeding, mostly in the first half of the month and enter the ground for pupation. A dingy cutworm kept under observation in my insectary from May 15 entered the ground June 16, and continiued as a larva in its earthen cell until August. On the 12th of this month it was found to have changed to the pupa, and on the 28th it became an adult. This long-delayed pupation was not due to drouth, as the earth in the breeding-cage was kept moist, and even wet. Besides the above we have found larvæ of different lots in a similar condition in our breeding-cages June 15, July 2, 19, and 23, and August 3. These facts indicate an unusually long period of midsummer preparation for the pupal transformation.

This life history suggests nothing exceptional by way of prevention or remedy. Where the field has become infested in fall, as shown by the general distribution of the cutworms in the corn in early spring, replanting, to be safe, should be postponed until towards the middle of June.

The Clay-backed Cutworm.

Feltia gladiaria Morr.

This cutworm (Fig. 10) is usually dark in average color, varying, however, from greenish gray to dark brown. The back is commonly decidedly light, grayish white or straw-color, or occasionally reddish brown. This light dorsal space is divided lengthwise by a more or less conspicuous median white line, which is usually bordered with darker. On each side of the pale dorsal space are two irregular whitish lines. The full-grown larva is about an inch and a quarter in length.

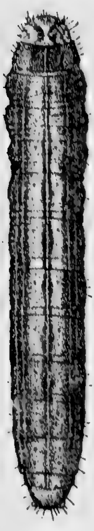


Fig. 10. The Clay-backed Cutworm (*Feltia gladiaria*). Enlarged.

This species is extremely variable in numbers, multiplying under some conditions to become a notable and widely destructive pest, and then occurring in scarcely noticeable numbers for some years thereafter. It was not distinguished as a cutworm until 1888, when it was bred to the adult in our insectary. In 1887 and 1888 it was the most destructive cutworm in Illinois, especially to clover and young corn. In 1895 it was by far the leading species in a general cutworm outbreak in Kentucky, and caused serious injury to a thirty-acre field of young corn on old sod ground near Champaign. In 1901 it was one of the most abundant cutworms in corn fields in western Illinois, and was excessively abundant in pansy beds at Urbana, cutting off and destroying all the plants. During its years of greatest abundance here it was especially notorious for its injuries to clover, which it preferred to blue-grass. It likewise ate oats, grass, and corn, invading corn fields from adjacent meadows, and devouring the plants as it went as thoroughly as does the army-worm.

Fig. 11. The Clay-backed Cutworm (*Feltia gladiaria*), adult. Enlarged.

It fed likewise on potatoes, beans, sweet potatoes, cabbage, tomatoes, and onions. When very abundant and their food supply had run short, these cutworms scattered in all directions — a habit common in varying degrees to most of the cutworms. Its mode of feeding is different from that of the cutworms generally, the corn leaf being seized by the hanging tip, drawn down, and eaten to the base. In clover fields, it begins at the tip of the plant and works downward, collecting about the roots.

This species is registered as inhabiting the United States east of the Rocky Mountains, but we have specimens of the adult from Utah and Colorado also.

It spends the winter, in our latitude, in the caterpillar stage, and is active in the destruction of its food plants from the middle of April to the beginning of June. By the middle of June all the cutworms have entered the earth for transformation. They do not change forthwith to the pupa stage, but remain there for a considerable period — more than six weeks in some cases — in a dormant or torpid condition. Moths (Fig. 11) consequently do not appear until September and early October, being most numerous in the latter half of September. Eggs are then laid without delay, and from these the larvæ hatch, which pass the winter partly grown.

It follows from this life history that the main measure for the protection of corn against this cutworm must be an impassable furrow along the margin of the field next to grass or clover, or, in the absence of this, the distribution of poisoned food — clover particularly — where the cutworms are likely to be drawn to it. Owing to the lateness of the period when the eggs are laid, a reasonably early fall-plowing will prevent the breeding of the species on that ground.

The Bronze Cutworm.

Nephelodes minians Guen.

This is an unusually large and plump cutworm (Fig. 12) about an inch and three quarters in length, conspicuously marked with alternate stripes of olive-bronze and yellowish, the former much the broader. A pale stripe runs along the middle of the back, and there are two such on each side, the lower below the spiracles. The bronze space immediately above the last is frequently divided lengthwise by a delicate, broken yellow line. The head is yellowish or gray, the neck-shield darker, with five pale stripes.

This is essentially a grass cutworm, being one of the commonest of its kind in grass-lands in early spring. It is somewhat injurious to corn, especially if this is planted on pasture or meadow lands occupied by it the preceding year. It eats clover sparingly or not at all, but seems to have a special preference for timothy. In the corn field it devours the whole plant insead of merely gnawing through the stem. It is not a garden species, although it sometimes climbs fruit-trees when its normal food is scarce, feeding on the buds and leaves like other so-called climbing cutworms.

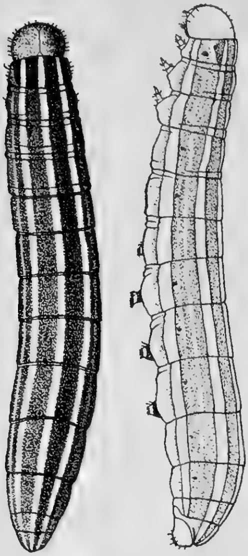


FIG. 12. The Bronze Cutworm (*Nephelodes minians*), back and side views. Enlarged.

It is generally common and abundant throughout the United States and Canada. In Iowa it is regarded by Gillette as the most abundant species, next to the glassy cutworm, in fields of grass and corn. It did much injury to grass in New York in 1881, and worked unprecedented destruction in 1886 near Columbus, Ohio, where, late in May, scarcely an acre of meadow or pasture had a vestige of grass on it for a distance of several miles, many fields being dry enough to burn. About three thousand acres were thus destroyed, the larvæ migrating *en masse* when their food was exhausted.

Hibernating in our latitude in the larval stage, they are found active in grass-lands in April and throughout May. They begin to disappear about the 1st of June, and all are gone by about the middle of that month. They remain under ground for a considerable period without pupating, changing in late July and August. The moths (Fig. 13) first appear in early August, become most abundant during the first half of September, and continue into October. The hibernating caterpillars have the singular habit of sometimes coming forth in winter and crawling about on the snow and ice. In the South, adults are frequently taken during the winter months.

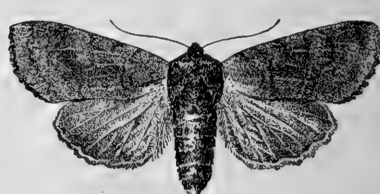


FIG. 13. The Bronze Cutworm (*Nephelodes minians*), adult. Natural size.

This cutworm is present in very unequal numbers year after year, what seems to be a bacterial disease checking its increase when it becomes unusually abundant. On this account, and also because much subject to insect parasitism, it is not likely to be excessively abundant in the same locality for two successive years.

The facts concerning it suggest no special preventive or remedial measures other than those frequently referred to in this article. Where it is so abundant in grass-lands as to threaten a migratory movement, this may be arrested by measures usually applied against the army-worm. In case it scatters into corn from adjacent fields of grass, it may doubtless be killed by the use of poisoned food, particularly the mixture of middlings and Paris green. In case corn is so injured by it as to require replanting, this may be safely done any time after the first of June, or possibly as early as the last week in May. To be sure that a grass sod shall be virtually free from the eggs, this should be plowed as early as the first week in September.

HADENA LIGNICOLOR Guen.

This cutworm closely resmebles the glassy cutworm, but has never been fully described in the caterpillar stage. We have not found it common in Illinois, but have collected the moths during June, July, and August. Gillette reports that the moths are very common in Iowa, They are found generally in the northern part of the United States east of the Rocky Mountains, and have been reported from Arizona.

A cutworm of this species which was found by Lintner preparing for pupation May 18, completed its transformations and came out as a moth on the 29th of June. Females dissected by Gillette July 13 were well filled with eggs.

These facts indicate a comparatively early close of active life as a cutworm, and a comparatively early appearance of the adult moth.

THE W-MARKED CUTWORM.

Noctua clandestina Harr.

This caterpillar (Fig. 14) is marked with four longitudinal rows of dark spots and some dark and pale longitudinal lines. The spots of the outer row on each side are oblique, and sometimes unite to form a continuous line; those on the inner row are more or less triangular (most evidently so on the hinder segments), and occasionally have the shape of the lett:r W.

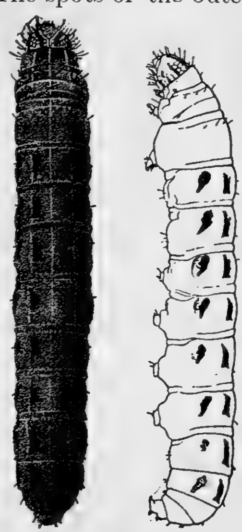


FIG. 14. The W-marked Cutworm (*Noctua clandestina*), back and side views. Enlarged

This is a very wide-spread species and a general feeder, but is ordinarily much more abundant in the East than in the north-central states. It is not found in the South. Dr. Lintner regards it as the most injurious corn cutworm in New York, where it is said to be common also on grass and grain, and to feed on buckwheat and clover. It is fond of garden vegetables, and feeds on lettuce, cabbage, celery, pumpkins, and beans. It is a well-known climbing cutworm, ascendingt rees and shrubs to eat the buds and leaves, particularly those of the apple, box-elder, soft maple, currant, and gooseberry. Plantain is mentioned as one of its wild food-plants.

The larvæ winter over about half grown, and mature early, becoming most injurious in April and May. The moths begin to appear soon thereafter, and are most abundant about June 20. The data on record indicate a probable second brood of the cutworms in midsummer, the moths appearing in August, September, and October.

The early transformation of the hibernating brood renders precautions against this cutworm virtually unnecessary, since it can injure only very early plantings of corn.

The Granulated Cutworm.

Feltia annexa Tr.

This species is best known by its rough, granulated skin, and by a pair of oblique marks on each segment, diverging backward. (Fig. 15, *a*, *e*.)

It is a general feeder, devouring corn, wheat, and other cereals, cotton, clover, grass, cabbage, peas, beans, and several weeds. It is particularly well known in the Southern States as a cotton cutworm, sometimes so badly injuring this crop as to compel replanting.

It is not common in Illinois, but is found, nevertheless, across the country from Massachusetts to California, and is abundant from Kentucky southward, and also in Cuba and South America. Lugger records a single capture in Minnesota.

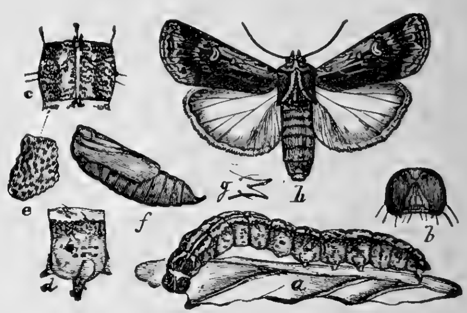


Fig. 15. The Granulated Cutworm (*Feltia annexa*); *a*, larva; *b*, its head, front view; *c*, *d*, one segment, top and side view; *e*, surface; *f*, pupa; *g*, tip of pupa; *h*, adult. Figures *a*, *f*, *h*, natural size, others enlarged. (Howard, U. S. Dept. of Agriculture.)

The facts with regard to its seasonal history have not yet been clearly established. It seems to winter as a larva, and is most destructive in April and May. Moths (Fig. 15, *h*) of this brood appear in June, July, and August. From eggs laid August 3, moths were reared again by October. Beutenmüller says a second brood flies in August, September, and October. There are almost certainly two generations in a year in Illinois, and quite likely three, or more, in the Gulf States.

The Dark-sided Cutworm.

Euxoa messoria Harr.

The common name of this cutworm (Fig. 16, *a*) is due to the contrast of a dark stripe on each side with the ashy gray ground-color. The small shining spots surounding the hairs are conspicuous and black.

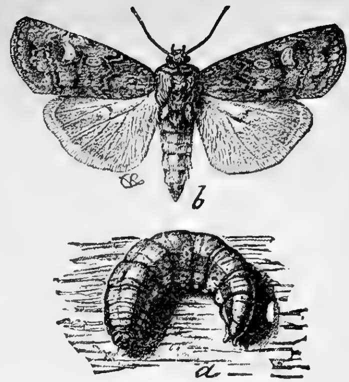


Fig. 16. The Dark-sided Cutworm (*Euxoa messoria*), larva and adult. Natural size.

Although one of the great destructive cutworms of the United States, this species is not reported as particularly injurious to corn. It is one of the climbing cutworms, and its most notorious injuries are done to fruits and garden vegetables. It is charged with a great destruction of the peach crop in Illinois, Indiana, and Michigan in 1887, and with devouring about half the onion crop of Orange, N. J., in 1885 and 1887, and again in 1896. In California it was held responsible in large part for the defoliation of grapevines in Fresno county. Smith speaks of it as the most injurious cutworm in southern New Jersey, especially to sweet potatoes. It ascends fruit-trees, the apple especially, and eats the buds of both flowers and leaves. It feeds, besides, on cabbage, spinach, lettuce, potatoes, tomatoes, beans, peas, radishes, turnips, tobacco, and sugar-beets. Specimens in confinement have freely eaten grass, corn, clover, buckwheat, currant, soft maple leaves, and various fleshy weeds. Indeed, it is so general a feeder, Gillette remarks, that in confinement it has not refused to eat any green thing offered it.

This species is not particularly common in Illinois, and has been rather infrequent in our collections either as caterpillar or as moth. It has been reported injurious, however, from New York to California and Washington state, and northward into Canada. It seems to be comparatively rare to the southward.

It is evidently a single-brooded species, the caterpillars being most abundant in May and disappearing by the middle of June. Occasionally adults (Fig. 16, *b*) occur in the latter part of June, but the main body of them appear late in July, and are most abundant in September up to about the 20th. The stage of hibernation is not yet positively ascertained. Caterpillars, apparently of this species, were taken by me from the stomachs of robins shot in February and March, and the species probably hibernates in the larval stage.

Highly satisfactory experiments for the destruction of this species and the protection of garden crops have been made by Sirrine, in New York, who used a mixture of twenty or thirty pounds of middlings or bran — the former preferred — to one of Paris green. A continuous row of this poisoned bait was laid along the ground by means of a seed-drill.

The Common Striped Cutworm.

Euxoa tessellata Harr.

About one and a 'ou:th inches in length, gray in general color, with a pale central dorsal line and three pale lines each side, the lower one the broadest.

The recorded food plants of this cutworm are corn, potato, onion, tobacco, radish, squash, cabbage, lettuce, tomato, cele y, spinach, beans, flax, cucumber, melon, beet, and parsnip, toge her with smartweed, *Rumex*, and various weeds, plum, apple, pear, and cherry. In confinement it feeds freely upon grass, clover, buckwheat, box-elder, and he fleshy weeds. It is not on record as especially injurious to corn, being evidently a garden species rather, and my own observations support this statement. Cook found it injuring corn in Michigan, and Fitch in New York, the latter treating it in his Ninth Report under the name o the corn cutworm.

It is essentially a northern species, very abundant in the northern United States and Canada, but less common in central Illinois and southward. The caterpillar hides in the earth by day, cuts off the plants by night about half an inch above ground (and not below the surface, as do the *Hadenas*), and drags the leaves into its hole to feed upon them during the day.

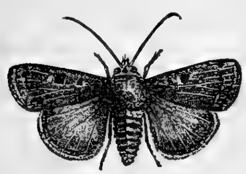


Fig. 17. - The Common Striped Cutworm (*Euxoa tessellata*), adult.

There is but one brood a year, and the cutworms pass the winter about half grown, becoming most destructive in the latter part of May and the first of June. The moths (Fig. 17) are most abundant early in July. They have been taken in Iowa from early June to the beginning of August, and in Canada during the latter half of July and all of the following month.

The Red-backed Cutworm.

Euxoa ochrogaster Guen.

This is a very well-marked species, the caterpillar quite large, more than an inch and a half long, gray or dull brown, with a broad sienna-red stripe down the middle of the back.

It is a Canada cutworm especially, ranging from Prince Edward Island to British Columbia, and often excessively abundant in that latitude. It is less abundant in the northern United States, and is not reported from localities farther south than Missouri, Colorado, and California.

It is regarded by Fletcher as the worst co n pest among the Canadian cutworms. It is also particularly troublesome in gardens, attacking all garden vegetables and flowering annuals. It has not been found by us in corn in Illinois, and is, so far as our observations go, scarcely to be regarded as an economic species in this state.

The larvæ are present in the field through May and June, and sometimes into the following month. The moths occur in the latter part of June and in July and August, with scattering examples continuing into October. There is apparently but one brood a year.

The Bristly Cutworm.

Mamestra renigera Steph.

This is a small yellowish gray species (Fig. 18) about an inch in average length when full grown, marked by two blackish stripes, one on each side, with an unusually broad pale dorsal area between them. There are other less conspicuous stripes and lines, and the hairs are coarse and long, giving the caterpillar a bristly appearance

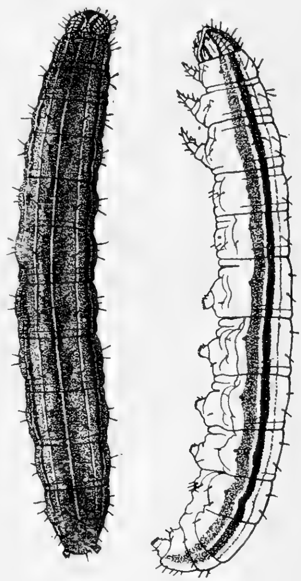


Fig. 18. The Bristly Cutworm (*Mamestra renigera*), back and side views. Enlarged.

This abundant little cutworm has been occasionally found by us at the base of injured corn plan s, but it is mainly a grass and garden species, the spring brood of the caterpillars getting their growth too early to injure corn materially. It feeds mainly on the roots of its food plants, especially on garden flowers. The food plants list d are clover, the common grasses, chicory, turnips, and comfrey, to which we add corn and cabbage. Gillette reared specimens on cottonwood leaves and alfalfa.

Thi species is found from Canada to Georgia, Colorado, and New Mexico, and it has been reported as very abundant in Iowa, Il inois, Ohio, and New York.

There are two generations each year, one of which hibernates as a cutworm partially grown. We have taken young larvæ at frequent intervals from December 2 to April. Injury to crops by this species is most serious in central Illinois in the latter part of April and early in May. The cutworms pupate during May, and the moths (Fig. 19) appear in the latter part of that month, continuing common until the middle of July. Representatives of the second brood of cutworms have been found in early August, and the second brood of moths begins to appear late in that month, and continues through September and into early October. In Kentucky the

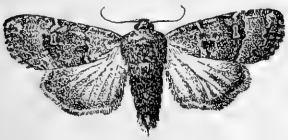


Fig. 19. The Bristly Cutworm (*Mamestra renigera*), adult. Enlarged.

first generation of the moths was reported present from April until after the middle of June, and the second generation in August and September. In Iowa the moths are said to be most abundant in June, and again about the end of August. In Canada the first generation begins to appear late in June.

THE SOD WEB-WORMS, OR ROOT WEB-WORMS.

Several Species of Crambus.

Every observer of insect life has noticed as he walks through grass on lawns or meadows in summer, multitudes of small white or grayish moths (Fig. 21, 23) rising before him, flying a short distance, and then lighting to rest on the grass, head downward, with the body parallel to the blade. These moths, or millers, if examined when at rest, are seen to have the wings folded around the body in a way to give them a cylindrical form instead of the usual triangular one of ordinary moths. These are the parent insects of small, slightly bristly, reddish caterpillars which live abundantly in the turf, hidden away by day in a silk-lined burrow among the roots of the grass, but becoming active at night, when they feed especially upon the underground part of the stem of the plant, sometimes also upon its roots or blades.

Fig. 20. The Sod Web-worm (*Crambus*): web (*a*) containing larva, at base of young corn plant. *b*, *c*, injuries to leaf and stem.

General Description. — These caterpillars (Fig. 20, 22) average about half an inch in length when full grown, are pinkish red or brownish, and covered with rows of comparatively smooth dark spots, from the center of each of which springs a rather coarse hair. They differ from cutworms in their habit of quickly wriggling away when picked up or disturbed, and making active efforts to escape. Cutworms, on the other hand, are sluggish, and take disturbance quietly, simply curling up and taking their chances.

Injuries. — Not infrequently the web-worms become so abundant as to cause brown or deadened spots in a lawn or meadow, sometimes, indeed, in seasons unfavorable to the growth of grass, deadening the turf as thoroughly as white-grubs or cutworms can do. When land so infested is planted to corn, this plant is very likely to be heavily injured, or even completely destroyed over considerable areas in early spring. The injury done is somewhat like that due to cutworms, and is largely under ground, but, on the other hand, the stems are rarely completely severed until the whole plant is eaten up. Commonly the first injury to the plant is done by gnawing the outer surface beneath the ground and about the roots. Then the caterpillar works upward, eating a superficial furrow or burrowing lengthwise along the center of the stem. The leaves are also frequently eaten, the lower ones first, and then the upper ones. The tips are eaten off, or irregular elongate holes are eaten through the blades. The injury being done at night, search must be made for the author of it by day by digging around the affected hills. The web-worms will commonly be found just below the surface (Fig. 20, p. 36), each in a retreat formed by loosely webbing together a mass of dirt, more or less cylindrical in shape, an inch and a half to two inches long, and about half an inch through. Within this mass is a silk-lined tube opening at the surface of the ground next to a stalk of corn, and within this specially prepared domicile a single caterpillar is secreted. Injuries due to these web-worms are commonly attributed by farmers to cutworms, and the caterpillars themselves are similarly confounded. This error would signify but little except for a single important difference in the midsummer life history which has its bearing on the proper time of plowing the sod in spring, and that for planting or replanting the corn. Cutworms are never protected by an underground web, are much larger than web-worms, make no active efforts to escape when disturbed, but curl up and remain inactive, and are without rows of conspicuous shining spots upon the body, these being represented by small and inconspicuous ones.

The injury to corn by the sod web-worms is not uncommon in fields planted on sod ground, and as it begins quite early and may last some weeks, it is fully as serious as a similar attack by cutworms or white grubs. Frequently more or less extensive replanting is required, and sometimes whole fields are completely destroyed two or three times in succession. In Ohio, for example, hundreds of acres of corn and oats were as completely killed in 1895 as if burned over, and similar injuries to corn have been reported from New York, New Jersey, Delaware, Maryland, Illinois, Iowa, and Nebraska. In Illinois and Iowa it was a most serious corn pest in 1887, destroying corn on sod ground in many fields distributed through several counties in both these states; and in Pennsylvania it was found destructive to corn in 1891, most injurious here as elsewhere, in one case at least, on old timothy sod. Besides its occasional injuries to corn, and to small grain where this follows upon grass – a rare event, indeed, at least in Illinois – its principal injuries are to grass in meadows and pastures. Its injuries here are much greater than are commonly attributed to it. "This fact is due," says Dr. Felt, "to its very insidious methods of work."

"Unless the damage they do is very serious it is hardly noticed, or, if noticed, attributed to other causes. As the larvæ live a retired life, close to the surface, eating mostly at night and remaining in their nests during the day, they are rarely seen. Like most larvæ they feed most voraciously just as they are completing their growth; consequently, when the damage is noticed most of the larvæ are hidden in their retreats where they pupate. In these places none but an experienced entomologist would find them, or would think of associating the damage done with the harmless appearing moths that fly later.

"Hardly any farmer would think seriously of the loss of only one stalk of grass in ten, yet the aggregate for the country at large would be enormous. Not only is the damage to a crop where nothing short of a serious injury would attract attention, but the damage is distributed throughout the growing season. As a general rule, each species is most destructive at a different time from the other species of that locality; hence, species of *Crambus* prey upon the grass as a succession of small armies. Could the loss caused by these species come at one time in the year their destructive power would be better appreciated. Less than a third of the species may be classed as of economic importance, but these possess a capacity to cause almost infinite loss if the conditions are favorable."

Additional Examples of Injury. From Office Notes. — At Champaign, May 28, 1885, *Crambus* larvæ were injuring young corn by gnawing the outer leaves at the surface of the ground, and also by eating out irregular holes in the leaves and the blades themselves. Frequently the leaves were eaten off and lying on the ground or partly drawn into the mouth of the web. Occasionally a plant was gnawed completely through at the surface of the ground, as by a cutworm. The injury here was sufficient to cause a partial replanting of the field. This land had been in pasture for fifteen years, and no damage to the grass had been noticed. It was plowed about the 8th or 9th of May, and planting was finished May 15.

At Milan, in Rock Island county, August 13, 1885, farmers reported the presence of a worm which made a web at the roots of the corn and ate the leaves while young, after which it worked about the roots, cutting them off just below the surface of the ground. Seven acres of corn on sod were almost completely destroyed, only a hill here and there being left. These larvæ fed mostly in the evening and just after a shower. They had been seen traveling from one hill of corn to another.

At Mt. Pulaski, Logan county, Illinois, according to observations and statements made June 16, 1885, larvæ of *Crambus zeëllus* (= *luteolellus*) had so far injured a small field of eight acres of corn that it had been replanted about the last day of May. On the 16th of June the worms were still somewhat active, and corn plants were frequently seen which had been more or less injured by it. Many of the webs were vacant, however, the larvæ evidently having gone largely into the earth for pupation. This field had never been plowed until the preceding fall, when it was broken up for corn.

A field of corn near Philo, in Champaign county, Illinois, visited June 1, 1886, was found unevenly infested by this insect, one patch of about an acre being completely destroyed. This corn was on sod broken April 7 and planted May 7 and 8

July 31, 1888, blue-grass was found entirely killed over large patches in a lawn at Urbana, Ill., by the larvæ of *C. trisectus*, and numerous webs, some of which still contained the larvæ, were exposed by clearing away the dead grass on the lawns. On one of these lawns, which ten days before had been thick and as soft as velvet, only a few small spots of green remained. It was spotted with tufts of dead grass pulled out by the birds, many species of which were evidently feeding freely on the web-worms. The larvæ, all nearly or quite full grown, were transforming rapidly at the date of this observation.

June 13, 1891, caterpillars of *trisectus* and *mutabilis* were found seriously injurious to forty acres of corn belonging to Mr. W. C. Baker, near Savoy, Champaign county, Illinois. At least two thirds of the first planting of the forty-acre field had been destroyed, and much of the second planting also. This field had been in pasture for eight or nine years, and was plowed the preceding fall, at just what time my information does not indicate.

Another field, of eighty acres, adjoining the foregoing, also broken in fall, had suffered still more heavily, most of the first two plantings of corn being devoured, and about a third of the third planting also. The caterpillars were still somewhat active June 13, but most of them had ceased their feeding and deserted their webs. It is evident, consequently, that in this case the proper time for replanting would have been about June 10, and that corn planted at this time would have escaped serious injury.

In another field adjoining this, about a fifth of the corn had been destroyed on sod ground plowed in spring. This field had also been in pasture for several years.

At Knoxville and Oneida, in Knox county, Illinois, corn on sod ground examined May 25, 1901, was found damaged by the larvæ of *trisectus* and *vulgivagellus*, associated with ordinary cutworms, to the amount of twenty-five per cent.; and at Buda, in Bureau county, May 28, a field was visited, from fifty to seventy-five per cent. of which had been destroyed by the same web-worms and striped gophers, necessitating a second planting.

From Office Correspondence. — The following reports of injuries by the web-worms are from my office correspondence. All were verified by an examination of specimens.

Galena, Jo Daviess County, Ill., May 23, 1887. I send a box containing worms which are very destructive to corn planted on spring-breaking. [This was *Crambus luteolellus.*]

Hoopeston, Vermilion County, Ill., August 2, 1888. About three weeks ago noticed that the blue-grass on my lawn was beginning to die in spots. Watering did no good. On examination I found worms, like those sent you to-day by mail, averaging one or more to the square inch. They cut off the blue-grass at the top of the ground, but do not disturb the timothy or white clover.

Payson, Adams County, Ill., May 21, 1886. I find a few of the corn root web-worms on a piece of clover sod plowed this spring and planted April 30 and May 1. I find them as often on clover growing in the field as in the hills of corn, and I think they may breed in the clover. The field was planted to corn in 1881 and 1882, sowed to wheat in the fall of that year and again the year following, sowed to clover in March, 1885, this being plowed up in the spring of 1886 and planted to corn.

Smithfield, Fulton County, Ill., May 31, 1887. I mail specimens of a worm that is cutting the corn planted on sod. They are likely to take the third planting, and are working some on stubble. [This was *Crambus trisectus.*]

Galesburg, Knox County, Ill., May 2, 1887. I send you a few grubs that have been eating up the sod corn. I find them on meadow plowed up last fall, also on meadow plowed this spring. They ate up nearly every hill of sod corn, but did not touch corn on old ground next to it. I replanted ten days ago. The new planting is now big enough to plow, and is all right as yet. [These larvæ belonged to *C. trisectus* and *C. mutabilis.*]

May 25. I learn that the corn on a large scope of country is injured in the same way as mine. One man is planting his sod corn to-day for the third time.

Eden, Peoria County, Ill., May 19, 1887. I send by this mail a box of worms found in a corn field on our farm. The field was an old timothy meadow plowed this spring and planted about the 5th of May. They are taking the corn here very rapidly.

Randolph, McLean County, Ill., May 16, 1887. I send you a sample of worms destroying our corn. The land is timothy sod broken the first two weeks in April, and planted the first of May. It has been in meadow for five years. On a part of it considerable clover is growing from seed sown two years ago, and on this part the worms are not so bad. The rest of the corn is taken clean, eaten off just above the ground. We find the worms an inch deep in the ground, the dirt being stuck together. Some of them are very small; others are half an inch long. [*C. trisectus* and *C. mutabilis.*]

Hanover, Jo Daviess County, Ill., May 24, 1887. I inclose several specimens of worms which have done a great deal of damage to corn in this county this spring. The damage has been exclusively on sod ground, both fall and spring plowing suffering alike. From reports from different parts of this county I learn that the ravages of this worm are general throughout the county. The plant is attacked just at the surface of the ground, where the worm weaves a web to protect itself from ants and other enemies, and then the stalk is eaten downward. One piece of ten acres on rich black soil on my own farm I replanted entire on the 14th of May, and now the worms bid fair to destroy it entirely again. Hundreds of acres have been replanted in my own town, and the area of ground in the county damaged by this worm will reach into the thousand acres. [*C. luteolellus.*]

Hamlet, Mercer County, Ill., May 19, 1887. My corn is infested with a larva that is a stranger to me. This morning I collected a few of them and put them in a box directed to you. They do their work at night above ground, and mostly on the upper part of the leaves, but often cut the stalk off at the base of the leaves.

Their nest has its mouth close to the corn they are eating, but may run on the ground an inch before going down. It consists of a web case, to which the dirt adheres. They are doing their worst work on a piece of ground on which rye was grown last year. I often find two or three of them to a single hill of corn. They are mostly small, but I have found a few over an inch in length.

Glenwood, Cook County, Ill., June 15, 1888. I send you inclosed some cots which are supposed to belong to the web-worm. I broke up and planted to corn seventeen acres of timothy sod that had been seeded about twelve years, and I find these cots lying around on this ground. The cutworms are so plenty that they do not let the corn get much above ground.

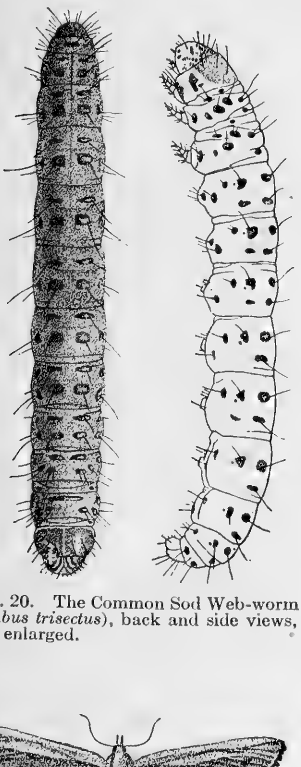


FIG. 20. The Common Sod Web-worm (*Crambus trisectus*), back and side views, Much enlarged.

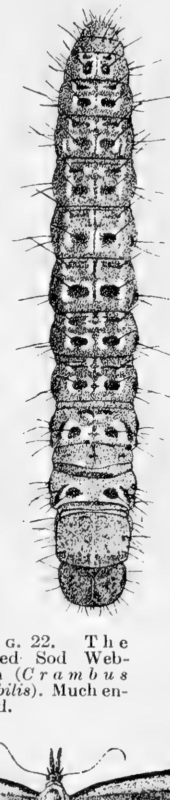


FIG. 22. The Striped Sod Web-worm (*Crambus mutabilis*). Much enlarged.

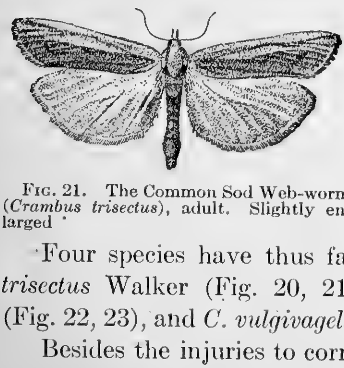


FIG. 21. The Common Sod Web-worm (*Crambus trisectus*), adult. Slightly enlarged

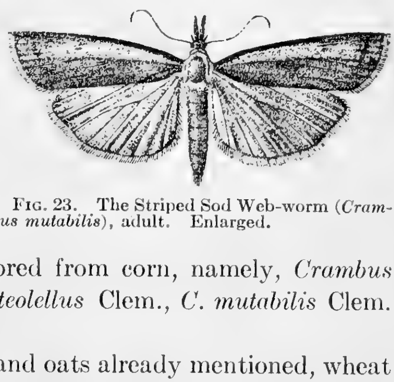


FIG. 23. The Striped Sod Web-worm (*Crambus mutabilis*), adult. Enlarged.

Four species have thus far been bred from corn, namely, *Crambus trisectus* Walker (Fig. 20, 21), *C. luteolellus* Clem., *C. mutabilis* Clem. (Fig. 22, 23), and *C. vulgivagellus* Clem.

Besides the injuries to corn, grass, and oats already mentioned, wheat and rye have been injured by *vulgivagellus*, tobacco by *luteolellus* (*caliginosellus*), and cranberry by *hortuellus*, a species not yet reported from corn.

There are about sixty species of the genus *Crambus* in the United States. So far as known they are of very similar habit, and it is quite likely that any of them living habitually on grass will injure corn if this is exposed to their attack. The species notably injurious to this crop will consequently depend, in all probability, upon those which happen to predominate in the grass at the time the field is plowed, and as these predominating species differ from year to year, the list above given is not to be regarded as final.

Distribution.—The recorded distribution of the four species actually bred from corn extends from the Atlantic to the Pacific, and from Maine, Canada, and California, to Texas, Louisiana, and Florida.

More specifically, the known distribution of the species with which we are here especially concerned is substantially as follows:

C. mutabilis, from Ontario, Massachusetts, Connecticut, and Dakota, to New York, Ohio, Illinois, Kentucky, Florida, Louisiana, Texas, Nebraska, and California.

C. trisectus, from Canada, Maine, Michigan, Minnesota, Dakota, Wyoming, and Vancouver, to New Jersey and New Mexico.

C. luteolellus,* from Maine, New York, Ontario, Minnesota, and Colorado, to North Carolina, Illinois, Texas, Arizona, and California.

C. vulgivagellus, from Maine, Massachusetts, New York, Canada, Wisconsin, and Vancouver, to North Carolina, Missouri, Colorado, Utah, and California.

Life History. — The biology of the species has not been sufficiently studied to give us a comparative knowledge of their life histories, although existing evidence indicates a difference in the species with respect to the number of annual generations, which varies from one to three in a season in the same locality. It is possible, however, that ampler data would remove this impression.

So far as known, all pass the winter in our latitude in the caterpillar stage, apparently not full grown. In early fall they close the mouth and thicken the wall of their cylindrical silk-lined nests before going into hibernation. In the spring they come forth, complete their growth, pupate near the surface, and later emerge as adults. "The eggs," says Dr. Felt, "are usually, if not always, allowed to fall at random in the grass. They hatch in from ten to twenty days." Eggs of various species have been obtained by us from June 9 (*trisectus*) to July 22

*A thorough study of authoritatively named adults, of the larvæ, and of the literature of the three so-called species *caliginosellus*, *zeëllus*, and *luteolellus*, amply confirm previous conclusions of this office, that they represent only variations of a single polymorphic species, *luteolellus*. The details will be given in a later portion of this report dealing with the data of less economic importance relating to corn insects.

(*hortuellus*), and these have hatched in from ten to fourteen days. Most of them were laid singly, but occasionally in clusters of five or six. When first laid they are nearly white, but they change with age to yellowish orange. The young caterpillars form their web-lined nests immediately upon or just under the surface of the soil, strengthening them by the addition of bits of grass or particles of dirt to the surface. They commonly cut off the blades of grass and draw the ends down into the nest so that they can feed without leaving it.

The data concerning the life histories of the various species are not sufficiently complete for all to warrant general comparative statements concerning them. It is certain that two of the species, *trisectus* and *mutabilis*, are at least two-brooded. A tabulation of the dates of collection of a very large series of adults made in several successive years, shows two well-marked periods of maximum occurrence, one in July and one in August, with a comparatively sparse showing towards the middle of July. Larvæ of *trisectus* have been found abundant in May and early June, and again in late July and early August. Those of *mutabilis* are commonest in the latter half of June. The fact that a thi d wave of abundance of the moths of *trisectus* was noted one year in early October suggests the possibility of a third brood of this species at least. *Vulgivagellus*, on the other hand, appears to be a single-brooded species. The larvæ mature late in May, but remain, as a rule, in their underground cells, like some cutworms, dormant through midsummer, emerging as adults in August and September. The eggs are then laid for the hibernating brood of the caterpillars, which will be found in young corn most abundantly during the latter part of May and early in June.

The data concerning *luteolellus* also indicate, so far as they go, a single brood, the moths appearing most abundantly in June and July, with only scattering occurrences in August, and none in the later months. Our breeding-cage results are likewise consistent with this supposition.

The points of especial economic interest in the life histories of these various species are virtually the same as in the case of cutworms. It is desirable to know at what time in fall the eggs are laid for the hibernating brood of caterpillars, since this will fix the time when grass-lands should be plowed as a preparation for corn-planting the following year. It is also desirable to know at what time in spring the hibernating caterpillars cease their work, and when eggs are laid for the next generation. The first of these dates fixes the time of planting or replanting corn on infested land, and the second determines when grass-lands may be plowed in spring to the best advantage if the sod was not broken up the preceding year.

Prevention and Remedy. — The facts concerning these web-worms all admonish the farmer to break up a grassy turf as early in the fall as practicable preliminary to planting the ground to corn; the middle of September is as late as safety permits. If, however, this is not done until spring, it may best be postponed, so far as web-worm injury is concerned, in most cases until the latter part of May. If an infested meadow or pasture is plowed earlier than this, when the larvæ are still young, they will probably live to attack the corn when it appears; and if plowing is postponed later, until the first brood of moths have emerged, they are likely to lay their eggs in the grass before plowing, and thus to give origin to a brood of caterpillars which, being quite young when the corn comes up, will make a long-continued attack upon it, against which replanting will be of no avail.

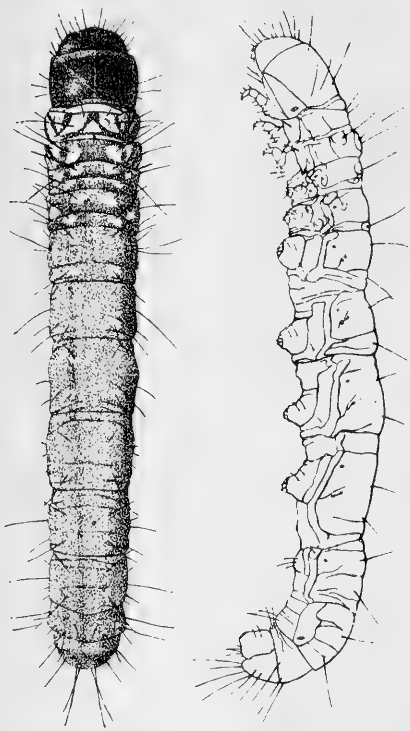


FIG. 24. A Burrowing Web-worm (*Pseudanaphora* or *Hypoclopus*), back and side views. Much enlarged.

THE BURROWING WEB-WORMS.

Anaphora popeanella Clem.

Pesudanaphora arcanella Clem.

Hypoclopus mortipennellus Grote.

These species, treated among the less important insects of the corn plant, are mentioned here merely to distinguish the larva of this group (Fig. 24) from the other web-worms, which it resembles somewhat in habit and injury to corn. It inhabits, however, a vertical cylindrical burrow penetrating the earth to a depth varying from six inches to two feet or even more. It is about the size of a common cutworm, but differs by its dull velvety surface and its colors, varying from silvery gray to brown, by the rows of polished spots on the body, and by its greater activity and more loosely jointed structure.

THE STALK-BORER.

Papaipema nitela Guen.

(*Hydroecia nitela, Gortyna nitela.*)

This well-known caterpillar, often called the "heart worm" because of the character of its injury to corn, may be at once known wherever it is seen by the peculiar break in the striping of the body at the middle (Fig. 25, *b*). It is about an inch long when full grown. The general color varies from purplish brown to whitish brown, according to age, and it is marked with five white stripes, one running down the middle of the back, and two on each side. These side stripes are interrupted, being absent on the first four segments of the abdomen, giving the larva an appearance as if it had been pinched or injured there. The stripes nearly vanish as the larva matures (Fig. 25, *c*).

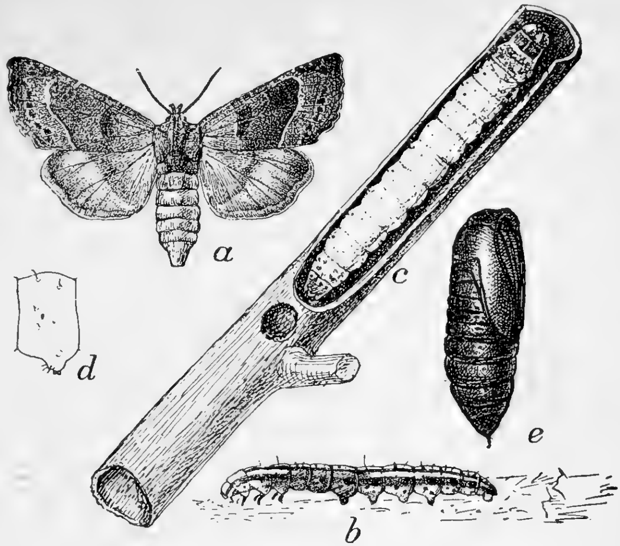


FIG. 25. The Stalk-borer (*Hydroecia nitela*): *a*, adult; *b*, half-grown larva; *c*, mature larva in burrow; *d*, side of one of its segments; *e*, pupa. All slightly enlarged. (Chittenden, U. S. Dept. of Agriculture.)

The head and top of the neck, and the leathery anal shield at the opposite end of the body are light reddish yellow, with a black stripe on each side.

Its presence in a young stalk of corn is very clearly indicated by the wilting, breaking down, and death of the top, and by the presence of a round hole in the side of the stalk (Fig. 25, *c*), plugged with the brown excrement of the caterpillar within.

It infests a great variety of other plants in a precisely similar way. It is most noticeable in early spring in blue-grass, by roadsides or around the borders of a field, its presence there being betrayed by the whitening of single heads of the grass while all the rest of the plant is green. At this time it is of small size, and finds sufficient food within the grass stem; but later it is compelled to resort to thicker-stemmed plants, and it is at this time that it may appear in fields of corn.

Going in usually from outside the field, its injury is, as a rule, almost wholly confined to the outer rows. It rarely does any serious general damage to corn, although it is reported to have once destroyed fifteen acres of that crop near Elmira, Illinois, and it has also been occasionally found injuriously abundant in fields of wheat. It is probable that where the injury is not limited to the margins of the field, but is general throughout its area, the eggs were laid in fall in grass or thick-stemmed weeds in corn fields, where these have sprung up profusely after the corn has been laid by. The burrow which the stalk-borer makes within the stem runs upwards from the entrance opening, and of course varies in size with the growth of the larva. Sometimes in leaving a stalk it makes a new hole above that by which it entered, and it may in this way burrow in succession several different stalks and several different kinds of plants. Corn is injured by it while from two to ten inches high.

Besides the corn, wheat, and blue-grass already mentioned, it may infest oats and timothy, various garden crops — including potatoes, tomatoes, rhubarb, and spinach — blackberry and raspberry canes, the thick-stemmed weeds — such as ragweed, burdock, and cocklebur — a considerable variety of garden flowers, and also the new growth of the peach, currant, grape, apple, willow, etc. Indeed, its food plants are so numerous as to indicate a practical indifference to kinds, the only necessary condition being a relatively thick stem, soft enough to allow it to enter and feed freely within. In the small grains and larger grasses, like oats and timothy, it makes its presence manifest by killing or even cutting off the stem within an ensheathing leaf, thus causing the head and the whole plant above the injury to turn white, and presently to dry up. It is only one of several insects which produce this general effect at this time, but its own injury may be at once distinguished by the round hole which it leaves in the stem of the infested plant.

It occurs throughout the United States and Canada east of the Rocky Mountains, but is most destructive in our own latitude, the adult moth having been, in fact, originally described from specimens sent from Illinois to France.

The caterpillar, when full grown, pupates, as a rule, within its last burrow, commonly below the opening at which it entered — seemingly a precaution against its destruction by the withering and breaking away of the upper part of the injured plant. The pupa (Fig. 25, *c*) is light mahogany-brown, about three fourths of an inch in length, and bears at the tip of the body a pair of spines. From it comes out a fawn-gray or mouse-colored moth (Fig. 25, *a*), with the outer third of the wings paler and bordered within by a whitish cross-line. Other specimens (var. *nebris*) have some white spots on the disks of the wings. The moth is nocturnal, and has been taken by us flying about electric lights, and also at sugar. The eggs have not as yet been found.

There is but one brood in a year, and by the end of June the caterpillars are over half grown, and have mostly left the grasses in which they made their start and entered the thicker-stemmed plants, of course including corn. They live in this stage until late in July, when pupation begins, but larvæ have been found until August 28. The moths begin to appear about the middle of August, and continue throughout September and October. They have never been found in hibernation, and it seems likely that they lay their eggs in fall in grass-lands, and that these hatch in fall or the following spring.

The stalk-borer is much infested by parasites, both dipterous and hymenopterous, access being got to the caterpillars, doubtless, during their intervals of wandering while outside the infested plants.

Fortunately, injuries by this insect are not of a kind to require special measures of prevention or remedy. It is, of course, impossible to poison the larva in the corn field, and the breeding habits of the insect are not such as to enable us to destroy it in the pupa state by any ordinary operation. If headlands and other grassy lots adjoining corn show in early spring an unusual abundance of these insects, it might be worth while to mow the infested turf and carry away and feed the cut grass promptly, before the caterpillars could escape to enter the corn.

A number of other stalk-borers besides the one especially referred to in this discussion, occur in Illinois, all closely related to the preceding, extremely like it in general appearance, and injuring vegetation in an identical manner. Their life histories, so far as we may infer from scattered observations and breeding-cage notes, are practically the same as those of the common species. None of them have been noticed in corn, although some of them may easily have been confused with *nitela* in corn-field collections. These related stalk-borers differ from *nitela* especially in the fact that the longitudinal lines are less developed in some of the species and more so in others.

The Army-worm.

Leucania unipuncta Haw.

(*Heliophila unipuncta.*)

(Plate II.)

This notorious entomological raider and marauder, although one of the most destructive of the insect pests of American agriculture, is actually noticed and distinguished by individual farmers only when it becomes so numerous as to travel in companies, that is, once in some ten or fifteen years, or so, in any given locality. Indeed, many Illinois farmers of several years' experience have never seen the army-worm at all to know it, and many more would not recognize it with any certainty, if found within their fields and meadows, until it got practically beyond control. It is often very desirable, however, that its presence in grass-lands should be detected before it has begun its career of general destruction, and a good and plain description of it is consequently very much to be desired.

This caterpillar should be looked for especially in the coarser, ranker grass growing in the lower, moister parts of the meadow. In the latitude of central Illinois, it appears in three broods or successive generations each year; the first about the middle of May, the second during the latter part of June, and the third in August and September. But one of these generations is seriously injurious during the same year, sometimes the first and sometimes the second, while the third, with rare exceptions, is economically insignificant. The earliest generation (May and early June) is most likely to be the destructive one in southern Illinois, and the second generation (late June and early July) in the central and northern parts of the State. The third generation (August and September) has never been injurious, to my knowledge, in Illinois, but has sometimes been so in New Jersey and New York. The abundant generation moves in hordes or " armies " out of its breeding grounds and into adjoining fields, destroying virtually every green thing as it goes.

Description of the Army-worm (See Pl. II).— This caterpillar has the general appearance of a cutworm, to which, in fact, it is closely related, and whose habits and injuries to vegetation it imitates in ordinary years when it is not unusually abundant. It is readily distinguished, however, from ordinary cutworms by its much more distinctly striped markings, in colors ranging from light greenish yellow to greenish black and black. Looking at the side of the caterpillar, one sees three such stripes very distinctly marked, of which the central one is dark, and the others are lighter. The back of the caterpillar is greenish black, and along the middle of it runs a narrow white stripe, broken and usually indistinct except at each end. Of the three side stripes, the lower one, which is just below the spiracles, is light greenish yellow and is narrowly edged with white. The upper one is a little darker, also edged with white, and with its center greenish black. The middle one of these three stripes, which has the spiracles at its lower edge, is black, sometimes a little lighter along its center. The head is of a greenish brown color, with coarse black mottlings, and with blackish lines where the pieces of the head seem joined together. The belly of the larva is lighter than the back and more or less mottled with blackish. This description applies quite closely to ordinary examples, which the colored plate in this report correctly illustrates. Sometimes, however, paler specimens are found, in which all the colors are less intense, but the pattern is unchanged.

The Army-worm Moth (See Pl. II). — The army-worm hatches from eggs laid by very common night-flying moths. These are yellowish brown, with a white speck near the middle of each fore wing, as shown distinctly in the colored plate. They are fond of sweets, and may be captured in large numbers at night by using sugary substances as a bait.

Habits of the Army-worm. — Army-worms are present every year, and are among the most numerous of our native insects. When present in only ordinary numbers they feed singly in grass-lands like cutworms, remaining hidden during the day, and are then little likely to be seen.

PLATE II.

The Army-worm, with pupa, moth, and egg.

Indeed, their stripes and colors make them difficult to distinguish among their food plants, and their habit of dropping when disturbed serves still further to conceal them. Their ordinary injuries thus pass unnoticed and their presence undetected unless the grass is so badly damaged as to turn brown in patches, when a close examination may disclose them in their retreats.

Their traveling habit, which has given them their common name, can scarcely be called normal to the species, since they resort to it only under circumstances which are, for them, little less than desperate. When, by extraordinary multiplication, they become so numerous in their breeding ground as to devour their own food supply before they have attained their growth, they must search for more food elsewhere. Unlike many insects under similar circumstances, they exhibit a gregarious habit, and instead of dispersing separately in every direction, as would seem to be the more rational course, they move off together in a definite direction in almost solid phalanx, putting themselves thus to the serious inconvenience of traveling great distances to find their necessary food, and exposing themselves likewise to wholesale destruction by birds and other enemies and to wholesale infestation by insect parasites. Fortunately for agriculture, they likewise expose themselves by this same act to destruction by the farmer, who can annihilate a compact mass of traveling caterpillars although he might be helpless against their attack if they separated and dispersed to all parts of the compass.

Feeding ordinarily upon grasses, they prefer these and grass-like grains, even on their desperate marches. They seem to eat with almost equal relish blue-grass, timothy, wheat, oats, corn, rye, and barley, and will likewise readily take sorghum, Hungarian grass, millet, and flax. In confinement they have grown and completed their transformations when fed exclusively on poppy, beet, lettuce, cabbage, raspberry, onion, parsnip, radish, carrot, or pea, but have declined cotton and grape. Ordinarily clover is not eaten by them, and it is said that the timothy in a mixed field is often eaten to the ground, leaving uninjured the clover scattered through it. A remarkable exception is reported, however, from New Jersey, where in 1880 clover was generally eaten by army-worms in some localities. In the field, besides the plants above mentioned, they have also eaten cranberry, strawberry, bean, sugar-beet, sweet potato, parsley, watermelon, cucumber, apple, pepper, honeysuckle, ragweed, wild *Solanum*, and amaranth.

When they enter a field of young corn they first climb up the plants, eating the blades of the leaves on each side of the midrib, but presently, as they become more abundant, they may virtually devour the whole plant to the surface of the ground. "Fully to realize the destructive capabilities of this insect," says Slingerland, "one must see (no description will suffice) an army of the worms on the march and at work. In most cases the caterpillars in each of these armies must have been numbered by the millions; even an approximate estimate of the worms of a single army would have been impracticable. Oftentimes when an army was marching across a lane or roadway, nearly the entire surface of the ground for several rods would be covered by a mass of worms; one could not step without crushing several of them." They feed mostly at night and on cloudy days, although not by any means refraining from travel and feeding in bright weather.

Geographical Distribution. — The army-worm is apparently a North American species, and was well known in New England before the Revolution, where, indeed, measures for the arrest of its movements were adopted which are still the best we can suggest. The species is now distributed throughout nearly the whole world, but it is only in the United States east of the Rocky Mountains and in Canada that it multiplies to a number such as to compel its movements *en masse* in search of food. It is particularly abundant throughout the region from Iowa and Maine to Texas, Alabama, and North Carolina, and in this region there is rarely a year in which it does not somewhere become numerous enough to do serious injury.

Life History of the Army-worm. — The yearly history of the species is not fully known as yet, some diversity of opinion prevailing as to the stage in which it hibernates. Many accurate observations on this subject relate to partly grown caterpillars found late in fall, winter, or early spring, and hibernation in this stage seems to be a somewhat general occurrence. On the other hand, we have taken the moth in March in Illinois, and have once seen it common at lights on April 11. It is also said by Prof. John B. Smith to have been found in New Jersey during the entire winter in sheltered places. We have seen no satisfactory evidence of its hibernation in the pupa stage, although this fact is likewise asserted by some.

When a brood of the caterpillars becomes full grown they rapidly disappear, entering the ground an inch or so, and forming there smooth cavities by twisting about, or making a slight cocoon under clods or other shelter. There they change to smooth brown pupæ (See Pl. II), from which later the moths emerge.

The eggs for the first generation are laid, in our latitude, about the middle of May. These hatch in from eight to ten days. The life of the caterpillar is twenty to thirty days; that of the pupa, twelve to fifteen days; and the moths begin oviposition about a week after they emerge. This gives about seven to eight weeks for the life cycle in midsummer. The eggs (See Pl. II) are placed by the mother moth behind the surrounding sheath of the leaf of grass or grain, from ten to fifty or more together, imbedded in a gummy substance which fastens them also to the leaf surface and closes the sheath around them. It is said that "early in the season the moths prefer to oviposit in the cut straw of old stacks, in haystacks, and even in old fodder stacks of corn, or in old bits of corn-stalks scattered about in pastures." Eggs have also been found in the spring in young grain. Slingerland reports that as many as 737 eggs have been found in the body of a single moth — a fact which goes far to account for the tremendous power of reproduction exhibited by this insect.

Until after the second molt the young caterpillars have the looping habit of the measuring-worms, and spin down at the end of a thread when disturbed, as do the canker-worms. They often leave their feeding grounds when they are scarcely more than half grown. They may travel at the rate of five to ten rods an hour.

Prevention and Remedy. — The fact that two successive generations of the army-worm are never injurious in the same locality is due to the sudden check placed upon their multiplication by a concentration and increase of their enemies of various kinds, the most important of which are insect parasites and parasitic diseases. Birds and ground-squirrels gather for their destruction, but these larger animal enemies are rarely numerous enough to produce any very marked effect upon the traveling horde. Their insect parasites and fungous diseases, on the other hand, presently come to affect them so generally that they perish wholesale either before or after entering the ground for pupation, the soil in such cases stinking with their decayed remains. Parasitic insects have been seen to swarm about them in such numbers that the sound of their flight was like that of a hive of bees.

In case by watchfulness and good luck a farmer detects a colony of army-worms before it has left its native field of grass or grain, he may to advantage surround it by a few deep furrows so plowed that the dirt shall be thrown inward towards the colony, and then either kill the caterpillars as they collect in this furrow in their efforts to escape, or poison them in a body by spraying the vegetation on which they feed with an arsenical poison, like Paris green.

To stop them and destroy them after they have taken up their line of march, deep furrows are plowed in front of them. The straight side of each furrow, which should be the side away from the worms, is trimmed, if necessary, with a spade so that the dirt shall be perpendicular or overhang a little, and post-holes are made in the bottom at intervals of ten or fifteen feet where the caterpillars may collect in quantity as they travel up and down the furrow seeking to escape. Here they may be readily killed by pouring a little kerosene upon the struggling mass in each post-hole, after which they should be shoveled out to make room for another collection.

Prompt and vigorous action is essential to success, since the presence of these insects is often not detected until they are well under way, and their rate of movement is such that acres of corn may be sacrificed by a few hours' delay.

The Corn Bill-bugs.

Sphenophorus parvulus Gyll.
S. venatus Say. (*S. placidus.*)
S. ochreus Lec.
S. pertinax Oliv.
S. cariosus Oliv.
S. scoparius Horn.
S. sculptilis Uhl.
S. robustus Horn.

(Plate III.)

The corn "bill-bugs" are snout-beetles of various size and color (see Pl. III, and Fig. 27 to 34), but averaging rather large; the majority of them dull black, with the surface much marked with small pits and narrow grooves. In form they are somewhat irregularly oval, with thick bodies, rounded above and beneath, and with rather long and thick "snouts" or "beaks" of medium length, curving downward from the front of the head. This so-called snout is really a part of the head itself, and bears always at its tip a pair of minute jaws or mandibles, used in taking in food. The beetles injure and often kill young corn in spring by thrusting the beak into the stem of the plant near its base and eating out the inner tissue beneath the point of puncture. Their presence in the field is very soon made manifest by the appearance of circular or oblong holes running in rows across the blade of the leaf, each row resulting from a single thrust of the beak when the leaves were closely rolled together in the young plant. (See Pl. III.) The injury done varies from insignificance up to complete destruction of practically every plant in several acres of corn and for two or three successive plantings.

The larvæ of these beetles (See Pl. III, and Fig. 26) are rarely found in corn fields except in some of the Southern States, where one of the species, *robustus*, may live as a larva in the pith of the stalk. The others feed in the larval stage, so far as known, upon the bulbous roots of grasses, sedges, and the like, or, in the smaller species, upon the fibrous roots of the smaller grasses. These larvæ are thick-bodied, oval, footless grubs, with hard, brown or blackish heads, the first segment behind the head being leathery and smooth and slightly tinged with brown. They are most frequently seen imbedded in the root-bulbs of timothy, or, in swampy situations, in the thick root-bulbs of the common reed, the club-rush, and other very coarse sedges and swamp grasses.

Fig. 26. The Corn Bill-bug (*Sphenophorus ochreus*). larva, side view. Greatly enlarged.

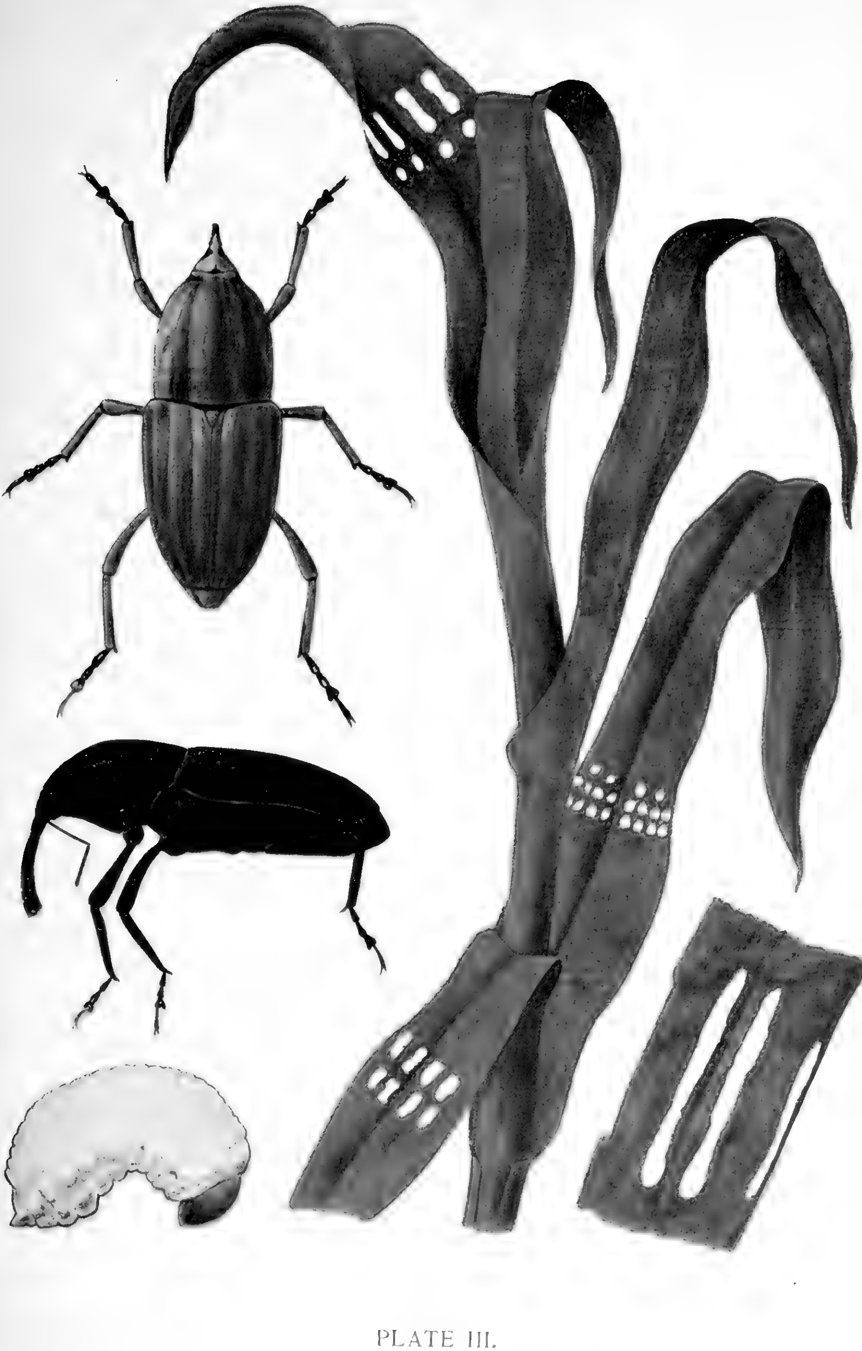


PLATE III.

Corn Bill-bugs and larva, with injured corn plant.

Fig. 27. *Sphenophorus parvulus*, adult, back and side views. Greatly enlarged.

Fig. 28. *Sphenophorus venatus*, adult, back and side views. Greatly enlarged.

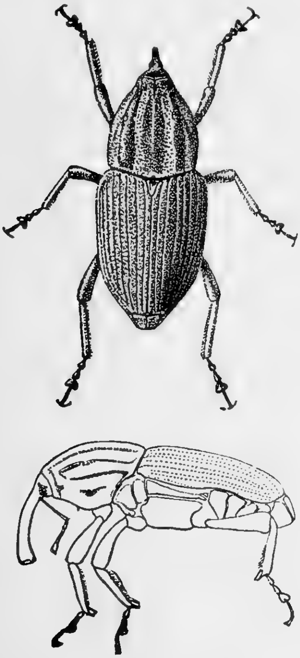


Fig. 29. *Sphenophorus ochreus*, adult. back and side views. Greatly enlarged.

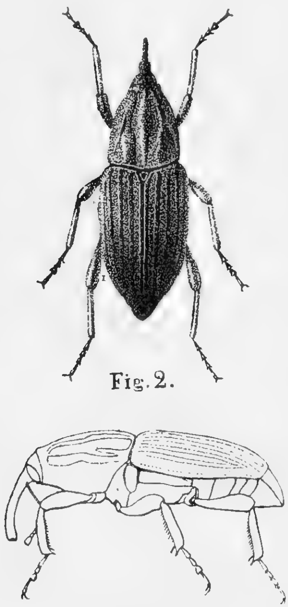


Fig. 30. *Sphenophorus pertinax*, adult, back and side views. Greatly enlarged.

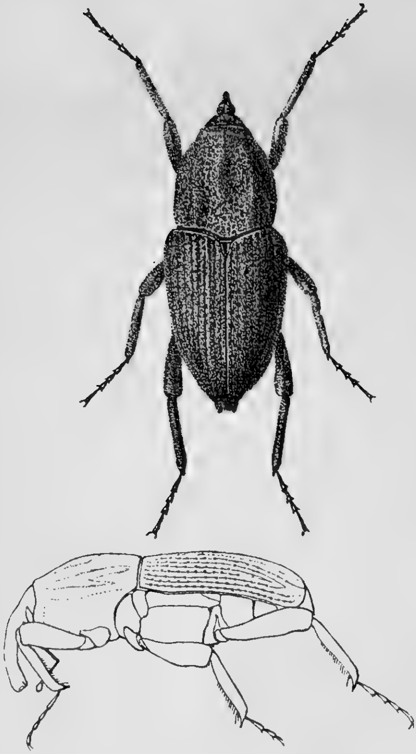
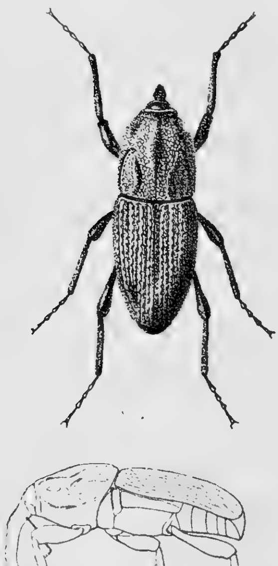
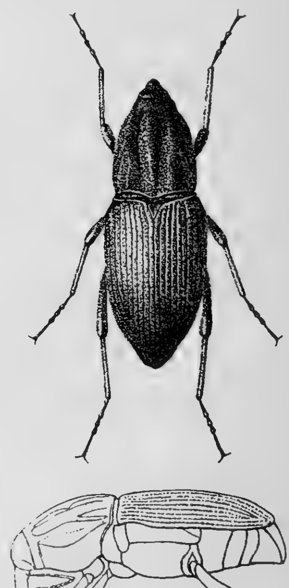


Fig. 31. *Sphenophorus cariosus*, adult, back and side views. Greatly enlarged.

Fig. 32. *Sphenophorus scoparius*, adult, back and side views. Greatly enlarged.





Injuries to Corn. — With the exception of the southern species mentioned above, the injuries to corn are done entirely by the beetles, and are commonly limited to the first year after grass. In some cases where freshly drained swampy tracts have been broken up, the injury may continue in diminished quantity the second year, provided that the crop has not been sufficiently well tilled to kill out thoroughly all the coarse native sedges and grass-like plants. The adults of all the species feed in substantially the same manner, as far as observed, and inflict a similar injury on the plants they infest. Placing itself head downward, with its stout legs embracing and firmly grasping the stalk, the beetle applies the tip of its beak straight against the surface, cutting the outer tissue with the jaws, the action of which is distinctly audible. Gradually, with an occasional twisting motion of the head, it sinks two thirds or more of its snout into the stalk, and then, slightly rolling its head from side to side with clocklike regularity, it uses its beak as a lever to split the stalk and pry the edges of the slit apart. It pauses from time to time to eat out the soft tissues within, and by moving forward and backward and twisting to the right and left, it hollows out an interior cavity much larger than the surface injury would indicate. Then, pulling the head strongly backward with the compressed beak inserted, the stalk is split upward as a boy would split a stick with a knife. In this way a slit an inch long may be made in the stalk of corn, beneath which all the softer parts have been eaten out.

The injury thus done varies in position from a little below the surface of the ground to the middle or upper two thirds of the larger leaves. The beetles are often seen at work on young stalks, head downward, with the beak inserted its full length. They are always on the lower part of the plant, from an inch above the ground to a little below it, and two or three of them are sometimes seen on a single stalk. They are not easily alarmed when thus engaged, and a plant may even be cut away if care is used, without disturbing them. Although they cling closely to it, they can readily be picked off with the fingers, and when thus detached they do not seek to escape, but feign death for a little time.

The effect on the corn plant of such injuries varies according to the size and number of the beetles. A small species like the abundant *parvulus* (Fig. 27) may do little more than to leave a trace of its visit in the form of a series or two of oblong parallel holes across one of the leaves; but the larger species, especially if several beetles attack the same plant, may so rag and deform the young leaves that no ear is matured, or may kill the plant outright.

While there is in Illinois a little general and unclassifiable injury to corn by the bill-bugs, by far the greater part of it occurs under one of three conditions. If swamp lands are broken up from grass in spring and planted to corn the same year, and especially if the common reed or the club-rush or other thick-stemmed grasses with bulbous roots are common in the turf, the corn is extremely likely to be badly injured if not wholly destroyed by one of the swamp-loving species of this group. If such land is poorly cultivated, allowing these bulb-root grasses to grow up again, the injury may continue for at least another year. If an old timothy-sod, either pure or mixed with some other grass, is plowed in spring and planted immediately to corn, this crop is likely to be severely injured by other and smaller species than those which attack the crop in swamps. I have known but one case of any considerable injury by these insects to a field of corn in Illinois except under one of the above conditions.

The damage on swamp sod is frequently so serious and extensive as to require the repeated replanting of large fields of corn. On timothy sod it is not often so complete, a badly infested field rarely having as much as fifty per cent. of the plants injured, and these less seriously because the bill-bugs breeding in timothy average much smaller than those living in swampy situations.

Injuries to Grass and Grain. — The injury to timothy meadows by the work of both beetles and larvæ is sometimes considerable, the former killing the stalk, and the latter destroying an entire stool by hollowing out the bulbous root.

In West Virginia, according to Hopkins, injuries by one of these beetles (*sculptilis*) are among the prime causes of the early decay of timothy meadows. One of the smaller species, *parvulus* (Fig. 27), has also been reported as slightly injurious in the larval state to wheat, oats, and barley. The grub feeds within the straw until it becomes too large for its burrow, and it then passes to the roots, often killing an entire stool of grass in this way.

Distribution. — The known distribution of these beetles is very general throughout the United States and Canada, and in Illinois they may occur anywhere within our boundaries if local conditions permit them to breed.

Life History. — So far as known to me, all our bill-bugs pass the winter in the beetle stage on the ground under rubbish or in other protected situations, and all whose life history has been closely observed, make their appearance in spring usually in fields in which they have lived as larvæ, and where they have fed on the roots of grasses or grass-like plants the preceding year. As the adult beetles feed on the same plants as their larvæ, there is little to tempt them to migrate from one field to another, and the known facts clearly indicate that they pass the winter, as a rule, in the same fields in which they went through their earlier stages, provided that these fields have been undisturbed. All whose life history has been traced with sufficient fullness to warrant an opinion are apparently single-brooded, although the long breeding period and the frequency, as a consequence, with which the insects may be found in various stages at the same time have sometimes led to the inference that there were several generations in a year. Injury to corn, however, is in all cases limited to spring and early summer, ceasing altogether by the middle of July even in the most serious cases. Corn not killed or crippled by these insects while it is young soon grows beyond their reach, and they then leave the field in search of more practicable food.

The eggs of the Illinois species studied, are laid mainly in May and June in the roots or stems of the plants; larvæ may occur throughout June, July, and August; and the beetles emerge in late summer and in fall.

Measures of Prevention and Remedy. — Probably no steps could be taken to arrest the injury to corn in spring by these beetles, and the only resource at that time must be replanting of the injured hills. To avoid repeated destruction, this should be postponed as late as practicable, but it would be virtually safe after the middle of June. The swamp bill-bugs are likely to continue their destructive work through June and well into July, and with them, consequently, this measure would usually fail, and the only alternative remaining is the planting of the ground to some crop not liable to injury by these beetles. It appears, from observations made in 1902, that injury by the swamp species may be forestalled by breaking up the sod in early fall, and it has also been repeatedly observed that corn growing upon timothy sod of early fall plowing was relatively — usually, indeed, completely — free from bill-bug injury the following spring.

For details concerning the several species the reader is referred to an article on the corn bill-bugs published in my Fifth Report, the sixteenth of this office (1890), and to another on "The Corn Bill-bugs in Illinois," in my Eleventh Report — the twenty-second of the office (1903).

THE CHINCH-BUG.

Blissus leucopterus Say.

(Plate I.)

This notorious insect, one of the very worst enemies of American agriculture, is, on the whole, the most destructive to corn of all the insect species to whose attack that crop is subject. It is true that in some parts of the state it has now been virtually unknown for many years, and that where it is most commonly destructive, periods of several years may succeed each other with no noticeable loss to the corn farmer on its account. There are considerable districts, however, in which it is permanently present in numbers sufficient to do every year more or less injury in corn fields, varying from what may be described as trifling to the total destruction of the entire crop over many square miles of territory. It is estimated that the total agricultural losses due to the ravages of this insect have amounted in single states to from ten to twenty million dollars in a season, and throughout the whole range of the insect to a hundred million dollars or more in a single year.

It must be admitted, however, that the weather conditions under which its injuries become serious are such that the corn would suffer materially from drouth if it were not infested by chinch-bugs at all, and as the effect of the insect attack is virtually indistinguishable from that of excessive dry weather, it is usually quite impossible to separate the effects of these cooperating causes. Estimates of injury by chinch-bugs are therefore exceptionally uncertain.

Description of the Chinch-bug.—Although this insect is so abundant and destructive at certain times and places, its appearances in numbers sufficient to attract attention are often separated by intervals of many years, and multitudes of farmers consequently do not know it at sight.

When fully grown (see Plate I) it is readily distinguished from other insect of its region by its size and form, and by the peculiar distribution of the white on its back. Looked at from above, the outline of the entire insect is an elongate oval with rather straight sides and broadly rounded ends. Its length is three twentieths of an inch or a little less, and its breadth about a fourth as much. The head and thorax are black, and all the surface is minutely hairy except that of the wings. The wing-covers, which conceal the abdomen, are milk-white, with a triangular black scutellum between them in front, and a black blotch at about the middle of each side. These invasions of the white area give it roughly the form of the letter X, and this cross mark of white on the back is the characteristic mark of the species. In winged specimens which have recently changed by molting from the preceding stage, the black of the above description is represented by a dull pink, the wing-covers, however, being wholly white, with pinkish veins.

The chinch-bug molts four times after hatching, and changes its appearance materially with each molt. There are thus five distinguishable stages, the first three of which together are often called the red stage of the insect.

In the first of the red stages the young chinch-bug is pale red throughout, with a band of yellowish across the base of the abdomen.

In the second stage the red of the head and the prothorax changes to a dusky tint, and the abdomen becomes a bright vermilion with a pale yellow band across its base, and with faint dusky patches on its posterior segments.

In the third stage, small rounded pads appear on the thorax, projecting backward in the place of the future wings. The head and the thorax are wholly black or dusky, and the abdomen is a dusky red with a patch of darker red near the middle, the light band across its base still remaining, although partly concealed by the wing-pads at its ends.

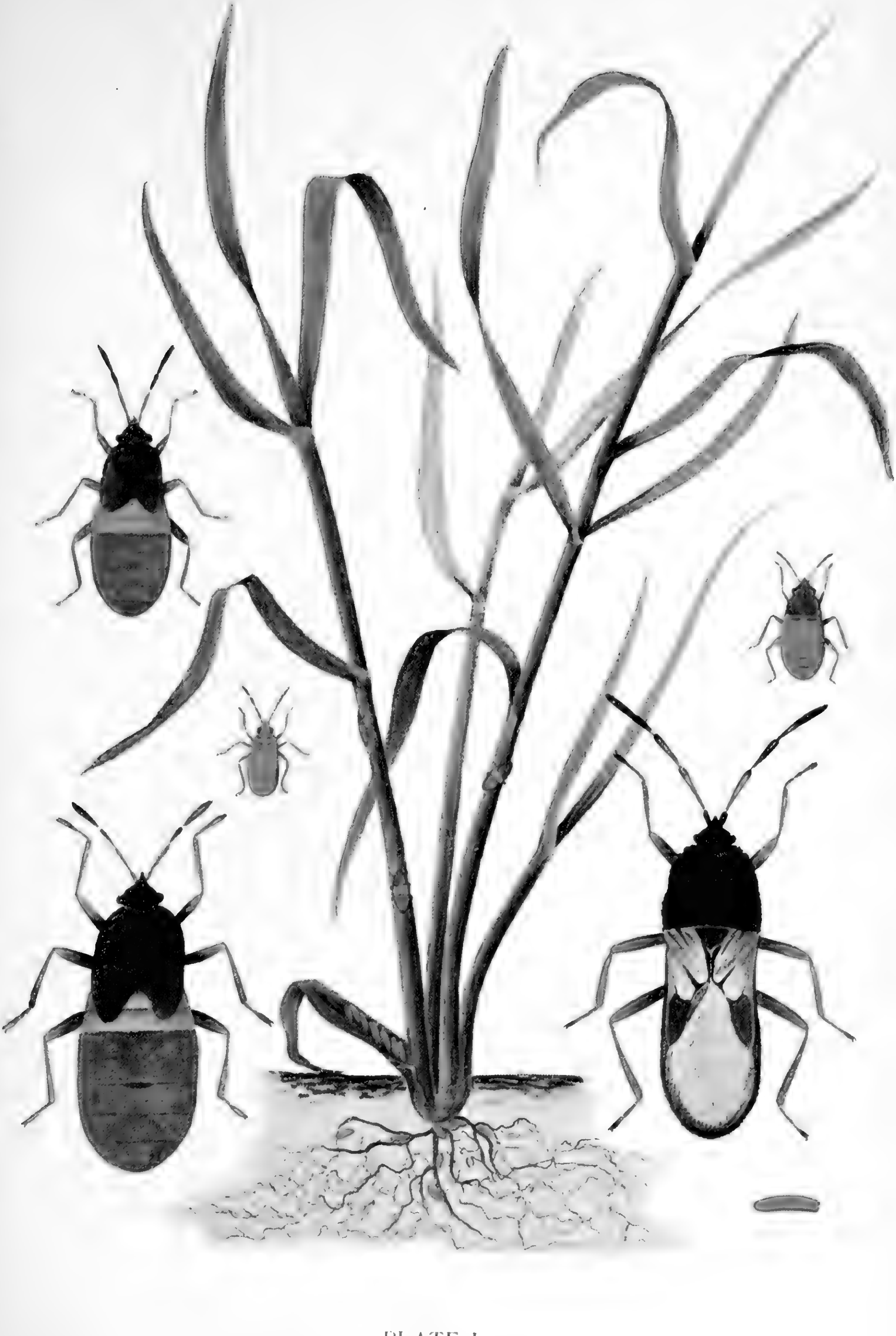


PLATE I.

The Chinch-bug: five stages of development and the egg.

In the fourth stage the original red color has wholly disappeared, the general tint varying from dusky gray behind to black in front, with a remnant of the pale band across the base of the abdomen showing behind the much enlarged wing-pads. This is sometimes called the pupa stage, and is, of course, the next preceding that of the winged insect.

The egg (see Pl. I) is a very slender oval, about .03 of an inch in length, rather narrowly rounded at one end, and slightly docked or squared at the other, where, under a high magnification, four small rounded tubercles may be seen. Its color is at first whitish and translucent, but later darkens to amber, and finally, as the insect develops within, becomes definitely red.

Food Plants and Injuries to Crops.—The chinch-bug injures all the grasses and cereal crops, but is strictly limited for food to plants belonging to the grass family and to certain wild sedges. It is most destructive to wheat, and next, probably, to corn, although it is likely to damage oats very severely. It infests the meadow and pasture grasses generally, and may destroy them as completely as any other crop; but owing to their perennial growth they afford in spring much less fresh and succulent herbage than the young and delicate plants in fields of corn and wheat. Where spring and winter wheat are grown in the same region, the chinch-bug is more likely to destroy the former, mainly because spring-sown grain is exposed for a longer time to chinch-bug attack before it is harvested. The chinch-bug never injures clover, the cowpea, or any forage crop which would not commonly be recognized as grass; neither does it injure potatoes, beans, or fruiting plants of any description.

There is probably never a year in which the chinch-bug does not injure grass or some cereal in some part of its territory. It is, however, subject to very wide fluctuations in number, becoming at irregular intervals a pest of such frightful character as to appall the agriculturist and reduce whole districts to temporary poverty. It has, indeed, modified in important ways the agriculture of large sections of our country, leading to the permanent abandonment of wheat culture in many counties of Illinois, and forcing in others the use of leguminous forage plants in place of the grasses and a substitution of orchard culture for the raising of grain and grass.

There is no very definite regularity in the recurrence of its periods of greatest destruction. These are, however, clearly dependent on the periodicity of the weather, injury by the chinch-bug reaching its maximum after several dry years, and being suspended by the occurrence of two or three wet years in succession. The chinch-bug period is, however, less definite and tangible than the weather period, since not every such change in the weather is followed by a notable corresponding change in the chinch-bug situation. The rise and the fall of a wave of chinch-bug abundance occupy unequal times, the period of annual increase being longer than the period of decline. Three or four or even five years of notable injury to crops may succeed one another, each worse than the preceding, before the maximum is reached, and then, within a year or two, hordes of these insects which may seem to have taken permanent possession of the fields and meadows over an immense district may disappear so completely that it will be difficult to find a few living specimens.

The injuries by this insect are done by sucking the sap from the plants. Being without jaws for biting, it can only appropriate fluid food by piercing the tissues of its food plant with the hair-like stylets of its beak, and then sucking out the sap from the lacerated cells. Owing to its immense numbers, it may so rapidly drain a strong and thrifty corn plant a foot or two in height that this will wither and fall to the ground as if cut off at the root.

Life History of the Chinch-bug.—The points of special economic interest in the life history of the chinch-bug are the stage and place of its hibernation, and the method of its escape from fields of wheat and other grains at harvest-time. It passes the winter as a full-grown winged insect among the roots of tufted grasses; under stones on grassy knolls; under leaves, sticks, logs, and bark; in thickets and the borders of woods; beneath the rails and boards of fences; and in similar sheltered situations. From these winter quarters it emerges in spring, the exact time varying according to the weather, flies freely about in every direction and to considerable distances, settles most generally in fields of wheat, the young growth of which affords it an abundant and attractive food, deposits its eggs there on the ground about the base of the plant, on the roots a little under the surface, or sometimes on the lower part of the plant above the ground (see Pl. I), and presently dies. The eggs are thus laid, in central and southern Illinois, during the last days of April and the whole of May. They begin to hatch about the middle of the latter month, and by the middle of June the old chinch-bugs which had wintered over are virtually all gone.

At harvest-time the young of the new generation are in various stages of development, due to the fact that the eggs are laid at intervals through a period of about a month. There are at wheat-harvest some winged bugs in the field, but the great majority of them are of ages varying from those just hatched up to the stage preceding the last molt. Forced out from these fields of small grain by the ripening of the plants and the consequent pressure of starvation, they enter fields of oats and corn adjoining in a continuous throng, making their migration almost wholly on foot. They thus concentrate in overwhelming numbers on the plants at the borders of the newly entered field, draining and killing everything as they go. It is at this time that the principal injury to corn is done, and it is the method of this migratory movement which gives us our special opportunity to protect the corn by destroying the invading army.

When the majority of the brood have acquired wings, flights of the adults occur, resulting in their dispersal through the field. The eggs for a second generation are laid most commonly in corn fields, particularly on roots of grass-like weeds growing among the corn. This second generation of the year reaches the winged stage late in August and early in September, and leaves the fields in search of winter quarters from the middle of the latter month to about the middle of October.

It should be noted, however, that none of these movements are made simultaneously by all the chinch-bugs of a locality. Even the movement from the winter quarters is a gradual one, and in some cases the chinch-bugs have not all placed themselves for the laying of their eggs before the oats are sown, or even by the time the corn is planted. These crops are consequently likely to become somewhat infested in spring by the first generation of the year, even though there may be an abundance of wheat growing also at the time.

If the weather is very dry at harvest, and especially if drouth and the abundance of the bugs have combined to kill both grain and grass-like weeds by harvest-time, chinch-bugs will desert such fields almost as fast as they can get out of them. If, on the other hand, the grain ripens gradually and normally, and the stubble is left with green weeds interspersed, the bugs are likely to linger for days and even for weeks before the harvested field is completely free of them.

The effect on corn varies with the gravity of the attack. Often in the migration movement every plant of several rows next an infested field of wheat or oats will be blackened by the invading hordes. In such a case the corn is completely killed, and the bugs move forward row by row, carrying the injury, it may be, from one side to another of a field of twenty or thirty acres, and leaving scarcely a living stalk behind. Where they are less abundant, however, they are commonly to be found first and most numerous behind the boots or sheaths of the leaves, where they drain and possibly kill the lower leaves of the plant, checking but not fully arresting its growth.

The second generation, hatching in the corn field, does much less injury to corn than the migrating one, not because it is less numerous, but because it is more widely dispersed, and because the corn plant is larger and more thrifty at that season of the year, and can support a loss of sap which would be fatal to younger plants.

A serious minor effect of chinch-bug infestation during the latter part of the season is a consequence of the clustering of the bugs about the base of the stalk of corn where the so-called brace-roots are putting forth. The growing tissues at this point are then so drained of sap that these roots do not develop, and the corn, lacking their support, falls to the earth in the first heavy wind, and often fails to form a perfect ear.

Preventives and Remedies. Without attempting to give in this special article any full program of procedure for the restriction of chinch-bug multiplication or the protection of crops against it, three measures will be discussed as particularly applicable to the corn crop.

A considerable mass of evidence has been accumulated, of both a popular and a scientific character, to the effect that the growing of wheat is favorable to the chinch-bug. This is seemingly due to the fact that the wheat plant offers in April and early May a perfect food to the adult, and likewise to the delicate young as they hatch from the egg, whereas, if the crop is not grown, the bulk of the hibernating bugs must distribute themselves over the meadow grasses, only the later ones establishing themselves in fields of oats and corn. The grasses seem at this season of the year to afford a less abundant and perhaps less nutritious food than does the young wheat plant, and general chinch-bug injury of the first or even of the second grade is rare in districts where no wheat is raised. The abandonment of wheat culture is too drastic a measure, however, for general use, since it would result in the obliteration of that crop over a great part of the so-called wheat belt in the central and north-central states.

The hibernating habit of the insect suggests at once the advantage of what is commonly known as clean farming—the destruction, that is, of all waste and rubbish of every description which may form a winter protection to hibernating insects, and the burning over of all waste places and accumulations of rubbish in early spring before the bugs have scattered abroad. The maintenance of thickets and of woodlands with their coating of leaves and masses of fallen brush is especially favorable to these hibernating insects, and an old rail fence will afford winter harborage to millions of them.

The main dependence of the corn farmer, however, must be the destruction of the bugs as they seek to enter his corn after the ripening of the small grain has forced them to migrate in search of food. As soon as the ripening of badly infested fields of small grain compels the chinch-bug to desert them, if the weather is dry, so that the ground may be thoroughly pulverized and kept in a dusty condition, a strip of ground six to ten feet wide should be deeply plowed along the side of the infested field adjoining corn. This strip should then be thoroughly and deeply pulverized, first with a disk harrow and then with a brush, until it is reduced as nearly as possible to the condition of dust. Next a short log eight or ten inches in diameter, or a triangular trough made by nailing two boards together, and afterward loaded with stone, should be dragged endwise back and forth in this strip, the driver riding the log or trough if necessary, until a deep groove or furrow has been made across the line of march of the chinch-bug host. The sides of the furrow should be dressed here and there with a hoe, as may be needful to make sure that no passageway out is left for the chinch-bugs which will presently accumulate in the bottom.

If the furrow has been well made, its dusty sides will prove impassable to the bugs which tumble into it, especially as those move at this time almost wholly on foot. If it is so placed that it is directly exposed to the sun, in very warm weather the great majority of the chinch-bugs caught in it will be speedily killed by the heat, the youngest succumbing first, but even adults finally perishing. Nevertheless, to insure their destruction, holes a foot in depth should be made in the furrow with a post-hole digger at intervals of about twenty feet, to serve as traps for the bugs. Here they will accumulate by pints and quarts or even by pecks in a place, according to the number in the traveling horde, and in these holes they may easily be killed by pouring a little kerosene upon them. The post-hole digger may be conveniently used for removing them when dead and for dressing up the holes again.

As the myriads of bugs attempt to escape from the furrow, climbing its dusty wall again and again with desperate persistence, they will gradually lessen the slope by dragging drown the dust as they fall back, and some of them may thus make their way out in time. It is consequently necessary that the barrier should be continuously watched and occasionally rectified here and there with a hoe. After a time it will perhaps be most convenient to make another furrow parallel with the first, abandoning the latter or using it for the coal-tar strip presently to be described.

This furrow and post-hole barrier will work to practical perfection so long as the ground can be kept thoroughly pulverized, but even a slight shower of rain is sufficient to destroy it, releasing the imprisoned chinch-bugs and giving free passageway into the threatened field. As a safeguard against this contingency, a barrel of coal-tar should be brought to the field, together with a watering-pot with a tubular spout, and a dipper for dipping out the tar. If a slender line of coal-tar be poured along the bottom of the furrow or on a hardened strip of ground outside, it will serve as a barrier to the progress of the bugs no less complete than that above described. When first applied it will soak speedily into the ground, but a hardened crust will thus presently be formed which will hold the tar until it slowly dries out. It must commonly be renewed about twice a day. Along this strip post-holes may be made as before, in which the chinch-bugs will be caught even though the ground may be thoroughly wet. A single man or boy can guard from eighty to one hundred and fifty rods of the barrier, but he must be in the field early and late.

This method may seem troublesome and costly to the reader of this description, but the actual expenditure of labor and money is practically insignificant as compared with the loss of crops which may thus be prevented. Such a coal-tar barrier kept up for a fortnight will commonly protect a field completely, and the average cost for tar at three dollars and a quarter a barrel (the current price in southern Illinois) will be twenty-five cents a day for a line of a hundred rods in length.

If, as a consequence of mismanagement or accident, chinch-bugs succeed in crossing this barrier or enter the corn before it is made, they will accumulate upon the nearest rows, where they may be killed at slight expense by spraying or sprinkling the plants with a mixture of kerosene and soap-suds known as the kerosene emulsion. This is made and applied as follows:

Dissolve a half-pound of soap (hard or soft) in a gallon of water by boiling. Remove from the stove and add two gallons of coal-oil and mix thoroughly by pumping this fluid back into itself by means of an ordinary spray pump. When the emulsion is formed it will look like buttermilk. To each quart of this mixture add fifteen quarts of water and sprinkle or spray upon the corn, preferably before 10 o'clock A. M. or after 3 o'clock P. M. The bugs should be washed off so that they will float in the emulsion at the base of the plant. A teacupful to a hill is generally sufficient but the quantity must vary with the number of bugs infesting the corn.

The cost of material per acre of corn treated, will be about seventy cents where the plants are practically covered with chinch-bugs, and about thirty cents per acre where it is moderately infested.

By the use of these various measures corn can be effectively protected against chinch-bug injury, and if so handled, will become infested only by flying bugs which, having been allowed to mature, are scattering over the country in search of food and a place of deposit for their eggs. Even this injury, if serious enough to demand treatment, may be arrested by the use of the kerosene mixture just described.

GRASSHOPPERS.

ACRIDIDÆ.

Injuries to corn by grasshoppers are rarely sufficient in Illinois to require special attention. These insects do not breed in corn, but come into it, if at all, from grass-lands near by. They first injure the outer rows by eating away the silks and kernels from the tip of the ears and by eating up the blades of the leaves, sometimes devouring the husks of the young ear.

FIG. 35. The Red-legged Grasshopper (*Melanoplus femur-rubrum*). Natural size.

The effect of the first injury is to prevent the fertilization of the kernel, thus blasting the ear. At long intervals, when a series of dry years has favored the multiplication of these insects, they become locally destructive in midsummer to grass and small grain, and later to corn. Under these circumstances several of our native species may fly from place to place for short distances in considerable swarms, imitating in a small way the habits of the notoriously destructive Rocky Mountain locust. This latter species does not occur in Illinois, and no grasshopper injury to which we are subject approximates that which sometimes overtakes the agriculturist of the Western States. Our Illinois grasshoppers are subject to destruction by a multitude of enemies, which become, of course, more numerous as the grasshoppers themselves increase in number. As a consequence, two "grasshopper years," so called, rarely succeed each other in the same locality.

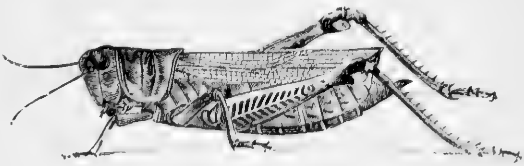


Fig. 36. The Olive Grasshopper (*Melanoplus differentialis*). Natural size.

The standard means for destroying grasshoppers has been until quite recently the use of a long, narrow, shallow pan or tray of sheet-iron, commonly called a "hopper-dozer," with a high back of iron or cloth, dragged across the field by hand or by horse-power, after a little kerosene has been placed in the bottom of the pan. Recently, however, a poison mixture particularly attractive to grasshoppers is taking the place of this apparatus, and is doubtless more likely to be used in Illinois wherever active measures against these insects are found necessary.

This mixture, known as the Criddle mixture, is composed of one part, by measurement, of Paris green to 120 parts of horse droppings, preferably fresh; or about a pound of Paris green to half a kerosene barrel of the droppings, with a pound of salt additional if the material is not fresh. Enough water is added to make the mixture soft without being sloppy, and it is then scattered about the field in quantities according to the number of the insects which will be attracted to it for a distance of forty feet. This poison is most effective when fresh, but it will do excellent work when several weeks old.

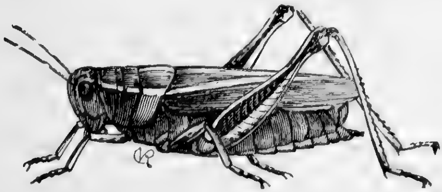


Fig. 37. The Two-striped Grasshopper (*Melanoplus bivittatus*). Natural size. (Riley, U. S. Dept. of Agriculture.)

In speaking of the use of the Criddle mixture, Dr. Fletcher, Dominion Entomologist of Canada, says: "In this section all used the poison and only a few acres of crops were destroyed." "I am convinced that had we begun the test earlier, hardly a bushel of grain would have been lost.

It is not exaggerating to say that dead locusts could be gathered up in wagon-loads, and at times be smelt a half-mile."

The ordinary method of making and using the hopper-dozer is thus given in the Third Report of the State Entomologist of Minnesota, that for 1897:

"A sheet of ordinary sheet-iron, such as is used for making stove-pipes, is turned up one and a half inches around the edges and riveted at the corners. This makes a shallow pan about eight feet long, two feet broad, and one and one-half inches deep. To the bottom of this are riveted six small strips which can be fastened to the three runners on which the pan rests. To the rear side of the pan is screwed a light wooden frame, as long as the pan and one and one half feet high. Over this frame a piece of canvas is stretched. This frame serves the important office of throwing back all those locusts that otherwise jump clear over the pan, and to throw them into the oil. The runners on which the pan rests are usually made from saplings or small pieces of boards having an upward curve in front to prevent them from catching in the ground. The front ends of the runners are all fastened by screws to a cross-piece, which is, in turn, drawn by two ropes, one at each end. These ropes are joined in front and fastened to a singletree. Sometimes two hopper-dozers are fastened to a long pole by means of short ropes; this is very easily drawn by one horse. Just in front of the pan is fastened a piece of rope which sweeps the ground a few inches in advance and serves to stir up the hoppers and make them jump into the pans. In the pan is laid a piece of cloth, which is first thoroughly saturated with water. About a pint of kerosene oil is then thrown in and the upright sheet or sail of canvas is also moistened with it. The machine is drawn over the fields or wherever the locusts are thickest. In a short time it is usually partially filled with dead or dying insects.

Fig. 38. The Bird Grasshopper (*Schistocerca americana*). Slightly enlarged.

"The slightest touch of kerosene oil, either from the pan or from the canvas sheet behind it, means death to the ocust, for the oil spreads over its body in the same way that a single drop of it will spread over a large surface of water. . . . A very large proportion of the locusts that come in contact with the oil in the pan immediately jump out again, but they invariably die in the course of a few seconds or minutes."

PLATE IV.

The Corn Worm: light and dark individuals, pupa, moth, and egg, with injured ear of corn.

The various species of grasshoppers injurious to corn in Illinois are so similar in their habits and life history that it is not necessary for any practical purpose to distinguish them, but all may be treated, so far as the corn crop is concerned, as a single economic group. It may be of some interest to know, however, that the most abundant species in corn is the red-legged grasshopper (*Melanoplus femur-rubrum,* Fig. 35), everywhere the commonest of its family in this state. With it is ordinarily associated the heavier and more sluggish olive grasshopper (*M. differentialis,* Fig. 36), with a sprinkling of the two-striped grasshopper (*M. bivittatus,* Fig. 37). In the southern part of the state the lesser migratory locust (*M. atlanis*) and the large conspicuous bird grasshopper (*Schistocerca americana,* Fig. 38) also become abundant, and, like the species *femur-rubrum,* sometimes collect in considerable swarms and make short flights across the country.

THE EAR-WORM OR CORN-WORM.

Heliothis armiger Hübn.

(Plate IV.)

This insect, known also as the cotton boll-worm, the tobacco bud-worm, the tomato-worm, etc., is a slender, nearly hairless caterpillar (see Pl. IV), an inch and a half to two inches long, varying in color from light green to brown, and marked with alternating light and dark stripes and lines running lengthwise of the body. A common type has a dark-brown stripe down the middle of the back, with a fine white line in its center, and bordered on each side by a pale brown stripe, and below the latter a distinct whitish stigmatal stripe. Inconspicuous shining tubercles, each bearing a delicate hair, are arranged in transverse rows on each segment of the body. The head is amber-yellow, and the legs are dark.

As an ear-worm this caterpillar feeds on the corn beneath the husk, from the time the ear is formed until after it is thoroughly ripe, and it also eats the husk, the leaf, the tassel, and the tender stalk. Although it probably prefers corn to any other of its food plants, it is likewise fond of cotton, tobacco, beans, and the fruit of the tomato, and feeds freely upon a great variety of other plants, including pumpkin, squash, peanut, pea, cow-pea, hairy vetch, pepper, okra, jimson-weed (*Datura*), asparagus, ground-cherry, hemp, morning-glory, gladiolus, mallow, mignonette, geranium, sunflower, poppy, and peach. It sometimes devours soft-bodied insects, such as the cabbage-worm and cotton-worm, and has been known to eat the young of its own kind even when vegetable food was plentiful. As a bean insect its injuries in the South are of the most serious character, whole crops being destroyed, and it is also one of the standing and most destructive pests of cotton and tobacco. In the truck-garden its injuries to green tomatoes are notorious, although in this work it is aided by a number of other kinds of caterpillars.

It is a cosmopolitan insect, being now found in virtually every part of the world. It is very common in Illinois, where it is most widely known because of its injuries to green corn in the garden and to field corn, particularly in the southern half of the state.

Early in spring it feeds on corn leaves, filling them full of holes the size of small shot, and later in the season it enters the tips of the ears, gnawing away the silk and eating out irregular winding channels among the soft kernels, thus often making its way down below the middle of the ear. A single caterpillar does not confine itself to a single ear, but leaves its work of destruction to be continued by other insects and by fungi, which are likely to follow up its injuries. It bores a round hole through the husk at the side of the ear, and infests others in succession. There are sometimes two or three caterpillars in the same ear, but in that case they are commonly of different ages.

There are three annual generations of these caterpillars in the North, and in the South from four to six, besides a series of broods preceding these, which come from a few individuals that pass the winter as adults. The species hibernates in the pupa stage, and emerges to lay eggs in early April. These range from two hundred to five hundred in number for each female, and are shaped like an inverted teacup (see Pl. IV), with the vertical ribs converging towards the apex and broken up by concentric grooves into little knobs. The caterpillars reach their growth in from two to four weeks, and the moths (see Pl. IV) appear about two or three weeks later. The first brood of caterpillars in Illinois feeds on the leaves and the tender shoots of corn, the second brood devours the tassel, the silk, and the ear, and the third infests the hardened ear. The fourth and fifth broods, where they occur, all attack various plants, particularly the cotton-boll in the South. A sixth generation is reported from Texas. The caterpillar enters the earth for pupation to a depth of from two to five inches, where it forms a slender cocoon by lining the end of the burrow with a few threads of silk. (See Pl. IV.)

The mastery of this pest in the corn field is still an unsolved problem. It is believed that late fall plowing of corn fields which have been infested by this insect will destroy it in the pupa stage by breaking up its underground shelter and exposing it to the vicissitudes of the weather. It is not often practicable, however, to plow corn ground in fall in Illinois, and the effect of such a measure at best can only be to diminish the number of moths in the neighborhood the following year

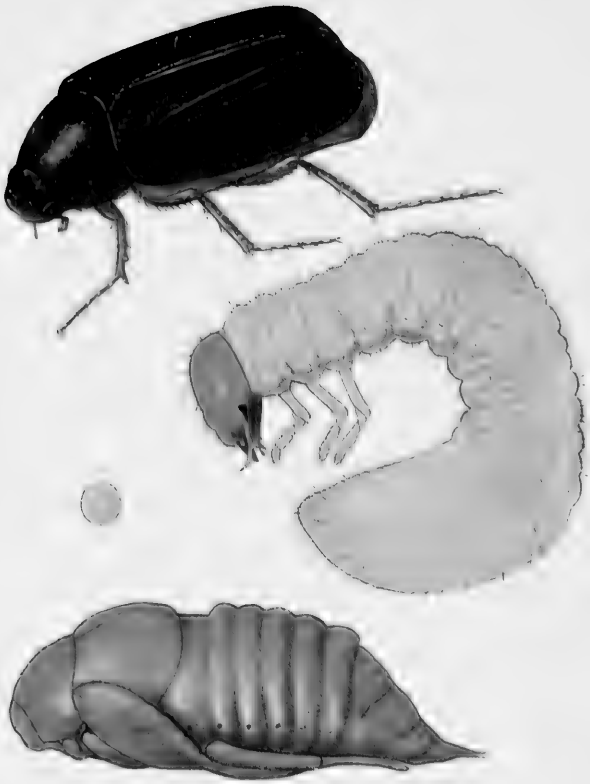


PLATE V.

THE WHITE GRUB. BEETLE, EGG, LARVA AND PUPA.
Enlarged 2½ Diameters.

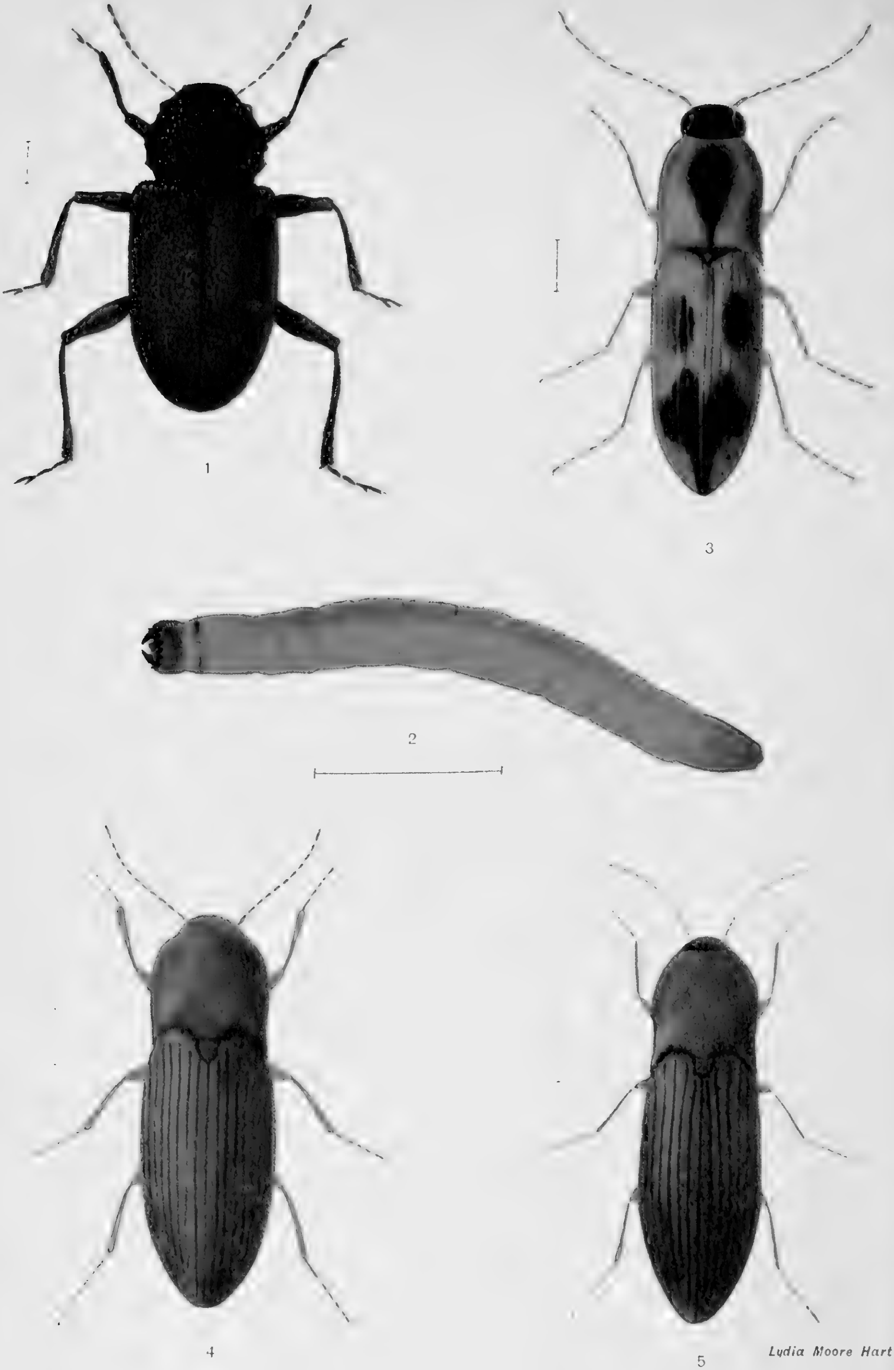


PLATE VI

Fig. 1—*Myochrous denticollis.* Fig. 2—The Corn Wireworm, *Melanotus cribulosus* Figs. 3-5—Click Beetles, adults of other Corn Wireworms; *3 Drasterius elegans ; 4 Agriotes mancus ; 5 A. pubescens.*

The More Important Insects Injurious to the Seed and Roots.

The following insects injurious to the seed and roots of Indian corn and belonging in this section of "the more important species," have been treated at length in the Eighteenth Report of this office, published in 1894 as an appendix to the Report of the State Department of Agriculture, and also in Bulletin 44 of the Illinois Agricultural Experiment Station, printed in May, 1896:

Wireworms (*Elateridæ*). 18th Rep., pp. 28–51; Bull. 44, pp. 224–233. (See Pl. VI., Fig. 2–5.)

The White-grubs (*Lachnosterna* and *Cyclocephala*). 18th Rep., pp. 109–144; Bull. 44, pp. 257–279. (See Pl. V.)

The Northern Corn Root-worm (*Diabrotica longicornis*). 18th Rep., pp. 154–165; Bull. 44, pp. 287–296.

The Southern Corn Root-worm (*Diabrotica 12-punctata*). 18th Rep., pp. 146–154; Bull. 44, pp. 282–287.

The Corn Root-aphis (*Aphis maidiradicis*). 18th Rep., pp. 58–85; Bull. 44, pp. 237–256.

ECONOMIC GROUP 2.

(The less important insects: those sometimes injurious to a corn crop, but not seriously or widely or frequently destructive in Illinois.)

THE SEED-CORN MAGGOT.

Pegomyia fusciceps Zett.
(*Anthomyia zeæ* Riley, *Phorbia fusciceps.*)

Since my publication of a brief article on this insect in my Seventh Report (1894) additional facts of interest have been learned with reference to its life history and its economic relations, such as require further mention of the species as a corn insect.

The larva is a footless cylindrical maggot, narrowed in front and enlarging gradually to the hinder end. It is about a quarter of an inch in length, and a sixth as wide at the thickest part. Alcoholic specimens are pale yellow, with the harder parts at the ends usually considerably darker.

This maggot, originally reported only as injurious to the corn kernel in the earth, is now known to infest planted seeds and young sprouting plants in considerable variety, preferring perhaps, on the whole, young beans, corn, cabbage, and peas. It also feeds on turnips and radishes, at least on such parts of these plants as are in process of decay in consequence of injury by other insects. Beets, onions, sweet potatoes, and mustard are other known food plants. The amount of injury to corn is too slight and occasional to require treatment.

The life history has not been fully made out, but it seems certain that at least two generations are ordinarily produced in a year. (Pl. VII., Fig. 1, adult.)

THE WOOLLY BEARS.

Arctiidæ sp.

The "woolly bears" are several species of hairy caterpillars of medium size, belonging to the family of the tiger-moths (*Arctiidæ*). They are covered with long coarse hairs, which "spread out on all sides like the bristles of a bottle brush, and grow in clusters or tufts on little warts arranged in transverse rows on the surface of the body. They run very fast, and when handled roll themselves up almost into the shape of a ball. . . . When about to transform they creep into the chinks of walls and fences, or hide themselves under stones and fallen leaves, where they inclose themselves in rough oval cocoons [Fig. 39, *b*], made of hairs plucked from their own bodies interwoven with a few silk threads. The chrysalis is smooth and not hairy, and is jointed and movable."*

* Harris's "Insects Injurious to Vegetation," 3d ed., p. 344.

One of the best known of these woolly bears is the hedgehog caterpillar (Fig. 39, *a*), *Isia isabella*, a large, densely hairy caterpillar, orange brown on the middle and black at each end, common and conspicuous in late fall, when it is seen hurrying about in search of winter quarters. It gets its common name from its habit of rolling itself into a ball as if relying upon the protection of its dense coat of stout bristles, which then radiate in all directions like the spines of a hedgehog. This species winters in the caterpillar stage, but most of the other common forms hibernate as pupæ, and are consequently less frequently noticed.

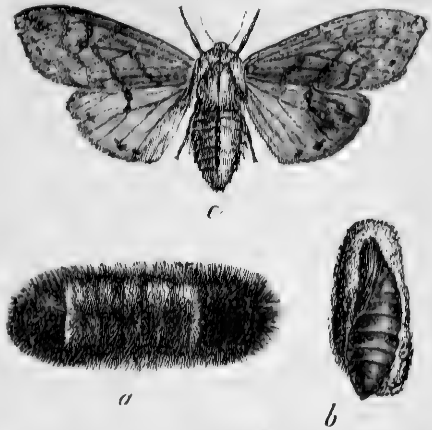


FIG. 39. The Hedgehog Caterpillar, *Isia isabella*: *a*, larva; *b*, pupa; *c*, adult. Natural size.

They live upon herbaceous plants in great variety, and do a damage correspondent to their numbers and the kinds of economic plants which they happen to encounter as they travel about in search of food. They are rarely notable as corn insects, their injuries to that crop being either strictly local or merely occasional. Six of the more abundant species have been reported from time to time as injurious to the corn plant, and it is very likely that none of them would refuse it as food if it came in their way. If, by dispersal from some adjacent field, a number of these caterpillars should threaten injury to corn, they could doubtless be excluded from that crop by a clean furrow with a vertical inner face, as is the army-worm; or they may be poisoned on their food plants by the usual arsenical insecticides.

A few notes on the known corn species will be consistent with the plan of this report.

EUBAPHE ROSA French.

(*Crocota rosa.*)

Several larvæ of the woolly-bear type, about an inch long (Fig. 40), were sent to us from Edgewood, Ill., by a correspondent who had found them feeding on corn leaves. When placed in a breeding-cage with young growing corn they ate the leaves but little, gnawed an exposed seed kernel, and soon pupated, appearing before long as moths (Fig. 41, 42) of the above species. Another example was bred by us two years previously from grass.

The larvæ are much like those of *Apantesis* (*Arctia*), except in their

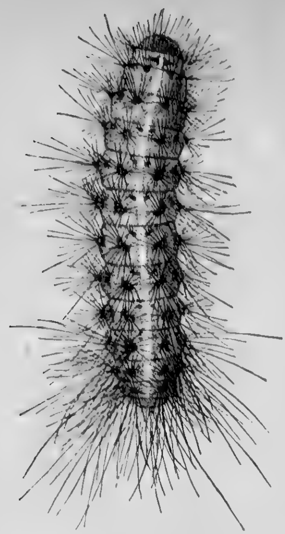


FIG. 40. *Eubaphe rosa*, larva. Twice natural size.

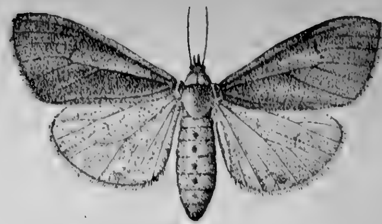


FIG. 41. *Eubaphe rosa*. Two and one half times natural size.

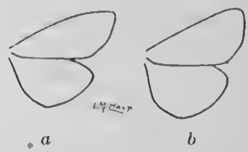


FIG. 42. Wing outline: *a*, of *Eubaphe rosa*; *b*, of *E. brevicornis*.

smaller size. Their covering of long black hairs is rather sparse, and there is a conspicuous narrow white line along the middle of the back.

Our larvæ were collected April 25 and May 14. The latter lot began to pupate early in June. The former became adult June 8; the latter, June 23. Another adult was taken June 5.

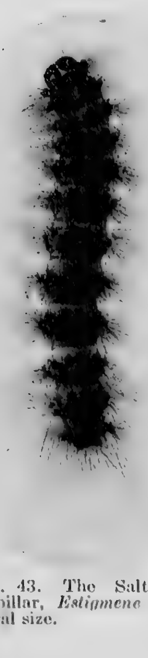


FIG. 43. The Salt-marsh Caterpillar, *Estigmene acræa*. Natural size.

THE SALT-MARSH CATERPILLAR.
(*Estigmene acræa* Dru.)

THE YELLOW BEAR.
(*Diacrisia virginica* Fabr.)

THE HEDGEHOG CATERPILLAR.
(*Isia isabella* Sm. & Abb.)

These common species are sufficiently similar in their habits and life history to make it convenient to treat them as one. They are one and a fourth to one and three fourths inches long, and are covered with erect hairs. In the *salt-marsh caterpillar* (Fig. 43), the head (Fig. 48, *a*, *b*) is more or less black, the hair is commonly dark brown, and the body is blackish, with pale stripes along the sides and one down the middle of the back. The hairy covering of the *yellow bear* (Fig. 46) is of nearly uniform color, commonly yellow-brown but varying from white to deep blackish brown, the body beneath it often with dusky stripes, and the head (Fig. 48, *c*) varying from white to brown and even deep blackish brown, this and the body conforming in color in general to the color of the hairy covering. In the *hedgehog caterpillar* (Fig. 39, *a*) the hairs on the first four and the last three segments of the body are black, and those on the intermediate rings are tawny red or orange-brown. The head (Fig. 48, *d*) and the skin beneath the hairs are also black.

FIG. 44. The Salt-marsh Caterpillar, *Estigmene acræa*, female. Natural size.

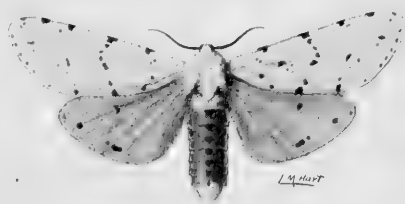


FIG. 45. The Salt-marsh Caterpillar, *Estigmene acræa*, male. Natural size.

These caterpillars are commonly and widely distributed, and are very general feeders on the leaves of a variety of garden vegetables, small fruits, vines, and young trees. When quite young they merely gnaw away the surface of the leaves, but when older they make large holes in them. The species are all double-brooded, the larvæ of the first brood being commonest in June and July, and those of the second in September. The hedgehog caterpillar differs from the others in the fact that it hibernates in our latitude as a full-grown larva, while the yellow bear and the salt-marsh caterpillar pupate in autumn and pass the winter in the pupal stage.

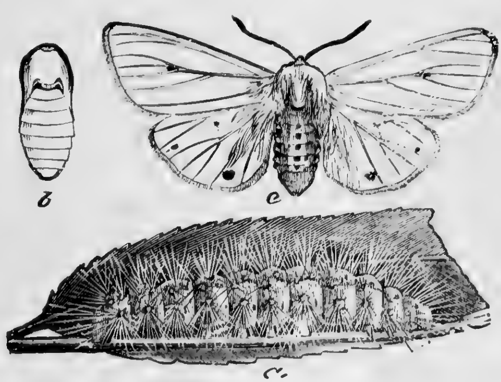


FIG. 46. The Yellow Bear, *Diacrisia virginica*: *a*, larva; *b*, pupa; *c*, adult. Natural size.

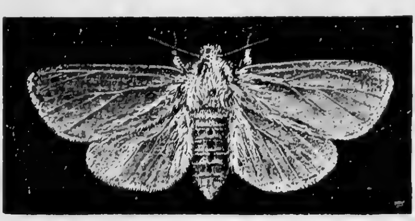


FIG. 47. The Yellow Bear, *Diacrisia virginica*, adult. Natural size.

The salt-marsh caterpillar feeds freely on garden vegetables as well as on corn. The young eat away all the substance of the corn leaf except the upper cuticle, and the older specimens make holes quite through the leaf. This caterpillar also eats clover, cabbage, lettuce, cotton, ragweed, burdock, sweet clover, plantain, etc., and in the East

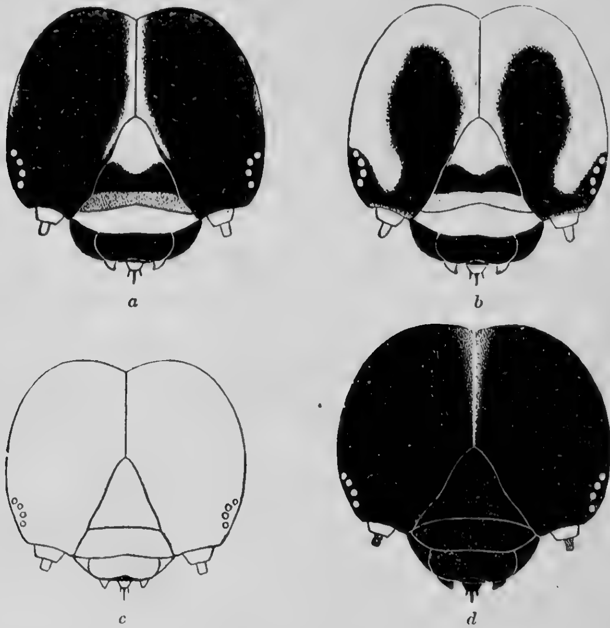


FIG. 48. Faces of Woolly-Bear larvæ: *a* and *b*, *Estigmene acræa*, showing extremes of coloration; *c*, *Diacrisia virginica*; *d*, *Isia isabella*.

was formerly a very destructive pest on the swampy grass-lands along the coast.

The moths of this species (Fig. 44, 45) have emerged in our breeding-cages in the latter part of April, but are most abundant at electric lights in the latter part of May and the first half of June. Caterpillars appear in late June and July, the second brood of moths following in late July and in August, and the second brood of larvæ in September and October.

The yellow bear eats the leaves of Indian corn (Fig. 49), and also those of peas, beans, plantain, and various grasses; and grape, currant, cabbage, gooseberry, butternut, lilac, sorrel, convolvulus, sunflower, smartweed, verbena, and geranium are among the other plants mentioned as eaten by this voracious feeder. Beutenmüller says of it, that it eats all kinds of low plants growing in gardens and fields.

The hedgehog caterpillar, like the preceding, eats almost all kinds of low plants, including clover, cabbage, lettuce, spinach, and grass.

It is on record particularly for serious local injury to young corn in Iowa, the only published report of the kind for the species.

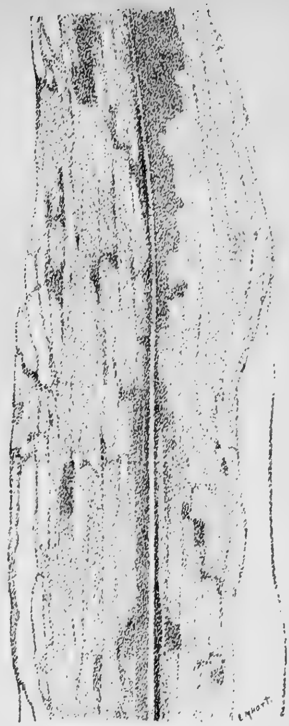


Fig. 49. Corn leaf eaten by the Yellow Bear, *Diacrisia virginica.*

Apantesis arge Dru.

(*Arctia arge.*)

This is the caterpillar of the large tiger-moth, and seems to have received no English name. Though not uncommon in Illinois, it is especially a southern species, and was reported many years ago as sometimes very destructive to Indian corn in the Southern States. It is distributed throughout the United States as far west as the Rocky Mountains.

The spreading hairs are placed in clusters on rows of dark gray warts. The hairs on the back are brown; those on the sides are tinged with red. The surface of the body is marked by three longitudinal stripes of reddish white on the back and a row of kidney-shaped spots of the same color on each side. The general color of the skin is greenish gray, and the head and neck-shield are black. The full-grown larva is an inch and a half in length by about a quarter of an inch in transverse diameter.

In addition to corn, it is known to feed upon plantain, evening primrose, smartweed, dock, cactus, lamb's-quarters, and pea.

Fig. 50. *Apantesis arge.* Slightly enlarged.

This species is double-brooded, passing the winter in our latitude as a caterpillar partly grown, and changing to the pupa in March and April of the following year. After a pupal period of about fifteen days the moth emerges and lays her eggs until late in May. These hatch in fifteen to twenty days, producing a second brood of the caterpillars in the middle part of June, and the pupæ from these are formed early in July. Late in this month and early in August the moths (Fig. 50) appear, after a pupal period of twenty days, and lay the eggs which, in September, produce the hibernating brood of caterpillars.

APANTESIS PHYLLIRA Dru.

(*Arctia phyllira.*)

This caterpillar, a woolly bear of medium size, with body jet-black* and hair also black, is an uncommon species in Illinois, but is more abundant in the South, where it is recorded as feeding on corn, wheat, peas, and various other kinds of low plants.

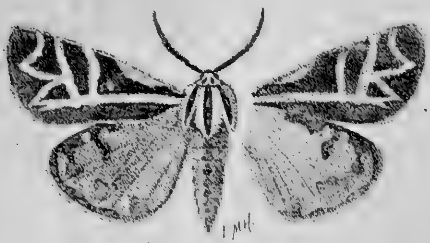


FIG. 51. *Apantesis phyllira.* Slightly enlarged.

It has been taken throughout the country, from Massachusetts, Canada, and Michigan on the north, to Colorado and Texas on the west.

It is at least double-brooded throughout the greater part of its range, the moths (Fig. 51) appearing in May and again in July. Adult larvæ are recorded in the South early in April and late in May, apparently representing the first and second broods respectively. Caterpillars taken April 4 became adults on the 29th of that month, and others taken May 27 completed their transformations by June 16.

APANTESIS PHALERATA Harr.

(*Arctia phalerata, A. nais phalerata, A. vittata phalerata.*)

This is a black or dark brown hairy caterpillar (Fig. 52, 53), about an inch and a quarter long, with a line of pale yellow—sometimes almost white—along the middle of the back. Its long whitish or brownish hairs, with short, black, spiny bristles intermixed, spring rather sparsely in tufts from transverse rows of warts. It is most abundant in grass, and is known as a corn insect only because it has been found to eat readily of that plant in confinement. It has also eaten, in breeding-cages, the leaves of peach, elm, grape, and knotweed (*Polygonum aviculare*).

FIG. 52. *Apantesis phalerata*, larva. About twice natural size.

* A figure given by Abbot and Smith has a row of yellow spots along the back and sides.—Beutenmüller.

The species ranges from the Gulf of Mexico to Canada and from the Atlantic to the Pacific.

The eggs have been found in clusters of thirty or more on strawberry and dandelion plants. The larva is commonest in fields and gardens. When full grown it spins a loose cocoon in some sheltered place, within which it changes to a black pupa about three quarters of an inch in length, with a dense tuft of hooks at the tip of the abdomen. The species winters in the caterpillar stage, partly grown. Adults appear in May and the early part of June. The second brood of caterpillars are most abundant in July and early August, and produce moths in late July, August, and September. Our dates for the moth range from May 5 to June 26 for the first brood, and from July 9 to October 8 for the second, the larger numbers occurring near the middle of May and August.

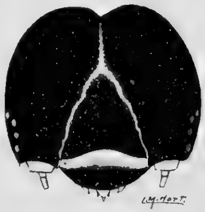


FIG. 53. *Apantesis phalerata*, face of larva. Greatly enlarged.

THE HADENA STALK-BORERS.

Hadena stipata Morr.

H. fractilinea Grote.

H. misera Grote.

Besides the common stalk-borer of this region treated on page 44, the spindle-worm, on page 85, and the two stalk-borers of the South, on pages 91 and 94, the above three species of *Hadena* have been observed by Mr. F. M. Webster* causing serious injury to corn by burrowing lengthwise in the heart of the plant.

Unlike the common glassy cutworms, which belong to the same genus, these caterpillars are striped with brownish, and are rather slender and active, resembling the common stalk-borer. There is no indication, however, of the abrupt obliteration of the lateral stripes on the middle part of the body, as in the latter species. *H. stipata* has four stripes, one on each side and two near together on the back.

In various parts of central Indiana *H. stipata* killed young corn in 1889 on clover, timothy, and prairie sod, but not on blue-grass. Both low and high lands suffered severely, and some fields were totally ruined, the injury continuing until it was too late to replant. The larvæ gnaw into the stem under ground and bore upward through the heart, ultimately killing the plant. They sometimes go from plant to plant, and may thus destroy an entire hill.

*Bull. 22, U. S. Dept. Agr., Div. Ent., p. 47; "Insect Life," Vol. II., pp. 134, 383; Bull. 51, Ohio Agr. Exper. Station, p. 139.

H. fractilinea and *H. misera* were bred from larvæ reported to be common and destructive to corn in northern Ohio. The fields infested were mostly timothy sod, plowed in spring, some early and some late. Corn on fall-plowed land was affected only at the margins; that on clover land, but little or not at all. Instead of entering the stalk from beneath, these caterpillars ascend the plants and burrow down through the heart to about the point of entrance of the preceding species. If the plant be only a few inches high they may enter the tubular opening formed by the innermost leaf; but if it be older and tougher, they will eat downward along the edges of a leaf until more tender tissues are reached within the plant.

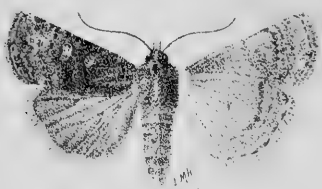


FIG. 54. *Hadena fractilinea*, adult. Slightly enlarged.

The larvæ of *stipata* were first seen May 28, but had apparently been active for the greater part of the month. They continued to feed throughout June, pupated in July, and emerged on the 25th of that month. Our specimens of the adult have been taken July 29, August 3, 4, and 7, and September 4. Gillette took the moths in Iowa from July 25 to August 13. Beutenmüller says that the moth flies in July and August. The larvæ of the other two species occurred in June, and gave moths in late July and early August. Moths of *fractilinea* (Fig. 54) have been collected from June to September, most abundantly in August, and those of *misera* in August. The species are presumably all single-brooded.

The moths are not common in collections, a fact perhaps due to their alertness and habits of concealment, as illustrated by *fractilinea*. *H. stipata* is known to range from Maine to Colorado; *fractilinea* has been taken from Canada and Maine to New Jersey, Ohio, and New Mexico; and *misera*, in New York, Ohio, Illinois, Wisconsin, Minnesota, and Colorado.

HELOTROPHA RENIFORMIS ATRA Grote.

The title of this species to appear in a list of corn insects rests upon a note published by Professor A. J. Cook, of Michigan, in the agricultural report of his state for 1888 (page 166). In this report it appears that, acting as a corn stalk-borer, this cutwormlike caterpillar damaged some corn quite seriously for at least two successive seasons in several counties of northern Michigan. It is said to be striped much like a cutworm, gray, and marked with darker lines.

This is a northern species, occurring in the middle and central states, and thence north to Canada and Alaska. The moth is reported as common in New York, New Jersey, and Minnesota, and as appearing very abundant "at sugar" in Canada. It is not uncommon in Illinois, although the caterpillar has never been distinguished here.

According to our collection records the period for the moth extends from the last of June to the middle of September, with the greatest abundance in the early part of August. We have, however, a single instance of a moth taken May 19. The species is apparently single-brooded.

THE COTTON CUTWORM.

Prodenia ornithogalli Guen.

(*Prodenia lineatella, P. eudiopta.*)

These caterpillars are not typical cutworms in habit, as they are often active by day, especially in cloudy weather, and they eat holes in the leaves of their food plants instead of cutting off the stems.

They are smooth, brownish, striped caterpillars (Fig. 55–57), about an inch and a half long, marked with a double row of oval-triangular velvety black spots down the back. The first abdominal segment, the fourth back of the head, bears a more or less evident lateral black patch (Fig. 56). This part of the body is somewhat enlarged in younger larvæ. They are quite general feeders, and have occasionally injured corn.

FIG. 55. The Cotton Cutworm, *Prodenia ornithogalli*, adult and larvæ. Natural size. (Chittenden, U. S. Dept. of Agriculture.)

The species is common in the South, and extends northward into Illinois, being fairly common throughout the state. It is found from Massachusetts to Minnesota and California, and south to the Gulf of Mexico.

FIG. 56. The Cotton Cutworm, *Prodenia ornithogalli*, showing lateral black patch. Twice natural size.

It has been several times reported as injurious to corn in Iowa, Louisiana, Indiana, and Kansas, feeding both on the lower leaves and on the tender unfolding leaves at the tip of the plant. In Kansas it was found in early June eating both leaves and stalk of late-planted corn devouring, in fact, the entire plant down to the ground. It has a varied list of additional food plants, including wheat, potato, cabbage, beets, asparagus, salsify, peach, raspberry, cotton, pea-vines, rape, the fruit of the tomato, violet, cucumber, morning-glory, pigweed, cottonwood, rye, and the grasses.

Fig. 57. *Prodenia ornithogalli eudiopta*, adult and larvæ. Natural size. (Chittenden, U. S. Dept. of Agriculture.)

The variety *eudiopta* (Fig. 57) has been bred by us from larvæ found eating leaves of clover and corn. It has also been taken eating tomato leaves and boring into the fruit. Among the published food plants of this variety are wheat, pokeweed, turnip, castor-bean, and various grasses.

The species generally passes the winter as a caterpillar, but sometimes, according to Riley, as a pupa or imago. The caterpillars have been seen from June 26 onward, but are commonest in Illinois in July and August, where there is perhaps but a single brood. In the South, however, there seem to be at least two generations annually, one in April and the other in June. Pupæ were found in our breeding-cages in an earthen cell about half an inch below the surface. The adults (Fig. 55, 57, 58) are of nocturnal habit, being often taken at lights and at "sugar." In Illinois the species is remarkable in the fact that specimens are very rarely taken in any stage in the early part of the season up to about the first of July. In the South they are common throughout the season, a fact strongly indicating that the species does not survive our Illinois winters, and that scattering moths flying northward lay their eggs in our latitude and produce a midsummer brood of larvæ from mid-June to early September.

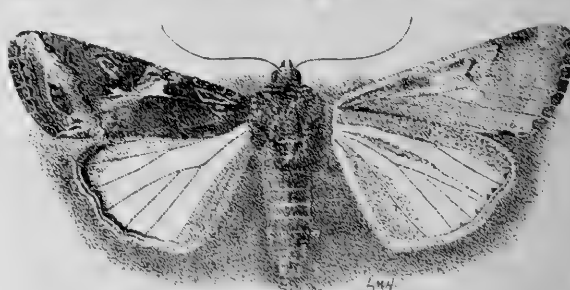


Fig. 58. The Cotton Cutworm, *Prodenia ornithogalli*, adult. Twice natural size.

These larvæ give origin to an abundance of moths in August, September, and October. Eggs obtained August 22 hatched, according to Chittenden, three days later, indicating the occurrence in the District of Columbia of a second brood of caterpillars produced in late fall. A full-grown larva taken September 2 in Illinois entered the ground for pupation September 9 and emerged October 16; another, taken by us on clover August 18, entered the ground August 26 and emerged September 12. In warm weather the pupal stage ordinarily lasts about two weeks. The earliest appearances of the moths in our local collections have been May 29, June 12, and July 11, after which no more have occurred until August 15, when they became common.

THE GRASS-WORM OR FALL ARMY-WORM.

Laphygma frugiperda Sm. and Abb.

This caterpillar, occasionally and locally very destructive, appears so infrequently in threatening numbers as to be virtually unknown at each of its appearances to ordinary observers of insect life. The facts of its occurrence and its life history in the Southern States point to the conclusion that it does not winter in our latitude, all remaining here after one of its destructive periods seemingly perishing before the following spring. As it lives continuously in the Southern States, its appearance in Illinois is probably due to the migration of the parent moths from the South in spring and early summer.

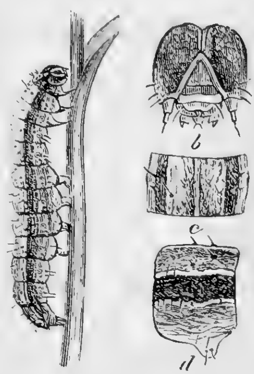


FIG. 59. The Grass-worm, *Laphygma frugiperda*: *a*, larva, natural size; *b*, face of larva; *c*, *d*, an abdominal segment, top and side views.

The caterpillar (Fig. 59) is about an inch and a half in length, blackish or grayish in general color, with three narrow whitish lines the entire length of the back. The head (Fig. 60, *a*) is black or dark brown, with a white λ-shaped mark on the face. The skin is smooth, with rather prominent tubercles, each bearing a single hair. This caterpillar resembles the common army-worm and the corn ear-worm both in habits and in appearance. From the ear-worm it is readily distinguished by its smooth skin (Fig. 60, *b*), the skin of the former (Fig. 60, *d*) being finely but roughly granulate, and from both it may be told at once by the white face-mark (Fig. 60, *a*), which is present in neither of the other species (Fig. 60, *c*; 63, *b*).

This caterpillar is not a common corn insect, but, nevertheless, occasionally does considerable injury to that crop, eating down into the growing tip of the young plant, and later in the season feeding upon the leaves, entering the ears like the ear-worm, and burrowing among the kernels beneath the husk. In 1889 it did considerable damage in broom-corn fields in Douglas county, Illinois, in one case diminishing the crop by fully a third. Later in this season it became generally abundant throughout the state, greatly injuring lawns in the towns and larger cities, especially in Quincy and Chicago. Its preference for grasses is so strong that it often eats them out from among other weeds and cultivated crops. Broom-corn, sorghum, sugar-cane, Kafir corn, timothy, rice, wheat, rye, millet, and sometimes oats and barley, are among the crops subject to injury by this caterpillar. It has also been known to feed upon buckwheat, alfalfa, clover, cow-pea, chick-pea, tobacco, sugar-beet, cotton, asparagus, sweet potato, spinach, turnip, kale, tomato, potato, cucumber, cabbage, beet, strawberry, grape-vine, apple, peach, orange, purslane, hollyhock, lamb's-quarters, pigweed, and cocklebur. The caterpillars even eat each other freely, not only when confined in company, but in the open field when they become abundant.

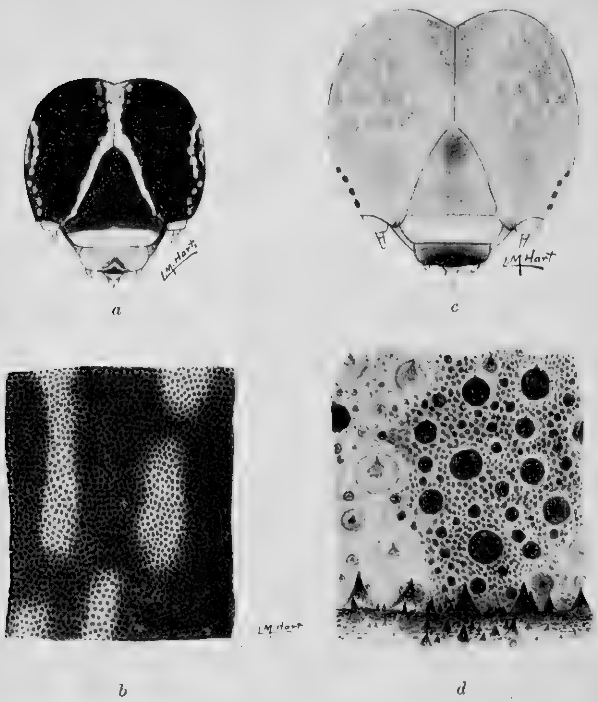


FIG. 60: *a*, the Grass-worm, *Laphygma frugiperda*, face of larva; *b*, surface of larval skin under microscope; *c*, the Corn Ear-worm, *Heliothis armiger*, face of larva; *d*, surface of larval skin under microscope.

The life history is as yet imperfectly known. We have no record of the occurrence of the species in Illinois before the middle of July, at which time larvæ appeared in considerable numbers in broom-corn fields, mostly pupating by the end of that month. These emerged in the winged stage (Fig. 61) early in August, after a pupal period of about ten days. A general outbreak of the caterpillar in grass lands occurred in the latter part of the August following. These caterpillars pupated late in August and early in September, and from them moths emerged late in the latter month after a pupal life of about two weeks. Eggs were obtained from these September 26 and 27, and began to hatch October 5, the caterpillars continuing into December. Three successive generations were thus clearly traced in central Illinois, beginning with about the middle of July. The female moths evidently do not distribute their eggs, but deposit them in large numbers on comparatively small areas, and the caterpillars hatching are likely to overtax their food supply, and thus to be forced to migrate in search of more. On this account they are sometimes called fall army-worms, although they do not move in fixed directions and in conspicuous armies like the army-worm, properly so called, but tend to spread in all directions from an overstocked area.

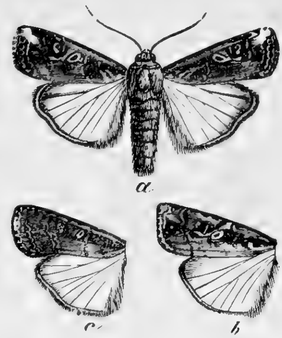


Fig. 61. The Grass-worm, *Laphygma frugiperda:* a, adult; b, c, two color-varieties. Natural size.

This appears to have been originally a tropical insect, and it now ranges from Brazil across Central America to the West Indies and throughout the United States. Caterpillars are occasionally found destructively numerous as far north as New York and the upper peninsula of Michigan, and the adult moth has been taken in Montana, Minnesota, Maine, and Canada. It has also been collected in California and Arizona.

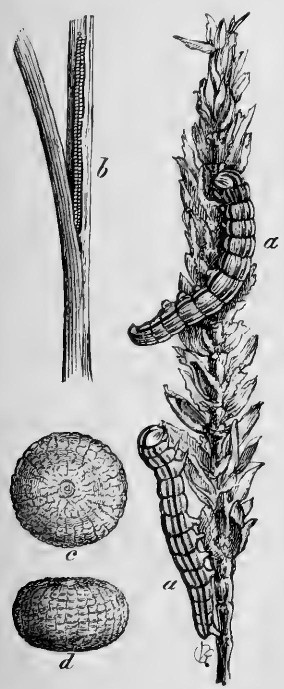


Fig. 62. The Wheat-head Army-worm, *Leucania albilinea:* a, a, larvæ, b, eggs, both natural size; c, d, eggs enlarged, top and side views.

THE WHEAT-HEAD ARMY-WORM.

Leucania albilinea Hübn.

(*Heliophila albilinea.*)

This caterpillar (Fig. 62, *a*, *a*) differs from the common army-worm especially in its peculiar preference for the heads and seeds of grasses and small grains. It is often seriously injurious to these crops, and also sometimes does considerable harm to corn by burrowing down into the growing top of the plant. Larvæ taken here and there in the corn field feeding in this way were bred by us to this species in two different years. Miss Murtfeldt found it doing great damage to corn, sorghum, and small grain in 1888, sweet corn especially being seriously and generally injured. It may be easily distinguished from the army-worm, which it closely resembles, by its more slender form and larger head, by the straight dark bands each side the middle of the head (Fig. 63), and by the clear-cut narrow brown and yellowish lines on the sides of the body.

Its injuries to corn can be scarcely regarded as more than occasional, its principal damage being done to wheat, barley, rye, and timothy, the leaves of which are eaten by the young larvæ, while the older caterpillars seem to prefer the heads, especially when the grain is in the milk. It is nocturnal in habit and feeds mainly after dark.

Its natural food is thought by Professor John B. Smith to be the heads and seeds of wild grasses, but it sometimes becomes so abundant as to compel it to migrate in search of food, when it is likely to infest the cultivated crops.

Fig. 63. Faces of Army-worm larvæ: *a*, the Wheat-head Army-worm, *Leucania albilinea*; *b*, the true Army-worm, *L. unipuncta*. Enlarged.

The species is generally common and frequently destructive from Texas, New Mexico, Colorado, and Nebraska east to the Atlantic States, and north into Canada.

The eggs (Fig. 62, *b*, *c*, *d*) are thrust between the sheath and the stalk of the food plant, and are placed in one to three rows, with from five to fifty eggs in each. They are flattened, cylindrical, irregularly corrugated, pale yellow at first, but become slate-colored as the embryo develops.

The life history is well defined. The species winters in the pupa state, and the moths come out in May, being usually most abundant about the middle of that month. Eggs are soon laid, and hatch in three to five days. The caterpillars gain their growth in three or four weeks, which brings them to full size in July. The pupal stage is ten to fifteen days in length, moths emerging from late July to August, and laying eggs for the second brood of larvæ, which come out in September and pupate before winter sets in. The pupa for the summer brood is found under weeds and rubbish, or just under ground, but the hibernating pupæ are found about six inches below the surface. They are mahogany-brown, the abdomen terminating in a stout horny point.

The only notable injury to corn done by these caterpillars is evidently due to migration at times of excessive abundance,—a movement which could be arrested, if necessary, by measures found efficient against the army-worm.

THE SPINDLE-WORM.

Achatodes zeæ Harr.

The habits of this caterpillar are similar to those of the common stalk-borer, already treated (pages 44–47); but, although it occurs in Illinois and is at times quite injurious to elder bushes, it has not yet been found by us injuring corn in this state, and its attacks on that crop are probably only occasional. The caterpillar is about an inch long, yellowish white, with black head, neck, and anal shield, and with a double row of small, smooth, elevated shining black dots across each of the other segments. It is thus easily distinguishable from the stalk-borer, which, it will be remembered, is livid brown, with conspicuous white stripes.

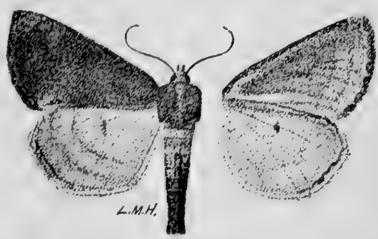


FIG. 64. The Spindle-worm, *Achatodes zeæ*, adult. One half more than natural size.

Maturing earlier in the season than the stalk-borer, it attacks only young corn, which it enters near the ground, and, working up or down in the stalk, cuts off the growing tip so that the withered tuft of terminal leaves may be pulled out of their sheath. It also makes round holes in the opening leaves as it eats its way downward, and destroys the developing ears, so that none form on stalks which have been thus attacked.

Little is on record of actual injury to corn by this species except the original report by Harris of its work in New England, where, he says, its ravages generally begin before the corn spindle rises much above the tuft of leaves in which it is embosomed. Besides corn and elder, it was found by him to infest the stems of dahlia, and it probably occurs in many other thick-stemmed plants.

When it breeds in elder twigs, the caterpillar gnaws towards the surface at some point when full grown, until only the thin bark remains, when it pupates within its burrow. Afterward the stem gives away at this point, allowing the part above to hang downward. In our breeding-cages one out of a number of these caterpillars pupated in the earth; the remainder, in their larval channels. The shining mahogany-brown pupa, three quarters of an inch long, is armed in front with a pair of roughened tubercles, probably used to break the cuticle left by the larva at the point of escape.

The life history of this species is very imperfectly recorded. The caterpillar was abundant in elder twigs May 27, and pupated in our breeding-cages about June 8, and the moths appeared from June 23 to June 26, when the experiment was interrupted with living pupæ still in the cage.

We have taken a few of the moths (Fig. 64) at lights from June 23 to July 20, and Lintner has recorded it in New York as occurring up to August 14.

Webster suggests for it, as he does for the common stalk-borer, treatment with pyrethrum, an ounce of the powdered drug to be mixed in two gallons of water and so applied that the fluid shall run down among the young unfolding leaves of an infested plant.

THE FODDER WORM.

Epizeuxis æmula Hübn.

This interesting snout-moth exhibits a peculiarity found in several microlepidoptera but rare in the macros, a fondness for dead or dry food material. It is generally common throughout the United States. Smith locates it "east of the Rocky Mountains," but we have it also from Salt Lake City, Utah, and Las Vegas, New Mexico. Riley says that it has been found feeding on the dry leaves of various plants in woods, also on a number of fodder plants in winter, and it has been bred by him from dead leaves. It has been collected by Packard twice from spruce, possibly eating dead tissues, and Edwards gives phlox as the food plant. It is most notable, however, for its injuries to corn fodder in Mississippi. In this state the corn leaves used for fodder are stripped off, dried in the sun, and tied in small bundles, these being piled up in cylindrical stacks about a central pole, butts next the pole and tips out. The larva works in the interior of the stack, especially where this is most compact, eating any of the leaf tissue except the midvein, but not touching moldy or spoiled portions or venturing out on the exposed tips. Thus the whole interior of an apparently sound stack may become filled with a mass of worms and filth.

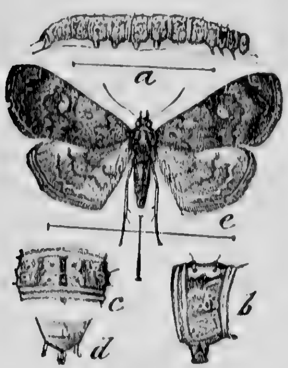


FIG. 65. The Fodder Worm, *Epizeuxis æmula*: *a*, *e*, larva and moth, enlarged as indicated; *b*, *c*, segment of larva, side and top views; *d*, tip of pupa. (Riley, U. S. Dept. of Agriculture.)

The larva (Fig. 65, *a c*) is about an inch long, not noticeably hairy, dull brown, distinctly striped with darker lateral and mediodorsal lines. It spins a cocoon, and the pupa (Fig. 65, *d*, tip) which is formed within is about half an inch long and peculiarly colored, being green with two parallel dorsal whitish stripes and two white stripes on each side. The adult (Fig. 65, *e*) is often taken at lights and at "sugar." It is about an inch across the wings, and marked as shown in the figure. The ground color is a rather uniform dull smoky gray, varying to paler gray with a brownish tint. The light color of the outer line throughout, and the usually paler and contrasting slightly yellowish reniform spot on the fore wings, are important characters.

The species is apparently single-brooded. The larvæ winter over, finding excellent opportunities to feed during warmer days on dead and drying vegetable tissue. In Mississippi they do their most serious injury in March, and then spin up, from April 1 in Mississippi to June in New York. After a brief pupal stage the moth is produced, most abundantly in this latitude in late June and in July, though scattering individuals have been found as late as October 4. These moths produce the hibernating brood of larvæ. There is a bare possibility of an August brood of larvæ preceding the fall brood, and the longer season in the South would easily admit of an extra brood.

Infested portions of fodder should be promptly destroyed, worms and all, before the whole mass is invaded and ruined, and waste should be cleaned up and burned, so that no materials may remain for the maintenance of the insect.

THE GYPSY-MOTH.

Porthetria dispar Linn.

This notorious insect is an introduced species, which made its first lodgment in Massachusetts by an accidental escape from the laboratory of a naturalist, and has now become a most destructive and almost uncontrollable pest over a considerable area of that state, to which it seems still to be confined.

Although primarily a forest insect, it feeds upon an immense variety of plants, and is apparently capable of injury to corn. It is a native of temperate Europe and Asia, ranging from England, where it is rare, to Algeria, and from France to Japan.

Although efforts to exterminate this pest in Massachusetts, quite unexampled in the history of the world, were made for a series of years at an expense of over a million dollars to the state, it is now virtually certain that it will gradually spread throughout the country. Like the canker-worm it spreads very slowly when left to itself, but

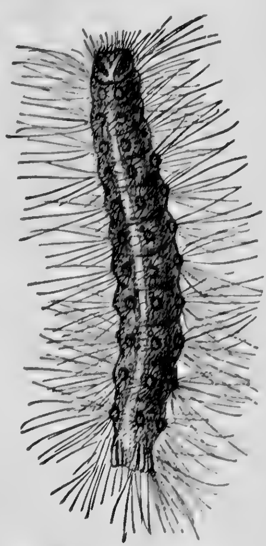


FIG. 66. The Gypsy-moth, *Porthetria dispar*, larva. Natural size. (Howard, U. S. Dept. of Agriculture.)

Fig. 67. The Gypsy-moth, *Porthetria dispar*, pupa. Natural size. (Howard. U. S. Dept. of Agriculture.)

may of course be taken great distances by wagon or railroad transportation.

It eats the leaves of nearly every kind of tree, wild and tame, and when this food fails, it resorts to herbaceous plants of all descriptions. Its latest published list of food plants contains five hundred and thirty-six different kinds of trees and other plants.

The eggs are about one twentieth of an inch in diameter. They are placed in clusters of four hundred or five hundred, or even as many as one thousand, covered with the yellowish hairs of the moth, so that the cluster looks like a bit of sponge. These clusters are laid on tree trunks, logs, and rocks, particularly in crevices and sheltering angles. The larvæ (Fig. 66) are hairy, like the tent-caterpillar or fall web-worm, and about two inches long. They feed mostly by night, and, except when young, descend to the ground by day, hiding under trash about the base of the tree. The full-grown larva spins a few threads on the bark as a sort of cocoon, and therein changes to a dark brown pupa (Fig. 67). The male and female moths are quite unlike. The former (Fig. 69) is slender bodied, olive-brown, freckled with black. The female (Fig. 68) is larger and heavier, whitish or buff, similarly marked with black. She is unable to fly from place to place, the spread of the species being mostly due to the activity of the caterpillar.

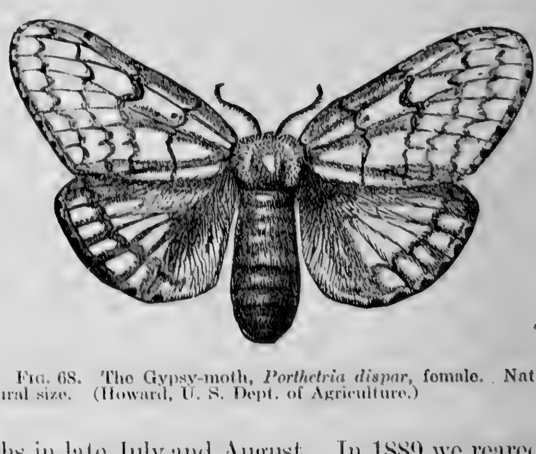


Fig. 68. The Gypsy-moth, *Porthetria dispar*, female. Natural size. (Howard, U. S. Dept. of Agriculture.)

There is but one brood. The eggs are laid in the latter part of summer, and winter over, the larvæ hatching and feeding in spring and producing moths in late July and August. In 1889 we reared a lot of this species, very carefully isolated, from eggs sent us the previous winter. The eggs began to hatch April 19, and were nearly all hatched by April 25. The larvæ to the number of several hundred were about half grown by the middle of May, and by June 22 nearly all had reached full size and many had pupated. This day the first moths emerged, and by July 8 nearly all were out. Eggs were laid by the moths in large numbers. The entire rearing was put into alcohol at different stages of growth, except the moths, which were all killed and mounted or else destroyed. As the larvæ neared maturity they daily devoured large quantities of apple leaves, upon which they were bred.

Fig. 69. The Gypsy-moth, *Porthetria dispar*, male. Natural size. (Howard, U. S. Dept. of Agriculture.)

The egg masses are destroyed by an application of creosote oil or by fire. The larvæ are trapped by bands of burlap as they descend or ascend the trees, and are poisoned by sprays of arsenate of lead.

THE GARDEN WEB-WORM.

Loxostege similalis Guen.

This widely distributed and common insect is especially notable because of its occasional outbreaks in the West, one in 1885, for example, and another, less serious, in 1892, in which garden and field crops generally were eaten up, corn suffering chiefly. Though the general corn crop for that year was larger than ever before, the yield per acre in five states,—Missouri, Arkansas, Nebraska, Kansas, and Texas,—as well as in Indian Territory, was much reduced because of the injuries of this species. Corn was quickly replanted, but some farmers had two and three plantings destroyed. As the larvæ do not climb far, older corn was not so seriously injured. According to Snow, a crop would usually be destroyed in five to ten days after the appearance in it of the worms. Although generally distributed and very common in Illinois, it seems to be particularly destructive in the states along the Mississippi River in the South. It is common throughout the United States, and occurs also in South America.

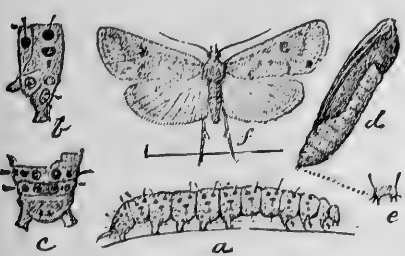


Fig. 70. The Garden Web-worm, *Loxostege similalis*: *a*, larva; *b*, a middle segment of same, side view; *c*, last segment, top view; *d*, *e*, pupa, and its tip enlarged; *f*, adult. Larva and pupa twice natural size; adult enlarged as indicated. (Riley, U. S. Dept. of Agriculture.)

Its ordinary food plants are a number of common weeds, especially pigweeds (*Amarantus* and *Chenopodium*) and purslane, but when these are used up because of exceptional abundance of the larvæ, the latter readily devour cultivated herbaceous crops, including cotton, cabbage, cucumber, melon, squash, pumpkin, sweet and Irish potato, eggplant, tomato, beet, bean, pea, lettuce, onion, castor-bean, tobacco, flax, sugar-cane, red clover, alsike, alfalfa, orchard-grass, timothy, meadow oat-grass, and millet. They have also eaten apple leaves, scarlet verbenas, and a few weeds—dogbane (*Apocynum cannabinum*), *Grindelia squarrosa*, cocklebur (*Xanthium strumarium*), and burdock (*Arctium*). They are especially fond of the finer and softer grasses in the South, such as the buffalo, crab, and joint grasses.

The mature larvæ (Fig. 70, *a–c*), about five eighths of an inch long, are whitish, or dusky, or even greenish, with black dots. They spin a loose but evident individual web—rarely more than one occupying the same web—inclosing more or less of the foliage of an infested plant. On beets, a single leaf is often spun over lightly with a webbed retreat along the midrib, where the leaf narrows into the stem. Most commonly, however, especially if the plant be small, the entire base is inclosed in a thin web, with a tubular retreat extending into the loose earth close by, or the plant may be completely webbed up. When very young the larvæ gnaw the surface of the leaves, but later they rag them with large irregular holes, or even devour them almost wholly, leaving a dead, web-covered skeleton. The larvæ are very active, feigning death when disturbed, or spinning a thread and dropping to the ground, and slipping out of sight in crevices or in loose earth. Most of the feeding is done at night, the larvæ usually resting in the web by day, until the last stage, when they are active during the daytime. The full-grown larva spins a delicate brownish cocoon within its silken retreat in the earth, changing there to a brown chrysalis (Fig. 70, *d*) with a terminal pair of prominences (Fig. 70, *e*), each bearing three short spines. The moth (Fig. 70, *f*) is buffy or grayish brown, with darker markings as in the figure. Like the other moths of its family it is strongly attracted by lights.

According to Sanderson, the web-worm hibernates not in the pupa stage, as Bruner indicates, nor in the adult condition, as was Riley's supposition—which we have previously followed—but as a dormant larva in the cocoon, pupating in spring and emerging soon after. This does away with the necessity of assuming an unobserved first brood of larvæ in spring. The probable number of broods is four. The annual history, thus amended, is as follows: The hibernating larvæ pupate in May, and the adults emerge in a week or ten days, that is, in late May and early June. The first brood of larvæ, previously called the second—the most destructive brood in the Western outbreaks—follows in June, maturing in about ten days after hatching and reaching the adult stage early in July. The second brood of larvæ, which, according to Sanderson, is ordinarily the most destructive brood, comes about the middle of July, and has been observed active in Illinois July 13 and 14. Adults of this brood have been taken by us abundantly in late July and in August. Larvæ found August 11 in Kansas probably represented the third brood of the season. Larvæ of this brood, taken by us on soy-beans August 27, had nearly all pupated by September 4, and gave adults September 10–13. On September 2, full-grown larvæ and moths were very common, also some very young larvæ, the latter probably representing the fourth generation.

"Deep plowing or thorough harrowing in the fall after the larvæ have entered the cocoons in the earth will destroy large numbers of them. When the worms appear in destructive numbers upon the foliage, they may be controlled by a spray of Paris green or other arsenite, using one pound to 125 gallons of water, providing, of course, that the tops are not to be fed to stock. An under-spray nozzle should be used, so as to reach all parts of the plant in an effective manner. When present in large numbers and doing serious injury, the worms can be more quickly killed by spraying with strong kerosene emulsion, but this will only kill those hit, and an arsenite should also be applied without delay."—Sanderson.

Since they breed especially on the pigweed or "careless weeds" (*Amarantus*), the destruction of these weeds will usually prevent serious injury.

THE LARGER CORN STALK-BORER.

Diatræa saccharalis Fabr.

This is a large dirty-white caterpillar (Fig. 71), from three fourths of an inch to one inch in length, with transverse rows of large brown or black shining spots on each segment. It becomes almost pure white after the last molt and as seen during the winter. The head and neck-shield vary from honey-yellow to black.

This is essentially a Southern species, and is unknown as a corn insect in Illinois. The northern limit of its range is, however, fixed at

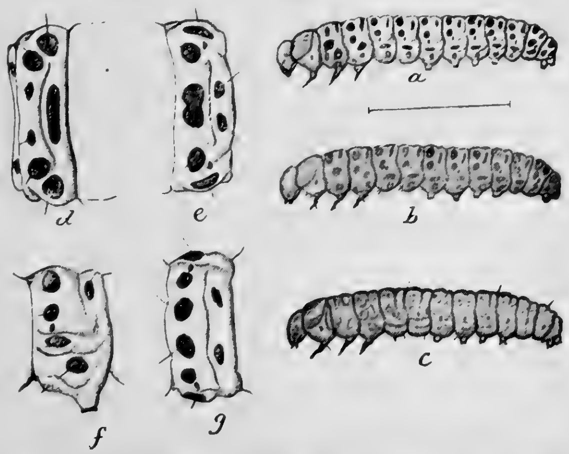


FIG. 71. The Larger Corn Stalk-borer, *Diatræa saccharalis*: *a*, *b*, *c*, varieties of larva, enlarged as indicated; *d*, 3d thoracic segment; *e*, 8th abdominal; *f*, *g*, a middle segment, side and top views. (Howard, U. S. Dept. of Agriculture.)

Maryland on the east and Kansas on the west, and it is consequently possible that it may at some time be noticeably injurious in southern Illinois. Thence it extends southward to the Gulf, and through Mexico to the northern coast of South America.

It injures corn by boring the young stalks (Fig. 72), and later in the season by entering the old stalks and working down into the tap-root, where it passes the winter. In the young plant it tunnels the center of the stalk and often bores out, re-entering elsewhere. Young corn is thus distorted and badly stunted. It injures older plants by weakening the stalks so that they are easily blown down. "Most of the corn fields from Alabama to Virginia suffer to some extent almost every year from the work of this species. In seasons of abundance there is frequently a loss of twenty-five to fifty per cent. of the crop." In 1895 a Virginia corn-planter estimated his loss from this insect at over nine hundred dollars, and severe injury to corn was again reported in Maryland in 1898, many fields being practically abandoned because of its work. It was also destructive in Georgia in 1899. Although it apparently prefers corn as a food plant, it is more widely known for its injuries to sugar-cane. It has, in fact, received its fullest treatment as a sugar-cane borer in the British West Indies. (West Indian Bulletin, Vol. I., No. 4.) It also infests various species and varieties of sorghum, including common sorghum (*S. saccharatum*), Johnson grass, Indian millet, and guinea-corn, and a closely related species, gama-grass (*Tripsacum dactyloides*):

FIG. 72. The Larger Corn Stalk-borer, *Diatræa saccharalis*: *a*, general appearance of stalk infested by the early generation of borers; *b*, same, cut open to show pupa and larval burrow. (Howard, U. S. Dept. of Agriculture.)

Wintering as a full-grown larva in the tap-root of the plant, the adult insect appears in spring, and soon after the young corn comes up it lays its eggs on the leaves in clusters of four to more than fifty, usually about ten to thirty in three or more overlapping rows fastened by a mucilaginous matter to the leaf. The eggs are about a millimeter long, oval, flattened, light yellow at first, but changing through orange to brown with a black center. The egg stage lasts about a week. The young larvæ spin a fine thread when traveling. They eat or mine the leaf at first, but quickly disappear within the stalk and commence to tunnel, usually upward, through the center. They grow rapidly, and are very active, frequently leaving the stalk at one place and entering it at another, each thus making several holes in the corn plant during its growth. They mature in about a month, then boring an opening for the escape of the moth and spinning a few threads across it. They pupate in their burrows about the middle of July, the pupa lying with its head near the opening. It is naked, shining brown (Fig. 73, *c*), from a half to three fourths of an inch long, with abdominal spines and tubercles. It is capable of violent contortions when disturbed. When about to hibernate, the caterpillar burrows down into the tap-root of the plant, and winters at or a little below the surface of the ground. In Virginia the pupa state is usually reached from the middle of July on, and the moths (Fig. 73, *a*, *b*) issue in from ten days to two weeks later. The eggs for the second generation are laid soon afterwards on the well-grown stalks, and these larvæ are full grown by harvest time. From ten days to two weeks later, moths of the second brood begin to appear, and lay eggs on the old corn for another generation of caterpillars.

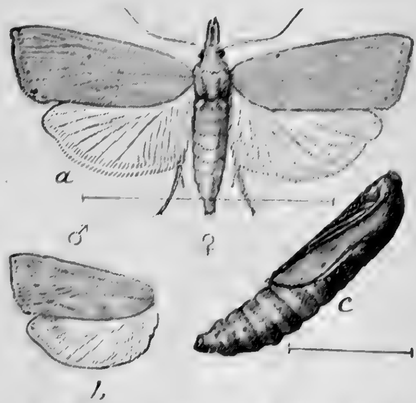


FIG. 73. The Larger Corn Stalk-borer, *Diatræa saccharalis*: *a*, female; *b*, wings of male; *c*, pupa. Enlarged as indicated. (Howard, U. S. Dept. of Agriculture.)

Early planted corn is said to be more liable to infestation than later plantings, and corn grown on ground where the crop was infested the previous year is particularly exposed to attack. The United States Division of Entomology computed in 1891 an average loss of ten per cent. to corn on sod land, and of twenty-five per cent. to corn following upon corn. If, notwithstanding a judicious rotation of crops, a field should become noticeably infested, the insects could be completely destroyed in hibernation by plowing out, raking up, and burning the corn stubble in the field in fall or early spring.

THE SMALLER CORN STALK-BORER.

Elasmopalpus lignosellus Zell.

Although the moths of this species have been occasionally taken in Illinois and in other states of our latitude, this is primarily a Southern insect, and in the United States breeds principally, if not exclusively, in the south Atlantic and Gulf States, where it is occasionally very destructive to corn.

The caterpillar (Fig. 74, *d*, *e*) is nearly cylindrical, something more than half an inch long when full grown, about eight times as long as

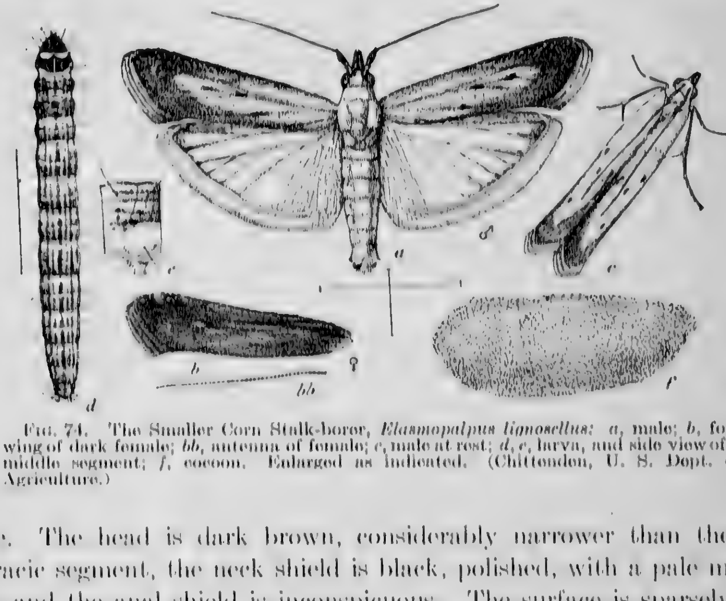


FIG. 74. The Smaller Corn Stalk-borer, *Elasmopalpus lignosellus*: *a*, male; *b*, fore wing of dark female; *bb*, antenna of female; *c*, male at rest; *d*, *e*, larva, and side view of a middle segment; *f*, cocoon. Enlarged as indicated. (Chittenden, U. S. Dept. of Agriculture.)

wide. The head is dark brown, considerably narrower than the first thoracic segment, the neck shield is black, polished, with a pale median line, and the anal shield is inconspicuous. The surface is sparsely covered with moderately long hairs.

Although chiefly injurious to young corn, destroying many stalks and necessitating much replanting, these caterpillars continue active work throughout the summer and fall until October, boring through the stalk in every direction, weakening or severing it so that the slightest gust of wind blows it to the ground; and the ears are often rendered worthless by contact with the wet earth. From six to fifteen of the caterpillars are usually found in a single stalk. They are extremely active, and upon the slightest disturbance retreat into their burrows with great rapidity.

"Their operations on the stalk when young are principally below the surface, their attacks being confined to the outer crust, which they sometimes completely girdle (Fig. 75). They generally commence to work between the rootlets, whereby these are also often girdled and die in consequence. This injury to the outer surface of the root-stalk extends, occasionally, as far down as the depth of two inches. After the worm has attained about half its size, it bores into the stalk, also below the surface, generally above and very close to one of the rootlets, in a more or less straight line, until it reaches the opposite hard parts, or it works gradually upwards, widening the channel more and more, until sometimes there is formed a large cavity, leaving only the rind of the stalk untouched. The nearly full-grown larva seems to prefer to work just above the surface of the ground." It has also been found injurious to the bean, peanut, cow-pea, and turnip.

FIG. 75. The Smaller Corn Stalk borer, *Elasmopalpus lignosellus*, larva, adult, and work on corn stalk. Natural size. (Riley, U. S. Dept. of Agriculture.)

The life history of the species is imperfectly known. In Texas the moths have appeared in March, and larvæ found injuring corn late in July gave the first moths August 4, and others sent in August 16 produced moths August 31 and early in the following month. Adults of this species have been taken by us in Illinois August 11 and September 4. Larvæ sent in to Riley from September 25 to October 28 may belong to a succeeding brood, and from those collected at the latter date moths emerged as late as January 31, and larvæ were occasionally seen up to January 25. From these data it would appear that the insect hibernates in all three stages of larva, pupa, and adult.

THE BURROWING WEB-WORMS.

Pseudanaphora arcanella Clem.

Hypoclopus mortipennellus Grote.

Anaphora popeanella Clem.

In examining injuries to young corn on sod ground resembling that of cutworms or web-worms, one will sometimes find a tubular web opening at the surface and leading down into a vertical cylindrical burrow about the diameter of a lead-pencil, and six inches to two feet, or even more, in depth. The occupant, known as the burrowing web-worm, is active in retreat when disturbed, and must usually be dug out to capture it. It is about an inch long (Fig. 76), of a soft, indefinite velvety gray or velvety brown color, darkening forward, and conspicuously marked with several large, irregular shining white areas on the thoracic region, the head and neck-shield being black.

Fig. 76. A Burrowing Web-worm, *Pseudanaphora* or *Hypoclopus*, back and side views. Three times natural size.

The principal food of these caterpillars is grass, corn being injured by them only when planted on sod, or occasionally, much less so, the next year thereafter. They have several times been found by us in sod, commonly when thrown out of their burrows by the plow.

They were the cause of noticeable injury to young corn near Urbana, but so far as our own observations go they scarcely deserve serious mention as agricultural insects. That the species is, nevertheless, capable of considerable injury to corn, is shown by a communication from a farmer of Scott county, Illinois, who wrote me May 27, 1887, that a great deal of his corn had been destroyed by this insect within the preceding ten days, the injury being confined entirely to sod land and to the higher and drier parts of the field. As many as one to three were found in each hill.

When they reach a hill of corn they surround the base of each plant with a fine web mixed with dirt and pellets, building this up to the lower blades,

Fig. 77. A Burrowing Web-worm, *Pseudanaphora arcanella*, adult. Three times natural size.

which they slowly eat away. As they get larger they eat the stripped plant to the ground. Though there may be a dozen destroying a hill of corn, each has its separate home, and on the least disturbance retreats to the depths of its web-lined burrow. They are said to feed in the evening, after sunset, the larger ones eating only next the ground, sometimes in this way cutting off the plant like a cutworm, while the smaller ones feed on the tender leaves and do not cut the stem. In a field of eighty acres of corn, from one to twenty larvæ were found in and about virtually every hill. The injuries of these insects to grass are inconspicuous so far as known, and have never been definitely reported.

The several species placed at the head of this article have not been distinguished in the larval stage, but as they have all been bred from burrowing web-worms of extremely similar appearance and virtually identical habit they may be properly considered together in this article.

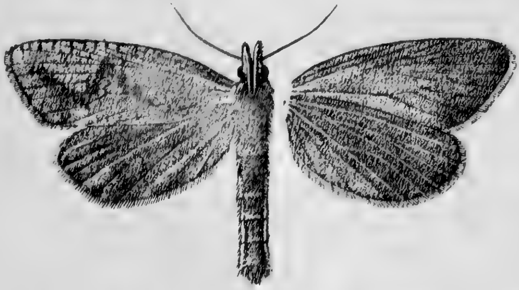


FIG. 78. A Burrowing Web-worm, *Hypoclopus mortipennellus*, adult. Three times natural size.

The species appear to be commonly distributed over the central and Southern States. So far as one may judge from the collection data on record, the species hibernate in the larval stage. The caterpillars are most active in May. They pupate in their burrows. Examples collected April 26 gave a moth of *Pseudanaphora* (Fig. 77) July 17. Others obtained April 17 emerged as moths of *Hypoclopus mortipennellus* (Fig. 78) June 17 and 18. One taken May 25 had changed to the pupa by July 8. This pupa was about six tenths of an inch in length, pale brown, slender, wing-pads extending about two fifths of the length, and the wing veins distinctly showing through. The thoracic region is smooth, abdominal segments three to eight, each with an acute transverse dorsal ridge at about the anterior fourth, set with a close row of fine, sharp teeth. Tip truncate, with four blunt tubercles, of which the ventral pair are farther apart than the dorsal. Adults of all three of the species have appeared in our breeding-cages in June and July, and have been taken quite abundantly at electric lights, especially in the latter half of June. Our latest record of the adult moth was that of *Anaphora popeanella*, taken August 8 in southern Illinois. Eggs were obtained by us June 26 and July 12 from moths of *Pseudanaphora arcanella* taken at electric light. In a breeding-cage supplied with earth and a tuft of blue-grass, the eggs on both occasions were deposited abundantly, being scattered on the earth, and looking like fine white sand. These eggs began to hatch about ten days after they were laid. We have found the larvæ once at the beginning of October, and an abundance of them during the last week of that month; and also early in April. The species are thus apparently single-brooded, and similar in seasonal history.

THE CARROT-BEETLE.

Ligyrus gibbosus DeG.

This beetle (Fig. 79) has the general appearance of one of the common May-beetles or June bugs (*Lachnosterna*) except that it is of much smaller size, and is darker and thicker, with a more robust body. It measures from a half to five eighths of an inch in length, and more than half as much in width. It has a minute pitlike depression at the middle of the front edge of the thorax. Its color varies from reddish brown to nearly black above, and is reddish brown below.

FIG. 79. The Carrot beetle, *Ligyrus gibbosus*. Two and a half times natural size.

It is common throughout Illinois, but has only once been reported as injurious to corn in this state, its injuries to that plant indeed being otherwise recorded only from Minnesota, Louisiana, and Arkansas. It was found in Christian county, Illinois, May 9, 1896, eating the kernel and the young shoot of corn under ground. An examination of injured kernels showed that the germ had been eaten out, with little disturbance of the rest of the grain. In Minnesota it ate the roots and gnawed the stalks of sweet corn in August, causing the plant to wilt and preventing the maturing of the ears. It works mainly under ground, commonly about three or four inches below the surface, but sometimes reaching a depth of seven inches. It has been reported, however, in Louisiana to injure the corn stalk just above the ground, and also to cut off the plant just above the roots. It has nowhere been found generally destructive to this crop, its favorite cultivated food being carrots, parsnips, celery, beets, sweet potatoes, and similar thick-rooted plants. To the carrot crop especially it is often extremely destructive. Cotton, sunflower, dahlia, and pigweed (*Amarantus*) are to be included among its food plants.

Its range extends throughout the greater part of the country from New York, Wisconsin, and Oregon, to Louisiana, Texas, and Arizona.

Its life history is imperfectly known, although the species is in all probability single-brooded. Eggs found June 8, hatched ten days later. The larvæ feed in the earth on decomposing roots, the tap-roots of herbaceous plants, manure, and even simple dirt. Pupation takes place in the earth, the beetles emerging in fourteen or fifteen days during the warm weather of June and early July. The species apparently hibernates as an adult.

THE SUGAR-CANE BEETLE.

Ligyrus rugiceps Lec.

This is a smaller insect than the carrot-beetle above described, and is not found in Illinois. Its injuries to corn are of the same character as those of the carrot-beetle, but seem to be more wide-spread and severe. It was reported by Riley in 1885 as cutting into young corn in North Carolina, killing the center blades but not cutting down the stalk. Successive plantings were destroyed, and even stalks in ear were caused to fall. It has also been reported similarly destructive to corn in Mississippi, Arkansas, and Louisiana, although its injuries to sugar-cane in the latter state are much more serious and important.

In North Carolina the eggs are laid among the corn roots from June 27 to July 9, and adults have been taken from the middle of March to December 1.

THE FLOWER-BEETLES.

Euphoria inda Linn.

Euphoria sepulchralis Fabr.

Euphoria melancholica Gory.

These large buzzing beetles (Fig. 80, *a*; 81), resembling June-bugs, but shorter, more flattened, and variously spotted above, are often abundant in spring and fall, feeding on the juices or the very soft tissues of plants. They are especially fond of sappy exudations from pre

FIG. 80. The Common Flower-beetle, *Euphoria inda*: *a*, adult; *b*, outline of egg; *c*, newly hatched larva; *d*, mature larva; *e*, pupa. (Chittenden, U. S. Dept. of Agriculture.)

viously damaged surfaces, a fact which has caused them to be charged with injuries of which they are incapable. They sometimes burrow into the tips of loosely closed ears of corn in the milk, and also eat into soft ripe fruit. They are thus somewhat troublesome at times, although as a rule they do comparatively little harm.

The common species in central and northern Illinois is the brown fruit-chafer, *E. inda*, distributed through the northern part of the country from the Atlantic to the Rocky Mountains. This beetle (Fig. 80, *a*) is about five eighths of an inch in length and a little more than half as wide as long, with the upper surface flattened and slightly ridged, clay-brown, with small black spots and transverse dashes on the wing-covers. The thorax is black. Beneath is a conspicuous coating of short yellow-brown hair, which gives a brownish color to the entire surface.

FIG. 81. *Euphoria sepulchralis*. Three times natural size.

The two other species charged with injury to corn are similar to the preceding but smaller, a half inch long or less, moderately shining and not noticeably hairy, blackish brown above, with a few chalky yellowish cross-dashes on the wing-covers.

E. sepulchralis (Fig. 81) is common in southern Illinois and throughout the South, extending into New Mexico. It has frequently been confused with the third species, *E. melancholica*, which is found in the southwest from Kansas to Mexico. The latter may, however, be known by the much smoother sculpture of the wing-covers and the sides of the thorax, and by the entire absence of hairs on the thorax above.

Lintner speaks of *E. inda* as a pernicious corn pest in New York, devouring the kernels from the tip of the ears to the butt, and quotes from a correspondent a statement that twenty of these beetles were picked from two ears of corn. Osborn experimented in Iowa, however, with beetles of this species by confining them on corn ears, and found that they had great difficulty in penetrating the husks unless these were quite loose or had previously been opened up for their entrance. The burrows of the corn ear-worm are often used by these beetles as a means of access to the soft grains and exuding fluids. The pollen from the tassel and exudations from the stalks also furnish them food.

E. sepulchralis was occasionally found by one of my assistants early in 1893 on ears of corn near Carbondale, Ill., gnawing the husks or kernels or drinking the sap in an ear-worm burrow. In Mississippi it is said to be found most commonly inside the base of the corn leaf, drinking the moisture accumulated there. In Riley's unpublished notes *E. melancholica* is reported to feed on the unripe kernels and the leaves of corn in the South.

The usual food of *inda* seems to be the sap exuding from the wounds of trees. This beetle has often been noticed in great numbers on ash, elm, maple, beech, birch, red haw, and oak, and has been taken burrowing into the fruits of apple, peach, pear, plum, strawberry, raspberry, persimmon, and tomato, and feeding on cotton bolls and the seed capsules of cocklebur and ragweed. Fruits spread out to dry are visited by them, and also decomposing vegetables, and they are common on flowers of thistle, goldenrod, etc., feeding on the pollen. *E. sepulchralis* and *inda* are said to injure cotton bolls, and the former has been seen burrowing into ripe apples, peaches, and pears.

The early stages are known for *inda* only. The adults of this species winter over, emerging in early spring, buzzing like bumble-bees as they fly about. Eggs, laid mostly in May and early June, hatch after about eleven days (Fig. 80, *b*, *c*). The natural food of the larvæ (Fig. 80, *d*) is evidently manure or other decomposing matter, but they have been accused of cutting off the roots of corn. They resemble the common white-grubs very closely, but are more robust and have shorter legs. There is also a triangular yellow horny plate on each side of the neck shield in front of the spiracle. They live under ground, and make a substantial oval cocoon there preparatory to pupation. The larvæ get their growth in eight or nine weeks, and continue in the pupal stage (Fig. 80, *e*) about sixteen days, making a total period of approximately twelve weeks from the time the eggs are laid to the appearance of the beetles. These appear in late July in southern Illinois, are most abundant in August, and usually go into winter quarters in September. *E. sepulchralis*, with its more southern range, makes its first appearance in June and July, and is most common in September and early October.

THE GREEN JUNE-BEETLES.

Allorhina nitida Linn.

Allorhina mutabilis Gory.

In central and in northern Illinois the June-beetles or June-bugs are brown, smooth, shining, thick-bodied beetles, parents of the common white-grubs. In the southern part of the state, and from thence southward, this name is applied to a large, beautiful, velvety green beetle, *A. nitida* (Fig. 82, *c*), the parent likewise of a thick-bodied underground grub, but chiefly notorious as an adult because of its injuries to ripe fruits. It also does considerable injury to corn, particularly to garden varieties, sometimes as many as a dozen of the beetles being found at work on a single ear, where they feed, head downward, gnawing the grains away often well down to the bases of the ears. The western green June-beetle, *A. mutabilis* (Fig. 83), inhabits the arid Southwest, and the common green June-beetle, *A. nitida*, ranges thence eastward to the Atlantic, and northward to the latitude of St. Louis, in the Mississippi Valley, and somewhat farther north near the Atlantic coast. These beetles are about the size of our common June-bugs, or a little larger, but have a much more flattened form and a different horizontal outline. They are especially broad across the bases of the wing-covers (between which the shield of the thorax extends in a broad point), and taper

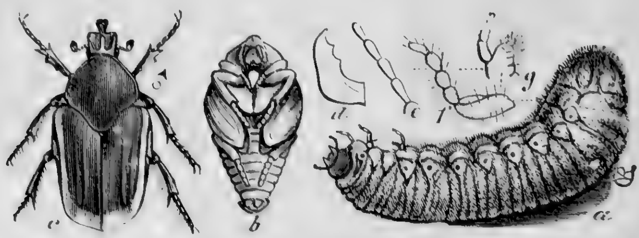


FIG. 82. The Common Green June-beetle, *Allorhina nitida*: *a*, larva, crawling on back; *b*, pupa; *c*, adult; *d*, *e*, *f*, *g*, mandible, antenna, leg, and maxilla of larva; *a*, *b*, and *c* about natural size.

thence notably backwards. *A. nitida* is three fourths of an inch to an inch in length and about half an inch wide. The upper surface is smooth, and the thighs and lateral pieces of the thorax beneath are dull yellowish. *A. mutabilis* is slightly larger than the other, and the under side is uniform metallic green.

The western species (*mutabilis*) feeds on the stalks of growing corn when fruits are not available in sufficient quantity, and its food habits are apparently about the same in other respects as those of the more eastern species. Both are very destructive to ripe fruit, *mutabilis* sometimes occurring in fruit trees in thousands. Peaches, grapes, and figs are its favorite fruits, and the crop of these is in some years badly injured, or even locally destroyed. Apricots, prunes, plums, nectarines, pears, apples, raspberries, blackberries, and even tomatoes and melons also suffer. *A. nitida* feeds on the flowing sap of oak, maple, and fruit trees, and is said to burrow into tender branches. Its fondness for sweets sometimes tempts it to enter a beehive.

The larvæ (Fig. 82, *a*) closely resemble ordinary white-grubs, but differ from those of the flower-beetles in being less robust and in having a different shaped chitinous spot on the first body-segment, as shown in the figures. From common white-grubs (*Lachnosterna*) they may be distinguished by their shorter heads and smaller legs, and by the absence of the peculiar double row of short, stiff spines extending forwards under the tip of the abdomen. They are perhaps most easily known by their peculiar mode of surface locomotion. They come up out of the ground, especially at night, and travel upon their backs, with their legs uppermost as shown in the figure. The dorsal surfaces of their segments are furnished with stout bristles, by the aid of which they may move along with considerable speed.

The species hibernate as larvæ in the ground, and pupate (Fig. 82, *b*) in spring in earthen cells, the beetles emerging about a month later, those of *A. nitida* in May and June, according to Howard, and in July, according to Garman, in Kentucky. As they fly through the remainder of the summer and until September and October, the period of egg-laying is supposed to be correspondingly prolonged. The larvæ hatching from these eggs may be about two thirds grown when cold weather begins. They live in burrows through the winter, a few inches under the surface, and come out to feed whenever the weather permits.

Fig. 83. The Western Green June-beetle, *Allorhina mutabilis*. Twice natural size.

The direct cause of unusual injury by these beetles seems to be the near proximity of manure and similar material. This forms a suitable medium for the breeding of numerous larvæ, which, on reaching the beetle stage, resort for food to fruit or corn nearest at hand. In small plats much good may be done by going over the ground at intervals and knocking off these conspicuous beetles into a pail of water covered with a film of kerosene.

THE SOUTHERN CORN LEAF-BEETLE.

Myochrous denticollis Say.

This beetle (Fig. 84; Pl. VI., Fig. 1) is about three sixteenths of an inch long and about a third as wide, black, with slightly bronzed luster, and densely covered with stout whitish hairs with which the dirt sometimes becomes so intermixed that the surface of the beetle is almost completely hidden. These insects injure young corn by gnawing the bases of the plants at or near the surface of the ground, and also by feeding on the leaves. Serious damage has been done in Ohio and in some of the Southern States, even the second planting sometimes being almost totally destroyed. They have also injured young corn in Kansas, and young broom-corn is said to be subject to their injury. In breeding-cages these beetles will feed freely not only on corn but on timothy and other grasses.

Injury to corn by this species has been reported to us from Edgewood, Ill., and the beetle has been occasionally found on corn or in corn fields in the central and southern parts of the state. In Ohio a peculiar outbreak of injury, extending over an area of about three square miles, was observed by Mr. Webster in June, 1887. The beetles begin their work early in May, as soon as the corn plants appear above ground, and feed during the early morning, towards evening, and on cloudy days. They are timid and drop to the ground when disturbed, are sensitive to sunshine, and conceal themselves during the middle of the day, but may come out and begin their depredations if the sun is hidden by a passing cloud. The injury seems almost strictly limited to lands in grass the preceding year, and is worse on the higher parts of the field.

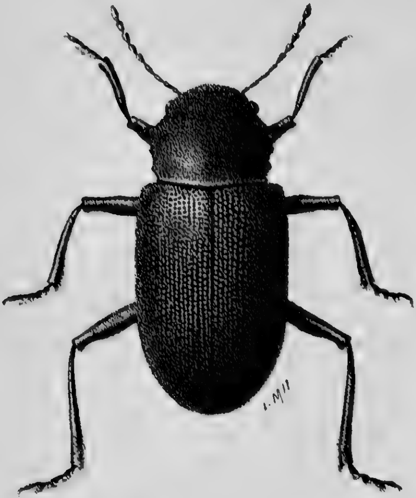


FIG. 84. The Southern Corn Leaf-beetle, *Myochrous denticollis*. Length about three sixteenths inch.

The immature stages of the insect are unknown, and, of course, the life history also, but the beetles have been taken at various dates from May to late October, and also in hibernation December 8.

The species is found from the District of Columbia, Ohio, southern Iowa, Kansas, New Mexico, and Arizona, to all the states bordering upon the Gulf.

THE COLASPIS ROOT-WORM.

Colaspis brunnea Fabr.

The small grub-like larva (Fig. 85, 86) of this common and well-known beetle has lately shown itself capable of a decided injury to young corn by destroying the roots, and a full account of the species with special reference to this

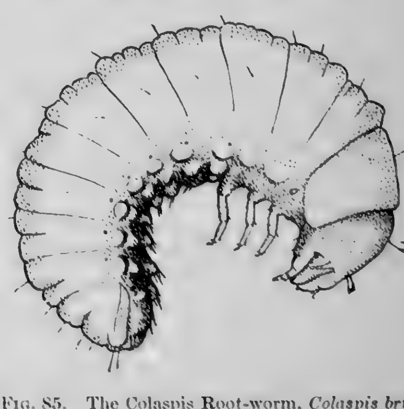


FIG. 85. The Colaspis Root-worm, *Colaspis brunnea*. Length about one eighth inch.

fact was published in the Twenty-second Report of this office. The species is treated here, out of its proper relation as a corn-root insect, as a convenience to those consulting these reports.

This root-worm in the larval stage is a white thick-bodied grub, an eighth of an inch long, with head and neck-shield smooth and harder than the remaining surface, both white after a molt, but soon becoming brownish or reddish. The remainder of the body is soft-skinned, and wrinkled crosswise. Young white-grubs resemble these, but are longer and more slender, and lack the smooth and leathery neck-shield.

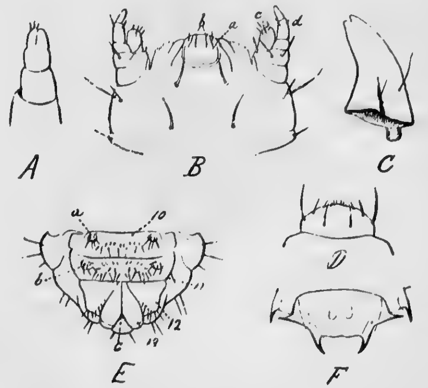


FIG. 86. The Colaspis Root-worm, *Colaspis brunnea*, larval and pupal structures; *A*, antenna of larva; *B*, labium and maxillæ; *C*, mandible; *D*, labrum; *E*, tip of abdomen beneath; *a*, *b*, abdominal tubercles; *F*, tip of pupa beneath. Enlarged.

These root-worms injure corn by gnawing away the soft surface tissue of the tap-root in an irregular, more or less winding line down one side. Spots may also be eaten out to the middle, but the root is never cut off, as by white-grubs, or burrowed lengthwise, as by the corn root-worm. The plant is thus, of course, stunted in its growth, and permanently injured to an extent varying with the severity of the attack. Thus, in Pike county, in June, 1900, when uninjured corn was waist high, injured plants averaged not over eighteen inches, and many were not more than six or eight inches high, with the lower leaves dry and brown. In another field, where uninjured corn stood about five feet in height, patches some two or three acres in size injured by these grubs, averaged only about eighteen inches high, the roots being gnawed and the lower leaves more or less dry. As many as twelve to eighteen root-worms were sometimes found in a single hill. These injured fields were in most cases on relatively high and rolling land, where the soil was light and the growth of the plant was slow; and usually the land had been in sod the previous year. In two instances, however, the root-worm was found in fields which were in corn the year before.

The larva has long been known as injurious to strawberry roots, and our recent field studies show that it feeds especially on timothy roots, most frequently infesting corn planted on timothy sod. In some timothy meadows one or more of the root-worms were turned up with every spadeful of sod.

The adult (Fig. 87) is a small, short, thick clay-yellow beetle, with fine lines of punctures on the wing-covers. It is common on the lower leaves of grape-vines, and on the leaves of the strawberry, the apple, and a variety of other plants, eating irregular rounded or elongate small holes, often causing appreciable damage to these plants.

The species ranges from Nebraska to the Atlantic States and Canada. It is evidently single-brooded, but its stage of hibernation has not been positively ascertained. The eggs are laid in summer and fall, and the larvæ have been found half grown in southern Illinois by the middle of May. It begins to pupate in June, and lives as a beetle during the summer months. Dates of capture of specimens in our collections range from June 22 to September 15, the greater number falling in July and August. It has never appeared with us among hibernating insects, even in situations where it had been abundant up to the close of the season, and it probably hibernates as a larva partly grown. The pupæ are about an eighth of an inch in length, white except the eyes and the mandibles, the former of which are red and the latter black at maturity. The abdomen terminates in a pair of incurved hooks, in front of which, on each side, is a large spine directed backward (Fig. 86, *F*).

FIG. 87. The Colaspis Root-worm *Colaspis brunnea*, adult. Length about one fifth inch.

THE FLEA-BEETLES.

Halticini.

Several kinds of minute hopping beetles feed on corn leaves, and some are occasionally abundant enough to riddle the leaves so severely as to kill them, and even to destroy the entire plant when it is quite small. They are from a twentieth to an eighth of an inch long, with the hind thighs greatly thickened, giving them the power to leap suddenly, like a flea, when disturbed. One of the most injurious species, the pale-striped flea-beetle, *Systena blanda*, is about an eighth of an inch long, rather slender, pale brown, with two creamy stripes down the back, the abdomen black beneath. The others here treated are smaller and more robust, with a uniform metallic green or bronze luster. The corn flea-beetle, one of the smallest of these, is not over a twentieth of an inch long. The beetles injure corn by gnawing away the surface of the leaf. On account of their small size they frequently do not eat entirely through the leaf, but merely cup or channel it out beneath. If they are not too numerous the plant is hardly injured; but when the spots become too dense the corn leaf wilts, turns brown, and finally dries up, and the plant is either killed or is seriously checked in its growth.

The larvæ are slender, worm-like grubs, white and soft-bodied, but with smooth heads and a leathery shield upon the neck. The pale-striped flea-beetle has been reared by me from roots of corn, but this is probably not its principal food plant. These beetles pass the winter, as a rule, in the adult stage, and are found feeding in early summer, producing larvæ in June or July, from which adults appear again in the latter part of the season. The pale-striped beetle, however, probably winters in the larval stage. The species here treated are all apparently single-brooded.

The Pale-striped Flea-beetle.

Systena blanda Mels.

This light colored, slightly elongate striped flea-beetle (Fig. 88) becomes at times excessively abundant over considerable areas, and may, notwithstanding its small size, completely destroy an otherwise promising crop. Corn, beans, peas, sugar-beets, and other crop plants have been thus destroyed by it. It gnaws small round pits in the leaf surface, and may not eat entirely through the blade, but holes are nevertheless likely to be made by the death of the leaf tissue at the injured spot. Many injuries of this kind soon cause the leaf to blacken and shrivel away. Fields of growing corn were thus damaged in Illinois in the '70's, and several reports of similar injury to corn have come from Indiana and Pennsylvania. In one Pennsylvania field the plants were eaten away to the bare stalks.

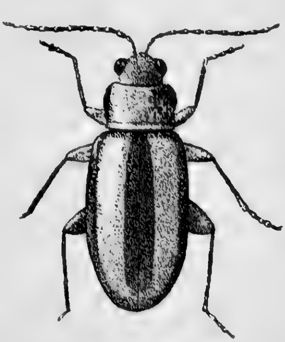


Fig. 88. The Pale-striped Flea-beetle, *Systena blanda*. Length about one eighth inch.

These beetles are said to have killed

twenty thousand apple seedlings in New York, and to have destroyed almost the entire carrot crop of two New Jersey counties and forty acres of tomatoes in Maryland. A large part of the sugar-beet acreage in Illinois was destroyed by them in 1899, necessitating a second, and in some cases a third, planting. They have been reported destructive to potatoes, cotton, young pear-trees, turnips, melons, radishes, cucumbers, peas, strawberry and blackberry plants, alfalfa, lettuce, parsnip, eggplant, summer savory, sweet potatoes, peanuts, oats, and white clover. They also feed on pigweed, ragweed, plantain, purslane, cocklebur, lamb's-quarters, nightshade, fleabane, and the sand-bur.

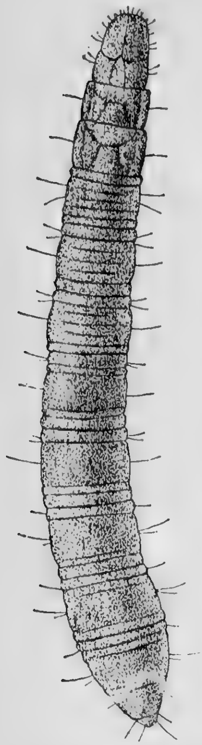


FIG. 89. The Pale-striped Flea-beetle, *Systena blanda*, larva. Length about one quarter inch.

Larvæ (Fig. 89) were found by me in 1886 among corn roots, one boring into a sprouting kernel.* They were fed on sprouting corn, and thus reared to the adult. The United States Entomologist found the larvæ at roots of lamb's-quarters, and apparently also at those of Jamestown weed. They are about a fourth of an inch long, slender, pale yellowish, broadening from the head to near the posterior end, which terminates in a blunt process with a crown of short spines and four stiff hairs.

The beetle has never yet occurred in any of our winter collections. Larvæ taken May 17 became beetles a month later, and those collected July 11 and 12 yielded adults on the 22d and 23d of that month. The beetles became abundant and destructive rather abruptly about the middle of June, continued thus throughout July, and finally vanished in September. Eggs were laid by the beetles at Washington June 10 to July 8, singly or in very small batches on leaves of plants in their breeding-cage. From the facts now on record it would seem most likely that larval hibernation is the rule, that the beetles appearing in June and July have recently transformed, and that the midsummer eggs give origin to the larvæ which pass the winter in the earth. The species ranges from the Atlantic to the Pacific, but probably does not reach south to the Gulf. It is apparently most destructive in the latitude of Illinois.

*Eighteenth Rep. State Ent. Ill., p. 21.

The Western Cabbage Flea-beetle.

Phyllotreta pusilla Horn.

(*P. albionica* in error.)

This species is included among the less important corn insects because of its injuries to corn in Nebraska in 1897. It appeared locally in swarms like black clouds, covering garden and other plants, and destroying from ten to twenty acres of corn on one farm in twenty-four hours. The beetle (Fig. 90) is only about a fifteenth of an inch long, uniform deep polished green above, and without stripes. It is most destructive to cabbage and other cruciferous plants, but it is also known to injure peas and sugar-beets. Its immature stages are unknown. Beetles noticed late in June disappeared about a month later. The species is found from the Dakotas to Mexico and thence to the Pacific coast.

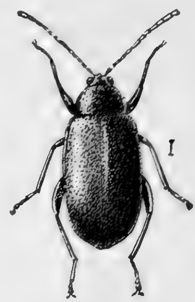


Fig. 90. The Western Cabbage Flea-beetle, *Phyllotreta albionica.* Enlarged as indicated. (Riley, U. S. Dept. of Agriculture.)

The Corn Flea-beetle.

Chætocnema pulicaria Mels.

This minute bronzed species seems quite partial to corn leaves, and is in some years abundant enough in Illinois to check the growth of young plants, and occasionally to destroy them by riddling the leaves with minute holes. The beetle (Fig. 91; Pl. VII., Fig 2) is less than a twentieth of an inch in length, oblong-oval, shining greenish-bronze above, except the thorax, which is notably dull. It feeds on the under side of the leaf, usually leaving the upper epidermis unbroken, but sometimes eating through the blade. The stalk is also occasionally injured.

Fig. 91. The Corn Flea-beetle, *Chætocnema pulicaria.* Length about one twentieth inch.

In various years, but especially in 1891, reports of marked injury to corn by this flea-beetle came to us from many Illinois localities, in twelve different counties. About Jacksonville it appeared in corn fields within a radius of thirty miles from town. Whole fields were wilted more or less, and some hills entirely killed. As many as forty beetles were counted on one hill. An infested field near Manchester, in Scott county, was visited by an assistant July 19, 1892. The beetles were quite abundant in it, and the corn was very small (not over ten inches high) and pale and unhealthy looking. In 1891 similar injuries were recorded in Missouri and Indiana. In Maryland, in 1897, the first plantings of corn were ruined in parts of six counties. This flea-beetle seems especially fond of sweet corn, and also injures broom-corn and millet. It has been found by us on sorghum in Illinois; we have seen it abundant on oats, blue-grass, and ragweed; and have noticed it on wheat, sugar-beet, and a few other plants. It ranges from the middle Atlantic coast westward to Colorado and Texas. It hibernates as a beetle, and has been found destructively numerous from early May to October. Its early stages are unknown.

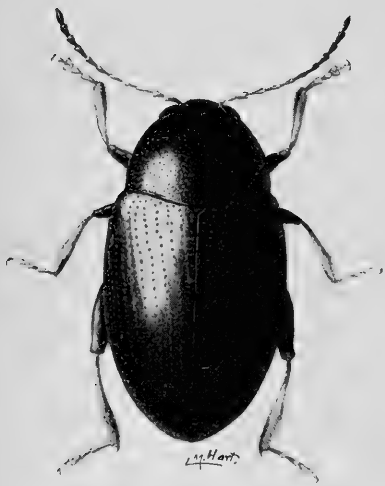


Fig. 92. The Toothed Flea-beetle, *Chætocnema denticulata*. Length about one tenth inch.

The Toothed Flea-beetle.

Chætocnema denticulata Ill.

This beetle (Fig. 92) is about a tenth of an inch long, oval, shining bronzed. It feeds principally on grass and grain, but has done conspicuous injury to corn, and has also noticeably damaged sugar-beets. In the East it has been reported as injurious to sweet corn, broom-corn, and millet. We have found the beetles in Illinois on wheat, oats, strawberry, and melon plants. The species is generally distributed over the United States east of the Rocky Mountains, and is also reported from Montana, Utah, and California. We have several times found the beetle in winter quarters, the hibernating individuals attacking corn in May and June. The eggs were obtained by Chittenden early in July, but other stages are as yet unknown. The beetles—doubtless of a new brood—become abundant again in August and September in the latitude of Illinois.

The Sweet-Potato Flea-beetle.

Chætocnema confinis Cr.

This common little species has been found by Webster doing considerable, though occasional, injury to corn leaves in Indiana and Louisiana. It is very minute (Fig. 93; Pl. VII., Fig. 3), about a twentieth of an inch long, blackish bronzed above, with a distinct flattened thickening or truncation of the front angles of the thorax. The beetles do not eat holes in the leaf of the corn; they simply gnaw out

Lydia Moore Hart

PLATE VII

Fig. 1—THE SEED-CORN MAGGOT, *Pegomyia fusciceps*, adult. Fig. 2—THE CORN FLEA-BEETLE, *Chætocnema pulicaria*. Fig. 3—*C. confinis*.

the tissue from beneath, leaving the veins and upper surface intact. They are most notable for their severe injuries to sweet potatoes, the leaves of which they eat out in narrow channels. The larvæ probably breed upon the roots of this plant and upon morning-glory and others of that family.

Fig. 93. The Sweet-Potato Flea-beetle, *Chætocnema confinis*. Length about one twentieth inch.

The worst injuries are done on low lands and near the winter shelters of the beetles. We have seen considerable injury done by them to raspberry plants, and Webster has recorded injuries by this species to buck wheat and to wheat. We have taken it in Illinois on sugar-beets, oats, timothy, red clover, blue-grass, box-elder, and wild strawberry. Raspberry and morning-glory leaves are riddled with small holes by it.

It is generally distributed east of the Rocky Mountains, and also occurs in Col orado and California. The beetles winter over, and are abundant in May, when they pair and doubtless lay their eggs. They disappear by the first of July, but a new brood comes on in the latter part of this month, becoming abundant in August and continuing until the close of the season. The injury to corn is done by these beetles principally in early summer, shortly after they come out of their winter quarters.

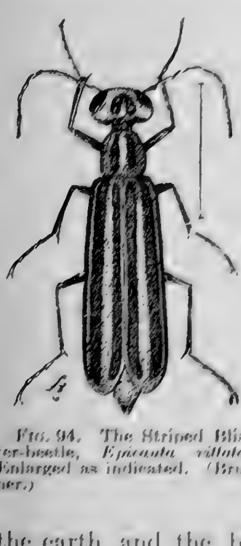


Fig. 94. The Striped Blister-beetle, *Epicauta vittata*. Enlarged as indicated. (Bruner.)

THE BLISTER BEETLES.

Epicauta vittata Fabr.

Epicauta pennsylvanica DeG.

Epicauta marginata Fabr.

The old-fashioned potato-bugs, or "long Johns," as they are called, are closely related to the medicinal "Spanish flies," and their body fluids have the same irritating property, raising blisters when crushed against the skin. These beetles are readily recognized by their cylin drical slender form, soft bodies, and flexible wing-covers, and by the unusual roundness and distinctness of their heads. They average half an inch, or a little more, in length.

Their larvæ feed on grasshoppers' eggs in the earth, and the beetles consequently vary in number from year to year according to the abundance of grasshoppers the preceding season. Years in which they are a temporary local pest are followed by seasons in which scarcely a specimen will be seen. The beetles feed on the leaves of a great variety of plants, among which corn is to be included. They are especially destructive to potatoes and tomatoes and cultivated flowers, but their injuries to corn are usually unimportant except when the plant is still quite small. The species known to attack corn are the striped blister-beetle (Fig. 94, 97), yellow above, with black stripes; the black blister-beetle (Fig. 95), solid black throughout; and the margined blister-beetle (Fig. 96), black above, with a narrow gray edge round each wing-cover except at the base.

Fig. 95. The Black Blister-beetle, *Epicauta pennsylvanica*. Enlarged as indicated. (Bruner.)

The striped species was unusually abundant in Michigan in late June and early July of 1900, and as the potatoes of that region had not yet come up the beetles heavily attacked young corn (about six inches high) and clover. They are fond of pigweed (*Amarantus*), and will feed on it in the corn fields, as long as it lasts, without molesting the corn. The margined blister-beetle exhibits a similar preference.

The black species is often very common on corn late in the season, eating the leaves, the silk at the tip of the ear, and even the husks and the soft kernels beneath. It may possibly do some harm by destroying the silk before the kernel is fertilized. The striped blister-beetle has also been noticed eating corn silks. The corn leaf is eaten away by these beetles from the edges until only the midvein is left. Potatoes, beets, and asters are among the principal cultivated plants attacked, but most garden vegetables are liable to injury by them. The black species is especially common on blossoms of the goldenrod in fall.

Fig. 96. The Margined Blister-beetle, *Epicauta marginata*. Enlarged as indicated.

These blister-beetles are widely distributed over the United States east of the Rocky Mountains.

Their life history is highly peculiar. The larvæ pass through five distinct and unlike stages, all but the last of which are shown in Fig. 97. The winter is passed in the fourth stage (Fig. 97, *g*), in which the larva is inactive. In the fifth stage it changes, in spring, to a pupa of the usual form. The adults of the striped and margined blister-beetles are abroad from June to October, and are especially abundant late in July and in August. The striped species is the earliest of the three to appear. The black blister-beetle comes out about a month behind the others, being most abundant in

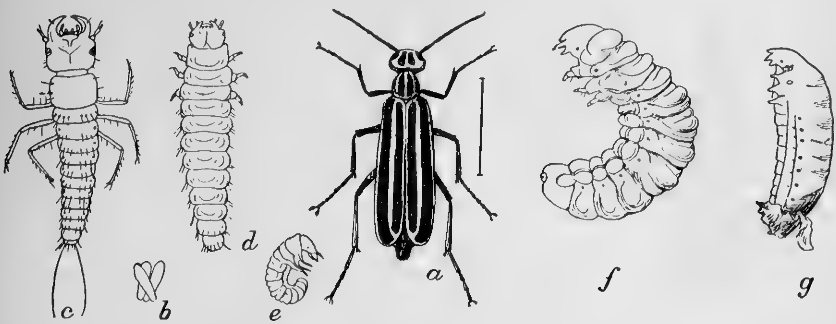


FIG. 97. The Striped Blister-beetle, *Epicauta vittata: a*, adult; *b*, eggs; *c*, first larval stage (triungulin); *d*, second (caraboid) stage; *e*, same as *f*, as doubled up in pod; *f*, third (scarabæoid) stage; *g*, coarctate larval stage. All but *e*, enlarged. (Chittenden, U. S. Dept. of Agriculture.)

August and September. The black and striped species are apparently single-brooded with us, but the margined blister-beetle is said to be double-brooded in this latitude.

Injuries to corn by these insects are not likely to call for treatment. In the garden they are readily poisoned by arsenical insecticides. The usefulness of their larvæ as powerful checks upon the increase of grasshoppers is such as to make their destruction a measure of doubtful value, even though the adults may be locally injurious.

THE IMBRICATED SNOUT-BEETLE.

Epicærus imbricatus Say.

This weevil or snout-beetle (Fig. 98, *a*, *b*) is about three eighths of an inch long, strongly convex in form, brownish, with grayish crossbars on the back. It is not usually common but becomes locally abundant, and though feeding upon a variety of food plants is sometimes considerably injurious to corn, eating out notches in the edge of the leaf, and even virtually devouring the young corn plant. It also does more or less injury to sugar-beets, beans, peas, onion, radish, cabbage, cucumber, melon, squash, potato, and tomato; to apple, cherry, and pear; and to raspberry, blackberry, gooseberry, and strawberry, besides feeding on a number of kinds of common weeds.

The species is generally distributed in the United States east of the Rocky Mountains except to the extreme north, and is especially abundant west of the Mississippi. It is single-brooded and hibernates as an adult, emerging in early spring, and becoming most injurious in May.

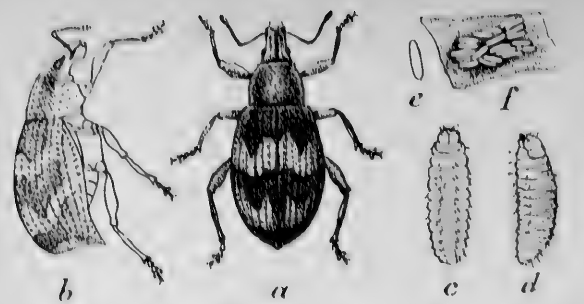


FIG. 98. The Imbricated Snout-beetle, *Epicærus imbricatus*: *a*, *b*, adult, top and side views, three times natural size; *c*, *d*, larva, top and side views, enlarged; *e*, *f*, eggs, twice natural size on leaf, and *e* more enlarged. (Chittenden, U. S. Dept. of Agriculture.)

The eggs (Fig. 98, *e*, *f*) are laid from April to July. They are placed on the surface of the leaf, where they are concealed and protected either by folding the leaf over them and gumming the flap in place or by fastening two leaves together with the eggs between them. The rate of multiplication is unusual. A single female laid while under observation, five hundred and forty eggs. The larvæ (Fig. 98, *c*, *d*) hatch in ten to fifteen days. The adults of the year appear in September and October.

THE RHUBARB AND DOCK CURCULIOS.

Lixus concavus Say.

Lixus mucidus Lec.

These are two closely similar, large, smooth, black snout-beetles, elongate and cylindrical, about five eighths of an inch in length, and more or less dusted over with a yellowish or whitish bloom. The larvæ are footless soft-bodied grubs (Fig. 99, *c*, *d*) which breed in the stems of stout weeds, but the adults feed on the soft tissues of plants, eating away the edges of leaves, and boring into stalks for food and oviposition.

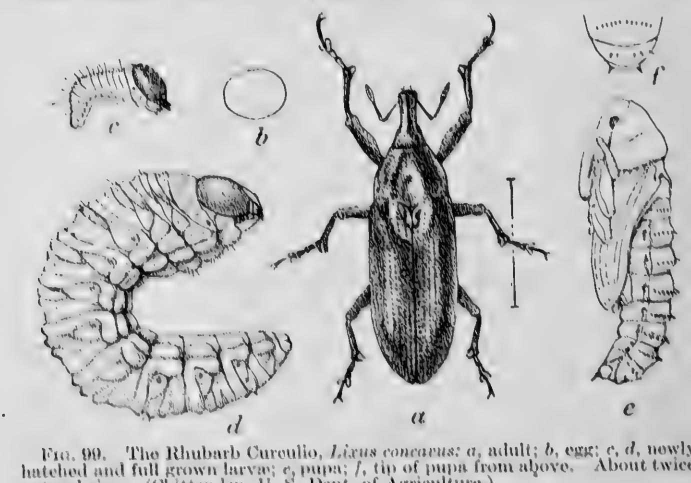


FIG. 99. The Rhubarb Curculio, *Lixus concavus*: *a*, adult; *b*, egg; *c*, *d*, newly hatched and full grown larvæ; *e*, pupa; *f*, tip of pupa from above. About twice natural size. (Chittenden, U. S. Dept. of Agriculture.)

Lixus mucidus seriously injured young corn in a Kansas locality by puncturing the stalk and eating out the heart like the ordinary corn bill-bugs (*Sphenophorus*), described in another section of this report. *L. concavus* (Fig. 99, *a*) likewise injures corn. The two species are readily distinguished by the difference in superficial color, *L. concavus* having a bright yellow bloom and *L. mucidus* a whitish. This bloom is due to a powdery pubescence, easily rubbed away when the insect is handled. The former species has a deep depression in the thorax at the base of the wing-covers, that in *mucidus* being much less marked. The eggs of *concavus* (Fig. 99, *b*) are deposited singly in cavities made by sinking the snout into stems of dock, wild sunflower, and rhubarb. Oviposition in rhubarb causes a copious flow of sap which apparently prevents the hatching of the egg, but the larvæ of both species have been reared from dock, and *concavus* from wild sunflower also.

L. concavus ranges from Canada to North Carolina, and westward to Iowa, Kansas, and Louisiana. *Mucidus* is known from Kansas, Illinois, and Ohio.

Concavus seems to be single-brooded. Eggs have been found in May, June, and July, and adults appear as early as August 12. C. M. Weed found the larvæ of *mucidus* in dock in the latter part of July and the first adults August 1. October 2 an adult and three pupæ were found in roots of the same plant. Hibernation seems to be in the beetle stage, although observations on this point are very few.

THE LITTLE NEGRO-BUG.

Corimelæna pulicaria Germ.

This is a smooth, black, shining, nearly hemispherical little insect (Fig. 100), often abundant during the greater part of the summer on a great variety of weeds and cultivated plants, the juices of which it sucks through its tubular beak to the occasional serious injury of a crop. We have frequently found it on corn in late June and in July, but never in numbers sufficient to do noticeable harm. It was reported to me, however, by Mr. F. S. Earle, in 1885, as injuring young corn near Cobden, in southern Illinois. The adults are about a tenth of an inch long and not quite so wide, with very convex surfaces. The back is protected by a large, convex, horny plate, the scutellum, beside which the small, narrow wing-covers are placed, each marked lengthwise by a line of white. The young are very similar, but the wing-covers are absent and the scutellum is small, leaving the red-marked surface of the abdomen ex-

FIG. 100. The Little Negro-bug, *Corimelæna pulicaria*. Length about one tenth inch.

posed. The favorite food plants of the species seem to be New Jersey tea (*Ceanothus americanus*), Spanish needles, and a small dooryard weed, *Veronica peregrina*. It is probable that the insect breeds principally on these plants. Wheat, blue-grass, strawberry, and celery have been injured by them, and they often occur on cultivated berries, to which they give a disagreeable taste. The species is single-brooded, and is widely distributed east of the Rocky Mountains. The adults hibernate and appear in early spring, laying eggs in May and June. The young which hatch from these eggs rarely fail to reach maturity by the early part of July, after which the adult insect is common until fall.

THE WESTERN GREEN STINK-BUG.

Pentatoma uhleri Stål.

This is a broad, oval, flattened, green bug (Fig. 101), about half an inch long and five sixteenths of an inch wide. It occurs from South Dakota to Texas and westward to California, and is more abundant in the eastern part of its range. It occasionally becomes exceedingly destructive, attacking almost every kind of cultivated crop. Its most serious recorded outbreak was that of 1897 in South Dakota, when over a thousand acres of corn in one locality were badly damaged or destroyed, while many other fields suffered severely but recovered under the influences of favorable weather sufficiently to make a light crop. Twenty-five or more of the bugs sometimes gathered around a single stalk of field corn, as near the ground as possible, and in a few hours this would wilt and break off where they had perforated it with their beaks. Stalks an inch and a half in diameter were thus killed. It is in their immature stages that the greatest damage is done to corn. The adults are first light green, darkening to a deep red by the close of the season. There is always, however, a narrow paler margin. The immature stages resemble the adults, but the back is marked with three dark cross-bars. Among garden vegetables these bugs have shown a preference for sweet corn, turnips, radishes, peas, beans, and potato blossoms. Wheat is sometimes greatly injured, and oats are also attacked. The adults hibernate variously under the bark of trees, in crevices, in piles of manure, and buried in the soft earth, which they penetrate to a depth of several inches—in one case to three feet. In late March and early April they appeared in South Dakota under weeds and rubbish, and in a few

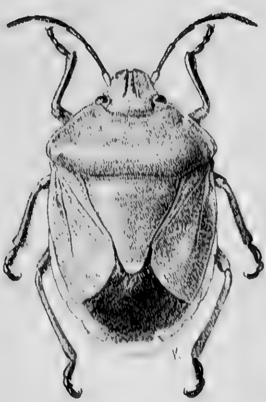


FIG. 101. The Western Green Stink-bug, *Pentatoma uhleri*. Three times natural size.

days began laying eggs, which hatched within a fortnight. By the middle of June the half-grown young began to overspread the fields and to injure cultivated plants. By July 10 the adults were developed, and the bugs began to gather on the wheat. About August 1, eggs were laid for a second brood, principally on Russian thistle, wheat, and cornstalks, the thistles being sometimes fairly white with eggs. Adults of this generation commonly hibernate.

THYANTA PERDITOR Fabr.

This small green "stink-bug," not known to occur in Illinois, is reported by Sanderson* to have appeared in extraordinary numbers in northern Texas in 1903, seriously damaging oats, corn, and sorghum. It is common in central and northern Texas, where it injures various crops, including milo-maize and cowpeas, in a manner similar to that of *Pentatoma uhleri*.

It is of the usual oval-triangular form of these insects (Fig. 102), a half inch or less in length, the shoulder angles spiny, and not rounded as are those of our common Illinois species, *T. custator*, which it otherwise greatly resembles. It is found from Colorado and Nebraska southward, through Texas, Arizona, and Mexico, to Venezuela and the West Indies.

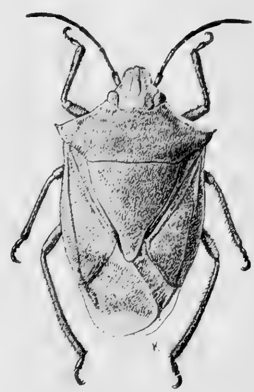


Fig. 102. *Thyanta perditor.* Three times natural size.

THE FALSE CHINCH-BUG.

Nysius angustatus Uhl.

Although occasionally mistaken for the chinch-bug, this insect is readily distinguishable from it by one who knows the latter species. It is a nearly uniform light gray (Fig. 103; Pl. VIII., Fig. 1), while the chinch-bug is black, with milky white wing-covers except for a pair of black spots on the sides of the latter, giving the effect of a white X-mark on the back. The false chinch-bug at times does a considerable injury to crops similar to that of the chinch-bug proper. The adults are light gray speckled with blackish, the young similar in general color but streaked lengthwise with fine dark lines (Fig. 104, *b*). They injure plants by sucking the sap from small punctures, thus causing rusty specks (Fig. 104, *a*), due to a deadening of the tissues drained. We have found them several times in small numbers

*Bull. U. S. Dept. Agr., Div. Ent., N. S., No. 46, p. 94.

FIG. 103. The False Chinch-bug, *Nysius angustatus*. Length about one eighth inch.

on corn, once (in 1895) seriously injurious to it in Logan and Mason counties. In the vicinity of New Holland several fields of corn a few inches high were found late in May swarming with young and adults. The insects had evidently come into the corn from a field adjoining which was in wheat the previous year, since the two or three marginal rows next this field were much the most injured. They had evidently found their later food on the weeds growing in this wheat stubble, and had passed the winter there, moving into the corn in search of food, and concentrating heavily on the outer rows. The plants in these rows, which were nearly covered by the bugs, were wilted and brown and blackened with excrement. Cruciferous plants such as cabbages and radishes seem to be preferred by them, though potato and strawberry plants have also been notably injured. The species probably winters, as a rule, in the adult stage, laying its eggs early in spring. The first brood matures the latter half of May. Osborn has noticed another brood, developing to the adult in July. In midsummer all ages and stages may be found together. There are thus two generations in a season, and possibly three. The species is widely distributed throughout the United States from California to New Jersey and south to Texas.

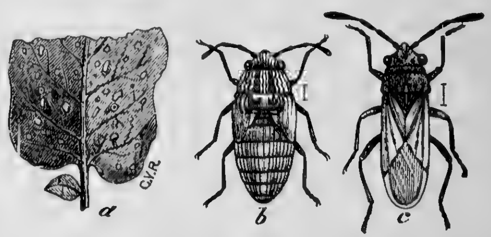


FIG. 104. The False Chinch-bug, *Nysius angustatus*: *a* injured leaf; *b*, nymph; *c*, adult; *b* and *c* enlarged as indicated

THE TARNISHED PLANT-BUG.

Lygus pratensis Linn.

This is a very active, rather fragile looking, soft-winged bug (Fig. 105), about a fourth of an inch long and half as wide, brassy brown, and variably streaked and spotted with yellow. The wingless young are greenish, and, except in the first stage (Fig. 107), there are five black spots on the back, as shown in the figure (Fig. 108). This sap-sucking bug infests a wide variety of food plants in nearly every sort of situation

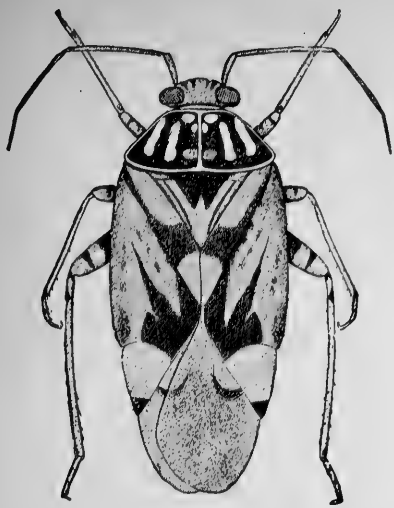


Fig. 105. The Tarnished Plant-bug, *Lygus pratensis*. Length about one quarter inch.

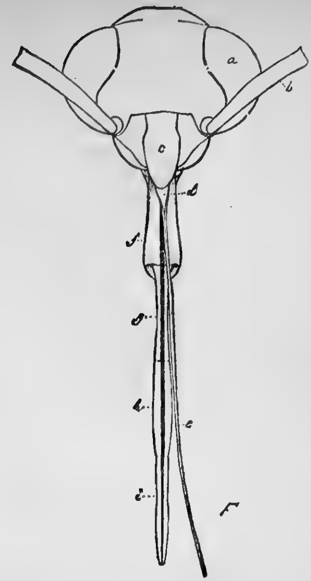


Fig. 106. The Tarnished Plant-bug, *Lygus pratensis*, head and sucking beak: *a*, eye; *b*, base of antenna; *d—i*, parts of beak.

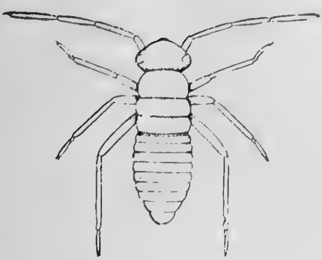


Fig. 107. The Tarnished Plant-bug, *Lygus pratensis*, nymph, first stage. Length about one fifteenth inch.

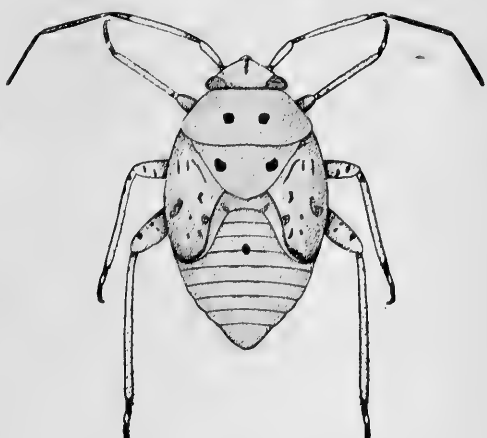


Fig. 108. The Tarnished Plant-bug, *Lygus pratensis*, nymph, last stage. Length about one sixth inch.

from the Atlantic to the Pacific, and from Mexico to British America. Fruits and garden vegetables are particularly subject to its attack, but corn and other field crops are also appreciably injured now and then. It sucks the sap from the leaves of the corn plant, and also from the silk and anthers and the kernels at the tip of the ear in the milk. It can scarcely be said, however, to be really injurious to corn, although A. J. Cook, of Michigan, reports that in 1876 it did noticeable damage to corn and wheat in some parts of Michigan.

The adults pass the winter under sticks and leaves and in tufts of plants and among other rubbish on the ground. They become active with the first warm days of spring, and lay their eggs on various plants. The young hatch late in April and early in May, and begin to reach the adult condition before the end of the latter month. From this time forward all ages may be found together throughout the season until frost puts an end to further breeding. Most of the young then mature, and all go into hibernation as adults. The number of successive generations has not yet been made out.

THE CORN DELPHAX.

Delphax maidis Ashm.

Injuries to corn by this little leaf-hopper have been reported from Florida and Louisiana, where considerable injury resulted from their draining the leaves of sap and slitting the midrib for the insertion

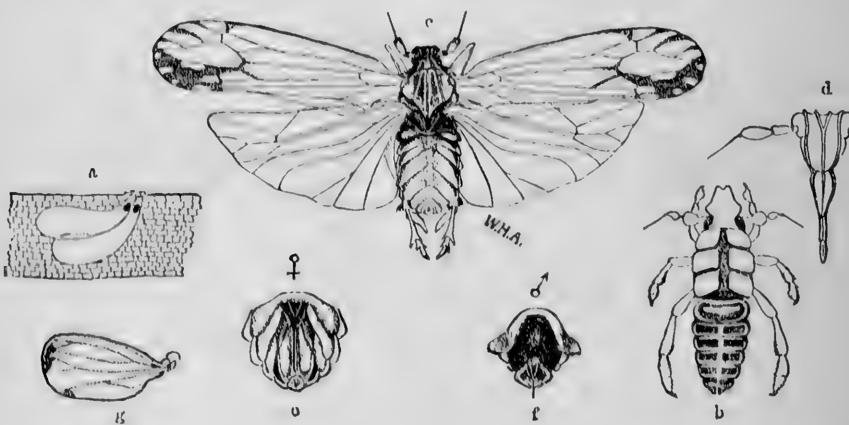


FIG. 109. The Corn Delphax, *Delphax maidis*: *a*, eggs in midrib of corn leaf; *b*, nymph; *c*, adult, length about one tenth inch; *d*, face of adult; *e*, *f*, tip of female and male abdomen, from beneath; *g*, fore wing of short-winged form. (Ashmead.)

of their eggs. This insect (Fig. 109) resembles a large winged plant-louse. It is about a fourth of an inch long, varying from greenish to brownish, with large, semitransparent membranous wings, clouded at the tip with a dark pattern along the veins. These insects move very actively when alarmed, by leaping or by quick sidewise movements around the stem or leaf. Two to four of the small curved eggs (Fig. 109, *a*) are inserted in slits, which are often cut in large numbers in regular rows along the midrib of the leaf. These injuries and the loss of sap from the tissues of the plant give the corn a yellow, diseased appearance, and check its growth to such an extent that the ears produced are poor; or, in extreme cases, the plant is killed outright. The sap exuding from the wounds thus made attracts numbers of ants, which often give the cultivator the first warning of injury to his corn.

The species probably fed originally on coarse grasses, among which it can frequently be found. Old and young occur in all stages virtually throughout the year, one generation following another in the mild southern climate, with scarcely any interruption for the winter. The development from egg to adult requires about a month in midsummer and two months in an open winter.

THE COMMON LEAF-HOPPERS.

Jassidæ.

Among these minute insects, which swarm like tiny grasshoppers on grass and grain, five may be selected as sufficiently injurious to corn to merit some attention. These are *Deltocephalus inimicus* and *D. nigrifrons*, *Cicadula sexnotata*, *Agallia 4-punctata*, and the apple leaf-hopper,

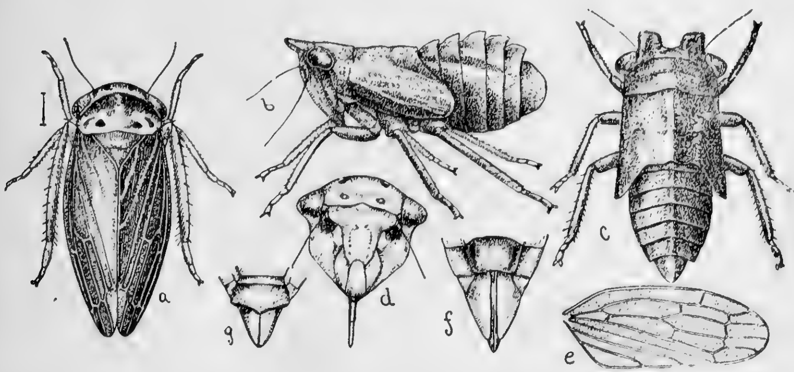


FIG. 110. *Agallia 4-punctata*: *a*, adult; *b*, *c*, nymph, side and dorsal views; enlarged as indicated for adult; *d*, face of adult; *e*, elytron; *f*, *g*, female and male genitalia. (Osborn and Ball.)

Empoasca mali. The first four of these were mentioned by me in the Fourteenth Report of this office as sufficiently common on young corn to cause some injury to the leaves, and the last becomes at times so excessively abundant on the corn plant, and on other crops, that it must produce a noticeable effect. These leaf-hoppers are not over an eighth of an inch long, brownish or greenish, and variously marked according to species. *Agallia 4-punctata* (Fig. 110, *a*) is wedge-shaped, with the head very broad and short, yellowish brown, with a pair of round black dots on the head and another pair on the thorax. The young, which live over winter under boards and rubbish, are blackish, and curiously horned and crested (Fig. 110, *b*, *c*). *Deltocephalus inimicus* (Fig. 111, *a*) is gray-brown, the wings whitish, with brown borders to the cells. It may be recognized by six blackish dots, a pair on

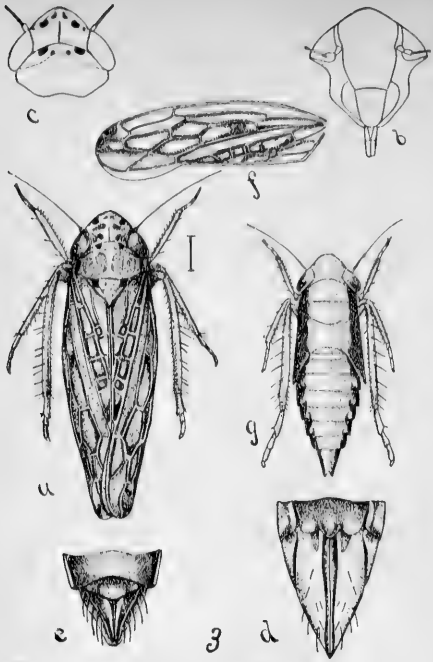


FIG. 111. *Deltocephalus inimicus:* *a*, adult, enlarged as indicated; *b*, face; *c*, top of head; *d*, *e*, female and male genitalia; *f*, elytron; *g*, nymph. (Osborn and Ball.)

FIG. 112. *Deltocephalus nigrifrons.* Enlarged as indicated.

FIG. 113. *Cicadula sexnotata.* Enlarged as indicated.

FIG. 114. The Apple Leafhopper, *Empoasca mali.* Enlarged as indicated.

the head, another pair on the prothorax, and still another on the triangular scutellum. The young (Fig. 111, *g*) are light yellowish, with a broad black border on each side. The other three species are green, with small distinctive markings. *Deltocephalus nigrifrons* (Fig. 112) has a row of six small, black, nearly equal dots along the front of the head, as seen from above, and the face is barred with black. *Cicadula sexnotata* (Fig. 113) has a pair of black dots at the back of the upper surface of the head, and in front of each of these a pair of short black cross-bars. The apple leaf-hopper (Fig. 114) is rather translucent green, with six white spots along the front edge of the prothorax.

These leaf-hoppers injure vegetation by inserting a tiny beak and sucking out the sap. Minute whitish or yellowish dots usually appear at these punctures, which sometimes become numerous enough to whiten the whole leaf. The growth of the plant is of course checked to a corresponding degree. The eggs are usually inserted under the epidermis of leaves or of soft stems, minute elevations of the surface being thus made.

The five species differ greatly in life history. *Agallia* is single-brooded and winters partly grown. The eggs are laid by the middle of July. The other species probably winter in the egg stage, like most leaf-hoppers. At any rate, neither adults nor young have ever been found by us in extensive winter collections. *Deltocephalus* and *Cicadula* are double-brooded. The eggs of *D. inimicus* hatch early in May in grass lands, and the adults are abundant from the first of June to the middle of July. A second brood of adults begins to appear the middle of August. *D. nigrifrons* and *Cicadula sexnotata* have a similar life history. *Empoasca mali* matures more rapidly, completing its growth from the egg within a month. There are probably four or five broods in a season, the first becoming adult in late April or early May.

All these species are widely distributed, *Agallia quadripunctata* and *Cicadula sexnotata* being more distinctly northern in their range than the others.

THE CORN LEAF-LOUSE.

Aphis maidis Fitch.

In the latter part of the summer this bluish green plant-louse may occasionally be found on the younger leaves, the tassel, and upper part of the stalks of corn, and more abundantly and frequently on broom-corn and sorghum. Multiplying in place by the birth of living young, which do not wander from their place of origin,

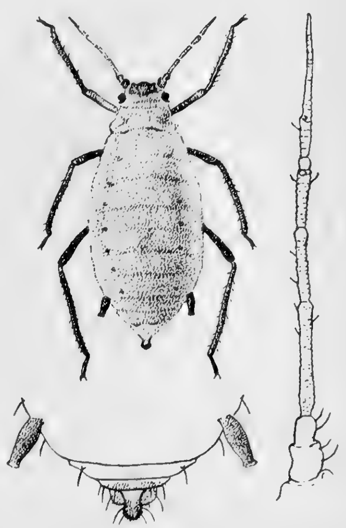


Fig. 115. The Corn Leaf-louse, *Aphis maidis*, wingless female, greatly enlarged, with antenna and tip of abdomen more enlarged.

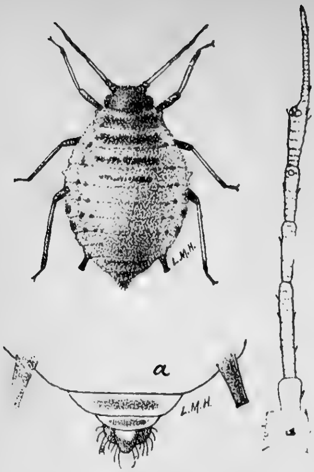


Fig. 116. The Corn Root-louse, *Aphis maidiradicis*, wingless female, greatly enlarged, with antenna and tip of abdomen more enlarged.

these leaf-lice may become abundant enough to kill the leaves and to affect to some extent the health of the plant. The insect is, however, rarely seriously injurious to corn, but there is some evidence, drawn from field observations of infested ears, that it may prevent the fertilization of the kernel by sucking the sap from the silk and killing it before it has performed its function. Heavily infested corn-leaves turn yellow or red, and may shrivel and die, particularly if the weather be dry at the time. Broom-corn is considerably damaged by a reddened discoloration of the brush, due to a bacterial affection following upon the plant-louse punctures. The growth of the brush is also doubtless sometimes checked and the crop thus injured. In Texas this insect has been found injuring barley as well as corn and sorghum.

The wingless form of this aphis is about 2 mm. long and half as wide at the widest part, the body being somewhat ovate in outline. The

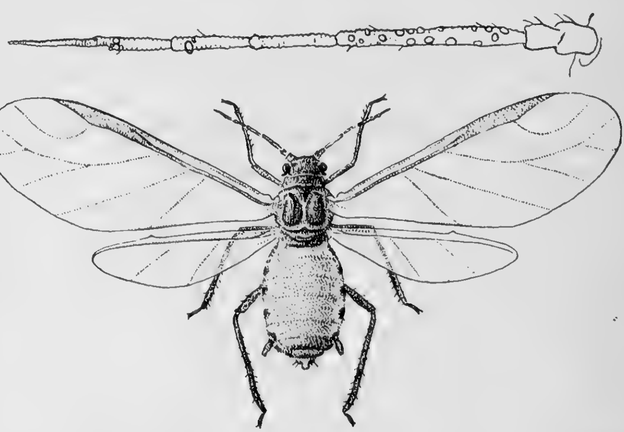


Fig. 117. The Corn Leaf-louse, *Aphis maidis*, winged female, greatly enlarged, with antenna more enlarged.

general color is pale green, with the cauda, cornicles, and the greater part of the rostrum, antennæ, and legs black. The head is marked with two longitudinal dark bands, and the abdomen with a row of black spots on each side and a black patch about the base of the cornicles. The latter are swollen in the middle, making the outlines convex. The cauda is somewhat spoon-shaped, narrowing behind the middle. The beak is short, seldom reaching the middle coxæ. The lateral tubercles of the thorax and abdomen are slender and minute.

The winged form is somewhat different in color, the head being black and the thorax chiefly black above. The abdomen is pale green, bluish at the sides, with two transverse black marks preceding the cauda, and the segments behind it edged with dark. The antennæ are rather long, the fourth and fifth segments longer than the basal part of the sixth. The sensory pores of the third antennal segment are thirteen to sixteen

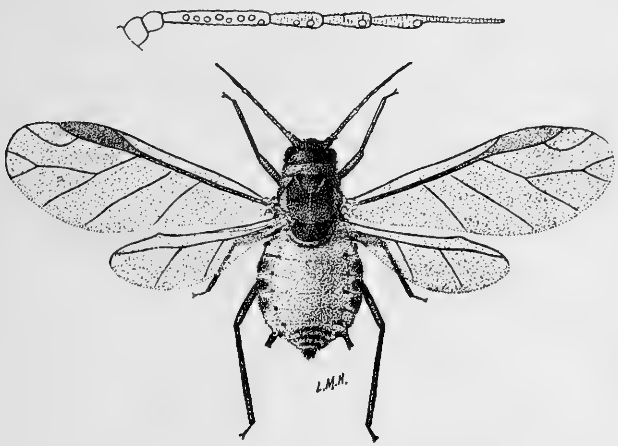


Fig. 118. The Corn Root-louse, *Aphis maidiradicis*, winged female, greatly enlarged, with antenna more enlarged.

in number, variable in size, and irregularly distributed along the under side of the segment.

The distinctions between this leaf-aphis and the corn root-aphis are sufficiently indicated by the accompanying figures of both.

Aphis maidis has been reported at various times as a corn insect, from New York to Texas, Minnesota, and California. The species makes its appearance in midsummer, our earliest date being July 9, when specimens were found on young leaves of corn. We have no record whatever to show whence it comes or where it lives preceding this time. Having once begun to breed on the food plants mentioned, it continues there until freezing weather overtakes it, when, with the death of its food plants, it gradually disappears, leaving neither eggs nor hibernating adults on or about these plants, and passing the winter we do not know how or where. The latest to develop in the field largely acquire wings, and as the sap supply in the plants diminishes they fly away. Wingless females, on the other hand, perish on the spot. Indications are thus very strong that this is a migrating species whose second food plant is thus far unknown. In view of this fact, detailed observations of its occurrence are worth reporting here.

Two lines of investigation have been carefully followed up at my office: the first, that of systematic observation in the field as the season closed and the plant-lice disappeared; and the second, that of insectary experiments carried on throughout the fall and winter. The most connected and careful series of field observations on the species was made under my direction in 1884 by Professor H. Garman, then an assistant in my office.

Field Observations.

July 25, *Aphis maidis* was reported present on corn (the earliest observation of the year) in all its summer forms—winged and wingless, adults, pupæ, and undifferentiated young. July 28, the winged louse was found in a field of small corn beneath the rolled terminal leaves of two stalks out of many examined. August 2, it was found on sorghum and broom-corn in all stages, the adults being both winged and wingless. August 11, it was common in all stages on the leaves and tassels of corn. August 21, it was again observed on corn at Effingham, and on the 29th, at Carmi, winged adults were seen on corn leaves. September 5, at Anna, in Union county, in southern Illinois, it was common in the field on corn, the winged form being moderately abundant. September 8, wingless females and young were observed on corn at Urbana, often with a single dead winged specimen among them—probably the parent female of the colony. "September 18, sorghum maturing and being cut. Plants previously infested by large colonies—as shown by cast skins—now have but few of the leaf-lice on them, and these mostly winged." They were most abundant on the greener parts of stunted plants. The winged lice were flying freely in the evening at this time. On corn they were commoner than on sorghum—mostly wingless specimens among the husks of the greener ears. September 19, an examination of large numbers of the winged lice showed that they were all viviparous females. Most of the growing young were developing wing-pads at this time. September 22. Still very abundant on corn, nearly all wingless viviparous females and their young. September 25. At Godfrey, Madison county, Illinois, common beneath the corn husks—all wingless females and their young. October 6. Still present on corn, concentrating, however, on the younger plants. Sometimes found on the greener ears of stalks which had been cut and shocked. Winged, wingless, and young all present. Living young obtained from bodies of both winged and wingless adults, and even, in one case, from a pupa which had not yet made its last molt. The winged ones fly very readily, and the wingless are often seen wandering restlessly about the plants. Ants in attendance (*Lasius niger* and *Cremastogaster lineolata*) make no attempt to carry them away. "At this time most of the sorghum cane in central Illinois was ripe and ready for the mill. *Aphis maidis* had been during the season abundant on the blades, and to save itself must now depart. Upon examination the species was found to be represented mostly by pupæ and alate females. The pupæ, as was found by confining them, were rapidly maturing, and the winged adults were leaving the sorghum and scattering in all directions. While standing at the edges of such fields at this time one's person interrupted the flight of many of these winged lice. . . . Whole plants were searched with the glass for eggs, and, though some of them had afforded nourishment to hundreds of aphides during the summer, no eggs could be found. The lice which were thus forced to leave the sorghum field doubtless resorted to the corn, which was less advanced, and for some time afterward continued to furnish them appropriate food." (Fourteenth Rep. State Ent. Ill., p. 27.) October 7. Greener ears still considerably infested, often quite heavily so. Young produced by both winged and wingless forms, both indoors and in the field.

October 25. Several heavy frosts have lately occurred, and corn is nearly all dead and dry. Winged and wingless females, both containing young, still present on the greener stalks of corn, usually behind the boot, or ensheathing part of the leaf. Many actively wandering about over the plants during the warmer part of the day. No trace of eggs. About fifty samples dissected, three fourths of them wingless and six of them pupæ. All contained young except two parasitized specimens. October 30. Several very severe frosts of late. Lice on corn, as before, many of them parasitized. Young comparatively few. All the adults dissected were viviparous females, as before. November 1. No change except that plant-lice are less abundant, and a great many are dead between the corn husks. November 6. Clear and cold since yesterday. Dead plant-lice found, but none alive. The apple aphis, on the other hand, was still maturing and active on apple-leaves. November 7, at Normal, McLean county, a long search on corn and among rubbish in the field showed that the leaf-lice had completely disappeared from fields where they were not uncommon three days before. Examples kept indoors all continued viviparous, even the smallest containing embryos. Those kept in unheated rooms still produced living young. November 9, Urbana. Winged and wingless viviparous females, and pupæ with wing-pads found under husks of nubbins, especially those which are somewhat moist. "These were the last seen alive out of doors. Previous to this date there had been severe frosts, and the corn was nearly all dry and hard. The lice obtained at this time were found chiefly among the husks of nubbins and in crannies between the ensheathing part of the leaves. They were evidently restless, and the warmth of the sun at midday aroused some of them to endeavors to find better quarters. These were found wandering about the stalks. An almost microscopic examination of stalks which had supported thousands of aphides was made after the lice disappeared, without finding an egg." (Fourteenth Rep. State Ent. Ill., pp. 27, 28.) November 17. Lice (mostly winged viviparous females) kept within doors still active. November 20. Careful search of grasses about corn fields revealed various plant-lice but no *Aphis maidis*. Notwithstanding the closest search and the dissection of hundreds of plant-lice of all forms and stages, no traces of eggs were found, and the conclusion was reached that the species certainly does not hibernate in the egg stage on or about corn.

Insectary Experiments.

Insectary experiments were begun in October, 1888, with a view to ascertaining whether an oviparous generation could be produced in fall, or at any time during the winter, by continuous breeding accompanied by changes of temperature. This work, placed in charge of Mr. John Marten, was carried on by him from October 9 to March 19. These experiments were conducted on seven lots of specimens, which may be numbered accordingly. All these lots were kept in the University greenhouse, to which they were transferred October 11.

In No. 1, young corn stocked with *Aphis maidis* was grown in pots in the open air, no precautions being taken to prevent the escape of the insects. In No. 2 the insects were confined under a small bell-glass, over an earthen pot containing corn, wheat, grass, purslane, and apple. It was the object of this experiment to ascertain whether the plant-lice would leave corn for any one of the other plants mentioned, maturing there a bisexual generation. No. 3 contained plant-lice under a bell glass with only wheat and apple at first, young corn being added later. In No. 4, wheat and corn only were used, and in No. 5, wheat alone. In No. 6 an isolated winged female was placed on wheat plants, under a separate bell-glass, with a view to following the series of generations throughout the winter. No. 7 was identical with 6, except that this lot was exposed to cold in the open air, with a view to determining whether a bisexual generation might thus be produced.

Experiment 1. Open-air experiment. October 9, 1888.—Adult *Aphis maidis* transferred from broom-corn, brought in from the field about two weeks ago, to young corn growing in pots. Most of the lice wandered away from the corn and persisted in leaving it, although replaced several times. Only five remained on the plant at the close of the day. October 10. Eight adults and ten young on the corn, the latter doubtless born during the night. October 12. Young still appearing, but total number of plant-lice does not seem to increase, some apparently wandering away. October 13. Additional plant-lice transferred from broom-corn and ears of corn to the young corn in pots, October 15. More winged individuals than were previously noticed. These and a few wingless ones persist in leaving the corn. October 16. A few more winged specimens have appeared, most of which leave the corn. October 18. A number of wingless lice on one corn plant in the cavity formed by the half-opened terminal leaves. Purslane placed in the pots to-day. October 20. No lice on the purslane plants in the pots. October 22. Cast skins abundant on the corn, and but few of the lice. Most have disappeared, doubtless developing wings and flying away. None have settled on the apple or purslane. October 23. Corn not under cover almost entirely deserted by the lice. Placed wheat near the corn in the open pots. Found one winged *Aphis maidis* on the glass of the greenhouse roof. October 24. Corn completely deserted by the lice this morning. Not a living specimen to be found on it or on apple, purslane, or wheat. Afternoon. Two wingless *Aphis maidis* and one winged specimen have returned to the uncovered corn. October 26. Corn not under cover entirely deserted this morning, except that two young were found far down in a rolled central leaf. Exposed wheat and apple leaves had no plant-lice on them. October 27. Removed all the apple twigs from the pots, having obtained no trace of transfer to the apple. No *Aphis maidis* in uncovered corn or wheat. Caught two winged lice on the glass roof of the greenhouse. October 29. On corn not under cover no lice were found. One wingless louse feeding on wheat. October 30. Corn not under cover, free from lice. Wheat with no increase since yesterday. October 31. Corn and wheat the same as yesterday. Transferred a few lice from wheat to corn not under cover. November 1. Wheat has one winged louse on it this morning. Lice transferred to corn doing well. Afternoon. Winged louse gone from wheat. Most of those transferred to corn have wandered away. Some remain, apparently feeding far down in the central rolled leaf. November 2. Wheat deserted. Lice transferred to corn seem far down in central leaf. November 3. Both corn and wheat not under cover entirely without plant-lice. Similar entries are made for the 5th, 6th, and 7th, but on November 8 a single louse was seen on the wheat. November 9, the corn was still free from insects, and the louse noticed the preceding day remained on the wheat plant; but the following day it had disappeared, and both wheat and corn remained destitute of lice from that time forward.

Experiment 2. A bell-glass experiment begun October 12 on infested corn, to which purslane was added the 18th, apple, the 19th, and wheat and grass, the 23d. The apple twigs were removed October 26. October 27. Many lice on corn and wheat; only one or two on grass. October 29. Many plant-lice, both winged and wingless, have deserted their food and are collected in the top of the bell glass. Enormous increase of young on wheat since last observation. Lice also plentiful on corn, and a few on grass. October 30. Further increase on wheat and growing corn, and some wandering over the grass. A very few on the purslane. October 31. More lice on wheat and corn, but no increase on purslane or grass. November 1. Wingless specimens disposed to wander from their food plants. No increase on grass or purslane. Winged females crushed, are found with living young. November 3. Corn and wheat continue fairly well stocked. Very few on grass and purslane. November 5. More winged females, mostly in the top of the glass. Wingless ones fewer than Saturday. November 6. One additional young one on grass; also some winged females. Corn and wheat about as before except for a slight increase of winged specimens. November 7. Grass with only one winged louse upon it. Wheat and corn with many winged and wingless and young. November 8. About the usual number of winged plant-lice in the top of the glass, with grass entirely deserted and corn almost so. Wheat more thickly stocked than previously. November 9. None on corn or grass; a few remaining on the wheat. November 10. Marked decrease in numbers. November 12. Only two winged specimens, and very few wingless. None on grass or corn. November 13. The only living specimen remaining is a winged louse. The whole colony had thus disappeared from all these plants within a month. Wheat and corn had both supported them for this period, with the production of numerous young, but none had bred on apple, grass, or purslane with the exception of a single young one born on grass. For a repetition of this experiment this bell glass was restocked with plant-lice obtained from sorghum in southern Illinois November 14. November 15. Lice have gone from sorghum to wheat, corn, and grass. November 16. Have almost all left the grass and gone deeper into the leaves of corn and wheat. November 17. Lice on corn and wheat but none on grass. No winged ones seen. Temperature of greenhouse, 44° Fahr. November 19. Lice dying or disappearing. One winged specimen seen this morning, the only one since sorghum was introduced. Most of the lice are on the corn; a very few on grass. November 21. Several winged specimens. Corn and wheat fairly well stocked. From November 23 to the 27th the plant-lice diminished rapidly, and on the latter date were practically all gone.

Experiment 3. Begun October 25, with wheat alone, under bell glass.—On the 10th of December the insects remaining were transferred to another pot, containing young corn and wheat. October 27. A few lice on wheat and on grass. October 29. A few on the wheat, both winged and wingless, have left their food and are collected in the top of the bell glass. A number of cast skins on the earth beneath. November 1 and 3. Increasing number of young. November 5. Both winged and wingless specimens. November 8. Quite a number of wingless on all parts of the wheat, and the winged individuals have disappeared. Moved this lot into the office, where it was kept at the usual temperature of a living-room. November 9. Lice molting and appearing with wings. Fungus-covered specimens under this glass. November 10. Increase in number of winged specimens. November 12. Still larger number of winged lice, but no increase in number on the wheat. November 13. Winged lice numerous but very few wingless. Some young born last night. November 14. Increased number of very young, evidently from winged females. November 15. Young lice plenty. Winged ones few. November 17. Some very young lice this morning, but no fresh winged specimens. November 20. Insects growing slowly; perhaps because of colder weather. November 21. A few winged lice this morning. Ten young found by dissection in body of wingless female. November 23. No winged lice this morning, but wingless ones numerous, and all full grown. November 24. Additional young born. November 26. One winged louse present. Adults growing very slowly. November 27. Two winged lice and numerous wingless. November 29. But one winged louse seen. Wingless of almost all ages, some very young, only a few hours old. November 30. Two winged lice and a large number of wingless ones. December 1. A number of wingless and young this morning, but none winged. December 3. Increasing number of winged lice and young, but many turning black and dying, as in other cages. December 4. More winged lice than yesterday. December 6. Increased number of winged lice, and also of very young. December 11. Lice changed to fresh plants doing well. Look fresher and more active. December 12. Several winged lice under this glass and many wingless ones. December 13. Very large increase in number of winged lice. All seem to be in the best condition. December 14. Not so many to be seen this morning. December 17. Lice dying. Dead blackened, like those brought in on sorghum when they died. Very few left alive. From this time forward insects in this lot died rapidly, and presently all disappeared.

Experiment 4. Begun November 13, with corn and wheat under bell glass. Supplied with plant-lice from sorghum brought in from Pulaski county.—November 14. Well stocked with *Aphis maidis*. November 15. Lice spread all over the corn. November 20. Nearly all dead. Blackened bodies numerous under the plant. Only one winged specimen seen alive. November 29. Two winged and very few wingless. Several of latter alive on earth beneath the plants. Careful search of surface roots of both corn and wheat was made for eggs, but none were found. November 30. Three winged and a very few wingless. A number dead on corn and wheat. December 1. A few of both winged and wingless plant-lice yet alive. December 3 and 4. Similar entries made. December 6. Three wingless and one winged specimen living. December 10. All dead and gone.

Experiment 5. An experiment with wheat alone, placed under a bell glass October 26.—October 27. Some winged specimens, but no young. November 1. Mostly winged females. November 3. Increasing number of young, many of which have wandered to the top of the glass. November 5. Both wingless and winged specimens present, but not much change in numbers. November 7. Fewer winged than previously. Wingless ones about the same. November 8. Winged specimens have gone. Very few wingless remaining. November 10 and 12. A few wingless specimens were detected, but by the 13th all were gone.

Experiment 6. A winged Aphis maidis isolated on wheat under a bell glass November 13, young corn being introduced December 3.—November 14. Gives birth to one young. November 16. Young still living. November 19. Female yet living, with rather feeble young. November 20. Female still alive, with three young. November 21. A fourth young one alive. Some cast skins show the molting of the others. November 22. Winged louse still living, and the four young increasing in size. November 24. Young lice molted again. The mother still living. November 26. Fresh young. Winged parent still living. November 27. The winged female and five young living. November 29. Winged parent and six young alive, the oldest of these almost full grown. November 30. More young, with the winged female still alive. December 1. Winged louse has disappeared, but two of her wingless descendants have each given birth to one young since the last observation. These are of the third generation, counting the winged isolated female as the first. December 3. Apparently fewer than on the 1st, but a large number of young. Growing corn placed in the earthen pot. December 4. Some very young of the third generation are feeding on the corn. December 5. Six wingless, young and old, this morning are inclined to wander from the wheat. One found creeping out under the bell glass. December 6. Two of the young plant-lice on the corn. December 10. Saw only four wingless plant-lice, three of them full grown. December 12. More young of the third generation. Some of the oldest of this generation have disappeared. Only one of the second generation now alive. December 13. Some of the third generation have molted again and seem about full grown. December 17. Third generation molted again, oldest one almost full grown. December 18. Two of the largest of this generation have disappeared. December 19. Only three of the third generation still alive. December 20. One young of the fourth generation has appeared. January 3. Several of the fourth generation more than half grown. Younger specimens more numerous. January 5. Two young of the fifth generation present. January 7. More of the fifth generation have appeared. January 17. Young of the sixth generation noted. January 21. Many young of the sixth generation present. January 29. Sixth generation notably increased in size. January 30. Winged aphis of sixth generation appeared this morning. January 31. First young of the seventh generation appeared; also second winged specimen of the sixth generation. February 4. Placed stalk of corn in this pot. Another winged female in this lot. February 5. More winged ones appearing. February 8. Crushed a winged louse and found it full of young. February 18. Eighth generation under this bell glass now appearing. All these are progeny of winged parents except those of one wingless female. Number seems to be diminishing. March 5. Plant-lice increasing and growing slowly. March 8. Number decreasing very much. March 11. Ninth generation has appeared since last observation. A considerable number of plant-lice in good condition. March 19. This lot fairly numerous, with one winged specimen. With this day the experiment closed. This series of observations is, on the whole, consistent and satisfactory, and establishes quite definitely the appearance of nine successive generations between November 13 and March 11 at intervals ranging from twelve to twenty-two days, with an average of seventeen. Differences in apparent interval are in some cases due to the death of the oldest of a generation without reproduction. The conditions under which these insects were maintained being of course far from the optimum, their rate of multiplication was small and the total number appearing very few. In this, as in other cases, the parent did not long outlive the reproductive maturity of her oldest young.

Experiment 7. An isolated winged female placed on wheat under a bell glass November 13.—November 16. Winged female dead, but a young louse feeding on the wheat. From this time forward growth and reproduction proceeded steadily but slowly, with some interruption from an attack of fungous disease, until February 14, at which time the pot and covering bell-glass were placed outdoors to test the effect of a change of conditions. On the 16th fewer insects were alive, and but few of these were wingless. No further examination was made until March 4, by which time everything had died—seemingly a week or so before. Careful search of the earth and plants yielded no trace of plant-louse eggs.

The foregoing data confirm our ignorance more than they increase our knowledge, showing, as they do, the failure of all attempts to find or produce a bisexual generation or an alternative food plant of *Aphis maidis*, or to learn how and where it normally passes the winter. Its willingness to feed on winter wheat and ability to breed freely on that plant, its indisposition towards grass or the foliage of the apple, and the natural frequency of successive generations, are the principal other facts evident from these observations.

THE SOUTHERN GRAIN-LOUSE.

Toxoptera graminum Rond.

Although found occasionally in Illinois, this plant-louse (Fig. 119) is a species of the Southern States. It also occurs in southern Europe, whence it has probably been introduced into this country in recent years.

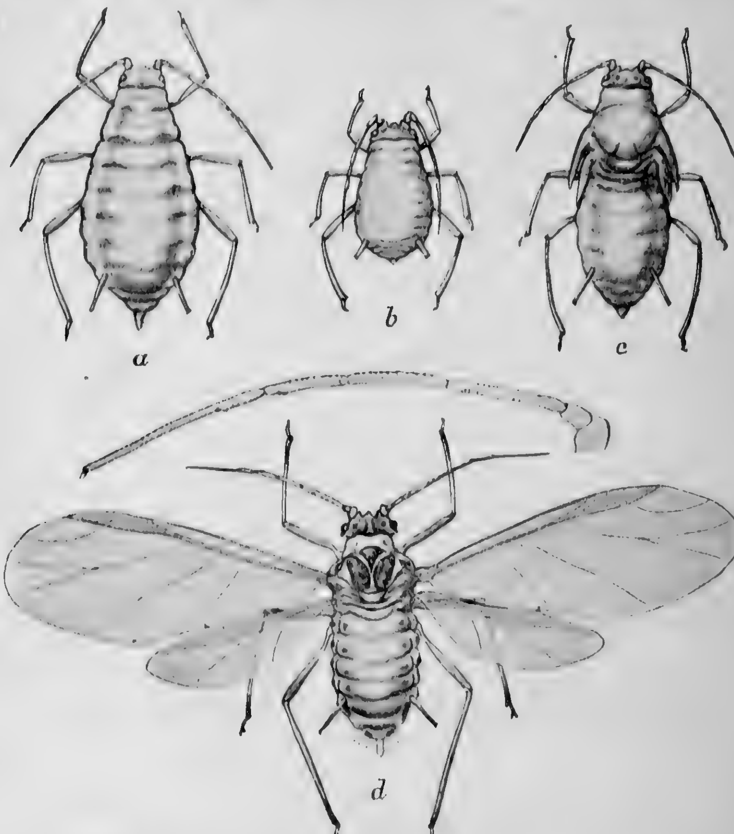


FIG. 119. The Southern Grain-louse, *Toxoptera graminum*: *a*, wingless female; *b*, young; *c*, pupa; *d*, winged female. All greatly enlarged; with antenna more enlarged. (Pergande, U. S. Dept. of Agriculture.)

It is primarily an insect enemy of wheat and oats, but breeding-cage observations by Mr. F. M. Webster show that it will feed on corn, and maize is listed among its European food plants. So far as known to me, however, there has been no positive identification of it among plant-lice actually taken from corn in the field, and its status as a corn insect is consequently somewhat uncertain.*

*Since the foregoing was sent to press, one of my assistants has found this species abundant on corn in early July.

The species apparently lives the year through on wheat and grasses. A migration of winged individuals sometimes takes place in the Southern States in May. Oviparous females were reared by Webster in breeding-cages on wheat, where they first appeared October 21, and deposited eggs—at first glossy green, but later turning to jet-black.

THE THRIPS FAMILY.

Thripidæ.

These very minute, slender, delicate insects, a sixteenth of an inch in length or less, belong to various species and range in color from black to yellow. Several species have been found by us on corn at different times (May 25 to September 23), in some cases injuring appreciably the more delicate tissues of the plant by sucking out the sap. They were frequently seen clustering in the shelter of the base of the uppermost leaf and sucking the sap from the lower part of the tassel. They infest grasses in a similar way, there causing the whitening of the heads commonly known as "silver-top." Their injury is similar in this respect to that produced by leaf-hoppers and other small suctorial insects. The young resemble the adults, except in size and the lack of wings; but the adults themselves are often wingless. The wings, when present, are narrow, delicate, and feather-like, with long and heavy fringes (Fig. 120). By sucking out the sap the *Thripidæ* cause a whitening at the point of injury, and as they move, in feeding, lengthwise of the leaf, a characteristic streaked appearance is produced. They are frequently found on flowers and growing fruits, and feed to some extent on other insects. They are charged with injuring young cotton bolls, and with causing that deformity of the strawberry known as "buttoning" of the fruit. This they do by sucking out the sap from the immature receptacle, thus preventing the filling out of the berry.

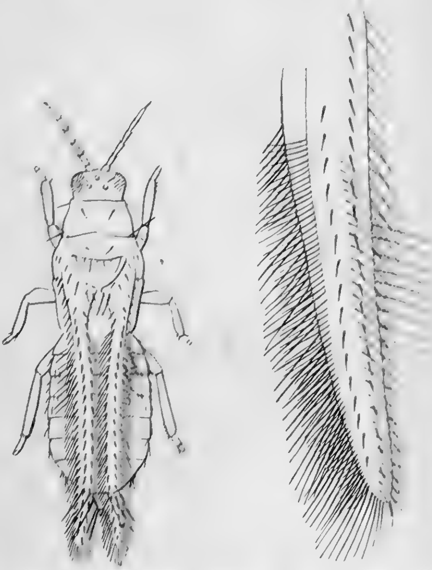


FIG. 120. *Euthrips tritici.* Length about one twentieth inch; wing, more highly magnified.

The winter is passed by them under convenient shelter, either as adults or in various immature stages. In any case the eggs are laid in early spring, commonly inserted beneath the epidermis of the leaf in a cut made by the ovipositor. We have found them thus placed on the inner side of the boot or sheathing base of leaves of corn. The young prefer concealment within the bases of the leaves, but the adults are more active and pass quite freely from plant to plant. Males are often rare, and these *Thripidæ* produce young without their aid, much as plant-lice do. The period of oviposition is somewhat prolonged, but a month is commonly sufficient to bring a generation to maturity, and there are consequently several broods in a season. We have seen eggs hatching in corn fields September 23. The *Thripidæ* have recently been treated by W. E. Hinds, in Volume XXVI. of the Proceedings of the United States Museum, and of the species there enumerated several have been recognized on corn. *Euthrips nervosa* Uzel (*Thrips maidis* Beach) was described by Miss Beach, as she informs us, from examples taken under husks and leaf-sheaths of corn. *T. perplexus* Beach was also described from specimens found on corn and on other plants. *Euthrips tritici* (Fig. 120) we have seen abundant under the corn leaf-sheath about the silk, and especially at the base of the tassel; and *Anaphothrips striata* has been found quite common on the young corn plant.

GRASSHOPPERS.

The Red-legged Grasshopper.

Melanoplus femur-rubrum DeG.

The Lesser Grasshopper.

Melanoplus atlanis Riley.

The Rocky Mountain Grasshopper.

Melanoplus spretus Uhler.

The Olive Grasshopper.

Melanoplus differentialis Thom.

The Two-striped Grasshopper.

Melanoplus bivittatus Say.

The above five species, which have been already mentioned in the general discussion of grasshopper injury to corn in the first section of this report (pages 64–67), are here again referred to in order to a fuller discussion. Among the near allies of these grasshoppers are katydids and meadow grasshoppers. These are, however, easily distinguished by the fact that they are of a grass-green color, with threadlike antennæ, longer than the body, while the common corn grasshoppers are dull brown or olive-green, with thicker antennæ, only a third to half the length of the body. From their nearer relatives of their own family

(*Acrididæ*) the latter may be known by the lack of striking colors on their hind wings. The upper wings are never conspicuously variegated, although in *bivittatus* (Fig. 122) a yellowish stripe runs along the angle of the wing, and the under wings are clear or very faintly tinted —never in part yellow, red, or black, as they are in other members of the family.

Fig. 121. The Olive Grasshopper, *Melanoplus differentialis*. Natural size.

The first three species of the above list (*femur-rubrum*, *atlanis*, and *spretus*) are about an eighth of an inch thick at the base of the wings, dull brownish in color, with a line of dark specks on the middle of the wing-covers. The remaining two (*differentialis* and *bivittatus*) are about a fourth of an inch through the body at the base of the wings. *Differentialis* (Fig. 121) is dull greenish, with yellow tibiæ; and *bivittatus* (Fig. 122) has a yellowish stripe along each side of the back. The western, typical form of the latter has the tibiæ yellow, but the eastern variety (*femoratus*), the common form in Illinois, has bright red tibiæ.

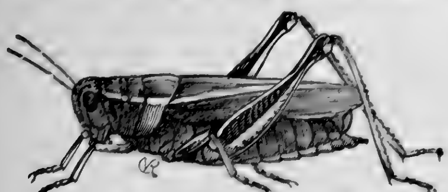


Fig. 122. The Two-striped Grasshopper, *Melanoplus bivittatus*. Natural size. (Riley, U. S. Dept. of Agriculture.)

Melanoplus femur-rubrum (Fig. 123) is by far our commonest species of grasshopper. *Atlanis* (Fig. 124) replaces it on dry hillside slopes. The Rocky Mountain grasshopper, *spretus* (Fig. 125, 126), is a migratory species, having its home within the Rocky Mountain region, from which it has descended in swarms upon the plains of the eastern slope; but this invasion is only temporary, the species quickly dying out in this region. *M. femur-rubrum* closely resembles *atlanis* and *spretus*. The males of these three species are readily distinguished by the structure of the last segment of the abdomen. In *femur-rubrum* the tip has a smooth rounded edge; in *atlanis* it is pointed above, with a notched apex; in *spretus* it ends more squarely, with two more widely separated points. The females show no marked differences in this segment, and are separable only by a number of less definite characters found in both sexes. *Femur-rubrum* is not very closely related to *atlanis*, and is usually readily distinguished from it. The finger-like projection just back of the mouth,

Fig. 123. The Red-legged Grasshopper, *Melanoplus femur-rubrum*. Natural size.

Fig. 124. The Lesser Grasshopper, *Melanoplus atlanis*. Enlarged as indicated. (Lugger.)

between the fore legs, called the prosternal spine, tapers but slightly and not at all in the outer half, so that the rounded tip is comparatively large; in *atlanis* the spine tapers throughout or the outer half is slender, so that the tip is small and narrowly rounded. The transverse grooves of the thorax are stronger in *atlanis*, and the fine, smooth, elevated median longitudinal line, although strong on the posterior half, is nearly or quite absent on the anterior half. In side view the notch between these two halves is broad, and the outline continues beyond it at a slightly different angle. In *femur-rubrum*, on the other hand, the smooth line is nearly always present on the front half and almost as strong as on the posterior half. In side view the notch is small, and there is no angle in the outline at this point. The black bar on each side of the thorax is usually solid in *femur-rubrum*, but has a light spot on the middle division in *atlanis*. *Spretus* is closely related to *atlanis*, and shows all the differences which exist between the latter and *femur-rubrum* but in a more marked degree. The wing-covers of *atlanis* are slightly longer than those of *femur-rubrum*; in *spretus* they are much longer, being half as long again as the body.

The eggs of these grasshoppers are laid in the earth (Fig. 126), the short, hooklike structures at the tip of the female abdomen being used to penetrate the ground, into which the abdomen is thrust, usually to its full length. A large number of cylindrical eggs are then extruded in a mass, forming an elongate-oval body imbedded in a tough secretion, fluid at first but hardening when exposed to the air. Firm dry ground is chosen by the female for the deposit of her eggs, unplowed borders of fields, pasture paths, and farm roadways being favorite locations. The two larger species, *differentialis* and *bivittatus*, lay their eggs in one or two masses, irregularly arranged, the former as many as 170 eggs in a mass, and the latter 54 to 72. The three smaller species deposit from two to four masses, the eggs in which are regularly arranged in four lengthwise rows. Commonly not over a hundred eggs are laid by each female.

Fig. 125. The Rocky Mountain Grasshopper, *Melanoplus spretus*. Natural size.

The egg masses of all these species remain over winter. Those of *bivittatus* begin to hatch in March; those of *spretus* in the latter half of that month in latitude 35°, and about four days later for each degree northward. Those of *femur-*

rubrum hatch mostly in May, the young feeding and growing during June and July and maturing in about seventy days. Scattering adults may appear in late June and in July, but the bulk of the species mature early in August. *Differentialis* has a similar history. *Bivittatus* and *atlanis*, on the other hand, appear as adults early in July, and disappear at a correspondingly early period in fall. All these grasshoppers are single-brooded as a rule, but *atlanis* and *spretus* may be two-brooded southward.

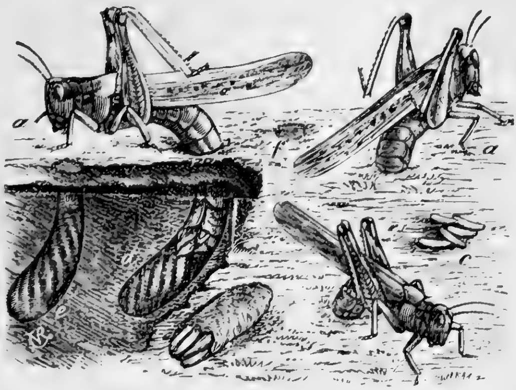


FIG. 126. The Rocky Mountain Grasshopper, *Melanoplus spretus*: *a*, *a*, *a*, females ovipositing; *b*, egg-pod removed from ground, with end broken open showing eggs; *c*, eggs; *d*, *e*, egg masses in the ground; *f*, egg mass completed and covered up. Natural size.

The Rocky Mountain species, as every one knows, is very destructive during its great migrations to the east. *Atlanis* is also migratory and destructive now and then in some eastern localities. The three smaller species prefer open country and short grass. The two larger ones are more common in moist rank grass along fences, among tall weeds, and near streams. The permanent home of the Rocky Mountain grasshopper is in the mountain country, from which it migrates at irregular intervals; that of *atlanis* is on dry slopes and lesser hills and mountains; while *femur-rubrum*, which is not common in the Atlantic region, prefers the low, level lands of the Mississippi valley. The two last mentioned occur in nearly all parts of the United States, except that *femur-rubrum* is replaced by another species in Florida and its neighborhood. *Differentialis* is especially central and western in its range but has been taken in New Jersey. *Bivittatus* proper, the form with yellow tibiæ, is principally western; but *femoratus*, with red tibiæ, is mostly eastern, and is the common form in Illinois.

THE CLEAR-WINGED GRASSHOPPER.

Camnula pellucida Scudd.

This is the most destructive grasshopper of northern North America, and barely reaches at times within the northern boundaries of Indiana and Illinois. It has the migratory habit, but its migrations are not definitely directed like those of the Rocky Mountain grasshopper. It is often excessively abundant, and frequently destroys considerable areas of corn and other crops, particularly in the mountainous regions of the Northwest. It is a rather small species (Fig. 127), about an inch long to the tips of the closed wings, which are conspicuously marked with large dark spots, with yellowish brown spaces between. The back of the closed wings is bordered each side by a yellowish stripe. The eggs are laid in the ground in fall in the usual podlike masses, about twenty or thirty in each mass. They hatch late in May and in June, and the adult stage is reached in the North about July 1.

FIG. 127. The Clear-winged Grasshopper, *Camnula pellucida*. Twice natural size.

THE BIRD GRASSHOPPERS.

Schistocerca americana Dru.

Schistocerca alutacea Harr.

These immense grass hoppers, two or three inches long to the wing tips, are much the largest in Illinois. They are common only in the southern half of the state and in the southern part of the country generally. They feed freely on the leaves of corn, but as they develop late in the season their injuries, even when severe, reduce the yield but little except for fodder. *Schistocerca americana* (Fig. 128) is very similar to the dreaded migratory locust of the Old World and is closely related to it. It never becomes excessively abundant, but occasionally moves short distances in swarms or flights in search of food.

FIG. 128. The Common Bird Grasshopper, *Schistocerca americana*. Slightly enlarged.

Both these grasshoppers are brown, with a central pale stripe, usually conspicuous the whole length of the back, but *americana* is larger and darker brown, with pale stripings on the head and thorax, and the wings heavily spotted with dark brown on a nearly transparent ground. *Alutacea* (Fig. 129) is a nearly uniform red-brown throughout, except for the central stripe.

Injury is done to corn by eating the leaves, and to some extent also the husks and silk, and even the kernels at the tip of the ear. In 1884, *americana* was occasionally found in southern Illinois doing considerable damage to corn in the borders of the fields, sometimes completely stripping the stalks of leaves; and *alutacea* was also found by us in corn in Clinton county, feeding on the leaves, but not seriously injurious. In 1876 very considerable damage was done by *S. americana* in this same region; but its most destructive recorded outbreak was in 1894 in a restricted district of Virginia. Within this infested area corn was almost entirely stripped of its leaves, the older plants, curiously enough, being apparently preferred to the younger. The silks and husks were in some instances eaten away, and the ears thus exposed were attacked by molds. The loss of fodder here was estimated at from a third to half a crop. Fields of oats and clover were also destroyed, and fruit trees were defoliated and seriously injured, even the twigs and fruit being more or less gnawed. Where the grasshoppers were not very numerous their injury to corn was principally limited to the outer rows adjoining clover and grain.

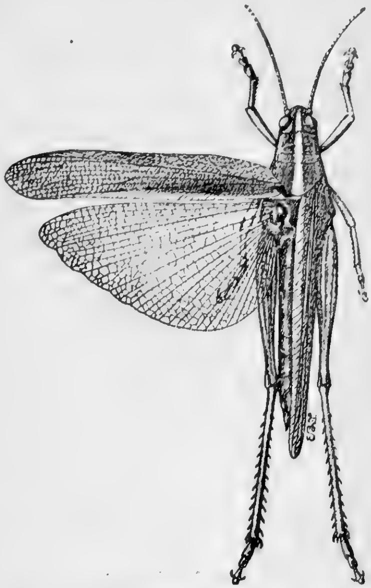


FIG. 129. *Schistocerca alutacea.* Natural size. (Lugger.)

The life history of *Schistocerca americana* has some unusual features. The insect hibernates as an adult, pairs in spring, and lays its eggs in May. The places of appearance of the newly hatched young in the Virginia outbreak clearly showed that the eggs were hatched in grass and clover fields and not in the corn. Winged individuals begin to appear early in August, but do not become abundant until late in that month and in September. Immature specimens have been found as late as October 15 to 21. The life history of *alutacea* is not definitely known, but it is probably similar to that of the other species.

During the Virginia outbreak a migration of *americana* was observed at one of the worst-infested points. The winged insects started off in the early part of the afternoon, in groups here and there, until thousands were flying before the wind, fifty or eighty feet in the air. Scarcely a winged specimen remained at last, and none returned so far as known. Similar migrations on a smaller scale were elsewhere observed.

Both these species are wide-spread. *Americana* occurs everywhere east of the Great Plains of the United States from about the fortieth parallel south to the Argentine Republic. *Alutacea* is found from New England to California, especially to the southwest. In central Illinois it prefers sandy localities, and is very common there. Like *americana*, it has a long and powerful flight, and is likely to rest in bushes, trees, or tall herbaceous growths. In the Virginia outbreak already mentioned, it was noticed that it was easily destroyed by the use of poisoned bran mash.

The Small Green Grasshopper.

Hesperotettix speciosus Scudd.

This species occurs in Illinois, but only in small numbers and in sandy situations. It is found from Texas and New Mexico to Wyoming and South Dakota, and east to Illinois. It has been known to do considerable injury to the sorghum crop in southern Kansas, but it is too rare in Illinois to be destructive here. The adult (Fig. 130) is grass-green throughout except for some slight red or dusky markings. The thorax and top of the head are roughened, and the wings do not quite reach the tip of the abdomen. It frequents roadsides and fence rows, especially in sandy soil, and shows a preference for wild sunflowers (*Helianthus*) and for the sorghum plant.

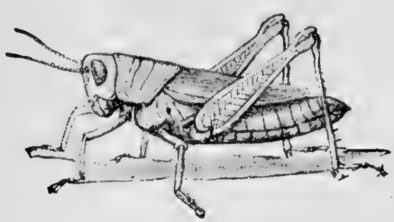


Fig. 130. The Small Green Grasshopper, *Hesperotettix speciosus*. Natural size. (Bruner, U. S. Dept. of Agriculture.)

Scudder's Short-winged Grasshopper.

Melanoplus scudderi Uhl.

This species closely resembles the common red-legged grasshopper in its general appearance and its red tibiæ, but the wings are only about half as long as the abdomen. It might easily be mistaken for a young *femur-rubrum*, but may be at once distinguished from the fact that the wings, though short, have the structure and position of those of the adult insect. It is common in dry situations along fences and roadsides in Illinois, and has twice been found eating the leaves of corn. It occurs from August until late fall, and, like the other common field species, it lays its eggs in the ground in a podlike mass, to hatch the following summer. The species ranges from the Atlantic to the Great Plains and from New England to Texas.

THE KATYDIDS.

Scudderia texensis Sauss.-Pict.
Scudderia pistillata Brunn.
Scudderia furcata Brunn.

These insects may be classed as katydids, as distinguished from the meadow grasshoppers, although their song is but a single note, quite different from that of the familiar katydid of our most abundant species. They are nearly uniform green, with long, threadlike antennæ, and long, slender legs, and with larger wings than those of the meadow grasshoppers. The commonest species in corn fields, *S. furcata* (Fig. 131), is about an inch and a half long; the other species about two inches, measuring to the tips of the closed wings. As compared with the meadow grasshoppers, there are relatively few of these katydids in corn fields. *Furcata* has been found by us several times feeding on corn and laying its eggs in the leaves, and *pistillata* is said by Bruner to be quite common in Nebraska corn fields. We have noticed two cases of small injury to corn by *texensis*. In one, the kernels at the tip of the ear had been eaten beneath the husks, a space being thus excavated as large as the insect's body. The eggs are inserted in the margins of the leaves of various plants. The corn leaf is used for this purpose by *furcata*, and probably also by other species. The leaf edge is first gnawed away, the strongly curved, knifelike, short, flat ovipositor is carefully forced into the cut edge of the leaf between the upper and the lower epidermis for a distance of nearly a fourth of an inch, and the large flattened egg is then deposited in the pocket thus formed. Several eggs are sometimes laid in succession along the margin of a leaf. The young are said to be found in July, feeding on corn like the adults, and mostly reaching maturity about the middle of that month. The winged insects are found thereafter until fall. The eggs are laid in September, remain in the leaves over winter, and hatch the following summer. Adults of *furcata* frequent the borders of thickets and fence rows and weedy fields. *Texensis* chooses similar haunts, but resorts perhaps more frequently to the open fields. It is very troublesome in cranberry bogs, mutilating the berries for the sake of the seeds, and ovipositing chiefly

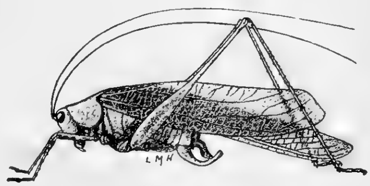


Fig. 131. A Katydid, *Scudderia furcata*, male. Natural size. (Lugger.)

in the leaves of two species of grasses of the genus *Panicum*, after the manner of *furcata*. *Pistillata* is most common about the swampy lake-shores. We have taken it near Urbana.

Texensis and *furcata* are found from the Great Plains to the Atlantic, while *pistillata* seems limited to the northern half of the country.

THE LARGER MEADOW GRASSHOPPERS.

Orchelimum vulgare Harr. (*O. agile.*)
O. glaberrimum Burm.
O. silvaticum McNeill.

The larger meadow grasshoppers are often heard singing in the corn fields, where they are frequently quite abundant, eating the leaves and gnawing the silks and kernels at the tip of the ear. They also make their presence conspicuous by laying their eggs abundantly in the tassel joint, until it looks as if it had been riddled by a charge of shot.

Like their relatives, they have long, threadlike antennæ, which extend beyond the wings, often twice the length of the body. In color they are greenish, with a brown stripe on the thorax. The ovipositor is shaped like the blade of a sickle but varies in curvature. In *vulgare*

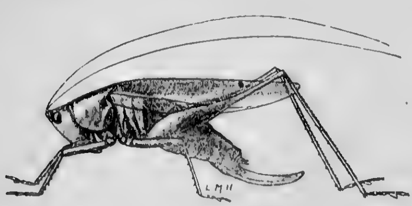


Fig. 132. *Orchelimum vulgare*, female. Natural size. (Lugger.)

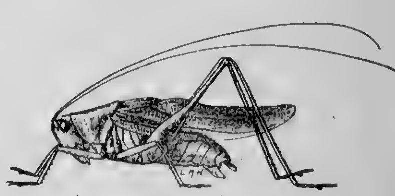


Fig. 133. *Orchelimum vulgare*, male. Natural size. (Lugger.)

(Fig. 132, 133), which is by far the commonest species, the tips of the hind thighs and of the two pairs of wings are all about in line, while in *glaberrimum* the thighs, the upper wings, and the lower wings form a series of noticeably increasing length. *Silvaticum* differs from *vulgare* in having spines on the lower edge of the hind thighs.

These grasshoppers are common in meadows and pastures, and their injury to corn is often most marked at the borders of fields adjoining grass lands.

Ordinary observation of these insects in the field apparently does not indicate accurately their average food, since dissection exhibits a considerable proportion of insects in it. Fourteen specimens of *Orchelimum vulgare* and *oblongifolia*, eight of the first and six of the second, were examined for me by Mr. R. G. Mills in 1903. Four of *vulgare* had eaten mainly insects, two of them, indeed, nothing else. These were mostly plant-lice. The vegetable constituent of the food of this group was made up almost wholly of the pistils and leaf tissues of grasses except that pollen and fungus spores had been eaten by one specimen. The six examples of *oblongifolia* had eaten only an insignificant quantity of insect food, and most of the vegetation taken was derived from grasses and grasslike plants.

In placing her eggs the female of *vulgare* gnaws and breaks up the fibers of the hard crust of the stems of weeds or of the uppermost joint of the corn plant just beneath the tassel, making a roughened spot an eighth to a quarter of an inch across (Fig. 134). The elongate eggs are then inserted into the pith lengthwise of the stem, one or two above the opening and the same number below, two to four in all. These openings are made at short intervals in a slightly spiral row along the stem, and the joint is often completely riddled with them. In one field visited by us fully one fifth of the stalks contained these eggs.

Fig. 134. *Orchelimum vulgare*, egg punctures in stem of corn tassel. Enlarged.

These and other marks very like them, made by tree-crickets laying their eggs in stalks of corn, are often noticed by farmers in fall, especially if horses and cattle are suddenly attacked by disease while running in fields of stalks from which the corn has been husked. Horses are especially liable to serious or even severe sickness shortly after they have been turned into a field of stalks, and in searching for the cause the farmer sees the curious marks made by meadow grasshoppers, and by tree-crickets also, in laying their eggs. Specimen stalks so scarred have been sent to me many times with the inquiry whether these eggs are injurious to the health of animals. Under date of November 11, 1898, Mr. W. B. Lloyd, editor of *Farm, Field and Fireside*, of Chicago, wrote me:

"The inclosed was sent to me by a subscriber at Smothersville, Ill., with the statement that it was a section of a corn-stalk filled with the eggs of an insect. He wished to know if they were injurious to his stock, and what they would hatch out, stating that the late corn was full of them, and that some in that locality thought they were the cause of so many deaths among the stock in that section. . . . . Will you please examine it and see if you can help me out in any way?"

To this I replied:

"The piece of corn-stalk which you send with yours of November 11 is like a great number which have come to me this fall from farmers throughout the state with statements and inquiries similar to those you report. Beneath the roughened spots a careful examination will disclose the eggs of the meadow grasshopper (*Orchelimum vulgare*), which is evidently very common this year.

"There is of course not the slightest reason to suppose that they have any injurious effect upon stock. What it is that kills animals so frequently shortly after they have been turned into corn fields in the fall I am unable to say, and I am told that experts differ on that matter. Their death is not infrequently attributed to any extraordinary circumstance which the farmer may notice in the field at the time. Some years it is believed to be the cast skins of chinch-bugs; this year it is the eggs of meadow grasshoppers."

We have found egg masses of these grasshoppers in stems of dogbane, lamb's-quarters, Spanish needles, horse-nettle, elder, crab-grass, raspberry, blackberry, timothy, *Boltonia*, *Baptisia*, and *Cuina arundinacea*. They have also been found in large numbers in cotton stalks in Louisiana. The other species, so far as known, oviposit in a similar manner. It is stated of *glaberrimum* that only a single egg is laid in each opening, but this needs verifying.

The eggs are elongate, slightly curved, about 6 mm. long by about .75 mm. thick, differing from those of the smaller meadow grasshoppers (*Xiphidium*) in being somewhat depressed. They are smooth, opaque, pale drab or bluish. They are usually laid in the first half of September and may be found thereafter during the winter, hatching somewhat late the following season, the young then scattering in search of food. The young are most abundant in July and August.

The adults begin to appear about the middle of July, becoming most abundant in September, when they lay their eggs, and by October they have mostly disappeared.

Silvaticum is known from Illinois only. The other species range from the Rocky Mountains to the Atlantic, *vulgare* being very common and *glaberrimum* comparatively rare.

Orchelimum vulgare is treated as a sugar-beet insect in the Twenty-first Report of this office (p. 135). By an error in marking drawings the figure (Fig. 58) of the egg cluster of *Œcanthus latipennis* was there used for this species.

THE SMALLER MEADOW GRASSHOPPERS.

Xiphidium strictum Scudd.
X. brevipenne Scudd.
X. nemorale Scudd.
X. fasciatum DeG.

The small, slender grasshoppers of this genus are often seen in fall in corn fields, where they feed freely on the leaves and husks and even gnaw the grains at the tip of the ear; but because of their small size and relative infrequency their injuries to corn are probably of very little consequence. The four species above mentioned have been found by us injuring corn in this way.

Forty specimens of this genus were dissected at my office for a study of their food, all the above species being represented in this collection. Vegetable food was in excess of that derived from insects in every species. Of the fifteen specimens of *fasciatum*, three had eaten only insects, and in seven these made the greater part of the food. In six instances vegetation predominated, and in one of these it was wholly of fungus origin. Pollen was found in the food of five specimens in amounts varying from a mere trace to almost fifty per cent. Fragments of grass blades and the anthers of grasses made the greater part of the food in one case, and in two others considerable amounts of dead vegetable tissues had been eaten. A single specimen of *X. brevipenne* had taken both insect and vegetable food, but less of the former than of the latter, which was all derived from grasses or grasslike plants. Six examples of *X. nemorale* had taken vegetable food, chiefly of a miscellaneous character, and so far as recognizable all derived from graminaceous plants. Two of this species had eaten more insects than vegetation, and a third almost as much. Pollen and fungi were found in six specimens out of twenty. *X. strictum* had fed mainly on insects, and, as usual, these were chiefly plant-lice, with fragments of a few larger insects. In six, pollen composed a minor part of the food, but predominated in three more, two of which were caught on flowers. Fungi in considerable variety and varying quantity occurred in the food of seven. By far the largest element of the food of these twenty specimens consisted of vegetable tissues, comparatively little of which had been derived

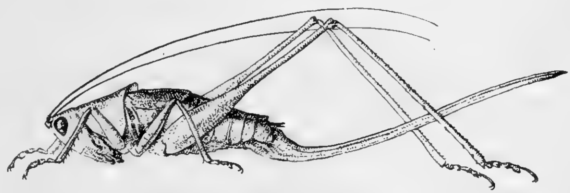


Fig. 135. *Xiphidium strictum*. Twice natural size.

from floral organs. In one case it was penetrated by a fungus mycelium, indicating a decaying condition of the tissue devoured.

These grasshoppers may be readily known by the long, straight, and slender ovipositor of the female, longer than the body in one of the commonest species. The antennæ are threadlike, and two or three times as long as the body. The above four species differ in the length of this ovipositor in the females, in the form of the terminal pair of stylets in the males, and in the length of the wings. In *fasciatum* the wings are longer than the body; in the others, usually much shorter than the body; in *brevipenne* the ovipositor is about as long as the body, in *fasciatum* and *nemorale* it is less than half as long, and in *strictum* (Fig. 135) slightly longer. The latter species has very short wings, about half the length of the abdomen in the male and one third or less in the female. In the males the terminal stylets of *brevipenne* curve strongly outward; in *strictum* they curve inward; while in the other two they are not curved but are nearly parallel.

The species with short ovipositors, such as *nemorale*, deposit their eggs usually in soft stems. Those with long ovipositors insert their eggs in small groups between the stem and leaf-sheaths of grasses, and also between the appressed scales of the cone-galls of the willow. We have found them thrust down between the leaf-sheath and stalk of wheat, in the situation where the "flaxseeds" of the Hessian fly occur. The eggs are about 4 mm. (one sixth inch) long and vary in thickness according to species. Those found by us in wheat were somewhat spindle-shaped, about seven times as long as thick, one end tapering and quite pointed. These were taken in September and hatched early in June of the following year. The young were probably those of *strictum.* Nymphs are observable from June into fall and adults from late July until frost. The species are quite similar in their life histories and habits, though *fasciatum* and *brevipenne* seem to be more fond of low ground along streams, while *strictum* and *nemorale* often abound on drier slopes in woods and weedy grounds.

X. fasciatum is found throughout the greater part of both North and South America; *brevipenne* is generally distributed east of the Rocky Mountains; and *nemorale* is especially a species of the northern, and *strictum* of the western, United States. All are common in Illinois.

THE GREAT PLAINS CRICKET.

Anabrus simplex Hald.

The so-called western crickets, which inhabit the arid regions of the West, are not true crickets, but heavy-bodied wingless insects of the same family as the meadow grasshoppers (*Locustidæ*). The species above mentioned breeds in the great sage-brush plains of the interior valleys of the Rocky Mountains, in Utah, Idaho, and their vicinity, migrating when abundant into adjacent cultivated regions, which it desolates as it goes. It has also appeared in Washington, Oregon, and Wyoming, but never, as yet, on the eastern slope of the Rockies.

These insects are rather long-legged, of a dull gray-brown color, the upper surface of the thorax leathery, projecting backward, with a rounded margin. In their migrations they press forward regardless of irrigation ditches or other passable obstacles, and only a large stream can cause them to change their direction. Their migrating armies are often very large, ten to twenty miles long and one to three miles wide. The eggs are laid in hard ground—probably about fifteen to eighteen in each lot—in an elongate cavity made by means of the ovipositor. Egg-laying begins in July and continues into September, individuals ovipositing at intervals of several days. Migrations usually begin in July. Since the country they invade is not their natural home they disappear after a time, and nothing more is seen of them until the next migration.

They can be herded like a drove of sheep and driven out of fields, especially when young, but this must be done repeatedly. Being wingless and poor "high jumpers" they are easily stopped by low barriers. A six-inch board with an overhanging strip of tin to prevent their climbing over will completely check them, and the accumulating masses may be crushed by a heavy drag drawn in front of the barrier.

THE SOD WEB-WORMS.

Various Species of Crambus.

Descriptive Distinctions.

The accumulation, from time to time, of a considerable collection of sod web-worms representing various localities, has given me a favorable opportunity to distinguish species and to connect them, by breeding, with the adult *Crambus*. The results of a study of this material, undertaken at my request by my assistant, Mr. C. A. Hart, are presented here for the information of entomologists.

Dr. Felt has described* and illustrated the eggs of a large number of New York species of *Crambus*, and also the young larvæ which hatched from them. Unfortunately these all died before reaching maturity. Similar experiments begun at this office ended in the same way; and even in our attempts to rear maturing larvæ to the adult, the proportion failing to complete their transformations was unusually large. In his monograph of the North American species of the family,† Fernald has included all published descriptions of their immature stages, among them, those of Felt. As is usually the case, however, these independently

*"On Certain Grass-eating Insects." Bull. 64 (1894), Cornell Univ. Agr. Exper. Station.
†"The Crambidæ of North America." Mass. Agr. Coll., 1896.

prepared descriptions are more or less occupied with characters of wide application, and contain but little that is sufficiently precise and reliable for specific identification. Biological notes on the adults of Ohio species have been published by Hine.*

The Larva.

In the collections of the Illinois State Laboratory of Natural History are 215 larvæ apparently of this genus, mostly from pastures and corn fields. These represent at least four or five species, three of which we have recognized and bred to the adult.

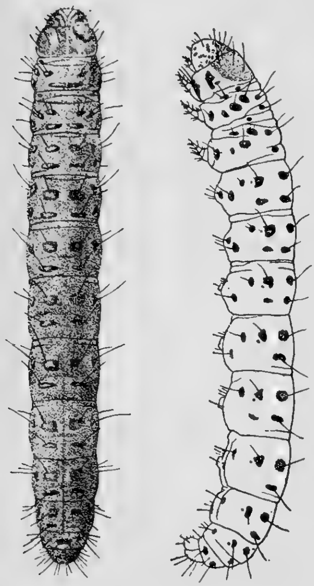


FIG. 136. *Crambus trisectus*, larva, dorsal and side views. About four times natural size.

Common Characters.—Body subcylindrical, usually about 12–25 mm. long, and 2–3 mm. thick, unicolorous, or with pale median line or irregular striping, no clear-cut pattern; finely granulate; setiferous corneous spots all present and very large, occupying nearly the full widths of the lobes bearing them, feebly elevated, rather smooth and shining, usually darker than the ground color; setæ pale, dark at base, puncture ringed with blackish. On each side of the third abdominal segment (first leg-bearing), as a typical segment, two of these spots are dorsal, one on the anterior lobe, and one behind it on the posterior lobe; two lateral, both anterior, one above, one below the spiracle, the lower bisetose (not unisetose as in the figure), and two subventral, one posterior, the other lower down, exterior to the leg base and trisetose. These spots are unisetose except as otherwise stated. Often a similar but non-setose accessory spot on the posterior lobe behind the upper or each of the lateral spots, and a smaller one (the stigmatal) just behind the spiracle, evidently a detached part of the suprastigmatal, with which it is often still connected. Spiracles oval, with a raised blackish rim of uniform thickness, the prothoracic much larger than the rest, which are about equal in size.

Head sub-alutaceous (Fig. 139, *a*), basally with some fine impressed reticulations which break up the color pattern more or less into smaller spots. A whitish V just outside the Y-shaped suture. Color pattern, when visible, of dark basal markings, with five anterior extensions, alternately tapering, as follows: A discal triangular extension with

*"Ohio Crambidæ." Journ. Columbus Hort. Soc., Vol. 12, pp. 24–27. 1897.

apex more or less enlarged, encircled by two arcuate extensions curving in toward its enlarged tip, which with them forms a more or less distinct broken semicircle, the upper arc bordering the whitish V-mark; a tapering extension toward the ocelli, and below this a blunt extension. Clypeus whitish; anterior margin of front and the labrum and mandibles usually dark. Ocelli six, about equal, three in a vertical row behind the antenna, the upper two of these closer together; one behind the lowermost; and a horizontal and more distant pair above and slightly behind the vertical row. Antennæ four-jointed, first two joints large and subequal in length, second bearing on inner side of apex the very small third, fourth joint minute. Labrum about twice wider than long, consisting of two rounded lobes separated by a deep V-shaped notch; a U-shaped carina encircles the notch, and each lobe is obtusely ridged centrally. Palpi two-jointed. Mandibles with latero-dorsal ridge ending in a saw-tooth on the broad cutting edge, which bears several smaller similar teeth, fading out downwards, one above the ridge-tooth. Labium styliform, straight, about as long as fore tarsus and its claw combined.

Cervical shield well developed, smooth, markings consisting of pale median line, darker hind margin, dark setiferous points and a dark dot near the lateral margin. Posterior pair of dorsal spots united or contiguous on three succeeding segments; a large dark one on each side below cervical shield, deeply emarginate to receive the spiracle. Legs yellowish to black above, ending in an appendiculate claw.

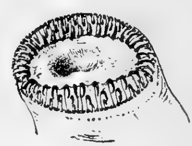


Fig. 137. Foot of larva of *Crambus trisectus*. Enlarged.

False feet (Fig. 137) short-cylindrical, bearing a complete ring of about fifty hooks with adnate bases, the smallest irregularly alternating with one or two others approximately two, three, or four times as large. Their dark chitinous bases all begin at the outer margin and extend inwards, the nearly vertical moderately arcuate hook rising from their inner ends, and half to two thirds as long as the base. Ring of posterior pair open behind. Anal shield subtriangular. On the leg-bearing segments a small black cicatrix behind the spiracle, and one on the inner part of the anterior dorsal corneous spot, also certain other variable small smooth scars near the spiracle.

Three other larvæ in the collection, taken from grass and supposed to be *Crambus*, probably represent some other genus of this or a related family. The surface is microscopically densely wavy-striate, not granulate; the dorsal corneous spots are more conspicuous than the others, rounded, surrounded by a vague pale ring, accessory spots wanting; the head markings differ slightly in form; the antennæ are longer, the labium is shorter and slightly arcuate; and the foot hooks differ only in that the ring is open (outwardly). They are larger than the average in *Crambus.*

Specific Characters.—The ground color varies considerably; the young are more or less pink, with heads darker, usually black, the corneous spots smaller as a rule, and the accessory ones fewer than in the adult. In well-grown larvæ, an accessory spot may in certain cases grow smaller on successive segments of the same larva until it vanishes, or a similar variation may occur on the same segment of different individuals of a species. However, these spots may be used to some extent in the recognition of species, and those here recognized are separated by means of them into two groups. Taking the first leg-bearing segment (the third abdominal) in all cases, in the first group of species (Fig. 141, *b*, *c*) the spots are smaller than in the second, sometimes quite small; there is very rarely even a trace of an accessory spot behind the substigmatal, the stigmatal is usually absent, and even the suprastigmatal accessory may also be wanting. In the second group (Fig. 141, *a*) the spots are usually large and well marked, with two accessory lateral spots present on the posterior fold behind the two setiferous ones, and usually the extension of the suprastigmatal behind the spiracle, often detached, herein called the stigmatal spot.

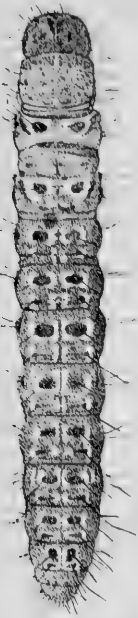


FIG. 138. *Crambus mutabilis*, larva, dorsal view. About four times natural size.

The head markings of the first group (Fig. 139, *a*), except in pale specimens apparently freshly molted, are well defined and clearly composed of aggregations of small spots; the lower setiferous puncture of the two in the substigmatal spot (Fig. 141, *b*, *c*) is normally only slightly in advance of the upper, but when the body is shrunken and contracted the line connecting them is more oblique. In this group, *Crambus mutabilis* (Fig. 141, *c*) is easily known by its color pattern of whitish blotches in six lines along the dark colored body, giving it a striped appearance. In the 23 specimens of this species the accessory tubercles, except rarely the stigmatal, are wanting. Of the remaining

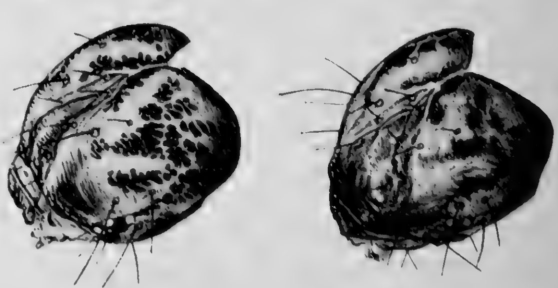
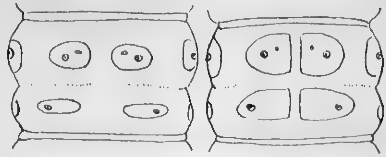


FIG. 139. Heads of *Crambus* larvæ: *a*, *C. trisectus*; *b*, *C. luteolellus*. Enlarged.

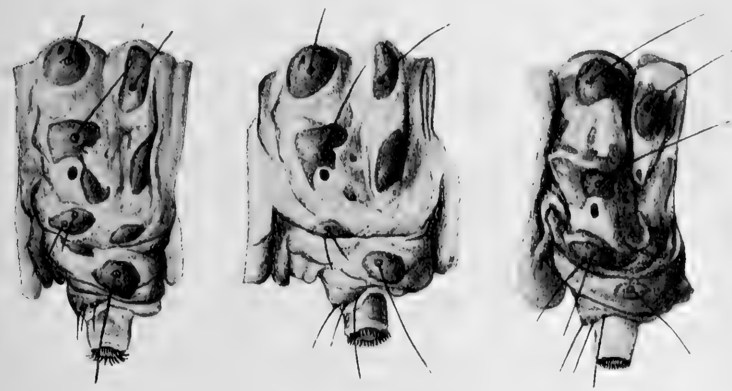
174 specimens of this group, a few have the suprastigmatal accessory very small or absent, or else have a small stigmatal one present, but nothing was found to justify further specific separation. Typical larvæ of this group, carefully assorted, have been repeatedly reared by us to the adult of *trisectus*, and at least the bulk of this lot undoubtedly belongs to this very common species.



a b

Fig. 140. Third abdominal segment of *Crambus* larvæ, seen from above: *a*, *C. trisectus*; *b*, *C. luteolellus*. Enlarged.

In the second group the head markings (Fig. 139, *b*), when traceable, are not clearly formed of small spots, and the substigmatal setiferous punctures are diagonally placed (Fig. 141, *a*). In this group, *luteolellus* (under which name *caliginosellus* and *zeëllus* are included for reasons discussed further on) is recognizable by its distinctly coarser and broader granulation, by its yellowish head with markings usually present, and by the equidistant dorsal tubercles,



a b c

Fig. 141. Side of third abdominal segment of *Crambus* larvæ: *a*, *C. vulgivagellus* (as in *luteolellus*); *b*, *C. trisectus*; *c*, *C. mutabilis*. Enlarged.

usually with parallel inner margins, leaving only a narrow median avenue between (Fig. 140, *b*). Fifteen of our specimens belong here. The remaining thirty-three have red to black heads, the head pattern nearly or quite obliterated. One lot of five smaller larvæ have red heads, and may be *ruricollellus*. The others have the heads entirely black or more or less castaneous near the white V-mark, and appear to belong to *vulgivagellus*, according to published descriptions.

These differences are tabulated in the following key:

Substigmatal non-setiferous accessory spot of posterior fold of third abdominal absent, stigmatal accessory small or usually absent (Fig. 141, *b*), head yellowish with darker markings clearly aggregations of well-defined small spots (Fig. 139, *a*); lower seta of substigmatal setiferous spot nearly underneath the upper in unshrunken specimens (Fig. 141, *b*).

Surface without definite markings other than corneous spots; suprastigmatal accessory usually present (Fig. 141, *b*). *trisectus* (bred).

Surface with six lines of irregular and broken whitish markings on sides and back, alternating with five darker lines, one median and four along the rows of dorsal and suprastigmatal spots; suprastigmatal accessory wanting (Fig. 141, *c*) .... *mutabilis* (bred).

Substigmatal and suprastigmatal non-setiferous accessory spots present, stigmatal usually present (Fig. 141, *a*); head yellowish to black, small spots composing markings more or less obscure (Fig. 139, *b*); lower seta of substigmatal spot about as far in advance as it is beneath the upper (Fig. 141, *a*).

Head reddish to black, markings very obscure or invisible; granulations very slightly coarser than in preceding group; posterior dorsal tubercles of third abdominal as in preceding group, narrowly rounded inwardly and more distant than anterior pair (Fig. 140, *a*).

Head orange-brown or red-brown .... *ruricollellus?*

Head black to very dark red-brown .... *vulgivagellus*.

Head yellowish, with darker markings; skin granulations relatively coarse; dorsal tubercles of third abdominal narrowly and equally separated, both pairs usually with straight and parallel inner margins (Fig. 140, *b*) .... *luteolellus* (bred).

The Pupa.

The number of pupae at hand is too small for definite specific separation, although two distinguishable species are apparently present, judging from differences in the peculiar and probably generically characteristic terminal structure. The pupae are red-brown, smooth, with some very finely wrinkled areas, and terminate ventrally (Fig. 142) in a subquadrate projection, surmounted by a longer snoutlike dorsal termination. In the hollow each side of the base of the latter is a nostril-like slit-shaped aperture from which a deep arcuate groove extends forward, outward, and downward. The snoutlike termination is blunt apically and bears a lateral pair of short setae and a terminal spinose pair. The biological significance of these structures deserves investigation.

FIG. 142. *Crambus trisectus*, tip of pupa, seen from above.

The Adult.

The paper by Fernald already mentioned, is an illustrated monograph of our North American *Crambidæ*, with a key to the species. That by Felt, in the Bulletin of the Cornell Experiment Station, illustrates the wings and genital structures of the local species, and gives tables for identification of the adults. Studies made at this office indicate that three closely allied forms listed as species by Fernald, *luteolellus*, *zeëllus*, and *caliginosellus*, are not specifically distinct. The form and color pattern of the wings are the same in all. *Caliginosellus* is dark fuscous on both pairs of wings, with brown markings; *zeëllus* is ashy gray and light brown or yellow-brown; *luteolellus* is yellowish or whitish, its variety *ulæ* slightly ashy on the outer part of the fore wing, the fore wings sometimes becoming nearly white, with very faint markings. The two extremes, *caliginosellus* and *luteolellus*, were originally described in a paper by Clemens.* A moth reared by us from corn crambid larvæ in 1884 was of the intermediate type, and on it and other specimens was based Fernald's description of *zeëllus*, published in the Fourteenth Report of this office (page 15), and also in the "Canadian Entomologist," Vol. XVII. (page 55). In the following summer all three forms, together with all possible intergradations, were quite common at the same time at electric lights near the University. A large number were sent to Professor Fernald, who made an attempt at separation of the three forms, but wrote: "You will see that these vary and run into each other so that I am in doubt whether they are anything more than varieties, trimorphic forms, or something of that kind."

Felt did not distinguish *zeëllus* in New York. He puts the other two in separate groups, but an examination of his key shows that the difference between these two species narrows down to that of ground color alone. He figures the male genitalia of both, but says that structurally they are most closely related, and can be separated only on the form of the scaphium, the form of the other organs being almost identical. In his two figures, the unlike dotted areas about the lower limb of the uncus merely represent membrane. I have examined, in our collection, males of all these forms as determined by Fernald, but could make out no especial differences in the proportions of the scaphium, the structures being in all very close to those figured by Felt for his *luteolellus*.

It would therefore seem best to treat these three as varieties of a single species, unusually variable in ground color but not especially so in wing pattern nor in the genital structures, under the name *luteolellus*—the first given by Clemens.

*Proc. Phila. Acad. Sci., 1860, pp. 203, 204.

ECONOMIC GROUP 3.

(The unimportant corn insects: visitants whose presence is not merely accidental, but which, on the other hand, do not injure the corn plant in a way to give them any appreciable economic consequence. A few species are included which have been once or twice locally injurious, but which are scarcely deserving of a place in the preceding section of this report.)

WILD BEES.

Halictus lerouxii Lep.

This small, dull, blackish bee, with narrow white or yellow bands across the abdomen, has been seen by us occasionally crawling over the silks, leaves, and husks of corn, gathering the pollen of the plant, apparently the only object of its visit. It appears very early in spring and continues until quite late in fall, making its collections from a great variety of flowers, evidently with no special preference for the corn plant.

ANTS.

Formicidæ.

Most direct injuries to corn by ants are economically insignificant. Their attentions to the corn plant-louse, *Aphis maidis*, found on the leaves, tassels, and silks of corn, are doubtless helpful to these insects as well as to themselves, but the corn leaf-louse is itself of slight importance, rarely doing any injury deserving of special attention. The corn root-louse (*Aphis maidiradicis*), on the other hand, is one of the most dangerous insects infesting the roots of corn, and often greatly diminishes the yield of the infested field. The ants which attend it are indispensable to its prosperity, and are thus indirectly highly injurious to the crop. These root injuries, however, have been treated in an earlier report.

FIG. 143. The Common House-ant, *Monomorium pharaonis*, worker. Enlarged as indicated. (Marlatt, U. S. Dept. of Agriculture.)

FIG. 144. The Common House-ant, *Monomorium pharaonis*, female. Enlarged as indicated. (Marlatt, U. S. Dept. of Agriculture.)

The Common House-ant.

Monomorium pharaonis Linn.

This minute insect, the common small red ant (Fig. 143, 144) which frequently infests the kitchen and the pantry and sometimes becomes an almost uncontrollable nuisance there, has been once reported as seriously injuring corn by gnawing the blades when they were but a few inches high for the purpose of drinking the sap which flowed from the wounds. In 1850 it was so numerous and active in some New York corn fields as to threaten to destroy every blade of corn in them.* It was first described from Egyptian specimens, and is world-wide in its distribution.

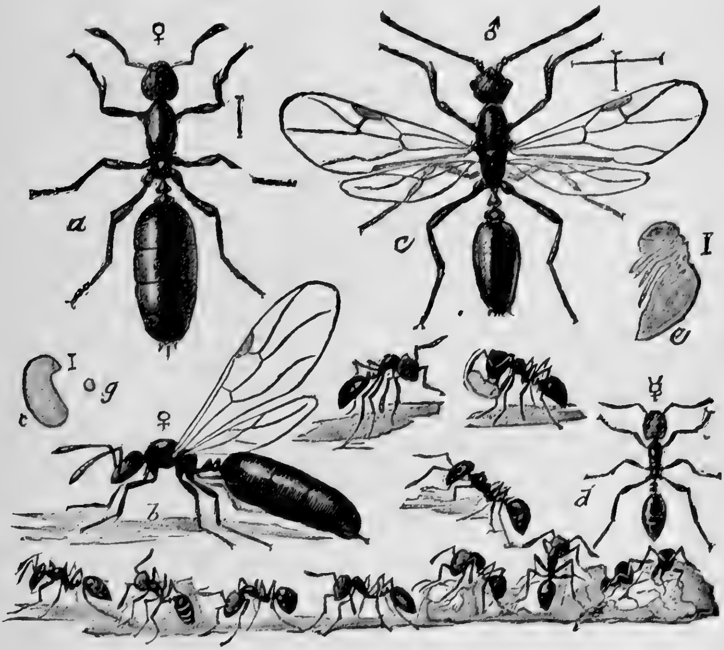


Fig. 145. The Little Black Ant, *Monomorium minutum:* *a*, female; *b*, same, with wings; *c*, male; *d*, workers; *e*, pupa; *f*, larva; *g*, egg of worker. Enlarged as indicated. (Marlatt, U. S. Dept. of Agriculture.)

The Little Black Ant.

Monomorium minutum Mayr.

This species closely resembles the troublesome small red ant of the kitchen and pantry except that it is entirely black (Fig. 145). It is also a house pest, but to a much lesser degree. It is frequently found in

*"First and Second Report on the Noxious, Beneficial, and other Insects of the State of New York," p. 129. By Dr. Asa Fitch. 1856.

fields, where its nests may be recognized by the little pyramids of fine grains of soil which surround the entrances. These ants are not uncommon on ripe ears in fall, about the exposed tips and under the husks. No appreciable damage by them has been noted, however, except to soft and imperfectly developed kernels, which they sometimes gnaw and hollow out.

Myrmica scabrinodis lobicornis Nyl.

In the discussion of the subterranean corn insects, this common, medium-sized, rough-bodied red ant (Fig. 146) was treated as injurious to the planted seed and as an attendant ant of the corn root-aphis.* It is mentioned here because of its occasional slight injury to corn grains in the ear in fall. In most cases, however, the kernels in which these ants have been found at work have apparently been previously injured by other insects or by birds. The species also attends the corn leaf-louse. It is distributed around the world in the northern hemisphere.

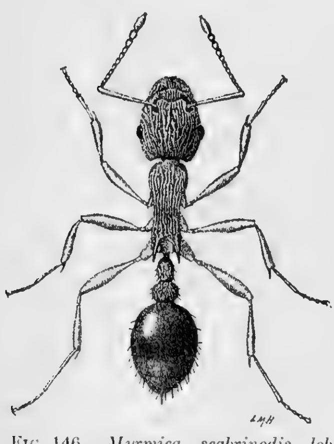


Fig. 146. *Myrmica scabrinodis lobicornis*, worker. Length, about three sixteenths inch.

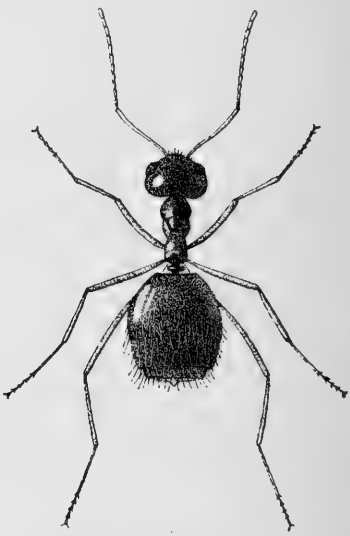


Fig. 147. *Prenolepis imparis*, worker. Length about one eighth inch.

Prenolepis imparis Say.

(*Prenolepis nitens*, in America.)

This small, shining, yellow and pitch-brown ant (Fig. 147) was found near Urbana, by Mr. John Marten, attending the corn leaf-louse September 25, and injuring corn grains at the tip of the ear in September and October. In the latter cases the grains had evidently been previously injured, one by an ear-worm which was still present in the ear. Web-

*Eighteenth Rep. State Ent. Ill., pp. 11, 66.

ster has found this ant feeding on broken grains at the tip of the ear. We have seen it in wheat and strawberry fields and on grasses and red clover. It resembles the small brown ant (*Lasius niger*) common in grass lands, but is much more shining, and the abdomen expands forwards strongly at the base, the scale of the nodal segment being correspondingly reduced. The head and abdomen are pitchy brown and darker than the thorax.

The Texan Agricultural Ant.

Pogonomyrmex barbatus Smith.

The curious agricultural ant of Texas bares the ground about its nest by cutting down and removing all vegetation, completely clearing a space often seven to twelve feet in diameter. Its nests occur in a great variety of situations, and cultivated crops, including corn, are sometimes seriously injured where the ants are abundant.

The mature inmates of a nest are the males, females, and minor and major workers, the latter being distinguishable especially by the large size of the head. The workers are wingless, dark claret-brown; the minor ones five sixteenths of an inch long, the major, seven sixteenths. The sexed individuals are winged, at least at first, paler in color; the males half an inch long; the females five eighths of an inch. These ants have a peculiar long beard on the under side of the head, which gives them their species name. They have been carefully studied by McCook, who has given us an interesting account of them and of their remarkable habits.* Farmers have reported to him the destruction of sweet potatoes, sorghum, and squashes, and in one case quite a serious injury to corn.

They open roadways—often radiating from the disks for hundreds of feet—a few inches wide at the starting-point, narrowing and branching as they go. Scattering over the surrounding area by means of these roadways, they harvest the fallen seeds of buffalo-grass and other grasses and store them in their nests. A growth of needle-grass or "ant-rice," supposed by some authors to have been planted by the ants, often springs up in their cleared areas. McCook thinks, however, that this is a voluntary growth which the ants permit for the sake of its seeds.

This ant occurs in Texas and Mexico, and probably northward into Indian Territory and New Mexico.

The Leaf-cutting Ant.

Atta fervens Say.

In this species we have another Texan ant of remarkable and interesting habits which is known to injure corn. It cuts out fresh leaves—

*"The Agricultural Ant of Texas." Philadelphia, 1880.

sometimes from the corn plant and stores the fragments in the nest, smooth leaves being preferred.

The worker ants are reddish brown, a third of an inch long, with disproportionately large heads. The winged females are about twice this size.

Oak and peach-trees are often completely defoliated by them, and they cut up the leaves of wheat, young corn, rose-bushes, and a variety of garden plants, and other smooth-leaved vegetation. Sugar, grain, dried tobacco, and berries are very attractive to them, but lettuce, figs, cedar, and mulberry are disliked.

The nest is opened in the morning, a procession issues to the plants to be attacked, and a return procession laden with leaf fragments soon appears. Their spoil is stored in large cavities under ground, where it seems to serve as a culture bed for fungi, which are used by the ants as food. They make deep excavations to reach a water supply, and also

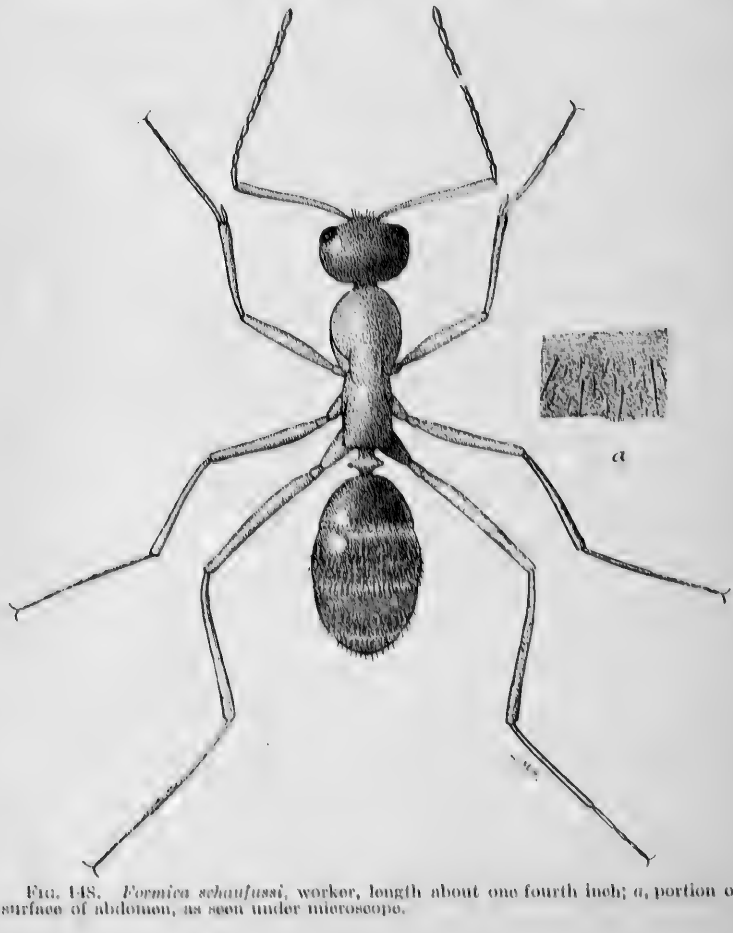


FIG. 148. *Formica schaufussi*, worker, length about one fourth inch; *a*, portion of surface of abdomen, as seen under microscope.

underground tunnels hundreds of feet in length, sometimes passing under streams, and thus gain access to orchards and gardens and other important food supplies.

They are very shy of poisons, and can scarcely be killed in their large and complicated nests by insecticide fumes, but can only be controlled by the expensive operation of digging out and destroying the breeding centers of their underground establishments.

The species occurs from Mexico northward to Texas and Arizona.

FORMICA SCHAUFUSSI Mayr.

This common, medium-sized, smooth, yellowish brown ant (Fig. 148) is referred to elsewhere as attending the plant-lice of both the roots and leaves of corn. It is mentioned here to record the fact that it is one of the insects which have been found several times by us gnawing the exposed kernels on ears of corn in fall. Sometimes these ants were merely enlarging injuries previously caused by grasshoppers, but in other cases they had evidently gnawed into exposed but unbroken grains.

This species is generally distributed over the United States.

FLIES.

Diptera.

A MEADOW MAGGOT.

Tipula costalis Say.

FIG. 149. A Meadow Maggot, *Tipula bicornis*. Three times natural size.

The meadow maggots or leather-jackets (Fig. 149), notorious for their various agricultural injuries in the Old World, have not been classed among the more important crop pests of America, the habits of our species seeming to be, as a rule, those of vegetarian scavengers. Occasional instances have been reported, however, of serious injuries to grass, clover, and cereal crops, but only one, so far as I know, to corn.

These maggots are thick-skinned, wrinkled, dirty gray, footless larvæ, without color markings of any kind, an inch or a little more in length when full grown, rather blunt behind, and somewhat narrowed forwards to the head, which is very small but distinct and hard, yellowish or brown in color, and commonly much withdrawn within the following segment. The general surface is without warts or other processes, but there are a few fleshy or finger-shaped lobes at the hinder end of the body, and in full-grown specimens a pair of small horny hooks. These maggots move with considerable activity, stretching out the body and pulling themselves forward by the aid of the hooklike jaws beneath the head.

Webster reports a case of possible injury to corn by the larvæ of *Tipula costalis** on ground which had been in clover the year before. An unusual abundance of meadow maggots had been noticed in the clover by the owner, and was by him believed to be the cause of a considerable reduction of the clover crop. The tipulid larvæ were also present in considerable numbers in the clover turf the following May, when the ground was planted to corn. The crop continued thrifty until August, when it ceased to grow, the roots being eaten in a way to suggest that the meadow maggots were responsible. As the adults of this crane-fly appear in September, laying their eggs in fall, the life history of the species is consistent with this interpretation. The immunity of the corn in the early part of the year may have been due to the fact that the debris of the clover turf furnished at first a sufficient food for the larvæ. The case is a doubtful one, however, and mention of the matter is made merely to call attention to the possibility of injury to corn under such conditions.

The Corn-feeding Syrphus-fly.

Mesogramma politum Say.

(*Mesograpta polita.*)

The soft, fleshy maggots (Fig. 150, *a*) of the syrphus- or flower-flies are very often seen preying on plant-louse colonies, and it is an exceptional fact that the above member of this group feeds, in the larva state, on the pollen and juices of corn. This very common species is widely distributed, ranging from Connecticut to Kansas, and south to Georgia, Mississippi, Florida, and Cuba. Its presence on corn has been noticed in Illinois, New Jersey, Delaware, Virginia, Florida, and Missouri, sometimes in great abundance. In one case "the stalks were literally covered by them," but in no case was there proof that they had done any serious injury.

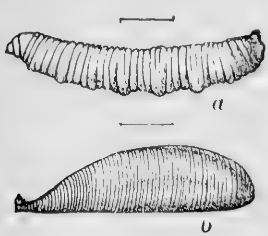


Fig. 150. The Corn-feeding Syrphus-fly, *Mesogramma politum*: *a*, larva; *b*, puparium. Enlarged as indicated. (Riley and Howard, U. S. Dept. of Agriculture.)

Like other syrphus larvæ, these are broadest posteriorly, tapering forwards to a comparatively small head. They are about a fourth of an inch long, yellowish, and many-ringed. They congregate upon the tassel, in the bases of the leaf-sheaths, on the husks, and wherever fallen pollen has collected. Examination of the alimentary canal of specimens collected by us showed that they had fed upon the pollen grains.

Ashmead found in Florida that instead of eating the pollen of corn

*Bull. No. 26, U. S. Dept. Agr., Div. Ent., p. 74.

they were puncturing the tissues and drinking the sap. He also reports them as feeding on cotton pollen in Mississippi.

"The whole transformation from egg to fly," says Ashmead, "is completed within a comparatively short period of less than three weeks. The eggs hatch in from three to four days; the larva matures in from eight to ten days; and the fly appears in from eight to thirteen days."* His studies were made in May and June, but in the Atlantic States larvæ have been reported from late August to September 15, after which no more were seen. A puparium was found on corn in southern Illinois July 29.

Fig. 151. The Corn-feeding Syrphus-fly, *Mesogramma politum*, x, x, puparia on corn tassels. (Sanderson.)

The brownish puparia (Fig. 150, *b*) are club-shaped, with the head at the small end, and are formed among the florets of the tassel (Fig. 151) and upon the surface of leaf or stalk. The adult flies (Fig. 152), like most others of this family, are prettily marked with yellow and black, giving them a suspicious resemblance to small bees or wasps, because of which they are often mistaken for the so-called "sweat-bees" (*Halictus*). They often cause

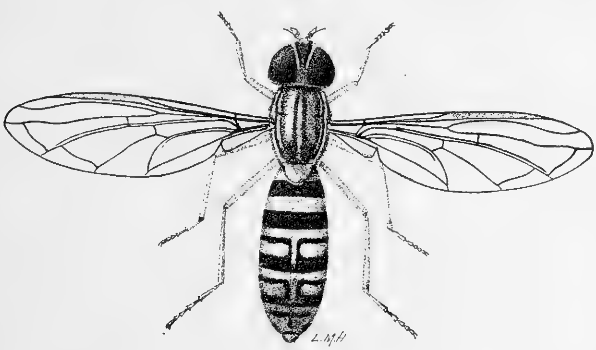


Fig. 152. The Corn-feeding Syrphus-fly, *Mesogramma politum*. Length about one third inch.

annoyance when very abundant by alighting on the hands, face, and clothing, especially when one is perspiring. We have taken them from July 15 to October 5; most frequently in August and September.

*Insect Life, Vol. I., p. 7.

The Corn Leaf-miner.

Diastata sp.

Not infrequently corn leaves are marked by serpentine light-colored tracks, caused by minute larvæ burrowing within the leaf, devouring the inner tissues, and leaving the semitransparent epidermis intact. Larvæ from burrows of this kind observed by us in Illinois have usually been those of leaf-mining moths.

The present species, however, is a fly belonging to the *Geomyzidæ*, a family closely related to the frit-flies (*Oscinidæ*). The other larvæ of the family live, so far as known, in the stems of plants. Those of this species were found by Comstock* in corn leaves in the south part of Washington, D. C. The mines were about a tenth of an inch wide and five or six inches long. They were quite abundant, three or four to a leaf, and situated near the edge. The larvæ were about a fifth of an inch long, greenish white, with arched back and a pig-like anterior end.

These mines were noticed late in June. About July 12 the larvæ began to mature and break through the upper epidermis, dropping to the ground. Just beneath the surface they transformed to oval brown puparia, and three weeks later a shining black adult fly about an eighth of an inch long emerged, apparently an undescribed species of *Diastata*.

The same species was reported by Ashmead as quite frequently met with in corn leaves in Florida.

The Stalk-maggot.

Chætopsis ænea Wied.

The yellowish maggots of this very common and widely distributed fly are frequently found in the stalks and under the leaf-sheaths of a number of crop and other plants, usually in the midst of more or less decaying tissue. In many cases, possibly in all, they are acting as scavengers in a previous injury, but they undoubtedly greatly aggravate the original wound, and there is reason to believe that healthy plants are also attacked by them.

These larvæ (Fig. 153, *a*) are about a quarter of an inch long and a twenty-fifth of an inch thick, footless, yellowish, the head end tapering and slender, the posterior end suddenly and bluntly rounded off, with two short, brown, cylindrical projections. They are found in the corn-stalk, usually not far above or below the surface of the ground, or behind a leaf-sheath. Young larvæ apparently of this species have been found by us in broom-corn roots, and once in a burrow in a corn root.

Their injury is often common and conspicuous in wheat and oats, the upper part of the affected plants withering and whitening. In 1894 it

*Rep. U. S. Ent., 1880, p. 245.

was reported from Florida that five per cent. of the sugar-cane sprouts were infested by them, and in Michigan they have been charged with an extensive injury to onions, including the destruction of two thousand acres of this crop. Rushes and wild grasses are also infested by them.

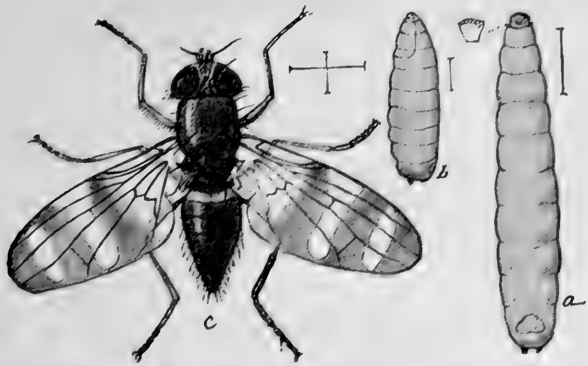


FIG. 153. The Stalk-maggot, *Chætopsis ænea*: *a*, larva; *b*, puparium; *c*, adult. Enlarged as indicated. (Riley and Howard, U. S. Dept. of Agriculture.)

We have bred the flies from larvæ in a large-stemmed grass and in the common reed, *Phragmites communis.*

The species is common throughout the United States east of the Rocky Mountains, and ranges from Canada to Cuba.

The slender, pointed eggs are inserted singly or in groups of two to five just beneath the leaf-sheath. The mature larva changes to a yellowish or brownish puparium (Fig. 153, *b*), from which, in due time, emerges a handsome, bright metallic-green fly (Fig. 153, *c*) about a fifth of an inch long, the transparent wings crossed by three blackish bars. Larvæ found in infested onions in Michigan in October wintered over and emerged the following spring. In Illinois the adults are common in May and the larvæ in late June and early July. Very few adults have been taken in June, but they are again common in July. This is probably the second brood, as Garman suggests. Larvæ taken by us in September and early October yielded adults, by breeding, in late September and October. None were taken in August, but they are again recorded in our notes as common in decaying tissue of corn November 6. There are therefore at least three broods, and possibly four.

CERATOMYZA DORSALIS Loew.

(*Odontocera dorsalis.*)

This leaf-mining maggot has been twice reared to the adult. The egg is inserted near the tip of the corn leaf, whence the larva burrows downward in a sinuous path (Fig. 155), eating away the green inner tissue as it goes. Its course is evident as a lighter colored track, gradually widening as the larva increases in size. One mine was nearly twenty inches long. Corn in a greenhouse at the Connecticut Agri-

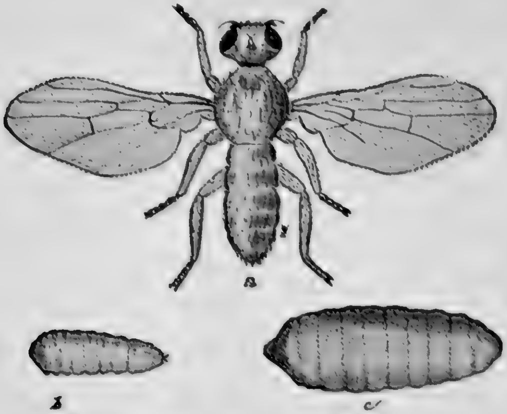


FIG. 154. *Ceratomyza dorsalis:* a, adult; b, larva; c, puparium. Length about one eighth inch. (Britton.)

cultural Experiment Station was extensively tunneled by this insect in July, and a few mines were also seen on garden corn. In West Virginia it did considerable damage to timothy in 1898.

The larva (Fig. 154, *b*) is pale yellow, footless, about an eighth of an inch long. It forms in the mine a darker colored puparium (Fig. 154, *c*), from which the adult fly emerges (Fig. 154, *a*). This is blackish varied with brown or yellow, with transparent wings. It has been found in New Jersey and the District of Columbia.

FIG. 155. *Ceratomyza dorsalis*, mine in corn leaf. Natural size. (Britton.)

LEREMA ACCIUS SM. & ABB.

(*Pamphila accius.*)

This little skipper butterfly inhabits the region bordering the Gulf and Atlantic coasts from New England to Mexico. It has been taken by French in southern Illinois, but its occurrence in our state must be altogether exceptional. Its caterpillar is said by Abbot to eat the leaves of Indian corn, and it is also recorded from a leguminous plant (*Wistaria frutescens*) and from the woolly beard-grass (*Erianthus alopecuroides*).

Both the larva and pupa are whitish or pale green, the larva with some darker markings. The pupa has the anterior end remarkably drawn out to a long, slender point. In the South the butterfly is said to occur from early spring till late in autumn. Scudder infers from the data obtainable that it hibernates in the pupa stage, the adults appearing in April and again in late June and in fall (September and October), three broods in all. The pupa stage lasts eight days in midsummer, according to Abbot.

THERETRA TERSA Linn.

(Chærocampa tersa.)

The caterpillar of this species (Fig. 156), which resembles the common tomato-worm but is smaller and differently marked, was found by us in southern Illinois feeding on late corn, in the crown of the plant.

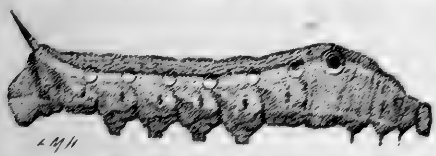


Fig. 156. *Theretra tersa*, larva. Natural size.

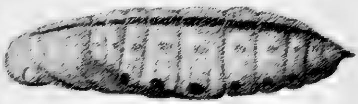


Fig. 157. *Theretra tersa*, pupa. Natural size.

The genus is essentially tropical, and the present species ranges from South America through Central America and the West Indies to the southern United States, and thence sparingly to Colorado, Minnesota, and eastern Canada. In the South and West it is common, but in our latitude it is met with infrequently. Beutenmüller says that it is rare in New York, where it is sometimes found flying in flower-gardens. Its favorite food plants seem to be of the madder family. We have bred it at Urbana from *Galium*, and in the University greenhouse from *Bouvardia*. In the South it feeds on buttonweed, *Spermacoce glabra*.

The larvæ are about two and a half inches long. As in the green grape-sphinx (*Everyx myron*), a pair of pale lines, one on each side, rise and converge behind to the base of the caudal horn. Instead of a line of dark dots down the middle of the back (as in the grape-sphinx) the back is covered with short longitudinal black lines, and the pale side-line bears a row of eye-spots ringed with black, that on the fourth being

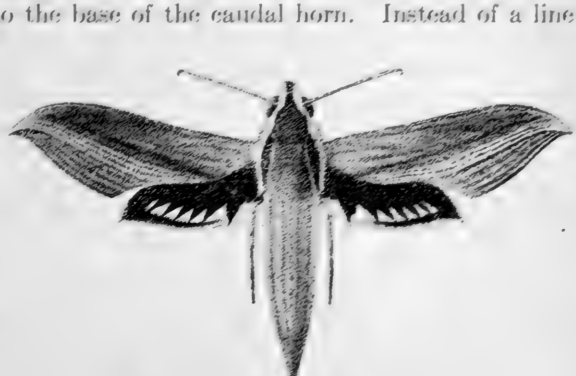


Fig. 158. *Theretra tersa*, adult. Natural size.

the largest, with a conspicuous black center. When full grown the caterpillar forms an imperfect cocoon in the earth, at or near the surface, by loosely webbing together particles of earth, leaves, or rubbish.

The species is evidently two-brooded, hibernates in the pupal stage (Fig. 157), and the first moths (Fig. 158) are produced in May and early June, and caterpillars of the first brood late in July and in August. The second brood of caterpillars appears in September and October and pupates before winter sets in.

FIG. 159 *Hyperchiria io*, larva. Slightly enlarged.

HYPERCHIRIA IO FABR.

(*Automeris io.*)

This large and conspicuous spiny caterpillar (Fig. 159) is widely distributed, although not especially common, throughout the country. It has a wide range of food plants, largely trees, but is not rare in cotton and corn fields, feeding on the leaves. On one occasion in Louisiana thousands of them stripped cotton plants of their leaves. It is a very miscellaneous feeder, and nearly one hundred kinds of plants have been reported as eaten by the caterpillar.

The young larvæ are dull yellow, with black spines and head. They arrange themselves in a row, side by side, across a leaf, beginning at the tip and eating towards the base. They keep close together, and when changing position on the plant travel single file. They rest by day, and when about to molt draw together with silken threads a few leaves for a protecting shelter. As they approach maturity they no longer keep together, but they make clean work of a plant or branch before leaving it. They are then pale green in color, with a dusky white stripe each side, edged above with lilac or red. On each segment is a row of usually six tufts of spiny bristles, about thirty in a tuft, more or

FIG. 160. *Hyperchiria io*, male. Natural size.

less branched, and green tipped with black. These spines are sharp and poisonous, and unless the larvæ are handled very carefully or with gloves will puncture the skin, causing white elevated blotches, sometimes followed by swelling, inflammation, and pain, continuing for days. The full-grown larva is about two and a half inches long. It descends to the ground and forms a rough covering in the loose leaves and

FIG. 161. *Hyperchiria io*, female. Natural size.

rubbish, within which it spins a slight cocoon of tough, gummy silk, soon changing to the pupa.

Except possibly in the extreme South, this species is single-brooded. A few moths (Fig. 160, 161) emerge in fall, but most continue in the pupal stage over winter, emerging in June and July. The caterpillars are found with us from the middle of June to the middle of September, the average larval life being about two months.

THE SORGHUM WEB-WORM.

Celama sorghiella Riley.

(*Nola sorghiella.*)

This troublesome pest of the sorghum plant, which webs the brush and seeds together, may be mentioned here because it has been taken by Ashmead from tassels of corn. In sorghum numerous delicate tubes are formed, through which the caterpillars pass, feeding primarily on the germ but sometimes devouring the whole seed.

The mature caterpillar is half an inch long, yellowish or light greenish yellow, with a small yellowish head. There is a sulphur-yellow line along the middle of the back, and on each side a brownish longitudinal stripe and a transverse row of six tubercles on each segment, each tubercle bearing a yellow bristle tipped with brown. These caterpillars are active when disturbed, and transform on the ground in delicate cocoons covered with particles of foreign material.

THE SMARTWEED CATERPILLAR.

Acronycta oblinita Sm. & Abb.

This is a brightly colored hairy caterpillar (Fig. 162, *a*) one and a fourth to one and a half inches long, black, striped and spotted with yellowish, especially common on smartweed and willow but also feeding on corn and a great variety of other plants. It has shown no sign, however, of becoming troublesome as a corn insect. It occurs through the United States east of the Rocky Mountains and in Canada. It is recorded from three species of smartweed, eating leaves and blossoms, and we have taken it on five species of willow, which it often seriously defoliates. It is also injurious to poplar and cottonwood, as well as to peach, apple, and strawberry. Other food plants recorded are grape, bean, asparagus, cotton, buckwheat, wheat, wild and cultivated raspberry, blackberry, grasses, button-bush, pear, Lombardy poplar, hazel, oak, butternut, elm, alder (*Alnus serrulata*), and pitch-pine, to which list recent observations in Chicago parks have added canna, lilac, honeysuckle, and soft maple.

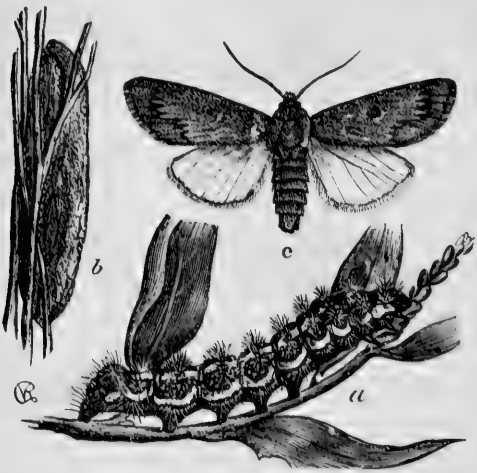


FIG. 162. The Smartweed Caterpillar, *Acronycta oblinita*: *a*, larva; *b*, cocoon; *c*, adult. Natural size.

In this latitude there are two broods in a year, but studies in Canada indicate that there the species is single-brooded. Pupæ are formed in fall and winter over, emerging the following spring from the beginning of April to the last of May, most abundantly about the middle of May,—in Canada not until June. The first brood of larvæ occur in June and July, but are not usually so numerous as the second brood. The next brood of moths may be taken from late June to September, especially in July and August. The second brood of larvæ are scattered through late August, September, and October, and pupate before winter sets in. In Canada the larvæ from the June moths spin up and pupate early in fall, ready for hibernation.

THE ZEBRA-CATERPILLAR.

Mamestra picta Harr.

This caterpillar (Fig. 163, *a*) is a highly miscellaneous feeder, most notable for its injuries to cabbages, but reported also as sometimes abundant in timothy, and in one case destructive to oats. It is included among the corn insects by reason of reports from various entomologists of its actual, but occasional, appearance on that plant. Webster found the caterpillar gnawing away the silk in September from ears of growing corn in Indiana, and Harvey reports that the species eats the silks of sweet corn in Maine. It was treated in the Twenty-first Report of this office (page 153). The known food plants not mentioned in that article are cabbage, strawberry, rose, sweet clover, lucerne, alsike and alfalfa, lettuce, and goldenrod, lily, gladiolus, and columbine.

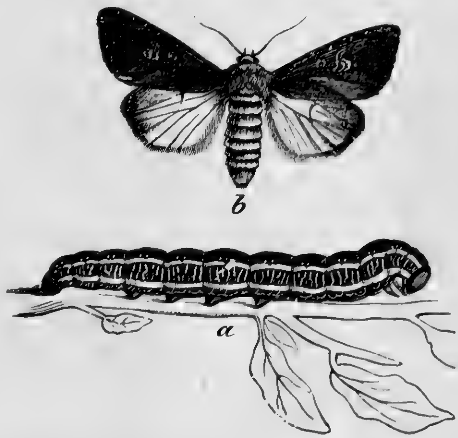


FIG. 163. The Zebra-caterpillar, *Mamestra picta*: *a*, larva; *b*, adult. Natural size. (Riley, U. S. Dept. of Agriculture.)

The moths (Fig. 163, *b*) appear in April, May, and June, the first brood of the caterpillars in June and July, and the second in September and October. Most of the latter pupate before winter and emerge the following spring, but in the latitude of Michigan those which fail to mature before cold weather may pass the winter as larvæ, and get their growth the following spring.

LEUCANIA PSEUDARGYRIA GUEN.

(*Heliophila pseudargyria.*)

Of this common and widely distributed relative of the army-worm, the obtainable data are remarkably imperfect, and further information is much to be desired. The species is generally distributed east of the Rocky Mountains, north into Canada, but seems not to occur in the Southern States. Beutenmüller says that it is common in New York, and that the larva feeds on grass, corn, wheat, oats, timothy, etc. Webster swept it from young wheat in Arkansas. All records agree that it feeds on species of the grass and grain family.

The larva is not conspicuously striped. It is dull greenish gray, sprinkled with dark brown above, the subdorsal and lateral areas lighter and freer from dots. There is a faint, clear whitish dorsal line, and sometimes another each side above the spiracles. There is a brown patch at the base of each abdominal leg. The head is like the body in color, with two brown streaks. The piliferous spots are small. The pupa is formed without a cocoon, both in the ground and under dry grass on its surface.

Fig. 164. *Leucania pseudargyria*. Slightly enlarged.

The adults (Fig. 164) are about the size of the army-worm moth, but the ground color is cold gray rather than brownish. In the army-worm there is a distinct blackish line leading from the outer edge of the fore wing, just behind its apex, diagonally inward to a variably distinct curved row of blackish dots crossing the wing, and exactly in line with this row, back of the meeting-point. In the present species this row of dots is straighter and a quite conspicuous feature, and the black line is represented only by a small isolated blackish cloud between it and the margin. There is also a zigzag dark line across the wing at its basal third, nearly or quite absent in the army-worm moth. The moth is seldom seen at lights, but is common on sugary mixtures spread on trees as baits. The males are uniformly larger than the females.

All the recorded larvæ were taken in early spring, having evidently spent the winter in this condition. They pupated in March or April, in one case without taking food, and, after a pupal life of twenty-seven days in two cases, emerged April 18 and May 20. Moths are recorded from this time on until September 18, sparsely in May, June, and the early part of July, more abundantly in the remainder of July and in August, sparsely in September. The August and September data are mostly in our own records for central Illinois. The species is probably double-brooded, the moths appearing in April and May producing a brood of larvæ in June and July, of which we have no record, these changing to moths in later July, August, and September, from which come in fall the hibernating brood of larvæ. Beutenmüller says that there are two or three broods.

SPANWORMS.

Geometridæ.

It is odd that not a single spanworm is listed by name among corn-feeding larvæ. J. B. Smith,* however, mentions a strongly marked "spanworm, the larva of a Geometrid," eating seed-corn and young corn plants. The correspondent sending it said that he felt certain that he had seen it in previous years in the stalks of dahlia and pigweed.

THE SADDLE-BACK CATERPILLAR.

Sibine stimulea Clem.

(*Empretia stimulea.*)

The saddle-back caterpillar is widely distributed throughout the United States but is not common. The red-brown larva (Fig. 165), about an inch long, is easily recognized by its footless, sluglike character, and by the peculiar markings upon its back, which suggest a green saddle-cloth with a brown saddle in the center.

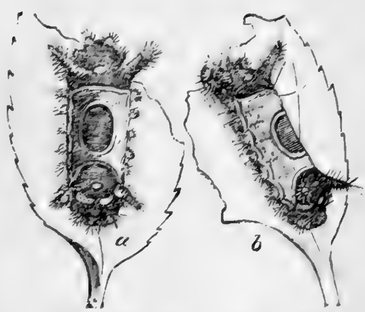


Fig. 165. The Saddle-back Caterpillar, *Sibine stimulea:* *a*, as seen from above; *b*, side view. Natural size. (John B. Smith.)

It has been frequently found feeding on the leaves of corn, and also eats the leaves of a few *Compositæ* and of a great variety of trees and shrubs.

The eggs are found in masses on the upper side of the leaf. The larva is a broad flattened caterpillar, and uses its entire fleshy under-surface for crawling. At either end of the body are two long stout horns armed with poisonous spines, and beside these is a row of spiny tubercles. The ends and sides of the body are brown, and a square green patch, edged with white, bearing an oval velvety-brown spot in the center, nearly covers the back. The larvæ feed in colonies until after the last molt, when they scatter over the surface. They lie, while feeding, upon the upper surface, and work from the tip to the base of the leaf. The cocoon is of tough, brown, parchmentlike material, and is short, oval, and flattened against the

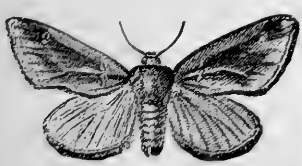


Fig. 166. The Saddle-back Caterpillar, *Sibine stimulea*, adult. Natural size. (Saunders.)

*Insect Life, Vol. VI., p. 188.

tree-trunk or other support to which it is fastened. It has a large circular flap at the anterior end, cut out by the larva so as to be easily pushed open by the emerging moth (Fig. 166).

LEAF-ROLLERS.

Tortricidæ.

The Sulphur Leaf-roller.

Epagoge sulfureana Clem.
(*Dichelia sulfureana.*)

Leaf-roller larvæ roll or fold up leaves or parts of leaves in various ways, making more or less of a web within the cell thus formed, to hold the leaf in position and to make a convenient and safe retreat. These larvæ are slender, greenish, and active. They venture forth to feed on the near-by leaf tissue, but do not destroy much of it. Unless very abundant, therefore, their injury is altogether insignificant. Corn leaves may occasionally be found folded or rolled lengthwise, and if the leaf is opened the larva or brown pupa may be seen in its web. Two or more species affect corn in this way. The present species is one of the commonest leaf-rollers, but, although too common at times on clover and celery, it has never been known to cause any injury of consequence to corn.

It is a slender, active, yellowish green or translucent green larva, half an inch long or more, which rolls and webs the corn leaf lengthwise, and, when disturbed, spins a thread for its escape.

It is recorded from most of the states in the northern half of the country, from Maine to the Mississippi River and south to Virginia; also from Missouri, Colorado, and Texas. Besides the food plants mentioned, it feeds on strawberry, cotton, salsify, asparagus, grape, orange, willow, locust, pine, and a variety of common weeds and wild plants, including *Ranunculus acris*, *Erigeron canadense*, *Verbena urticæfolia* and *hastata*, *Monarda fistulosa*, and burdock. It seems quite partial to opening flowers, as of clover and fleabane (*Erigeron*). It has been found inhabiting large cecidomyiid galls on willow.

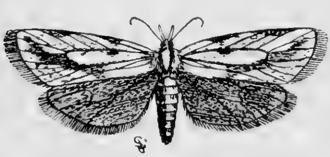


Fig. 167. The Sulphur Leaf-roller, *Epagoge sulfureana*, adult. About three times natural size.

The larva tapers each way, and is translucent or yellowish green, with pale head and no definite markings. It pupates in the rolled leaf, the pupa being very dark in color—almost black. The adult (Fig. 167), with folded wings, is about a quarter of an inch long, somewhat flat and squarish, the wings being rather broad. Their ground color is sulphur-yellow, the purplish markings conjointly forming an X, usually quite distinct.

From the records of about twenty-seven rearings and a large number of dates for the adult, the species seems to be imperfectly three-brooded in Illinois. In the District of Columbia it is three-brooded, according to Comstock, in Michigan two-brooded (Cook), and in Maine probably single-brooded (Fernald), as also in Minnesota, judging from Lugger's statements. Davis's supposition that it winters as a pupa is apparently wrong, as its first records for the season are all of the larval stage. Very probably it winters as a larva, as Comstock suggests. The first brood of moths in the District of Columbia and New Jersey appears in the latter part of May and early June; in Illinois, from June 10 to the beginning of July; still later in Michigan (Cook); and in Minnesota in July (Lugger). The second brood comes about a month and a half later; in Illinois, from late July to the beginning of September. In Michigan, larvæ of this brood probably hibernate, but in Illinois a part, at least, reach the imago stage in late September and early October, as is indicated by a slight increase at that time in the number of imagos present at lights. In the District of Columbia there seems to be a full third brood of adults in September. The larvæ with us are found from the middle of May until after the middle of June; the second brood, in July and the first part of August. A single larva taken early in September, which became an adult September 17, probably belonged to the third brood.

The Red-banded Leaf-roller.

Eulia triferana Walk.

(*Lophoderus triferanus.*)

This is another wide-spread leaf-roller which includes the corn plant among its diversified food resources. It has lately caused a very unusual and severe injury to green pop-corn in New York by infesting the ear and destroying the kernels. Over a fourth of the crop was involved, and about three eighths of the corn on the infested ears was destroyed.

This species is found from Maine to New Jersey and west to Missouri, and also in Texas. It has a large and varied list of food plants, including among trees, the apple, oak, elm, soft maple, and Osage orange; among garden crops, beans, asparagus, salsify, and tomato; among field crops, corn, pop-corn, and clover; also raspberry, cranberry, *Gnaphalium polycephalum*, rose, chrysanthemum, lobelia, and honeysuckle. Raspberry and tomato have not previously been recorded.

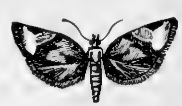


Fig. 168. The Red-banded Leaf-roller, *Eulia triferana*, adult. Twice natural size.

The larvæ are light green. They pupate in the rolled leaf according to an observation made at this office. The adult (Fig. 168) is a small, deep reddish brown moth, about half an inch across the expanded wings.

Felt surmises that the species is probably two-brooded, and, with numerous records of collection and breeding to judge from, this seems likely to be correct. Moths have been taken in April, larvæ in May, moths bred and collected in June, larvæ appearing again in July and early August, and these bred on five different occasions to the adult in late July and in August. The adults of this brood probably winter over, reappearing in April and producing larvæ in May.

The Rusty-Brown Tortrix.

Platynota flavedana Clem.

This is a small, dark greenish caterpillar, not uncommon in the eastern part of the country as a leaf-roller on the strawberry, raspberry, and red and white clover. It is said by Titus and Pratt* to feed in ears of green corn, no further details being given.

The full-grown larva is about half an inch long, dark yellowish green, and covered with minute brown granulations. The head and neck-shield are reddish, and the anal plate colored about like the body, with three dusky spots near its anterior margin. The piliferous tubercles are a little lighter. The larvæ pupate early in September, and soon afterwards the moths appear. The sexes are unlike: the males, dark brown, with the tip and base of the fore legs reddish yellow; the females, dull rust-red, with three oblique bands. The hind wings are rust-red.

A TINEID LEAF-MINER.

Batrachedra rileyi Wlsm.

This tineid has been bred by the U. S. Department of Agriculture from larvæ injuring corn in the husk, both in field and in storage, and also cotton bolls in Texas and probably other parts of the South. No further biological information about the species has been published.

THE GROUND-BEETLES.

Carabidæ.

The ground-beetles are of medium size, usually black or green. They may be seen actively running for other shelter when boards or sticks are lifted from the ground, or scurrying through the grass or over the ground in the fields. They are generally regarded as predatory in habit, and they often capture caterpillars and other soft-bodied insects and suck out their juices and softer portions, or else devour their bodies

*Bull. No. 47, N. S., U. S. Dept. Agr., Div. Ent., p. 56.

entire. Many of them, however, feed more or less on vegetation, principally the seeds and tissues of grasses and grains, including corn; and some common genera, notably *Anisodactylus*, *Harpalus*, and *Amara*, derive the greater part of their food from such sources. Species of these genera are often seen on the tops of grasses and other plants, feeding on the

Fig. 169. *Pterostichus permundus.* Five times natural size.

Fig. 170. *Pterostichus lucublandus.* Five times natural size.

seeds. So far as the habits of the larvæ are known they seem to be much the same as those of their respective adults.

Several species have been seen by us in fall hollowing out grains of corn, especially on fallen ears or broken-down stalks or where decay or previous injury facilitated their work. *Pterostichus permundus* (Fig. 169) was found eating away the side of a fallen kernel, beginning at a point of previous injury. *P. lucublandus* (Fig. 170) was seen on fallen ears, eating into a number of grains and leaving only a thin shell. *Amara musculus* was found with other insects among husks and on the ears of standing corn. Individuals of *Platynus crenistriatus* were seen on a fallen and slightly decayed ear of corn, feeding freely on the grains. *Platynus cincticollis*, found on an ear of corn on the stalk, had completely hollowed out two of the kernels. *Anisodactylus rusticus* was found beneath the husks of an ear of corn on the stalk, in a cavity which it was making in one of the grains, and other grains were seen similarly injured.

Agonoderus pallipes (Fig. 171) has already been treated in the Eighteenth Report (page 12) as injurious to the seed and roots of corn; and it was also found by us injuring corn in the ear—especially fallen ears—more frequently than any other ground-beetle. Often the enwrapping husks are eaten away by it, and then the grains beneath are eaten out. Serious injury to sprouting corn in Texas by this beetle has lately been reported by a correspondent of the U. S. Bureau of Entomology, involving a loss of about nine tenths of the crop on fifty acres planted. It has been noticeably injurious to planted seed-corn in several Illinois counties during the spring of the present year (1905). It may well be called *the seed-corn beetle.*

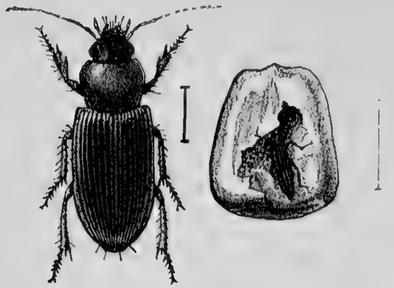


Fig. 171. *Agonoderus pallipes*, and injury to seed kernel. Enlarged as indicated.

A remarkable charge of injury to corn has been made against *Omophron labiatum* (Fig. 172). The ground-beetles of this genus live in wet sandy places, especially along shores, and are usually predaceous. The subfamily *Carabinæ*, to which they belong, is otherwise exclusively predaceous so far as known. The *Omophron* beetles are hemispherical, and quite unlike typical ground-beetles. The larva of this species, which is not known to occur in Illinois, is said to be very destructive to young corn in the Southern States. One author says that it feeds on the grains, and another, on the young shoots.

The adult ground-beetles usually winter over; sometimes, perhaps, the larvæ. Eggs of some species are known to be laid in early summer in the ground. The larvæ live in burrows and mature in the latter part of the season. They are rather long-legged and active, whitish to brownish, sometimes more or less black.

Fig. 172. *Omophron labiatum*. Length about one fourth inch.

THE LADYBUGS.

Coccinellidæ.

The common black-spotted red or yellow ladybugs are well-known enemies of plant-lice, upon which both larvæ and adults generally feed. They also eat larvæ and soft-bodied insects of various kinds, together with the pollen and floral organs of grasses and some other plants, and spores of fungi and lichens. They have been repeatedly reported in different parts of the country, eating corn kernels, especially when in the milk, and occasionally, also, the leaves of the plant. *Megilla maculata* has been seen by us hollowing out exposed kernels at the tip of the ear, following upon some previous injury. Pergande saw several beetles and larvæ eating young corn kernels near Washington, and in Maryland this ladybug has done considerable injury by eating holes in the leaves of corn. *Coccinella novemnotata* was once seen eating the leaf, and has also been taken by us within the husks on the standing ear.

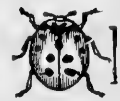


Fig. 173. *Coccinella 9-notata.* Enlarged as indicated.

Fig. 174. The Common Ladybug, *Megilla maculata.* Length about three sixteenths inch.

The common ladybug, *Megilla maculata* (Fig. 174), is rather narrowly oval, about a quarter of an inch long, a bright pinkish red, spotted with black. The thorax is distinctively marked with two oval black spots, one each side of the middle. On the wing-covers are ten black spots, alternately three and two in four transverse rows. The nine-spotted ladybug, *Coccinella novemnotata* (Fig. 173), is of about the same size, but broadly oval and very convex, and yellowish or orange. The thorax is black, with an irregular yellowish margin in front. The wing covers bear a black central spot on the suture in front, and four spots in diamond-shaped arrangement on each wing-cover. The larvæ are elongate, marked with black, yellow, and red, and bear rows of small tubercles and short, stiff hairs.

SCAVENGER-BEETLES.

Clavicornia, Lamellicornia, etc.

A large number of our common very small beetles come under this general head, the club-shaped antenna, which suggested the term *Clavicornia*, being usually, though not always, associated with a preference for dead animal and vegetable substances. Very few of them are ever serious crop pests, although a number are quite destructive to stored grain and to other vegetable and dry animal substances. Occasional species have appeared on corn plants for various reasons, sometimes causing minor injuries, such as the gnawing of ripe grains in the ear. These belong to the families *Staphylinidæ*, *Phalacridæ*, *Nitidulidæ*, *Latridiidæ*, *Trogositidæ*, and *Scarabæidæ*.

The Rove-beetles.

Staphylinidæ.

These active beetles are remarkable for their very short wing-covers, which leave a large part of the abdomen exposed above. They are rather elongate, mostly quite small, and very common under sticks and boards lying on the ground. Sometimes they fill the air, looking like small gnats, and cause much annoyance by getting into the eyes of people in motion. They are usually scavengers, or predatory on other insects. Two species have been noticed in numbers in corn ears, but were very likely feeding on exudations or organic debris.

Professor Harvey, of Maine, found *Ancyrophorus planus* feeding on the exudations in an old burrow of the corn ear-worm.

A number of specimens of a species identified for us by Casey as *Bolitochara* sp. were found by us on ears of fallen corn.

Phalacridæ.

These tiny, polished, black or brown, nearly hemispherical, oval beetles are found on flowers and leaves of various plants, and under boards and sticks on the ground in early spring. They are believed to subsist mostly on pollen and fungus spores and similar vegetable substances.

Phalacrus politus, a common black species, has been taken by us eating corn pollen and the smut on broom-corn. Lintner mentions its feeding on wheat smut in Nebraska. *Eustilbus apicalis*, a black species, with yellow-brown tips to the wing-covers, was found by us in injured corn grains at the tip of the ear and on the leaves, and very abundantly in shocked wheat at Anna, Illinois. *Orthoperus scutellaris* we have found crawling in numbers over corn silk and excavated grains probably previously injured by some insect. It was also reported to us as very abundant on apple-trees at Petersburg, Ill., especially on blighted twigs.

NITIDULIDÆ.

These are moderately small flattened beetles, usually oblong, sometimes oval or elongate, yellowish to blackish brown, often with one or more pairs of small spots above. The wing-covers are usually cut squarely off, not reaching the tip of the abdomen, but they are rarely so short as in the rove-beetles. The larvæ are rather broad and flattened, with short legs. These insects feed on a great variety of organic substances, notably fungi, bones, skins, exuding sap, and damaged stored grain, and at times extend their injuries to sound fruit and grain.

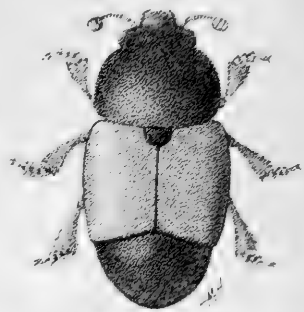


FIG. 175. *Carpophilus pallipennis.* Length about one eighth inch.

Species of *Carpophilus* occur on corn in the ear, and may gnaw the ripe grains. They are from an eighth to a sixth of an inch long, a fourth to a third of the body length being exposed above, behind the wing-covers. *C. pallipennis* (Fig. 175), dark brown with pale wing-covers, is found in Illinois, but is more common in the Southern States, where it is said to be numerous in late summer and fall on corn, feeding on grains injured by the corn ear-worm, and in cotton bolls that have been eaten by the boll-worm. It is known to feed readily on decaying cotton and fruits, and on the juices of bruised fruits and injured tree-trunks and limbs. Stored grain is eaten by it, especially if at all unsound from injury or decay. *C. dimidiatus* and *antiquus* are small brown species, which we have frequently found with other insects on injured corn ears in fall. The former is common in the Southern States, and has been noticed in injured cotton bolls and in figs and other fruits. It is a cosmopolitan species.

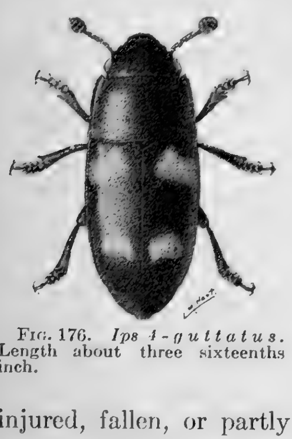


FIG. 176. *Ips 4-guttatus.* Length about three sixteenths inch.

Colastus semitectus has been found in decaying cotton bolls and corn ears in the Southern States, and also in injured figs. It probably feeds on fungi and rotten matter.

Ips quadriguttatus (Fig. 176), a larger species, already fully treated as a seed-corn insect in the Eighteenth Report of this office (*fasciatus*, page 23), is often very common about ripe ears in fall, especially on injured, fallen, or partly decayed corn; and the same fact has been reported by Harvey from Maine. An exceptional outbreak of this species was reported to us by Dr. F. W. Goding, who found the beetles in myriads in corn fields, swarming over stalks, leaves, and tassels, and feeding on the stalks. This beetle is sometimes very common in houses, and occasions much annoyance by getting into milk and other foods.

Latridiidæ.

These minute, elongate, light brownish beetles are quite common under boards and leaves in spring, on plants, and at times fly in numbers at dusk. Some species feed on stored cereals and on other vegetable or animal products. Others probably feed on pollen.

Fig. 177. *Melanophthalma distinguenda.* Length about one sixteenth inch.

A species called by Lintner* "the Corn Beetle," and doubtfully identified by him with *Cartodere ruficollis* Marsh (*Latridius pulicarius*), was reported by him as feeding on corn just from the field. The specimens sent him indicated, however, that it merely followed a previous injury.

Melanophthalma distinguenda (Fig. 177; Pl. VIII., Fig. 4), the commonest species of the family with us, has been taken by us several times on injured corn kernels in the ear, on the silk at the tip of the ear, and on corn lying on the ground. It has been confused with a northern species (*M. pumila*), and under the latter name Webster has mentioned† what is probably this species as abundant in Indiana in August and September, feeding on the kernels at the tips of ears of young corn.

Trogositidæ.

The species of *Tenebrioides* (Fig. 178) are flattened, elongate, black beetles, about a fourth of an inch long. One of them, the cadelle (*T. mauritanica*), is a cosmopolitan insect in stored grain and meal. Our native species live under bark. One of them, *T. corticalis dubia*, is said by Glover‡ to destroy wheat, corn, and other grain, in Maryland. In a later report|| he indicates that the injury is done in the larval stage, but no details are given in either case.

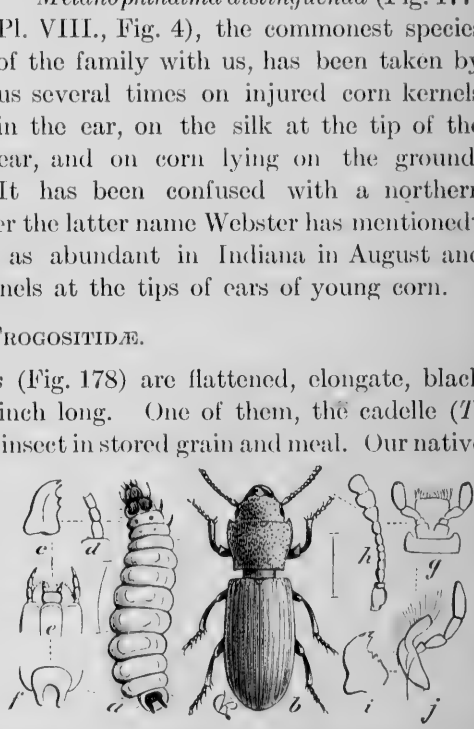


Fig. 178. *Tenebrioides corticalis:* *a*, larva; *b*, adult; *c—f*, larval structures, and *g—j*, structures of adult, more enlarged; *a* and *b*, enlarged as indicated.

*Sixth Report, pp. 183, 184.

†Rep. U. S. Dept. Agr., 1887, p. 151.

‡Rep. U. S. Dept. Agr., 1868, p. 83.

||*Idem*, 1870, p. 66.

Scarabæidæ.

The greater part of these large beetles are leaf-chafers, but among the members of this extensive family is a group of scavengers, of which the tumblebug is a common example. These feed on dung and other dead organic matter, and the dung feeders occasionally turn their attention to ripe corn in the ear or on the ground. The club of the antennæ in this family is not solid, but is composed of several thin leaves, which can be separated like those of a book.

Fig. 179. *Onthophagus hecate.* Length about one fourth inch.

Aphodius granarius has been known to eat the planted corn kernel, and is therefore treated in the Eighteenth Report of this office (page 14). The muck-beetles (*Ligyrus*) are discussed on another page. The following other species, which may be included in this group, have been found by us eating corn grains in the field in fall.

Onthophagus hecate (Fig. 179) resembles a small tumblebug. It has a blunt forward-projecting horn on the thorax. It is generally abundant, most so about decaying animal or vegetable matter. It was found in September, near Urbana, hollowing out the kernels in a number of ears of corn, all of them softened, however, by dampness or decay.

Fig. 180. *Atænius cognatus.* Length about one sixth inch.

Examples of *Atænius cognatus* (Fig. 180), a small species formerly confused with the very common *A. stercorator*, were taken from wet, decaying husks of a fallen ear of corn at Farina, Illinois, and another specimen emerged July 23 from a pupa found among corn roots on the 21st.

Another species of this family, *Cremastochilus knochii*, has been taken by us more than once on fallen ears of corn. It is a black beetle about half an inch long and less than a quarter of an inch broad, with a flattened rough back. Little is known of its habits except that it occurs in ants' nests. It is not common.

Aphonus tridentatus Say resembles the smaller muck-beetle, *Ligyrus gibbosus*, treated on page 98 of this report, except that it has no trace of any indentation on the front part of the thorax. Its habits appear to be very similar to those of the muck-beetles. Two correspondents of Professor F. L. Harvey,* in Maine, sent him specimens of the adults taken in late June and early July from injured hills of corn. The stalks had been cut off after the manner of cutworms, but lower down and nearer the seed kernel. Cutworms were present in one case only, and the injury appeared to be due, in large part at least, to the beetles. In both cases the land had been treated with barnyard manure, and in this the larvæ probably bred, as is the case with *Ligyrus*.

The species ranges from Maine to Texas, but is rarely found in Illinois. It is more common in the Eastern States.

THE LEAF-CHAFERS.

(*Scarabæidæ*, in part.)

The most important group of the leaf-chafers, the common June-bugs or white-grubs, has already been treated herein. Three other species remain to be considered among the unimportant corn insects.

The Scaly June-bug.

Lachnosterna lanceolata Say.

This curious June-bug is quite rare in Illinois, having been taken by us but once in the central and once in the southern part of the state. It is more common in the West and Southwest, and has been recorded from New Mexico, Texas, Kansas, and Colorado. In New Mexico the beetle was brought to Cockerell† with the statement that it injured corn by eating the growing cob. In Texas it often occurs in large swarms, cutting off the young cotton plants over considerable areas. It differs from all our other June-bugs in having a sparse covering of minute whitish scales, giving it an ashy gray and speckled appearance.

The Rose-chafer.

Macrodactylus subspinosus Fabr.

The rose-chafer is an abundant and destructive pest in the United States and Canada in the region north of a line from Virginia to Colorado, and including Illinois. Its favorite food plants are rose, grape, blackberry, raspberry, etc., but when excessively abundant it often

*Rep. Maine Agr. Exper. Station, 1891, p. 199.

†Bull. 15, N. Mex. Agr. Exper. Station, p. 69.

turns for food to a great variety of garden and other plants. Various authors report that corn is one of the plants thus injured, and it is one of a number of plants upon the roots of which the larvæ are known to feed. A correspondent at Elgin, Illinois, once sent us specimens of the beetle with the statement that they were found on corn.

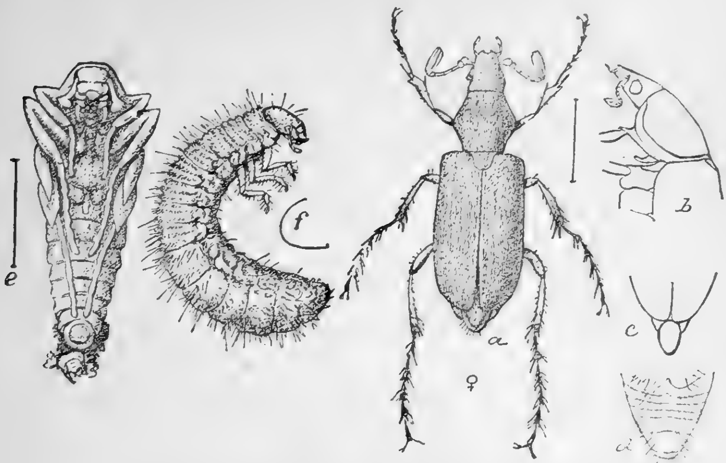


FIG. 181. The Rose-chafer, *Macrodactylus subspinosus:* *a*, female; *b*, fore part of male, side view; *c*, tip of male from above; *d*, same from below; *e*, pupa; *f*, larva. Enlarged as indicated. (Chittenden, U. S. Dept. of Agriculture.)

The beetles (Fig. 181, *a–d*) bear some resemblance to June-bugs. They are about a third of an inch long, rather slender and long-legged, and dull yellowish brown. The larvæ (Fig. 181, *f*) are subterranean, and also resemble those of June-bugs,—the common white-grubs,—but are much smaller and more slender.

ANOMALA UNDULATA Mels.

This small leaf-chafer (Fig. 182) is not uncommon locally in Illinois and throughout the country generally. It is recorded as infesting a variety of crop plants, often to their serious injury. A correspondent of *Home and Farm*, writing from Chapel Hill, Arkansas, to the editor (who forwarded the specimens to me for determination), reports that these beetles were feeding on the corn silk, cutting it off as if with a knife. Twelve of them were found in a single ear, burrowing down

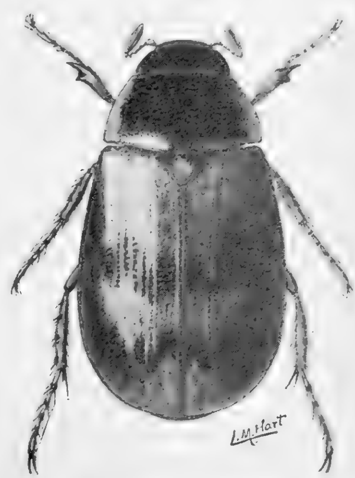


FIG. 182. *Anomala undulata.* Six times natural size.

and eating the silk. In 1887 they had almost ruined a patch of early corn.

They are similar to June-bugs in form, but are much smaller--about a third of an inch long. The thorax is black, with a yellowish border; the wing-covers yellowish, with two cross-rows of ill-defined dark spots, sometimes almost wanting. These beetles have been found stripping the leaves from plum- and pear-trees in Ohio, and from cherry-trees in southern Illinois. They are said to be not infrequently injurious to wheat and other grains. In Kansas they once caused serious injury to wheat, feeding on the heads when the grain was "in the dough," destroying thus a thousand bushels on one farm. They are reported as destructive to grape-vines also.

The immature stages are unknown. In Illinois the beetles have been taken from the middle of April to the last of June. They feed in the evening and hide under boards and the like by day.

Unknown Coleopterous Larva.

Elateridæ?

Mr. C. H. T. Townsend has reported* that in the latter part of July, 1891, the corn ear-worm was present in nearly every ear of corn in a patch on the farm of the New Mexico Agricultural College, and that it was almost invariably accompanied by large numbers of coleopterous larvæ, doubtfully determined as belonging to the *Elateridæ* (wire-worms). These seemed to work independently of the ear-worms, and bored all through the ripening kernels, causing much destruction.

THE LEAF-BEETLES.

Chrysomelidæ.

A considerable number of these beetles are known to injure corn, and several of them have already been treated herein as corn insects of more or less importance.

The Spotted Willow-beetle.

Melasoma lapponica Linn.

The foliage of our willows is often devoured by two species of plant-beetles about the size of ladybugs. The larvæ and pupæ of these two are scarcely distinguishable, and bear a general resemblance to those of ladybugs. One of these beetles (*Melasoma scripta*) is usually yellowish, streaked with black. The other one (Fig. 183), dark red, with black spots, closely resembles the common ladybug, and has been identified with the *Melasoma lapponica* of Europe. Examples of this were sent us by Mr. Fred S. Allen, of Delavan, Illinois, in June, with the state-

*Insect Life, Vol. IV., p. 26.

ment that they had nearly denuded ten rods of willow fence along a corn field, and were then entering the field and eating the young corn.

The larvæ are elongate, oval, blackish, and rough, with small tubercles. They emit, when disturbed, along each side, a row of white globules of a very strongly odorous milky secretion. The beetles are more regularly oblong than the common ladybug, the black spots of the wing-covers are different in number and arrangement, and there is only one large black spot on the thorax, instead of two.

FIG. 183. The Spotted Willow-beetle, *Melasoma lapponica*. Seven times natural size.

On coming out of their winter quarters the beetles lay their eggs upon the young leaves as they unfold, and the larvæ soon hatch and develop rapidly. Several broods are matured in the course of a season.

LUPERODES VARICORNIS Lec.

(*Luperus brunneus.*)

This is a species of southern range —from North Carolina to Kansas, and southward. A correspondent at Manhattan, Kansas, wrote to the *American Entomologist** in 1880 that the beetle had been quite abundant a few years previously, feeding on the silk of sweet corn and on hollyhock, but that at the time of writing it had almost disappeared. In 1892 it was sent to the U. S. Department of Agriculture from Georgia, where it was apparently doing great damage to cotton blossoms. It is a small oval or oblong beetle, about an eighth of an inch long, varying in color from yellowish to brownish. Its life history is unknown.

THE ROOT-WORM BEETLES.

Diabrotica.

We have four common species of this genus in Illinois, the larvæ of two of which, *longicornis* and *12-punctata*, are seriously destructive as corn root-worms, and as such have been treated in the Eighteenth Report of this office. A third, the striped cucumber-beetle, is also a serious pest, the larva eating the roots of cucurbitaceous plants. The adults of these and other members of the genus are more varied in their food habits, and several have been known to infest corn.

Diabrotica tenella occurs only in the extreme Southwest, and is very closely related to our southern corn root-worm. In Arizona the beetles

*Vol. III., p. 77.

are said to cause the greatest injury to young melon vines, to feed also to some extent on the leaves of corn, and to have caused considerable injury to the foliage of apricots and peaches. The larvæ are reported to live in the ground and to be more or less injurious to the roots of corn and other plants. In New Mexico the adult has been recorded as feeding on pea, squash, sorghum, and allied plants, and, in one locality, as generally injurious to trees, potatoes, and miscellaneous vegetables.

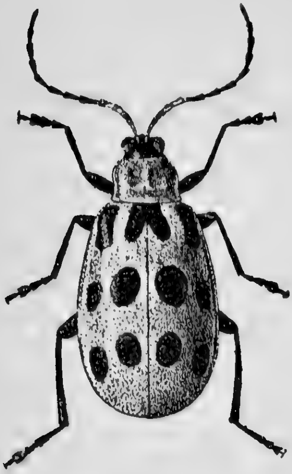


FIG. 184. The Southern Corn Root-worm, *Diabrotica 12-punctata*, adult. Length about one fourth inch.

The southern corn root-worm, *D. 12-punctata*, is frequently found in the adult stage (Fig. 184) on the corn plant, eating small irregular or longitudinal holes in the leaves or gnawing away the edges, cutting off the silk, devouring the pollen, and sometimes eating the unripe kernels. We have seen it quite numerous in red clover, eating the leaves and blossoms. Further details are given in the Eighteenth Report of this office (page 148).

D. soror is very similar to the preceding, and replaces it on the Pacific coast, where it injures corn in the same manner, both in the larval and adult stages, as does its eastern relative.

The adult striped cucumber-beetle, *D. vittata* (Fig. 185), has several times been found by us eating the leaves, pollen, silk, or unripe kernels of corn, but not to any serious extent.

The beetle of the common corn root-worm, *D. longicornis* (Fig. 186), eats the leaves of corn to a small extent, and feeds freely on the pollen and silk, occasionally injuring also the kernels at the tip of the young ear where this is not covered by the husk. When corn has been heavily infested by the root-worm itself, the beetles often collect in surprising numbers in the green silk, a fact which has given them the name of the "silk-fly" in extreme southern Illinois. In

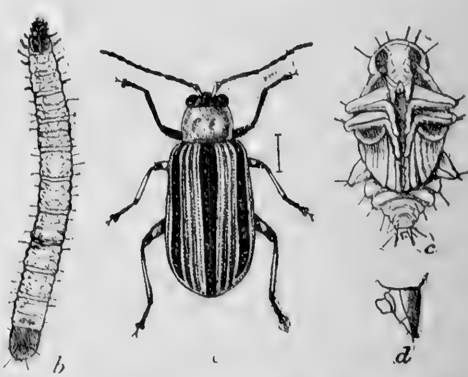


FIG. 185. The Striped Cucumber-beetle, *Diabrotica vittata:* *a*, adult; *b*, larva; *c*, pupa; *d*, tip of larva, side view. Enlarged as indicated. (Chittenden, U. S. Dept. of Agriculture.)

a field in Saline county, an assistant, Mr. E. B. Forbes, found July 29, 1899, an average of seven or eight beetles eating the fresh silk at the tip of each young ear. "The beetle," he says, "makes its way as fast as possible into the closely compressed silk, which it then feeds upon. As the threads are cut off they dry up and fall to the ground in brown locks, the tip of the ear being left denuded."

It has been supposed that this injury must result in the blasting of the ear through failure of fertilization, but this conclusion is rendered doubtful both by observations made in the field and by known facts concerning the growth of the corn silk. We have noticed, for example, that the beetles usually begin their injury at the center of the tuft of silk, first cutting off the inner filaments, which fertilize the smaller and poorer kernels at the tip of the ear. Again, in fields of fairly early corn, very many of the ears are fully fertilized before the beetles appear in any considerable numbers, and these ears are of course not injured in the least by the loss of their silks. It is further well known that the corn silk grows indefinitely until it is effectively acted upon by the pollen, and that its growth thereupon ceases. It is consequently quite possible, as suggested to me by Professor P. G. Holden, that the silks will continue to grow after mutilation, presenting a fresh effective surface to the pollen grains, and that unless continuously eaten away until the power of growth is exhausted, no final injury to the ear may be done. Comparative observations, backed by experiment, will be needed to show whether an injury of any economic consequence is done by the various insects which eat the fresh corn-silk, or by those which kill it by sucking its sap.

FIG. 186. The Northern Corn Root-worm, *Diabrotica longicornis*, adult. Length about one fifth inch.

Diabrotica atripennis is the last of the four Illinois species here referred to. It is a black beetle with reddish or black thorax. The larval habits are unknown. The adult was seen by Webster eating corn pollen and corn silk before fertilization had taken place. It usually feeds on the pollen of *Compositæ* and has been taken on *Silphium*. Chittenden found the adults devouring blossoms of Lima beans in Maryland.

THE FLEA-BEETLES.

Halticini.

The important corn flea-beetles have been treated on pages 106–111 of this report. In addition to these, the following species have been found on corn.

FIG. 187. The Potato Flea-beetle, *Epitrix cucumeris.* Enlarged as indicated. (Chittenden, U. S. Dept. of Agriculture.)

The potato flea-beetle, *Epitrix cucumeris* (Fig. 187), breeds on the roots of potato and tomato and of a related weed, *Solanum nigrum.* The adults feed on the leaves of potato and other garden plants and weeds, and have been seen by us on corn leaves. Professor Cyrus Thomas, writing of this beetle to the *Prairie Farmer* for June 22, 1878, says: "It attacks the corn soon after it comes out of the ground, riddling the leaves with minute holes. I had a field of corn that was considerably injured by them." This species is discussed in the Twenty-first Report of this office (page 117) in connection with its injuries to sugar-beets. It has lately been found seriously injuring tobacco and petunias.

The smartweed flea-beetle, *Systena hudsonias* (Fig. 188), has also been treated in the article on sugar-beet insects in the Twenty-first Illinois Report (p. 119). The larvæ are unknown. The adults feed

FIG. 188. The Smartweed Flea-beetle, *Systena hudsonias.* Enlarged as indicated.

FIG. 189. *Glyptina brunnea.* Enlarged as indicated.

primarily on smartweed and dock, but also infest a large number of other plants. Chittenden* repeatedly found stragglers on growing corn, but he did not see them feeding. Examples of this species and of the pale-striped flea-beetle were sent him by an Indiana correspondent,† who charged them with injuring corn in his neighborhood. On the other hand, in one New York locality, serious damage was done by them to pole-beans, while sweet corn and other plants in the vicinity remained exempt.

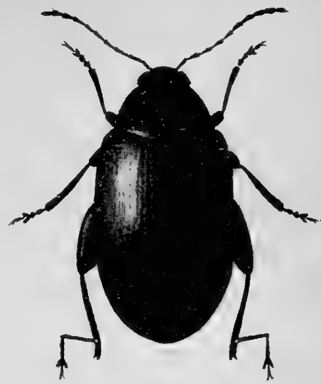


Fig. 190. *Psylliodes convexior.* Length about one twelfth inch.

Glyptina brunnea (Fig. 189), a minute brown flea-beetle, was found in considerable numbers on very young corn and in the loose soil about the plants May 24, near Champaign. The beetles were eating holes in the leaves and cutting off the central leaf. The injury was quite noticeable, but not especially serious. This beetle has been previously mentioned by us‡ as found in July and as being quite abundant in October on sugar-beets in Illinois. It is known to occur from Georgia to Texas and Wisconsin. Its life history is unknown.

Fig. 191. *Psylliodes punctulata.* Length about one twelfth inch.

Chætocnema parcepunctata, a small brassy flea-beetle only about a sixteenth of an inch long, was found by Chittenden feeding on corn leaves in Pennsylvania. It was not seen on any other plant, and the extent of injury is not given. It is known from Massachusetts to Texas, but has not been taken by us in Illinois.

Psylliodes convexior (Fig. 190; Pl. VIII., Fig. 3) and *P. punctulata* (Fig. 191), two common flea-beetles, have been taken on corn, the latter sev-

*Proc. Ent. Soc. Wash., Vol. III., p. 266.

†Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., p. 113.

‡Twenty-first Report, p. 122.

eral times. *P. convexior* (*interstitialis*) was found by Webster in Indiana* in June, feeding on corn leaves and on a grass (*Panicum crus-galli*). It worked almost exclusively on the lower leaves, but gnawed the tissues from beneath, leaving the upper skin and the veins intact. Both these species are treated in relation to their injuries to sugar-beets in the Twenty-first Report of this office (p. 124). They are small, elongate-oval, bronzed flea-beetles, about a twelfth of an inch long. Nothing is known of their immature stages.

THE ARGUS TORTOISE-BEETLE.

Chelymorpha argus Licht.

This is a convex oval leaf-beetle (Fig. 192), resembling a large lady-bug. It is about three eighths of an inch long, yellowish to red, with a number of small black dots. It has been charged with feeding on corn and other plants in New York, and has been taken on corn in Iowa. Its native food is known to be the species of the morning-glory family (*Convolvulaceæ*), and it also feeds commonly on milkweeds. Dr. John Hamilton says, as quoted by Webster,† that the beetles wander from their natural food plants to others, on which they occasionally feed. They seem very fond of the water held in the axils of corn leaves, but it is not certain that they injure the plants. The species occurs in Illinois, but is not known to be common.

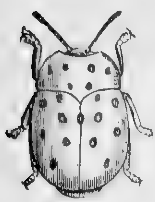


FIG. 192. The Argus Tortoise-beetle, *Chelymorpha argus*. Twice natural size. (Saunders.)

THE SNOUT-BEETLES.

Rhynchophora.

In addition to the bill-bugs and curculios already treated in this report, the two following species have been found injuring corn in a similar manner, by gnawing or puncturing the surface of the stem.

THE STRAWBERRY CROWN-GIRDLER.

Otiorhynchus ovatus Linn.

Adults of this species were found at Urbana July 22 by Mr. J. S. Terrill, an assistant of this office, in hills of corn. One of them was gnawing the surface tissues at the base of a corn-stalk, the others were found among the roots. Placed in a breeding-cage with corn plants, one of the beetles burrowed down at the base of the stalk, which was afterwards found to be slightly gnawed. In a few days all died.

*Rep. U. S. Ent., 1887, p. 150.

†Ent. News, Vol. IV., p. 227.

This snout-beetle (Fig. 193) is about a fifth of an inch long, red to pitch-brown, rough-surfaced, but somewhat shining. The thorax is nearly globular, and the part of the body behind the thorax is oval. The beak is short, broad, and flattened.

We have found the beetle frequently in blue-grass, on apple leaves, on wheat, and at the roots of pumpkin. At the Michigan Agricultural College, the larvæ were found in May and June girdling the crowns of strawberries. These were reared to the adult by Mr. C. M. Weed, who published a full account of the species.* Similar injuries to the strawberry have been reported from Massachusetts and Minnesota. In Illinois it has lately been found eating strawberry roots. The adult is said to have done serious damage to cabbage and shrubbery in New York, and it has been taken feeding on rose leaves and borage.

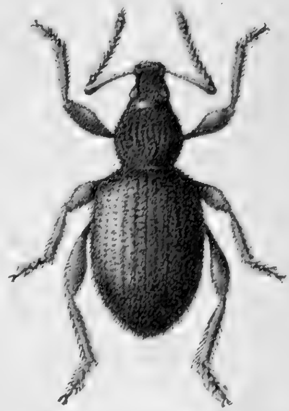


Fig. 193. The Strawberry Crown-girdler, *Otiorhynchus ovatus*, adult. Length about one fifth inch.

According to Mr. Weed, the larvæ found in May and June were full grown from the middle to the last of June. The pupa is formed in an earthen cocoon in the soil near by, and the adult emerges eight or ten days later. The stages overlapped, however, so that all three could be taken at the same time. Our collection contains examples of the adults taken from March to the middle of August, and also in October. Probably there is but a single brood, the species hibernating in the beetle, and possibly also in the larval, stage.

The species is a native of Siberia and Europe, whence it has invaded this country, and is now widely distributed in the United States and Canada westward to the vicinity of the Rocky Mountains. It is common in the East, but not especially so in Illinios.

Limnobaris deplanata Casey.

A single example of a small, slender, dark gray snout-beetle, about an eighth of an inch long, was found at Urbana September 18, by an assistant of this office, behind a corn leaf-sheath at the second joint above the ground. Numerous small punctures of the form usually produced by snout-beetles—opening into small cavities but not perforating the leaf-sheath—were found at this point, doubtless the work of this beetle. It agrees fairly with Casey's description of *deplanata*, but is possibly an undescribed species.

*Rep. Mich. Hort. Soc., 1884, p. 84.

THE CORN-SMUT BEETLE.

Brachytarsus variegatus Say.

This little snout-beetle (Fig. 194) is mentioned here because it is found on corn, although it merely breeds in and feeds upon the smut of corn and wheat. It is also known to eat freshly stored wheat. It is about a tenth of an inch long, oval, brownish, with lines of alternating yellowish white and dark brown marks, a pair of squarish dark brown spots near the middle of the wing-covers, one on each side of the suture, and a second pair at their base. It has a very broad, short snout. The species is common in Illinois.

FIG. 194. The Corn-smut Beetle, *Brachytarsus variegatus*. Length about one tenth inch.

THE STINK-BUGS.

Pentatomidæ.

The wing-covers of this group are separated at the base by a triangular scutellum, of relatively large size in the larger forms, and beyond this their membranous outer portions overlap. Most of the species spend the winter as adults, producing nymphs in spring. The number of broods in a year varies, but the adults are usually most abundant in the latter part of the season. Some are predaceous, capturing other insects and sucking their blood; some confine themselves to plants for food; and others divide their attentions between the two. Of the plant-feeding species, some are confined to one or two plants, and others have an extremely varied diet.

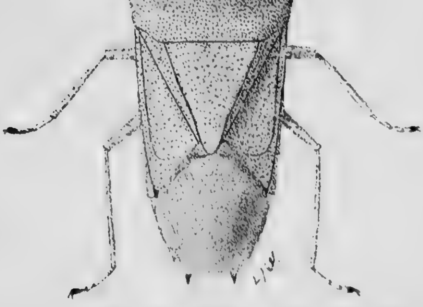


FIG. 195. *Œbalus pugnax.* Five times natural size.

ŒBALUS PUGNAX Fabr.

This "stink-bug" (Fig. 195) is especially injurious to grasses and wheat, often interfering seriously with the development of the heads. It has been seen by Ashmead "feeding on corn pollen" in Florida, and we have taken it in corn fields in Illinois. It is also known to attack insects. The species is common in the South, but is rarely seen in central Illinois, although it has appeared in injurious numbers on wheat as far north as Minnesota. It may be known at once from other stink-bugs by the forward direction of the sharp shoulder-spines.

Euschistus fissilis Uhl.

We have taken specimens of this common Illinois "stink-bug" on corn —in one case feeding on corn ears—and on various other plants. It has been known to cause considerable injury to wheat. The adults have been taken by us from April 20 to December 8, most frequently in June and July, and again in September, thus indicating two broods in a season. The front margin of the head is slightly notched, and the abdominal segments have no median black spots in either sex. It occurs quite generally throughout the United States from Maine to California.

Euschistus servus Say.

Ashmead has reported finding this species on corn in Florida. He supposed it to be predaceous, but it was more probably feeding, in part at least, upon the corn. The beak is quite slender, suited to plant-feeding, and very unlike the strong beak of the distinctively predaceous species, such as *Podisus*. It inhabits the Southern States, and has not occurred in our Illinois collections. It is closely related to *E. fissilis*, but the front margin of the head is not notched. As in *fissilis*, the shoulders are rounded or very obtusely angled.

Euschistus variolarius Pal. Beauv.

This is one of our commonest species of "stink-bug" (Fig. 196). It is known to suck the sap from a great variety of plants, including corn, and by reason of its large size and abundance it frequently does some noticeable injury to the plants infested. We have repeatedly found it on corn, sucking sap from the leaves, from the husks and kernels at the tip of the ear, and from other parts of the plant.

In Kentucky it has been found feeding at the base of tobacco leaves, causing them to become limp and the stalk to wilt and fall. Lugger says

FIG. 196. *Euschistus variolarius* Four times natural size.

that asparagus plants have been killed by it, and that considerable damage was done to the wheat crop in one field. We have also taken the adults on rye, red clover, broom-corn, oats, thistle, grasses, and flowers; and they have been reported to eat tomatoes, red raspberries, peaches, mullein, and *Thermopsis*.

The adults hibernate, and have been taken by us from February 20 to December 20, most abundantly in spring and in July, August, and September. The nymphs we have taken during the summer with the adults. Eggs supposed to be of this species were found on corn as late as August 13.

The species is common in the United States east of the Rocky Mountains. It closely resembles the two other species of this genus, but the shoulders are more or less acute, the head is not notched, and the male has a round black spot on the last segment beneath, the female being unmarked. In color it is light brownish, dotted with darker punctures. All three are of about the same size, half an inch long and a fourth of an inch wide, broad and flattened, with large central triangular scutellar plate.

Thyanta custator Fabr.

This insect is not very common in Illinois. It resembles the preceding species but is smaller, with rounded shoulders. In color it varies from brownish, with a paler median streak, to grass-green with a red stripe across the thorax from shoulder to shoulder. We have found it several times on corn, in one case sucking the sap from a leaf; also on wheat, grasses, and weeds. Chittenden reports it as injuring asparagus in South Carolina. We have taken it from April 20 to December 10. It is widely distributed over the country, but more commonly to the south and west.

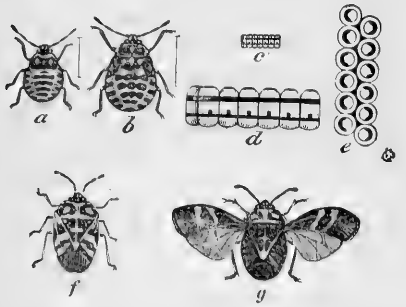


Fig. 197. The Harlequin Cabbage-bug, *Murgantia histrionica*: *a* and *b*, young, enlarged as indicated; *c*, eggs, natural size; *d* and *e*, same, enlarged, from side and above; *f* and *g*, adults, natural size, with wings closed and open. (Howard, U. S. Dept. of Agriculture.)

The Harlequin Cabbage-bug.

Murgantia histrionica Hahn.

This well-known enemy (Fig. 197) of cabbage and other cruciferous plants in southern Illinois and the South at large has been known to feed on a variety of other plants when its normal food became exhausted. Corn has been thus infested in Delaware, Kentucky, and Virginia. In the latter state it was said to have injured shoots of late corn, and was also present in large numbers about the young silk. It is rarely seen north of southern Illinois.

OTHER PLANT-FEEDING HETEROPTERA.

THE LEAF-FOOTED PLANT-BUGS.

Leptoglossus.

The leaf-footed plant-bugs resemble the common squash-bug but are somewhat larger, and the bases of the hind shanks are dilated into flat, leaf-like expansions. *L. oppositus* Say ranges from Virginia to Kansas and southward to the Gulf, and is locally, though not generally, common in central Illinois. It prefers cucurbitaceous plants, especially their fruits, for food, but early in the season it is often found on fruit trees. Plums, peaches, cherries, apricots, grapes, and tomatoes suffer more or less, and green corn is frequently infested. *L. phyllopus* does not range so far north as its relative, being confined mostly to the states bordering on the Gulf. Our collection contains, however, two examples taken in Kansas. Its natural food plant is the yellow thistle, but a variety of orchard, garden, and field crops are eaten by it, including sorghum, wheat, and rice, so that its occurrence on corn is to be expected. It is especially injurious to oranges and melons.

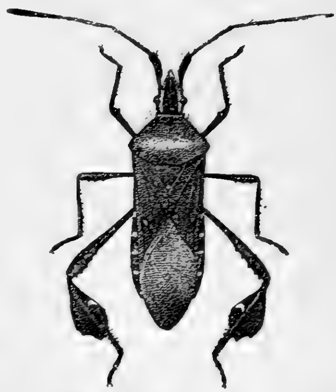


FIG. 198. A Leaf-footed Plant-bug, *Leptoglossus oppositus*. Twice natural size. (Chittenden, U. S. Dept. of Agriculture.)

L. oppositus (Fig. 198) has a pair of white dots above, one near the center of each wing-cover; *phyllopus* (Fig. 199) has a whitish cross-band in place of the dots. These insects have the odor of the squash-bug, but in a comparatively slight degree. *Oppositus* was reported in 1886 as working in clusters of twenty or thirty on stalks of corn in Virginia, and recently, in two successive seasons, it was noticed there several times in corn distant from other crops, on the stalks and puncturing kernels "in the milk."

FIG. 199. A Leaf-footed Plant-bug, *Leptoglossus phyllopus*. Twice natural size. (Chittenden, U. S. Dept. of Agriculture.)

This insect appears to poison the tissues at the point of puncture, causing in fruits a circular discoloration and a distortion of growth. In 1896, at Lincoln, Ill., it was found by us July 27 very common on apricots, peaches, and plums, and was said to have occurred there also on corn and watermelons. The infested trees had promised good crops, but the fruits were then largely rotten and spotted with a fungous growth. Similar injuries are caused by *L. phyllopus* in the South.

The life history and immature stages are similar to those of the squash-bug. The singular eggs are bronze to bronze-brown in *oppositus*, golden in *phyllopus*. They are cylindrical, about a sixteenth of an inch long, and are placed end to end in rodlike chains from three eighths to over one inch in length. The adults appear in July, and nymphs appear in Illinois in the latter part of this month and in August. These mostly become adult in September. There is but one brood a year. Fuller accounts of these species are given by Chittenden.*

Ligyrocoris sylvestris Linn.

We have taken this small gray-brown plant-bug on corn silk in July. It is widely distributed, occurring over most of North America and in Europe. In Illinois it has been taken from March to September, most commonly from the middle of June to the middle of July. It probably hibernates as an adult.

Sphragisticus nebulosus Fall.

The favorite food of this pale gray and black plant-bug (Fig. 200) is the white pigweed (*Chenopodium album*), but we have also found it puncturing corn leaves, causing sear brownish spots. It is of an even long-oval form and about a fifth of an inch in length. It is common in Illinois, and is found over most of North America and of Europe. It has been taken from February 4 to December 19, and evidently hibernates in the adult stage. It has been discussed as a sugar-beet insect in the Twenty-first Report of this office (p. 94).

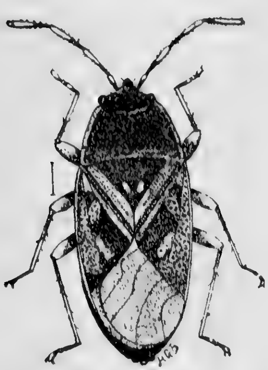


Fig. 200. *Sphragisticus nebulosus.* Length about one fifth inch. (Bruner.)

Microtoma atrata Goeze.

This insect resembles the preceding in form but is entirely black. It is credited to the Eastern States but is not uncommon in Illinois. Adults and nymphs were taken by us in September on the husks and grains of the ear, once with the beak inserted. We have found it from February 1 to November 2. The adults hibernate under bark and similar shelter.

*Bull. U. S. Dept. Agr., Div. Ent., No. 19, N. S., p. 44 (*oppositus* and *phyllopus*); No. 33, p. 18 (*oppositus*); and No. 40, p. 113 (*phyllopus* notes).

THE DUSKY LEAF-BUG.

Calocoris rapidus Say.

We have seen this common leaf-bug (Fig. 201) many times on corn leaves, silks, and ears, often with beaks inserted in the kernels at the tip of the ear. Webster reports a similar occurrence in Indiana, as many as ten being counted on a single ear.

It is about a quarter of an inch long, blackish brown, with a very narrow yellow border, the prothorax pale reddish, with a black cross-

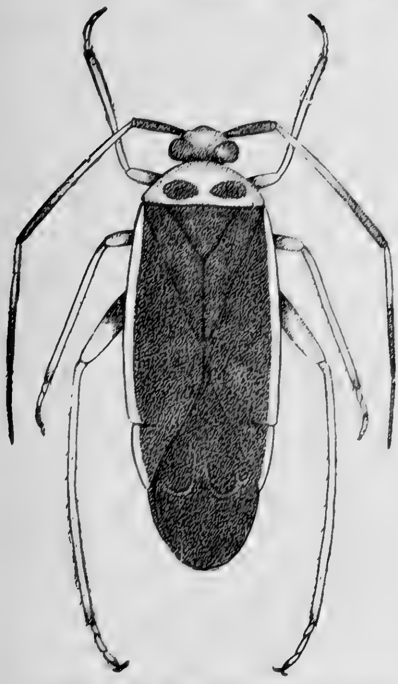


FIG. 201. The Dusky Leaf-bug, *Calocoris rapidus*. Length about one fourth inch.

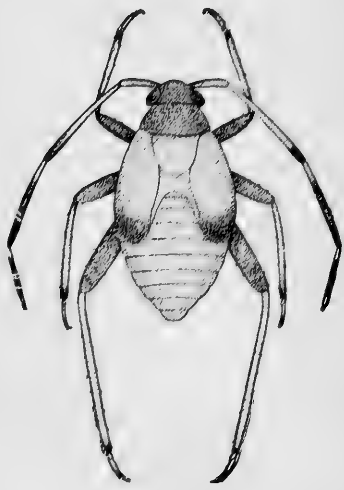


FIG. 202. The Dusky Leaf-bug, *Calocoris rapidus*, nymph. Greatly enlarged.

bar, often divided into two spots. The young (Fig. 202) are pale green marked with red. The species also feeds on cotton blooms, beets,* strawberries,† celery, buckwheat, cabbage, alfalfa, rye, buckeye, evening primrose, thistle, goldenrod, ragweed, and sumac (*Rhus glabra*), and has been taken on mulberry, red clover, and various grains and grasses.

There are probably two broods, much as in the tarnished plant-bug, one maturing rather early in the season, the other somewhat later, the two overlapping to a considerable extent.

It ranges from the Atlantic to the Pacific.

*Twenty-first Rep. State Ent. Ill., p. 92.
†Thirteenth Rep. State Ent. Ill., p. 135.

The Four-lined Leaf-bug.

Pœcilocapsus lineatus Fabr.

Bulletin 58 of the Cornell Agricultural Experiment Station contains an exhaustive account of this prettily striped leaf-bug (Fig. 205). Its injury to gooseberry and currant and their relatives is especially severe,

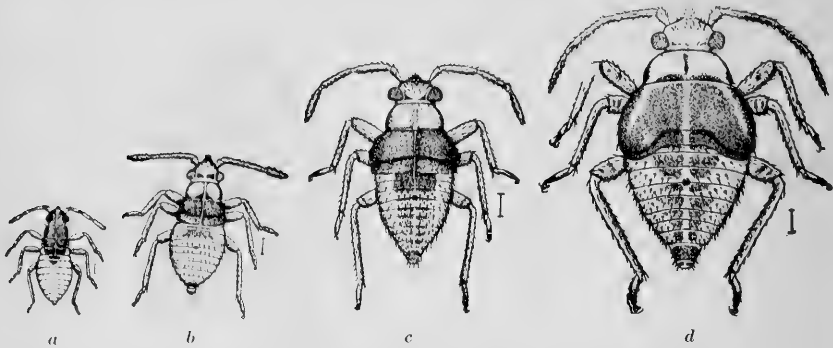


Fig. 203. The Four-lined Leaf-bug, *Pœcilocapsus lineatus*, immature stages: *a*, first stage, recently hatched; *b*, second stage; *c*, third; *d*, fourth. Enlarged as indicated. (Slingerland.)

more or less of the foliage often being destroyed. In addition, a remarkably long list of cultivated and wild plants are more or less injured by it, and Fletcher quotes a correspondent as saying that this species and the tarnished plant-bug will feed on young sweet corn kernels when they can get at them. We have seen dock leaves entirely riddled and seared by their punctures.

It is about a third of an inch long, green (yellow in dried specimens), with four large black stripes and two dots on the wing tips. The eggs (Fig. 206) are inserted nearly vertically in stems, in short longitudinal

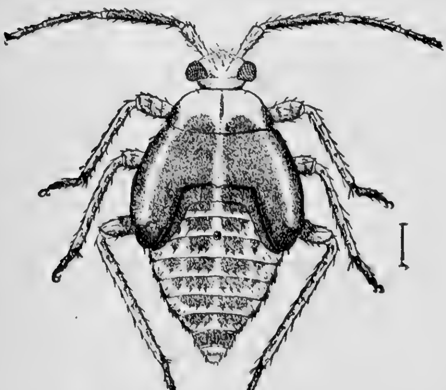


Fig. 204. The Four-lined Leaf-bug, *Pœcilocapsus lineatus*, nymph, fifth stage. Enlarged as indicated. (Slingerland.)

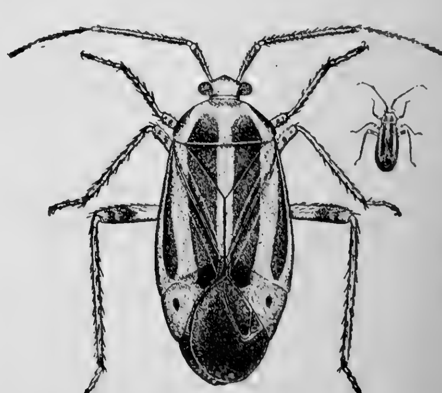


Fig. 205. The Four-lined Leaf-bug, *Pœcilocapsus lineatus*, natural size and enlarged. (Slingerland.)

rows in midsummer, and remain over winter, hatching the following May. The adults appear in June and disappear by the end of July, there being but one brood a year.

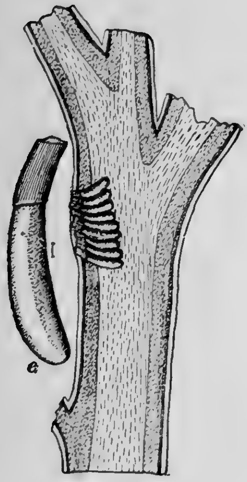


FIG. 206. The Four-lined Leaf-bug, *Pœcilocapsus lineatus*, eggs in currant stem, and one greatly enlarged. (Chittenden, U. S. Dept. of Agriculture.)

FIG. 207. *Plagiognathus obscurus.* Length about one eighth inch.

PLAGIOGNATHUS OBSCURUS Uhl.

Examples of this little leaf-bug (Fig. 207) have been observed by us several times in fall with their beaks inserted in corn kernels at the tip of the ear, in one case as many as half a dozen on a single ear. No appreciable injury was noticed.

The species is shaped much like the tarnished plant-bug, but is smaller, dull blackish and yellowish, without definite markings. It is generally distributed over the United States east of the Rocky Mountains, and is recorded from a considerable variety of plants. The data of our collections indicate the development of two successive broods and hibernation in the egg. We have found it occasionally on sugar-beets, and it is therefore discussed in the Twenty-first Report (p. 89).

Undetermined Leaf-bug.

Capsidæ.

Ashmead* reports an undetermined capsid taken feeding on corn pollen in Florida.

THE COMMON FLOWER-BUG.

Triphleps insidiosus Say.

In the Twenty-first Report of this office (page 86) it was said that while there is undoubted evidence of the value of this species (Fig. 208) as a predaceous insect it has been charged with injury to plants, and its fairly common occurrence on beets renders it an object of suspicion. The same is true of it as a corn insect. Webster† reports that it may frequently be found, in all stages, literally swarming among the silks, with no other visible food supply. We have also found it several times, sometimes in great numbers, on corn silks, on the tips of the ears and on the leaf-sheaths, and also on broom-corn. It is a minute, flattened, blackish bug with yellowish wing tips, and is found throughout the United States. The nymphs are reddish brown.

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Fig. 208. The Common Flower-bug, *Triphleps insidiosus.* Enlarged as indicated. (Osborn, U. S. Dept. of Agriculture.)

THE FLATAS.

The Flatas are odd-looking insects, wedge-shaped as seen from above. The two species known to feed on corn have been discussed in treating the sugar-beet insects.‡ The young are very short and broad and are concealed in a woolly excretion. They live in groups

Fig. 209. The Green Flata, *Chlorochara conica.* Length about three eighths inch.

*Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16.

†"Insects Affecting the Corn Crop," p. 20. (From Ind. Agr. Rep. for 1885.)

‡Twenty-first Rep. State Ent. Ill., p. 83.

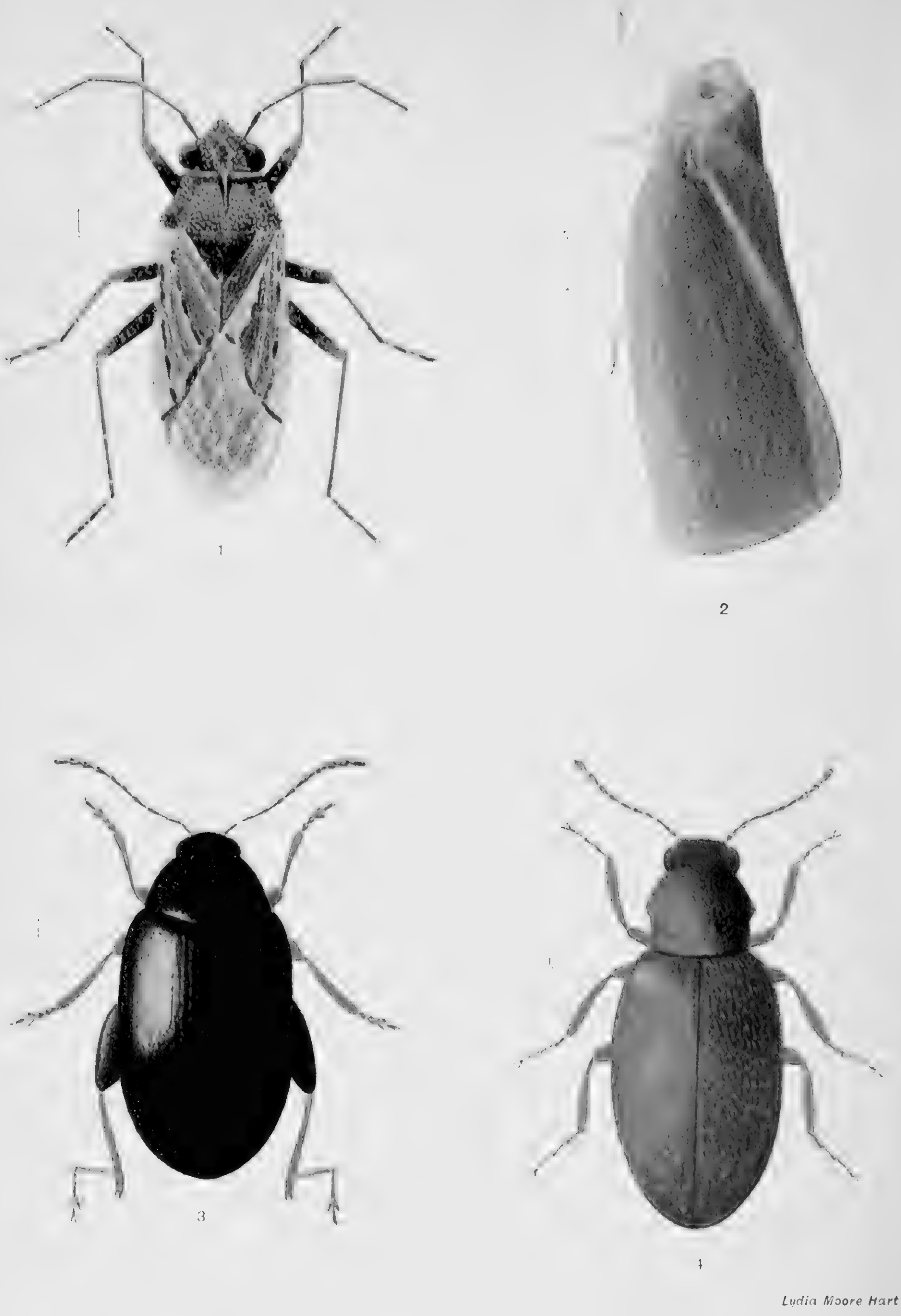

PLATE VIII

Fig. 1—The False Chinch Bug, *Nysius augustatus*. Fig. 2—The Mealy Flata. *Ormenis pruinosa*, light colored example. Fig. 3—*Psylliodes convexior*. Fig. 4—*Melanophthalma distinguenda*.

on leaves or stems and breed on trees and shrubs, but also occur on herbaceous plants. Probably these species hibernate in the egg, which, according to Riley, hatches about the middle of May. The record strongly indicates that there is but one brood a year, nymphs occurring from about the middle of May to late in July and imagos from July to the end of the season.

That these insects are especially sensitive to the effects of rainy weather and are not sufficiently protected from it when on the corn plant, was strikingly shown by colonies of *Chlorochara conica* observed by us. After a heavy rain very few could be found on corn-stalks where they had been common before, while on plants which afforded them better shelter their numbers were little diminished.

The Mealy Flata.

Ormenis pruinosa Say.

Miss Murtfeldt found this Flata (Fig. 210; Pl. VIII., Fig. 2) especially destructive to dahlias, which were injured beyond recovery. We have taken it once on corn and once on sorghum, but not doing appreciable injury. The eggs (Fig. 211) are laid in a lengthwise row in a slit in the bark of twigs. The adults are about a quarter of an inch long, at first pale bluish green, darkening to slate color or sooty brown, with a whitish "bloom." The species is found in the United States, Mexico, and the West Indies.

Fig. 210. The Mealy Flata, *Ormenis pruinosa*. Enlarged as indicated.

Fig. 211. The Mealy Flata, *Ormenis pruinosa:* *a*, eggs; *b*, in bark of twig; *c*, natural size.

The Green Flata.

Chlorochara conica Say.

(*Chlorochroa conica.*)

This species was found by an assistant of this office, Mr. C. C. Adams, breeding quite abundantly in one corner of a corn field near Urbana on the corn-stalks, and also on ragweed, catnip, and milkweed, and the adjacent hedge. They formed large colonies on the bases of the corn-stalks not more than a few inches from the ground. After a heavy rain had swept most of them off the corn they were still abundant on the ragweed and catnip. Later they became more abundant on the hedge, which probably affords them a more suitable food. The year following they were again found in the same place in smaller numbers on the corn and weeds and on the hedge.

The woolly secretion develops only on the abdominal surface of the nymph. The adults (Fig. 209) are about three eighths of an inch long, with very broad wings, clear yellowish green throughout. Chittenden says that their favorite food is the hop plant. The eggs described by us in the Twenty-first Report (p. 84) as perhaps those of this species have since been determined by the U. S. Division of Entomology to belong to *Ceresa taurina*. The species is only locally common, but is known to occur from Texas to Iowa and Ohio and in Virginia.

THE LEAF-HOPPERS.

Delphacinæ, Jassidæ.

The important corn leaf-hoppers have already been treated on pages 121–123. Five others, which follow, have been taken on corn.

DICRANOTROPIS sp.

Examples of this delphacid have twice been noticed on corn in southern Illinois, in one case apparently feeding.

LIBURNIA ORNATA Stål.

Occasional specimens have been taken by us on corn, in one case in the act of feeding. This insect was erroneously determined for us as *Stobera tricarinata*, and the record concerning corn under that name in the Twenty-first Report (page 67), should be transferred. The species ranges from the Mississippi to the Atlantic and is frequently taken in Illinois. It apparently hibernates as an adult and has two broods a year. It occurs on grasses, grains, and weeds. The adult (Fig. 212) is slender, about an eighth of an inch long, orange-brown trimly marked with white and black, the wings clouded with blackish.

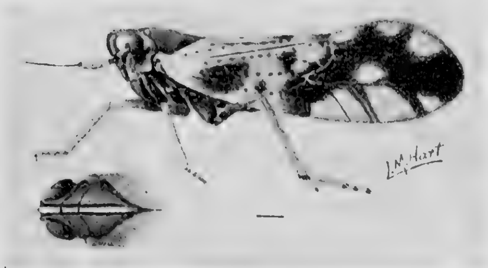

FIG. 212. *Liburnia ornata*; also head and thorax seen from above. Enlarged as indicated.

ONCOMETOPIA UNDATA Fabr.

This large leaf-hopper (Fig. 213) is full half an inch in length, with purplish wings, the head and scutellum orange reticulate with black. It seems to be especially a grape insect, but has been taken on corn, broom-corn, and other plants. It is discussed as a sugar-beet insect in the Twenty-first Report of this office (page 70).

FIG. 213. *Oncometopia undata*. Natural size.

Dræculacephala mollipes Say.

(*Diedrocephala mollipes.*)

This large dull green species is one of the commonest of our large leaf-hoppers. It feeds principally on sedges, grasses, and grains, including corn, and especially in low grounds, but is hardly abundant enough to cause any appreciable injury to the crop. Its corn-feeding habits have been observed by Garman in Kentucky.* Nymphs and adults were found abundant in July on corn in low ground, as many as twenty to a single plant in some fields, when the corn was about two feet high. Near the end of July a fungous disease similar to that which is seen on house-flies on window-panes greatly reduced their numbers. In Illinois we have found it quite common on corn in late June, in one case laying its eggs in a corn leaf; also on sorghum leaves.

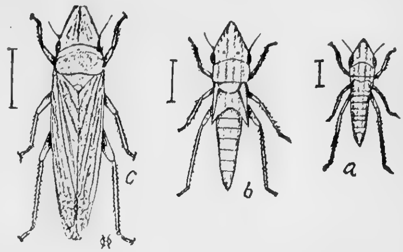

Fig. 214. *Dræculacephala mollipes:* *a*, young; *b*, half grown; *c*, adult. Enlarged as indicated. (Osborn.)

The adults (Fig. 214, *c*) are from a quarter to three eighths of an inch long, the wings dark green, with bluish veins and yellow edges, the thorax, scutellum, and front of head yellowish, the first with some fine black lines irregularly placed. The nymphs (Fig. 214, *a*, *b*) are light green or yellowish. The species is discussed as a sugar-beet insect in my Twenty-first Report (page 71). It ranges from Canada to Mexico and Cuba. The eggs are laid mostly in rank grasses and sedges, and in this stage as a rule the winter is passed. There are two broods in a season, the adult stage being reached in June and July and again in fall.

Fig. 215. *Phlepsius irroratus.* Enlarged as indicated.

Phlepsius irroratus Say.

A nymph of this genus, and very probably of this species, was taken by Garman on young corn at Normal, Illinois, in June. The species is treated in my Twenty-first Report (page 76). It attacks a great variety of plants, and causes on some a dark purple spotting of the leaves. There are probably two broods, and the

*Second Rep. Ky. Agr. Exper. Station, p. 12.

winter is presumably passed in the egg state. The species is of northerly distribution in the United States.

Gnathodus spp.

The statement in the Twenty-first Report that some species of this genus feed on corn is unwarranted.

PLANT-LICE.

Aphididæ.

Several root-lice on corn, including the common corn root-aphis, were fully treated in the Eighteenth Report of this office. The so-called corn leaf-louse, which seems to be more especially a broom-corn and sorghum insect, and the southern grain-louse, which is primarily a wheat insect, have been discussed as of secondary importance to corn-growers on pages 123–135 of this report. Six other species, which chiefly infest other plants and whose presence on corn is apparently unusual or accidental, are here briefly mentioned.

The European Grain-louse.

Siphocoryne avenæ Fabr.

This plant-louse (Fig. 216), according to Pergande,* is our common apple-aphis, and is taken also on grains, grasslike plants, and a few weeds. The broods revert in the fall of alternate years to the apple, upon which the sexed individuals appear. Eggs are laid by the oviparous females on twigs of apple and related trees and hatch the following spring. The return migration is completed early in July, after which none of the lice are to be seen on the trees until about September 15, when individuals descended from apple-lice of the previous year migrate to the trees and produce oviparous females. These mature and are then joined by male migrants. Winged females from corn August 29 were pronounced by Mr. Pergande to be of this species. They are said to be found most frequently on wheat.

The English Grain-louse.

Macrosiphum granaria Buckt.

(*Nectarophora avenæ*, in part.)

On two occasions winged examples of this species (Fig. 217) have been taken on corn, and in one of our large corn breeding-cages a small colony of wingless individuals showing the maculation of the abdomen found in this species was observed on the leaves.

*Bull. No. 44, N. S., Div. Ent., U. S. Dept. Agr., p. 5.

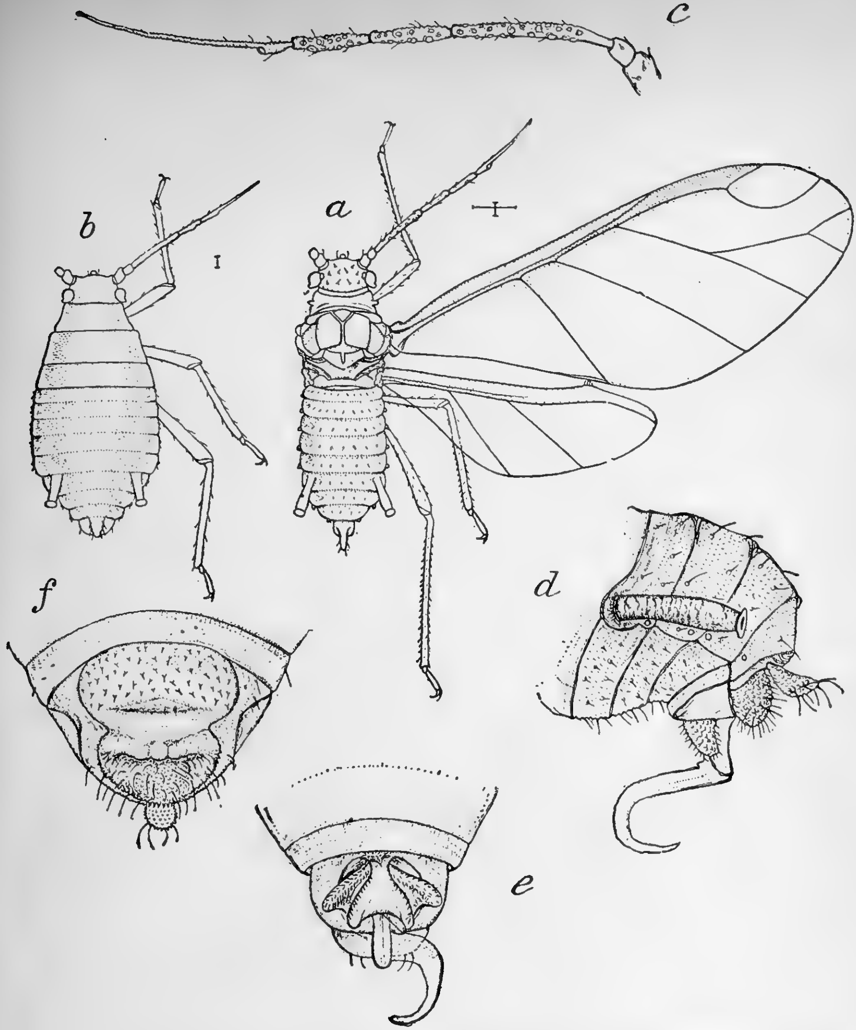

FIG. 216. The European Grain-louse, *Siphocoryne avenæ: a*, winged viviparous female; *c*, its antenna; *b*, sexual female; *d* and *e*, tip of male abdomen from side and beneath; *f*, tip of female abdomen from beneath. Enlarged as indicated. (Pergande, U. S. Dept. of Agriculture.)

In a letter from Dr. C. M. Weed, dated at Columbus, Ohio, November 2, 1888, he informs me that he found the grain-aphis early in the season establishing colonies on the older leaves of corn plants; but since Pergande* has shown that three or four species have until lately been confused under this common name the identity of the species observed by Weed is doubtful. Our specimens of grain-aphis from Illinois belong as a rule to the present species as described by Pergande. It occurs principally on wheat and oats but also on grasses and wild rye.

*Bull, No, 44, N. S., U. S. Dept. Agr., Div. Ent., p. 5.

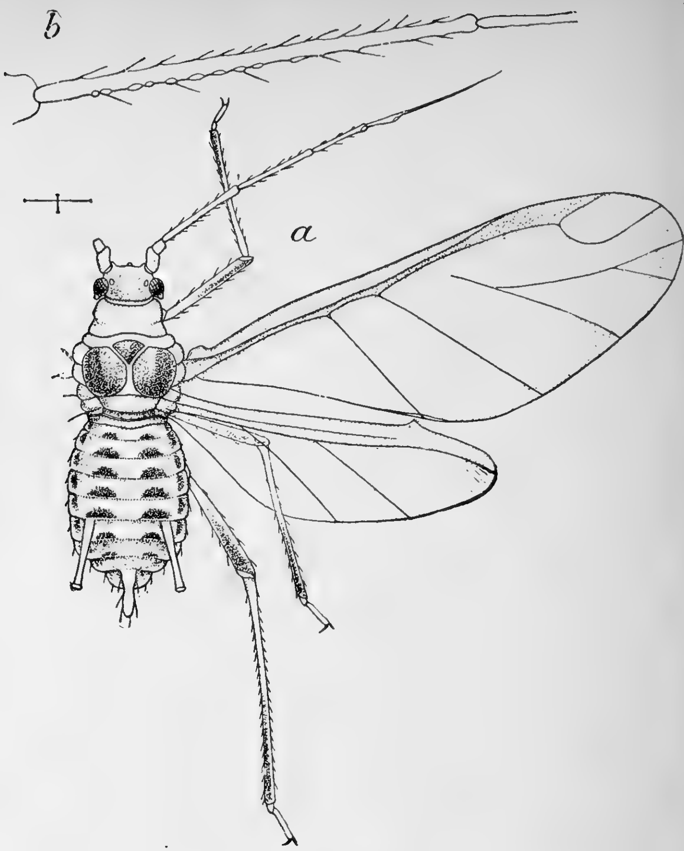

Fig. 217. The English Grain-louse, *Macrosiphum granaria*; winged female (*a*) and its antenna (*b*). Enlarged as indicated. (Pergande, U. S. Dept. of Agriculture.)

The Clover Plant-louse.

Macrosiphum trifolii Perg.

On the upper leaves of experimental corn in an inclosed frame at the University of Illinois Mr. H. Garman found colonies containing young, pupæ, wingless females, and characteristic winged females of this species (Fig. 218), recently described by Pergande in the paper just cited. Another winged example was taken by us on a corn leaf at Urbana. This is a pale green species with unusually long cornicles, and with numerous sensoria crowded along the outer side of the third antennal joint. It is common on red clover, strawberry, dandelion, and sow-thistle, and has also been found occasionally on wheat and oats.

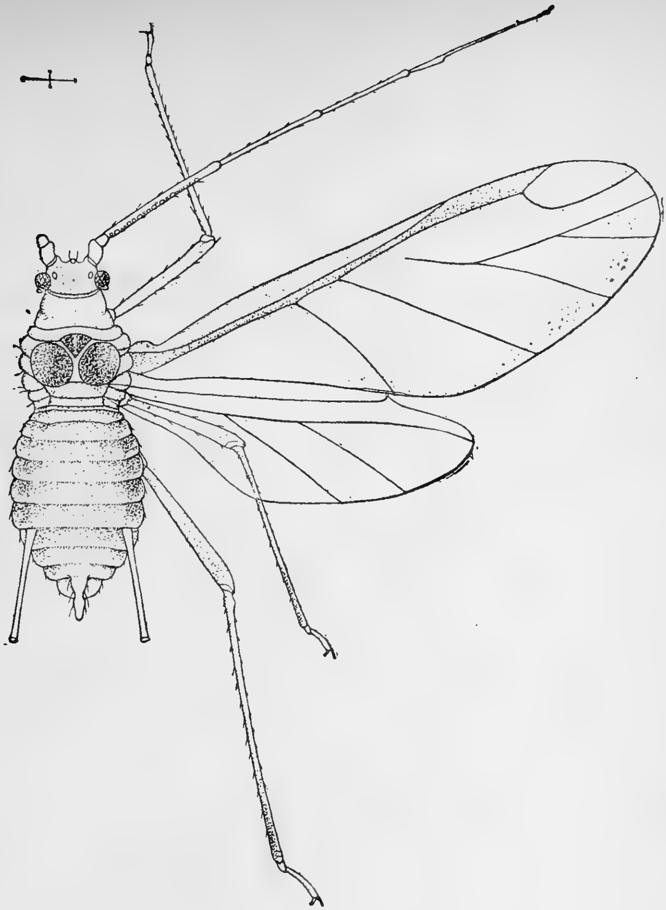

FIG. 218.—The Clover Plant-louse, *Macrosiphum trifolii.* Enlarged as indicated. (Pergande, U. S. Dept. of Agriculture.)

MYZUS ACHYRANTES Monell.

Colonies of this species appeared on corn in a large experimental breeding-cage at my office August 19. Some females were giving birth to young. All that could be found there on this and the following day were killed. However, on August 29 winged examples and young were abundant, mostly on the under sides of the upper leaves. September 12 they were still abundant, and examples were also taken by sweeping in a corn field in June. I have previously treated this as a sugar-beet insect,* the colonies of leaf-lice occasionally found by us on sugar-beet leaves all belonging to this species. It was originally described from examples found in Missouri on a plant of the pigweed family, and has been found on the common pigweed, *Amarantus.* These are probably

*Twenty-first Report State Ent. Ill., p. 82.

its natural food plants. The inner side and angle of the antennal tubercle is strongly prominent, rounded, and finely serrate, and the first antennal joint is similarly modified but in a less degree (Fig. 219). There is a large dark patch on the disk of the abdomen.

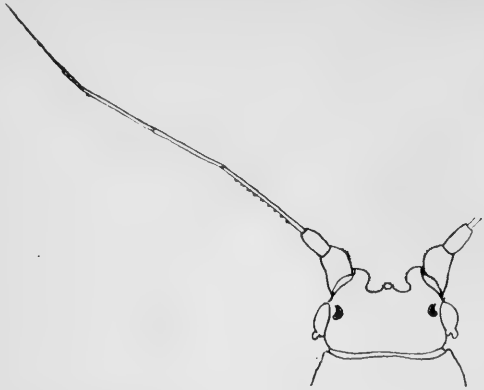

FIG. 219. *Myzus achyrantes*, head and antenna. Greatly enlarged.

RHOPALOSIPHUM DIANTHI Schrank.

This species has been observed by Williams in a greenhouse in Nebraska on a number of different plants, including corn. It is elsewhere reported from a few greenhouse and garden plants.

THE YELLOW SORGHUM PLANT-LOUSE.

Chaitophorus flavus Forbes.

This lemon-yellow, short, bristly plant-louse (Fig. 220, 221), sometimes abundant and destructive on sorghum and broom-corn, has been found by us in small numbers breeding on leaves of corn also, in late June and early July. In September it occurred in all stages on corn leaves in an experimental breeding-cage. It rarely infests corn, however, even in the near vicinity of seriously infested sorghum fields.

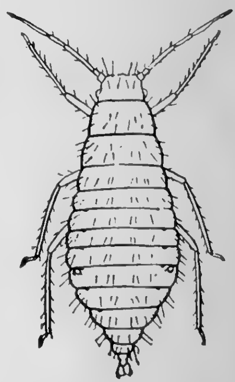

FIG. 220. The Yellow Sorghum Plant-louse, *Chaitophorus flavus*, wingless female. Greatly enlarged.

Cornicles are present but quite short, not longer than broad. The species resembles the box-elder plant-louse, *Chaitophorus negundinis*, but that has six distinct antennal joints, not counting the terminal spur, while *flavus* has only five joints, or often but four in wingless females. It was found by me in June on young sorghum plants only three or four inches high, and in each of the following months up to late September, but in October none were to be seen. The winter history remains unknown. It also occurred on foxtail- and panic-grass (*Setaria* and *Panicum*) in the vicinity of infested sorghum plants, and has been taken by us breeding on grass in May, and on wheat in September.

Although most plant-lice prefer the growing tops of their host plants, this species has the remarkable habit of infesting especially the lower and older leaves, usually their under sides. Ants which often attend plant-lice for their sweetish excretions seem to pay no attention to this species.

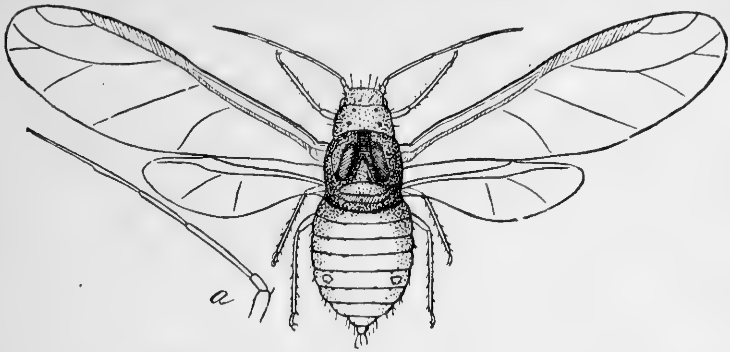

FIG. 221. The Yellow Sorghum Plant-louse, *Chaitophorus flavus*, winged female; *a*, antenna. Greatly enlarged.

THE PRAIRIE WALKING-STICK.

Diapheromera velii Walsh.

(*D. veliei.*)

Gillette reports this species* as abundant on two occasions in Colorado, once on corn and once on grass. It prefers weedy open situations in marked contrast with the habits of *D. femorata*, which is a forest species. We have found it common on open sandy ground in

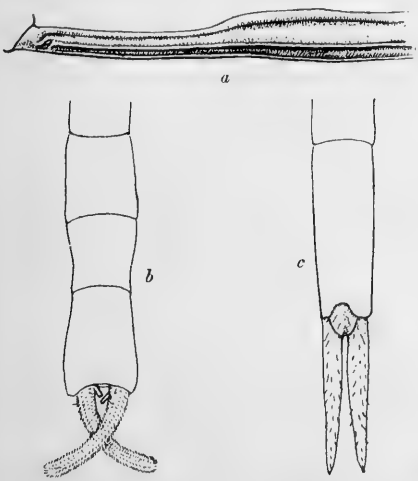

FIG. 222. The Prairie Walking-stick, *Diapheromera velii*: *a*, fore femur of female; *b*, tip of male abdomen; *c*, of female abdomen. Much enlarged.

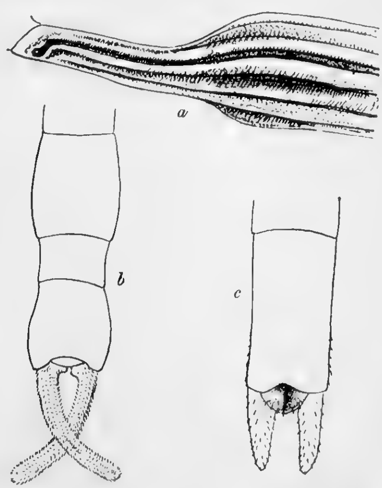

FIG. 223. The Common Walking-stick, *Diapheromera femorata*: *a*, fore femur of female; *b*, tip of male abdomen; *c*, of female abdomen. Much enlarged.

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*Bull. 94, Col. Agr. Exper. Station, p. 22.

Illinois. It has been taken by us at various Illinois localities, and on open ground at Lake Geneva, Wisconsin. It ranges from Maryland to Georgia, and thence to the Rocky Mountains and Mexico. It may be either green or brownish, and the males have usually a pale stripe each side. Their middle thighs are neither dilated nor banded, as in the common walking-stick, *D. femorata.* The fore thighs of the females are narrower (Fig. 222, *a*) and the cerci much longer (Fig. 222, *c*) than in *D. femorata* (Fig. 223, *a, c*). We have collected nymphs and adults at Urbana July 30, and adults in August and September.

GRASSHOPPERS.

Acrididæ.

The general subject of grasshoppers has been treated elsewhere in this report (see pages 64 and 136), but two additional species of this family have been knwn to cause minor injuries to corn, and two others are under suspicion.

The Short-winged Green Grasshopper.

Dichromorpha viridis Scudd.

This species (Fig. 224) is readily distinguished from other grasshoppers of its kind by its short wing-covers,—only about half the length of the abdomen in the female,—and by the oblong flat upper surface of the thorax, sharply separate from the vertical sides, its side margins nearly straight and parallel to each other and to a median raised line. The color is either grass-green or gray-brown. It is especially common in central and southern Illinois about the edges of woods and roads and in weedy places, particularly near water. It has several times been found eating corn leaves in September, and has been taken in general collecting from a variety of wild plants and flowers. Our earliest record of its occurrence is July 10, at Urbana, and we have repeatedly taken the adults at various dates from this time forward until September 24. The eggs are doubtless laid in fall.

Fig. 224. *Dichromorpha viridis.* Enlarged as indicated.

Boöpedon nubilum Say.

Gillette says* that this western grasshopper is rather common along the Arkansas River valley below Pueblo on moist ground where grasses grow, and that it has also been taken in wheat and corn fields. It ranges along the eastern slope of the Rocky Mountains from Texas to Nebraska.

*Bull. Col. Agr. Exper. Station, No. 94, p. 27.

Dissosteira longipennis Thom.

The permanent breeding-grounds of this species are in the Rocky Mountains, from Montana to New Mexico, and from these it is known to migrate in large numbers into the states bordering the mountains on the east. It has never entered Illinois.

It has occurred in great numbers early in the season in grain and corn fields, but does little damage, feeding principally on the grama-grasses and buffalo-grass, and later, to some extent, on corn. Alfalfa and potatoes are also eaten. The species is closely related to our common black-winged Carolina grasshopper, but differs from it in that the wing-covers are pale, with numerous brown blotches, and the dark area of the hind wings is bluish and does not cover so much of the wing.

Campylacantha olivacea Scudd.

This short-winged green grasshopper, with rounded thorax, has not hitherto been reported east of the region extending from Nebraska to Texas, in which it is often common. It is nevertheless not infrequent in Illinois, but has probably been overlooked because of its close resemblance to the nymphal forms of the common species. It has been taken at Havana, Edgewood, and Ashley, in west-central, southeastern, and southwestern Illinois respectively, in sandy grass-land and on wheat and corn in August and September. In the West it feeds on sunflower and lamb's-quarters and is suspected of injuring beets.

THE CRICKET FAMILY.

Gryllidæ.

This family includes the common black and brown house- and field-crickets (*Gryllus* and *Nemobius*), and the whitish and greenish white climbing crickets of the genera *Œcanthus* and *Xabra*. Numerous as these insects often are, they are of but little importance to the corn farmer. Some trifling injury now and then to the leaves of corn, and the occasional eating of a few kernels at the tip of an ear, usually when the stalk has fallen to the ground, are practically all the damage to corn which can be laid to their account.

The family is readily distinguished from other principal members of its order by the fact that the wing-covers are flat above and bent downwards at the sides; that the antennæ are long, slender, and many-jointed; that the foot is three-jointed and has no pads between the claws; that the ears are not in the abdomen, as in the grasshoppers, but in the tibia of the fore-leg; and that the body ends with a pair of slender-jointed appendages, the cerci, while the ovipositor of the female, when present, is a long spear-shaped structure, consisting of four pieces so grooved within that they form, when brought together, a tube through which the eggs are passed. The crickets travel mostly by jumping, and the hind thighs are usually enlarged. The males all make a peculiar rasping noise by rubbing the veins of one wing-cover upon those of the other.

The Pennsylvania Field-cricket.

Gryllus pennsylvanicus Burm.

This common black cricket has been many times found in September and October injuring corn grains at the tip of the ear, in no case, however, except where the ear was wholly or partly on the ground. It is very closely related to the common field-cricket, and quite possibly some of the nymphs found eating corn may be of the latter species. Field-crickets are much more generally injurious to other plants, to the tomato, for example, which they may cut off close above the ground, and to strawberries, which they occasionally spoil by eating the seeds. They sometimes make their way into houses, where they do injuries identical with those of the common domestic cricket. They have also been known to injure clover, and have shown traces of a carnivorous habit in the destruction of young grasshoppers.

The eggs of this species are laid in midsummer, the young hatching in July and August and mostly maturing the following spring. The adults remain until the advent of frost. They are most common in open woods among leaves.

This cricket has a short body, about three fourths of an inch long, with a large and globose head and large and rounded eyes. The ovipositor is from half to three fifths of an inch in length. The whole surface is shining black except the wing-covers, which are often more or less grayish or reddish.

The Striped Cricket.

Nemobius fasciatus DeG.

A small blackish species (Fig. 225, 226), about three eighths of an inch long. On the head are four pale longitudinal stripes, often indistinct, and there is also a black line on each side of the prothorax continuous with a line of the same color along the sides of the wing-covers. The ovipositor is straight and pointed obliquely upwards, and is as long as the hind femora. The hind wings of one variety are over twice the length of the wing-covers, and project beyond them like tails. In another variety of the species these wings are aborted and broadly rounded at the end. This latter form is the more abundant in Illinois, and has been found late in September feeding on the corn grain in fields at

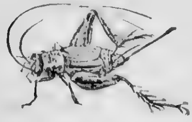

Fig. 225. The Striped Cricket, *Nemobius fasciatus*, female. About natural size.

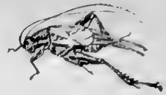

FIG. 226. The Striped Cricket, *Nemobius fasciatus*, male. About natural size.

Urbana where many stalks had fallen. Wherever the ear touched the ground, one or more of these crickets were beneath the husks, sometimes at a considerable distance from the tip. In such cases the substance of the grains had been gnawed away, sometimes deep enough to destroy the germ. This species was at the same time even more abundant in timothy and blue-grass fields, in woods, on thistle, iron-weed, and other wild plants, and in orchards, where it is occasionally slightly injurious to the fruit of the pear, apple, peach, and quince.

TREE-CRICKETS.

Œcanthinæ.

The white crickets, or tree-crickets, or climbing crickets (Fig. 227, 228), as they are variously called, are so numerous and vociferous everywhere from midsummer onward that their rhythmic shrilling is a constant feature of the summer night's experience. In town and country, all night long, the air rings with the ceaseless beat of their social song, all in a given spot keeping time with each other like trained musicians—an entomological choral union. Consistently with their habit of nocturnal song they are attracted to electric lights, and often visit the sugary lures of the night collector of insects. They are little seen by day, although not completely dormant then, and are rarely charged with feeding to any noticeable extent upon the vegetation of the garden or the farm. They are, in fact, in considerable measure insectivorous, especially when young. Plant-lice are evidently one of the favorite objects of their food, and other soft-bodied insects are said to be eaten by them. Dissections show that they feed largely on fungi and on the pollen, anthers, and pistils of flowers.

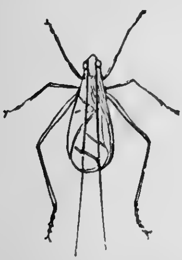

FIG. 227. A Tree-cricket, *Œcanthus*, male. Natural size.

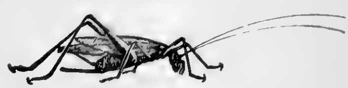

FIG. 228. A Tree-cricket, *Œcanthus*, female. Natural size.

These crickets are rarely common enough in corn fields to attract attention except for the row of punctures made in laying their eggs in the slender, naked part of the corn-stalks just below the tassel.

There are three forms of these egg punctures in the corn-stalks, two of them those of climbing crickets, and the other those of the meadow grasshoppers (*Orchelimum*). The eggs of the common white crickets of the fields *Œcanthus nigricornis*, for example), are closely placed in somewhat irregular rows running lengthwise of the stalk (Fig. 229), the punctures separated from each other a fifth of an inch or less, and often almost touching by their borders. The surface tissue of the stalk is torn and lifted where the puncture is made, causing a continuous line of tufted, roughened spots. The scars made by the broad-winged climbing cricket (*latipennis*) are larger than those just described, arranged in more or less regular rows, or sometimes irregularly scattered, and separated from each other by considerable distances—from a third to half an inch or more. The common meadow grasshopper (*Orchelimum*), on the other hand, makes a row of large blotches or patches of torn tissue, each a quarter of an inch across (Fig. 134), the fibers of the surface being broken and lifted and the eggs thrust into the pith beneath. The eggs of all these insects may of course be readily found by carefully splitting the stalks containing them. They are slender, cylindrical, slightly curved, blunt at both ends, shining yellow, with a darker roughened cap at the end nearest the surface. The snowy cricket lays one egg for each puncture, making a single row (Fig. 229). The broad-winged cricket pushes out from two to six eggs in two sets to the right and left (Fig. 230), and the meadow grasshopper does the same.

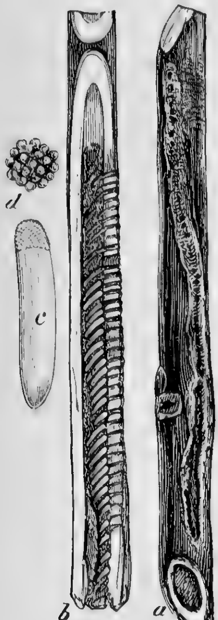

FIG 229. Eggs of Tree-cricket, *Œcanthus*, in raspberry cane: *a*, twig with row of eggs; *b*, section along row of eggs, showing arrangement; *c*, an egg enlarged; *d*, sculpture of cap, more enlarged.

Assistants have several times found these crickets at the injured tips of ears of corn in the field, but dissection of specimens so found indicates that they are feeding on the fungi which develop on the broken kernels, and not on the grain itself.

They are injurious chiefly to trees, shrubs, and vines, in whose twigs and branches they may lay their eggs. Raspberries, blackberries and grape vines are sometimes considerably injured by them. Where their eggs have been laid in a close row of punctures the twig is likely to split to the center after a little, and to die beyond the point of injury. Half the canes in a raspberry field were thus affected in one case reported to me.

These eggs are also laid almost indiscriminately in a considerable number of thick-stemmed annual weeds. All the species hibernate in the egg so far as known, and the young, hatching in early spring, get their growth from the middle of summer to early fall.

Eight species of climbing crickets are known for Illinois, seven of them belonging to the genus *Œcanthus* and one to *Xabea*. But two of them have been certainly noticed in corn fields, *Œ. nigricornis* and *Œ. latipennis*. *Œ. niveus* has been frequently reported from corn, both here and elsewhere, but not, so far as I know, by those who were aware at

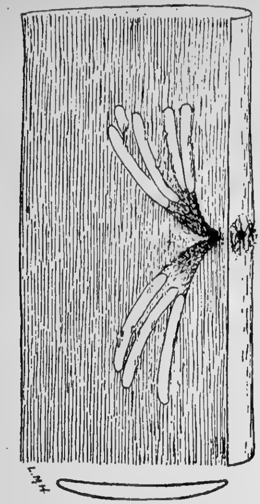

Fig. 230. Egg mass of *Œcanthus latipennis* in stem of corn tassel, enlarged; also single egg, more enlarged.

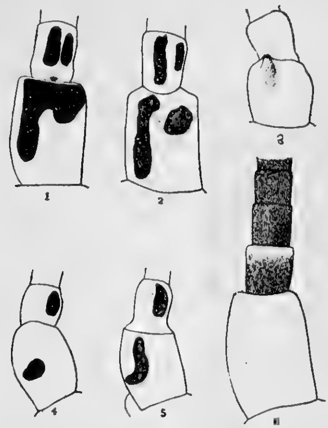

Fig. 231. Basal joints of antennæ of species of *Œcanthus* and *Xabea*: 1, *Œ. nigricornis*; 2, *Œ. quadripunctatus*; 3, *Xabea bipunctata*; 4, *Œ. niveus*; 5, *Œ. angustipennis*; 6, *Œ. latipennis*.

the time of the differences between this species and *nigricornis*. *Niveus* and *angustipennis* are usually found in orchards and similar situations. *Œ. 4-punctatus*, on the other hand, like *nigricornis*, is found in open situations and in the vicinity of corn fields, and in all probability occurs on corn.

The species may be distinguished by the following synoptical key: *

A. Hind legs slender, and tibæ having weak spines.
  B. First two segments of antennæ with black markings beneath.
    C. First joint of antennæ with a single straight black line on the inside beneath, second joint with two parallel lines beneath; third joint of maxillary palpi nearly or quite as long as fourth and fifth united; pale yellowish; wings much longer than wing-covers; wing-covers flattened above, transparent, and very narrow; the abdomen and leg not marked with black. .... *Œcanthus forbesi*.†
    CC. Third, fourth, and fifth joints of maxillary palpi subequal.
      D. First and second joints of antennæ each with a single mark.
        E. Wholly pale whitish green, with a single dot on under side of each of first two antennal joints (Fig. 231, 4); wing-covers about twice as long as abdomen, wings as long as wing-covers........................ *Œ. niveus*.

*Prepared by E. S. G. Titus.

†Can. Ent., Vol. XXXV., p. 260.

EE. Pale greenish white, generally with a brownish yellow spot on top of head; wing-covers very narrow, sides almost parallel, wings about as long as wing-covers; the first joint of antennæ with J-shaped mark beneath, the hook turning inward, mark on second joint elongate and slightly curved (Fig. 231, 5) ....*Œ. angustipennis.*

DD. First and second joints of antennæ each with two black marks.

E. First joint of antennæ beneath with a long, slender black mark inside and a dot outside, the second joint with two short, nearly equal parallel lines (Fig. 231, 2), remaining antennal joints brownish; pale yellowish green, sometimes with dark markings on abdomen; wings always somewhat longer than wing-covers......*Œ. 4-punctatus.*

EE. First antennal joint with a line inside, a bar outside.

F. Dark yellowish green, head and thorax with several brown or black longitudinal stripes, body beneath brownish or all black, legs varying from yellow to black, wings longer than wing-covers. The two black marks on the under side of first joint of the antennæ are connected at the top with black, giving a mark having the shape of an inverted L; on the second joint they are long and parallel, the outer one the shorter (Fig. 231, 1).........................*Œ. nigricornis.*

FF. Dark yellowish green, head and antennæ reddish brown, thorax dark brown sometimes marked with black lines on each side above, body black beneath, sides yellowish green, above black with a central greenish stripe; wing-covers transparent, with bright grass-green veins, wings very little longer than wing-covers; first joint of antennæ beneath with straight longitudinal line inside, and near the top on the outside a short oblique line; second joint with two parallel lines.....................................*Œ. pini.*

BB. No black marks on first two antennal joints beneath, these joints and the top of the head distinctly pinkish (Fig. 231, 6). Pale yellowish green; wing-covers very broad as compared with other species of the group and extending beyond the abdomen, longer than the wings in the male, about equal to them in the female. This species is generally longer than any other of the genus...................................*Œ. latipennis.*

AA. Hind legs slender, and tibæ having no spines. General color pale pinkish brown, wing-covers in female with two large brownish or black spots on each, those of male without spots; head broader than thorax, which is long with the sides parallel, wings almost twice as long as wing-covers. Maxillary palpi with the third joint very long and slender, but shorter than the fifth joint, which is obliquely truncate at the end, fourth joint very short. Antennæ have on basal joint, beneath, a short tubercle (Fig. 231, 3) .... *Xabea bipunctata.*

Notes on the Food of the White Crickets.

The food of four species of white crickets has lately been investigated by Mr. E. S. G. Titus and myself, and by Mr. Ralph G. Mills, a student working under my direction. Our material consisted partly of freshly collected specimens, and partly of pinned specimens from my office collection which were softened up by boiling in potash solution. These were then dissected and the contents of the alimentary canal were displayed in glycerine on glass slides, and examined under the microscope.

Fig. 232. Mandible of a White Cricket, *(Ecanthus 4-punctatus.* Greatly enlarged.

Generally speaking, the food of the genus *Œcanthus* is highly miscellaneous, consisting largely of the floral organs of grasses and other plants, quantities of pollen, various fungi, many plant-lice, with traces of other insects, and occasional fragments of leaf tissue not definitely recognizable as to their origin but derived from both veined and parallel-veined plants. Serious injuries to vegetation by these insects are virtually impossible owing to the weakness of their mandibles, which, while permitting them to eat stamens and pistils of plants and soft-bodied insects, are not adapted to the biting and mastication of resisting vegetable tissues. The difference in this respect from the ordinary herbaceous *Orthoptera* is shown by figures 232 to 234, comparing the mandible of the white cricket (*Œcanthus*) with that of the common field-cricket (*Gryllus pennsylvanicus*) and the red-legged grasshopper (*Melanoplus femur-rubrum*).

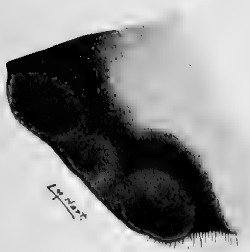

Fig. 233. Mandible of the Common Field-cricket, *Gryllus pennsylvanicus.* Greatly enlarged.

Fig. 234. Mandible of the Red-legged Grasshopper, *Melanoplus femur-rubrum.* Greatly enlarged.

Œcanthus angustipennis Fitch.

The food of eighteen specimens was examined by Mr. Mills. Remains of insects predominated in nine, the food of the other nine being almost wholly vegetable, largely fungi in four. Pollen of various kinds was present in eleven cases and was the principal food in two. Miscellaneous vegetable fragments, consisting largely of stamens and pistils, were detected in eight cases, in three of which they composed the principal part of the food. In a single case dead vegetation was present, penetrated by fungus threads.

Œcanthus quadripunctatus Beut.

No. 1. An adult specimen taken in wheat stubble at Duquoin, in Perry county, September 7, 1883, had fed mainly on plant-lice, remains of which consisted of antennæ, legs, and recognizable parts of heads with beaks attached. There were also pieces of anthers, with trilobed pollen grains and a fragment of leaflike vegetation.

No. 2. An adult from a strawberry field at Anna, in Union county, September 17, contained a quantity of fungus spores and fragments of anthers and styles, together with a great amount of large globular pollen, all evidently graminaceous in origin.

No. 3. A nymph from the same place as No. 2 had eaten mainly anthers and styles of a graminaceous plant, the anther tissue and pollen largely predominating.

No. 4. A small nymph taken August 6 at Centralia, in Marion county, from wheat stubble, had fed on obscure vegetable matter containing scalariform and spiral ducts, together with plant hairs, pollen, etc., a few fungus spores and pistil tissue, and a little black mycelium. Some of the cellular vegetation was penetrated by mycelial threads in a way to show that it was in a state of decay.

No. 5. A nymph of this species obtained at Anna July 17 contained only minute fungus debris, mainly a black mycelium, with occasional small spores.

No. 6. Another nymph collected at the same time and place as No. 5 had, like that, fed mainly on spore-bearing fungi, including *Alternaria*, but contained also some very minute fragments of plant-lice.

No. 7. Another nymph, obtained at Anna, July 17, had made its last meal largely on plant-lice, as shown by minute but unmistakable fragments. Some additional parts of the food were unrecognizable.

No. 8. Collected from wheat stubble July 5, at Duquoin. The food consisted wholly of various fungus spores, some of them thick-walled and oval and others clavate and septate.

No. 9. The same as No. 8 and from the same place, containing a larger quantity of virtually the same food.

No. 10. Another specimen from southern Illinois, in August, a full grown female, contained spores and mycelia of various fungi, together with some other vegetation, fragments of plant-lice, and traces of other insects.

No. 11. A specimen from Milan, in Rock Island county, obtained August 13, had fed on plant-lice, and also contained fragments of cellular vegetation, with spiral cells and large scalariform ducts.

Four specimens of this species taken in August had fed mainly on the pollen of various plants. Fungi were found in all, and were the entire food of a single specimen and the greater part in another. Miscellaneous vegetable tissues, about equally divided between the leaves and the floral organs of grasses, predominated in one case and were present in two others. In one specimen was a piece of vegetable tissue penetrated by threads of the mycelium of a saprophytic fungus. Insect remains were found in three specimens, but in very small amounts.

Œcanthus nigricornis Walk.

Seven specimens were dissected by Mr. Titus with the following results:

No. 1. An adult female from Milan, Rock Island county, obtained August 13, had fed mostly on vegetation, the fragments of which contained spiral ducts. The structure suggested the leaves of a graminaceous plant, possibly corn.

No. 2. Another specimen, an adult female, collected from a milkweed in the field at Champaign August 27, had eaten little else than the anthers of grass.

No. 3. A third specimen of this species, taken at the same time and place as the preceding, had fed on pollen of a graminaceous plant, and contained also some vegetable fragments with spiral cells.

No. 4. In a third specimen of the same origin as the preceding, only pollen grains, some spherical and others triangular, were found.

No. 5. An adult male specimen from Champaign county, taken August 28, contained only fungus spores and mycelia of various kinds.

No. 6. Origin and food identical with those of No. 5.

No. 7. An adult female taken on corn at Neoga September 27. Many *Alternaria* spores, and also large pollen grains together with fragments of anther tissue.

Eighteen specimens, taken from five localities in central and southern Illinois at various dates from August 10 to October 10, were studied by Mr. Mills. In but one of these was there a preponderance of insect food, though minor percentages were found in ten others. The greater part of this consisted of plant-lice, but occasional fragments were noticed of insects provided with a heavy chitinous crust. Fragments of vegetation predominated in seventeen cases, and made nearly half the food in the eighteenth. Fungi were noticed in but two specimens, and in these in comparatively small amount. Miscellaneous vegetable tissues largely derived from floral organs of grasses were present in all specimens, and formed a greater part of the food in eleven. There was little evidence that this species eats the leaves or other more solid tissues of the plants.

Œcanthus pini Beut.

No. 1. A nymph collected at Normal, McLean county, July 20, from a field of oats, contained only fungus spores, a majority of them unicellular but some of them clavate.

No. 2. A specimen collected from grass near Tolono, Champaign county, July 25, had eaten the tissues of grass blossoms, as shown by fragments of the very slender filamentous pistils of that plant.

It will be noticed that in this little collection of twenty specimens plant-lice were found a more important element in the food of the young than in that of the adult; and that ordinary cellular vegetation is insignificant in amount, the greater part of the vegetable food consisting of the floral organs of grasses— and possibly of other plants—and minute fungi of various descriptions, such as are found on leaves and on decaying vegetation.

THOUSAND-LEGGED WORMS.

Myriapoda.

These many-jointed, wormlike forms, crawling more or less rapidly by means of a multitude of small legs, feed on both decaying and living vegetable matter, but in this country their injuries to cultivated plants are rarely serious. Several species have been taken feeding on planted seed-corn, and also in ears on the stalk, especially those fallen or resting on the ground.

Some species eat tubers, roots, and other underground plant structures; others feed above ground on fruits, stems, and leaves. Potatoes, cucumbers, squashes, melons, ripe raspberries, and strawberries are favorite objects of their food. They sometimes cause trouble by feeding on flowers and foliage in greenhouses.

We have found myriapod eggs under ground April 27 in small rounded cavities a little less than half an inch in diameter and about three or four inches below the surface. The young hatched next day, and by May 10 were strong enough to burrow into the ground. The species was not determined, as we failed to rear them to maturity.

Julus cœruleocinctus Wood.

This myriapod seems to have a preference for garden vegetables, and especially for tubers and roots. It has been reported by Lintner as feeding on kernels of ripening corn at Madison, Wisconsin. We have not taken it in Illinois.

Parajulus venustus Wood.

This is one of our commonest species (Fig. 235). We have found it in fall inside the husks and on ears of corn, burrowing in raspberry and currant stems in May, and about clover roots in September. Most of our specimens were collected in April and May; the remainder from September to December. It is a species of northern range, not known to occur south of Kentucky, while the closely related *P. impressus* is southern, and rare in this latitude. The specimens reported upon by Coquillett* under the name *Julus impressus*, which he calls the corn myriapod, were very probably this species. He found them feeding on kernels of corn on ears lying upon the ground, and says they are frequently found beneath shocks of corn and other grain.

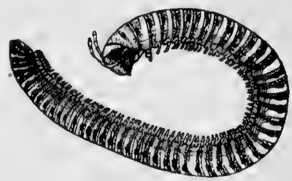

Fig. 235. *Parajulus venustus*. Three times natural size.

Parajulus diversifrons Wood.

This species is common in Illinois and has been taken eating corn grains in the ear, both on the ground and on the stalk. We have found it under the husks between the rows of kernels.

THE RED SPIDERS.

Tetranychus.

Injuries by the tiny pale mites (Fig. 236, 237) commonly called the red spider are most serious on greenhouse plants and trees and shrubbery of various kinds, especially in unusually hot and dry weather. The leaves and stems of infested plants are coated with a very delicate, almost invisible web, and the under surface is dirtied with numerous fine dark particles, which, under a lens, are seen to be empty egg-shells and excreta. The mites themselves are easily seen moving about over the surface of the leaf. In hot dry weather almost any herbaceous plant is liable to infestation, but rarely to serious injury. On two occasions in fall we have found them at work on corn in Illinois. The same injury has been noted on sugar-beets, and a full treatment of the species from

*Eleventh Rep. State Ent. Ill., p. 44.

FIG. 236. The Common Red Spider, *Tetranychus bimaculatus*, female. Greatly enlarged. (Harvey.)

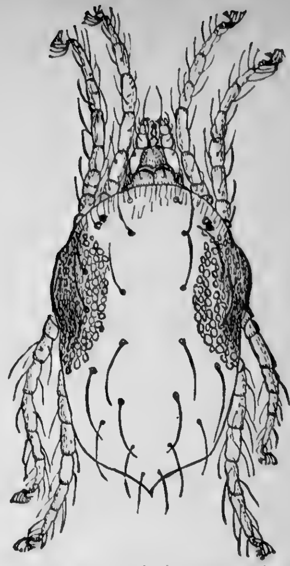

FIG. 237. The Common Red Spider, *Tetranychus bimaculatus*, male. Greatly enlarged. (Harvey.)

this point of view may be found in the Twenty-first Report of this office (page 58).

These insects are believed to winter as adults among dead leaves, in the crevices of sticks, and in similar shelters. They begin to breed as soon as the weather favors their multiplication and continue active throughout the season. The eggs are red and are laid on buds and twigs.

FIG. 238. The Common Red Spider, *Tetranychus bimaculatus*, foot. (Harvey.)

TETRANYCHUS BIMACULATUS Harv.

This is by far the most abundant and troublesome species of red spider throughout the United States. It is the species mentioned as found by us on corn and on sugar-beets. It is also recorded by Banks as occurring on corn at Washington, D. C.

TETRANYCHUS MODESTUS Banks.

This species was described from examples found causing a rust-like appearance on blades of corn at Washington, D. C., in August.

KEY TO THE DISCUSSION OF INSECT INJURIES TO CORN.

The following analysis of insect injuries to the corn plant is intended to aid the observer of such injuries to find the essential matter relating to any one of them contained either in the present report or in the Eighteenth Report of this office—devoted to insect injuries to the underground parts of the plant. The use of this synopsis or key will be easy to those accustomed to the determination of species, either of plants or of animals, by means of ordinary analytical tables; but to others, some explanation may be necessary.

With an example of an injury under examination, the observer will first refer to the "General Grouping of Injuries to Corn," on this page, and will ascertain under which of the six groups there given his example belongs. Against the description of each of these groups is a reference to a page where the group is further analyzed, and to this analysis he will of course turn next.

Suppose, for example, that he has a corn plant the leaves of which have rows of similar holes running across the blade. Referring to the general groups below, he finds that injuries to the leaves are analyzed on page 226. Going to this analysis and reading the first two items of the table, he assigns his specimen to the first,—that of "Injuries to the green leaf,"—and is thence referred to the series of items numbered "2," under the second of which—"Regular parallel rows of similar holes running across the leaf of the young plant"—he gets a reference to colored Plate III. of this report, and to page 229, where snout-beetles injurious to corn are partially analyzed by a supplementary key, which requires that the insect itself should be in hand. Even if the beetle responsible for the injury has not been detected at work, the facts concerning this class of injuries may be found by following up the page references under the various items of this table, since this will give an exhaustive account of all the insects producing this injury.

It will be seen that in the preparation of this key no technical terms have been used except where necessary to an intelligible expression of the meaning. It will also be noticed that the character of the injury to the plant has been depended upon, so far as plain and available, the insects themselves being used to help out where the injuries are not clearly distinguishable and recognizable.

General Grouping of Injuries to Corn.

A. Injuries to the leaves . . . . p. 226
B. Injuries to the stalk above ground . . . . p. 226
C. Injuries to the silks or to the kernels at the tip of the ear or beneath the husks . . . . p. 226
D. Injuries to the tassel . . . . p. 227
E. Injuries affecting the whole plant . . . . p. 227
F. Injuries to the underground parts of the plants—the roots, the planted seed, or the stalk near the roots . . . . p. 227

A. Injuries to the Leaves.

Injuries to the green leaf. 2

The dry leaf eaten in the fodder stack, mostly inside the stack, by a dull-brown striped caterpillar about an inch long (Fig. 65) .... The Fodder Worm (*Epizeuxis æmula*), p. 86

2. Leaves coarsely ragged in late summer or fall, often eaten away to the midrib, injury much the worse at the edge of the field. .... "The Leaf-eating *Orthoptera* of the Corn Field," p. 229

Regular parallel rows of similar holes running across the leaf of the young plant (Pl. III.) .... The Snout-beetles, p. 229

Leaves of young plant irregularly peppered with small holes or surface pits, made by small jumping beetles (Fig. 88, 90–93, 187–189) .... The Flea-beetles, pp. 106, 190

Leaves marked with winding pale streaks like worm tracks, a footless maggot within the leaf (Fig. 154, 155) .... *Ceratomyza dorsalis*, p. 165 .... The Corn Leaf-miner (*Diastata* sp.), p. 164

Leaves folded, the sides of the fold fastened together, and a caterpillar concealed within .... Leaf-rollers, p. 174

Leaves gnawed superficially between the veins in small oblong patches (Fig. 49) by young caterpillars, especially by young garden web-worms (p. 89) and by the white hairy young of the yellow bear (Fig. 46), ... p. 72

Leaves eaten at the edge, or irregular holes made. 3

Leaves with minute, specklike discolorations, due to small sucking insects. .... "Insects injuring the Corn Plant obscurely," p. 233

3. Injury to the young plant, the stem often gnawed; a webbed nest at the base of the plant made of particles of dirt held together by webbing (Fig. 20), with a tubular retreat in the center, opening at the surface near the plant .... The Sod Web-worms, p. 230

A silk-lined tubular burrow opening at the base of the plant and going at least several inches into the earth; leaves or stalk eaten. .... The Burrowing Web-worms, p. 95

Miscellaneous leaf injuries not above included (See "The Corn Cut-worms," p. 231, and "The Stalk-borers," p. 232) .... "Insects Eating Irregular Holes," etc., p. 230

B. Injuries to the Stalk above Ground.

Stalk of young plant cut off smoothly at the surface of the ground. Cutworms, p. 231 .... The Burrowing Web-worms, p. 95

Stalk irregularly eaten into, sometimes irregularly severed, leaves also irregularly eaten, (Fig. 20) .... The Sod Web-worms, p. 230 .... The Burrowing Web-worms, p. 95

Stalk penetrated and burrowed within by caterpillars ..... The Stalk-borers, p. 232

Decaying cavities in stalk due to footless maggots usually found working therein (Fig. 153) .... The Stalk-maggot (*Chætopsis ænea*), p. 164

C. Injuries to the Silks or to Kernels at the Tip of the Ear or beneath the Husks.

Round hole through husks, with excrement exuding; kernels eaten beneath by a brownish or greenish striped caterpillar (Pl. IV.) .... The Ear-worm, or Corn-worm, p. 67 .... The Grass-worm, p. 81

Other injuries to the growing ear, and to the silk. 2

Other injuries to the ripened ear in fall, especially to the exposed grains at the tip or to ears on fallen stalks. 3

2. Injuries to the tip of the ear by grasshoppers, katydids, etc .... "The Leaf-eating *Orthoptera*," p. 229

The ear penetrated at the tip by broad green or brown beetles half an inch long or more, and the kernels eaten beneath the husks. 4

The growing cob eaten by an ashy gray June-bug .. The Scaly June-bug, p. 184

The ripening kernels burrowed in all directions by beetle larvæ. New Mexico .... p. 186

Small dark green caterpillars about half an inch long feeding in the growing ear .... The Rusty Brown Tortrix, p. 176

The silk eaten by a black or dark green caterpillar with two yellow stripes on each side connected across the back by numerous fine white lines (Fig. 163) .... The Zebra-caterpillar, p. 171
By green or yellow, black-spotted or -striped beetles about a quarter of an inch long (Fig. 184–186) .... The Root-worm Beetles, p. 187
By a small oval or oblong beetle, yellowish to brownish, about an eighth of an inch long .... *Luperodes varicornis*, p. 187
By a beetle about a third of an inch in length (Fig. 182) and shaped like a June-bug .... *Anomala undulata*, p. 185
By slender, soft-bodied, cylindrical beetles, black or striped (Fig. 94–97) .... Blister-beetles, p. 111

3. Ants hollowing out grains on ear............................ p. 159
Very small caterpillars eating kernels on the ear.... *Batrachedra rileyi*, p. 176
Active ground-beetles of medium size hollowing out the ripened grain, p. 176
Minute beetles of various kinds common on corn in the ear, sometimes injuring the kernels, but usually feeding on fungi due to previous injury .... p. 180
A black beetle with four yellow spots (Fig. 176), occasionally common on ripe ears, especially those fallen, injured, or partly decayed....... .... *Ips 4-guttatus*, p. 181
Dung-beetles and related species, a sixth to a half inch long, feeding on rotten or fallen corn .... p. 183
Crickets, black or white, hollowing out the grains .... p. 213
Dark, cylindrical, hard, many-jointed worms, with many pairs of legs (Fig. 235), eating the green silks, or feeding on corn in the ear, particularly when fallen or touching the ground .... Millipeds, p. 222

4. Green beetles nearly an inch long, with dull yellowish margin to thorax and wing-covers (Fig. 82, 83) .... The Green June-beetles, p. 101
Brownish beetles about half an inch long (Fig. 80, 81) .... (Flower-beetles), p. 99

D. Injuries to the Tassel.

Stem with row of small roughened patches containing elongate eggs (Fig. 134) .... Tree-crickets and Meadow Grasshoppers, pp. 215, 144
Tassel covered by web and eaten by active yellowish caterpillars about half an inch long .... The Sorghum Web-worm (*Celama sorghiella*), p. 169
Fallen pollen eaten by insects of various kinds .... pp. 156, 162, 179, 180, 188

E. Injuries Affecting the Whole Plant.

Plant not inclosed in web. The entire plant more or less completely eaten, the leaves first and then the stalk, in June and early July by hordes of striped caterpillars commonly coming into the field from one side (Pl. II.; Fig. 63, *b*). .... The Army-worm (*Leucania unipuncta*), p. 47
Young shoots eaten by an oval beetle (Fig. 172). Southern States........... .... *Omophron labiatum*, p. 178
The young plants eaten by an elongate, long-legged, buff-colored beetle (Fig. 181) .... The Rose-chafer (*Macrodactylus subspinosus*), p. 184
The young plant, or the base of older plants, more or less completely inclosed in a distinct web, and the leaves eaten by small, active, slender caterpillars five eighths of an inch long (Fig. 70) .... The Garden Web-worm (*Loxostege similalis*), p. 89
Plant dwarfed or apparently unhealthy, generally or diffusely discolored, or wilted, or merely dwarfed without notable discoloration. No local loss of substance under or above ground sufficient to account for its condition .... "Insects injuring the Corn Plant obscurely," p. 233

F. Injuries to the Underground Parts of the Plant: the Roots, the Planted Seed, or the Stalk near the Roots.

Injuries to the seed. 2
Roots injured or destroyed, with evident loss of substance. 6
Growth of plant retarded or arrested; roots stunted or deadened without apparent loss of substance. Ants burrowing among hills; plant-lice on roots. .... Corn Root-lice, Eighteenth Report, p. 55
Injuries to the stem under ground. 7

2. Seed gnawed, superficially penetrated, or bored through, by long, cylindrical, smooth, hard larvæ, yellowish white to chestnut-brown, half an inch to about an inch in length, with three pairs of distinct short legs just back of the head (Pl. VI., Fig. 2–5)..Wireworms, Eighteenth Report, p. 28

Seed gnawed by cylindrical, very many-jointed and many-legged worm-like creature, with a distinct head, hard crust, and generally brown color. Curls up into a disk or coil when disturbed.. Thousand-legs (*Myriapoda*), p. 222

The kernels gnawed from without by beetles, injury commonly beginning at the germ. 3

Seed injured by footless whitish maggots which bury themselves in the kernel. 4

Seed gnawed or bored through by soft larvæ about a fourth of an inch long, with three distinct pairs of short legs just back of the head. Pupa with free wing-pads. Adult a beetle. 5

Seed injured by small ants which hollow out the kernel ....*Solenopsis debilis*, Eighteenth Report, pp. 9, 66
.... *Myrmica scabrinodis lobicornis*, Eighteenth Report, pp. 11, 66

3. A small yellowish beetle, head darker, thorax and wing-covers blackish centrally..................*Agonoderus pallipes*, Eighteenth Report, p. 12

An elongate uniformly dark reddish beetle with neck-like separation of thorax and abdomen. *Clivina impressifrons*, Eighteenth Report, p. 15

A small, sluggish dung-beetle, cylindrical, short, and black ....*Aphodius granarius*, Eighteenth Report, p. 14

A large, heavy, dark beetle, closely resembling a June-bug, eating the germ of the planted kernel and the young shoot. *Ligyrus gibbosus*, p. 98

4. A fleshy maggot about a fourth of an inch in length, tapering to the front but with distinct head; posterior end blunt...Seed-corn Maggot, p. 70; also Eighteenth Report, p. 16

A cylindrical, smooth, white, thickish larva about a third of an inch long, with distinct black head...Black-headed Grass-maggot, Eighteenth Report, p. 19

5. A slender, yellowish, worm-like larva, thickening slightly backwards and ending in a rounded point...Pale-striped Flea-beetle, p. 107, and Eighteenth Report, p. 21

A rather broad and short flattish larva with short, wide joints, sides with a row of blunt points, ending in two short forked spines.............................*Ips quadriguttatus* (*fasciatus*), Eighteenth Report, p. 23

6. Roots eaten away, not burrowed or perforated, and without rotten or withered tips. Tap-root commonly eaten off. Large white grubs in soil among or beneath roots. The White-grubs, Eighteenth Report, p. 109

Roots deficient, often withered at tips or dried up. Not visibly penetrated or perforated from without. Principal injury interior to the root in the form of a minute longitudinal burrow usually containing a small, slender white larva with distinct head and six short legs...................................... The Northern Corn Root-worm, Eighteenth Report, p. 154

Roots penetrated, perforated, irregularly burrowed, and more or less eaten off or eaten up. Underground parts of stalk also usually similarly injured. Small, slender, soft-bodied yellowish white larva, about half an inch long, with three pairs of short legs back of head, a brown head, and brown patches on neck and on last segment, to be found in the roots and adjacent earth ....The Southern Corn Root-worm, Eighteenth Report, p. 146

Tap-root irregularly gnawed but not severed or burrowed lengthwise. Injury by white thick-bodied grubs an eighth of an inch long, with brown or reddish head and neck-shield, and with six jointed legs (Fig. 85)....................................... The Colaspis Root-worm, p. 104

The roots eaten away by thick-skinned, wrinkled, dirty gray footless maggots about an inch long when full grown, narrowed forward to a very small hard head (Fig. 149)...................Meadow Maggots, p. 161

7. Stalks deeply gnawed, or cut off at the base under ground, by large dark-colored beetles (Fig. 79)..........................*Ligyrus*, pp. 98, 99
....*Aphonus*, p. 184

Stalk gnawed at base by a blackish snout-beetle with round thorax and oval abdomen (Fig. 193).................. *Otiorhynchus ovatus*, p. 192

Young plants gnawed at the base by a black beetle a fifth of an inch long, slightly bronzed, dirty, or white-hairy, with margins of thorax toothed.............................. *Myochrous denticollis*, p. 103
Stalk penetrated and burrowed by an elongate larva. 8
8. Larva, hard, smooth, shining, cylindrical, brown or yellowish.......... ....Wireworms, Eighteenth Report, p. 28
Larva, soft, yellowish white, with brown head, and brown patch at tip of body........The Southern Corn Root-worm, Eighteenth Report, p. 146

The Leaf-eating Orthoptera of the Corn Field.

Antennæ not over half as long as the body; color usually brownish (*Acrididæ*, pp. 64, 136, 212). 2
Antennæ at least as long as the body; colors green or greenish (Meadow Grasshoppers, Katydids, and Walking-sticks). 5
2. Wings nearly or quite as long as the abdomen. 3
Wings not over half as long as the abdomen. 4
3. Smaller species about an eighth of an inch wide....................
..........................The Red-legged Grasshopper, pp. 67, 136
..............................The Lesser Grasshopper, pp. 67, 136
.... The Rocky Mountain Grasshopper, p. 136
............................The Clear-winged Grasshopper, p. 139
.... *Boöpedon nubilum* (western), p. 212
Larger species a quarter of an inch, or more, wide ....
.... The Olive Grasshopper, pp. 67, 136
.... The Two-striped Grasshopper, pp. 67, 136
.... The Bird Grasshoppers, pp. 67, 140
..........................*Dissosteira longipennis* (western), p. 213
4. Grass-green (Fig. 130) ....The Small Green Grasshopper, p. 142
.... *Campylacantha olivacea*, p. 213
Green or brown (Fig. 224)................. *Dichromorpha viridis*, p. 212
Dark brownish .... *Melanoplus scudderi*, p. 142
5. Winged species. 6
Wingless species. 7
6. Wings green, hind legs two or three inches long, ovipositor pointed upwards (Fig. 131). Eat leaves and soft kernels, and insert flattened eggs in edge of the leaf .... Katydids, p. 143
Wings merely tinted with green, hind legs about an inch and a half long, ovipositor curved (Fig. 132, 133). Eat leaves, silks, and young kernels. Deposit eggs in stalk of tassel (Fig. 134).................. ....The Larger Meadow Grasshoppers, p. 144
Wings tinted with green, hind legs not over an inch long, ovipositor nearly straight, often very long (Fig. 135). Leaves, husks, and grain eaten. .... The Smaller Meadow Grasshoppers, p. 147
7. Large, wingless, heavy-bodied grasshoppers, migrating in hordes and destroying vegetation. Western......... The Great Plains Cricket, p. 148
Very slender cylindrical insects with very long legs and no wings (Fig. 222)............................The Prairie Walking-stick, p. 211

Snout-beetles Injurious to Corn.

Beetles with head drawn out in the form of a curved cylindrical beak, or snout, with a pair of minute jaws at its tip.
Wing-covers rather distinctly ridged, punctured, and striated; surface often coated with a hard earthen crust (Fig. 27–34, The Corn Bill-bugs, p. 52). 2
Smoother snout-beetles, over half an inch long, slender, covered only with a whitish or yellowish bloom easily rubbed off (Fig. 99). 3
Small snout-beetle, an eighth of an inch long, which punctures the corn leaf-sheath ....*Limnobaris deplanata*, p. 193
2. A large clay-yellow species over half an inch long, found on swampy ground (Pl. III., upper figure; Fig. 29)......................... .... The Clay-colored Bill-bug (*Sphenophorus ochreus*), p. 52
Medium-sized black species frequent on corn, with at least three smooth ridges on the thorax (Fig. 28, 30–34)............................. ....Various Corn Bill-bugs (*Sphenophorus*), p. 52
A small black species a quarter of an inch long, with a fine, smooth median ridge on its otherwise evenly punctured thorax (Fig. 27) ....The Timothy Bill-bug (*Sphenophorus parvulus*), p. 52
3. The bloom bright yellow.......................*Lixus concavus*, p. 114
The bloom whitish .... *Lixus mucidus*, p. 114

Sod Web-worms Injurious to Corn.

Small, active, reddish brown caterpillars, an inch long or less, with conspicuous shining brown spots, each with a strong hair arising from near its center (Fig. 20, 22).

Head pale, with darker markings. 2

Head black..................... The Vagabond Crambus (*vulgivagellus*), p. 41

2. A smooth shining spot behind the substigmatal spot (Fig. 141, *a*) .... *Crambus luteolellus*, p. 41

No smooth shining spot behind the substigmatal spot (Fig. 141, *b*). 3

3. No stripes except for the rows of shining spots (Fig. 20)..The Common Sod Web-worm, p. 41

A dark dorsal line; an indefinite pale border about each dark spot (Fig. 22). .... The Striped Sod Web-worm, p. 41

Insects Eating Irregular Holes in the Leaves or Notching the Edges.

Caterpillars either smooth or hairy. 2

Beetles (*Coleoptera*). 15

Leaf-cutting ants .... p. 159

2. Caterpillars conspicuously hairy, more than six long hairs on the back of each segment (Fig. 39, *a*; 159). 3

Caterpillars nearly smooth, not more than six long hairs on the back of each segment. 11

3. The hairs of the caterpillar dense, at least partly concealing the body (Woolly Bears, p. 70). 4

The hairs of the caterpillar not dense nor concealing the body. 9

4. Hairs very dense, projecting like a bottle-brush. Orange-red on middle part of body, black at ends, (Fig. 39, *a*,) head black, often lighter on the middle line (Fig. 48, *d*) ....The Hedgehog Caterpillar, p. 72

Hairs less dense, color longitudinally uniform. 5

5. Head not entirely black, no conspicuous white line down the back. 6

Head black; hairs also black.................. *Apantesis phyllira*, p. 76

Head black, a whitish line down the middle of the back. 7

6. Head whitish to brownish (Fig. 48, *c*), hairs white to dark brown (Fig. 46, *a*) ....The Yellow Bear, p. 72

Head with a broad black band extending back on each side, clypeus with at least the middle line and sides pale (Fig. 48, *a*, *b*), hairs brown to black (Fig. 43)......................The Salt-marsh Caterpillar, p. 72

7. Caterpillar over an inch long when mature. 8

Caterpillar not over an inch long, hairs black (Fig. 41)...*Eubaphe rosa*, p. 71

8. Hairs of back blackish, those of sides brown (Fig. 52, 53).............. .... *Apantesis phalerata*, p. 76

Hairs of back brown, those of sides reddish white, dorsal stripe broad... .... *Apantesis arge*, p. 75

9. The head, body, and hairs greenish, the latter spiny, black-tipped, poisonous, arising from a tapering base. Mature caterpillar two and a half inches long (Fig. 159)......................... *Hyperchiria io*, p. 168

The head marked with black; the hairs soft, arising from rounded cushions, not poisonous. 10

10. A bright yellow stripe each side (Fig. 162). The Smartweed Caterpillar, p. 170

Sides not striped with yellow (Fig. 66), caterpillar defoliating trees and spreading to other plants. Eastern ....The Gypsy-moth, p. 87

11. A thick, short caterpillar, flattened beneath, without evident feet, the back brown, with a green saddle-mark, each end with a pair of projecting horns armed with poisonous spines (Fig. 165)................... .... The Saddle-back Caterpillar, p. 173

A large cylindrical caterpillar with a sharp tail-horn and a row of eye-like spots each side (Fig. 156)......................... *Theretra tersa*, p. 167

Caterpillar smooth, without projecting horns. 12

12. Head brown or black, without longitudinal stripes. 13

Head pale, with a pair of longitudinal dark lines. 14

13. A striped caterpillar with a row of brown patches each side of the back, and a brown patch on the side of the fourth segment behind the head (Fig. 55, 56, 57) ....The Cotton Cutworm, p. 79

A striped caterpillar with black head, bearing a white ⅄-mark (Fig. 60, *a*), five uninterrupted white lines running backward from the head (Fig. 59; 60, *b*). Eats into the growing tip of the partly grown plant from July on. . . . . The Grass-worm, p. 81

14. Ground color livid brown (paler when full grown); five longitudinal white lines, the dorsal line continuous, the others absent on several segments in front of the middle of the body. Head with dark lateral bands. Enters very young plants at tip and eats downward into the "heart" (hence called "heart-worm"). Later, eats into stalk from without. . . . . The Common Stalk-borer, p. 44

Grayish, with a faint whitish line at the middle of the back, a broad dark patch at the base of each leg. . . . . *Leucania pseudargyria*, p. 171

Striped brown and yellowish, with a distinct narrow black line on each side of the body (Fig. 62). Head with parallel bands (Fig. 63, *a*). . . . . The Wheat-head Army-worm, p. 83

Plant covered by a web, caterpillars dotted with black. . . . . Garden Web-worms, p. 89

15. Small beetles a quarter of an inch long or less. 16

A black-spotted beetle, like a ladybug, about three eighths of an inch long, sometimes found on corn (Fig. 192). . The Argus Tortoise-beetle, p. 192

Slender beetles, over half an inch long, eating the leaves, especially between the veins (Fig. 94–97, Blister-beetles, p. 111). 19

Broad, flat, heavy beetles, clay-brown, with small black spots and dashes. . . . . *Euphoria inda*, p. 99

16. A dark grayish beetle, with three or four toothlike projections of the sides of the thorax (Fig. 84). . . . . . The Southern Corn Leaf-beetle, p. 103

Yellow or greenish elongate beetles, rarely blackish, eating the leaves, silks, pollen, and immature grain. 17

Reddish or yellowish black-spotted oblong or oval beetles. 18

A grayish, banded, inflated beetle with broad snout eating the leaves (Fig. 98). . . . . The Imbricated Snout-beetle, p. 113

17. Green; no markings (Fig. 186). . . . . *Diabrotica longicornis*, p. 188

Yellowish; eleven or twelve black spots (Fig. 184). . . . . The Spotted Diabrotica, p. 187

Yellowish; three black stripes (Fig. 185). . The Striped Cucumber-beetle, p. 188

Blackish throughout. . . . . *Diabrotica atripennis*, p. 189

18. An oval red beetle with two oval black spots on the thorax and ten black spots on the wing-covers (Fig. 174). . . . . . . The Common Ladybug, p. 179

A convex, oval, yellowish beetle, with one black spot on the thorax and nine on the wing-covers (Fig. 173). . . . . *Coccinella 9-notata*, p. 179

Oblong, yellowish or reddish, with one spot on the thorax (Fig. 183). . . . . The Spotted Willow-beetle, p. 186

19. Yellowish, striped with black (Fig. 94, 97) . . . . The Striped Blister-beetle, p. 111

Black throughout (Fig. 95). . . . . The Black Blister-beetle, p. 112

Black, with gray border to wing-covers (Fig. 96). . . . . The Margined Blister-beetle, p. 112

The Corn Cutworms.

These are thick, soft-bodied, smooth, sluggish caterpillars, whitish to dark brown in color, variously marked, in many cases with longitudinal stripes. When disturbed they curl up without attempting to escape.

A glassy whitish or slightly smoky caterpillar without stripes or other markings and with a red head. Cuts off the plant below ground. 2

A smooth caterpillar marked only with even stripes. 3

A caterpillar with spots or distinctly irregular markings, the head pale, with a network of dark lines on each side and a distinct narrow dark stripe each side of the middle. 9

2. Neck shield blackish brown (Fig. 1). . . . . The Glassy Cutworm, p. 19

Neck shield the same color as the head. . The Yellow-headed Cutworm, p. 21

Distinctive characters not known. . . . . *Hadena lignicolor*, p. 31

3. Pale stripes not of similar width; head not entirely pale. 4

Five uniform pale stripes, with intervals about twice the width of the stripes; ground color of younger caterpillars green, that of the older dark bronze-brown, and the stripes darker; head uniformly pale (Fig. 12). . . . . The Bronze Cutworm, p. 29

4. Dorsal stripe not distinctly reddish. 5
A broad sienna-red dorsal stripe.......... The Red-backed Cutworm, p. 34
5. Subdorsal dark stripes including the posterior piliferous spots and not widely separated; head mostly dark. 6
Subdorsal dark stripes not including the dorsal piliferous spots, separated by a broad pale stripe. 8
6. Body color dark greasy gray, with vague lateral stripes (Fig. 3).......... .... The Greasy Cutworm, p. 21
Within the pale dorsal stripe a pale median line with dark border. Three pale lines below the subdorsal dark stripe, the lowest the broadest. 7
7. Head with broad dark stripe each side of middle, sides of head pale, with network of dark lines (Fig. 10).... The Clay-backed Cutworm, p. 28
Head shining black. A northern species .... The Common Striped Cutworm, p. 34
8. A broad lateral dark stripe (Fig. 16)....... The Dark-sided Cutworm, p. 32
A narrow black lateral stripe; hairs coarse and long; length about one inch (Fig. 18)........................... The Bristly Cutworm, p. 35
9. Dorsal stripe narrow, with a pair of diverging oblique marks on each segment; skin roughly granulated (Fig. 15).......................... .... The Granulated Cutworm, p. 32
Dorsal pale stripe broad, including the dorsal piliferous spots; each segment with an oblique mark on each side leading from the lateral dark stripe, in front of which this stripe is obliquely notched (Fig. 9)........ .... The Dingy Cutworm, p. 26
.... The Western Striped Cutworm, p. 26
Lateral dark stripe broken up into narrow streaks. A large dark patch near the posterior end and a row of yellow dots at the middle on the anterior half of the body (Fig. 5, 6).......................... .... The Variegated Cutworm, p. 23
Body pale, with indefinite markings except for a row of dark brown subtriangular spots each side of the back, beginning near the posterior end and fading out before reaching the head (Fig. 7).......... .... The Spotted Cutworm, p. 25
Body pale, two rows of similar dark spots each side, not fading out forwards but stopping abruptly on the fourth segment behind the head (Fig. 14)......................... The W-marked Cutworm, p. 31

The Stalk-borers of Corn.

Under this heading are brought together several caterpillars which injure corn by burrowing inside the young stalk.

The heart of the corn-stalk bored lengthwise. 2
The base of the stalk, throughout the season, gnawed and tunneled in all directions by small, slender, active caterpillars (Fig. 74, 75), causing it to break down readily. A southern species........................ .... The Smaller Corn Stalk-borer, p. 94
2. A striped caterpillar one or two inches long when full grown. 3
A smaller, pale caterpillar, with darker shining piliferous spots. 4
3. The interior of the stalk irregularly eaten out, the leaves with irregular holes and the terminal leaf often killed; the side of the stalk often penetrated by a round hole which is more or less plugged by excrement. Within the stalk a purplish brown caterpillar with longitudinal white lines (Fig. 25, *b*, *c*) . . The Stalk-borer or "Heart-worm," p. 44
A gray, striped, cutwormlike caterpillar. . . *Helotropha reniformis atra*, p. 78
A slender caterpillar with four complete brown stripes, two lateral and two near together on the back. Eats the stem of the plant under ground and bores upward, often killing several plants in succession.... .... *Hadena stipata*, p. 77
A slender caterpillar with brown stripes, which feeds on the rolled leaves of the growing tip of the plant and bores downward to its base .... *Hadena fractilinea*, p. 77
.... *Hadena misera*, p. 77
4. The young corn entered near the ground, the heart of the stalk eaten out, round holes made, and the opening leaves and the growing tip cut off and killed.......................... The Spindle-worm, p. 85

The young stalks entered and tunneled lengthwise, distorting and stunting them (Fig. 72), the old stalks bored by caterpillars (Fig. 71) which pass the winter in the tap-root. A southern species.......... .... The Larger Corn Stalk-borer, p. 91

Insects Injuring the Corn Plant obscurely, without Visible Destruction of any Part of it. True Bugs (Hemiptera, including Plant-lice), which Suck the Sap through a Jointed Beak; also Thrips and Ants.

Minute slender insects not over a sixteenth of an inch long, yellowish to black wingless or with delicate feathery wings (Fig. 120). Found under leaf-sheaths, especially at the base of the tassel joint. On a corn leaf they cause whitish streaks........................... The Thrips family, p. 135

Corn leaves pale above, or with paler patches, and often shrunken or curved; surface seemingly dirty and very finely webbed beneath. Minute rounded mites, visible with a glass, on under surface (Fig. 236)................... ....The Red Spiders (*Tetranychus*), p. 223

Insects with a jointed beak at the front end of the head (Fig. 106); more or less leathery wings closely applied together, nearly or quite flat on the back and separated at the base by a triangular or hemispherical piece: tips of wings distinctly membranous, and overlapping when folded. 2

Front of head prominent, usually extending forward in a more or less conspicuous point, a jointed beak directed backwards from the lower hind angle of the head (Fig. 110, *b*; 209), the wings often meeting roof-shaped, not overlapping at the tip. Visible injury in the form of whitish dots on the leaf. 4

Minute, oval, soft-bodied, sluggish insects, clustered in colonies of old and young together on leaf or stalk, usually attended by ants. Individuals wingless or with delicate membranous wings. Growth of heavily infested leaves often stunted, belated, and discolored......................... ....Plant-lice (*Aphididæ*), pp. 123, 134, 206

2. A small black bug less than an eighth of an inch long, the hind part of body covered by a single large plate grooved at the edges to receive the wings (Fig. 100). The Little Negro-bug (*Corimelæna pulicaria*), p. 115

   Large broad-backed ill-smelling bugs, about half an inch long and a fourth of an inch wide, with large central triangular shield on back. ....The Western Green Stink-bug (Fig. 101), p. 116
   ....*Thyanta perditor* (Fig. 102), p. 117
   ....Other Stink-bugs (*Pentatomidæ*, Fig. 195–197), p. 194

   Large elongate bugs with leaf-like expansions on the hind legs (Fig. 198, etc.)........................... Leaf-footed Plant-bugs, p 197

   Small plant-bugs, about a quarter of an inch long or less. 3

3. Plants infested by small red or dusky bugs or somewhat larger blackish ones with irregular white blotch on the back. These insects cluster behind the leaf-sheaths of the corn on the outer surface of the stalk or on the surface of the leaves, the plants wilted or otherwise unhealthy, lower leaves yellow or brown (Pl. I.)............... ....The Chinch-bug, p. 57

   Insects similar to the foregoing but gray rather than black, the wingless ones streaked with gray (Fig. 103, 104).. The False Chinch-bug, p. 117

   Plant-bugs without whitish wing-covers, found on corn but rarely causing visible injury.............................*Ligyrocoris sylvestris*, p. 198
   ....*Sphragisticus nebulosus* (Fig. 200), p. 198
   ....*Microtoma atrata*, p. 198
   .... The Tarnished Plant-bug (*Lygus pratensis*, Fig. 105–108), p. 118
   ....The Dusky Leaf-bug (*Calocoris rapidus*, Fig. 201, 202), p. 199
   ...The Four-lined Leaf-bug (*Pœcilocapsus lineatus*, Fig. 203–206), p. 200
   ....*Plagiognathus obscurus* (Fig. 207), p. 201
   .... An undetermined Leaf-bug, p. 202
   ....The Common Flower-bug (*Triphleps insidiosus*, Fig. 208), p. 202

4. Large wedge-shaped green or brownish species about three eighths of an inch long (Fig. 209, 210)...........................The Flatas, p. 202

   Elongate, and usually small, leaping species (Fig. 109-114 and 212–215.) ....The Leaf-hoppers, pp. 120, 121, 204

A LIST OF CORN INSECTS, WITH REFERENCES TO ECONOMIC ARTICLES.*

GENERAL ARTICLES.

1856. Fitch, Asa.—Indian Corn. Affecting the Stalks. Sec. Rep. Ins. N. Y., pp. 310–320.

1878. Thomas, Cyrus.—Notes on Corn Insects. Seventh Rep. State Ent. Ill., pp. 15–106.

1885. Forbes, S. A.—On New and Little-known Corn Insects. Fourteenth Rep. State Ent. Ill., pp. 11–33.

1886. Hunt, T. F.—Partial Economic Bibliography [and List] of Indian Corn Insects. Misc. Essays on Ec. Ent. by State Ent. Ill. and Assts., pp. 57–126.

Webster, F. M.—Insects affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, pp. 180–215; also as separate.

1887. Ashmead, Wm. H.—Report on Insects Injurious to Garden Crops in Florida. Bull. No. 14, U. S. Dept. Agr., Div. Ent., pp. 15, 16.

1890. Webster, F. M.—Notes upon some Insects affecting Corn. Insect Life, Vol. III., pp. 159, 160.

Webster, F. M.—Report of Observations upon Insects affecting Grains. Bull. No. 22, U. S. Dept. Agr., Div. Ent., pp. 42–72.

1892. Bruner, L.—Report of the Entomologist. Rep. Neb. State Bd. Agr., 1891, pp. 240–309; also as separate.

1893. Webster, F. M.—Insect Foes of American Cereal Grains, with Measures for their Prevention or Destruction. Insect Life, Vol. VI., (corn insects) pp. 152–157.

1894. Osborn, H.—Corn Insects. Their Injuries and how to treat them. Bull. No. 24, Iowa Agr. Exper. Sta., pp. 991–1005.

Forbes, S. A.—A Monograph of Insect Injuries to Indian Corn. Part I. Eighteenth Rep. State Ent. Ill. 170 pp.

1895. Weed, H. E.—Insects Injurious to Corn. Bull. No. 36, Miss. Agr. and Mech. Coll. Exper. Sta., pp. 147–159.

1896. Forbes, S. A.—Insect Injuries to the Seed and Root of Indian Corn. Bull. No. 44, Ill. Agr. Exper. Sta. 88 pp. (209–296).

LIST OF SPECIES.

Hymenoptera.

Halictus lerouxii Lep., p. 156.

Solenopsis debilis Mayr.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 112, 113. (*fugax.*)

1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 181; separate, p. 2. (*fugax.*)

1890. Webster, F. M.—Bull. No. 33, Ind. Agr. Exper. Sta., p. 45. (*fugax.*)

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 9–11, 66.

1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 214, 215. (*molesta.*)

Monomorium pharaonis Linn.

1865. Fitch, Asa.—Trans. N. Y. Agr. Soc., 1865, p. 133. (*Myrmica molesta.*)

1896. Lintner, J. A.—Eleventh Rep. State Ent. N. Y., in 49th Rep. N. Y State Mus.; also as separate.

*Page numbers immediately following species names refer to this report.

Monomorium pharaonis Linn.—*continued.*

MARLATT, C. L.—Bull. No. 4, N. S., U. S. Dept. Agr., Div. Ent., pp. 95–97.

1898. MARLATT, C. L.—Circ. No. 34, Sec. Ser., U. S. Dept. Agr., Div. Ent., pp. 1, 2.

Monomorium minutum Mayr.

1896. MARLATT, C. L.—Bull. No. 4, N. S., U. S. Dept. Agr., Div. Ent., p. 97.

1898. MARLATT, C. L.—Circ. No. 34, Sec. Ser., U. S. Dept. Agr., Div. Ent., p. 3.

Myrmica scabrinodis lobicornis Nyl.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 11–12, 66.

1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 215.

Prenolepis imparis Say.

1888. WEBSTER, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 150; also in sep. ed. Rep. Ent. (*nitens.*)

Pogonomyrmex barbatus Smith.

1880. McCOOK, H. C.—The Natural History of the Agricultural Ant of Texas. 208 pp.

Atta fervens Say.

1860. BUCKLEY, S. B.—Proc. Acad. Nat. Sci. Phila., 1860, pp. 233–236. (*Myrmica texana.*)

1879. McCOOK, H. C.—Proc. Acad. Nat. Sci. Phila., 1879, pp. 33–40.

Lasius niger Linn.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 82–85.

1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 253–256.

Lasius interjectus Mayr.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., p. 66.

Formica fusca Linn.

1888. WEBSTER, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 149; also in sep. ed. Rep. Ent.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., p. 66.

Formica schaufussi Mayr.

1888. WEBSTER, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 149; also in sep. ed. Rep. Ent.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., p. 66.

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 509; 21st Rep. State Ent. Ill., p. 161.

Diptera.

Tipula costalis Say.

1892. WEBSTER, F. M.—Bull. No. 26, U. S. Dept. Agr., Div. Ent., pp. 73, 74.

1902. SANDERSON, E. D.—Insects Injurious to Staple Crops, p. 90.

Sciara sp.

1884. FORBES, S. A.—Thirteenth Rep. State Ent. Ill., pp. 57–59.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 19–21.

1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 220.

Pegomyia fusciceps Zett.

1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 718. (*Anthomyia zeæ.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 16–19. (*Anthomyia zeæ.*)
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 218, 219. (*Phorbia fuscipes.*)
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 84–92. (*Phorbia.*)
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 68–70.
1904. Garman, H.—Bull. No. 114, Ky. Agr. Exper. Sta., pp. 45, 46.

Mesogramma politum Say.

1888. Riley, C. V., and Howard, L. O.—Insect Life, Vol. I., pp. 5–8.
1889. Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., p. 115.
1895. Ashmead, Wm. H.—Insect Life, Vol. VII., p. 326.
1897. Howard, L. O.—Bull. No. 7, N. S., U. S. Dept. Agr., Div. Ent., p. 86.
1900. Smith, J. B.—Rep. N. J. Agr. Coll. Exper. Sta., 1899, pp. 442, 443; also as separate.
1901. Sanderson, E. D.—Twelfth Rep. Del. Coll. Agr. Exper. Sta., pp. 202–205.

Diastata sp.

1881. Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1880, pp. 245, 246; also as separate.

Chætopsis ænea Wied.

1890. Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., p. 281.
1895. Howard, L. O.—Insect Life, Vol. VII., pp. 352–354.
1896. Garman, H.—Eighth Rep. Ky. Agr. Exper. Sta., pp. XLIII., XLIV.
1902. Pettit, R. H.—Bull. 200, Mich. Agr. Exper. Sta., pp. 206–208.

Ceratomyza dorsalis Loew.

1895. Britton, W. E.—Rep. Conn. Agr. Exper. Sta., 1894, pp. 143–145. (*Odontocera.*)
1898. Hopkins, A. D.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 45. (*Odontocera.*)

Lepidoptera.

Lerema accius Sm. & Abb.

1889. Scudder, S. H.—The Butterflies of the Eastern United States and Canada, Vol. III., p. 1768.

Theretra tersa Linn.

1881. Coquillett, D. W.—Tenth Rep. State Ent. Ill., p. 159. (*Chærocampa.*)
1895. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. VII., pp. 287, 288.

Hyperchiria io Fabr.

1869. Packard, A. S.—Guide to the Study of Insects, p. 299.
1874. Reed, E. B.—Can. Ent., Vol. VI., pp. 227–229. (*Saturnia.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 195.
1881. Coquillett, D. W.—Tenth Rep. State Ent. Ill., p. 169.
1884. Beutenmüller, Wm.—Papilio, Vol. IV., pp. 155–157.
1890. Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., pp. 394–395, 451.
1898. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 438. (*Automeris.*)
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 126–129.

Celama sorghiella Riley.

1882. RILEY, C. V.—Rep. [U. S.] Comm. Agr., 1881–82, pp. 187–189; also as separate. (*Nola.*)

1887. ASHMEAD, WM. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16. (*Nola.*)

Eubaphe rosa French.

1890. FRENCH, G. H.—Can. Ent., Vol. XXII., p. 133. (*Crocota.*)

1893. FRENCH, G. H.—Can. Ent., Vol. XXV., p. 25. (*Crocota.*)

1898. BEUTENMÜLLER, WM.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 365. (*aurantiaca brevicornis.*)

Estigmene acrœa Dru.

1869. HARRIS, T. W.—Insects Injurious to Vegetation, pp. 351–355. (*Arctia.*)

1878. FRENCH, G. H.—Seventh Rep. State Ent. Ill., pp. 79–80, 183. (*Leucarctia.*)

1881. COQUILLETT, D. W.—Tenth Rep. State Ent. Ill., p. 170. (*Leucarctia.*)

1898. BEUTENMÜLLER, WM.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 372. (*Leucarctia.*)

1899. CHITTENDEN, F. H.—Yearbook, U. S. Dept. Agr., 1898, p. 258. (*Leucarctia.*)

LUGGER, OTTO.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 79. (*Leucarctia.*)

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 504–506 ; 21st Rep. State Ent. Ill., pp. 156–158. (*Leucarctia.*)

1903. CHITTENDEN, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 43, 44. (*Leucarctia.*)

1904. HINDS, W. E.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., pp. 80–84.

Diacrisia virginica Fabr.

1881. MARTEN, JOHN.—Tenth Rep. State Ent. Ill., p. 116. (*Spilosoma.*)

COQUILLETT, D. W.—Tenth Rep. State Ent. Ill., p. 169. (*Spilosoma.*)

1890. PACKARD, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., pp. 340, 341. (*Spilosoma.*)

1891. LINTNER, J. A.—Seventh Rep. Ins. N. Y., in the 44th Rep. N. Y. State Mus., pp. 304, 305; also as separate. (*Spilosoma.*)

1898. BEUTENMÜLLER, WM.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 374. (*Spilosoma.*)

1899. CHITTENDEN, F. H.—Yearbook, U. S. Dept. Agr., 1898, pp. 257, 258. (*Spilosoma.*)

LUGGER, OTTO.—Fourth Ann. Rep. as Ent. of State Agr. Exper. Sta., Univ. Minn., pp. 79–81. (*Spilosoma.*)

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 504–506; 21st Rep. State Ent. Ill., pp. 156–158. (*Spilosoma.*)

Isia isabella Sm. & Abb.

1894. OSBORN, H.—Iowa Homestead, May 25, 1894. (*Pyrrharctia.*)

1898. BEUTENMÜLLER, WM.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 373. (*Pyrrharctia.*)

1899. LUGGER, OTTO.—Fourth Ann. Rep. as Ent. of State Agr. Exper. Sta., Univ. Minn., pp. 77–79. (*Pyrrharctia.*)

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 504–506; 21st Rep. State Ent. Ill., pp. 156–158. (*Pyrrharctia.*)

1903. CHITTENDEN, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 44, 45.

Apantesis arge Dru.

1881. Marten, John.—Tenth Rep. State Ent. Ill., p. 115. (*Arctia.*)
Coquillett, D. W.—Tenth Rep. State Ent. Ill., p. 170. (*Arctia.*)
1892. Bruner, L.—Rep. Neb. State Bd. Agr., 1891, p. 244; also author's reprint. (*Arctia.*)
1898. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. X., pp. 379, 380. (*Arctia.*)

Apantesis phyllira Dru.

1837. Drury, Dru.—Illustr. Exot. Ent., Vol. I., p. 15. (*Callimorpha.*)
1898. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. X., pp. 380, 381. (*Arctia.*)

Apantesis phalerata Harr.

1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 181–182, 280. (*Arctia.*)
1889. Weed, C. M.—Bull. Ohio Agr. Exper. Sta., Tech. Ser., Vol. I., No. 1, p. 21. (*Arctia.*)
1898. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. X., p. 381 (*Arctia nais*), p. 382 (*Arctia phalerata*).

Acronycta oblinita Sm. & Abb.

1871. Riley, C. V.—Third Rep. Ins. Mo., pp. 70–72.
1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 201.
1881. Thomas, Cyrus.—Tenth Rep. State Ent. Ill., p. 131. (*Apatela.*)
Coquillett, D. W.—Tenth Rep. State Ent. Ill., p. 170.
1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 82–84. (*Apatela.*)
1890. Bruner, L.—Bull. No. 14, Neb. Agr. Exper. Sta., pp. 65–68.
Garman, H.—Bull. No. 31, Ky. Agr. Exper. Sta., pp. 25, 26. (*Apatela.*)
Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., p. 567. (*Apatela.*)
1898. Smith, J. B., and Dyar, H. G.—Proc. U. S. Nat. Mus., Vol. XXI., pp. 169–171; also authors' reprint.
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 155–157.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., pp. 260, 261. (*Apatela.*)

Cutworms.

1875. Cook, A. J.—Thirteenth Rep. Sec. State Bd. Agr. Mich., pp. 109–111.
1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 717.
1878. French, G. H.—Trans. Ill. State Hort. Soc., 1877, pp. 185–198.
1885. Lintner, J. A.—Forty-fourth Rep. N. Y. State Agr. Soc., 1884, pp. 56–80; also as separate.
1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, pp. 190, 191; separate, pp. 11, 12.
1888. Lintner, J. A.—Bull. No. 6, N. Y. State Mus. 36 pp.
1891. Aldrich, J. M.—Insect Life, Vol. IV., p. 67.
1892. Bruner, L.—Rep. Neb. State Bd. Agr., 1891, pp. 247–252; also as separate.
1895. Smith, J. B.—Rep. N. J. Agr. Coll. Exper. Sta., 1894, pp. 541–549; also as separate.
Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., pp. 89–107.
Slingerland, M. V.—Bull. No. 104, Cornell Univ. Agr. Exper. Sta. 45 pp. (555–600).
1899. Howard, L. O.—Yearbook, U. S. Dept. Agr., 1898, pp. 140–142.

Hadena stipata Morr.

1890. Webster, F. M.—Bull. No. 22, U. S. Dept Agr., Div. Ent., p. 47. (*Luperina.*)
 Webster, F. M.—Insect Life, Vol. II., p. 134.
 Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., p. 383.
1893. Webster, F. M.—Bull. No. 51, Sec. Ser., Ohio Agr. Exper. Sta., pp. 138, 141; also author's ed.

Hadena devastatrix Brace.

1875. Cook, A. J.—Thirteenth Ann. Rep. Sec. State Bd. Agr. Mich., p. 111. (*amputatrix.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 96.
1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 296, 297; also as separate.
1887. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1886, pp. 578–580; also in sep. ed. Rep. Ent.
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 96.
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 543.
1892. Harvey, F. L.—Rep. Me. State Coll. Agr. Exper. Sta., 1891, pp. 191, 193.
1893. Lintner, J. A.—Eighth Rep. Ins. N. Y., in the 45th Rep. N. Y. State Mus., p. 235; also as separate.
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 163, 164.
 Webster, F. M., and Mally, C. W.—Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., p. 72.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., pp. 305, 306.
1902. Fletcher, James.—Rep. Exptl. Farms Canada, 1901, pp. 217, 218; also as separate.

Hadena arctica Boisd.

1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 96, 97.
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 97.
1893. Lintner, J. A.—Ninth Rep. Ins. N. Y., in the 46th Rep. N. Y. State Mus., p. 447; also as separate. (*Mamestra.*)
1899. Fletcher, James.—Rep. Exptl. Farms Canada, 1898, p. 180; also as separate.
1900. Fletcher, James.—Trans. Roy. Soc. Can., Sec. Ser., Vol. V., Sec. IV., pp. 209, 210.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 306.

Hadena lignicolor Guen.

1874. Lintner, J. A.—Twenty-sixth Rep. N. Y. State Mus., p. 161.
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 544.

Hadena fractilinea Grote.

1893. Webster, F. M.—Bull. No. 51, Sec. Ser., Ohio Agr. Exper. Sta., pp. 139–141; also author's ed.
 Webster, F. M.—Insect Life, Vol. VI., pp. 154–156.

Hadena misera Grote.

1893. Webster, F. M.—Bull. No. 51, Sec. Ser., Ohio Agr. Exper. Sta., p. 140; also author's ed.
 Webster, F. M.—Insect Life, Vol. VI., p. 156.

Helotropha reniformis atra Grote.

1888. Cook, A. J.—Twenty-seventh Ann. Rep. ('87–'88) Sec. State Bd. Agr. Mich., p. 166. (*H. atra.*)

1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 426, 427.

Prodenia ornithogalli Guen.

1890. Webster, F. M.—Insect Life, Vol. III., p. 149. (*lineatella.*)

1892. Webster, F. M.—Bull. No. 45, Sec. Ser., Ohio Agr. Exper. Sta., p. 187. (*lineatella.*)

1895. Ashmead, Wm. H.—Insect Life, Vol. VII., pp. 324, 325. (*lineatella.*)

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 496, 497.; 21st Rep. State Ent. Ill., pp. 148, 149.

1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 64–71.

1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 422, 423.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 33, 34.

Laphygma frugiperda Sm. & Abb.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 55–67.

Hubbard, H. G.—Insects affecting the Orange, pp. 150, 151.

1890. Webster, F. M.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., p. 46.

1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 164.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 497, 498; 21st Rep. State Ent. Ill., pp. 149, 150.

Chittenden, F. H.—Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 78–85.

1901. Chittenden, F. H.—Bull. No. 29, N. S., U. S. Dept. Agr., Div. Ent., pp. 5–45.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 84–89.

Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp.421, 422.

Agrotis ypsilon Rott.

1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 93–94, 210–211.

1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 294, 295; also as separate.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 93.

1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 540.

1892. Harvey, F. L.—Ann. Rep. Me. State Coll. Agr .Exper. Sta., 1891, p. 194.

1893. Lintner, J. A.—Eighth Rep. Ins. N. Y., in the 45th Rep. N. Y. State Mus., pp. 188–191; also as separate.

1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., p. 97.

1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., 1898, pp. 159, 160.

1900. Guercio, G. del.—Nuove Relaz. R. Staz. Ent. Agr., 1 ser., No. 2, pp. 269–303.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 452; 21st Rep. State Ent. Ill., p. 104.

1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 270.

1904. Garman, H.—Bull. No. 114, Ky. Agr. Exper. Sta., pp. 35, 36.

Peridroma margaritosa saucia Hübn.

1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 94–95, 211–213. (*Agrotis saucia.*)
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 93, 94. (*Agrotis saucia.*)
1895. Slingerland, M. V.—Bull. No. 104, Cornell Univ. Agr. Exper. Sta., pp. 579–584. (*saucia.*)
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 160. (*saucia.*)
1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 50–54. (*saucia.*)
Fletcher, James.—Rep. Exptl. Farms Canada, 1900, pp. 215–227; also as separate. (*saucia.*)
Doane, R. W., and Brodie, D. A.—Bull. 47, Wash. Agr. Exper. Sta., pp. 3–16. (*saucia.*)
Chittenden, F. H.—Bull. No. 29, N. S., U. S. Dept. Agr., Div. Ent., pp. 46–64. (*saucia.*)
1902. Stedman, J. M.—Thirty-fourth Rep. Mo. State Bd. Agr., pp. 118–124; author's reprint, pp. 66–72. (*saucia.*)
1904. Garman, H.—Bull. No. 114, Ky. Agr. Exper. Sta., pp. 34, 35. (*margaritosa.*)

Noctua c-nigrum Linn.

1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 89, 202–203. (*Agrotis.*)
1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 93, 94. (*Agrotis.*)
Lintner, J. A.—Cutworms, p. 6. (*Agrotis.*)
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 86, 87. (*Agrotis.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 541. (*Agrotis.*)
1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., p. 98. (*bicarnea.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 451, 452; 21st Rep. State Ent. Ill., pp. 103, 104.
Webster, F. M.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., p. 85.
1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 54–59.
Fletcher, James.—Rep. Exptl. Farms Canada, 1900, pp. 227–229; also as separate.
Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 274.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 31, 32.

Noctua clandestina Harr.

1871. Saunders, W.—Can. Ent., Vol. III., pp. 35, 36.
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 95, 96. (*Agrotis.*)
1881. Thomas, Cyrus.—Tenth Rep. State Ent. Ill., p. 135. (*Agrotis.*)
1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 293, 294; also as separate. (*Agrotis.*)
Lintner, J. A.—Cutworms, pp. 6, 8. (*Agrotis.*)
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 85, 86. (*Agrotis.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 541. (*Agrotis.*)
1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., p. 99.
Slingerland, M. V.—Bull. 104, Cornell Univ. Agr. Exper. Sta., pp. 571–574.
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 161.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 277.

Feltia subgothica Haw.

1869. Riley, C. V.—First Rep. Ins. Mo., pp. 82, 83. (*Agrotis jaculifera.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 89, 90. (*Agrotis.*)
1885. Lintner, J. A.—Cutworms, p. 6. (*Agrotis.*)
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 88, 89. (*Agrotis.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., pp. 539, 540. (*Agrotis.*)
1895. Slingerland, M. V.—Bull. 104, Cornell Univ. Exper. Sta., pp. 574–579.
1899. Chittenden, F. H.—Yearbook, U. S. Dept. Agr., 1898, p. 257.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 277. (*Noctua.*)
1902. Stedman, J. M.—Rep. Mo. State Bd. Agr., 1902, pp. 115–117; separate, pp. 63–65.

Feltia jaculifera Guen.

1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., pp. 95, 96.

Feltia jaculifera herilis Grote.

1869. Riley, C. V.—First Rep. Ins. Mo., pp. 81, 82. (*Agrotis subgothica.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 90. (*Agrotis herilis.*)
1890. Webster, F. M.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., pp. 43, 44. (*Agrotis herilis.*)
Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 89. (*Agrotis herilis.*)
1895. Webster, F. M.—Bull. No. 2, N. S., U. S. Dept. Agr., Div. Ent., p. 85. (*herilis.*)
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 278. (*herilis.*)

Feltia gladiaria Morr.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 89–93. (*Agrotis morrisoniana, A. gladiaria.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 542. (*Agrotis.*)
1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., pp. 93–95.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 279.

Feltia annexa Tr.

1882. French, G. H.—Can. Ent., Vol. XIV., pp. 207–210. (*Agrotis.*)
1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 291, 292; also as separate. (*Agrotis.*)
1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., pp. 99, 100.
1899. Cockerell, T. D. A.—Bull. No. 32, Ariz. Agr. Exper. Sta., pp. 288, 289.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 280.

Euxoa messoria Harr.

1875. Cook, A. J.—Rep. Sec. State Bd. Agr. Mich., 1874, pp. 144, 145. (*Agrotis cochrani.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 92, 93. (*Agrotis.*)
1885. Lintner, J. A.—Cutworms, p. 7. (*Agrotis.*)
Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 290, 291; also as separate. (*Agrotis.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., pp. 538, 539. (*Agrotis.*)
1893. Smith, J. B.—Rep. Sec. State Bd. Agr. N. J., 1892, pp. 168, 169. (*Agrotis.*)
1897. Sirrine, F. A.—Bull. No. 120, N. Y. Agr. Exper. Sta., pp. 186–196. (*Carneades.*)
Sirrine, F. A.—Rep. N. Y. Agr. Exper. Sta., 1896, pp. 628–635. (*Carneades.*)
1900. Doane, R. W.—Bull. 42, Wash. Agr. Exper. Sta., pp. 12–14. (*Carneades.*)

Euxoa tessellata Harr.

1865. Fitch, Asa.—Ninth Rep. Ins. N. Y., pp. 237, 243–249. (*Agrotis nigricans.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 91, 92. (*Agrotis.*)
1885. Lintner, J. A.—Cutworms, p. 7. (*Agrotis.*)
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 539. (*Agrotis.*)
1900. Webster, F. M.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., p. 85. (*Carneades.*)
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 284. (*Carneades.*)
Gillette, C. P.—Thirteenth Ann. Rep. Agr. Exper. Sta. Col., p. 127. (*Carneades.*)

Euxoa ochrogaster Guen.

1889. Fletcher, James.—Rep. Exptl. Farms Canada, 1888, p. 71. (*Agrotis turris.*)
1892. Fletcher, James.—Insect Life, Vol. V., p. 124. (*Agrotis.*)
1900. Fletcher, James.—Trans. Roy. Soc. Can., Sec. Ser., Vol. V., Sec. IV., p. 214. (*Carneades.*)
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 285. (*Carneades.*)
1902. Fletcher, James.—Rep. Exptl. Farms Canada, 1901, pp. 217, 220; also as separate. (*Carneades.*)

Mamestra picta Harr.

1881. Coquillett, D. W.—Tenth Rep. State Ent. Ill., p. 185. (*Ceramica.*)
1883. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1883, pp. 124, 125; also as separate. (*Ceramica.*)
1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 197; Separate, p. 18. (*Ceramica.*)
1889. Lintner, J. A.—Fifth Rep. Ins. N. Y., in 42d Rep. N. Y. State Mus., pp. 206–210; also as separate.
1890. Webster, F. M.—Insect Life, Vol. III., p. 149.
1893. Davis, G. C.—Bull. 102, Mich. Agr. Exper. Sta., pp. 44–47.
1898. Harvey, F. L.—Thirteenth Rep. Me. Agr. Exper. Sta., p. 173.
Felt, E. P.—Fourteenth Rep. State Ent. N. Y. Bull. N. Y. State Mus., Vol. V., No. 23, pp. 201–207.
1899. Fernald, H. T.—Bull. No. 48, Pa. Dept. Agr., pp. 9, 10.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 501, 502; 21st Rep. State Ent. Ill., pp. 153, 154.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 42, 43.
1904. Garman, H.—Bull. No. 114, Ky. Agr. Exper. Sta., pp. 31, 32.

Mamestra renigera Steph.

1869. Riley, C. V.—First Rep. Ins. Mo., pp. 86, 87. (*Celæna.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 215, 216.
Lintner, J. A.—Thirtieth Rep. N. Y. State Mus., p. 161.
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 95, 96.
1891. Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 543.
1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., p. 100.
1901. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XIV., p. 298.

Nephelodes minians Guen.

1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 99. (*violans.*)
1882. Lintner, J. A.—First Rep. Ins. N. Y., pp. 99–110. (*violans.*)

Nephelodes minians Guen.—*continued.*

1887. Alwood, W. B.—Fifth Ann. Rep. Ohio Agr. Exper. Sta., pp. 219–221 (*violans.*)

1888. Lintner, J. A.—Fourth Rep. Ins. N. Y., in 41st Rep. N. Y. State Mus., pp. 54–57; also as separate. (*violans.*)

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 85. (*violans.*)

1891. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1890, pp. 244–246; also as separate. (*violans.*)

Gillette, C. P.—Bull. No. 12, Iowa Agr. Exper. Sta., p. 544. (*violans.*)

1893. Fernald, C. H.—Fifth Ann. Rep. Hatch Exper. Sta., Mass. Agr. Coll., p. 150.

1895. Garman, H.—Bull. No. 58, Ky. Agr. Exper. Sta., p. 101.

1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 425, 426.

Leucania unipuncta Haw.

1881. Thomas, Cyrus.—Tenth Rep. State Ent. Ill., pp. 5–43.

1882. Coquillett, D. W.—Eleventh Rep. State Ent. Ill., pp. 49–64.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 102.

Riley, C. V.—Third Rep. U. S. Ent. Comm., pp. 89–156.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., p. 84.

1889. Bruner, L.—Bull. No. 5, Neb. Agr. Exper. Sta., pp. 25–33; Rep. Neb. State Bd. Agr., 1888, pp. 110–114.

1894. Howard, L. O.—Circ. No. 4, Sec. Ser., U. S. Dept. Agr., Div. Ent. 5 pp.

1895. Lounsbury, C. P.—Bull. No. 28, Hatch Exper. Sta., Mass. Agr. Coll., pp. 10–15.

1897. Lintner, J. A.—Twelfth Rep. Ins. N. Y., in the 50th Rep. N. Y. State Mus., pp. 190–214; also as separate.

Slingerland, M. V.—Bull. 133, Cornell Univ. Agr. Exper. Sta. 26 pp. (233–258).

Kirkland, A. H.—Rep. Sec. Mass. State Bd. Agr., 1896, pp. 264–274.

Lowe, V. H.—Fifteenth Ann. Rep. N. Y. Agr. Exper. Sta., pp. 583–605.

1898. Webster, F. M., and Mally, C. W.—Bull. 96, Ohio Agr. Exper. Sta., pp. 4–13.

Forbes, S. A.—Twentieth Rep. State Ent. Ill., pp. 106–109.

1900. Tryon, Henry.—Queensland Agr. Journ., Vol. VI., pp. 135–147.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 495, 496; 21st Rep. State Ent. Ill., pp. 147, 148.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 79–84.

Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., p. 443. (*Heliophila.*)

Leucania pseudargyria Guen.

1881. French, G. H.—Can. Ent., Vol. XIII., pp. 24, 25.

1890. Beutenmüller, Wm.—Ann. N. Y. Acad. Sci., Vol. V., p. 214. (*Heliophila.*)

1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 443, 444. (*Heliophila.*)

Leucania albilinea Hübn.

1877. Riley, C. V.—Ninth Rep. Ins. Mo., pp. 50–57.

1889. Murtfeldt, M. E.—Ann. Rep. State Hort. Soc. Mo., 1888, pp. 127, 128.

Osborn, Herbert.—Ann. Rep. Iowa State Agr. Soc., 1888, pp. 674–676.

1894. Osborn, Herbert.—Bull. No. 32, U. S. Dept. Agr., Div. Ent., p. 50.

1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 444, 445. (*Heliophila.*)

Achatodes zeæ Harr.

1869. Harris, T. W.—Insects Injurious to Vegetation, p. 439. (*Gortyna.*)
1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 719. (*Anthomyia.*)
1878. French, G. H.—Seventh Rep. State Ent. Ill., pp. 100, 222–223.
1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, pp. 193, 194; Separate, pp. 14, 15.
1896. Smith, J. B.—Economic Entomology, p. 299.
1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., p. 439.

Papaipema nitela Guen.

1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 719. (*Gortyna.*)
1878. Smith, E. A.—Seventh Rep. State Ent. Ill., pp. 112–114. (*Gortyna.*)
French, G. H.—Seventh Rep. State Ent. Ill., pp. 221, 222. (*Gortyna.*)
1882. Lintner, J. A.—First Rep. Ins. N. Y., pp. 110–116. (*Gortyna.*)
1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p., 103. (*Gortyna.*)
1885. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1884, pp. 392, 393; also in sep. ed. Rep. Ent. (*Gortyna.*)
1890. Lintner, J. A.—Sixth Rep. Ins. N. Y., in 43d Rep. N. Y. State Mus., p. 168; also as separate. (*Gortyna.*)
1893. Lintner, J. A.—Eighth Rep. Ins. N. Y., in 45th Rep. N. Y. State Mus., pp. 191, 192; also as separate. (*Gortyna.*)
1894. Osborn, Herbert.—Bull. No. 24, Iowa Agr. Exper. Sta., pp. 1000, 1001. (*Gortyna.*)
1898. Bird, Henry.—Can. Ent., Vol. XXX., pp. 127, 128. (*Hydrœcia.*)
1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 167, 168. (*Gortyna.*)
1902. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. XVI., pp. 438, 439. (*nebris.*)
Lugger, Otto.—Bull. 77, Minn. Agr. Exper. Sta., pp. 46, 47. (*Hydrœcia.*)
Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 11, 12. (*Hydrœcia.*)

Heliothis armiger Hübn.

1878. Thomas, Cyrus.—Seventh Rep. State Ent. Ill., pp. 102–106.
1879. Comstock, J. H.—Report on Cotton Insects, pp. 287–291.
1882. French, G. H.—Eleventh Rep. State Ent. Ill., pp. 82–104.
Riley, C. V.—Rep. [U. S.] Comm. Agr., 1881–82, pp. 145–152; also as separate.
1889. Beckwith, M. H.—Bull. No. IV., Del. Coll. Agr. Exper. Sta., pp. 17–19.
Bruner, L.—Rep. Neb. State Bd. Agr., 1888, pp. 95–97.
1890. Neal, J. C.—Bull. No. 9, Fla. Agr. Exper. Sta., p. 8.
Olliff, Sidney.—Agr. Gaz. New S. Wales, Vol. I., p. 125.
1893. ————————Agr. Gaz. New S. Wales, Vol. IV., pp. 213, 214.
Chambliss, C. E.—Bull. Agr. Exper. Sta. Tenn., Vol. VI., No. 4, pp. 83–85.
Mally, F. W.—Bull. No. 29, U. S. Dept. Agr., Div. Ent. 73 pp.
1894. Osborn, Herbert.—Bull. No. 24, Iowa Agr. Exper. Sta., pp. 1003, 1004.
1895. Lounsbury, C. P.—Bull. No. 28, Hatch Exper. Sta., Mass. Agr. Coll., pp. 16, 17.
1896. Howard, L. O.—Bull. No. 33, U. S. Dept. Agr., Office Exper. Stations, pp. 328–334.

Heliothis armiger Hübn.—*continued.*

Lowe, V. H., and Sirrine, F. A.—Fourteenth Ann. Rep. N. Y. Agr. Exper. Sta., pp. 559–565.

Lugger, Otto.—First Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 100–104.

1898. Webster, F. M., and Mally, C. W.—Bull. 96, Ohio Agr. Exper. Sta., pp. 15–18.

1899. Chittenden, F. H.—Yearbook, U. S. Dept. Agr., 1898, pp. 255, 256.

1901. Quaintance, A. L.—Thirteenth Ann. Rep. Ga. Exper. Sta., p. 362. (*armiger.*)

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 151–154, 201, 220.

1904. Quaintance, A. L.—Farmers' Bull. No. 191, U. S. Dept. Agr. 24 pp.

1905. Quaintance, A. L., and Bishopp, F. C.—Farmers' Bull. No. 212, U. S. Dept. Agr. 32 pp.

Epizeuxis æmula Hübn.

1886. Packard, A. S.—Rep. [U. S.] Comm. Agr., 1885, pp. 325, 326; also in Fifth Rep. U. S. Ent. Comm., pp. 843, 844.

1889. Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., pp. 18, 19. (*Helia.*)

1891. Riley, C. V.—Insect Life, Vol. IV., p. 111. (*Helia.*)

Porthetria dispar Linn.

1890. Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., pp. 208–211. (*Ocneria.*)

1897. Howard, L. O.—Bull. No. 11, N. S., U. S. Dept. Agr., Div. Ent. 39 pp.

1901. Felt, E. P.—Sixteenth Rep. Ins. N. Y. Bull. N. Y. State Mus. No. 36, Vol. 7, pp. 955–962.

Geometrid.

1893. Smith, J. B.—Insect Life, Vol. VI., p. 188. [=*Papaipema nitela?*]

Sibine stimulea Clem.

1878. French, G. H.—Seventh Rep. State Ent. Ill., p. 187. (*Empretia.*)

1883. Saunders, Wm.—Insects Injurious to Fruits, pp. 113, 114. (*Empretia.*)

1888. Beutenmüller, Wm.—Ent. Amer., Vol. IV., pp. 75, 76. (*Empretia.*)

1890. Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., pp. 146, 147. (*Empretia.*)

1892. Webster, F. M.—Bull. 45, Ohio Agr. Exper. Sta., pp. 166, 167.

1898. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. X., pp. 394, 395.

1899. Barrows, W. B.—Bull. 175, Mich. State Agr. Coll. Exper. Sta., pp. 350, 351. (*Empretia.*)

Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 98, 99. (*Empretia.*)

Loxostege similalis Guen.

1886. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1885, pp. 265–270; also as separate. (*Eurycreon rantalis.*)

1891. Kent, Geo. H.—Insect Life, Vol. III., p. 338.

Bruner, L.—Bull. Agr. Exper. Sta. Neb., No. 16, pp. 55–59. (*Eurycreon rantalis.*)

1892. Bruner, L.—Bull. Agr. Exper. Sta. Neb., No. 24, pp. 3–7. (*Eurycreon similis.*)

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 456, 457; 21st Rep. State Ent. Ill., pp. 108, 109.

Loxostege similalis Guen.—*continued.*

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 260, 261.
Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept Agr., Div. Ent., pp. 46, 47.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 39, 40.

Crambus.

1894. Smith, J. B.—Rep. Ent. Dept. N. J. Agr. Coll. Exper. Sta., 1893, pp. 473–478.
Felt, E. P.—Bull. 64, Cornell Univ. Agr. Exper. Sta. 56 pp.
1895. Webster, F. M.—Bull. No. 2, N. S., U. S. Dept. Agr., Div. Ent., p. 86
1896. Fernald, C. H.—The Crambidæ of North America. 81 pp.

Crambus vulgivagellus Clem.

1882. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1881–82, pp. 179–183; also as separate.
1883. Lintner, J. A.—First Rep. Ins. N. Y., pp. 127–149.
1893. Osborn, Herbert.—Rep. Bd. Direc. Iowa State Agr. Soc., 1892, pp. 675, 676.
1894. Felt, E. P.—Bull. 64, Cornell Univ. Agr. Exper. Sta., pp. 69–71.
1898. Hine, J. S.—Proc. Columbus Hort. Soc., 1897, p. 26.

Crambus mutabilis Clem.

1894. Felt, E. P.—Bull. 64, Cornell Univ. Agr. Exper. Sta., pp. 64, 65.

Crambus trisectus Walk.

1882. Lintner, J. A.—First Rep. Ins. N. Y., pp. 149–151. (*exsiccatus.*)
1888. Osborn, Herbert.—Rep. [U. S.] Comm. Agr., 1887, pp. 154–160; also in sep. ed. Rep. Ent. (*exsiccatus.*)
1894. Osborn, Herbert.—Bull. No. 24, Iowa Agr. Exper. Sta., p. 999. (*interminellus.*)

Crambus luteolellus Clem.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 12–17. (*zeëllus.*)
Fernald, C. H.—Can. Ent., Vol. XVII., pp. 55, 56. (*zeëllus.*)
1891. Beckwith, M. H.—Insect Life, Vol. IV., p. 42. (*zeëllus.*)
1894. Felt, E. P.—Bull. 64, Cornell Univ. Agr. Exper. Sta., pp. 61, 62. (*luteolellus* and *caliginosellus.*)
1896. Webster, F. M.—Bull. 68, Ohio Agr. Exper. Sta., pp. 44–46. (*zeëllus* and *luteolellus.*)
1897. Webster, F. M.—Fifteenth Rep. Ohio Agr. Exper. Sta., pp. 44–46. (*zeëllus* and *luteolellus.*)
Johnson, W. G.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., pp. 84, 85. (*caliginosellus.*)
1898. Johnson, W. G.—Bull. No. 57, Md. Agr. Exper. Sta., p. 9. (*caliginosellus.*)
1899. Johnson, W. G.—Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., pp. 99–102. (*caliginosellus.*)
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 130–134. (*caliginosellus.*)

Diatræa saccharalis Fabr.

1881. Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1880, pp. 240–245; also as separate.
1890. Correspondents and Editors.—Insect Life, Vol. III., p. 64. (*Chilo.*)

Diatræa saccharalis Fabr.—*continued.*

1891. Howard, L. O.—Insect Life, Vol. IV., pp. 95–103.
Morgan, H. A.—Bull. No. 9, Sec. Ser., La. Agr. Exper. Sta., pp. 218–228. (*Chilo.*)

1896. Howard, L. O.—Circ. No. 16, Sec. Ser., U. S. Dept. Agr., Div. Ent. 3 pp.

1898. Johnson, W. G.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., pp. 93, 94.

1899. Quaintance, A. L.—Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., p. 58.

1900. Maxwell-Lefroy, H.—West. Ind. Bull., Vol. I., No. 4, pp. 327–353.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 146–150.

1905. Smith, R. I.—Bull. No. 16, Ga. State Bd. Ent., pp. 37–40.

Elasmopalpus lignosellus Zell.

1882. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1881–82, pp. 142–145; also as separate. (*Pempelia.*)

1900. Chittenden, F. H.—Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 17–22.

1903. Chittenden, F. H.— Bull. No. 40, U. S. Dept. Agr., Div. Ent., p. 119.

Epagoge sulfureana Clem.

1881. Comstock, J. H.—Rep. [U. S.] Comm. Agr. 1880, pp. 255, 256; also as separate. (*Tortrix.*)

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 17–20. (*Dichelia.*)
Hubbard, H. G.—Orange Insects, p. 154. (*Dichelia.*)

1890. Packard, A. S.—Fifth Rep. U. S. Ent. Comm., pp. 789, 780. (*Dichelia.*)

1893. Davis, G. C.—Bull. 102, Mich. Agr. Exper. Sta., pp. 49, 50. (*Dichelia.*)

1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 232, 233. (*Dichelia.*)

Platynota flavedana Clem.

1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn. pp. 231, 232.

1904. Titus, E. S. G., and Pratt, F. C.—Bull. No. 47, U. S. Dept. Agr., Div. Ent., p. 56.

Eulia triferana Walk.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 20, 21. (*Lophoderus.*)

1890. Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., pp. 195, 196. (*Lophoderus.*)

1899. Lugger, Otto.—Fourth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 231. (*Lophoderus.*)

1901. Felt, E. P.—Sixteenth Rep. Ins. N. Y. Bull. N. Y. State Mus., No. 36, Vol. VII., pp. 998, 999. (*Lophoderus.*)

Batrachedra rileyi Wlsm.

1897. Chittenden, F. H.—Bull. No. 8, N. S., U. S. Dept. Agr., Div. Ent., p. 33.

Hypoclopus mortipennellus Grote.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 101. (*Cænogenes.*)

Anaphora popeanella Clem.

1890. Riley, C. V., and Howard, L. O.—Insect Life, Vol. III., p. 27.

Pseudanaphora arcanella Clem.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 98–101.

Coleoptera.

Omophron labiatum Fabr.
  1869. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1868, p. 79.
  1874. LeBaron, Wm.—Fifth Rep. State Ent. Ill., p. 42.

Clivina impressifrons Lec.
  1890. Webster, F. M.—Insect Life, Vol. III., p. 159.
  1894. Forbes, S. A.—Eighteenth Rep. State Ent, Ill., pp. 15, 16.
  1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 217.
  1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 484; 21st Rep. State Ent. Ill., p. 136.

Pterostichus permundus Say.
  1894. Ashmead, Wm. H.—Insect Life, Vol. VII., p. 246.

Pterostichus lucublandus Say, p. 177.

Amara musculus Say, p. 177.

Platynus cincticollis Say, p. 177.

Platynus crenistriatus Lec, p. 177.

Agonoderus pallipes Fabr.
  1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 12–14.
  1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 216.
  1904. Howard, L. O.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., p. 90.

Anisodactylus rusticus Dej., p. 177.

Bolitochara sp., p. 180.

Ancyrophorus planus Lec.
  1894. Harvey, F. L.—Rep. Me. State Coll. Agr. Exper. Sta., 1893, Pt. II., p. 147.

Phalacrus politus Mels.
  1890. Lintner, J. A.—Sixth Rep. Ins. N. Y., in 43d Rep. N. Y. State Mus., p. 170; also as separate.
  1894. Ashmead, Wm. H.—Insect Life, Vol. VII., p. 246.

Eustilbus apicalis Mels., p. 180.

Orthoperus scutellaris Lec., p. 180.

Megilla maculata DeG.
  1881. Forbes, S. A.—Bull. Ill. State Lab. Nat. Hist., Vol. I., No. 3, p. 159. (*Hippodamia.*)
  Riley, C. V.—Am. Nat., Vol. XV., p. 326.
  1883. Forbes, S. A.—Bull. Ill. State Lab. Nat. Hist., Vol. I., No. 6, pp. 51, 52. (*Hippodamia.*)
  Riley, C. V.—Am. Nat., Vol. XVII., p. 323.
  1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 21, 22. (*Hippodamia.*)
  1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 202; Separate, p. 23.
  1888. Lintner, J. A.—Fourth Rep. Ins. N. Y., in the 41st Rep. N. Y. State Mus., pp.——; Separate, pp. 80–84.
  Riley, C. V.—Insect Life, Vol. I., pp. 101, 102.
  1891. Riley, C. V.—Insect Life, Vol. III., p. 430.

Coccinella 9-notata Hbst., p. 179.

Carpophilus pallipennis Say.

1891. Weed, H. E.—Bull. No. 17, Miss. Agr. and Mech. Coll. Exper. Sta., pp. 9, 10.

1895. Stedman, J. M.—Bull. No. 61, Ala. Agr. Exper. Sta., pp. 58, 59.

Carpophilus dimidiatus Fabr.

1889. Riley, C. V.—Insect Life, Vol. I., p. 253. (*mutilatus.*)

1896. Chittenden, F. H.—Bull. U. S. Dept. Agr., Div. Ent., Tech. Ser., No. 4, p. 28.

Carpophilus antiquus Mels., p. 181.

Colastus semitectus Say.

1869. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1868, p. 83.

Ips quadriguttatus Fabr.

1861. Walsh, B. D.—Insects Injurious to Vegetation, p. 14. (*quadrisignata.*)

1894. Harvey, F. L.—Rep. Me. State Coll. Agr. Exper. Sta., 1893, Pt. II., p. 147. (*Pithyophagus.*)

Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 23–28. (*fasciatus.*)

1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 222–224. (*fasciatus.*)

1899. Hopkins, A. D.—Bull. 56, W. Va. Agr. Expr. Sta., p. 266.

1901. Harvey, F. L.—Rep. Me. Agr. Exper. Sta., 1900, p. 35. (*fasciatus.*)

Cartodere ruficollis Marsh.

1890. Lintner, J. A.—Sixth Rep. Ins. N. Y., in 43d Rep. N. Y. State Mus., pp. 183, 184; also as separate. (*Lathridius pulicarius.*)

Melanophthalma distinguenda Com.

1888. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 151; also in sep. ed. Rep. Ent. (*Corticaria pumila.*)

Tenebrioides corticalis dubia Mels.

1869. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1868, p. 83. (*Trogosita dubia.*)

1871. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1870, p. 66. (*Trogosita dubia.*)

Wireworms.

1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 718.

1891. Comstock, J. H., and Slingerland, M. V.—Bull. 33, Cornell Univ. Agr. Exper. Sta. 80 pp. (193–272).

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 28–51.

1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 224–234.

Slingerland, M. V.—Bull. 107, Cornell Univ. Agr. Exper. Sta., pp. 37–56.

1898. Webster, F. M.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., pp. 101, 102.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 509–511; 21st Rep. State Ent. Ill., pp. 161–163.

1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 77, 78.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 48–52.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 66–68.

Cardiophorus sp.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 32–34.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 226.

Drasterius elegans Fabr.

1891. COMSTOCK, J. H., and SLINGERLAND, M. V.—Bull. 33, Cornell Univ. Agr. Exper. Sta., pp. 267–270.
1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 34–36.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 224, 225, 226.
SLINGERLAND, M. V.—Bull. 107, Cornell Univ. Agr. Exper. Sta., pp. 54, 55.
1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 510, 511; 21st Rep. State Ent. Ill., pp. 162–163.

Agriotes mancus Say.

1891. COMSTOCK, J. H., and SLINGERLAND, M. V.—Bull. 33, Cornell Univ. Agr. Exper. Sta., pp. 251–258.
1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 36–39.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 226, 227.
SLINGERLAND, M. V.—Bull. 107, Cornell Univ. Agr. Exper. Sta., pp. 51, 52.
1900. WEBSTER, F. M.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., p. 85.
1901. CHITTENDEN, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 77, 78.

Agriotes pubescens Mels.

1894. FORBES, S. A.—Eighteenth Rep. State Ent., Ill., p. 39.

Melanotus communis Gyll.

1891. COMSTOCK, J. H., and SLINGERLAND, M. V.—Bull. 33, Cornell Univ. Agr. Exper. Sta., pp. 262–267.
1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 39–41.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 230.
SLINGERLAND, M. V.—Bull. 107, Cornell Univ. Agr. Exper. Sta., pp. 53, 54.

Melanotus fissilis Say.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., p. 41.

Melanotus infaustus Lec.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., p. 42.

Melanotus cribulosus Lec.

1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 42–44.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 230.
1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 510, 511; 21st Rep. State Ent. Ill., pp. 162, 163.

Asaphes decoloratus Say.

1891. COMSTOCK, J. H., and SLINGERLAND, M. V.—Bull. 33, Cornell Univ. Agr. Exper. Sta., pp. 258–262.
1894. FORBES, S. A.—Eighteenth Rep. State Ent. Ill., pp. 45–47.
1896. FORBES, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 228.
SLINGERLAND, M. V.—Bull. 107, Cornell Univ. Agr. Exper. Sta., pp. 52, 53.

Elateridæ? sp.

1891. TOWNSEND, C. H. T.—Insect Life, Vol. IV., p. 26.

Onthophagus hecate Panz., p. 183.

Atænius cognatus Lec., p. 183.

Aphodius granarius Linn.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 14, 15.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 217.
1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., p. 83.

Macrodactylus subspinosus Fabr.

1878. Thomas, Cyrus.—Seventh Rep. State Ent. Ill., pp. 34, 35.
1890. Riley, C. V.—Insect Life, Vol. II., pp. 295–302.
1891. Smith, J. B.—Bull. 82, N. J. Agr. Exper. Sta. 40 pp.
1895. Chittenden, F. H.—Circ. No. 11, Sec. Ser., U. S. Dept. Agr., Div. Ent. 4 pp.
1896. Marlatt, C. L.—Yearbook, U. S. Dept. Agr., 1895, pp. 396–398.
1899. Webster, F. M., and Mally, C. W.—Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., p. 70.
Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 80–82.

Lachnosterna.

1890. Webster, F. M.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., pp. 48–51.
1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., pp. 30–53.
1893. Riley, C. V.—Proc. Ent. Soc. Wash., Vol. II., pp. 132–134.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 109–144.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 257–279.
1898. Forbes, S. A.—Twentieth Rep. State Ent. Ill., pp. 26–34.
1900. Forbes, S. A.—Bull. No 60, Ill. Agr. Exper. Sta., pp. 511–513; 21st Rep. State Ent. Ill., pp. 163–165.
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 44–48.

Lachnosterna lanceolata Say.

1895. Cockerell, T. D. A.—Bull. No. 15, N. Mex. Agr. Exper. Sta., p. 69.
1904. Sanderson, E. D.—Bull. No. 46, U. S. Dept. Agr., Div. Ent., p. 95.

Lachnosterna fusca Fröhl.

1886. Smith, J. B.—Insect Life, Vol. I., pp. 180–185.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 113, 138, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 262, 263, 265, 268.

Lachnosterna inversa Horn.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 113, 138, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 262, 263, 265, 268.

Lachnosterna rugosa Mels.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 113, 139, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 261, 262, *et al.*
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 512.; 21st Rep. State Ent. Ill., p. 164.

Lachnosterna hirticula Knoch.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 113, 139, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 263, 265.

Lachnosterna gibbosa Burm.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 113, 139, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 263, 265, 268.

Anomala undulata Mels.

1898. Webster, F. M., and Mally, C. W.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 98.

Cyclocephala immaculata Oliv.

1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., pp. 40–46.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 121, 138, *et al.*
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 259, 269.

Ligyrus gibbosus DeG.

1889. Webster, F. M.—Insect Life, Vol. I., p. 382.
1891. Bruner, L.—Bull. No. 23, U. S. Dept. Agr., Div. Ent., p. 17.
1894. Webster, F. M.—Insect Life, Vol. VII., p. 206.
1895. Weed, H. E.—Eighth Ann. Rep. Miss. Agr. and Mech. Coll. Exper. Sta., pp, 71, 72.
Weed, H. E.—Bull. No. 36, Miss. Agr. and Mech. Coll. Exper. Sta., pp. 156, 157.
1898. Howard, L. O.—Bull. No. 18, N. S., U. S. Dept. Agr., Div. Ent., pp. 92, 93.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 513; 21st Rep. State Ent. Ill., p. 165.
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 32–37.
Washburn, F. L.—Bull. No. 77, Minn. Agr. Exper. Sta., pp. 47–49.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 65–66.

Ligyrus rugiceps Lec.

1880. Riley, C. V.—Am. Ent., Vol. III., p. 130.
1881. Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1880, pp. 236–240; also as separate.
1888. Howard, L. O.—Insect Life, Vol. I., pp. 11–13.
1890. Webster, F. M.—Insect Life, Vol. III., p. 159.
1898. Howard, L. O.—Bull. No. 18, N. S., U. S. Dept. Agr., Div. Ent., p. 92.

Aphonus tridentatus Say.

1892. Harvey, F. L.—Ann. Rep. Me. State Coll. Agr. Exper. Sta., 1891, pp. 199–202.

Allorhina nitida Linn.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 149, 150.
1887. Ashmead, Wm. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16.
1893. Riley, C. V.—Bull. No. 23, Md. Agr. Exper. Sta., pp. 77–81.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 144, 145.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 280, 281.
Garman, H.—Eighth Rep. Ky. Agr. Exper. Sta., p. 39.
Smith, J. B.—Rep. N. J. Agr. Coll. Exper. Sta., 1895, pp. 510, 511.
1898. Howard, L. O.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., pp. 20–26, 93.
1899. Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 99–101.
1901. Chittenden, F. H.—Bull. No. 27, N. S., U. S. Dept. Agr., Div. Ent., pp. 76, 77.
1905. Garman, H.—Bull. No. 116, Ky. Agr. Exper. Sta., pp. 67–73.

Allorhina mutabilis Gory.

1897. Cockerell, T. D. A.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 25.
1898. Howard, L. O.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., pp. 20–26.
1899. Cockerell, T. D. A.—Bull. No. 32, Ariz. Agr. Exper. Sta., pp. 279, 280.
1900. Howard, L. O.—Bull. No. 22, N. S., U. S. Dept. Agr., Div. Ent., p. 104.

Euphoria inda Linn.

1862. Harris, T. W.—Insects Injurious to Vegetation, p. 40 (*Cetonia.*)
1882. Lintner, J. A.—First Rep. Ins. N. Y., pp. 232–239.
1888. Cook, A. J.—Rep. Sec. State Bd. Agr. Mich., 1887–88, p. 166.
1890. Riley, C. V., and Howard, L. O.—Insect Life, Vol. II., p. 277.
1891. Osborn, Herbert.—Bull. No. 15, Iowa Agr. Exper. Sta., pp. 255–258.
1894. Lintner, J. A.—Country Gent., Vol. 59, Sept. 27, 1894, p. 701.
1896. Schiedt, R. C.—Rep. Pa. Dept. Agr., 1895, p. 583.
Lintner, J. A.—Bull. No. 6, N. S., U. S. Dept. Agr., Div. Ent., p. 58.
Lugger, Otto.—Bull. No. 48, Minn. Agr. Exper. Sta., pp. 54, 55.
1897. Slingerland, M. V.—Can. Ent., Vol. XXIX., pp. 50, 51.
1899. Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 101–103.
Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., pp. 67–74.
1901. Fletcher, James.—Thirty-first Ann. Rep. Ent. Soc. Ont., p. 74.

Euphoria sepulchralis Fabr.

1890. Webster, F. M.—Insect Life, Vol. III., p. 159.
1895. Weed, H. E.—Bull. No. 36, Miss. Agr. and Mech. Coll. Exper. Sta., p. 157.
1899. Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 103, 104. (*melancholica.*)

Euphoria melancholica Gory.

1880. Horn, G. H.—Synopsis of the Euphoriæ of the United States. Proc. Am. Philos. Soc., Vol. XVIII., p. 404.
1891. Mally, F. W.—Bull. No. 24, U. S. Dept. Agr., Div. Ent., p. 29. (=*sepulchralis?*)

Cremastochilus knochii Lec., p. 183.

Prionus laticollis Drury.

1870. Riley, C. V.—Sec. Rep. Ins. Mo., pp. 88–89, 91.
1890. Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., pp. 437, 438.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., p. 146.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 281.
1899. Lugger, Otto.—Fifth Ann. Rep. as Ent. State Exper. Sta., Univ. Minn., pp. 109–111.

Prionus imbricornis Linn.

1870. Riley, C. V.—Sec. Rep. Ins. Mo., pp. 89–91.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., p. 146.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., p. 281.

Myochrous denticollis Say.

1888. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 150; also in sep. ed. Rep. Ent.
1900. Webster, F. M.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., p. 87.
1901. Webster, F. M.—Journ. N. Y. Ent. Soc., Vol. IX., pp. 127–132.

Colaspis brunnea Fabr.

1871. Riley, C. V.—Third Rep. Ins. Mo., pp. 82–84. (*flavida.*)
1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 156–159.
1890. Garman, H.—Bull. No. 31, Ky. Agr. Exper. Sta., pp. 22–24.
1895. Webster, F. M.—Bull. No. 2, N. S., U. S. Dept. Agr., Div. Ent., p. 90.

Colaspis brunnea Fabr.—*continued.*

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 473; 21st Rep. State Ent. Ill., p. 125.

1903. Forbes, S. A.—Twenty-second Rep. State Ent. Ill., pp. 145–149.
Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 13, 14.

Luperodes varicornis Lec.

1880. Riley, C. V.—Am. Ent., Vol. III., p. 132. (*Luperus brunneus.*)

1892. Riley, C. V., and Howard, L. O.—Insect Life, Vol. V., p. 47. (*Luperus brunneus.*)

Melasoma lapponica Linn.

1890. Bruner, L.—Bull. No. 14, Agr. Exper. Sta. Neb., pp. 91, 92. (*Lina.*)

Diabrotica tenella Lec.

1892. Townsend, C. H. T.—Insect Life, Vol. V., p. 39.

1893. Toumey, J. W.—Bull. No. 9, Ariz. Agr. Exper. Sta., pp. 8, 9.

Diabrotica 12-punctata Oliv.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 104.

1890. Webster, F. M.—Insect Life, Vol. III., p. 150.

1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., pp. 71–73.
Garman, H.—Psyche, Vol.VI., pp. 28–30, 44–49.

1893. Murtfeldt, M. E.—Bull. No. 30, U. S. Dept. Agr., Div. Ent., p. 50.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 146–154.

1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 282–287.

1898. Chittenden, F. H.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., pp. 30, 31.
Chittenden, F. H.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 86.

1899. Howard, L. O.—Yearbook, U. S. Dept. Agr., 1898, p. 144.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 473, 474; 21st Rep. State Ent. Ill., pp. 125, 126.
Quaintance, A. L.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., pp. 35–40.

1901. Quaintance, A. L.—Thirteenth Rep. Ga. Agr. Exper. Sta., pp. 366–371.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 129, 130.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div Ent., pp. 12, 13.

1905. Chittenden, F. H.—Circ. No. 59, U. S. Dept. Agr., Bur. Ent., pp. 1–5.
Smith, R. I.—Bull. No. 16, Ga. State Bd. Ent., pp. 40–42.

Diabrotica soror Lec.

1890. Koebele, A.—Bull. 22, U. S. Dept. Agr., Div. Ent., p. 87.

1891. Koebele, A.—Insect Life, Vol. III., p. 468.

Diabrotica vittata Fabr.

1890. Webster, F. M.—Insect Life, Vol. III., p. 149.

1896. Lowe, V. H., and Sirrine, F. A.—Fourteenth Rep. N. Y. Agr. Exper. Sta., pp. 567–573.

1898. Chittenden, F. H.—Circ. No. 31, Sec. Ser., U. S. Dept. Agr., Div. Ent. 7 pp.
Chittenden, F. H.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., pp. 26–30.

1899. Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., pp. 48–51.
Sirrine, F. A.—Bull. No. 158, N. Y. Agr. Exper. Sta. 32 pp.

Diabrotica vittata Fabr.—*continued.*

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 474, 475; 21st Rep. State Ent. Ill., pp. 126, 127.

1901. Sanderson, E. D.—Twelfth Rep. Del. Coll. Agr. Exper. Sta., pp. 208, 209.

Garman, H.—Bull. No. 91, Ky. Agr. Exper. Sta., pp. 3–15.

Diabrotica longicornis Say.

1882. Webster, F. M.—Am. Nat., Vol. XVI., p. 514.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., pp. 10–31.

1889. Bruner, L.—Rep. Neb. State Bd. Agr., 1888, p. 110.

1890. Bruner, L.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., p. 100.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 154–165.

1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 287–296.

1899. Webster, F. M., and Mally, C. W.—Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., p. 69.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 475; 21st Rep. State Ent. Ill., p. 127.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 125–129.

1905. Chittenden, F. H.—Circ. No. 59, U. S. Dept. Agr., Bur. Ent., pp. 1, 6–8.

Diabrotica atripennis fossata Lec.

1882. Webster, F. M.—Am. Nat., Vol. XVI., p. 514. (*fossata.*)

1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., p. 103. (*atripennis.*)

Epitrix cucumeris Harr.

1878. Thomas, Cyrus.—Prairie Farmer, June 22, 1878. (*Haltica.*)

1893. Davis, G. C.—Bull. 102, Mich. Agr. Exper. Sta., p. 41. (*Crepidodera.*)

1895. Weed, C. M.—Bull. 29, N. H. Coll. Exper. Sta., pp. 3, 4–7. (*Crepidodera.*)

1896. Stewart, F. C.—Bull. No. 113, N. S., N. Y. Agr. Exper. Sta., pp. 311–317. (*Crepidodera.*)

1897. Sirrine, F. A.—Proc. Iowa Acad. Sci., pp. 170–172. (*Crepidodera.*)

1899. Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., p. 89.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 465; 21st Rep. State Ent. Ill., p. 117.

1904. Chittenden, F. H.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., p. 96.

Systena hudsonias Forst.

1893. Chittenden, F. H.—Proc. Ent. Soc. Wash., Vol. II., p. 266.

1899. Stone, J. L.—Bull. 166, Cornell Univ. Agr. Exper. Sta., p. 425.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 467; 21st Rep. State Ent. Ill., p. 119.

1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 113, 114.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., p. 17.

Systena blanda Mels.

1874. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1873, p. 152.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., p. 86.

1888. Lintner, J. A.—Fourth Rep. Ins. N. Y., in 41st Rep. N. Y. State Mus., pp. 155, 156.

1889. Cassidy, James.—Bull. No. 6, Col. Agr. Exper. Sta., p. 18. (*mitis.*)

1891. Bruner, L.—No. 16, Bull. Agr. Exper. Sta. Neb., p. 60.

Systena blanda Mels.—*continued.*

1893. Smith, J. B.—Insect Life, Vol. VI., pp. 188, 189.
Gillette, C. P.—Bull. No. 24, Col. Agr. Exper. Sta., pp. 10–12. (*tæniata.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 21–23. (*tæniata.*)
1895. Webster, F. M.—Bull. No. 2, N. S., U. S. Dept. Agr., Div. Ent., p. 87. (*tæniata.*)
1900. Chittenden, F. H.—Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 22–29.
Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 468–470; 21st Rep. State Ent. Ill., pp. 120–122. (*tæniata.*)
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 110, 111.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., p. 16.

Phyllotreta pusilla Horn.

1898. Howard, L. O.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., pp. 92, 93.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 471; 21st Rep. State Ent. Ill., p. 123. (*albionica.*)
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 18, 19.

Chætocnema denticulata Ill.

1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 22.
1898. Chittenden, F. H.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 85.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 466; 21st Rep. State Ent. Ill., p. 118.
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 114, 115.

Chætocnema pulicaria Mels.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 22.
1891. Riley, C. V., and Howard, L. O.—Insect Life, Vol. III., pp. 336, 484.
1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 22.
Johnson, W. G.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 81.
1898. Chittenden, F. H.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., pp. 84, 85.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 466, 467; 21st Rep. State Ent. Ill., pp. 118, 119.
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 115, 116.

Chætocnema parcepunctata Cr.

1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 22.

Chætocnema confinis Cr.

1888. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 150; also in sep. ed. Rep. Ent.
1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 22.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 467; 21st Rep. State Ent. Ill., p. 119.

Glyptina brunnea Horn.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 470; 21st Rep. State Ent. Ill., p. 122.

Psylliodes punctulata Mels.

1867. Fitch, Asa.—Eleventh Rep. Ins. N. Y., in Trans. N. Y. State Agr. Soc., 1866, pp. 494–496.

1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 22.

1900. Doane, R. W.—Bull. 42, Wash. Agr. Exper. Sta., pp. 11, 12.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 472; 21st Rep. State Ent. Ill., p. 124.

Psylliodes convexior Lec.

1888. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1887, p. 150; also in sep. ed. Rep. Ent. (*interstitialis.*)

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 472; 21st Rep. State Ent. Ill., p. 124.

Chelymorpha argus Licht.

1887. Lintner, J. A.—Fourth Rep. Ins. N. Y., in 41st Rep. N. Y. State Mus., p. 201; also as separate.

1890. Osborn, Herbert.—Orange Judd Farmer, Sept. 6, 1890, p. 148.

1893. Webster, F. M.—Ent. News, Vol. IV., p. 227.

1897. Chittenden, F. H.—Bull. No. 9, N. S., U. S. Dept. Agr., Div. Ent., p. 23.

1899. Sanderson, E. D.—Bull. No. 59, Md. Agr. Exper. Sta., pp. 140–141.

Epicauta vittata Fabr.

1878. Riley, C. V.—Am. Nat., Vol XII., pp. 282, 283.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 104.

1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 198; Separate, p. 19.

1890. Lintner, J. A.—Sixth Rep. Ins. N. Y., in 43d Rep. N. Y. State Mus., pp. 132–134; also as separate.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 488; 21st Rep. State Ent. Ill., p. 140.

1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 266–268.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 22, 23.

Epicauta marginata Fabr.

1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 198; Separate, p. 19. (*cinerea.*) [=? *marginata.*]

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 489; 21st Rep. State Ent. Ill., p. 141.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., p. 24.

Epicauta pennsylvanica DeG.

1882. Webster, F. M.—Am. Nat., Vol. XVI., p. 514.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 104.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 489; 21st Rep. State Ent. Ill., p. 141.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., p. 25.

Epicœrus imbricatus Say.
1880. Riley, C. V.—Am. Ent., Vol. III., p. 200.
Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1879, p. 249; also as separate.
1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 104.
1889. Bruner, L.—Rep. Neb. State Bd. Agr., 1888, p. 117; also as separate.
1890. Beutenmüller, Wm.—Can. Ent., Vol. XXII., p. 200.
1896. Osborn, Herbert, and Mally, C. W.—Proc. Iowa Acad. Sci., Vol. III., pp. 206–208.
1899. Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., pp. 62–67.
Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 182, 183.
1900. Chittenden, F. H.—Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 31, 32.
Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 491, 492; 21st Rep. State Ent. Ill., pp. 143, 144.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 28, 29.

Otiorhynchus ovatus Linn.
1853. Laboulbène, A.—Ann. Soc. Ent. Fr., III. Sér., I. Bull., p. 48.
1885. Weed, C. M.—Rep. Sec. State Hort. Soc. Mich., 1884, p. 84; also in author's separate. (*ligneus.*)
1895. Lintner, J. A.—Tenth Rep. Ins. N. Y., in 48th Rep. N. Y. State Mus., pp. 416–419; also as separate.
1899. Lugger, Otto.—Fifth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 184, 185.

Lixus mucidus Lec.
1890. Weed, C. M.—Bull. Ohio Agr. Exper. Sta., Vol. III., No. 8, pp. 232–235. (*concavus.*)
1898. Webster, F. M., and Mally, C. W.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 100.

Lixus concavus Say.
1889. Webster, F. M.—Ent. Amer., Vol. V., pp. 11–16.
1900. Chittenden, F. H.—Ent. Amer., Vol. VI., p. 169.
Chittenden, F. H.—Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 61–69.

Limnobaris deplanata Casey, p. 193.

Sphenophorus œqualis Lec.
1889. Webster, F. M.—Insect Life, Vol. II., pp. 132–134; abstract, 22d Rep. State Ent. Ill., p. 23. (*ochreus.*)
1890. Webster, F. M.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., pp. 52–55; abstract, 22d Rep. State Ent. Ill., p. 23. (*ochreus.*)
Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 59, *et al.* (*ochreus.*)
1894. Osborn, Herbert.—Bull. No. 24, Iowa Agr. Coll. Exper. Sta., p. 997; abstract, 22d Rep. State Ent. Ill., p. 26. (*ochreus.*)
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 143–146. (*ochreus.*)
Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., pp. 436, 443–452, *et al.*; also in 22d Rep. State Ent. Ill., pp. 1, 9–17, *et al.* (*ochreus.*)

Sphenophorus pertinax Oliv.

1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 195; Separate, p. 16.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 60, *et al.*

1899. Parrot, P. J.—Kansas Farmer, May 11, 1899, p. 314; abstract, 22d Rep. State Ent. Ill., p. 26.

1902. Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., pp. 452, 453; also in 22d Rep. State Ent. Ill., pp. 17, 18.

1905. Chittenden, F. H.—Proc. Ent. Soc. Wash., Vol. VII., pp. 52, 53.

Sphenophorus maidis Chitt.

1881. Riley, C. V.—Am. Nat., Vol. XV., p. 915. (*robustus.*)

1882. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1881, pp. 138–142; also as separate. (*robustus.*)

1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, p. 413; also as separate. (*robustus.*)

1887. Ashmead, Wm. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16. (*robustus.*)

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 60, 71, *et al.* (*robustus,* except Ill. references.)

1905. Chittenden, F. H.—Proc. Ent. Soc. Wash., Vol. VII., pp. 57, 59.

Sphenophorus cariosus Oliv.

1871. Glover, Townend.—Rep. [U. S.] Comm. Agr., 1870, p. 68.

1882. Lintner, J. A.—First Rep. Ins. N. Y., p. 261.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. 58, 71, *et al.*

1902. Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., pp. 453–456; also in 22d Rep. State Ent. Ill., pp. 19–21.

Sphenophorus zeæ Uhl.

1877. Packard, A. S.—Rep. U. S. Geol. and Geogr. Surv. Terr., 1875, p. 718.

1882. Lintner, J. A.—First Rep. Ins. [illegible]., pp. 253–263. (*sculptilis.*)

1885. Riley, C. V.—Rep. U. S. Comm. Agr., 1884, p. 413; also as separate. (*sculptilis.*)

1889. Beckwith, M. S.—Sec. Ann. Rep. Del. Coll. Agr. Exper. Sta., p. 129. (*sculptilis.*)

Bruner, L.—Rep. Neb. State Bd. Agr., 1888, pp. 117, 118; also as separate. (*sculptilis.*)

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 61, *et al.* (*sculptilis.*)

1891. McCarthy, Gerald.—Bull. No. 78, N. C. Agr. Exper. Sta., p. 18; abstract, 22d Rep. State Ent. Ill., p. 23.

1892. Beckwith, M. H.—Fifth Ann. Rep. Del. Coll. Agr. Exper. Sta., p. 102; abstract, 22d Rep. State Ent. Ill., p. 24. (*sculptilis.*)

1898. Hopkins, A. D.—Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 45; abstract, 22d Rep. State Ent. Ill., p. 26. (*sculptilis.*)

1900. Webster, F. M.—Bull. No. 26, N. S., U. S. Dept. Agr., Div. Ent., p. 86. (*sculptilis.*)

1902. Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., p. 456; also in 22d Rep. State Ent. Ill., p. 21. (*sculptilis.*)

Sphenophorus scoparius Horn.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 68, *et al.*

1902. Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., p. 456; also in 22d Rep. State Ent. Ill., p. 21.

Sphenophorus venatus Say.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 62, *et al.* (*placidus.*)

1902. Forbes, S. A.—Bull. 79, Ill. Agr. Exper. Sta., p. 442; also in 22d Rep. State Ent. Ill., p. 8. (*placidus.*)

1904. Chittenden, F. H.—Proc. Ent. Soc. Wash., Vol. VI, p. 133.

Sphenophorus parvulus Gyll.

1882. Riley, C. V.—Rep [U. S.] Comm. Agr., 1881, p. 139; also as separate.

1886. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1885, pp. 315, 316; also in sep. ed. Rep. Ent.

1887. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1886, p. 580; also in sep. ed. Rep. Ent.

1890. Bruner, L.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., p. 99.

Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 58, 63, *et al.*

1892. Osborn, Herbert, and Gossard, H. A.—Bull. No. 18, Iowa Agr. Exper. Sta., pp. 509–512; abstract, 22d Rep. State Ent. Ill., p. 24.

1902. Forbes, S. A.—Bull. No. 79, Ill. Agr. Exper. Sta., pp. 437–442; also in 22d Rep. State Ent. Ill., pp. 3–8.

Brachytarsus variegatus Say.

1885. Lintner, J. A.—Second Rep. Ins. N. Y., pp. 139–141.

1890. Beutenmüller, Wm.—Can. Ent., Vol. XXII., p. 261.

1897. Chittenden, F. H.—Bull. No. 8, N. S., U. S. Dept. Agr., Div. Ent., p. 31.

Hemiptera.

Corimelæna pulicaria Germ.

1875. Riley, C. V.—Seventh Rep. Ins. Mo., p. 48.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 106–111. (*Thyreocoris.*)

1885. Webster, F. M.—Ind. Farmer, July 18, 1885.

1893. Lintner, J. A.—Eighth Rep. Ins. N. Y., in 45th Rep. N. Y. State Mus., p. 213; also as separate.

Davis, G. C.—Bull. 1[illegible], Mich. Agr. Exper. Sta., pp. 13–18.

1897. Quaintance, A. L.—Bull. No. 42, Fla. Agr. Exper. Sta., pp. 583, 584.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 447, 448; 21st Rep. State Ent. Ill., pp. 99, 100.

Œbalus pugnax Fabr.

1887. Ashmead, Wm. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16.

1891. Garman, H.—Psyche, Vol. VI., p. 61.

1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 91, 92.

Euschistus fissilis Uhl.

1886. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1885, p. 317; also in sep. ed. Rep. Ent.

Euschistus servus Say.

1887. Ashmead, Wm. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16.

Euschistus variolarius Pal. Beauv.

1893. Webster, F. M.—Bull. 52 and 12th Ann. Rep. Ohio Agr. Exper. Sta., p. XXXVI.

1897. Garman, H.—Bull. No. 66, Ky. Agr. Exper. Sta., pp. 33, 34.

1899. Howard, L. O.—Yearbook, U. S. Dept. Agr., 1898, p. 136.

Euschistus variolarius Pal. Beauv.—*continued.*

1900. Howard, L. O.—Farmers' Bull. No. 120, U. S. Dept. Agr., p. 18.
Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 91.
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 219, 220.

Thyanta custator Fabr.

1898. Chittenden, F. H.—Bull. No. 10, N. S., U. S. Dept. Agr., Div. Ent., p. 62.

Thyanta perditor Fabr.

1904. Sanderson, E. D.—Bull. No. 46, U. S. Dept. Agr., Div. Ent., p. 94.

Pentatoma uhleri Stål.

1898. Saunders, D. A.—Bull. No. 57, Exper. Sta. S. Dak., pp. 36–47. (*Lioderma.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 445–447; 21st Rep. State Ent. Ill., pp. 97–99.
Howard, L. O.—Bull. 10, N. S., U. S. Dept. Agr., Div. Ent., p. 94. (*Lioderma.*)

Murgantia histrionica Hahn.

1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 309–312; also as separate.
1889. Beckwith, M. H.—Sec. Ann. Rep. Del. Coll. Agr. Exper. Sta., p. 130.
1892. Murtfeldt, M. E.—Bull. No. 26, U. S. Dept. Agr., Div. Ent., pp. 37, 38.
1893. Lintner, J. A.—Ninth Rep. Ins. N. Y., in 46th Rep. N. Y. State Mus., pp. 315–317; also as separate.
1895. Howard, L. O.—Circ. No. 10, Sec. Ser., U. S. Dept. Agr., Div. Ent. 2 pp.
1896. Garman, H.—Eighth Rep. Ky. Agr. Exper. Sta., pp. XLIV–XLVIII.
1897. Webster, F. M.—Bull. 74 and 15th Ann. Rep. Ohio Agr. Exper. Sta., p. XXXIV.
Smith, J. B.—Bull. 121, N. J. Agr. Exper. Sta. 14 pp.
1899. Fernald, H. T.—Bull. No. 48, Pa. Dept. Agr., pp. 12–14.
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., p. 82.
1904. Garman, H.—Bull. No. 114, Ky. Agr. Exper. Sta., pp. 40, 41.

Leptoglossus phyllopus Linn.

1890. Neal, J. C.—Bull. No. 9, Exper. Sta. Fla., p. 9.
1896. Quaintance, A. L.—Bull. No. 34, Fla. Agr. Exper. Sta., pp. 300, 301.
1899. Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., pp. 46–48.
1901. Garman, H.—Bull. No. 91, Ky. Agr. Exper. Sta., pp. 36, 37.
1903. Chittenden, F. H.—Bull. No. 40, N. S., U. S. Dept. Agr., Div. Ent., pp. 113, 114.
1904. Sanderson, E. D.—Bull. No. 46, U. S. Dept. Agr., Div. Ent., p. 96.

Leptoglossus oppositus Say.

1886. Lintner, J. A.—Country Gent., Vol. 51, Oct. 7, 1886, p. 753.
1899. Chittenden, F. H.—Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., pp. 44–46.
1901. Garman, H.—Bull. No. 91, Ky. Agr. Exper. Sta., pp. 35, 36.
Howard, L. O.—Yearbook, U. S. Dept. Agr., 1900, p. 727.
1902. Chittenden, F. H.—Bull. No. 33, N. S., U. S. Dept. Agr., Div. Ent., pp. 18–25.

Nysius angustatus Uhl.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 104–106.
1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 315–317; also as separate.
1890. Webster, F. M.—Insect Life, Vol. III., p. 160.
1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 74–76.
Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 443, 444; 21st Rep. State Ent. Ill., pp. 95, 96.

Blissus leucopterus Say.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., pp. 32–63.
1889. Bruner, L.—Rep. Neb. State Bd. Agr., 1888, pp. 88–94; also as separate.
1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., pp. 1–57, and App., pp. 1–122.
1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., pp. 74–87.
1895. Forbes, S. A.—Nineteenth Rep. State Ent. Ill., pp. 5–189.
1898. Forbes, S. A.—Twentieth Rep. State Ent. Ill., pp. 35–102.
Webster, F. M.—Bull. No. 15, N. S., U. S. Dept. Agr., Div. Ent. 82 pp.
Howard, L. O.—Bull. No. 18, N. S., U. S. Dept. Agr., Div. Ent., pp. 97, 98.
1899. Webster, F. M.—Bull. 106, Ohio Agr. Exper. Sta. 20 pp. (237–256).
1901. Marlatt, C. L.—Farmers' Bull. No. 132, U. S. Dept. Agr., pp. 6–13.
Webster, F. M.—Proc. 22d Ann. Meet. Soc. Promotion Agr. Sci., pp. 47–57; also as separate.
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 52–58.

Ligyrocoris sylvestris Linn., p. 198.

Sphragisticus nebulosus Fall.

1890. Bruner, L.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., p. 96. (*Trapezonotus.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 442; 21st Rep. State Ent. Ill., p. 94.

Microtoma atrata Goeze, p. 198.

Lygus pratensis Linn.

1883. Forbes, S. A.—Twelfth Rep. State Ent. Ill., p. 104. (*lineolaris.*)
1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 115–135. (*lineolaris.*)
1885. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1884, pp. 312–315; also as separate. (*lineolaris.*)
Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 79, 80. (*lineolaris.*)
1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 200; Separate, p. 21. (*Capsus lineolaris.*)
1890. Woodworth, C. W.—Sec. Rep. Ark. Agr. Exper. Sta., pp. 147–158. (*lineolaris.*)
1891. Riley, C. V., and Howard, L. O.—Insect Life, Vol. III., p. 348.
1893. Webster, F. M.—Bull. 45, Ohio Agr. Exper. Sta., pp. 213–216.
1894. Fletcher, James.—Rep. Exptl. Farms Can., 1893, pp. 180, 181; author's ed., pp. 26, 27.
1898. Lintner, J. A.—Thirteenth Rep. State Ent. [N. Y.], in 51st Ann. Rep. N. Y. State Mus., pp. 351–357; also as separate.
1899. Stedman, J. M.—Bull. No. 47, Mo. Agr. Exper. Sta., pp. 77–87.
1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 55–57.
Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 438–440; 21st Rep. State Ent. Ill., pp. 90–92.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept Agr., Div. Ent., pp. 52–54.

Calocoris rapidus Say.

1884 Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 135–138. (*Deræocoris.*)

1890. Webster, F. M.—Insect Life, Vol. III., p. 159.

1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 65.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 440; 21st Rep. State Ent. Ill., p. 92.

Pœcilocapsus lineatus Fabr.

1882. Lintner, J. A.—First Ann. Rep. Ins. N. Y., pp. 271–281.

1888. Lintner, J. A.—Fourth Rep. Ins. N. Y., p. 200.

1893. Slingerland, M. V.—Bull. 58, Cornell Univ. Agr. Exper. Sta., pp. 207–237.

1894. Fletcher, James.—Rep. Exptl. Farms Can., 1893, pp. 180, 181; author's ed., pp. 26, 27.

1899. Fletcher, James.—Rep. Exptl. Farms Can., 1898, pp. 196, 197; also as separate.

Plagiognathus obscurus Uhl.

1890. Riley, C. V., and Howard, L. O.—Insect Life, Vol. III., p. 351.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 437; 21st Rep. State Ent. Ill., p. 89.

Capsid.

1887. Ashmead, Wm. H.—Bull. No. 14, U. S. Dept. Agr., Div. Ent., p. 16.

Triphleps insidiosus Say.

1886. Forbes, S. A.—Can. Ent., Vol. XVIII., p. 176.

Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 199; Separate, p. 20. (*Anthocoris.*)

1888. Riley, C. V.—Insect Life, Vol. I., p. 122.

1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 53, 54.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 434; 21st Rep. State Ent. Ill., p. 86.

Ormenis pruinosa Say.

1873. Riley, C. V.—Fifth Rep. Ins. Mo., p. 122. (*Pœciloptera.*)

1887. Murtfeldt, M. E.—Bull. No. 13, U. S. Dept. Agr., Div. Ent., pp. 61, 62. (*Pœciloptera.*)

1890. Packard, A. S.—Forest Insects. Fifth Rep. U. S. Ent. Comm., p. 281. (*Pœciloptera.*)

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 431–433; 21st Rep. State Ent. Ill., pp. 83–85.

Chittenden, F. H.—Bull. No. 22, N. S., U. S. Dept. Agr., Div. Ent., pp. 98, 99.

Chlorochara conica Say.

1887. Murtfeldt, M. E.—Bull. No. 13, U. S. Dept. Agr., Div. Ent., p. 61. (*Flata.*)

1900. Chittenden, F. H.—Bull. No. 22, N. S., U. S. Dept. Agr., Div. Ent., pp. 98, 99. (*Chlorochroa.*)

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 431–433; 21st Rep. State Ent. Ill., pp. 83–85. (*Chlorochroa.*)

Dicranotropis sp., p. 204.

Liburnia ornata Stål.

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 415; 21st Rep. State Ent. Ill., p. 67.

Delphax maidis Ashm.

1888. ASHMEAD, WM. H.—Trans. Am. Ent. Soc., Vol. XV., p. X. (*Kormus maidis.*)

1890. ASHMEAD, WM. H.—Psyche, Vol. V., pp. 323, 324.

1897. MORGAN, H. A.—Bull. Agr. Exper. Sta. La., Sec. Ser., No. 48, pp. 153, 154.

1898. QUAINTANCE, A. L.—Bull. No. 45, Fla. Agr. Exper. Sta., pp. 61–67.

Agallia 4-punctata Prov.

1885. FORBES, S. A.—Fourteenth Rep. State Ent. Ill., p. 22. (*Macropsis nobilis.*)

1898. OSBORN, HERBERT, and BALL, E. D.—Rep. Iowa Agr. Exper. Sta., 1897, pp. 113, 114; Separate, pp. 2, 3.

OSBORN, HERBERT, and BALL, E. D.—Proc. Dav. Acad. Nat. Sci., Vol. VII., pp. 48–50.

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 416; 21st Rep. State Ent. Ill., p. 68.

Oncometopia undata Fabr.

1886. RILEY, C. V.—Bull. No. 12, U. S. Dept. Agr., Div. Ent., p. 42. (*Proconia.*)

1890. RILEY, C. V., and HOWARD, L. O.—Insect Life, Vol. III., p. 123. (*Proconia.*)

1900. LUGGER, OTTO.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 136, 137.

Dræculacephala mollipes Say.

1890. GARMAN, H.—Sec. Ann. Rep. Ky. Agr. Exper. Sta., pp. 12, 13. (*Tettigonia.*)

1891. OSBORN, HERBERT.—Bull. No. 13, Iowa Agr. Exper. Sta., pp. 98, 99. (*Diedrocephala.*)

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 419, 420; 21st Rep. State Ent. Ill., pp. 71, 72. (*Diedrocephala.*)

Deltocephalus inimicus Say.

1885. FORBES, S. A.—Fourteenth Rep. State Ent. Ill., pp. 22, 67. (*Jassus.*)

1891. OSBORN, HERBERT.—Bull. No. 13, Iowa Agr. Exper. Sta., pp. 99, 100.

1896. SCHIEDT, R. C.—Rep. Pa. Dept. Agr., 1895, p. 582. (*Jassus.*)

WEBSTER, F. M.—Bull. No. 68, Ohio Agr. Exper. Sta., p. 43. (Also in App. to 15th Rep. of Station.)

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 422, 423; 21st Rep. State Ent. Ill., pp. 74, 75.

Deltocephalus nigrifrons Forbes.

1885. FORBES, S. A.—Fourteenth Rep. State Ent. Ill., pp. 22, 67, 68. (*Cicadula.*)

1897. OSBORN, HERBERT, and BALL, E. D.—Proc. Iowa Acad. Sci., 1896, pp. 218–220.

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 423; 21st Rep. State Ent. Ill., p. 75.

Phlepsius irroratus Say.

1900. FORBES, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 424; 21st Rep. State Ent. Ill., p. 76.

Cicadula 6-notata Fall.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., pp. 22, 68–69. (*quadrilineata.*)
1891. Osborn, Herbert.—Insect Life, Vol. IV., p. 197. (*quadrilineata.*)
1893. Davis, G. C.—Bull. 102, Mich. Agr. Exper. Sta., p. 8. (*quadrilineata.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 425; 21st Rep. State Ent. Ill., p. 77.

Empoasca mali LeB.

1893. Davis, G. C.—Bull. 102, Mich. Agr. Exper. Sta., p. 8.
1899. Chittenden, F. H.—Yearbook, U. S. Dept. Agr., 1898, p. 260.
1900. Lugger, Otto.—Sixth Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 131.
Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 425–427; 21st Rep. State Ent. Ill., pp. 77–79.

Siphocoryne avenæ Fabr.

1904. Pergande, Theo.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., pp. 5–13.

Macrosiphum granaria Buckt.

1904. Pergande, Theo.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., pp. 13, 14.

Macrosiphum trifolii Perg.

1904. Pergande, Theo.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., pp. 21–23.

Myzus achyrantes Monell.

1879. Monell, J.—Bull. U. S. Geol. Surv. Terr., Vol. V., No. 1, pp. 18, 19; Supp. 8th Rep. State Ent. Ill., p. 187. (*Siphonophora.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 430, 431; 21st Rep. State Ent. Ill., pp. 82, 83.

Aphis maidiradicis Forbes.

1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., pp. 64–70.
Weed, C. M.—Bull. Ill. State Lab. Nat. Hist., Vol. III., Art. XII. 8 pp. (207–214). (*maidis.*)
Forbes, S. A.—Insect Life, Vol. III., pp. 233–238.
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 58–85.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 237–256.
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 134–141.

Aphis maidis Fitch.

1856. Fitch, Asa.—Sec. Rep. Ins. N. Y., pp. 318–320.
1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 43–50.
1885. Garman, H.—Fourteenth Rep. State Ent. Ill., pp. 23–33.
1888. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1887, pp. 148, 149; also in sep. ed. Rep. Ent. (*Rhopalosiphum.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 69–74.
1904. Sanderson, E. D.—Bull. No. 46, U. S. Dept. Agr., Div. Ent., p. 93.

Rhopalosiphum dianthi Schrank.

1891. Williams, T. A.—Special Bull. No. 1, Univ. Neb., Dept. Ent., p. 9.
1896. Sirrine, F. A.—Fourteenth Rep. N. Y. Agr. Exper. Sta., p. 602.

Toxoptera graminum Rond.

1890. Webster, F. M.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., p. 70.
1892. Webster, F. M.—Insect Life, Vol. IV., pp. 245–248.
1902. Pergande, Theo.—Bull. No. 38, N. S., U. S. Dept. Agr., Div. Ent., pp. 7–19.

Chaitophorus flavus Forbes.

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., pp. 41, 42–43.
1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 70.

Schizoneura panicola Thom.

1879. Thomas, Cyrus.—Eighth Rep. State Ent. Ill., pp. 138, 139.
1890. Osborn, Herbert.—Bull. No. 22, U. S. Dept. Agr., Div. Ent., pp. 32–41. (*corni.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 85–93.
1896. Forbes, S. A.—Bull. No. 44, Ill. Agr. Exper. Sta., pp. 256, 257.

Trama erigeronensis Thom.

1879. Thomas, Cyrus.—Eighth Rep. State Ent. Ill., pp. 168, 169. (*Tychea.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 93–95.

Forda occidentalis Hart.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 95–97.

Tychea brevicornis Hart.

1894. Forbes, S. A.— Eighteenth Rep. State Ent. Ill., pp. 97, 98.
1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., p. 62.

Geoica squamosa Hart.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 98–104.

Rhizobius spicatus Hart.

1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 104–106.

Dactylopius sorghiellus Forbes.

1884. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 71. (*Coccus.*)
1894. Forbes, S. A.—Eighteenth Rep. State Ent. Ill., pp. 106–108.

Euthrips tritici Fitch.

1890. Forbes, S. A.—Sixteenth Rep. State Ent. Ill., p. IX. (*Thrips.*)
1891. Forbes, S. A.—Seventeenth Rep. State Ent. Ill., p. XIII. (*Thrips.*)
1892. Forbes, S. A.—Insect Life, Vol. V., pp. 126, 127. (*Thrips.*)
1898. Quaintance, A. L.—Bull. 46, Fla. Agr. Exper. Sta. 14 pp. (77–103).
1902. Hinds, W. E.—Contribution to a Monograph of the Thysanoptera of North America. Proc. U. S. Nat. Mus., Vol. XXVI., pp. 148–152.

Euthrips nervosus Uzel.

1896. Beach, Alice M.—Proc. Iowa Acad. Sci., Vol. III., pp. 219, 220. (*Thrips maidis.*)
Hinds, W. E.—Contr. to a Monograph of the Thysanoptera of N. A. Proc. U. S. Nat. Mus., Vol. XXVI., pp. 155, 156.

Anaphothrips striata Osb.

1900. Fernald, H. T., and Hinds, W. E.—Bull. No. 67, Hatch Exper. Sta., Mass. Agr. Coll. 12 pp.
1902. Hinds, W. E.—Contr. to a Monograph of the Thysanoptera of N. A. Proc. U. S. Nat. Mus., Vol. XXVI., pp. 161–166.
Cary, L. R.—Bull. No. 83, Me. Agr. Exper. Sta., pp. 97–128.

Thrips perplexus Beach.

1896. Beach, Alice M.—Proc. Iowa Acad. Sci., Vol. III., pp. 216–218. (*Sericothrips?*)
1902. Hinds, W. E.—Contr. to a Monograph of the Thysanoptera of N. A. Proc. U. S. Nat. Mus., Vol. XXVI., pp. 184–186.

Orthoptera.

Diapheromera velii Walsh.
1864. Walsh, B. D.—Proc. Ent. Soc. Phila., Vol. III., pp. 409, 410.
1904. Gillette, C. P.—Bull. 94, Col. Agr. Exper. Sta., p. 22.

Dichromorpha viridis Scudd.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 124.
1903. Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Natural Resources Ind., pp. 238, 239.

Boöpedon nubilum Say.
1904. Gillette, C. P.—Bull. 94, Col. Agr. Exper. Sta., p. 27.

Camnula pellucida Scudd.
1880. Riley, C. V., and Thomas, Cyrus.—Sec. Rep. U. S. Ent. Comm., pp. 243–246.
1891. Bruner, L.—Insect Life, Vol. IV., p. 19.
1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 34–36.
1896. Lugger, Otto.—First Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 48, 49.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 148–150.
1903. Simpson, C. B.—Circ. No. 53, U. S. Dept Agr., Div. Ent. 3 pp.
Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 262, 263.

Dissosteira longipennis Thom.
1891. Bruner, L.—Insect Life, Vol. IV., pp. 18, 19.
Popenoe, E. A.—Insect Life, Vol. IV., p. 41.
1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 36–39.

Schistocerca americana Dru.
1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 23. (*Acridium.*)
1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 10, 11.
1894. Garman, H.—Bull. No. 49, Ky. Agr. Exper. Sta., pp. 11–17.
Howard, L. O.—Insect Life, Vol. VII., pp. 220–223.
Coquillett, D. W.—Insect Life, Vol. VII., pp. 223–229.
1895. Howard, L. O.—Insect Life, Vol. VII., p. 429.
1898. Lugger, O.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 174–176.
1903. Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 290–293.

Schistocerca alutacea Harr.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 172, 173. (*alutacea* + *emarginata.*)
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 480; 21st Rep. State Ent. Ill., p. 132.
1903. Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 294–296.

Campylacantha olivacea Scudd.
1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 51, 52.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 483; 21st Rep. State Ent. Ill., p. 135.

Hesperotettix speciosus Scudd.

1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 12, 13. (*Acridium frontalis.*)

1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 66–68.

Melanoplus femur-rubrum DeG.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 23. (*Pezotettix.*)

1889. Weed, C. M.—Fifteenth Rep. State Ent. Ill., pp. 40–44. (*Pezotettix.*)

1891. Riley, C. V.—Bull. No. 25, U. S. Dept. Agr., Div. Ent., pp. 27, 28. (*Caloptenus.*)

1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 30–32.

1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 278–285.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 195–198.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 481, 482; 21st Rep. State Ent. Ill., pp. 133, 134.

1903. Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 317–319.

Melanoplus atlanis Riley.

1884. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1883, pp. 170–180; also as separate. (*Caloptenus.*)

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 23. (*Pezotettix.*)

1891. Riley, C. V.—Bull. No. 25, U. S. Dept. Agr., Div. Ent., pp. 26, 27. (*Caloptenus.*)

1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 29, 30.

1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 178–183.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 190–193.

1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 482; 21st Rep. State Ent. Ill., p. 134.

1903. Blatchley, W. S.—The Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 314–316.

Melanoplus spretus Uhl.

1878. Riley, C. V., Packard, A. S., and Thomas, Cyrus.—First Ann. Rep. U. S. Ent. Comm. (*Caloptenus.*)

1880. Riley, C. V., Packard, A. S., and Thomas, Cyrus.—Second Ann. Rep. U. S. Ent. Comm. (*Caloptenus.*)

1891. Riley, C. V.—Bull. No. 25, U. S. Dept. Agr., Div. Ent., pp. 9–26. (*Caloptenus.*)

1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 27–29.

1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 184–190.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 193, 194.

Melanoplus differentialis Thom.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 23. (*Caloptenus.*)

1886. Coquillett, D. W.—Rep. [U. S.] Comm. Agr., 1885, pp. 295, 296; also in sep. ed. Rep. Ent. (*Caloptenus.*)

1889. Weed, C. M.—Fifteenth Rep. State Ill., pp. 40–44. (*Pezotettix.*)

1891. Riley, C. V.—Bull. No. 25, U. S. Dept. Agr., Div. Ent., pp. 30, 31. (*Caloptenus.*)

Melanoplus differentialis Thom.—*continued.*

1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 15–17.
1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 349–354.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 204–206.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 480, 481; 21st Rep. State Ent. Ill., pp. 132, 133.
1901. Morgan, H. A.—Bull. No. 30, N. S., U. S. Dept. Agr., Div. Ent., pp. 7–26.
1902. Sanderson, E. D.—Insects Injurious to Staple Crops, pp. 69, 70–78.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 326–331.

Melanoplus bivittatus Say.

1886. Forbes, S. A.—Misc. Essays on Ec. Ent. by State Ent. Ill. and Assts., pp. 127, 128. (*Pezotettix.*)
1891. Riley, C. V.—Bull. No. 25, U. S. Dept. Agr., Div. Ent., pp. 31, 32. (*Caloptenus.*)
1893. Bruner, L.—Bull. No. 28, U. S. Dept. Agr., Div. Ent., pp. 19–21.
1897. Scudder, S. H.—Revision of the Melanopli with Special Reference to N. Am. Forms. Proc. U. S. Nat. Mus., Vol. XX., pp. 363–368.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 206–208.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 481; 21st Rep. State Ent. Ill., p. 133.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 329–331.
Phillips, J. L.—Bull. No. 40, N. S., U. S. Dept. Agr., Div. Ent., p. 87. (*femoratus.*)

Melanoplus scudderi Uhl.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 184, 185.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 302–305.

Scudderia furcata Brunn.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 218, 219.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 348, 349.

Scudderia texensis Sauss.-Pict.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 216, 217. (*curvicauda.*)
1903. Smith, J. B.—Farmers' Bull. No. 178, U. S. Dept. Agr., pp. 26–29.
Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 344, 345.

Scudderia pistillata Brunn.

1892. Bruner, L.—Ann. Rep. Neb. State Bd. Agr., 1891, pp. 305, 306; also as separate.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 220, 221.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 347, 348.

Orchelimum vulgare Harr.

1885. Forbes, S. A.—Fourteenth Rep. State Ent. Ill., p. 23.
1890. Webster, F. M.—Insect Life, Vol. III., p. 160.
1892. Bruner, L.—Ann. Rep. Neb. State Bd. Agr., 1891, p. 305; also as separate.
1893. Wheeler, W. M.—Journ. Morph., Vol. VIII., p. 35.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 234, 235.
1900. Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., p. 483; 21st Rep. State Ent. Ill., p. 135.
1901. Morgan, H. A.—Bull. No. 30, N. S., U. S. Dept. Agr., Div. Ent., p. 30. (*agile.*)
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 383–385.

Orchelimum glaberrimum Burm.

1890. Webster, F. M.—Insect Life, Vol. III., p. 160.
1893. Riley, C. V., and Howard, L. O.—Insect Life, Vol. V., p. 204.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 385, 386.

Orchelimum silvaticum McNeill.

1891. McNeill, Jerome.—Psyche, Vol. VI., p. 26.

Xiphidium fasciatum DeG., p. 147.

Xiphidium brevipenne Scudd.

1894. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. VI., pp. 283, 284.
1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 239.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 373, 374.

Xiphidium nemorale Scudd.

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 374, 375.

Xiphidium strictum Scudd.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 242.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 378, 379.

Anabrus simplex Hald.

1880. Packard, A. S.—Sec. Ann. Rep. U. S. Ent. Comm., pp. 164–168.
1883. Bruner, L.—Third Ann. Rep. U. S. Ent. Comm., pp. 61–64.
1892. Bruner, L. Ann. Rep. Neb. State Bd. Agr., 1891, p. 305.
Bruner, L.—Bull. No. 27, U. S. Dept. Agr., Div. Ent., pp. 30, 31.
1893. Milliken, Robert.—Insect Life, Vol. VI., pp. 20–24.
1904. Marlatt, C. L.—Insect Life, Vol. VII., p. 275.
Doten, S. B.—Bull. No. 56, Nev. Agr. Exper. Sta. 10 pp.

Gryllus pennsylvanicus Burm.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 264, 265.
1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 437–439.

Nemobius fasciatus DeG.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 261, 262.

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 421–423.

Nemobius fasciatus vittatus Harr.

1870. Riley, C. V.—Am. Ent. and Bot., Vol. II., p. 373. (*vittatus.*)

Œcanthus niveus DeG.

1873. Riley, C. V.—Fifth Rep. Ins. Mo., pp. 120, 121.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 269–271.

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 446–450.

1904. Garman, H.—Bull. No. 116, Ky. Agr. Exper. Sta., pp. 64–67.

Œcanthus nigricornis Walk.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., pp. 271, 272. (*fasciatus.*)

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 450–452. (*fasciatus.*)

Œcanthus 4-punctatus Beut.

1894. Beutenmüller, Wm.—Bull. Am. Mus. Nat. Hist., Vol. VI., pp. 250, 251.

1900. Howard, L. O.—Farmers' Bull. No. 120, U. S. Dept. Agr., p. 25.

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 452, 453.

1904. Howard, L. O.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., p. 97.

Œcanthus latipennis Riley.

1873. Riley, C. V.—Fifth Ann. Rep. Ins. Mo., pp. 119, 120. (*Orocharis saltator.*)

1889. Murtfeldt, M. E.—Insect Life, Vol. II., pp. 130, 131.

1898. Lugger, Otto.—Third Ann. Rep. as Ent. of State Exper. Sta., Univ. Minn., p. 273.

1903. Blatchley, W. S.—Orthoptera of Indiana. Twenty-seventh Ann. Rep. Dept. Geol. and Nat. Res. Ind., pp. 445, 446.

Myriapoda.

Julus cœruleocinctus Wood.

1895. Lintner, J. A.—Tenth Rep. Ins. N. Y., in 48th Rep. N. Y. State Mus. pp. 445, 446; also as separate.

Parajulus venustus Wood.

1882. Thomas, Cyrus.—Eleventh Rep. State Ent. Ill., pp. 44. 45. (*Julus impressus.*)

Webster, F. M.—Prairie Farmer, Apr. 15, 1882, p. 114. (*Julus impressus.*)

1884. Forbes, S. A.—Thirteenth Rep. State Ent. Ill., p. 140. (*Iulus impressus.*)

1886. Webster, F. M.—Insects Affecting the Corn Crop. Rep. Ind. State Bd. Agr., 1885, p. 202; Separate, p. 23. (*Julus impressus.*)

1893. Bollman, C. H.—The Myriapoda of North America. Bull. No. 46, U. S. Nat. Mus., p. 144. (*Julus impressus.*)

1905. Webster, F. M.—Can. Ent., Vol. XXXVII., p. 172. (*Iulus impressus?*)

Parajulus diversifrons Wood.

1867. Wood, H. C.—Proc. Acad. Nat. Sci. Phila., 1867, p. 43. (*Iulus.*)

Acarina.

Tetranychus bimaculatus Harv.

1900. Banks, Nathan.—Bull. No. 8, Tech Ser., U. S. Dept. Agr., Div. Ent., pp. 73, 74.

Forbes, S. A.—Bull. No. 60, Ill. Agr. Exper. Sta., pp. 406, 407; 21st Rep. State Ent. Ill., pp. 58, 59.

1901. Chittenden, F. H.—Bull. No. 27, U. S. Dept. Agr., Div. Ent., pp. 35–42.

1903. Chittenden, F. H.—Bull. No. 43, U. S. Dept. Agr., Div. Ent., pp. 70, 71.

Tetranychus modestus Banks.

1900. Banks, Nathan.—Bull. No. 8, Tech. Ser., U. S. Dept. Agr., Div. Ent., p. 73.

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