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Beet Worms and their Remedies

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THE BEET WEB-WORM,

Loxostege sticticalis L.

CLARENCE P. GILLETTE.

The beet web-worm did more or less damage in all the beet growing sections of the state last summer and fall. In the vicinity of the Loveland and the Longmont factories very little harm was done but the beets grown for the sugar factories at Rocky Ford, Sugar City, Fort Collins, Windsor, Greeley and Eaton all suffered to a considerable extent in some of the fields.

This insect does not possess any great notoriety as yet as a crop pest. Twelve years ago * last summer it attracted some attention because of its injuries to sugar beets in Nebraska during the months of July and August, and because of its injuries to a field of mint in Michigan late in September. Since 1892 it has not attracted much attention.

For thirteen years at least the moth, which is the adult form of this insect, has been abundant in the vicinity of Fort Collins, where it has been one of the most common of the insects taken at electric lights. In 1897, when Mr. E. S. G. Titus was running a lantern trap for this department, he took this moth in large numbers. The record runs as follows: May 20th, 439 moths; May 22d, 2 moths; May 23d, 191 moths; May 25th, 7 moths; May 29th, 24 moths; May 31st, 31 moths; June 11th, 5 moths; June 16th, 6 moths; June 18th, 57 moths; June 20th, 76 moths; June 25th, 58 moths; Oct. 1st, 1 moth.

From my notes upon captures of this insect in 1897 I quote the following:

May 13, *Loxostege* moths have been very abundant for more than a week flying to the flowers of plum and other fruit trees.

The moths taken May 20 by Mr. Titus are about half males and half females. Dissections of the females show that the eggs are still immature in the great majority of cases.

June 8, The moths are becoming scarce. Some of those taken are full of eggs, while others have nearly finished laying.

June 10, Very few of the moths are coming to light now.

* See article by C. V. Riley in Report of the Department of Agriculture for 1892, p. 172, also article by Riley and Howard in "Insect Life" Vol. V, p. 320; an article in the same publication by L. O. Howard, Vol. VI, p. 369, and an article by Lawrence Bruner in Bulletin 30, U. S. Dep. of Agr., Div. of Entomology.

From my notes of 1896 I extract the following:

May 22. Took about 500 *Lorostege sticticalis* moths last night. Cloudy and warm.

May 24. Took about 200 moths of *L. sticticalis* last night. Examined 100 moths and found that 29 were males and 71 females. The females predominating so greatly indicates that the eggs have quite largely been deposited. Dissections show that the majority of those taken have their ovaries full of eggs; in some cases the eggs are still immature, and in others many or nearly all of the eggs have been deposited.

June 10. The moths are still numerous at light and females are still found containing immature eggs.

These records with others at this station indicate maxima of the broods about the 20th of May, June, July, and August. The records have not been continuous throughout a season, but are sufficient to strongly indicate a brood of moths and worms prior to the brood that attacks the beets in July though no one seems to have discovered the worms of this brood as yet.

HISTORY OF THE WORMS IN COLORADO.

The first complaint of injuries of any importance done by this insect in Colorado that came to my notice was on the 9th of July, 1903, when Mr. H. V. Norton, living a couple of miles northeast of Fort Collins, sent word that some kind of a worm had suddenly appeared in great numbers in one of his fields and was rapidly destroying his onions and cabbages. I visited Mr. Norton's place at once and found near the center of the infested lot a small patch, perhaps a half acre, of dry uncultivated ground above water, that was densely grown up to pigweed (*Chenopodium album*). The weeds appeared to have died and dried up, but upon examination I found that the leaves had been eaten away by the worms of the insect under consideration, and that some of the worms were still upon the plants, but the great proportion of them had migrated out in all directions into the patches of onions and cabbages which were close at hand. The worms were nearly full grown and after a few days disappeared.

Two days later, July 11, I was informed that a little striped worm had appeared in many of the beet fields northeast of Ft. Collins and was doing serious injury to the plants which were still rather small. In company with Mr. Charles Evans, manager of the Ft. Collins Beet Growers Association, I visited several farms where injuries were reported. In most cases the injury was not severe. Where the worms were most numerous, in nearly every case, the field was in alfalfa the previous summer, and considerable alfalfa had been allowed to grow among the beets up to about the time of our visit. Whether the alfalfa had any direct bearing upon the presence of the worms or not is, however, quite uncertain. The late brood of worms which did the chief harm the past season, were not heard from in 1903.

During the last week of June of the past year (1904) word came from Mr. P. K. Blinn, field agent of the Experiment Station, and Mr. W. K. Winterhalter, agriculturist of the American Beet Sugar Co. at Rocky Ford, stating that a worm was troubling the beets in the Arkansas Valley. Mr. S. A. Johnson of this department was sent to investigate the matter. Mr. Johnson did not find the injuries very severe except in small areas in a few fields, and several patches had already been sprayed with Paris green or arsenite of lime in water. Mr. Johnson concluded that the Paris green sprays had given best results, and especially where a second application had been made a few days after the first. A sample of the spraying outfits used, from a photo taken by Mr. Blinn, is shown at Plate II, Fig. 1. Plate II, Fig. 2, shows the work of the worms in one of the fields visited by Mr. Johnson at that time. The writer visited the same locality again Aug. 19th and was much assisted in his investigations by Mr. Winterhalter and Mr. Blinn. At this time the August brood of worms had about completed their work of destruction which exceeded that of the July brood.

The first complaint that came to the experiment station last summer was Aug. 13. On that date I went with Mr. C. M. Liggett to his ranch about 10 miles northeast of Ft. Collins and found the worms doing considerable damage. Occasional moths were still in the field. Mr. Fred Wright, agriculturist for the Ft. Collins factory, told me that the moths were abundant in Mr. Liggett's field ten days before. A week later many other fields were seriously attacked. The worms continued to increase and devastate other fields for fully two weeks, but they had nearly disappeared in Mr. Liggett's field on Aug. 22.

Mr. Timothy, agriculturist for the Greeley sugar factory, told me that he first noticed the worms at Sterling August 3, and at Greeley August 10. The worst of the injuries were over at Greeley August 20. Mr. Johnson was at Sterling August 18 and noted that the injuries were practically over there at that date. He also reported immense flocks of sparrows feeding upon the worms.

FOOD PLANTS.

I have noticed the worms feeding freely upon beets, cabbages, onions, pigweed (*Chenopodium album*), Russian thistle and alfalfa. They will probably feed upon many other plants in case of an emergency.

LOSSES.

Growers have estimated their losses all the way from one to five tons per acre as the result of the injuries by the worms.

Analyses by the chemists at the sugar factory indicate a loss of about 2 per cent. in both sugar content and in purity in beets that were defoliated badly during August. Probably more than 1000 acres of beets suffered substantial loss from the web-worm in Colorado last year.

LIFE AND HABITS OF THE INSECT.

The worms that were in the beet fields last August disappeared by burrowing into the ground to the depth of an inch or two and spinning about themselves white silken tubes from three-fourths of an inch to one and one-half inches in length, and three-sixteenths of an inch in diameter. A few of these worms changed to pupæ and emerged again as moths during September, but nearly all of them have spent the winter as worms in the silken tubes. Mr. G. P. Weldon, a special student in entomology, dug 69 of these tubes from one square foot of ground in a badly infested beet field on Aug. 31. On the same day he opened 111 tubes and found 13 pupæ and 97 worms. He also noted that the moths were quite numerous in the field, more so than a number of days previous. Moths which the writer placed over beets in cages Aug. 25 deposited eggs which began hatching Aug. 31. On September 20, I visited beet fields in the vicinity of Wellington (12 miles northeast of Fort Collins) in company with Mr. Fred Wright, Agriculturist of the Fort Collins Sugar Factory. The worms had disappeared but, although the day was cold, several of the moths were taken and many of the secondary parasites (*M. agilis*) over the beets, but there was no September brood of worms seen or heard from. Mr. Johnson took a few moths as late as Oct. 12.

Judging from the investigations by Riley and Howard, and Bruner in Nebraska and our own records at Ft. Collins, it is probable that the spring brood of moths will begin hatching about the 10th of May in the beet growing districts of the northern portion of the State, and probably about the first day of May in the Arkansas valley. We have found the moths very numerous at Fort Collins from the 10th to the 25th of May, and it is probable that they are depositing the first brood of eggs at about this time and somewhat earlier in the warmer sections as at Rocky Ford and Sugar City. At this time the beets are not up or are too small to attract the moths so that probably pigweed (*Chenopodium*) alfalfa and other plants that are more advanced serve as food for the early brood. About Sterling, Mr. Johnson noticed that the beets planted after the 25th of June escaped injury from the worms.

The second brood of moths, judging from our records, are most numerous at Ft. Collins, about the last week in June which should give a brood of worms about the 10th of July and this is the brood that did some injury to beets, onions and cabbages near

Ft. Collins in 1903 and about Rocky Ford and Sugar City during the first week of July, 1904. But it was the next, or third (?), brood that did most mischief in Colorado the past year. In the Northern portion of the State the worms were most destructive from the 10th to the 25th of August.

Most moths are on the wing only after dark, or in the twilight, but the moth that lays eggs to produce the beet web-worms is active in the day-time also and may be seen flying about the beets a week or ten days, at least, before the worms appear.

THE EGGS.

The eggs are sometimes deposited singly but usually in clusters or rows of from 2 or 3 to 8 or 10 together. They are oval in form, and about 1 millimeter long by .7 of a millimeter broad (one-twenty-fifth by one-thirty-sixth of an inch), and are quite flat below but strongly convex above. When clustered, the eggs are laid in a row, one overlapping upon another and making an angle of about 45 degrees with the surface of the leaf. In color they are a very pale green with a beautiful pearly reflection. They are deposited upon either the upper or lower surface of the leaves. In our breeding cages the greater number were deposited on the under surface. After once seeing them they are quite readily detected by the naked eye. They are shown once and a half natural size at *a* and *c*, Fig. 2, Plate I. At the end of about the second day there appears a small black speck upon the eggs as shown at *c*. This is the black head of the little worm that is developing within the shell. In about two or three days more the little worm eats a ragged exit hole in one end of the shell and escapes.

THE WORM.

The little worms are almost black at first and so small (one-sixteenth of an inch long) that they are easily overlooked. For the first two or three days the worms eat very little and skeletonize the leaves instead of eating entirely through them, but when they are about half grown and the white stripes begin to show plainly, they begin to eat and grow very rapidly so that the owner of the beets is often made to believe that the worms have migrated in the night from an adjoining crop or field. I have seen no general migrations of the worms except in a few instances where their food supply had given out or become very scanty. A peculiarity of the attacks of this insect in nearly every case that I have observed is that the chief injuries are well in the fields and almost never at the borders. We have also noticed the injuries to be worse in the higher and dryer portions of the fields but we have not found the injuries more common on light than on heavy soil. On individual plants, the young tender leaves at the center were always the last to be eaten.

REMEDIES.

If the worms are numerous enough to attract any attention at all late in the summer or in the fall, the beet ground should be plowed deeply and as soon as possible after the beets are gathered, for the purpose of burying the worms so that the moths will not be able to escape the following spring. If it is impossible to plow in the fall, then the surface of the ground should be thoroughly harrowed or disced for the purpose of crushing the worms and bringing the tubes to the surface where freezing and thawing and the attacks of birds may destroy a large proportion of the worms.

On Feb. 28, 1905, Mr. S. A. Johnson visited a beet field near Ft. Collins that was plowed last fall and collected 94 of the silken tubes on the surface and 76 beneath the surface. The 94 tubes from the surface contained 4 living and 4 dead worms and there were 86 tubes that were empty. The last all had openings in them, some at the end but most of them had been torn open along the side, probably by birds. Riley and Howard in "Insect Life," Vol. 5, P. 321, report Mr. Walter Maxwell, of Schuyler, Nebraska as stating that cocoons that were exposed by repeated harrowings were largely emptied by birds and he mentions particularly meadow larks and quails.

The 76 tubes that Mr. Johnson dug from beneath the surface contained 52 living worms, 13 dead worms and 11 were empty. If we suppose that moths or parasites were hatched from the 11 empty tubes last fall, we should have an indication that about 20 per cent of the worms were killed from mechanical injuries from fall plowing, and a considerable additional number were killed as the result of exposure upon the surface. Those that were deeply covered, it is believed will never find their way out.

If plowing was neglected in the fall, the next best thing will be to plow as soon as possible after the frost is out of the ground in the spring. After plowing the ground should be thoroughly pulverized and leveled so as to fill in with fine dirt between the clods and prevent the escape of the moths.

It is doubtful if anything farther can be done for this insect before the worms appear upon the beets except to keep the beet fields and surrounding territory as clean as possible of weeds that are attractive to the moths for the deposition of their eggs.

POISONING THE WORMS.

The worms accomplish their work of destruction so quickly that it is important that the beet grower should be prepared to check the injuries as soon as they are seen. In order to do this it will be necessary to be on the look out for the moths which will always appear in the beet fields from one to two weeks before the

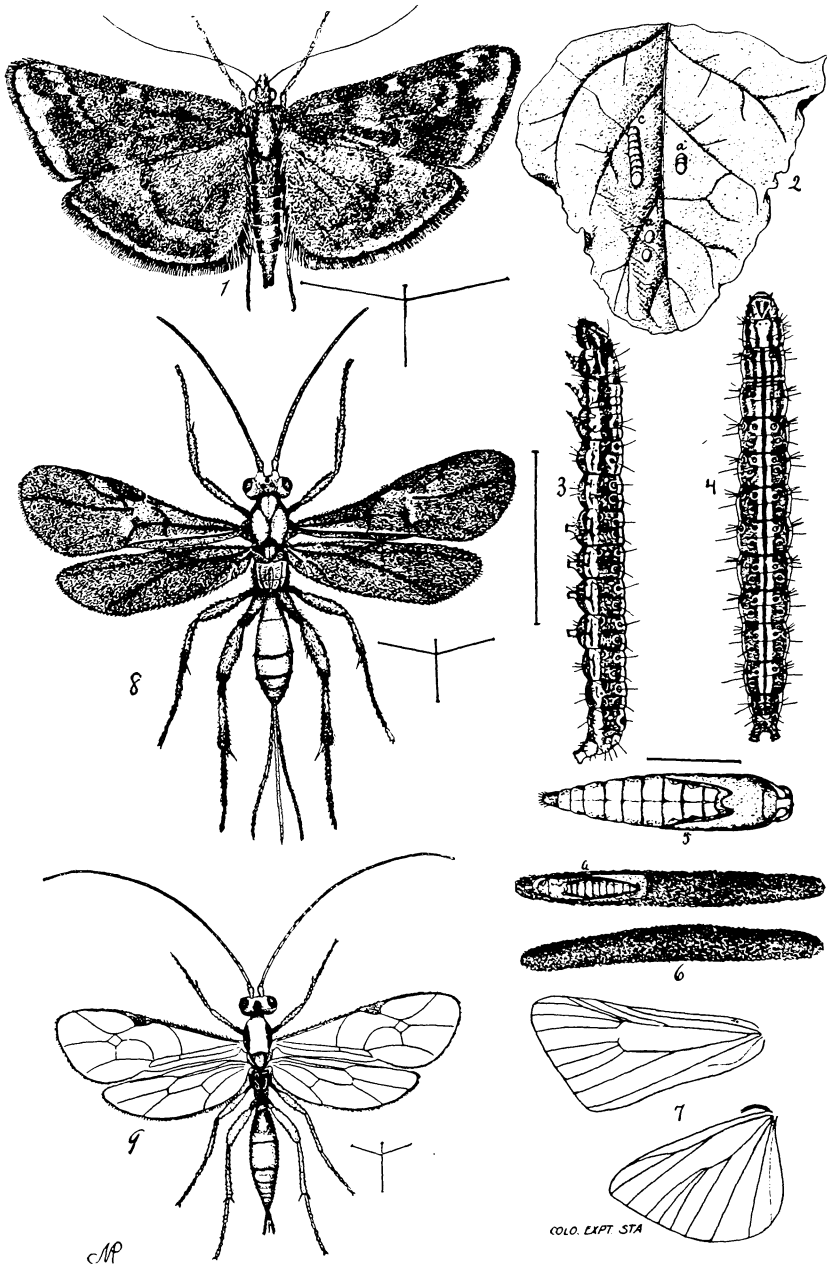
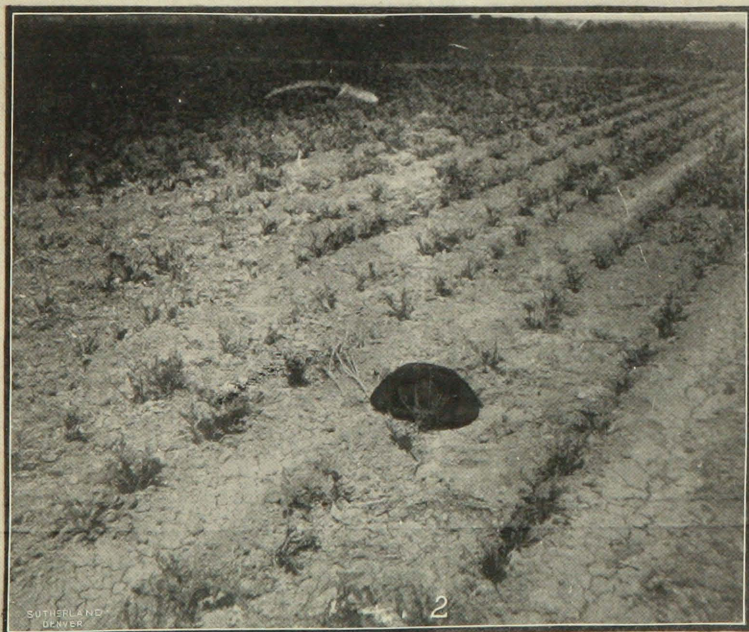
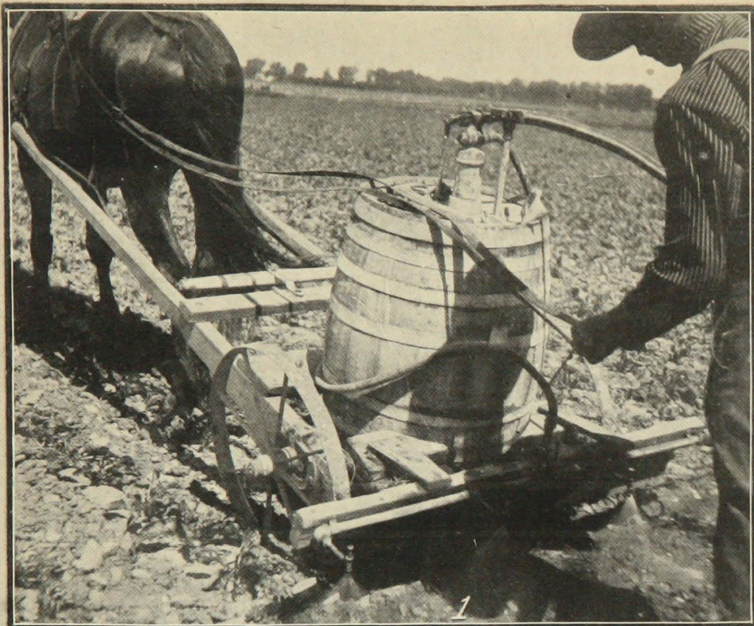


PLATE I.

THE BEET WEB-WORM AND PARASITES.

1. Moth of *Loxostege sticticalis*. 2. Eggs on leaf of beet. 3 and 4. Lateral and dorsal views of larvæ. 5. Pupa. 6. Larvæ tubes from earth. 7. Venation of wings of moth. 8. Parasite *Cremopsis vulgaris*. 9. Parasite *Mesochrus agilis* Cress.

Drawings by Miss Miriam A. Palmer.



SUTHERLAND
DENVER

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PLATE II.

Fig. 1.—Home-made apparatus for spraying four rows of beets at one time.

Fig. 2.—Beets eaten down by the beet web-worm at Rockyford, Colo., July 4, 1904.

worms will be noticed. These moths span about one inch from tip to tip of their wings when spread and are of a dark grayish or grayish-brown color. (See Plate I Fig. 1.)

They will fly up and go a short distance and then suddenly alight, usually upon a leaf of a plant. The presence of the moths in anything like large numbers among the beets should be the signal to prepare for war by procuring a quantity of poison and a spray pump or some other instrument for the distribution of the poison upon the beet leaves.

THE POISON TO USE.

Some combination of arsenic, as arsenite of lime, arsenate of lead, Paris green, or London purple should be used. The arsenite of lime is the cheapest of these but is a little more troublesome to prepare and apply. Arsenate of lead is more easily mixed and applied but is by far the most expensive poison to use. Paris green settles badly in the barrel or tank and must be kept thoroughly stirred. It would be cheaper than the arsenate of lead but dearer than the arsenite of lime. The chief objection to Paris green last year in Colorado was its serious adulteration with white arsenic causing it to burn foliage. Samples of this poison obtained at Greeley last year, where it was selling for 14 and 15 cents a pound, were badly adulterated which accounts for the low price at which it was sold. A sample of this Paris green was taken to the station chemist, Dr. W. P. Headden, for analysis to determine percentage of arsenic. The report of the analysis was as follows:

"Total Arsenic	-	-	-	60.69 per cent.
Soluble (free) Arsenic	-	-	-	8.51 per cent."

Such Paris green is unfit to use because of its tendency to burn foliage, and it will mix with difficulty with water.

These poisons may be applied dry by means of dust sprayers, or by shaking them through porous cloth sacks (as cheesecloth) carried in the hands, or they may be applied in water by means of force pump and spraying nozzles attached to a barrel or tank. Both of these methods have their strong advocates but after considerable investigation I am convinced thoroughly that the wet spray is much better where it can be used. The principle objection to it is the expense of getting pumps and barrels or tanks necessary to spray large fields. At Plate II, Fig. 1, is illustrated a barrel sprayer mounted on cast off cultivator wheels such as is used by the American Beet Sugar company and by Mr. P. K. Blinn of the Colorado Experiment Station at Rocky Ford. One man with this barrel pump will spray four rows of beets as fast as a horse will walk across the field. The dust sprayers are very inexpensive but all that I have seen used distribute the poison very unevenly over the plants. The dust sprayers have been used quite

extensively about Greeley and many who used them seem well pleased with the results obtained.

PREPARATION OF THE POISONS.

IN WATER.

Paris green or London purple.—Mix one pound of the poison in 50 gallons of water and make a thorough and even application.

Arsenate of lead.—Mix 5 or 6 pounds of the poison in 100 gallons of water and apply thoroughly.

Arsenite of lime.—Boil together white arsenic, lime and water for a full half hour in the following proportions:

White arsenic	1 pound
Lump lime	2 pounds
Water	3 gallons

Then dilute to 100 gallons with water and apply.

Or prepare as follows: Dissolve one pound of white arsenic and 4 pounds of sal-soda by boiling them together for 15 minutes in a gallon of water. Use two quarts of this stock solution to 50 gallons of water and before using stir into it 8 pounds of freshly slaked lime of best quality. Spray thoroughly as with the other poisons.

DRY APPLICATIONS.

About Greeley the past summer the growers used the Paris green dry without any dilution and they applied from 1½ to 3 pounds to the acre. Mr. Timothy, agricultural superintendent of the Greeley Sugar Company, said they had found the dry applications very satisfactory.

Whatever the application, it must be made promptly upon the first appearance of the worms, the poison must be evenly distributed, and the treatment must be thorough, to secure good results.

NATURAL ENEMIES.

Insect-eating birds devour the worms in large quantities. Where the worms were abundant last August the blackbirds were attracted in flocks of thousands and in several instances that came under our observation the worms were all cleaned out of fields by them in the course of two or three days.

Another check which nature has provided to keep this insect from becoming too numerous is a parasitic fly with dusky wings shown in Plate I, Fig. 8, and known to science as *Cremops vulgaris*.§ The large numbers of the worms last year was probably due more to the small numbers of this parasite than to anything

§ Determined for me by Mr. E. S. G. Titus.

else, and if the worms are to be kept down without our efforts, it will probably be chiefly through the attacks upon them by this parasite. Judging from the number of parasites raised in our breeding cages last fall, it would seem that not more than 10 per cent of the worms were destroyed by them last summer. The reason for the small numbers of this friendly parasite we can blame partly, if not entirely, to the presence of another yellow, clear-winged parasitic fly (*Mesochrus agilis* § *Cress.*) shown at Fig. 9, of Plate I, which preys upon the smoky winged parasite of the worms, and so is an enemy of the beet grower. In capturing these parasites over the beets last fall we took almost as many of the clear winged parasite as of the other. This, together with the fact that the worms have passed the winter in good condition makes it seem probable that the worms may appear in large numbers again the coming season but of this we cannot be certain. I would, at least, advise all beet growers in Colorado to be prepared to treat their beets on short notice with some arsenical poison in case the worms should appear.

SUMMARY.

The worms have passed the winter in good condition and the moths will doubtless appear in large numbers about the middle of May.

The May brood of moths will probably lay their eggs upon weeds and other plants and not trouble beets.

If the worms from the May brood of moths succeed in developing well, another large brood of moths may be expected about June 20, from which may be expected the first brood of worms upon the beets, about the first week in July.

Should the July brood of worms meet with no disaster, look for a second brood of worms upon the beets about the middle of August. This brood will probably be more extended than the others and may appear to consist of two or three broods close together.

The exact time of the appearance of the broods will vary in different portions of the state and with the earliness or lateness of the spring.

Be prepared with poison and spray pump so as to strike the blow in time to prevent serious injury to your beets if the worms should appear.

Where worms have appeared during late summer or fall, always plow the ground deeply before winter if possible and harrow the surface. Failing to do this, plow as soon as possible in the spring and work the surface as finely as possible with disk and harrow.

‡ Determined for me by Dr. L. O. Howard.

Adverse weather conditions or abundance of their enemies may prevent the occurrence, in destructive numbers, of any of the insects mentioned in this bulletin this year, but be on the look out for them.

Whenever insects are troubling your crops, write the Experiment Station for information and send specimens.

THE BEET ARMY-WORM.†

(*Caradrina exigua* Hub.)

This insect might easily be taken for the Beet Web-worm. The moth is a little larger than that species, spanning a trifle more than an inch from tip to tip of wings when spread. The fore wings are quite uniformly grayish brown in color with a pale spot about mid-way near the front margin, and the hind wings are almost pure white except for a narrow strip on the anterior margin which is darker. See Plate III Fig. 1. The worms are also a little larger when fully grown being about an inch and a quarter long. They are also plumper in form, greenish in color and without distinct white stripes, but often with quite distinct dark lateral stripes. See Plate III, Fig. 2.

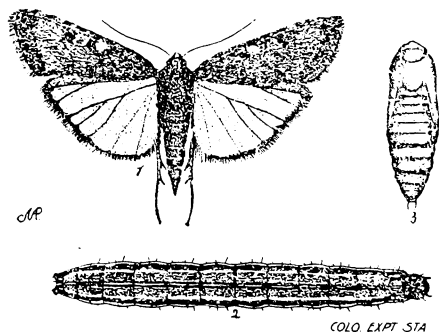


PLATE III.

THE BEET ARMY WORM (*Caradrina exigua*).

1. Adult moth.

2. The Army Worm, dorsal view.

3. Pupa.

The pupa, or chrysalis, is a good half inch long, mahogany brown in color and has two straight slender spines at the small end as shown in Plate III, Fig. 3.

So while these two insects are much alike in general appearance and in the damage they do, they are easily separated in any stage of their development. Their habits are also quite different as we shall see presently.

† This insect was treated in Press Bulletins 1 and 3; Report 12, p. 39; Report 13, p. 128; and Bull., 64; pp. 4 and 10, of this Station.

About the 10th of August, 1899, the worms of this insect seemed suddenly to appear in fields of sugar beets about Grand Junction. Many acres of beets had their tops all eaten away and then the worms turned their attention to the beets themselves eating them out below the crown. Mr. H. H. Griffin, then at Rocky Ford, reported this insect as doing some injury to experimental plats of sugar beets in that locality. Since 1900 this worm has been reported as doing some injury to beets in the Arkansas valley, but it has not been reported in injurious numbers since 1899 at Grand Junction.

LIFE HABITS OF THE INSECT.

The worms that were so numerous in the Grand Valley in 1899, burrowed into the ground to the depth of about an inch when they became full fed, formed an earthen cell about themselves, apparently without spinning any cocoon, and from these cells the moths appeared in great numbers during the latter part of August and September. The moths appeared so late that it seems probable that they hibernate during the winter in that stage, but of this I have no positive knowledge. I was shown injuries done to beets by this worm during June of the same season at Grand Junction, so there are two, and possibly three broods of this insect in a year.

In June 1900 Mr. E. D. Ball visited Rocky Ford where this insect was doing some injury and learned that the worms began hatching about June 1st, and that the moths were noticed in the fields two weeks prior to that date. He also noted that early planted beets suffered most and the application of Paris green had proven a satisfactory remedy*.

The following life history notes are extracted from breeding cage records kept by Mr. Ball upon the development of worms of all sizes taken by him at Las Animas, July 16, 1901, while an assistant in this department:

July 22, 1 chrysalis, (or pupa.)

July 24, another worm in earthen cell ready to pupate.

July 27, several worms have pupated in the last few days.

July 29, all have changed to pupæ.

Aug. 5, first moth emerged.

Aug. 6, another moth.

Aug. 7, another moth and a parasite from July 22, pupa.

Aug. 8 to 14, one to 4 moths each day.

Aug. 9, four moths that hatched today were put in a cage with sweetened water which they ate freely.

Aug. 14, 552 eggs have been laid upon under side of leaves and upon sides of cage. They are in groups of from 12 to 50 and each group is coated with a white downy secretion.

Aug. 15, some of the eggs are looking darker.

*See 13th Annual Report of Colo. Agri. Exp. Sta. p 128.

Aug. 16, half of the eggs are hatched and worms are feeding on leaves. Last night 38 more eggs were laid.

Aug. 17, nearly all of the 552 eggs are hatched.

Aug. 18, 14 more eggs laid last night.

Aug. 21, the eggs laid Aug. 16 have hatched.

Aug. 22, the eggs laid Aug. 18 have mostly hatched.

Aug. 22, 1 male moth dies.

Aug. 24, 100 fresh eggs laid.

Aug. 25, 1 female moth dies.

Aug. 29, another female moth dies. Total eggs laid by the two females, 704. Time from emergence to laying first eggs, 5 days; to laying last egg, 16 days. Time required for eggs to hatch, 4 to 5 days.

The writer was at Palisade, Colo., July 8, 1901, at which time the worms were found in all stages of growth upon beets. The small worms were usually found in groups of from 3 or 4 to 6 or 8 beneath slight webs which they spin for protection. These worms were most common upon the younger central leaves and were more common below than upon the upper surface. The webbing continues with this insect until the worms are nearly grown. In the early stages of the worms they skeletonize the leaves as in the case of the web-worms. Worms taken July 8th at Palisade began changing to pupæ July 14th.

REMEDIES.

When the beets have been gathered it is too late to destroy this insect by cultivation, but a thorough stirring of the surface soil immediately after the worms disappear would probably destroy many of the pupæ in the ground.

The worms may be destroyed by the use of poisons the same as in case of the preceding species.

CUTWORMS.

BY S. ARTHUR JOHNSON.

Each year farmers and gardeners suffer greater or less loss from the ravages of cutworms. This loss is commonly most severe in the spring or early summer when the crops are just appearing. Injuries occur in midsummer, as well, but they are commonly unnoticed because of the abundance of vegetation. By proper care these may be largely if not entirely prevented. Cutworms are quite generally distributed and in favorable seasons become so numerous that farmers are dismayed at the prospects of losing a crop.

LIFE HISTORY AND HABITS.

Injuries.—The most common and injurious species in this state is peculiar to the Rocky Mountain region, and is figured in the accompanying drawing. In times of great abundance it will travel in immense numbers in search of food, in consequence of which it has been called the "Army Cutworm." An outbreak of this kind occurred in Colorado in the spring of 1903 and is quite fully reported by Prof. Gillette in Bulletin 94 of this Station. During the previous season the moths were unusually abundant. They always fly at night and hide by day among the leaves of trees, in the grass, under boards, or other places of shelter. In the suburbs of Denver they fairly besieged the houses when the lamps were lighted. In a very few minutes after dusk the windows and screen doors would be covered with moths. They crept in by every crack and crevice much to the annoyance of the people who were at times forced to put out the lights and retire to escape the enemy. The insects were noticeably more abundant at houses near alfalfa fields.

Dates of Appearance.—The college records show that this and the closely allied species, *Chorizagrotis agrestis* and *C. introjercens*, appear in two broods, the dates of the spring captures at Fort Collins ranging from April 16th to July 27th, and those in the fall from September 3d to October 12th. These dates, how-

ever, represent only stragglers at either ends of the broods. The greatest abundance of the moths in the spring comes between the middle of May and the first of July and in the fall in the later half of September.

Eggs.—The eggs laid by the fall brood cause the troublesome worms in the spring. The eggs are laid almost exclusively upon vegetation, and, although the worms are very general feeders, they appear to show some preference for particular crops. They are always more or less abundant in fields of alfalfa. Where virgin soil is broken they may usually be found. A significant instance came to our notice two years ago. In a number of cases cutworms were quite destructive to sugar beets where these were planted in ground which bore a crop of barley the previous year.

When the egg is laid it is white in color, hemispherical in shape and attached to the leaves or grass by the flat side. Under the magnifying glass it shows beautiful striations which radiate from the center toward the edge of the disc. Before hatching, which occurs in a very few days, the eggs become brown in color.

Young Worms.—The young worms are very small and travel about for a short time with the looping motion of the measuring worms. They feed during the night and hide by day under some protecting object or in holes which they make in the ground.

Hibernation.—By the time cold weather begins the young are about half grown and range from a half inch to an inch in length. In color they are brownish or greyish with in many cases a distinct greenish tinge. At this time they are provided with three pairs of sharp pointed feet under the forepart of the body and four pairs of blunt prolegs under the posterior part. In this condition the worms spend the winter buried in the ground.

Spring Injuries.—With the warm spring days the worms come to the surface at the time the first blades of grass and leaves appear. Their appetite is now ravenous. Their growth during the fall has been rather slow, but now the size increases by leaps and bounds. At this time of year vegetation is scarce. Most of the green has been killed by the winter's cold, and the young, tender shoots, which give promise of harvest, furnish a most pleasing feast for the hungry worms. Then the seriousness of the pest becomes evident, especially if the field has been recently plowed and seeded or set with plants, in this way reducing the amount of food. In beet fields the worms cut off and devour the seedlings as soon as they appear above the ground, often following along the drill mark and taking everything in the row for several feet.

Full Grown Worms.—The worms are now between one and two inches in length, rather plump and sluggish, and have a habit of curling up when touched or suddenly exposed to the sunlight. The color is dull green or greenish brown. Two broad, irregular stripes extend down the back which are lighter in color than the rest of the body and more brownish. On the sides will also appear broad light colored lines. The number of pro-legs is now found to be five pairs. The easiest way to discover the presence of worms in the field is to examine under boards, clods and other objects, or dig in the earth near the base of plants. Often when a plant has been injured the culprit may be found by digging in the ground near it. They seldom bury themselves to a greater depth than two inches.

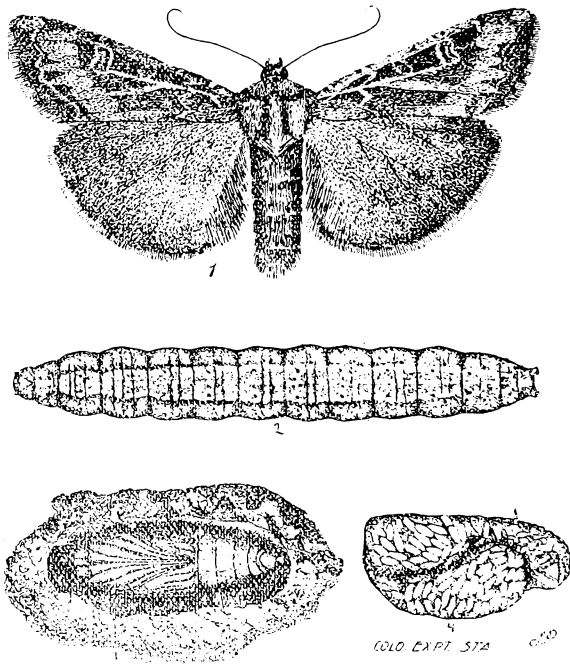


PLATE IV.

THE ARMY CUTWORM. (*Chorizagrotis auxillaris*.)

1. The adult moth. 2. Full-fed larva. 3. Pupa in case of hardened earth.
 4. Cutworm filled with chrysalids of tiny parasite.
- [We have reared as many as 2005 of these parasites from one cutworm.]
All twice natural size.

At Aurora, near Denver, in 1903 the larvæ were so abundant that they ate off entire fields of alfalfa. The early garden crops were almost entirely destroyed. The larvæ covered the sidewalks in such numbers that it was impossible to walk without

crushing them under the feet. They crawled in at the doors and became a household pest. Mr. Rauchfuss saved his garden by hunting the worms with a lantern at night. The field injuries were most noticeable in the cases of early sown barley, sugar beets and alfalfa of one year's standing. At Fort Morgan Prof. Gillette found that there were two distinct forms of attack. Where virgin soil had been broken, the larvæ were abundant in all parts of the field and the entire crop in some cases was taken, the young plants being eaten down to some distance below the surface of the ground. In other places where the ground was plowed the previous fall the field itself was not infested, but the worms migrated in from adjoining lands to a distance of several rods denuding the ground as they went. See Plate IV, Fig. 2.

Pupation.—When the larvæ have attained their full growth they make vertical burrows in the ground to the depth of about two inches and change to the chrysalis form with the head of the chrysalis pointed to the opening of the burrow. This change usually takes place in May or early June. Of course injuries cease when this transformation is accomplished. The chrysalis is dark brown and much shorter and more plump than the worm from which it came. See Plate IV, Fig. 3.

The Adult Moths.—The adult moths appear in about a month. They have a ground color of blackish brown. In the species whose life history we have just been over, the front wings are marked with lighter brown. The front and back edges are margined with this and patches occur between these lines. The back wings are lighter than the front and are dusky in color, darkest on the outer margins. The eggs are laid shortly after the moths appear and the summer brood of worms live and produce the fall brood of moths. See Plate IV, Fig. 1.

ENEMIES AND PARASITES.

The rate of increase in cutworms, as in most insects, is enormous, but this is offset commonly by the raids made upon them by their natural enemies. When the parasites fail to keep the insect down, things become serious for the farmer. The enemies may be divided into two classes; those which prey upon the worm, killing and eating it, and those which live within and upon the tissues of the worm, finally killing it.

Vertebrate Enemies.—To the first class belong chickens, birds, ground squirrels and pigs. Under the conditions existing in Colorado, probably the birds are the most useful. Quail, meadowlarks, bluebirds and bluejays are known to feed upon them. The flocks of blackbirds which constantly patrol the fields destroy immense numbers. When a field of alfalfa is flooded

the worms crawl out and are thus exposed, the blackbirds congregate and help to rid the farmer of his hungry foes.

Parasites.—The insects which live within the worms are many in kind and number. The maggots of several kinds of flies attack them. Wasp-like insects, both large and small, help in the good work. Two species of the larger kinds (*Ichneumon longulus* and *Amblyteles subrufus*) have been reared at the Station while the worms at Denver two years ago were very largely parasitized by a tiny insect belonging to the genus *Copidosoma*. Plate IV, Fig. 4. Counts were made from those reared from several worms and gave in individual cases from one to two thousand. So many of the worms were overcome by these agencies that there was no recurrence of the pest.

REMEDIES.

There are two methods by which injuries may be controlled. One is preventive and aims to forestall trouble, and the other tends to lessen losses after the injuries are noticed.

Preventive.—Early fall plowing will almost surely prevent the presence of worms in the field, for it leaves no vegetation on which the eggs may be laid. In the case of alfalfa, plow to the depth of three or four inches in September. This will not only prevent the pest, but will give the young foliage time to rot and furnish nourishment for the young beetles. After plowing, harrow or otherwise treat the field so that it will be kept bare until winter sets in.

Late fall plowing is almost equally beneficial for it turns the young worms under so deeply that they seldom come to the surface or else it exposes them in such a way that they fall an easy prey to the watchful birds or the inclement weather.

Clear away all rubbish from the borders of the field. Such collections furnish the best kind of shelter for the worms over winter, from which they may invade the growing crop.

If the field has not been plowed in the fall for any reason, it should be thoroughly examined for the presence of the pest in the spring. This may be done by examining under any object which may be laying on the ground. It would be well to lay bits of board or shingles in different places and look under them every few days for worms.

Alleviative.—If the worms are present in the fields in the spring, they may be almost surely checked by one of the following practices:

Spray heavily with Paris green or other arsenical mixture a growing patch of alfalfa or grass, mow it close to the ground and

spread over the plowed field in small handfuls at a distance of every few feet. The Paris green should be used at the rate of one pound to a hundred gallons of water and the grass distributed late in the day so that it will not wither before the worms attack it at night. Of course ground must be sprayed which will not soon be eaten over by stock. If desirable the poison may be mixed in a barrel of water and the green material dipped into it and then distributed over the ground. The water must be constantly stirred to keep the poison in suspension.

If fresh vegetation is not available arsenic bran mash may be used. This is made by the method used for grasshoppers. The U. S. Department of Agriculture gives the following directions for preparing this insecticide: "Paris green, arsenoid, white arsenic, or in fact any arsenical can be used for poisoning this bait, and in its preparation, on account of the weight of the poison and the fact that it soon sinks to the bottom of the water when stirred, it is best to mix the bran with water and sugar and then add the poison. The proportions are two or three ounces of sugar or a similar quantity of glucose or molasses to a gallon of water and a sufficient amount of bran (about a pound per gallon) to make, when stirred, a mixture that will readily run through the fingers." About one pound of poison should be used for every fifty pounds of bran. Often syrup may be had at the sugar factories at a very much cheaper rate than the cost of the other sweetening materials. Scatter this preparation over the fields late in the day, preferably when the ground is bare, either before the seed is planted or before it comes up. Dr. John B. Smith is authority for the statement that a field may be cleared in forty-eight hours by this means. If the beets have already begun to come up the bait should be placed in little heaps of a tablespoonful each along the rows.

A dry mash composed of Paris green 1 lb., equal parts of bran and middlings 20 lbs. is recommended by Dr. Forbes.

Either of the bran preparations are dangerous to fowls and these should be kept off the fields for several days.