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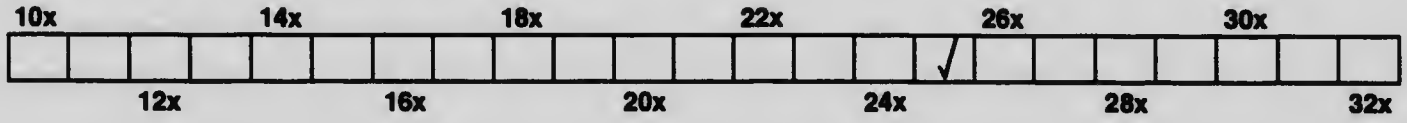

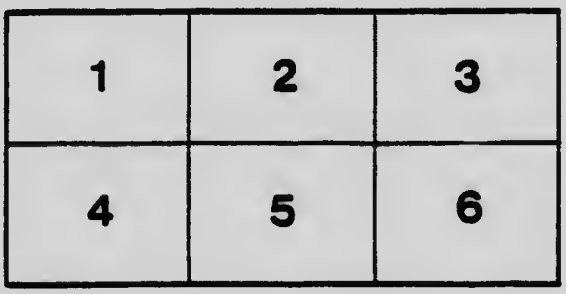

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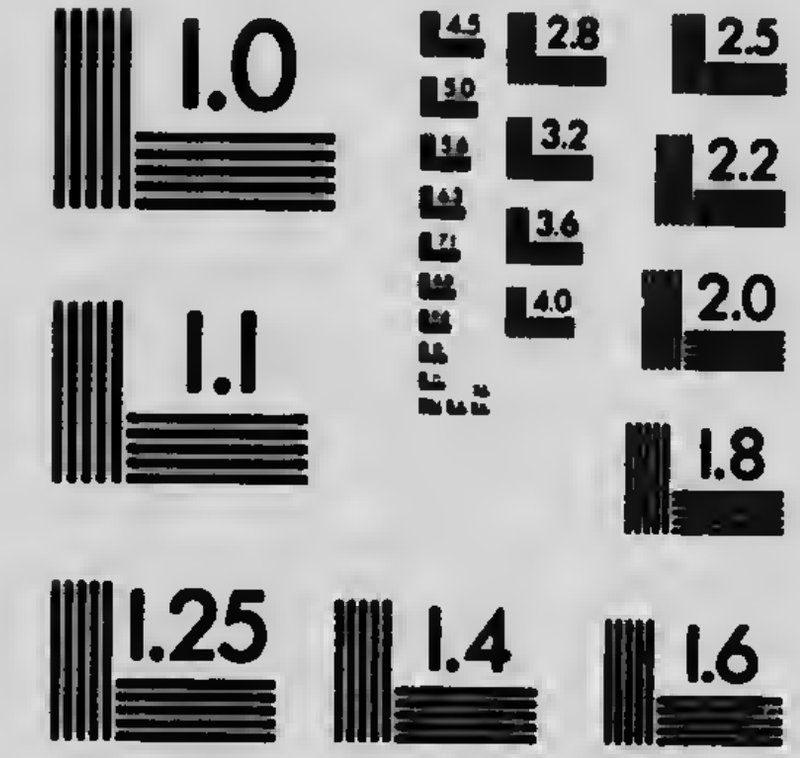

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DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
ENTOMOLOGICAL BRANCH
C. GORDON HEWITT, DOMINION ENTOMOLOGIST

THE ARMY CUTWORM

Euxoa (Chorizagrotis) auxiliaris GROTE.

BY

E. H. STRICKLAND, M.Sc.

Field Officer

BULLETIN No. 13

Published by direction of Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa

OTTAWA
GOVERNMENT PRINTING BUREAU
1916

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NOTE.

All inquiries relating to insect pests, and packages (up to 11 ounces in weight) containing specimens may be mailed "Free" if addressed to the Dominion Entomologist, Department of Agriculture, Ottawa.

In all cases where it is possible, living specimens of the insects should be sent inclosed in a strong wooden or tin box to prevent damage in transit. Living insects should be supplied with a liberal quantity of their food plant, and in all cases they should be carefully packed.

The name and address of the sender should be written on the outside of the package, and a letter giving as full details as possible should in all cases accompany the insects sent in for report.

Farmers in the Prairie Provinces may communicate with either of the following Field Officers: Mr. E. H. Strickland, Dominion Entomological Laboratory, Lethbridge, Alta.; or Mr. Norman Criddle, Dominion Entomological Laboratory, Treesbank, Man., regarding insect injuries, particularly in cases of emergency. Letters and packages to these officers must bear postage and cannot be mailed free.

OTTAWA, March 1, 1916.

To the Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit for your approval, Entomological Bulletin No. 13, entitled "The Army Cutworm," which has been written by Mr. E. H. Strickland, Field Officer in charge of the Entomological Laboratory at Lethbridge, Alta.

The Army Cutworm, which should be distinguished from the true Army Worm, is new to Canada as a field pest, although we have previous records of minor injuries by this species. In 1915 an extensive outbreak, covering a territory of about 3,000 square miles, occurred in Alberta. Fortunately, the presence of Mr. Strickland in that region enabled us to undertake an immediate investigation of this insect, and to advise the farmers in regard to the methods of control. Mr. Strickland's knowledge of the cutworms and their habits and of local conditions enabled him to discover a method of controlling this species that could be used under prairie conditions at a cost that was not prohibitive. Further, he demonstrated this method of control to the farmers in the infested district with satisfactory results, and his efforts were undoubtedly the means of preventing serious losses to the grain crop in that region. The results of this investigation are recorded in this bulletin; they will, in this manner, be available should another outbreak of this insect occur at any time.

The warning cannot be given too often that farmers should watch their g g crops carefully for the first signs of insect injury, so that the necessary control measures may be taken before the magnitude of the infestation renders their application a matter of extreme difficulty and the chances of saving the crop very slight.

I have the honour to be, sir,

Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

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ILLUSTRATIONS.

THE ARMY CUTWORM.

Euxoa (*Chorizagrotis*) *auxiliaris* Grote.

By E. H. STRICKLAND,

Field Officer, Dominion Entomological Laboratory, Lethbridge, Alberta.

SUMMARY.

The Army Cutworm (*Euxoa auxiliaris*) is new to Canada as a field pest, though it was recorded as doing damage to gardens in 1903. Since 1898 it has been a frequently recurring field pest in the state of Montana, where it has caused considerable damage.

In 1915 an extensive outbreak of this insect occurred in Alberta, and covered a territory of about 3,000 square miles.

The cutworms are variable in appearance, some of them being almost black, while others resemble the Red-backed Cutworm (*Euxoa ochrogaster*), although the back is more yellowish and striped (page 9).

The eggs are laid in the autumn, upon weedy fields. They hatch before winter sets in, and the cutworms may be half grown before the ground freezes up. They are dormant throughout the winter, and remain in the soil until the spring (page 11). Soon after the frost is out of the ground they come to the surface and feed freely upon the weeds. When the cutworms are numerous they soon destroy all of the weeds upon the fields where they hatched and have passed the winter. Then, like the Army-worm, they move off more or less in a body, in search of more food (page 13). In all of the cases that we have observed, their general line of march has been towards the northwest. Light appears to direct the larval migration (page 13). The larvæ are strongly attracted to artificial light, and can be captured at night in lantern traps.

The food plants include practically all weeds, all field crops such as grain, flax, beets, alfalfa, etc., as well as garden crops (page 12). When food is scarce the larvæ become very cannibalistic, and feed freely upon each other.

The larvæ do not feed from below the surface of the soil as do the common cutworms (page 12).

By the middle of May the most advanced larvæ have matured, but the majority of them do not form cells until about the first week of June. Most of them transform to the pupal stage within their earthen cells in about twelve days' time (page 14).

The moths fly from the middle of June till the end of September or early in October. They may æstivate during the hottest part of the summer and so appear to be double brooded (page 19). These moths, with those of *Noctua clandestina*, constitute a most annoying domestic pest. Most of them enter houses between the shingles or though cracks around doors and windows. They are not very strongly attracted by light, and the majority do not enter houses because of the lights in them (page 16). Light traps in the field are not a satisfactory means of control, for they capture very few of these moths (page 16).

The eggs are laid from the last week in August to the middle of October. Although apparently most of them are laid in the soil, the moths always choose places where there is plenty of green growth near which to lay eggs (page 17). Weedy summer-fallow is a specially favourable place, for the moths hide under

the clods by day (page 23). Fallow land can be kept unattractive to all cutworm moths by destroying all green growth on it from the last half of August to the end of October.

The destruction of larvæ by poison can be accomplished with comparative ease. This is done most economically by the use of a poisoned bait applied to specially prepared furrows. In wet seasons vertical-sided furrows can be used (page 25), but often these cannot be employed, since the soil is usually too dry for their construction without expensive hand labour. Under such circumstances they can be replaced with dusty-sided furrows (page 25). The furrows are made around clean fields which are to be protected. If the fields are already infested, supplementary furrows may have to be made through them (page 28). Two classes of bait may be used as carriers of the poison. They are shorts sweetened with molasses (page 26), and green vegetation. For the latter the best results have been obtained with stinkweed, or alfalfa (page 27).

A method of destroying the larvæ by the use of irrigation ditches has been evolved in Montana. This might be used where water is available during an army cutworm outbreak (page 29).

INTRODUCTION.

The spring of 1915 was marked, in southern Alberta, by an outbreak of a cutworm which was almost unknown, previously, as a species of economic importance in Canada. This cutworm is the larva of the noctuid moth *Euxoa* (*Chorizagrotis*) *auxiliaris* Grote.

Three fairly well-defined varieties of this moth have been described as three distinct species. These are *E. auxiliaris* (s.s.) Grote, *E. introferens* Grote, and *E. agrestis* Grote. Observers who have studied long series of these moths have doubted the validity of these species, and Mr. F. H. Wolley Dod now tells me that breeding experiments conducted by himself and Mr. W. H. T. Tams leave little doubt as to the specific identity of the three varieties.

The species is a native of North America. It occurs most abundantly on the western prairies, though it extends as far east as central Manitoba, while a specimen of the moth has been taken in Mexico. It has never, however, been recorded as a pest of much economic importance at a distance of more than a hundred miles east of the Rocky mountains.

This cutworm appeared, for the first time, in the literature of economic entomology in 1898, when Wilcox described a serious outbreak of the larvæ in the Missoula and Bitter Root valleys of Montana. He proposed for it the popular name of an *Army Cutworm*, on account of the migratory habits assumed by it being similar to those of the true Army-worm (*Cirphis unipuncta*).

From that date to the present the reports of the Montana State Entomologist have recorded local outbreaks on various occasions, culminating with an account of an "almost statewide" outbreak in the spring of 1915.

At this latter date the larvæ appeared for the first time in sufficient numbers to constitute a menace to the grain and other crops of southern Alberta. Inquiries regarding them were received from farmers in a district of about 3,000 square miles in extent. Infestations were particularly heavy in the Raymond and the Bow Island districts.

On one previous occasion only had the larvæ been sufficiently abundant in Canada for this insect to be regarded as one of economic importance. In 1903, Fletcher recorded it as injurious to gardens in Calgary and Regina. In the same year, Gillette reported an outbreak in Colorado, though on this occasion there is no record of their attracting attention in Montana.

The references cited above comprise all that has been written on the biology of the species. In these accounts there is no record of the larvæ being present in destructive numbers for two years in succession. It is highly improbable,

therefore, that the Army Cutworm is a pest that we shall have to fight annually, even though it appeared this year in such large numbers that it constituted a serious menace to grain fields in Alberta. It is liable, however, to occur at any time in sufficiently large numbers to warrant the adoption of efficient control measures.

DESCRIPTION OF THE STAGES.

Eggs. (Fig. 1.)

These are nearly globular, but are a little flattened dorso-ventrally. Diameter, 0.6 mm. Colour, white, when first hatched, highly refractive ventrally though dull dorsally. As they mature they become slate-grey. Surface, almost smooth, though with a very fine dorsal etching consisting of a few fine lines, the course of which can be defined with certainty only with the aid of transmitted light, after the egg is hatched. From the micropyle, about fifteen short, well-defined

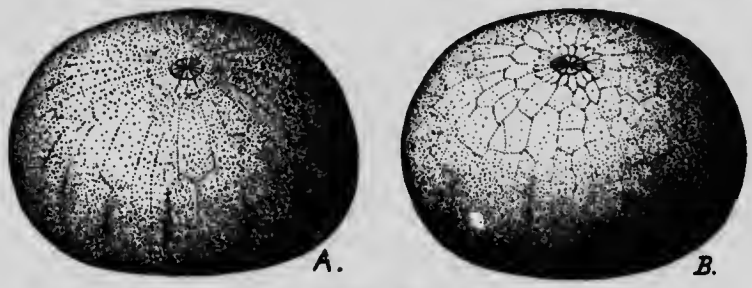

Fig. 1.—Army Cutworm eggs. 80 times natural size. (Original.)

lines radiate to a raised crenulate circle, about 0.06 mm. in diameter. Beyond this the lines are very faint and they disappear entirely towards the equatorial region of the egg. They may consist of almost straight radial lines, fifteen to twenty in number, connected by a few transverse lines, or the lines may be sufficiently irregular to form a network. In most cases there is a moderately well-defined secondary ring around the micropyle. Two of the extreme types are illustrated. The eggs of a single moth may vary from one type almost to the other.

Larvæ.

When first hatched these are 1.5 mm. long, light cream coloured, and with a shiny, black, head. In this and the second stage there are two pairs of prolegs only, besides the anal pair. Each subsequent stage is darker than the preceding one, until the third stage is passed, after which the larvæ segregate into about three fairly well-defined varieties.

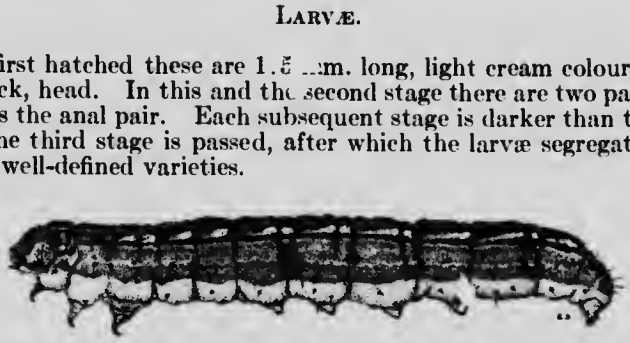

Fig. 2.—Full grown Army Cutworm. Twice natural size. (Original.)

Most of them are darkest in colour when about half grown, at which time the dorsum usually has some dull maroon-red coloration while with the exception of the indefinite white median line the remainder of the body is dark greenish-black.

The typical mature larva (fig. 2) is much lighter in colour. Its average length is about 1½ inches, when it is in a naturally extended position, though a few specimens may be a little over 2 inches long.

A detailed description of this type is as follows: Head: light yellow with dark mottlings on the genæ and vertex, and with dusky areas around the eyes and along the clypeal sutures; clypeus, yellow, dusky in the centre. Body: the prothoracic shield is dark greenish-grey, mottled with black and lighter shades of grey, and with an indefinite white median line. The general colour of the body is dark green, with a dull creamy dorsum mottled with reddish-brown, and with a white median line of varying intensity running the length of the body. This line is generally margined with dark green. Laterally, the body is dark olive green mottled with a lighter shade which forms a single, or in some cases a double, indefinite light line along its entire length. The spiracles are small and black, and are situated on a lighter creamy band which merges into the indefinite green of the venter, though it is sharply contrasted with the dark green of the laterals. The tubercles are not prominent, those on the dorsum are black and shining, while the ventral tubercles are light green. From each arises a short, black hair. The true legs are fuscous, and the five pairs of prolegs are provided with lateral plates of green chitin. The anal shield is but little contrasted with the body colour, and has a well-defined median line.

This type of larva is sometimes much like that of the common Red-backed Cutworm (*Euxoa ochrogaster*), from which it is distinguished by its more dull coloration, especially that of the dorsum, which is more yellowish and mottled, by the dark margins of the median line which give it a more striped appearance, and by the more extensive mottling on the head.

Another variety of the larva, which is almost as common as the above, has the dorsum almost entirely dark green, though on the posterior half of each segment there are two creamy patches.

Still other larvæ are found in which all pigment is reduced, and the dorsum is almost white.

All of these varieties intergrade, and since among the larvæ from one moth's eggs nearly all degrees of variation are found, while all of the three varieties of moths can be bred from any variety of larva, it is seen that larval and adult variations are not specifically correlated.

Pupæ.

The pupæ are indistinguishable from those of other species of this genus, and of the closely related genera which we have studied. The length varies, but it is usually about two-thirds of an inch (17 to 18 mm.), while the diameter at the base of the thorax is about one-fifth to one-quarter of an inch. The colour varies according to the maturity of the pupa and to the variety of the inclosed moth. When first disclosed the pupa is light straw yellow, but when mature it may be pitchy black if it contain a dark *auxiliaris* s.s. adult, or chestnut red if the inclosed moth is of the *agrestis* variety. The cremastral spines are very variable in disposition and shape, though in most normal pupæ they consist of two stout spines. These may be close set, or wide apart, strongly divergent or parallel, and occasionally they are set on a prominence. They tend, however, to be more often closely set, and to run parallel, than in other related species. One or more subsidiary spines may be present. Since the pupæ of our common field and garden cutworms show these variations also, we have found no method of distinguishing with certainty those of any one species of the *Euxoa* group from the other related forms. In all species we have been able, however, to distinguish the sex by the position of the genitalia. The disposition of the female genitalia on the pupa indicates that it consists of the external organs of three segments, whereas that of the male is confined to a single segment.

Adults. (Fig. 3.)

The moths of this species, as previously stated, are very variable in appearance, and no attempt will be made here to give technical descriptions of the varieties. They are fairly uniform in size, and the spread wings are usually between $1\frac{1}{2}$ inches and $1\frac{3}{4}$ inches in expanse. The antennæ of both sexes are

filiform, but the sexes can usually be separated by the males having a more reddish or brown tinge than the females, in which sex grey predominates. When at rest the wings are folded flat over the body.

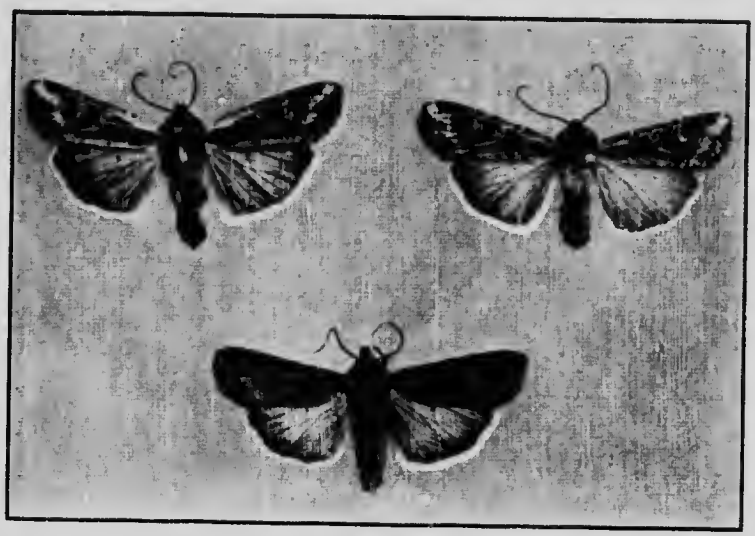

Fig. 3.—The three varieties of Army Cutworm moths: var. *auxiliaris*, var. *introferens*, and var. *agrestis*. Natural size. (Original.)

HABITS.

Habits of the Larvæ.

Under artificial conditions all of the eggs obtained from captive moths have hatched between September 10 and October 27, and it is probable that somewhere within the range of these dates the majority of young larvæ appear under natural conditions. We have made repeated efforts to find them in the field during the autumn of 1915, but without success.

Cooley (1908) states that in Montana the young larvæ hide in stools of wheat, and do not avoid the light as noticeably as they do when they are larger.

Hibernation.

At the approach of winter the larvæ, many of which are then half grown, become dormant and remain in or on the soil until the spring days are sufficiently warm to bring them to life once more. The winter is not passed in any special stage, for the larvæ from one batch of eggs develop with surprising irregularity in the fall, and when their activity is suspended by cold, those from different batches of eggs may be in any stage from the earliest to about half grown. Cooley states also that they do not hibernate in specially constructed cells, and that some farmers report finding them between the snow and the soil, while at other times they are 2 to 3 inches deep in the soil.

Our attention was drawn to them first, in 1915, on April 3, when numerous specimens had been attracted over night to the electric light at the main entrance of the provincial jail at Lethbridge. They varied in size from one-quarter inch to nearly 1 inch in length. Since at this date the frost had been out of the ground

for two or three days only it is evident that they had hibernated in several stages.

During the next few days we received reports from various quarters of an alarming abundance of larvæ in fields which were being prepared for spring seeding.

FOOD PLANTS.

Infested fields examined at this time contained a mixed growth of tansy mustard (*Sisymbrium incisum*), tumbling mustard (*Sisymbrium altissimum*), volunteer fall wheat, prairie grasses, and patches of stinkweed (*Thlaspi arvense*). Although subsequent observations showed that the Army Cutworm will feed upon practically all green growth, it was seen at this time that they showed a marked preference for tansy mustard and stinkweed. Fall wheat and tumbling mustard were almost untouched until the fields had been practically denuded of the other weeds, while prairie grasses were eaten only as a last resource.

In 1898, Wilcox gave a list of forty-two food plants besides native grasses. Our observations this year have brought up the number to fifty-one, chief of

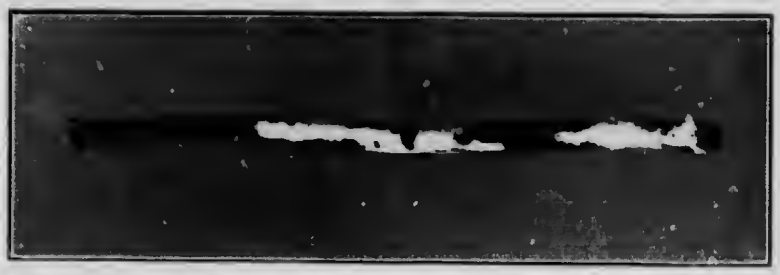

Fig. 4.—Twig of Manitoba Maple with bark eaten off by Army Cutworms. Natural size. (Original.)

which are: wheat, oats, rye, barley, alfalfa, clovers, all vegetable crops in infested gardens, foliage of fruit trees, stinkweed, all mustards, lamb's quarters, and willow sage. In addition to the above we received two accounts from Purple Springs of damage to Manitoba Maple seedlings (fig. 4) by these larvæ. They ascended the young trees and fed freely upon the bark of the smaller branches. Several trees were killed in this manner. We obtained some of the damaged twigs, together with the larvæ taken upon them, and the latter were bred through to maturity in order that we might establish their identity.

FEEDING HABITS.

Unlike the more common prairie cutworms, the Army Cutworm feeds above ground, and has never been seen to attack a plant from below the surface of the soil. When food is scarce it will sometimes follow a plant upon which it is feeding down into the soil. This is unusual, and when food is plentiful the larvæ feed most extensively upon the leaves only, when they are attacking grain crops.

The subterranean feeding species of cutworms almost invariably kill all of the young plants that they attack, and they feed to so small an extent on each of them that they destroy a large number before their appetites are satisfied. When, on the other hand, army cutworms are present in their normal small numbers the damage they do individually is slight, for with abundance of food they usually do not destroy the growing point of a plant and, therefore, though development is retarded to some extent, the majority of these plants will survive the attack. In years such as 1915, when on some fields these

caterpillars were so numerous that there were 100 to 150 of them to [illegible] are foot, they will, however, consume all available food rapidly and completely.

MIGRATION OF LARVÆ AND BEHAVIOUR TO LIGHT.

As soon as the food supply is exhausted the larvæ, as though by common consent, leave the stripped fields where they passed the winter and migrate, more or less in a body, in search of pastures new. We do not know for certain what factors control their course of migration, but it is evident that something very definite causes each individual to take up a general line of march and hold to it with little variation. The guiding principle appears to be that of light. They are certainly positively phototropic to artificial light at night time. We proved this by setting out in an infested field a number of 18-inch pans, in some of which we placed lanterns. The pans were all sunk in the ground so that the rim was level with the surface of the soil. Each was partly filled with coal oil.

Each of four pans, provided with lanterns, caught on an average 850 larvæ a night, whereas similar pans without lights captured an average of 94 larvæ only.

This attraction to light was demonstrated also at Bow Island, where the streets are lighted with natural gas. Although the larvæ were not sufficiently numerous in the immediate vicinity of the town to attract general attention, they swarmed in dense masses under every street lamp, covering an area of about six feet in diameter.

When our lantern experiments were made, the larvæ ranged from about the third stage to full grown, and the various stages were found in the oil in about the same proportions whether a light had been placed in the pans or not. From this it would seem that all of the stages found in the spring are similarly oriented by light.

It has been noticed both here and elsewhere that the larvæ usually remain below the soil from sunrise until about 4 or 5 p.m., when they come to the surface in search of food. At this time the sun has lost most of its strength, and it is seen that the general migration is towards it. Thus their course of migration at this time is towards the west.

Usually the larvæ hide from the direct rays of the sun when it is high. The reason is, apparently, that at such times the light is too powerful for them, and its action has changed from one of attraction to one of repulsion. Normally, then, they remain below ground during bright sunny days, until the sun is sufficiently low for its weakened rays to have lost their repelling power. When food is scarce, however, hunger overcomes their aversion to exposing themselves to the sun, and at such times the larvæ may come above ground during the hottest part of the day. If the day be clear they will then crawl directly away from the sun, and thus travel in a northerly direction. At such times they move with great rapidity. This appears to be the explanation of the phenomenon noticed here and elsewhere that the general trend of migration is in a north-westerly direction. There are, of course, local and temporary variations due to cloudy days and excessive migratory activity at night, but in all instances which have come under our observation the general direction of migration has been as above indicated.

The distance traversed by the worms in their migration depends largely upon the abundance of food. We have not data upon this point as definite as desirable. It was seen, however, that within a week nearly all of the larvæ had left a newly seeded, and therefore quite clean, quarter-section which had been protected against further infestation.

Wilcox (1898) states that in Montana an army of worms travelled 3 miles in a north-west direction between the first of April and the first week in May, "doing considerable damage all along the line of mareh". This would indicate that there was a moderately plentiful supply of food available, and it is reason-

able to suppose that they would have travelled over a considerably greater distance had the land been clean. It will be seen that this is an important point when we are considering the question of control.

PUPATION.

When the larva is full grown, and has finished feeding, it burrows into the soil for the purpose of constructing a hard-walled cell in which to transform into a pupa or chrysalis.

Since it is necessary for the larva to have either solid or moist earth for the construction of such a cell, it burrows down until such conditions are obtained. The depth at which the cell is formed varies considerably, therefore, and it may be just below the surface or from 2 to 3 inches deep.

The cell is oval, and, in so far as we have been able to see, it is modelled by the head in conjunction with a revolving motion of the whole body. The internal surface is quite smooth. The fine particles of earth are not held together by silk, though there is evidence of some other salivary secretion which cements them together though it does not make the wall waterproof. (Fig. 7.)

Fig. 5.—Earthern cell in which the cutworm pupates. Natural size.

The internal measurements of the cell are usually a little under an inch in length and half an inch in diameter. The wall varies in thickness from about one twenty-fourth inch, to one-sixteenth inch when all superfluous loose earth has been removed.

These cells may lie in almost any plane in the soil. We have found them most frequently lying more or less horizontally, while Gillette (1904) found that their position in the soil was usually vertical, with the head end up.

In 1915, the earliest evidence of cell formation observed was on May 9, and the last captive larva to make a cell did not do so till June 15. The majority of larvæ had formed cells by June 2, which appears to be about the average date of maturation in the field. This date refers only to the brood at Lethbridge, which we were observing, for the average date varied by up to a week earlier or later in neighbouring localities.

The mature larvæ remain for a varying period in their cells before pupation. The shortest time that we have on record is four days, and the longest is seventeen days. The average seems to be about twelve days.

The first pupa was obtained in the laboratory on May 26, though the majority of transformations were not accomplished until June 2 to 5, between which dates about 60 per cent of the larvæ pupated. Our latest record was on July 1.

In 1915, the length of the pupal stage varied between seven and eight weeks, and in most cases the longer extreme was approached. Two specimens of the same species were bred in 1913, and in each case the pupal period was of thirty days' duration only.

Habits of the Moths.

EMERGENCE.

From field cages in which conditions were practically normal, it was found that recently emerged moths came to the surface at all hours of the day as well as during the night.

The dates upon which seventy-five adults appeared above ground extended from July 19 to August 2. Over seventy-five per cent of these emerged between July 21 and July 27.

A light trap was run in conjunction with breeding work, and from this we obtained data to the effect that the maximum flight at Lethbridge was over before our first adult emerged in the cages. Our larvæ were collected mainly upon the Experimental Farm, where they were not particularly numerous.

Since our cages were set out in connection with parasite work we did not collect larvæ for them till they were approaching maturity. The larvæ thus caged cannot have been seriously affected by the handling this necessitated, and their subsequent life was such a close approach to normal that we believe the dates given above are those upon which the brood under observation would have hatched in nature.

Our light trap consisted of a half gallon mason jar "killing bottle", fitted with a paper funnel, as described by J. D. Evans (1908). This was hung under the porch light of the superintendent's house at the Experimental Farm, and was allowed to run all night.

DATES OF FLIGHT.

Our first catch of *E. auxiliaris* was made on June 15, when three specimens (one male and two females) were taken. From this date up till July 13, when over two thousand moths of this species were taken in 1½ hours, the nightly catch increased very rapidly. The number of moths taken varied considerably from night to night, and the capture made on July 13 was abnormal, for the number of specimens taken represented a comparatively small percentage of an innumerable swarm of moths which smothered the ceiling, walls, and pillars of the porch, and could not gain admission to our already overflowing trap. On the previous and subsequent nights we took, on an average, 215 moths only. This figure represents a normal nightly catch for the trap, such as was maintained with considerable temporary fluctuations until about August 7 (fig. 7).

From this date there was a steady decline until early in September, when there was a marked increase, particularly among the males. On September 12 there was a sudden drop in temperature to 4° F., which practically stopped the flight around buildings. Six specimens were taken, however, on September 18, after which date no more captures were made with the light trap. Specimens were present in the fields till early October.

As before stated, larvæ were not very abundant on the Experimental Farm. Neither did any farmers, in the immediate vicinity, report their presence in such numbers as would account for over 9,000 adults being taken in a single light trap during the two weeks preceding the first emergence from larvæ collected locally. It is evident, therefore, that they were the moths from some early maturing brood which had developed in a nearby place. We received, earlier in the year, a notification of a large mass of "worms" moving across the prairie to the north of the farm, and it is probable that this was the source of the flight.

ATTRACTION TO LIGHT AND BUILDINGS.

The moths of this species, and to a less extent those of *Noctua clandestina*, constitute one of the most annoying household pests in districts where they are abundant. It is practically impossible to keep them out of the houses, where they leave not only disgusting deposits on windows and furniture, but in addition they have a most annoying habit of darting around such lights as there may be in the house, suddenly falling into food or anything left uncovered, and also of shooting up one's sleeves or down one's neck in a most disconcerting manner.

It is generally considered that it is the lights in the houses which attract the moths into them. This, however, is only partially true, for the action of the lighted lamps is for the greater part only that of concentrating the moths, which are already in the house, around them. The swarms of moths seen in the evenings attempting to escape from windows of barns which are never lighted at night time is a proof of this statement.

The moths of this species live for a remarkably long time before the ovaries begin to develop. This period appears to be in all cases of at least three months' duration.

The fields, with their comparative lack of shelter and food, are not well suited to the requirements of the moths during this lengthy period, whereas trees and buildings offer shelter, and often nourishment also. Since there are very few trees on the prairies, the moths assemble rapidly around buildings and straw piles. This holds true also for *Noctua clandestina*, which has a similar life-history.

Of all places chosen by the moths for congregation, those in which both buildings and flowering plants are present seem to be the most favoured. The light trap, to which we have already referred, was hung on a porch over which grew a flourishing clematis. This, besides adding to the shelter afforded by the building, offered a large supply of nectar and moisture which were sought so eagerly by the moths that they could be seen feeding upon it at all hours of the day.

Though a light will not attract the moths of this species from a great distance, it will draw them readily from 15 or 20 feet, and our trap thus recorded the varying abundance of moths at the creeper, and around buildings. A similar trap hung outside a small building, which was destitute of vegetation, captured on an average 10 males and 12 females of this species per night, while the former trap was taking 142 males and 147 females per night. Lantern traps placed in the field during July and August, both at Lethbridge and at Welling, failed to catch any of the moths, though at the same time they were swarming around lights near and in buildings.

ENTRANCE INTO HOUSES.

Every morning the majority of the moths leave the flowers, etc., where they have been feeding during the night, and seek out small crevices in which to shelter from the daylight. Many hide in foliage or in straw piles, while others creep under roof shingles, in cracks around doors or windows, and in chinks between weather-boards. In most of the cases observed, where moths were present in houses in such numbers that they constituted a pest, they had gained admission mainly under the shingles. When these are slightly warped or shrunken they offer innumerable small crevices into which the moths creep far enough to be protected from the daylight. Where there is a possibility of working their way through into the building, by however devious a course, many of them will do so. In one house at Lethbridge, which had every door and window screened, we took as many as 700 moths a night from a light trap hung in the attic. Needless to say, the attic was not plastered.

MATURATION OF THE OVARIES.

From July 10 to the middle of September a number of female moths were dissected each week. At the beginning of the flight there was very little fat body present in the abdomens, and the ovaries were always undeveloped. By the end of July the fat body in most moths had increased considerably. The ovaries were developing very slowly, though at this time the individual ova could be seen with a dissecting microscope. The fat body reached its maximum

abundance by about the middle of August, at which time the ovaries began to develop more rapidly, till, by August 31, dissected specimens revealed eggs which were almost completely developed.

In 1915 the majority of captive moths did not lay eggs until the end of September or the beginning of October. By this time the moths had disappeared from the lights around buildings, the last capture being made on September 18. An examination of a summer-fallow field on September 29 resulted in the discovery of several very much rubbed females of this species, hiding under clods. Although we were unsuccessful in our attempts to find laid eggs at this time, we found that in each case the abdomen was half filled with mature eggs, which indicated that a number had been already laid. Earlier in the year, when the moths were at the height of their flight around buildings, we had examined the same field without finding as many moths as we did on this occasion, which was over a week after we had taken our last moth at the light trap.

Oviposition and Eggs.

Date of Oviposition.

In Alberta the eggs of this moth are laid exclusively in the fall. The earliest date upon which we have an actual record of oviposition is August 30. This record was obtained in 1914. In 1915 the first eggs were obtained on September 3. The oviposition period extends probably for nearly two months, since the latest date on which we obtained eggs was October 18, and twelve only of our captured females oviposited.

Location of Eggs.

In so far as we can judge, the eggs are laid most frequently in the soil. We have not, however, found them in the field, and our observations were made under artificial conditions. In a large attic, swarming with the moths of *Euxoa auxiliaris* and *Noctua clandestina*, we placed pots in which were growing several species of common weeds, wheat, etc. Both species of moths laid their eggs exclusively in the soil, or under collections of dust. No eggs were laid upon the vegetation. The same result was obtained in 1914, in a mason jar containing earth, into which pieces of vegetation were inserted. All of the eggs laid by *E. auxiliaris*, placed in the jar, were deposited in the earth.

Johnson (1905) states that the eggs of this species are laid "almost exclusively on vegetation," and describes them as hemispherical, attached to leaves or grass by their flat side, and showing, under the magnifying glass, beautiful striations. He adds also that they turn brown when mature.

This description does not agree with that of the eggs we obtained from a number of moths, all of which were determined by Mr. Wolley Dod as *Euxoa auxiliaris*. These eggs were obtained from representatives of all of the three varieties of this species. In all cases they agreed with the illustrations (fig. 3) and descriptions we have given of them. The etchings on the chorion are so fine that they cannot be seen without a compound microscope, and in addition our eggs all turned slate-grey before hatching.

It is possible that many are laid on vegetation in Alberta, though we have found no indication that this is the case. It seems, however, that they are laid in the vicinity of vegetation whenever possible, and that *summer-fallow which is absolutely clean during the oviposition period is avoided by the moths.* A quantity of the small weed and volunteer growth on a summer-fallow field, in which moths were plentiful, was examined on September 29, but no eggs could be located. Neither could they be found in the soil, but it should be borne in mind that these eggs are .6 mm. only in diameter, and that on those

occasions when they were laid by captive specimens in the soil they were never attached to each other in groups of more than three. Their discovery in nature, if in the soil, is therefore a very difficult matter. The Pale Western Cutworm (*Porosagrotis orthogonia*) undoubtedly does lay its eggs in the soil, for on three occasions we have found its comparatively large eggs in the loose earth under clods, though on every occasion they were sufficiently near to vegetation to ensure, as far as possible, a supply of food for the larvæ when they hatched.

Fig. 6.—Diagram showing the nightly capture of Army Cutworm moths in 1914. The captures and mean temperatures are averaged weekly. (Original.)

Rossikov (1914) found in Russia that the moths of *Euxoa segetis* laid their eggs in the soil or on straw, and not upon green vegetation, whereas the eggs of various species of other genera were found upon the vegetation growing in the same fields.

NUMBER OF EGGS LAID BY AN INDIVIDUAL MOTH.

The largest number of eggs that we have obtained from a single moth in captivity is 1,109. Though the average was considerably under this figure, others laid over a thousand, and it is probable that in nature the average would

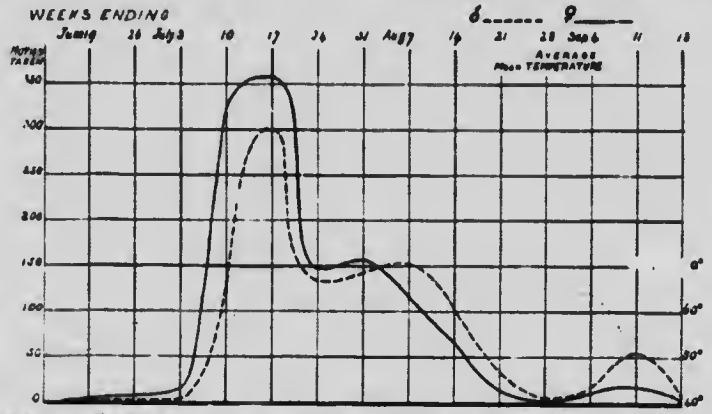

Fig. 7.—Diagram showing the nightly capture of Army Cutworm moths in 1915. The captures and mean temperatures are averaged weekly. (Original.)

approach the maximum figure, since in most of those cases where a small number of eggs was obtained, the moths had been in captivity for several weeks.

LENGTH OF EGG STAGE.

Since no eggs were kept under natural conditions, we have no exact data upon this point. A tube containing eggs laid on September 28 to 29 was placed

out-of-doors, and was half buried in the soil. The eggs began to hatch on October 29, and they had all hatched within four days.

NUMBER OF BROODS.

Our observations show that the moth is single-brooded in Alberta, though a tendency to æstivate gives the impression, in some years, that there are two distinct broods. The summer of 1914 was exceptionally hot in Alberta. Our trap recorded two well-marked flights that year, the first lasting till the end of July and the second extending from about August 20 till September 12 (fig. 6). From the temperature curve on the chart it will be seen that there was the least activity during the protracted hot spell in late July and August.

In 1915, the flight was more continuous (fig. 7), though the temporary diminution during August corresponds fairly closely with the rise in temperature recorded during that month.

Local disturbances, such as wind or rain, caused variations in nightly captures, and the charts do not show as plainly as we could wish the evident relation of the flight of this moth to temperature.

We imagine that the two distinct flights of moths recorded by Gillette (1904) in Colorado resulted from an accentuation of this tendency to æstivate. He describes the first flight, which extended from April 16 to July 10, as being more abundant than the later flight from September 13 to October 12, of which occasional specimens only were seen. From the adults of the first flight he was unable to obtain developed ova, whereas most of the females from the second flight contained mature eggs.

This condition regarding the ova is identical with that found in Alberta, and the following observations will, we think, throw some light on the matter.

Towards the end of July a number of captured female *E. auxiliaris* moths were placed in separate pill boxes, and were fed on dilute molasses. These belonged to our first flight, and at the time of capture no female moths contained developed ova. During October three of these laid eggs. The eggs were sterile, but they were laid after the last moths of the second flight had been taken at lights, and at the same time as moths captured during this second flight were laying eggs also.

Cooley (1908) considered it improbable that this species is double-brooded in Montana.

The only occasion upon which we have observed copulation was on August 27, 1914. The female was boxed and laid over 1,000 fertile eggs between September 1 and September 10.

NATURAL ENEMIES.

As with most of our common pests we are saved from considerably more extensive and frequent outbreaks of the Army Cutworm by its enemies. The most important of these are other insects which, either as predators, feeding from time to time upon such cutworms as they capture, or as parasites, living inside cutworms, kill more of them every year than we can hope to with all of the means at our disposal.

During 1915 we found the following enemies destroying army cutworms in southern Alberta.

PREDATORS.

Calosoma tepidum (fig. 8). It is probable that this large ground beetle, especially when in the larval stage—"the cutworm lion"—is the most useful predacious enemy of the Army Cutworm. Although we do not know as yet the

life-history of this beetle, we imagine that it hibernates in the adult stage, since the beetles are seen running about the fields actively searching for prey soon after the frost is out of the ground.

We obtained several eggs from this species during May, but all of them failed to hatch. The larvæ are found in largest numbers towards the end of June, by which time their natural cutworm food is so scarce that they feed freely on each other and thus reduce their numbers considerably.

Calosoma zimmermanni is less abundant than the preceding species, but has been taken feeding on army cutworms.

Fig. 8.—*Calosoma tepidum*. *a* larva (cutworm lion), *b* adult. Natural size. (Original.)

Small *carabidæ*. Several of the small Harpaline species have been found feeding upon small cutworms, but they will not attack the large specimens. They are probably of little value in helping to keep cutworms under control.

Ammophila luctuosa. This black "digger" wasp is attracted to infested fields in large numbers, and we have seen them capture and paralyze full grown larvæ, which they then drag to their nests.

Of lesser importance may be mentioned *Cicindellid* adults (Tiger beetles), which are evidently attracted in numbers to infested fields, though we have not seen them feeding on healthy cutworms; and the ant, *Formica sanguinea*, the workers of which were observed dragging larvæ towards their nests.

Cannibalism. When food is scarce, the larvæ feed extensively on each other. Dead specimens are eaten most readily, but many healthy larvæ are killed as a direct effect of the attacks made upon them by others.

Birds and mammals. Wild birds, among which may be mentioned especially meadow larks and sparrows, feed extensively on the larvæ, while poultry range far out into infested fields in search of them. These birds destroy, also, many adults. Hogs turned out into an infested alfalfa field destroy large numbers of larvæ, and the common gopher feeds readily upon these and other cutworms.

PARASITES.

About 28 per cent of the larvæ collected around Lethbridge in 1915 were parasitized. This is rather a low percentage, but it is due probably to the abnormal abundance of the host.

The hymenopterous parasites were determined by Messrs. Girault and Gahan through the courtesy of Dr. L. O. Howard, of the U. S. Bureau of Entomology.

Apanteles laeviceps Ashm. (fig. 9). Masses of the cocoons of this species were obtained from 10.5 per cent to 11 per cent of larvæ which were collected at Lethbridge within about a week of maturation.

The parasites mature at about the same time as the host does, but the latter, instead of burrowing in the ground, crawls up some convenient object,

such as a fence post, or a stem of grass. The larval parasites then emerge from the body of their host, each through a separate hole and, after attaching themselves to the support, proceed immediately to spin up. The yellow, oval cocoons are attached to each other in a single mass. The host may remain

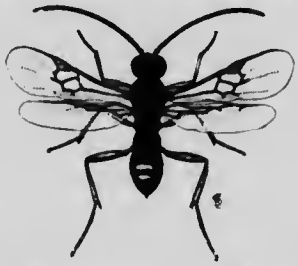

Fig. 9.—*Apanteles laeviceps* Ashm. 8 times natural size. (Original.)

held by stray silks to the mass of cocoons, though it usually lives long enough to crawl away, and it may re-enter the soil. The number of cocoons from one larva varied from three to forty-two, and averaged about thirty-five. The adults hatch about three weeks after the cocoons are made.

Meteorus sp.—Probably undescribed—(fig. 10) parasitized 8 per cent of the larvæ. The host does not come above the soil when it is mature, but may form a normal cell, though generally it wanders aimlessly in the soil till the contained larvæ bore through the skin and spin up. Their emergence does not

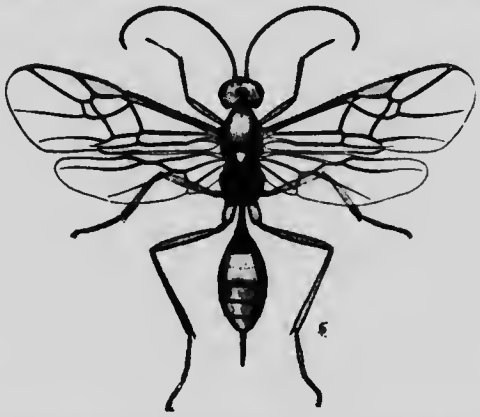

Fig. 10.—*Meteorus* sp., probably undescribed.—8 times natural size. (Original.)

kill the larva immediately, and it may come to the surface and crawl around for a day or two before dying. The cocoons are light straw yellow and are parchment-like. The largest number of parasites obtained from a larva was thirty-two, but the average is about twelve only. They began to hatch on June 24. In all cases they hatched between twenty-four and twenty-eight days, after emergence and spinning up.

Berecyntus bakeri How. *var. euxoæ* (fig. 11). This parasite was bred from 6 per cent of the larvæ. Usually the parasitized cutworm made a cell towards the latter part of May, at which time the inclosed larvæ are seen plainly, for the first time, through the cuticle. The parasites are now mature, and the host dies. In all cases observed the adults emerged between July 23 and 31. We obtained between 1,100 and 1,200 adults from a single host, but Gillette (1904) has bred as many as 1,705 of these flies from an army cutworm.

Other parasites were bred in small numbers only. *Amblyteles* sp. hatched from about 1 per cent of the pupæ. Of other hymenopterous species single specimens only have been reared.

Fig. 11.—*Bercecyntus bakeri* How. var. *cuzoæ*. 20 times natural size. (Original.)

Tachinidæ. Although larvæ of these parasitic flies were found from time to time during the season while cutworms were being dissected, they were bred on one occasion only. On July 6 two *Phorichaeta sequax*[1] were obtained from a specimen taken at Lethbridge.

Diseases.

Two diseases caused a high mortality among larvæ. One of these, seen only at Welling, attacks immature and mature larvæ, turning them to an opaque pink colour, which is most noticeable ventrally Many dead larvæ were found on the surface of the ground on May 12, especially under the shelter of dry cow droppings. Dull pink, sluggish, specimens were numerous. Some of these diseased specimens were killed, fixed, and sent to Dr. Glaser at Boston. He replied that they had every appearance of suffering from an intestinal bacterial disease, though it was impossible to diagnose with certainty without living material.

We dissected specimens after death and found that all of the vital organs were normal. At this time, however, the musculature had a bleached pinkish-white appearance, while from the fat body a semi-white fluid escaped in large quantities.

Diseased specimens were taken to Lethbridge in order that the disease might be transmitted, if possible, to the healthy specimens of that locality. Such attempts were never successful, whatever the method adopted. The diseased larvæ regurgitated a quantity of greyish white fluid when irritated, This was smeared on grass and fed to other larvæ, but in no case was any effect produced, for they matured, pupated, and moths emerged.

A cage of 100 larvæ collected at Welling suffered seriously from this disease, although only specimens which were apparently healthy were put into it. One moth and one Ichneumon only hatched from this cage, while many typically diseased larvæ were seen on the surface of the ground.

A second disease was prevalent at Lethbridge. This attacked mature specimens only, often after they had made their cells. The diseased larvæ became inflated, turned brown, and when dissected were found to have their body contents decomposed and liquifying.

[1]Determined by Prof. J. M. Aldrich.

METHODS OF CONTROL.

Preventive Measures.

CLEAN SUMMER-FALLOW.

When we described the egg laying habits of this species we stated that the moths always lay their eggs in the vicinity of green vegetation, even though we believe that they are usually laid in the soil.

On fields which have borne a good stand of grain there is very little green growth during September and early October, and we have not found evidence of extensive infestation originating in such clean stubble land. Gillette (1904) states that, in Colorado, barley stubble is a favourite breeding place. We have no data to confirm this statement under Alberta conditions, for little barley is grown here, while probably less will be grown in the future.

The various swarms of larvæ which migrated on to all kinds of land during the spring of 1915 appeared to originate, in nearly every case, upon land which had been summer fallowed in 1914, and had been allowed to become weedy during September, or upon land on which there had been a crop failure resulting in a strong growth of weeds later in the season.

Weedy summer-fallow appears to be specially adapted to the requirements of these moths. They hide under the clods by day, and are surrounded with the green vegetation among which they lay their eggs.

In a large tract of fallow land examined during September, we turned up many more moths when moving clods on such parts as bore weeds than we did upon the clean areas.

It is essential, therefore, that summer-fallow be kept clean—absolutely clean—from the middle of August until after the end of September. In this way only can summer-fallow be rendered unattractive for egg laying to the moths of the Army Cutworm, as well as to the moths of other cutworms.

It is advisable, also, that the surface be worked up as finely as is compatible with good farming practices in order that it may offer as little shelter as possible to the moths.

Gillette (1904) states that the moths lay their eggs freely on the prairie. This is true, apparently, in Alberta also, for we have found the larvæ far out in unbroken tracts of prairie. They do less harm there than they would on grain fields, and if fallow land is made less attractive to the moths, more of them will lay their eggs on the prairie instead of on cultivated land.

REMEDIAL MEASURES.

On account of the migratory habits of these larvæ, no unprotected fields are absolutely safe from attack in years when the larvæ are sufficiently numerous to be moving across the county in search of food. At such times they may arrive in swarms upon fields where every precaution has been taken to prevent them from breeding. When army cutworms are abundant, therefore, everyone must keep a sharp lookout for them, and take steps to deal with them immediately if they appear on his farm.

POISONED BAITS.

The Army Cutworm can be controlled in a similar manner to other cutworms by the judicious use of poisoned baits.

These can be applied broadcast to attacked fields, but it is advisable so to use them only when the larvæ are present in large numbers in a crop which is well above the ground. For such a use we have obtained the best results by

the employment of a mixture consisting of: shorts, 50 pounds; molasses, 1 gallon; water, 1½ gallons; and Paris green, 1 pound.

The shorts and Paris green are mixed while dry. The molasses is then dissolved in the water and the solution is added slowly to the shorts mixture, which is stirred constantly with the hands in order that any lumps which form may be broken up.

The mixture is spread broadcast at the rate of 20 pounds of the shorts to the acre, and by preference should be applied as late in the afternoon as is convenient.

Where the soil is wet the shorts may be replaced fairly satisfactorily with bran, or half bran and half shorts, but wherever possible the shorts should be used. On perfectly dry land bran is almost useless. The reason for this is that bran, under prairie conditions in southern Alberta, appears to have very little attraction for cutworms when it is dry, even though it be flavoured with molasses. Shorts, when similarly flavoured, however, are almost as attractive when dry as they are while moist.

When bran is used the water should be increased to 6 gallons to every 50 pounds.

When obtainable, cheap crude beet molasses should be used, such as that which is made by local sugar factories. This is more attractive to cutworms than cane molasses, and is incomparably cheaper.

TRAP FURROWS.

Broadcasting is an expensive means of checking cutworm devastation, and on account of the migratory habits of the species we are considering, the benefit derived from it may be temporary.

Wherever possible, therefore, we would advise that farmers utilize trenches, in which to trap and kill the Army Cutworm.

In our description of the life-history of this pest, we stated that the larvæ are seen first soon after the frost is out of the ground. At this time farmers are beginning to prepare their seed-beds. They may find that an enormous number of cutworms are present in, and on, the soil of the fields they intend to sow.

Our experience is that it is safe to proceed, and to sow the crop on such an infested field, provided that it is cleared of all growth, and that efficient furrows are made around, and in some cases, through it. Such furrows, when made and poisoned in the manner described below, prevent practically all fresh incursions of larvæ, and will in a short time capture most of those already in the field.

We have already shown that the general movement of larvæ is north and west, and that even when allowance is made for temporary variation the migration is, on the whole, in one direction.

In the early spring the period intervening between the time when the preparation of the seed-bed is begun and the time when the crop first appears above the ground is from one to two weeks. We have thus at least a week in which to take advantage of the migratory habits of these larvæ.

When the land is freed from green growth there is no food left for the larvæ, and they migrate at maximum speed, sooner or later to enter one of the trap furrows prepared for them. If, on the other hand, the spring cultivation has not killed or buried all green growth, migration will be much retarded, and the crop may be up before the larvæ have been destroyed. In this event, expensive broadcasting of poisoned bait alone will ensure the crop against serious damage.

It is essential, therefore, that an infested field be thoroughly cleaned before the crop is sown.

Construction of trap furrows.—Usually the soil is very dry during the seeding period in southern Alberta, and for this reason it is very difficult, and often impossible, to construct a vertical-sided trench of the type usually advocated

for holding back an invading army of this pest, or the Army-worm. In wet seasons, however, such a trench would be practical. The plough with which the furrow for such a trench is made must be provided with a coulter. The earth is thrown toward the advancing larvæ, so that the furrow is vertical on the side which is to be protected (fig. 12). Such a furrow must be trimmed with a spade upon its vertical side, so that this may be sufficiently smooth to prevent the larvæ from climbing up it.

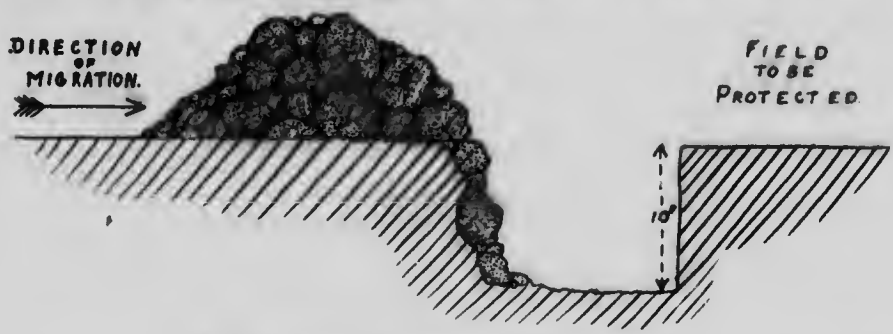

Fig. 12.—Diagram of vertical-sided furrow. (Original.)

Such a furrow cannot be made successfully when the soil is loose and dry, and in any case the subsequent trimming up with a spade calls for more labour than is usually available, on account of the length of the trenches farmers may have to construct. Under such conditions a *dusty-sided furrow* will be found to be more effective, and is considerably cheaper in construction (fig. 13.)

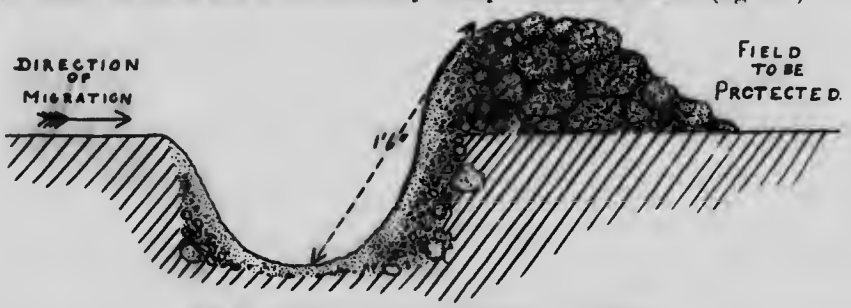

Fig. 13.—Diagram of dusty-sided furrow. (Original.)

This is made as follows: Turn as deep a furrow as possible with a walking plough, throwing the earth *towards the field to be protected.* This furrow should be sufficiently deep so that the distance from the crest of the ridge to the bottom of the furrow is at least a foot. If this is not obtained with ploughing once, the plough should be run through the furrow again in the same direction as before.

Now drag a heavy log down the furrow. The man who is in charge of the horses should stand on the back end of the log to weight it down. This operation will crush all of the large clods, and leave a smooth, dusty, sloping side to the furrow (fig. 14).

Usually the soil is sufficiently moist to crumble most easily directly after the furrow has been ploughed, while if the log is not drawn down it till the clods have thoroughly dried out, it will be difficult to crush them sufficiently with one operation.

The army cutworms which attempt to cross such a furrow experience great difficulty in doing so, for the loose particles of earth move under them, and offer no foothold whatever.

No form of trench, however, except one calling for expensive hand labour, is effective as a permanent mechanical barrier against the migration of a large number of cutworms. Such a trench, of which a description is given by Gibson (1914) in connection with Army-worm control, is not often practicable upon large western farms on account of the labour for which it calls.

Fig. 14.—Preparing a dusty-sided furrow. (Original.)

Poisoned bait in furrows.—To make a trap furrow effective it is necessary, therefore, to treat it with a poisoned bait which will kill the larvæ entering it.

Several mixtures have been recommended for this and for similar purposes. We have given most of them careful and repeated trials under varying conditions, and as a result of these numerous experiments we can strongly recommend any of the following mixtures:—

1. *Poisoned shorts.*—The mixture which we described for use when broadcasting bait is the one which can be most readily prepared by farmers. The ingredients are: shorts, 50 pounds; molasses, 1 gallon; water, 1½ gallons; and Paris green, 1 pound. These should be mixed in the manner described on page 24.

This bait should be applied at the rate of 10 pounds of shorts to 60 or 70 rods of trench.

The cost of materials used in this bait, when crude molasses is used, is about $1.20 per mile.

When shorts are not available in sufficient quantities they can be replaced with, or mixed with, bran. As before stated, bran is distinctly inferior to shorts, especially in a dry season.

2. *Poisoned vegetation.*—In several of the localities attacked there were patches of stinkweed (*Thlaspi arvense*) which, on account of its being a winter annual, makes a large and rapid growth early in the spring. Cutworms are particularly fond of this weed, and it can be used to advantage to replace the shorts and molasses as a carrier for Paris green in bait. It is, moreover, a noxious weed, which should be hand pulled in any case. The labour involved in collecting this weed is therefore serving a double purpose, and is chargeable to the requirements of good farming more than to the expense of controlling army cutworms.

Stinkweed bait is prepared as follows: Weigh out 50 pounds of the freshly pulled weed, and place it in a heap on the floor of a barn or, if the day is calm, on dry hard ground. Sprinkle with sufficient water to moisten it thoroughly. Now dust in 1 pound of Paris green, turning the vegetation over constantly with a fork till the poison is evenly distributed throughout the heap. The bait is now ready for application to the furrow, along the bottom of which the plants should be scattered, 6 to 9 inches apart, so that 10 pounds will cover up to 50 or 60 rods (fig. 15).

Fig. 15.—Applying poisoned stinkweed to a dusty-sided furrow. (Original.)

The cost of the bait, exclusive of labour, is about 35 cents per mile.

It is advantageous to apply the bait late in the afternoon, since its attractiveness depends mainly upon the freshness of the stinkweed.

This bait proved to be as effective as poisoned shorts during the first two days after application, but it was not eaten to any extent when quite dry.

When stinkweed is not available it can be replaced with other vegetation upon which the larvæ will feed readily. We have used *alfalfa* with considerable success, and as a bait it is almost as good as stinkweed, though it is a little less retentive of its moisture. Since, however, no benefit is derived as a direct result from pulling alfalfa, the labour involved makes this a somewhat expensive bait when it is used to replace a noxious weed such as stinkweed. The new growth at this season is not sufficiently advanced to allow of its being cut with a mower.

In some cases it may be more convenient to spray vegetation intended for bait, before pulling. For this purpose a mixture of about 1 pound of Paris green to 30 gallons of water should be used, in order that the bait may be heavily coated with poison.

Some farmers are unable to obtain either shorts or green vegetation. For such we would recommend one of the two following baits, though they are distinctly inferior to the mixtures we have already described:—

Fair results were obtained from the use of *Alfalfa hay* sweetened with molasses; 1½ gallons of crude molasses, dissolved in about an equal quantity of water, is mixed into 50 pounds of hay, to which as much water is now added as it will soak up. Two pounds of Paris green are then stirred into the mixture, which should be applied in the evening in as wet a condition as possible, since it loses its attractiveness when dry. On account of its bulk, 10 pounds of hay will cover more than 100 rods.

A bait can be made also from fresh *horse droppings*, of which 100 pounds are sweetened with a gallon of crude molasses and poisoned with 1 pound of Paris green, but this is a poor substitute.

Effect of cannibalism upon poisoning in furrows.—The quantities of Paris green recommended in the above mixtures are considerably in excess of the actual amounts necessary to kill the individual larvæ which feed at all extensively upon the bait. The reason for this is that larvæ feeding upon such heavily poisoned bait are killed quickly and very few of them leave the furrow.

We have stated already that larvæ feed readily upon each other, especially upon dead specimens. No exception is made with poisoned larvæ, and subsequent arrivals feed almost as freely upon these as they do upon green vegetation. These dead larvæ thus become, themselves, poisoned bait, and when a large number are migrating, the killed specimens soon cover the bottom of the furrow. We have not tested the length to which this secondary poisoning can be carried, though we find that two larvæ are killed readily with a single dead specimen which has been poisoned by the bait in a furrow. In any case, the majority of living larvæ apparently prefer to stay in the furrow and continue to feed upon the dead bodies of those which have been poisoned, till sooner or later they themselves succumb.

The post holes we made in treated furrows for estimating the relative value of baits continued to yield up to an 80 per cent mortality a week after the bait had been applied.

Comparative value of poisoning in furrows and broadcasting.—When larvæ are migrating, we have seen them pass rapidly over dry bait, without appearing to be aware of its presence. In a prepared furrow, however, their progress is impeded, and after one or more unsuccessful attempts to escape, nearly all of them will stop and feed upon the bait with which it keeps them in contact.

Experiments were made in which similar amounts of bait were placed upon the open soil and in prepared furrows. An average of about three times as many dead larvæ were taken from under the bait in the furrows as from that on the level ground, and in all cases much more of the former bait had been eaten.

In order to estimate the value of a dusty sided furrow treated with the shorts mixture we have described, we made counts of the dead larvæ to the foot of our experimental furrow at Welling eight days after the bait had been applied. The average number of dead larvæ was 537 to the foot of trench, which is equivalent to nearly 3,000,000 to the mile. At this time there was no sign of the bait left, and since the larvæ had been continuously feeding freely on dead specimens the total number already killed must have greatly exceeded this figure.

Number and location of furrows.—When a field is considered to be in danger of attack by larvæ, which are known to be in the vicinity, a single furrow should be made around it. By watching this furrow the farmer will be able to see whether larvæ are attempting to enter his fields. If in the evenings numbers are present in the furrow, it should be treated with bait immediately.

If the larvæ are migrating on to a field in large numbers it may be advisable to make two parallel furrows, about a rod apart, along the side or sides from which they are entering. The inner one need not be treated unless it is seen to contain many larvæ which have escaped from the first.

This should effectively prevent further invasion in large numbers.

When a crop has been sown, and the larvæ are already numerous in the field, furrows should be ploughed through it in one or both directions, and poisoned at once.

The distance between these furrows varies according to the time when the crop will be up. If it is not anticipated that the crop will be above ground in less than a week, and the field is quite clean, the furrows need not be less than 40 or 60 rods apart. Within a few days most of the larvæ will have entered one of them, and will be poisoned.

Before making these furrows, notice the general trend of migration, and arrange them in such a way that they will cut across the line of march.

Maintenance of furrows—After rain it is necessary to draw the log once more down the furrow and so crumble up the surface crust which forms on its sides. This will necessitate a second treatment with bait. In any case it is advisable to watch the furrows from time to time during the migration period, and to replenish the bait when necessary.

It cannot be claimed that this method of poisoning in furrows will kill all of the larvæ upon a field, for some will not enter the furrows at all, and a certain percentage of those that do will escape. It is claimed, however, that for the money expended it gives greater benefits than does any other method with which we have been able to experiment. Upon the field through which we ploughed the furrow that killed over three million larvæ to the mile, the larvæ which escaped were not sufficiently numerous to cause appreciable damage. As we have already stated, a small number of larvæ do comparatively little damage because they do not kill all of the plants which they attack, when there is abundance of food.

Thus, at a minimum cost, Army Cutworm damage can be reduced to negligible proportions by the use of poisoned bait in conjunction with properly constructed trenches.

SPRAYING ALFALFA.

We have not known the Army Cutworm to kill out alfalfa in Alberta, though when a large number are working across a field of it they seriously retard its growth. In this case it is best to spray the alfalfa, to just beyond the limits of damage, with Paris green at the rate of 1 pound to 100 gallons of water, to which has been added 2 to 3 pounds of lime.

IRRIGATION DITCHES.

Dr. Wilcox in 1898 gave a complete account of a method whereby these larvæ could be successfully controlled by the use of running water in irrigation ditches. We were unable to experiment along these lines in Alberta, since there was no water available for irrigation during the outbreak. We quote, therefore, from the description given by Dr. Wilcox:—

"A ditch should be ploughed through the field somewhat in front of the advancing army. The ditch should be so laid out that the fall is considerable and as regular as possible. It is advisable to make the banks of the ditch as steep and as smooth as may be. There should be no sharp curves or other obstructions which might produce an eddy, or dead water. The width ought not to be less than a foot at the bottom. The water should be about 6 inches deep, and the ditch ought not to be level full."

"According to our experience it is necessary not only to have smooth ditches with a regular fall, but also to shovel out the worms occasionally where there is danger of them damming the stream. Nor is this all. The worms should be killed. By actual experiment we determined that a large proportion of the worms remained alive when submerged in water for forty-eight hours, and

some few kept alive for three days. The apparently dead worms from the bottom of the ditch began to move within a few minutes after they were exposed to the air."

CONTROL MEASURES SOMETIMES RECOMMENDED BUT UNSUITABLE TO PRAIRIE CONDITIONS.

Trapping in post holes.—A method of trapping larvæ in post holes bored at intervals of one or two rods along prepared furrows has been used with success in controlling local outbreaks of the Army-worm, and has been occasionally recommended to prairie farmers. This method entails too much expensive labour for large fields, for besides the labour involved in boring the post holes, the larvæ trapped must be destroyed.

Lantern traps for the adults.—Suggestions of various traps for use in the fields, when the moths of this species are flying, have been made from time to time in the local press and elsewhere. As we have shown in discussing the habits of these moths, such traps would be of so little value that they would certainly not pay for the expense of running them.

Where they might be of value would be near houses and in other places where the moths swarm before they return to the fields in September.

Rolling.—Crushing the larvæ with a heavy roller is sometimes advocated, but this is rarely practicable under southern Alberta conditions. It is of value only when cutworms are on the surface of hard unbroken soil. On land which has been recently worked the majority of larvæ are simply pressed into the loose soil, while many of them are subjected to no pressure at all.

A float drawn over such places would be more effective than a roller, since the action is then more one of grinding than of simple pressure.

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