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METHODS OF COMBATTING FOUR FIELD CROP PESTS IN COLORADO

(Beet Webworm, Alfalfa Webworm, Army Cutworm, Pale Western Cutworm)

By CHAS. R. JONES, JOHN HOERNER and C. L. CORKINS

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METHODS OF COMBATTING FOUR FIELD CROP PESTS IN COLORADO

By CHAS. R. JONES, JOHN HOERNER, and C. L. CORKINS

The present bulletin is issued to supply the constant call for information in regard to some of the common insect pests and the remedies that are commonly used for their control. No attempt has been made to include all of the insect pests injurious to crops, but simply four of the most important worms and to give the method of preparing and applying the remedies used in their control. There are many other insects equally troublesome that might be mentioned had we the time and space to do so, and to those who are troubled with other pests, we wish to state that the Department of Entomology will be glad to receive inquiries concerning them. Specimens of the insects in question should, whenever possible, be sent with samples of its injury as this information materially helps in suggesting control measures and determining the pest. This should be done as soon as the insect makes its appearance and not after the damage has been accomplished.

The importance of promptness in the treatment of any insect pest cannot be too strongly urged. The effectiveness of the remedy becomes useless if deferred too long as the damage will have been already accomplished and the application of the remedial measure of no avail.

In many cases, it happens that fatal damage to the plant in question has been accomplished or the insect has passed the favorable stage of control before this office is asked for assistance. By careful inspection of plants or crops from time to time during the early part of the season, the infestation or injury can be detected at the outset and treatment is then comparatively easy and more satisfactory results will be obtained.

It is particularly true that an outbreak of grasshoppers is seldom reported while the hoppers are small, and when the remedial measures would be most effective. After the 'hoppers' wings develop, which is about six weeks to two months after they hatch, they fly upon the least provocation, are very conspicuous and the damage they do is very noticeable. Their control at this time is more difficult and more poison is required than when they are small.

Then again, outbreaks of the melon louse, which attacks melons and cucumbers thruout our state, are often not noticed until the infestation is at its zenith and the plants begin to wilt and die. At this time it is useless to apply any remedy. The damage is done and the plants are gone.

It often happens that people applying remedial measures for any insect pest fail to get results. This is generally due to a lack of thoroughness or a failure to follow directions. It is advisable to follow the instructions given in books or bulletins by experienced persons relative to mixing and applying insecticides, in order that the maximum results may be obtained.

It is also advisable to send to the Experiment Station samples of the pest in question, with a short account of the extent and nature of the damage.

Insects are in a general way divided into three classes relative to control measures and there are classes of insecticides for each. Insects that devour the plant tissues outright can usually be killed by a stomach poison such as Paris green, arsenate of lead, arsenite of zinc, etc. Those that suck the juices from the plant must be controlled by a contact spray, such as kerosene emulsion, tobacco decoctions, miscible oils, etc., while the secluded or hidden class, such as bedbugs, grain weevils, clothes moths, etc., must usually be controlled with a fumigant. To say "A bug is killing my squash vines. What is a good remedy?" is therefore insufficient, because the pest may belong to any one of the above classes and if the proper treatment was not applied, the results would be negative.

THE BEET WEBWORM

(*Loxostege sticticalis* Linn)

By CHAS. R. JONES, Colorado Experiment Station

HISTORY AND DISTRIBUTION

The beet webworm is one of the most destructive pests of sugar beets and undoubtedly causes a greater loss to the sugar industry than any other pest that we have to cope with in Colorado. The exact history of this pest is not definitely known, but it was probably introduced into this country, as is the case with a great many of our most destructive insect pests. According to Chittenden (1), it first made its appearance on the Pacific Coast and in 1869 was recorded in Utah. In 1873 it was reported from Missouri and in 1893 from Michigan. It first occurred in Colorado in 1891 (6) and was a serious pest in 1903 (3). Records (1) show that it has been taken from New Mexico up to an altitude of 11,000 feet, consequently it has a wide range and can sustain life in several zones. Its present distribution in this country is quite broad, especially in the beet growing sections. In fact it occurs in every state where beets are grown and also in the island possessions of the United States and in Europe.

The dissemination of the beet webworm is generally by flying, but it may also be spread long distances by mechanical carriers with sugar beets or other products. The period of greatest activity of the moths usually occurs during the period of egg laying.

FOOD PLANTS AND ECONOMIC IMPORTANCE

The main food plant of the beet webworm is the sugar beet. However, it will feed upon several other plants such as garden beets, cabbage, onions, pigweed, Russian thistle, alfalfa, weeds, etc. Sugar beets have been produced commercially for several years in Colorado and the first serious outbreaks of this webworm in Colorado were in the Arkansas Valley in 1909, 1910 and 1911, although this pest has been known to exist here since 1891.

The injury done by the worms often kills the young beets. The older ones also die when the crown is destroyed. Simple defoliation, which most times occurs, retards the growth of the beets and decreases the yield and also the sugar content. Complete defoliation of the plants exposes the beets to the direct rays of the sun and consequently a rapid evaporation of moisture content. In 1910 when the severe outbreak occurred in the Arkansas Valley, practically 4,000 acres were infested, causing a loss of 20,000 tons of beets with an estimated loss (4) of approximately $100,000.00.

Every year more or less damage is done by this pest. Probably the greatest injury in Colorado occurred in 1918 when the sugar beets were quite generally attacked and severely damaged, two broods appearing in sufficient numbers to be very detrimental. According to A. C. Maxson, of the Great Western Sugar Company, 31,000 acres were damaged, 5,500 by the first brood and 25,500 by the second brood. Over 7,000 acres were damaged to the extent of two tons per acre; and 7,000 acres to the extent of one ton per acre, while 15,000 acres suffered about ¼ ton per acre, making a total loss to the growers of 26,450 tons of beets worth $264,500.00. Out of the infested area, 16,000 acres were sprayed at the rate of four pounds of Paris green per acre, and using, in all, 64,000 pounds.

LIFE HISTORY AND HABITS

The adult is a moth (Plate I, Fig. 1) of a tawny-brown color with a wing expanse of about one inch and is closely allied and sometimes mistaken for the alfalfa webworm.

The miller of the beet webworm may generally be distinguished from that of the alfalfa webworm by the markings or light spots on the front wings. The light band running across the tip of the wing that runs from the front backward, is narrow, less than one-sixteenth of an inch, and nearly the same width throughout, while in the alfalfa webworm it is usually broader at the hinge margin of the wing and tapers toward the front margin.

In the beet webworm there is one distinct rectangular light spot a short distance from the front margin of the wing and about midway between its base and apex, while in the alfalfa webworm the front margin of the wing has three or four indistinct spots which blend more or less with the general ground color. In cases where the distinct spot corresponding to that of the beet webworm appears, it is rectangular and penetrated with a dark line.

These two insects are closely allied. They belong to the same genus and their life histories are quite similar. They both spend the winter in the larval or pupal stage in a silken tube in the ground and emerge as adult moths in May, the alfalfa webworm moths being about two weeks earlier than the other species. The entire life history from egg to adult moth requires a little over one month.

THE EGG

The eggs are pearly-white in color and are deposited in groups or rows, one partly overlapping the other (Plate I, Fig. 2) and usually on the underside of a leaf. They are oval in form and about one mm. long. Two days after being deposited, the head of the young larva is discernible within the shell as a small dark spot. The period of incubation is from five to seven days, when the little worm eats a ragged hole in one end of the egg and escapes. Each female is capable of depositing, at least, two hundred eggs and Marsh (7) gives from one hundred fifty-two to five hundred or an

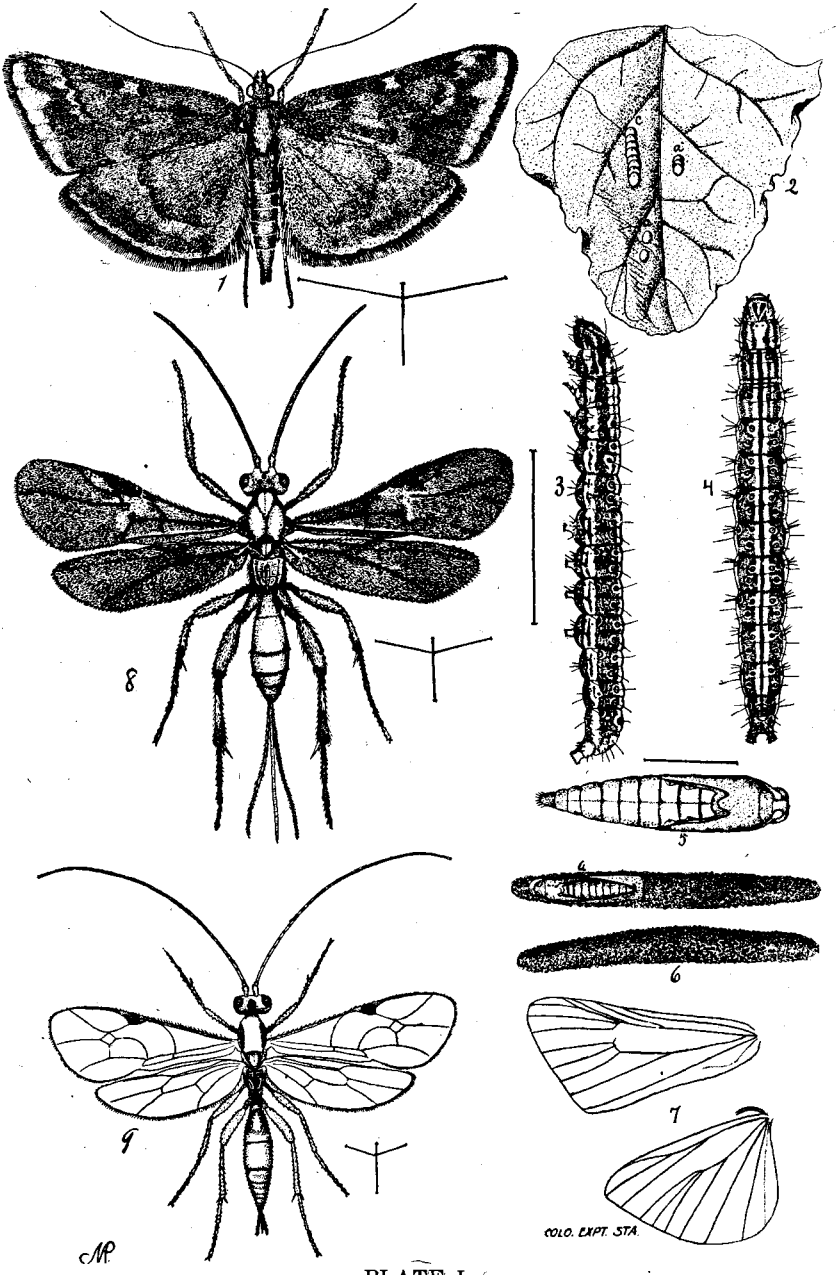

PLATE I.

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 larvae. 5. Pupa. 6. Larvae tubes from earth. 7. Venation of wings of moth. 8. Parasite *Cremops vulgaris*. 9. Parasite *Mesochrus agilis Cress*.—Drawings by Miss Miriam A. Palmer.

average of three hundred and fifty, the egg laying extending over fifteen days. In severe outbreaks, from fifty to three hundred eggs have been deposited upon a single beet.

THE WORMS

When first hatched, the worms are whitish in color with a black head. Upon feeding, they become greenish with dark side markings. Mature worms reach the length of about one inch or a little more (Plate I, Fig. 3 and 4). They remain upon the beets until maturity, unless all the leaves are destroyed, when they are forced to migrate to other food plants. The damage of newly hatched larvae is rather unnoticed as they feed upon the under surface of the leaves and their ability for doing damage is limited. As they increase in size, their capacity also increases and, in a very short time, entire fields may be defoliated. Upon reaching maturity, the worms enter the ground, form a pupa case of silk (Plate I, Fig. 6) and transform to pupae (Plate I, Fig. 5) and two or three weeks later emerge as adult moths. The moths feed upon the nectar of flowers and lay eggs for another brood and the whole life history is repeated.

There are two full generations of the beet webworm in Colorado, and a partial third. Marsh (4) states that there may be a possible fourth. However, if so, this generation is not clearly defined and possibly occurs early in the season, the worms feeding upon weeds such as Russian thistle and lambsquarter. The periods of occurrence of the worms are: For the first generation from about the first of June to the middle of July, and for the second, from July 15th thru August, and the third appear in September. The average time under favorable conditions from the deposition of the egss until the moths emerge is a little more than a month and may be summed up as follows (7):

Egg stage varies from five to seven days.

Larval stage from seventeen to twenty days.

Pupae about eleven days.

Of course the time depends upon the climatic conditions.

The period of greatest damage to the beets is from June to September. The first generation often causes the most damage because the beets are very small and unable to resist the attack. At this period the beets may be actually killed as the worms are likely to eat into the crown. By the time this pest reaches the second generation, the beets have grown to a large size but still they may be completely defoliated. As a rule, the first and second generations are most destructive. The third rarely causes serious damage. It is very rare that two successive generations will infest the same field. New and undefoliated fields are generally sought. Marsh (4) attributes this to the drifting of the moths.

The worms of the first generation, after maturing, burrow into the ground and pupate and within a short time the adult moth emerges and lays eggs for the second generation. The larvae of this brood (Marsh 5) do not all pupate and emerge. Those that emerge furnish a supply for the third generation and these larvae all remain in the soil in the worm stage, not pupating until the following spring. This makes the three generations somewhat overlap.

METHODS OF CONTROL

There are many natural enemies of the beet webworm and of these the birds play a very important part. Blackbirds are among the foremost of the bird enemies. There are also insect enemies or parasites. The most common are wasp-like parasites known as *Cremops vulgaris* and *Mesochrus agilis* Cress. (Plate I, Fig. 8 and 9.)

As the beet webworm pupates in the ground and the larvae pass the winter there, many of them are destroyed by digging the beets. This exposes the pest to the weather conditions, birds, etc., and is a help in their control. Deep plowing or harrowing after the beets are dug will prove quite effective. If this is not feasible, land for beets should be plowed deeply or given several harrowings early in the spring.

Clean cultivation is an important factor, as the worms will feed on several weeds and especially on Russian thistle and lambsquarter. These should not be allowed to grow around fence rows or in the fields as the moths will lay their first eggs on them and, when the worms have consumed these plants, they will migrate to the beets and may cause serious damage.

Arsenical poisons are very effective in beet webworm control. Paris green has proven to be the most effective and satisfactory remedy as its action is quick and the beets are very resistant to its burning qualities. Arsenate of lead may be used in lieu of Paris green, but its action is slower, so it must be applied in larger amounts at a stronger rate.

Success in the control depends largely upon applying the poison at the proper period, and that is when the worms are but a few days old. It will then require less poison to kill them and they will not have an opportunity to do serious damage to the crop.

There are several formulas given for the use of Paris green, but only one need be mentioned here, that is the one used by The Great Western Sugar Company and is 4 pounds of the poison to 50 gallons of water, applied so as to cover one acre. A pressure of about 80 pounds is also important. The spraying apparatus generally used by this company is the Iron Age traction spraying machine, with eight nozzles so arranged that each nozzle covers a row of beets. In applying any given amount of spray to an acre, the machine must first be tested so that the required amount is spread to the given

area. This is easily accomplished by filling the tank with water and spraying all of it on an area of known dimension and then dividing this area by the number of square feet in an acre to obtain the part of an acre sprayed. From this data one may determine how much poison to add to each tank of water to apply 4 pounds to an acre.

If Paris green cannot be obtained, arsenate of lead or arsenite of zinc may be used, at about twice the strength of the Paris green. Arsenate of lead comes in two forms, dry powder and paste. The latter contains about 50 per cent water. If the powder is used, it must be applied at the rate of eight pounds to an acre and the latter at the rate of sixteen pounds.

Home-made sprayers may be made by mounting a hand sprayer in a barrel on wheels. If this is used, some mechanical device for agitating the solution must be provided to prevent the poison from settling to the bottom of the barrel. If this type is used, one should not try to cover more than four rows of beets at one time. In spraying small beets, the nozzles should be placed directly over the row.

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THE ALFALFA WEBWORM

(*Loxostege commixtalis* Walker)

By JOHN HOERNER, Colorado Experiment Station

The alfalfa webworm* has been known to Colorado for several years. In 1914, it appeared in the northern part of this state in large numbers, doing considerable damage to the first cutting of alfalfa and threatened to damage the sugar beet crop.** During the summer of 1920, it appeared in numbers sufficiently large to be of economic importance, extending over Northern Colorado in the alfalfa and sugar beet sections, occurring as far south as Canon City and Pueblo, and was reported from the Arkansas Valley by Mr. W. F. Droge.

Most of the young beets in the northern part of the state where it appeared were sprayed, lessening the injury that might have occurred. Some fields not so treated were totally destroyed.

LIFE HISTORY

Adult: The moths appear very early in the spring, having been observed in the field as early as the third of April. This time varies, depending upon the climatic conditions. The first brood moths continue to appear until the latter part of June, being most numerous during the first half of May. They are seldom seen during the day except when disturbed, then they fly short distances and suddenly alight on the underside of a leaf or on the ground, folding the wings in a triangular form over the back. As their color harmonizes very closely with the ground and alfalfa stubble, they are very difficult to see when at rest. On warm nights they often collect in large numbers around electric lights.

This moth is rather small, having a wing expanse of 1 to 1¼ inches and is of a buff color, with gradations of light and dark shades of gray. The old moths are dull gray in color due to the absence of wing scales.

This insect is closely allied to the sugar-beet webworm and resembles it in general appearance, but can be distinguished by the markings of light spots on the front wing.

In the alfalfa webworm moth the front wing has three or four indistinct spots which blend more or less with the ground color and a distinct interrupted rectangular light spot a short distance from the front margin of the wing, about midway between its base and apex. In the sugar beet webworm, the latter spot is distinctly

*This is a local name and not to be confused with *L. similaris* Guen, also calleed alfalfa webworm in Bul. 109, Okla. Exp. Sta., Feb., 1916.

**A. C. Maxson, "Injurious Insect Enemies of the Sugar Beet," p. 84, 1919.

rectangular and uninterrupted. Both species fly very similarly and can very seldom be told apart when on the wing.

Eggs: A few days after the adult moths appear, they mate, and the females soon begin to lay eggs, and continuing for about two weeks.

The eggs are about half the size of a small pinhead, oval, somewhat flattened on the under surface, and strongly convex on the upper surface. When first laid, they are pearly-white in color, turning yellow as the worm develops within. A black spot appears a day or two before hatching. This is the head of the small worm which is developing inside. Very few of the eggs are laid singly. They are almost always deposited in groups of two to twenty, overlapping each other, and usually placed on the under surface of a leaf, seldom on the upper surface. The average number laid per female is about two hundred. When fully developed, which takes from four to six days in warm weather, the small larvae eats a ragged hole in the egg shell and crawls out, leaving the semi-transparent shell.

It is difficult, if possible at all, to distinguish the single eggs from those of the beet webworms. In groups, however, a distainction can usually be made, as the latter place their eggs in single rows, over-lapping, end to end, while the former deposit theirs in over-lapping masses, and not in single rows.

Larvae or Worms: When first hatched, the worms are about one-sixteenth of an inch in length, pale yellow or greenish yellow in color, changing somewhat darker as they increase in size. The first feeding is on the underside of the leaf to which the young worms attach themselves with a flimsy web. This web, on small plants, usually leads in tubular form to a place of concealment, sometimes several inches from the base of the plant and under a clod of earth. When disturbed, they retreat rapidly down this tubular web, or, if on the ground and disturbed, they rapidly crawl back to the plant, traveling as well backward as forward.

Small worms skeletonize the leaves. As they increase in size, they eat the entire plant down to the midribs and stems. On large plants the web is generally attached so that it draws the leaves together and within this area the worms feed until all the green tissue is devoured, when they web a new area and proceed as before. The amount of food they consume the last four or five days before they enter the ground to change to moths again is surprisingly large.

It takes five or six weeks* for the worms to become full grown, at whihch time they are about 1 to 1¼ inches long and a little thicker than a common match. They vary in color from greenish yellow to almost black on the dorsal half with a broad light stripe

*Insectary Conditions.

extending down the back, while the under side is almost free from stripes or markings. Laterally on each segment are three dark spots, each containing one to three bristle-like hairs.

Pupa: When ready to pupate, the worms enter the ground one half to one and a half inches and construct earthen cells, which are loosely lined with silk. In a few days they shed their skin and change from worms to pupae, resembling nothing of their former worm-like appearance, or the adult moths that they turn into later. They are light yellow to dark brown in color, depending upon their age, about one-half inch long and one-eighth inch in diameter. The anterior end is rounded and the posterior comes to a point, bearing eight small spoon-shaped appendages. This character makes it easy to distinguish the alfalfa webworm pupae from the sugar beet webworm pupae, which have eight bristle-like appendages on the posterior end. The pupa stage takes from two to three weeks, and then the adult moth emerges, and soon after copulation lays eggs for the next generation. In 1920, three broods were reared in the insectary of the Colorado Experiment Station. This is probably the usual number for Northern Colorado. The broods overlap and different sized worms and adult moths can be found in the field at the same time. This insect passes the winter as a larva or pupa in its silk-lined cell beneath the surface of the ground.

FOOD PLANTS

The larvae or worms of this insect feed on a large number of plants. The cultivated plants on which most injury occurred are the sugar beets and alfalfa. If short of food, the larvae will migrate like the army worm, going in large numbers in search of food. In several instances the alfalfa was cut on which large numbers of worms were feeding, and they migrated to adjacent fields and were noted feeding on cabbage, beans, corn, young cherry trees, etc. The larvae are general feeders and will eat almost any succulent growth if necessary.

The following is a list of the food-plants on which worms were found feeding:

Cultivated

1. Sugar beets
2. Alfalfa
3. Cabbage
4. Beans
5. Corn
6. Sunflower
7. Cherry trees
8. Peas
9. Strawberries

Uncultivated

1. Sunflower
2. Lamb's quarter
3. Russian thistle
4. Pig-weed
5. Wild morning glory
6. Resin weed
7. Erect door weed
8. Wild parsnip
9. Lady's Thumb
10. Malva (Cheeses)
11. Old witch grass
12. Ragweed
13. Wild cucumber
14. Salt bush
15. Ragged robin
16. Wild carrots
17. Thistle
18. Red root
19. Sweet clover

CONTROL ON SUGAR BEETS

This pest has been successfully controlled on sugar beets by The Great Western Sugar Company by spraying with Paris green, four pounds per fifty gallons of water, and the sprayer set so that fifty gallons covers one acre. The sprayer commonly used is the tractor "Iron Age" machine with one nozzle for each row, with a total of eight nozzles. These machines have a good mechanical agitation and maintain a pressure of about seventy-five to eighty pounds. The height of the nozzle above the beets should be about one foot.

Home-made sprayers for small patches can be made by mounting a hand spray pump on a barrel, and this placed on wheels. When this is done, some means of mechanical agitation should be provided, as a pipe transferring some of the pressure to the bottom of the tank cannot be depended upon to keep the material stirred, and soon clogs up. Paris green is a heavy powder and settles to the bottom of the tank if not *constantly* stirred.

The spray machine used should maintain sufficient pressure to apply the spray in a fine mist or fog, as coarse spray collects in drops and runs off.

Sugar beets are not easily burned by arsenical sprays, consequently they may be used without danger to the foliage. Paris green is a quick acting poison and should be used in preference to arsenate of lead or arsenite of zinc. When it cannot be obtained, arsenate of lead or arsenite of zinc can be used, but more poison is necessary and should be used at double the strength of Paris green, or eight pounds of the powdered form to fifty gallons of water. Apply in the same manner as described above.

As high as six to eight pounds of Paris green to fifty gallons of water have been used per acre on sugar beets with good results and very little burning of the leaves, but four pounds to fifty gallons for the same area will give just as good results when properly applied, and the expense for material is much less.

The best time for applying the spray is when the worms are small. At this stage they are hard to see and easily overlooked. The first indication that this pest is in the field will be the moths that fly up when walking thru the field. After this, the undersides of the leaves should be examined daily for eggs and young worms. Picking leaves at random in the field and examining them is the best way. When the eggs are observed in considerable numbers, all the material for spraying should be prepared and the field sprayed when the eggs are found to be hatching. If spraying is delayed until the worms have the plants webbed over, results will not be as rapid as when sprayed sooner, due to the web tending, to a certain extent, to keep the poison from the leaves, and one must not expect results until the worms web a new area.

CONTROL ON ALFALFA

Alfalfa that is heavily infested with worms, should be cut and harvested early as it will decrease in quality on standing. After the hay has been removed, the stubble should be sprayed with arsenate of lead, four pounds, or Paris green at the rate of two pounds, to fifty gallons of water. This can be done without danger of poisoning stock to which the hay will be fed later.

In young alfalfa fields, when irrigating water is available, the best method of procedure for combating this pest, is to apply water in order to force the growth of the plants to exceed the injury of the worms.

Renovating alfalfa fields is beneficial in controlling this pest as well as being beneficial to the alfalfa. If the fields are treated before cold weather sets in, the exposure to the freezing and thawing will destroy practically all of the insects passing the winter therein.

The moths are night flyers and are attracted to lights in large numbers, fifteen hundred being caught in one night with a Gillette trap, using a 60-watt electric light. A strong light placed over a pan of water with a little kerosene on top would serve as well. It is doubtful if this method has much practical value except to show when the moths are numerous.

NATURAL ENEMIES

Very few natural enemies of this insect are known. A medium sized ground bettle *(Pterostichus scitulus* Lec.) was found feeding on the larvae. Maxson mentions an undescribed Tachina fly as a parasite. An Ichnumon fly has also been bred from pupae, but as yet is undetermined.

One ring-necked pheasant, containing some three hundred larvae was taken near Ft. Collins by W. L. Burnett, while determining the food habits of that bird. Other birds and poultry feed on the worms as they have opportunity.

THE ARMY CUTWORM

By C. L. CORKINS, Deputy State Entomologist

HISTORY AND DISTRIBUTION

The Army Cutworm *(Chorizagrotis auxiliaris* Grote) has been one of the leading insect pests of field and garden crops in the Rocky Mountain States. In Colorado, at the present time, it ranks first among the economically important species of cutworms. It is undoubtedly a native here.

Altho this species does some damage in restricted areas from year to year, no widespread outbreak was recorded in the state until 1903. At that time a large section of Northern Colorado was badly infested and considerable damage done. It was found epidemic at the following places: Fort Collins, Fort Morgan and Aurora (1).

Our records show definitely that this cutworm occurs at Fort Collins, Estes Park, Fort Morgan, Aurora, Denver, Canon City and Steamboat Springs. It is, without doubt, distributed over most all sections of the state. Gillette (1) states that he has found the moths not uncommon near timber line under the loose bark of stumps.

LIFE HISTORY

The Eggs: The eggs are about one-half the size of a pin head and are nearly round. They are white in color when laid, but darken with the development of the larvae.

Egg-laying occurs in the fall, during the latter part of September and early October. Our latest record of moths captured is October 12th, though it is altogether probable that some egg-laying occurs later. Cooley (2) says that it may be safely stated that the egg-laying period is two weeks or more in duration. As many as one thousand eggs have been found in one female. This is doubtless more than the average number laid.

Data taken by Cooley (2) in Montana and Strickland (4) in Canada shows that the eggs are deposited directly upon the soil, one to three in a spot. They may be dusted over or laid slightly under the surface of the soil, thus being effectively obscured. These eggs hatch in about two weeks.

The Larvae: The larvae or worms are very tiny when hatched and have a light cream colored body with a shiny, dark head. These feed during the night and hide during the day either in the ground or under rubbish. With snow and cold weather, feeding ceases and the worms go into hibernation buried in the ground. They are now from one-half to one inch in length and are brownish or greyish

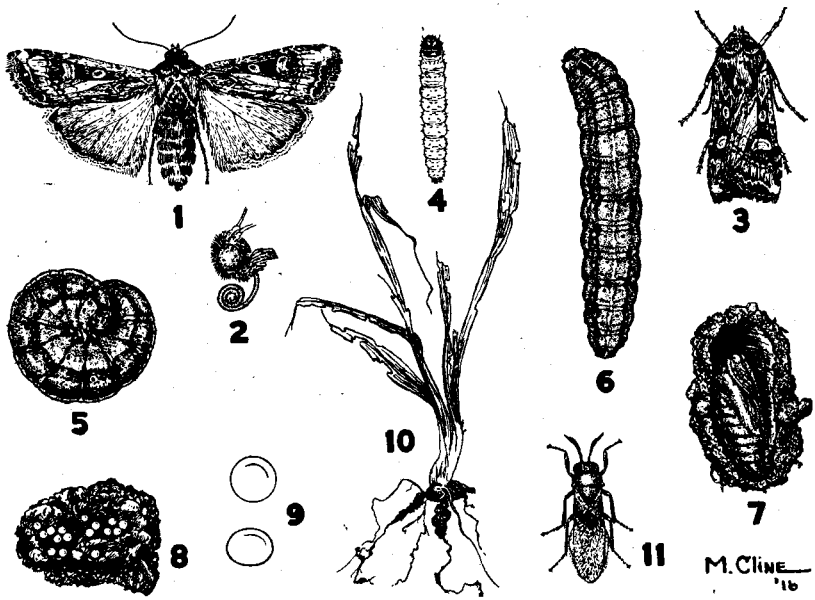
in color, varied with a green tinge. In the spring, as soon as green vegetation makes its appearance, the worms begin feeding again and now, being quite large, are capable of doing much injury. When full grown, they are usually one and a half inches in length, though some may be as long as two inches when fully distended. The general coloration is greenish brown, light and dark stripes running in alternation along the body. At this stage, the worms are rather sluggish and curl up when touched or exposed to the sunlight.

The Pupa or Chrysalis: Johnson (4) made the following observation on the pupal stage in this state: "When the larvae have attained their full growth, they make vertical burrows into 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. The chrysalis is dark brown and much shorter than the worm from which it came. The period of pupation varies from thirty to sixty days."

The Adult: Adults or moths appear as early as April 16th and usually are abundant about the first of June. Specimens of what may be two broods have been taken here. After the abundant flight of moths in June there is a gradual decrease until about the middle of September when they again become numerous. However, specimens have been taken in July and August. Also no ova or eggs were found in the bodies of the moths of the spring flight (Gillette). Therefore, it cannot be stated definitely that there is more than one brood each year.

The adults feed upon the nectar of flowers and do no damage.

The moth has a wing spread averaging one and three-quarters inches, and a body length of three-fourths of an inch. The general coloration varies from a light to a dark brown. The fore wings are dark brown with various lighter markings. The most characteristic of these lighter markings is a crescent shaped patch near the front margin about two-thirds the way out. Nearer the body on the same margin is another characteristic lighter spot which is usually either round or oval. The hind wings are a lighter brown than the front, with the fringe on the outer margin almost white. (See cut.)

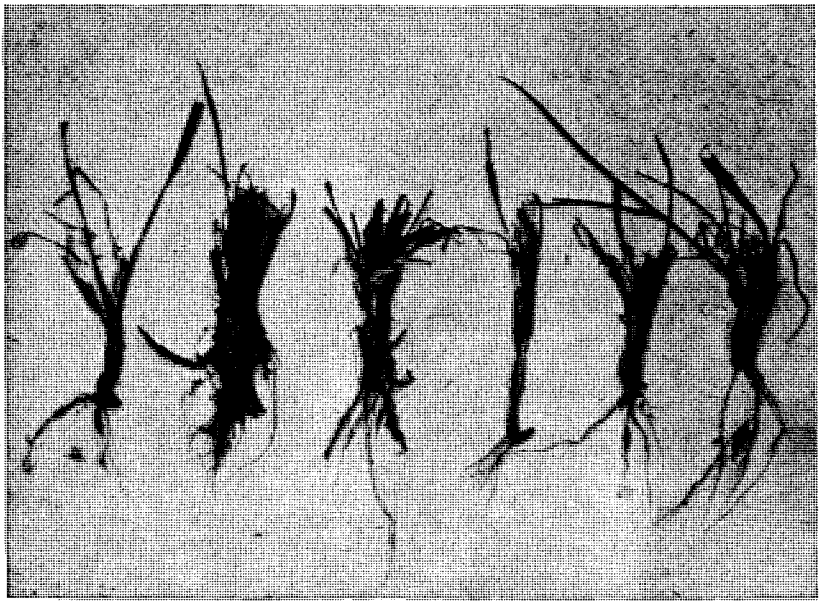


The Army Cutworm. 1, Moth with wings spread; 2, side view of head; 3, moth with wings closed; 4, young cutworm shortly after hatching; 5, cutworm in position taken when disturbed; 6, full-grown cutworm, showing markings; 7, pupa or resting stage in earthen cell; 8, eggs of cutworm moth on clod of earth; 9, outline drawing of eggs to show shape; 10, wheat plants showing first signs of cutworm injury; 11, a minute paraiste which destroys many cutworms. (Circular 52, Montana Experiment Station.)

HABITS

Food Plants: In this state alfalfa, sugar beets, barley and wheat have suffered the most from injury by this cutworm. They have also been quite troublesome in gardens, feeding on all early vegetables. Strickland (4) lists fifty-one food plants in Canada besides native grasses. Gillette (1) found them feeding upon gramma and buffalo grasses in this state and says that these are evidently among the native food plants.

Nature of Injury: This cutworm feeds above the surface of the ground. Small grains are eaten off as soon as they are up in the spring. The leaves of sugar beets are completely taken and such injury done to the crown that the plant dies. Alfalfa may be completely defoliated and young plants killed.



Stubs of wheat plants eaten to the ground by cutworms. Wheat plants cut off as closely as these seldom recover. The presence of stubs and well established roots in the drill row will distinguish cutworm injury from winter-killing. (Circular 52, Montana Experiment Station.)

The Marching or Migration Habit: When abundant, this species has a marching or migration habit, which has given it the name "Army Cutworm." This migration occurs in the spring when all the available food in the place of hibernation has been eaten. The march on normal days begins about four or five o'clock in the afternoon. On cloudy days, it may begin almost any time. When the cutworms are very numerous, all vegetation in their pathway is cleaned up, leaving barren ground in their wake.

The distance traveled varies somewhat, depending largely upon the food supply. As great a distance as three miles has been recorded by Wilcox (5).

Flight of Moths: During the day, the moths conceal themselves in trees, straw stacks, buildings, cloths, rubbish, etc. At night they fly about, feeding upon the nectar of flowers, and are attracted by light. In May and June and again in September they often become so troublesome flying into houses that the residents put out the lights to avoid them.

ARTIFICIAL CONTROL MEASURES

REMEDIES

Poison Bran Mash: As with grasshoppers, the most practical means of control is by the use of poison bran mash. The formula is essentially the same except that no fruit or other agent of attraction is necessary.

Shorts or bran	100 pounds
Crude white arsenic	5 pounds
Salt	2 pounds
Stock molasses (or any cheap grade)	2 gallons
Water	9 to 11 gallons

Bran is always preferable to shorts, but not so easily obtained in large quantities. Shorts may be used when it contains no gluten and is not too finely pulverized. The essential point is to use a medium which will not ball up and stick together when moist, but will readily flake upon broadcasting.

Refined white arsenic, or Paris green, can be used in the place of the crude white arsenic. The objection to them is that they are more expensive and no more effective.

The amount of water may vary with the kind of bran used. Ten gallons is usually sufficient. If the bran balls up and sticks together, too much water has been used.

Mixing the Mash: Success in using the poison bran-mash depends so largely upon proper mixing that too much stress cannot be laid upon closely following directions, as simple as they are.

Mixing may be accomplished either by hand or by a power machine. Except in large outbreaks, hand mixing is by far the most practical and will be discussed here.

A building with a tight board or a cement floor makes an ideal mixing station. In lieu of this, mixing may be done outdoors on large tarpaulins.

Five hundred pounds of bran may be mixed at one time. The water, molasses and salt are all vigorously stirred in a tank or some other adequate receptacle. The arsenic is then added and vigorously stirred. This mixture or "soup" must be well agitated just before applying to the bran because the arsenic is not soluble in cold water and has a tendency to settle to the bottom. The soup is then poured over the bran slowly and mixed in by means of beet forks, shovels or rakes. Five or six mixings from one pile into another will usually be sufficient. If the mash is left to stand, it may be kept without injury for several days by covering with wet sacks.

Application: Fields may be found infested in two distinctly different ways, first, either the entire area is covered with worms which hatched there or, second, the borders or edges may be at-

tacked by armies moving in. These two types may be treated differently.

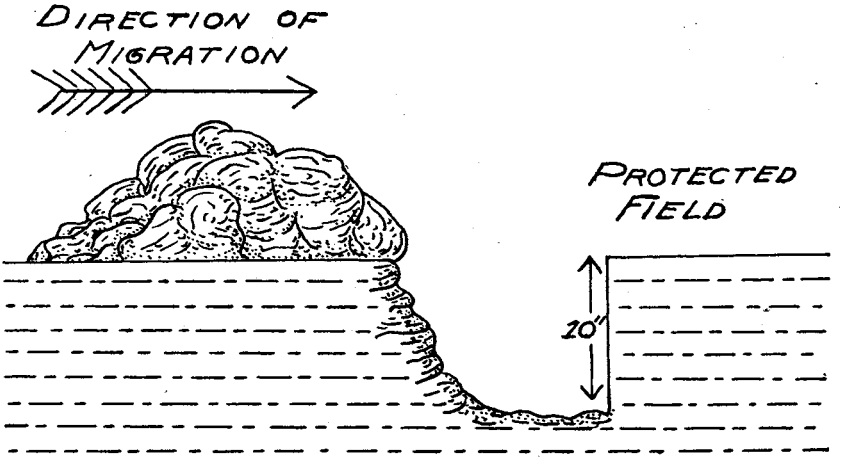
Broadcasting the Mash: In the event of a rather general infestation over the field, broadcasting at the rate of 10 to 15 pounds to the acre is very effective. The mash should be spread only during the evening after the worms begin feeding. This, as a rule, is about five o'clock.

When the infestation is of the second type mentioned, heavy broadcasting in advance of the army will give good results. However, this is not the most effective method.

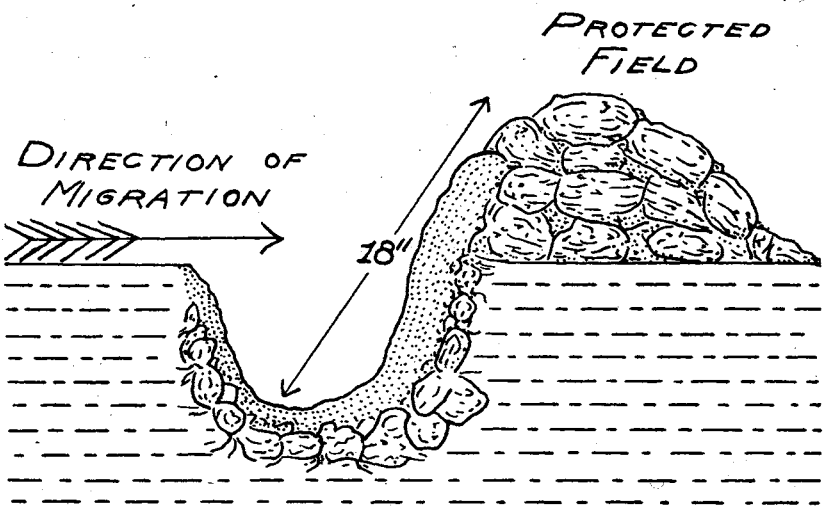
Trap Furrows: Trap furrows are used to control the marching hordes of cutworms in the case of the second type of infestation. These have proved to be less expensive and more practical than broadcasting. The furrows are of two types, (1) the vertical-sided and (2) the dusty-sided.

In firm, moist ground the vertical-sided furrow can be constructed. The vertical side of the trench is started by means of a disc cutter attached to the plow. It can be later trimmed off with a sharp spade so as to be sufficiently smooth to prevent the worms crawling up it. The vertical side is made next to the crop to be protected.

This type is expensive, due to the labor involved. During a rainy season it may be impossible to construct the dusty-sided furrow.



Diagrammatic cross-section of the dusty-sided furrow. (After Strickland.)



Diagrammatic cross-section of the duty-sided furrow. (After Strickland.)

The dusty-sided furrow is adapted to dry, loose soil. It is more efficient and less expensive. When ever possible, this type should be made.

It is constructed by turning a deep furrow with a hand plow, throwing the earth toward the crop to be protected. Usually the plow should be run thru a second time in order to obtain a depth of sixteen to eighteen inches from trough to crest. Following the plow, a smooth log large enough to fill the trench and weighted down should be run thru. This should crush all the clods and reduce the sides and bottom of the furrow to a dust. If such a dust does not result the first time thru, the operation should be repeated as often as necessary.

Neither of the trenches are intended to be entirely a mechanical means of stopping migration. Worms can get by them. They are intended to check the marching and concentrate the army in such a way as to make poisoning more effective. This done, the poison bran mash described above is applied to the trench in the evening at the rate of fifty to one hundred pounds to the mile. Cannibalism will occur, the live worms eating the poisoned dead ones and in turn become poisoned. The trench should be watched and fresh bait added when this secondary killing ceases.

If the marching army is extremely large, as a measure of safety, a secondary trench may be made about a rod inside the first. This need not be poisoned unless the first entrenchment fails to stop the worms.

Spraying with Arsenicals: When alfalfa or clover is attacked, it may be protected by spraying with such arsenicals as Paris green or arsenate of lead. One pound of Paris green to sixty gallons of water, to which two pounds of lime has been added, is effective. This should be applied with large power sprayers. Because of the requirement of spraying by machinery, this method may not always be practical.

PREVENTION.

No cultural methods as means of prevention have proved successful enough to warrant unqualified recommendation.

Clean culture during the egg-laying season (September and October) has given good results in some cases. Gillette (1) found that plowing during the summer or fall and keeping the ground clean of all vegetation until winter will give almost perfect protection against these cutworms unless there are adjacent infested lands from which the worms may migrate into the borders of growing crops. However, later observations (2) have proved that the eggs will be laid upon freshly worked ground, which is entirely free of vegetation. It, therefore, cannot be said that this preventive measure is infallible.

LATE SPRING PLANTING.

When the worms cease feeding and turn into pupae, reseeding of infested fields to early maturing crops will give good returns. By watching the activity of the worms in the field, the farmer can best tell when reseeding is safe. In general, this will be about May 10th to 15th. *Farmers should make sure that it is the Army Cutworm which is doing the damage.* Another common species in this state, the Pale Western Cutworm, does not pupate until much later and reseeding is of no avail.

The farmers will do well to consult the Agronomist of the Experiment Station concerning the best paying crop to sow after Army Cutworm injury.

NATURAL CONTROL

VERTEBRATE ENEMIES.

Of the vertebrate enemies of this cutworm, birds are by far the most important. Quail, meadow-larks, blue-birds, robins, blackbirds and bluejays are known to feed upon them in this state. Johnson (3) states that 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.

Ground squirrels are also known to eat cutworms. Of these, the Thirteen Striped Spermophile or Ground Squirrel *(Citellus*

tridecemlineatus pallidus) is of most importance. Burnett (6) says of this species, "In some sections of the state it is no doubt very injurious to corn and newly planted seeds of various kinds, while, on the other hand, in other sections, it is beneficial by the destruction of grasshoppers and other injurious insects, cut worms, etc." Gillette (7) noted that insects, almost exclusively injurious species, constitute a large proportion of the food, chief among which seemed to be cutworms, webworms and grasshoppers.

INSECT ENEMIES.

A great number of insect parasites destroy this cutworm. Most common of these in Colorado has been a tiny insect *(Copedosoma* sp.) which fills the body of the cutworm with its tiny larvae. As many as two thousand of these parasites have been reared from a single worm, (Johnson). Maxson (8) lists the following bee-like insects as important parasites in the state: An Ichneumon fly *(Amblyteles longula* Cress) a Braconid *(Microgaster* sp.) and a Chalcis fly (Berecyntus bakeri bakeri). It is perhaps as much be cause of these insect enemies as of any other one means that this cutworm appears in destructive abundance only at irregular intervals.

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3. Cutworms, S. Arthur Johnson, Colorado Agricultural Experiment Station Bulletin 98, 1905.
4. The Army Cutworm, E. H. Strickland, Bulletin No. 13, 1916. Government Printing Office Ottawa.
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THE PALE WESTERN CUTWORM

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HISTORY AND DISTRIBUTION

Heretofore the Pale Western Cutworm *(Porosagrotis orthogonia* Morr.) has not been considered an important pest of field crops in Colorado. It is altogether possible that it will not become as serious as present conditions would indicate. Yet, the discovery of considerable injury, and in some cases, complete loss of winter wheat over widespread areas of Boulder, Larimer and Weld Counties, points out the desirability of calling the attention of the farmers to this insect.* Approximately 3,500 acres have been seriously affected according to our personal knowledge.

The Pale Western Cutworm in all probability is a native of this state. The first record of it taken by the Station was September 30, 1896 (Gillette). It was not until 1911 that this insect was known to do damage to crops. In that year, it took a toll of 40,000 acres of grain in Alberta, Canada. Since that time the total acreage destroyed there has increased and Montana has come within the range of its destruction. In those regions, it is looked upon as their most serious cutworm pest.

LIFE HISTORY

The life history of the Pale Western Cutworm has not been worked out in this state. We are, therefore, indebted to the Montana Experiment Station for the information here given.

The Egg: The eggs are very small, about two-thirds the size of a pin head, and whitish. To lay them, the female moth works the tip of her abdomen into the soil and there deposits groups of three to ten, about one-fourth of an inch below the surface. For this reason, a soft mellow dirt is selected, such as freshly worked fields. Each moth will lay from two to three hundred eggs. These are ready to hatch in a few days, but will not do so unless moistened. They may, then, either hatch in the fall or remain over until spring, depending upon the amount of moisture in the soil.

The Worms or Larvae: The worms usually hatch out in the fall, feed until cold weather and then winter over in a partly grown state. During the last half of April or in May, they have become large enough to do such injury as will attract attention. At this

*The species has been determined from larvae only in the case of the injuries this spring. No adults have yet been reared.

time they are from three-quarters to an inch in length and are a glassy, greenish-gray color, without distinct body markings except two blackish lines on the head. Just how long they will continue to feed in Colorado has not been definitely determined, but at least until the middle of May and, during a normal season, perhaps until in June. They may continue to feed until after early maturing spring grains can be planted. In this respect, they differ from many of our destructive cutworms.

The Pupa: When the cutworm has completed its growth, it is about 1¼ inches long. It then forms an earthen cell from two to three inches below the surface of the ground, within which it changes to a shiny brown, inactive pupa. In August the pupa breaks open and the moth emerges.

The Adult or Moth: The adult or moth is a brownish grey insect with a wing spread of 1¼ to 1½ inches and a body length of ⅝ of an inch. A few scattering individuals will come out the first week in August, but during the season of 1920, the extensive flight did not commence until in September at Fort Collins. Egg-laying occurs shortly after the moths emerge.

HABITS

Food Plants: Winter wheat is the chief cultivated food plant. This is probably due to the fact that the winter wheat fields are in a mellow condition at the time when egg-laying is at its height, thus making these the areas of heaviest infestation. Other small grains planted after the winter wheat is eaten off may suffer just as severe injury. Either barley, spring wheat or flax succeeding destroyed winter wheat have in turn been lost. Alfalfa has not been attacked, but it seems altogether probable that young plants re-seeded with a cover crop after winter wheat injury will not escape damage. So far as known, no crop can safely be planted where these worms are abundant in the ground.

Nature of the Injury: This cutworm works entirely under the ground cutting off the plants about one or two inches below the surface. Only a small portion of the tender stem of the plant is eaten and the worm goes on to the next, showing a decided tendency to follow the drill row. They differ in this feeding habit from most other cutworms of grain which generally work above the surface or a very little below it. Thus an apparently small infestation of worms is capable of doing a great amount of damage. Plants cut off, wither to the ground and dry up. No leaf injury can be found.

Movement of the Worms: These worms do not migrate, even when food is no longer available. Their moving habit is from plant to plant along a drill row. Thus, if worms fail to find a food plant in a short distance, they will lie dormant in the ground perhaps for several weeks without feeding or developing further. In this way

they may remain after one crop is destroyed and attack the next that comes up that season. As many as three plantings have been destroyed in Montana.

CONTROL METHODS

ARTIFICIAL.

No practical method of control has as yet been developed. Due to the fact that this cutworm works entirely underground, the usual method of control with poison bran mash has given no satisfactory results. Montana Experiment Station has carried on extensive experiments in drilling and harrowing the mash into the ground. They conclude that tho these methods will kill a part of the worms, there are always enough left to ruin the crop so that poison bran mash used in any way is a waste of time and money.

There is some evidence gathered here this spring which indicates that irrigation in the fall is an effective control measure. So far as is now known, all fields injured are irrigable. Tho there is no experimental data that makes possible the recommendation of this practice without qualification, yet farmers will probably do well to irrigate their winter wheat up in the fall in infested districts wherever possible.

NATURAL ENEMIES.

Again the Pale Western Cutworm, by remaining under the surface of the ground, is unusually well protected. The common parasitic insects of cutworms do not reach it. No parasites have been reared in our laboratory and it is doubtful if there are any of importance.

RESEEDING FIELDS.

Reseeding of fields with success depends upon the time the cutworms change into the pupal stage. It will be noted that in Montana this was too late to make reseeding practical. Such will probably be the case in Colorado as well. At the date this is written, May 23, reseeded fields near Longmont have been two-thirds destroyed.

THE FUTURE

It will be noted that the foregoing information points to no satisfactory control, either naturally or artificially. The question then naturally arises, will this cutworm increase in abundance year after year, spread from the territory now infested and seriously threaten the winter wheat industry? Again, no definite assurance can be given. However, the fact that this insect has been present in the state at least for twenty-five years would indicate that some natural factor which is not well understood may have held it in

check. Likewise, the present abundance may suddenly be diminished without apparent cause. There is not yet reason to look upon this insect with great alarm.

CO-OPERATION NEEDED

In order that all information possible may be gained about this cutworm, farmers are requested to report their injury either to their County Agent or to the Experiment Station. These reports, so far as possible, should include an accurate history of the way the infested field has been handled. Such co-operation will greatly facilitate studies in life history and control. In the event of any cutworm injury, as a matter of protection to himself, the farmer should advise with the proper authorities because of the fact that *other species than the Pale Western Cutworm can be controlled.*