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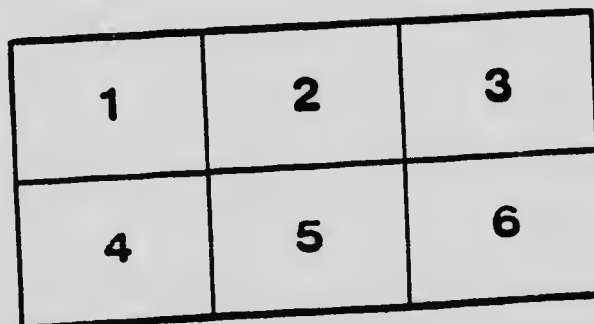
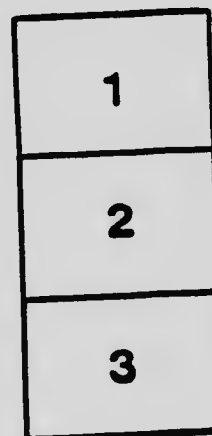
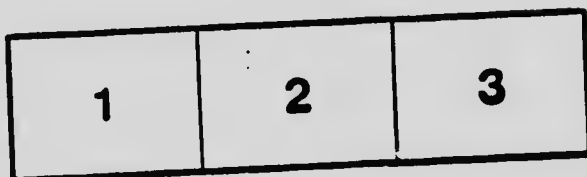
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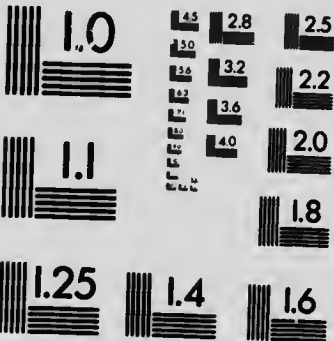
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THE ARMY-WORM

Cirphus (Leucania) unipuncta Haw.

BY

ARTHUR GIBSON

Chief Assistant Entomologist.

BULLETIN No. 9.

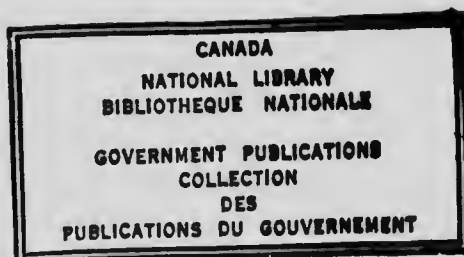
Published by direction of the Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa.

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NOTE.

Farmers and others are invited to send specimens of insects which are found causing injuries to their crops. Such specimens should be enclosed with a supply of food plant or grass in a tin or wooden box, (not a paper box) which may be mailed "Free", up to 12 ounces in weight, if addressed to the Dominion Entomologist, Department of Agriculture, Ottawa. In all cases the specimens should bear the address of the sender, and should be accompanied by a letter giving the crops which are being attacked and the extent of the damage.

OTTAWA, January 26, 1915.

To the Honourable
The Minister of Agriculture,
Ottawa.

Sir,—I have the honour to submit for your approval Entomological Bulletin No. 9, on "The Army-worm, *Cirphus (Leucania) unipuncta* Haw.", which has been prepared by Mr. Arthur Gibson, Chief Assistant Entomologist, who has charge of investigations on insects affecting field crops.

The outbreak of the army-worm in 1914 in Eastern Canada, and especially in the affected regions in Ontario, will be long remembered by those whom it concerned. Of all native insects that periodically increase in numbers sufficiently to constitute an outbreak of economic importance, the army-worm is perhaps one of the most spectacular. Fortunately, it can be readily controlled if the control measures are known and immediately carried out. Ignorance of control measures, delay and lack of co-operation in their execution will always mean very serious loss.

The last serious outbreak of the army-worm in Canada occurred in 1896. The outbreak of last year enabled us to demonstrate the value of modern control measures, by far the more efficient of which is the trench, when correctly made. In this bulletin the habits and life-history of the insect and the control measures are fully described and illustrated, and we hope that the distribution of this practical information will enable agriculturists to be fully informed on the subject when future outbreaks occur.

While the losses occasioned by the outbreak were considerable, amounting in Ontario alone to over one-quarter million dollars, the prompt action of our officers, especially our Field Officer, Mr. H. F. Hudson, and of the officers and district representatives of the Ontario Department of Agriculture, prevented a much greater loss. I should like to take this opportunity of impressing upon the agriculturists who may be affected by future outbreaks the necessity of immediate action and of the greatest co-operation among neighbouring farmers, a policy which is of the utmost importance in all efforts of this kind.

I have the honour to be, Sir,
Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

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The Army-worm, *Cirphus (Leucania) unipuncta* Haw.

By ARTHUR GINSON, Chief Assistant Entomologist.

SUMMARY.

The army-worm is a smooth cutworm-like caterpillar belonging to the family Noctuidae, the moths of which are known popularly as the "owlet moths." When full grown it is about one and one-half inches long, with conspicuous stripes along the body. On either side are three stripes which are wide and very distinct, the central one being blackish and the upper and lower ones of a yellowish colour, more or less flushed with red.

In ordinary years of abundance the army-worm feeds on wild, succulent, rank-growing grasses, and it is in low-growing situations, where such grasses flourish, that the female moths chiefly deposit their eggs. A single female moth is capable of laying as many as 700 eggs. When, owing to certain natural factors, such as suitable weather conditions, absence of parasites, etc., the army-worms increase in enormous numbers the food in such breeding places becomes exhausted, and it is then that the caterpillar assumes the marching habit owing to which it was given the popular name of the "army-worm." When such outbreaks occur, as was the case in 1914, the worms migrate to cultivated crops, such as oats, corn, barley, wheat, etc., and very often before the farmer is aware of their presence, serious losses take place.

Two annual broods occur in Canada, the moths appearing in June and again in autumn. Eggs are laid by the late-appearing moths, and the caterpillars from these pass the winter in a partly grown condition. The destructive brood of caterpillars appears in July and early August.

In 1914, the estimated damage caused by the ravages of the army-worm in Eastern Canada amounted to \$300,000. Five-sixths of this loss should refer to the province of Ontario, the balance of \$50,000 being losses occasioned in the provinces of Quebec, New Brunswick, and Nova Scotia.

Among the methods of control, the digging of trenches at least ten feet deep in advance of the caterpillars' line of march, in which post holes were made to trap the worms, proved the best remedy in 1914. When in the post holes they are easily killed by pouring coal-oil over them, or by crushing them by means of the blunt end of a piece of fence rail. The poisoned bran mash used for cutworms was also found useful in some localities. Spraying the edges of crops towards which the worms are approaching with a strong Paris green or arsenate of lead solution, may be used to good advantage, particularly where it is impossible to plough proper trenches. As a preventive measure it is a wise practice to burn over in the autumn following an outbreak of the army-worm in any locality the old grass and stubble, and then plough deeply.

Large numbers of parasitic and predaceous insects prey upon the army-worm, and these and other natural agencies have in the past controlled outbreaks and prevented serious losses in the same locality two years in succession. Many of our native wild birds are fond of the worms and will devour large numbers of them. Domestic poultry are also very useful, as are, in addition, toads and skunks. Diseases, both bacterial and fungous, are also known to attack the caterpillars.

INTRODUCTION.

There are several caterpillars in Canada to which the name "army-worm" is erroneously applied. For instance the tent-caterpillars are often spoken of as the army-worm, and the same may be said of certain of the cutworms, as for example the Variegated Cutworm, which some years appears in large numbers and assumes the marching habit, owing to the scarcity of food. During 1914, the Sugar-beet Webworm, *Loxostege sticticalis*, was destructive in the provinces of Manitoba and Saskatchewan and was seen to be crossing roads in army-like fashion, owing to which, it was called by farmers the "army-worm." In certain parts of British Columbia, notably in the northern section of the Okanagan, the Alfalfa Looper, *Phytometra (Plusia) californica*, was remarkably abundant and was referred to as the "army-worm." This name, however, should only be applied to the caterpillar of *Cirphus unipuncta*.

The army-worm has long been known to devastate crops in the United States and Canada. It has a world-wide distribution occurring, in addition to North America, in South America, Azores, Maderia, Canaries, England, Europe, Asia, Australia, and New Zealand.



FIG. 1.—Ten-acre field of corn, near Kinburn, Ont., showing destructive work of army-worm. (Original).

As to the first army-worm year, 1743 has been recognized by entomologists as the earliest year of which we have the most authentic information. In that year Mr. John Bartram,* under date of July 16, in describing the welcome given him by the Indians at a place called Tohicon, which lay on a branch of the Susquehanna river, records injury by worms to "maize and long white grass so that the stems of both stood naked 4 foot high." The worms were described as dark-coloured grubs half an inch long. He further states: "They clear all the grass in their way in any meadow they get into." Under date of July 28, the following is recorded: "News came that the worms had destroyed abundance of corn and grass in Canada." The following extract is from the Journal of the Rev. Thomas Smith, Falmouth, Me., and refers to the outbreak of worms in the same year: "June 27, 1743. There are millions of worms, in armies,

*Observations on the Inhabitants, Climate, Soil, Rivers, Productions, Animals, and other matters worthy of Notice, made by Mr. John Bartram in his Travels from Pensilvania to Onondago, Oswego, and the Lake Ontario in Canada. London: printed in 1751.

appearing and threatening to cut off every green thing; people are exceedingly alarmed."

In the United States, in certain years, the army-worm has destroyed crops to the value of many thousands of dollars. In 1861, in Massachusetts, the damage caused by the caterpillars was estimated at \$500,000, and in 1881, the oat crop of Indiana and Illinois was destroyed to the extent of \$750,000. Serious outbreaks have also occurred in Canada from time to time, notably in 1861, 1875, 1881, and 1896.

From a study of the records of injury caused by the army-worm in Canada, it would appear that in no year has more injury been caused and such widespread infestation observed than in the year 1914. Farmers in the eastern provinces, particularly in the southern portion of Ontario will long remember the devastating hordes of the army-worm which attacked their fields of oats, corn, barley, etc., in the latter half of July and during August. In many districts in Eastern Canada, the infestation was light, and in such places, apparently, little damage was done. Fortunately, too, the caterpillars appeared at a time when many fields of grain, such as oats and barley, were approaching maturity, owing largely to the dry season which forced the growth. The army-worm naturally feeds on succulent plants such as rank-growing grasses, and consequently the leaves of grain crops, when these become hard and dry owing to maturity are by no means relished.

The worst previous outbreak in Canada of which we have definite knowledge was in 1896, but in that year the injury was largely confined to the province of Ontario. During 1914, however, not only was the army-worm present in Ontario throughout the whole province, but widespread and serious infestations also occurred in the provinces of Quebec, New Brunswick, and Nova Scotia.

No evidence was at hand which would indicate that this widespread infestation would occur. Reports of the presence of the worms were not received until they were found by the farmers in their fields of oats, corn, etc., when assistance was immediately solicited from the department in the matter of control measures. The only recent record which we had was one which referred to an outbreak in Manitoba in 1913. This occurred near Treesbank, Man., where in August the army-worms were in great abundance, particularly in a large field of oats, which had been practically stripped of all leaves. Mr. Norman Criddle, in charge of the Entomological Field Station at Treesbank, estimated that the average damage where the worms occurred was about 20 per cent, and the greatest damage 50 per cent.

In almost every instance where invasions of this insect have occurred in Canada, the injury has been done by the brood of caterpillars which appeared in July and the beginning of August. Fortunately, the army-worm is seldom abundant in enormous numbers in the same locality for two years in succession. After an outbreak, many parasitic insects, as well as parasitic diseases attack the caterpillars and bring their numbers again down to normal. Although it is not altogether thoroughly understood how such insects increase in numbers so suddenly, it would appear that dry weather is favourable to their development. This was instanced in one of the more recent of the serious outbreaks of this insect which we have had in Canada. In Ontario, the season of 1895 was dry and this was followed by a mild winter and another dry summer in 1896. In this latter year the army-worm was present in very large numbers, particularly all through the western part of the province, and devastated fields of oats, timothy, wheat, rye, barley, and corn. In the following year (1897) not a single report of the presence of the insect was received.

DESCRIPTION.

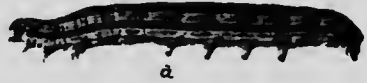
Like other kinds of moths, there are four stages in the life-history of the army-worm.

The Egg.—This is globular, or round, in shape, smooth, white or pale yellowish; about 0.5 mm. in diameter (one twenty-fifth of an inch).

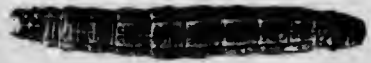
The Larva.—When hatched the young caterpillar is whitish in colour with indistinct tubercles from each of which is a pale hair. As it increases in size, it passes through several moults, the colour soon after feeding becoming greenish, and later brownish or blackish; longitudinal stripes appear and, in the case



FIG 2.



a



b

FIG 3.

Fig. 2.—Eggs of the army-worm moth, natural size and much enlarged. (Redrawn after Riley).

Fig. 3.—Mature army-worms, enlarged one-quarter: a, showing conspicuous bands on side; b, showing stripes on back. (Original).

of the mid-summer brood, in about a month from the time of hatching, it is full grown and ready to enter the ground for pupation. At this time it is about an inch and a half long, smooth, the back being of a greenish-brown or blackish colour, with three pale yellowish or whitish stripes above, one down the middle and the others on either side of the back. The central of these stripes is edged on both sides with black, and the two others bordered above with a narrow band of the same colour. On each side of the body are three conspicuous wide bands, the median one being blackish and the upper and lower ones of a yellowish colour, more or less flushed with red. Touching the upper edge of the blackish band is a white stripe. The under surface of the body is dull greenish, with dark brownish or blackish streaks and spots. The head is brown, with two distinct, curved, blackish bars down the centre of the face. The sides bear a network of brown. In width, it is slightly less than one-eighth of an inch. The front six legs are light brown in colour, the posterior five pairs of legs being of the same colour as the underside of the body. Each of the four anterior pairs bear on the outside a large, shiny, blackish spot. The caterpillars vary considerably in general colour and intensity of the markings, some specimens being much paler than others.

The Pupa.—Reddish-brown in colour, from about 15 to 19 mm. in length (three-fifths to four-fifths of an inch), 5 to 6 mm. in width (one-fifth of an inch) at widest part. At the pointed end, are two stiff blackish spines curled at the tips, and close by four additional shorter spines also curled at the tips, but these are slender and not nearly so conspicuous.

The Moth.—This is about from an inch and a half to rather more than an inch and three-quarters in width when the wings are spread. The fore-wings are of a reddish-gray, or fawn colour, speckled with black. About the centre of each wing there is a distinct white spot. The round and kidney-shaped spots are indistinct in some specimens, but appear as two yellowish-red patches. A row of small black spots near the outer margins of the wings and a dark streak from each apex to these spots completes the important markings. The hind wings are mostly brown, darker at the outer margins and whitish towards the base, the veins being blackish. The thorax is of the same colour as the fore-wings and the abdomen is similar to the hind wings. When the moth is at rest the fore-wings are folded back over the hind wings.



FIG. 4.—*a*, Earthen cocoon, in which army-worm changes to pupa; *b*, pupae, ventral and lateral aspects; natural size. (Original).



FIG. 5.—Moths of army-worm, natural size: *a*, with wings spread; *b*, at rest. (Original).

LIFE-HISTORY AND HABITS.

BREEDING PLACES

In most of the outbreaks investigated, the injury was chiefly done in low-lying areas, and there seems no doubt but that the eggs were laid in such areas and that the caterpillars fed quietly and unnoticed until they were large enough to become active, when migration began and they assumed the well-known marching habit. The fact of their occurring in such localities was also referred to by correspondents. In an outbreak which I investigated near Ottawa, the army-worms were extremely numerous in a large corn field. Directly opposite the middle of the western side of this field is a rather wide ditch in which weeds and grasses, such as couch and timothy, had been growing luxuriantly. Examination showed that the worms had undoubtedly flourished in their younger stages in the ditch. The leaves of the couch grass, timothy, etc., had been wholly eaten, only the stems remaining, and the feeding could be traced along the ditch to the corn field, where opposite the ditch the initial injury to the corn took place.

It is difficult, however, for the farmer to understand how the army-worms reach fields of grain, such as oats, etc., growing on comparatively high land. During the recent outbreak many fields were visited, and from appearances

it would certainly seem that the caterpillars had emerged from eggs laid in such fields, immediately near which there were apparently no ditches nor any low-lying land. In this connection, however, we must remember that a large low-lying area is by no means necessary as a breeding ground for the worms. Any low area where grass is growing rank, even only of a few square yards, on higher ground, in a meadow or pasture field, is large enough to furnish a breeding ground for many thousands of caterpillars. An army of worms breeding in such a small space soon devours the immediate food supply and naturally begins to spread in search of further succulent food. They travel chiefly in early evening and during the night, and when for any reason the food supply is not to their liking, considerable distances are traversed by them.

NUMBER OF BROODS.

In Canada, there are two annual broods of the army-worm, the moths appearing in June and again in August and September, specimens even occurring abundantly some years in October. Those which emerge in late summer lay eggs which hatch in about ten to twelve days. The young larvæ winter in a partially grown condition beneath tufts of grass and other low herbage, and in spring complete their growth, feeding chiefly on grasses. In June, moths from these caterpillars appear and lay eggs producing another brood of caterpillars. A single female moth is capable of laying as many as 700 eggs. They are deposited in rows or patches (see figure 2) on wild or cultivated grasses—corn, etc., and in about a week the young larvæ appear. These, at first, are greenish in colour, and loop when walking.

FEEDING HABITS.

When cultivated crops are attacked and the food is in plenty, the worms hide, during bright, sunny days, beneath pieces of earth, sod, etc., near the bases of oats or other grain plants upon which they have been feeding. In the case of corn plants, not only do they hide on the ground near the plants, but they will also be found between the curled leaves. With corn the tender young inner leaves are particularly relished by the worms.

In years of ordinary prevalence the general habit of the army-worm is to feed in the evening and during the night. On dull days, however, during seasons of abundance, when it has migrated to fields of grain crops, it may be commonly found on the stems devouring the leaves or cutting off the heads. In such years of prevalence the army-like habit is assumed, owing to the enormous numbers of the worms causing a shortage in the food supply. At such times, as was the case in 1914, huge armies were frequently seen crossing roads and travelling in the direction of fields of grain, etc. They were seen to cover a distance of two feet in a minute. The caterpillars at the time of such migrations were from about one-half to two-thirds grown. When hungry, the worms feed actively during the day as well as during the night. In the 1914 outbreak in western Ontario, Mr. H. F. Hudson, Field Officer of the Branch, found that in the morning the worms were quiet and not feeding to any extent, but that they were very active towards maturity, between the hours of 2 p.m. and 5 p.m.

PUPATION.

When the army-worm reaches maturity it enters the ground to a depth of an inch or so and, after making an earthen cocoon, or cell, changes to a reddish-brown pupa about four-fifths of an inch in length (see figure 4 *a* and *b*), and in about from two to four weeks the moths emerge. In western Ontario (1914) the first pupa was found, on July 16, one-half an inch below the surface, and

numbers of the worms were pupating three days later. Larvæ collected at Carp, near Ottawa, pupated on July 24; in Digby County, N.S. (1914), where the outbreak appeared later, I found the larvæ pupating on August 13.

In one instance, at Smith's Cove, N.S., I observed the worms preparing to pupate beneath boards lying on the road side. Mr. George E. Sanders, in charge of our Field Laboratory at Bridgetown, N.S., states that he found the worms pupating, on the average, about 1 inch below the surface of the ground; some specimens in hard ground pupated right at the surface, while others were found 2 inches down. None were found deeper than 2 inches. In New Brunswick (Queen's county), Mr R. P. Gorham, of the Provincial Department of Agriculture, informs me that worms were seen to be pupating on August 17. In St. John county, in the same province, larvæ were changing to pupæ on August 26, and as late as the first week in September. In our breeding cages at Ottawa the pupal stage, in 1914, varied from eighteen to twenty-eight days, three weeks being about the average pupal period. The adult moths conceal themselves during the day, but at night they are very active, flying about and being readily attracted to the well-known "sugar," a bait applied to trees by collectors of insects for the purpose of collecting noctuid moths.

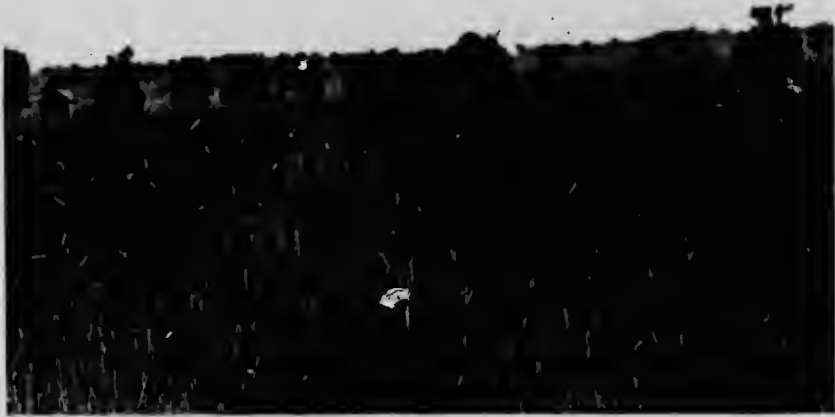


FIG. 6.—Field of oats near Carp, Ont., largely destroyed by army-worms. (Original).

The complete life-history of the army-worm in Canada is not fully known. There are several points concerning which further information is desired. It would seem, owing to the late date in autumn, in certain years when the moths are abundant, that some may pass the winter in this stage. We have no definite data that this ever happens in Canada, nor have we any facts indicating that the insect may hibernate as a pupa.

FOOD PLANTS.

The usual food-plants of the army-worm are the wild, native grasses which flourish in low-lying areas. In such places the growth is rank and luxuriant, and in ordinary years of abundance the caterpillars find food in plenty. When, however, owing to favourable conditions the insect increases in extraordinary numbers, the food in the natural breeding places is not sufficient for the hungry hordes, and the caterpillars migrate to crops grown by man.

On the marsh lands along the St. John river in New Brunswick, the favorite food of the larvæ in 1914 was the grass known locally as "Sheep's Skin," which, according to Dr. M. O. Malte, Dominion Agrostologist, is a creeping form of Red Top, *Agrostis stolonifera*. This grass, I am informed by Mr. R. P. Gorham, Department of Agriculture, Fredericton, N.B., was the one species that was most generally eaten, right to the sod in nearly every case. Another common grass, known locally as "Bank Grass," was also eaten with avidity. Specimens of this grass have been determined by Dr. Malte as *Spartina Michauxiana*. It is a common species in the coast districts of the Maritime Provinces, and in Gray's Manual of Botany the common name is given as Slough Grass. Common timothy, the chief grass on the higher banks of the marsh lands, was scarcely eaten at all. At Carp, Ont., on August 21, couch grass was seen by me to have been freely eaten. In a field of barley, where much of this grass was growing it was noticed to have been largely chosen as food by the worms. Little damage had been done, in this instance, to the barley. In a large ditch at the same place, couch grass and other weeds, including mustard, were completely defoliated. Near Treestbank, Man., in 1913, Mr. Norman Criddle found the army-worm feeding freely upon Green Foxtail, *Setaria viridis*, leaving in most instances, only the heads. This weed, which is becoming a pest of considerable importance, was growing freely in a field of oats in which the army-worms were present.

In Nova Scotia, the crops most attacked, in 1914, were oats, barley, corn, and wheat, and to a slight extent timothy, clover, rape, mangels, and turnips. In New Brunswick, in addition to the grasses above mentioned, oats were freely attacked and, in some places, corn and pasture lands suffered to a noticeable extent. In Quebec province, the caterpillars attacked oats, barley, wheat, corn, and timothy. In the province of Ontario, of the definite reports of damage to cultivated crops received at the Entomological Branch,

43	per cent.	referred to injury to	oats,
17	"	"	corn,
16.5	"	"	barley,
12.5	"	"	hay and pasture,
2.5	"	"	wheat,
2	"	"	peas,
1.5	"	"	clover,
1.5	"	"	mangels,
1.5	"	"	millet,
0.5	"	"	rye,
0.5	"	"	alfalfa,
0.5	"	"	beets,
0.5	"	"	turnips.

Of these crops it will be seen that in 1914 oats were decidedly the crop most attacked, corn, barley and hay being the other crops which suffered most. These were also the crops which were chiefly devastated in Ontario during the outbreak of 1896.

In addition to the crops mentioned above, such garden vegetables as beans, lettuce, and onions have been eaten. These, however, are seldom touched if any of the grasses are available.

NATURAL ENEMIES OF THE ARMY-WORM.

PARASITIC INSECTS.

In years of abundance the army-worm is freely attacked by dipterous and hymenopterous insect parasites. During the 1914 outbreak large numbers of these useful insects were present in the eastern provinces. The following species of parasites were reared.

TACHINIDÆ.

The Red-tailed Tachina fly, *Winthemia quadripustulata* Fab., was extremely numerous and rendered most valuable service in destroying army-worms. This fly deposits its white, seed-like eggs usually upon the fore-parts of the living worms. During the 1914 outbreak of the army-worm the presence of these eggs on the caterpillars was readily observed, large numbers of the flies being present throughout the infested areas. In some fields it was estimated that from 60 to 70 per cent of the larvæ bore eggs. The number of eggs deposited on a single worm ranged, on the average, from two to five. A very much larger number of eggs are sometimes deposited on one caterpillar; in fact, as many as fifty are stated to have been found on a single larva. Many of the eggs, however, are laid on the caterpillars about the time they are moulting, and the old skins bearing the eggs are cast off. All of the young tachinid fly maggots, therefore, do not reach the body of the army-worm. The young maggots which succeed in hatching on the caterpillars immediately enter the body, feeding entirely within and gradually kill the host. Very often one army-worm will be sufficient food for several of these fly maggots. Professor L. Caesar, Provincial Entomologist for the province of Ontario, informed me that during the recent



FIG. 7.—a, Army-worm bearing eggs of Red-tailed Tachina fly; b, Red-tailed Tachina fly, *Winthemia quadripustulata* Fab.—both enlarged one-third. (Original).

outbreak he reared four of these tachinid flies from a single army-worm upon which six eggs had been deposited. From another worm which bore thirty-eight eggs, ten mature larvæ ready to pupate were obtained. Caterpillars bearing the eggs were kept under observation by Mr. H. F. Hudson at the Dominion Entomological Laboratory at Strathroy, Ont., and in no cases did he succeed in obtaining more than one tachinid fly per host, although several of the caterpillars had as many as five eggs deposited upon them. At this laboratory the flies emerged from August 20 to August 26. In our breeding cages at Ottawa, from army-worms collected at Carp, Ont., the first specimen of the Red-tailed Tachina fly emerged on August 19, and other specimens issued on August 21, 23, 24, 26, 28, and one specimen on October 13. The maggot of this latter changed to puparium on September 24, the stage, therefore, lasting in this instance nineteen days. At the Dominion Entomological Laboratory at Vineland, Ont., Mr. W. A. Ross, Field Officer in charge, reared the adult flies on the dates August 10 to August 15. At Ottawa we also reared this tachinid from larvæ received from Mahone Bay, N.S., the date of issue being August 25. Prof. Brittain also reared the species from Nova Scotia army-worms, the date of issue being October 8.

Phryxe (Exorista) vulgaris Fall.—This species has been reared from larvæ collected in Nova Scotia and New Brunswick. At Smith's Cove, N.S., 2 per cent of larvæ collected by Mr. G. E. Sanders, Field Officer of the Branch, were parasitized, the adults issuing during September. Adults were also collected in fields where the army-worm was present, near Digby, N.S., by Mr. C. A. Good, of the Provincial Department of Agriculture. The writer also collected the species in an infested army-worm field at Smith's Cove, N.S., August 15. In New Brunswick, flies were reared by Mr. R. P. Gorham, the Provincial Assistant Horticulturist, from army-worms collected in King's county, specimens emerging on September 11, 17, and October 1.

Phorocera (Euphorocera) claripennis Macq.—This species was reared at the Ontario Agricultural College, Guelph, by Mr. A. W. Baker. It is a well-known enemy of caterpillars. Coquillet, in his compiled list of tachinid flies and their hosts,¹ gives 26 hosts, none of which, however, refer to the army-worm.

Wagneria (Phorichata) sequax Will.—Also reared at Guelph, Ont., by Mr. A. W. Baker. This species is also known to attack other caterpillars. It has been reared in Michigan from the Black Army-worm, *Noctua fennica* Tausch.

BRACONIDÆ.

Among the braconid four-winged flies are some important species which attack the army-worm, and which were present in Eastern Canada in 1914. These flies, owing to their small size, are inconspicuous, but they are extremely useful parasites. Their larvæ live within the bodies of the army-worms, and when mature they leave the caterpillars and spin loose, white, or yellowish, egg-shaped cocoons. These cocoons, when noticed by farmers, are often mistaken for the eggs of insects.

Apanteles militaris Walsh.—The most abundant species which occurred during the recent outbreak of the army-worm was the one known as *Apanteles militaris*, which makes a loose, white cocoon, many of which were seen massed together. This species was reared in our breeding cages, and Mr. A. W. Baker, of the Ontario Agricultural College, informs me that the cocoons were commonly noticed in all counties of Ontario which he visited. Mr. H. F. Hudson, Field Officer of the Branch, reported that the cocoons were fairly abundant on July 19. This species has long been known as an enemy of the army-worm.

Apanteles sp.—In Nova Scotia, Mr. G. E. Sanders, Field Officer of the Branch, reared an *Apanteles* which makes a loose, very pale yellowish cocoon. Army-worms collected at Smith's Cove, N.S., were parasitized to the extent of 2 per cent. Specimens of the adults submitted to the Bureau of Entomology, Washington, D.C., were returned unnamed. At our Entomological Laboratory at Bridgetown, N.S., specimens of the adults emerged from the cocoons on September 22.

Apanteles limenitidis Riley.—Although we did not actually rear any of these parasites from the army-worm in 1914, clusters of the conspicuous yellowish cocoons occurred in fields near Fitzroy Harbour, Ont., not very far from which locality reports of the presence of army-worms were received. On one farm our correspondent reported that the ground was thickly covered with the cocoons. From material forwarded to the Branch, adults emerged on November 3, some of which have been determined by Mr. A. B. Gahan, of the U. S. Bureau of Entomology, as *Apanteles limenitidis*. The form *flaviconche* Riley is supposed to be parasitic on the army-worm.

Meteoris communis Cr.—Mr. A. W. Baker, of the Ontario Agricultural College, Guelph, informs us that he reared this parasite from the army-worm in 1914. He states that it was not very common.

¹ Bull. Tech. Series No. 7, Div. of Ent., U. S. Dept. Agriculture.

ICHNEUMONIDÆ.

Several species of ichneumonid flies which are much larger than the braconid flies are also important parasites of the army-worm. The female ichneumon fly, with its long ovipositor, punctures the skin of the caterpillars and lays its eggs within. The young maggots from these eggs soon hatch and at once begin to feed upon and live inside of the army-worm. The caterpillar, however, is able to complete its growth, the parasites emerging from the pupæ. The following ichneumonids were reared in 1914:—

Paniseus geminatus Say.—At the Ontario Agricultural College this ichneumonid parasite was bred from material collected at Guelph. Mr. A. W. Baker states that it was very common in that locality. This species attacks also other smooth noctuid caterpillars. At the Entomological Laboratory at Treesbank, Man., Mr. Norman Criddle, Field Officer in charge, reared the parasite from the Red-backed Cutworm, *Euxoa ochrogaster*, the date of emergence being July 21, 1914.

Pimplidea pedalis (Cress).—Prof. W. H. Brittain, Provincial Entomologist for Nova Scotia, informs us that this species was reared in his department from the army-worm collected in Nova Scotia in 1914. It attacks a number of different kinds of caterpillars.

Ichneumon canadensis Cr.—This species was evidently abundant throughout the infested districts in Eastern Canada. Mr. A. W. Baker states that it was "common at Guelph, Ont." The species was also fairly plentiful in Nova Scotia. Pupæ of the army-worm collected at Smith's Cove, N.S., by Mr. G. E. Sanders, Field Officer of the Branch, were parasitized by this ichneumon to the extent of 2 per cent, and 200 pupæ collected at Granville Ferry, N.S., to the extent of 6 per cent. Prof. W. H. Brittain, Provincial Entomologist for Nova Scotia, informs me that he also reared the species.



FIG. 8.—Ichneumonid parasites: a, *Ichneumon lactus* Br.; b, *Ichneumon canadensis* Cr.—both enlarged one-third. (Original).

Ichneumon lactus Br.—This parasite was reared in numbers at the Entomological Field Laboratory, Bridgetown, N.S. Two hundred pupæ of the army-worm collected at Granville Ferry, N.S., on September 5 by Mr. G. E. Sanders, Field Officer of the Branch, were parasitized to the extent of 10 per cent, by the species. Prof. Brittain also reports the rearing of it from Nova Scotia pupæ. Mr. H. G. Payne, of the Provincial Department of Agriculture, forwarded to me specimens of this ichneumon fly, which he noted on October 4 to be very abundant at Granville Ferry, N.S., in fields which were infested by the army-worm in August. In New Brunswick this parasite also occurred, specimens being forwarded to the Branch by Mr. R. P. Gorham, of the Provincial Department of Agriculture.

Ichneumon jucundus Br.—Mr. A. W. Baker informs us that this species was reared in numbers in the Entomological Department at the Ontario Agricultural College. He reports that it was common in the Guelph district.

Ichneumon leucaniæ Fitch.—It is surprising that no specimens of this well-known ichneumonid parasite of the army-worm were reared in our laboratories in 1914. In the previous outbreak in 1896 this species was present in the province of Ontario.

PREDACEOUS INSECTS.

Among the predaceous insects which prey upon the army-worm, the ground beetles of the genus *Calosoma* are of much importance. These beetles hunt out the worms and eagerly devour them. The Common Fiery Hunter (*Calosoma calidum* Fab.) was abundant in 1914, and was frequently seen in the furrows or post holes where such control measure was adopted. In western Ontario the closely allied species known as the Searcher (*Calosoma scrutator* Fab.) was also commonly observed to be eating the worms. Another common carabid beetle which is known to attack the army-worm is the Large Harpalus (*H. caliginosus* Fab.).



FIG. 9.—Predaceous Beetles: a, Common Fiery Hunter, *Calosoma calidum* Fab.; b, Large Harpalus, *H. caliginosus* Fab.—both natural size. (Original).

DISEASES.

Bacterial Disease.—In Ontario in 1914 large numbers of the army-worm were destroyed by a bacterial disease. Mr. H. F. Hudson, Field Officer of the Branch, reported that the disease was very apparent at the time the caterpillars were approaching full growth. Diseased worms were particularly observed at Burford, Brant county, and at Princeton, Oxford county, Ontario. In one experiment, 100 apparently healthy specimens were collected by Mr. Hudson, taken to the laboratory and confined in two breeding cages, with abundance of food. Two days later all but two were dead from the disease.

Fungous Disease.—A parasitic fungus of the genus *Empusa* is known to attack the army-worm, but we have received no reports of the presence of any fungus during the 1914 outbreak. In the Ottawa district, cutworms of several kinds were attacked by a fungus of the genus *Sorosporella*.

VERTEBRATE ANIMALS.

Birds.—The wild birds are an important aid in outbreaks of noctuid caterpillars, and in 1914 large numbers of army-worms were devoured by them. Blackbirds were frequently noticed feeding upon the caterpillars in Ontario, and also in New Brunswick, as were also crows. During a local outbreak of the army-worm near Treesbank, Man., in 1913, Mr. Norman Criddle, Field Officer of the Branch, observed, in August, thousands of crows feeding upon the larvæ. They were also seen to dig out and eat the pupæ. A large flock of probably three thousand birds visited the infested locality every day from the time Mr. Criddle first noticed the worms until at least two weeks after the larvæ had pupated. In western Ontario, the English sparrow was reported to have fed freely upon the worms during the past season, and in Nova Scotia the writer saw the Vesper sparrow devouring the caterpillars. Other wild birds which previously have been seen to feed upon the army-worm are the Bobolink, Robin, Meadow-lark, Bluebird, Kingbird, Blue Jay, Flicker, Cat-bird, Phoebe, Cowbird, Baltimore Oriole, Chipping sparrow, Chickadee, and Quail. The Sharp-tailed Grouse, common in Manitoba, feeds on smooth caterpillars, and doubtless

would devour the army-worm. The same statement undoubtedly holds good for other birds than the above mentioned, which find their food in the open. The value of protecting our native insectivorous birds will thus be readily seen, and farmers, gardeners, etc., should do all they possibly can to protect them from being shot and their nests from being robbed.

Domestic Poultry.—In many districts where the army-worm was present in 1914, domestic poultry were noticed to feed freely upon the caterpillars. From Essex county, Ontario, reports were received of the value of ducks and turkeys in consuming large numbers. One farmer in Wentworth county, Ontario, turned his geese and ducks into infested fields, and these lived on the worms for nearly three weeks. At Bear River, N.S., on August 11, I saw a portion of a barley field near a dwelling-house into which hens had been turned, and these were doing splendid work in destroying the larvæ. In Ontario, numbers of the worms were also eaten by pigs, some farmers reporting that the caterpillars were much relished by these animals.

Toads and Skunks.—In addition to the above other vertebrate animals are known to eat the worms with avidity, such as, for instance, toads and skunks. Both of these animals feed on many kinds of injurious insects, and should, therefore, be protected. In the Twelfth Report of the New York State Entomologist it is recorded that the remains of fifty-five army-worms were found in the stomach of one garden toad. In Farmers Bulletin No. 587, United States Department of Agriculture, it is stated that the skunk is the best known mammal enemy of army-worms. In the 1896 outbreak of the army-worm in Pennsylvania, many farmers testified to the value of skunks in devouring these caterpillars. In other parts of the United States similar statements have been made.

METHODS OF CONTROLLING THE ARMY-WORM.

In dealing with outbreaks of the army-worm the important essentials are *promptness* and *thoroughness of action*, if crops are to be saved from its ravages.

Trenches.—In the outbreak of the army-worm in western Ontario in 1914 it was found that the important method of control was the ploughing or digging of trenches in advance of the caterpillars' line of march. Ordinary furrows 3 or 4 inches deep were found to be useless. The trenches should be at least 10 inches deep—14 inches is better—and throughout their length post holes at least from 1 to 2 feet in depth should be dug every 15 feet. As the main roots of grass and grain plants extend at least 6 inches below the surface, the importance of the deep ditch will readily be seen. Otherwise, the worms will crawl up the roots and escape from the furrow. The side of the trench nearest the crop to be protected should be straight, trimmed, if necessary, with a spade. In the recent outbreak it was found that in clay, or even muck land, it was necessary as soon as the trench was dug to rake the straight side, with an ordinary garden rake, in order that the soil as it dried and became crumbly would fall off with any worms which attempted to climb up. Such raking is important, otherwise the soil becomes baked like cement and many of the worms will crawl up the side and reach the crop to be protected. When the army-worms reach the trench they are blocked by the straight side and at once change their course, wandering along in the trench until they reach a post hole, into which they fall. When thus trapped they are easily destroyed by pouring coal-oil into the hole, or by crushing them by means of the blunt end of a post. Many farmers in the recent outbreak who used coal-oil, ignited the oil, thus having the added satisfaction of watching their enemy burn.

The value of co-operation in fighting injurious insects was again very apparent during the recent outbreak in western Ontario. It was most encouraging to see the spirit of co-operation which was present among the farmers, in the districts where serious damage was being done. Near Princeton, Oxford county, at the time of Mr. Hudson's visit, July 19, twenty-five farmers and six teams were at work digging a proper trench, and on this occasion it was amply demonstrated that no matter how big the armies of worms approaching might be, that they could be controlled by trenches correctly made. Another interesting record is the fact that on Sunday afternoon, July 26, fifty men



FIG. 10.—Showing army-worms escaping up the side of a furrow. The ditch should have been deeper and the side trimmed with a spade. (Original).

congregated on one farm in the township of West Zorra, Oxford county, to assist in the making of trenches. This instance of co-operation was reported to us by Mr. G. R. Green, District Representative of the Ontario Department of Agriculture.

In the province of New Brunswick, as mentioned on page 28, ditches were dug in one instance by means of a traction ditcher. These ditches varied from 16 inches to 2 feet in depth, depending upon the evenness of the ground. The engineer in charge reported that 5,000 feet of trench were dug at an average cost of 22 cents per rod.

Poisoned Bait.—The poisoned bran mixture as ordinarily applied for cut-worms was used in many districts, some farmers reporting excellent results. In one instance in New Brunswick the poisoned bran was placed around the outside of the field and the farmer reported that the mixture had been very successful, "the ground being heaped with dead caterpillars in the mornings after it was put out." During the outbreak of the army-worm in Kansas, in 1914, the Kansas Grasshopper formula of poisoned bran was tested out and proved to be an excellent remedy. Prof. G. A. Dean, Entomologist, Kansas State Agricultural College, Manhattan, Kansas, has given us the following statement: "During the recent outbreak of the army-worm we had a good opportunity to test out the efficiency of the bran mash as a means of control. Our results here were 100 per cent effective. Several counties organized for

this work, and every farmer who used the poisoned bran mash had excellent success. My regular men who were in the field report that they never found an insect so easily controlled as the army-worm was when it was migrating from one field to another. In the evening a strip of the poisoned bran mash was sown along the edge of the field into which they were migrating. On several occasions the poisoned bran mash was sown during the day simply because the weather was cloudy and the worms were moving during the main part of the day. This is especially true during one day when there was a slight rain. In



FIG. 11.—Making a trench in western Ontario, showing three necessary essentials, namely, ploughing, deepening and trimming the furrow with spade, and digging post hole. (Photo by J. Moore).

many cases the army-worms were already in the corn fields, but even here one application of the poisoned bran mash was sufficient. The bran mash was simply sown broadcast, some of it falling on the corn and the balance on the ground. The worms that were feeding on the corn crawled to the bran mash that had lodged on the blades and ate it in preference to the corn."

The bran was broadcasted thinly in such a manner as to spread 20 pounds over 3 acres. The mixture is made as follows:—

Bran.....	20	pounds.
Paris green.....	1	pound.
Molasses.....	2	quarts.
Oranges or lemons.....	3	
Water.....	3½	gallons.

In preparing the bran mash, mix the bran and Paris green thoroughly in a wash tub while dry. Squeeze the juice of the oranges or lemons into the water and chop the remaining pulp and the peel to fine bits and add them to the water. Dissolve the molasses in the water and wet the bran and poison with the mixture, stirring at the same time so as to dampen the mash thoroughly. In our experiments with this mixture near Ottawa for the control of grasshoppers, the farmers prepared the mixture on the cement floor of a stable or other outhouse, stirring it thoroughly by means of an ordinary field hoe.

The results obtained with the mixture in Kansas are certainly very remarkable, and we have no hesitation whatever in recommending this new remedy for the army-worm whenever the insect should again appear in destructive numbers in Canada. It will also undoubtedly prove equally useful in the control of ordinary cutworms. The mixture should be broadcasted early in the evening so that it will retain the moisture and be in the most attractive condition when the worms feed at night.

Spraying.—At some places in 1914 spraying with Paris green or arsenate of lead was used to good advantage. This, of course, should be done ahead of the line of march of the worms, and is only satisfactory where the foliage is dense and an area of four or five rods wide is sprayed. In the Ontario outbreak the spraying of roadsides was found to be useless owing to the fact that the plant growth was not dense enough to hold sufficient poison to stop the advancing army of worms. Where it appeared impossible to plough a trench, spraying with a strong Paris green solution, 4 pounds to 100 gallons of water (in which 4 pounds of soap had been dissolved), or 6 pounds of arsenate of lead to 100 gallons of water, was recommended, and this recommendation was included in a proclamation issued by the Municipal Council of the township of Burford. Wherever such spraying is done, it is important that live stock, including poultry, be kept away. It is a wise precaution also to gather up the remaining portion of the sprayed crop and destroy the same by burning. In the 1896 outbreak in Ontario the late Prof. J. H. Panton records¹ that in one instance where windrows of green oats had been sprayed with Paris green (1 pound to 75 gallons of water) and placed in the line of march, myriads of the worms were destroyed. By actual count 2,560 dead worms lay on a single square foot beneath a windrow.

Rolling.—When the worms are seen to be crossing roads, large numbers may be destroyed by crushing them with heavy rollers. Such rollers have also done useful work in pasture fields where the ground was level.

Early harvesting of crops.—As previously mentioned the army-worm, in some districts, during 1914, did not appear in destructive numbers in fields of grain until the crops were almost ready to harvest. When such happens, the crops may be cut at once and removed to land not infested by the worms. Here the grain may be allowed to dry, or if preferable, the crops may be used for feed while green.

Preventive Measures.—In the autumn following a severe outbreak of the army-worm in any locality, it is a good practice to burn over the old grass and stubble and then plough deeply. In this way young hibernating caterpillars will be destroyed and the place rendered unattractive for egg-laying for the moths of the army-worm and of the various common species of injurious cutworms.

Although it is not usual for the army-worm to appear in destructive numbers in the same locality two consecutive years, it is wise, nevertheless, for farmers, in the months of June and early July following a serious outbreak, to watch carefully low-lying areas where the growth is thickest, and if the caterpillars are observed in numbers, it will be possible to control the infestation before the worms leave their natural breeding places, either by confining them to such areas by digging trenches, or by scattering the poisoned bran mixture, as indicated on page 19. When searching for the partly grown caterpillars, the lower leaves of the plants should be examined and if these are seen to be noticeably eaten, the worms will usually be found beneath loose pieces of earth, etc., or just below the surface of the ground near the plants.

Collection of the Moths.—The adult moths conceal themselves during the day, but at night they are very active, flying about and being readily attracted to the well-known "sugar," a bait applied to trees by collectors of insects for the purpose of collecting noctuid moths. In some districts in August, 1914, large

¹ Report Entomological Society of Ontario, 1896, p. 51.

numbers of the moths were seen, and it would seem possible to destroy many before they deposit their eggs, by applying an attractive poisoned mixture to tree trunks. The "sugar" is simply molasses thinned with sour beer, or vinegar, which is smeared on to the trunks of trees, fence posts, etc., at dusk. In 1896, the moths were extremely abundant in Ontario, and, at Port Hope, Mr. W. Metcalfe collected over six hundred specimens, mostly females. These were collected from August 10 to August 25. On August 17 over a hundred examples were attracted to the bait before nine o'clock. The mixture used was cheap sugar dissolved in hot water, and enough rum added to give it an attractive odour. In 1908, Prof. H. Garman, of the Kentucky Agricultural Experiment Station, suggested poisoning such baits with either cobalt or arsenious acid. In a circular published in August, 1914, by the Ohio Agricultural Experiment Station, Prof. H. A. Gossard recommends one ounce of cobalt, or one-half ounce of arsenious acid, to about one-fourth pint of molasses mixed with 1 pint of water.

THE 1914 OUTBREAK OF THE ARMY-WORM.

IN THE PROVINCE OF ONTARIO.

On the morning of July 14, information was received at the Entomological Branch that the army-worm had been suddenly discovered in large numbers in fields of oats, etc., in Burford township, Brant county, Ontario. A request was made for an officer of the branch to visit the infested district, and accordingly Mr. H. F. Hudson, stationed at the Field Laboratory, Strathroy, Ont., was instructed by telegram to proceed at once to Burford and give all possible assistance. Mr. Hudson reached Burford at noon on July 15, and at once visited nearby farms where the army-worm was doing considerable damage. His report on the investigation is as follows:—

"The first stopping place was the farm of Mr. Derby, where the worms were crossing the road in thousands, heading for a corn field. He had already ploughed a furrow, which was partly keeping them in check, but this was not deep enough and much too short. With the assistance of four neighbours, a suitable trench 10 inches deep and a quarter of a mile long had been dug by evening, by which time several bushels of worms had been caught. The worms had left their old feeding ground, a pasture of about 25 acres, practically bare. Continuing in a westerly direction, worms were observed in huge numbers on both sides of the road. I stopped at every farm in passing, urging upon the farmers the absolute necessity of prompt action and united effort. Cathcart was reached in the evening, and here I found the greatest injury, viz., on the farm of Mr. Chant. Two hundred acres of flats, which were used for pasture, had been entirely stripped, a 10-acre field of corn was as bare as a summer fallow, and the oat fields were partly injured. To prevent further destruction of the oat crop, a swath was cut through the oat fields ahead of the worms; a proper trench was dug and post-holes 2 feet deep placed 15 feet apart in the trench. In a very short time the trench was simply a wriggling mass of worms, and some of the post-holes were half filled with the caterpillars. Visiting the same field two days later, nearly all of the post-holes were filled with worms. A conservative estimate of the worms thus trapped would be between ten and twelve bushels.

"Realizing the extent of country over which the army-worm was present, a meeting of farmers was called at Harley, on the afternoon of July 15 by the reeve, Mr. Milmine. As a result a proclamation was issued, duly printed and distributed. This urged upon all farmers the seriousness of the outbreak and the general methods of control. The meeting resulted in much good. As a result, farmers were more willing to help one another, and those who had not

looked carefully at their crops were surprised to find the army-worm present. On the following morning, Mr. A. W. Baker, of the Ontario Agricultural College, Guelph, accompanied me to Princeton, where we were pleased to find twenty-five men and six teams busy at work. It was gratifying to find such excellent co-operation. When we arrived there a trench, one-quarter of a mile long had been dug, and before noon over a mile of trench had been completed. In this particular spot no injury except to the pasture and hay crop had been done, so that by ploughing an efficient trench all round the pasture and hay fields, no grain or other crops were injured.



FIG. 12.—Digging trench at Burford, Ont. This shows the spirit of co-operation which was so apparent among the farmers. (Original).

“Continuing in a northerly direction we found the worms had been doing serious injury on the 2nd and 4th concessions of Blenheim township, Oxford county, and after advising the farmers as to control measures, we proceeded in an easterly direction to Falkland. Here we found a great deal of low-lying pasture land, an ideal feeding and breeding ground for the army-worm, and they had certainly cleaned the pasture up. In the evening Messrs. Green and Sutton, the Ontario Agricultural Representatives of Oxford county, and also Mr. Schuyler, the Ontario Agricultural Representative of Brant county, came to Burford, and the question of the best methods of control and division of the work was taken up. I made my headquarters at Burford until Sunday morning, July 19, in the meantime visiting Belmont, New Durham, Northfield, Harley, Falkland, and Catheart. Realizing the situation was well in hand, and rendering all assistance possible, I motored to Brantford Sunday afternoon, where I found that there was a bad infestation at Cainesville, and also at the Mohawk Institute, on the outskirts of Brantford. The outbreak at Cainesville was partly checked by an army of men and boys, working all day Sunday. Early Monday morning I visited the Mohawk Institute, where I looked over the situation with Mr. Spence, the farm manager. Cutting a swath ahead of the worms in the oat fields and ploughing a trench, and also protecting the corn by trenches, saved the

bulk of the crops. As the outbreak was becoming more extensive and more serious, a special meeting of the County Council was called at the city hall in Brantford to discuss the situation, and the most efficient methods of control. I addressed the council, laying particular stress upon prompt action and co-operation, while Mr. Schuyler pointed out the serious lack of help to cope with the present invasion. After a short discussion, led by Mr. Fisher, M.P., it was unanimously resolved that the council expend a sum not exceeding five hundred dollars, the said sum to be used in securing help where such was necessary.

"On Monday evening, I left for Hamilton to assist Mr. Vining, the Agricultural Representative for Wentworth county. Several small outbreaks had been recorded, but nothing of a serious nature. In response to several calls, Mr. Vining and I went to Jerseyville and Ancaster on Tuesday. The outbreak at Jerseyville was purely local, and did not call for any remedial measures.



FIG. 13.—Showing army-worms caught in trench and in post-holes, near Catheart, Ont. Yard rule indicates numbers of worms in trenches. (Original).

On Wednesday morning I went to Greenville, in Wentworth county. Here the worms were well scattered through a 12-acre field of oats, the leaves had been eaten off and part of the grain also. The only recommendation that seemed possible in this case was the cutting of the crop for feed. As the outbreak did not seem to be gaining in extent or seriousness in Oxford county, and learning of its appearance in Middlesex county, I journeyed to London. The first outbreak recorded was that at Appin in a 5-acre barley field. Little injury had occurred, and the barley was so ripe it was being cut. On reaching London I found that several calls had been received at the office of the Ontario Department of Agriculture. In conjunction with Mr. J. B. Whale and his assistant, Mr. Noble, we motored to East Nissouri, where we found a low-lying piece of pasture a living mass of worms. Six men and a team were busy preparing a trench, and with a little extra help which was readily obtained, it was possible to keep them to their original quarters. In Dorchester township several bad outbreaks had occurred, necessitating the cutting of oat fields before the grain was ripe in some

cases, in others a trench around the corn field was all that was necessary. The situation being well in hand, I left future calls for Mr. Whale, the Agricultural Representative, to deal with.

"The outbreak of the army-worm occurred principally in the dairying sections, where there is a great deal of low-lying land. Perhaps it might be safe to say that wherever there has been low-lying land, the army-worm has been present in exceptional numbers, thousands of acres of pasture being entirely ruined. The infestation in Burford district alone was about fifteen miles long and from 8 to 10 miles wide. It has not only been the loss of crops, injury to pasture fields, forced sale of stock, but all farm work has had to stop to cope with the invasion. A description of their vast numbers seems impossible; one must see for himself the wriggling, seething mass of worms to gain any adequate idea of their numbers. I have seen them on the march, when it would be impossible to drop a five cent piece without touching several of them."—H. F. HUDSON.

In Burford township of Brant county, Ontario, Mr. R. Schuyler, the District Representative of the Ontario Department of Agriculture, estimates that at least fifteen hundred acres of hay and pasture, largely the latter, were destroyed. In addition, about one hundred acres of grain—corn, oats, and barley—were ruined. In Brantford township (Brant county) about three hundred acres of pasture land were devastated and about fifty acres of pasture land in South Dumfries township (Brant county).

In addition to Brant county, serious outbreaks resulting in more or less loss to crops occurred in the following counties and districts: Essex, Kent, Lambton, Elgin, Middlesex, Huron, Bruce, Perth, Norfolk, Oxford, Waterloo, Wellington, Grey, Dufferin, Simcoe, Peel, Halton, Wentworth, Haldimand, Welland, Lincoln, York, Ontario, Durham, Victoria, Northumberland, Peterborough, Muskoka, Parry Sound, Nipissing, Algoma, Manitoulin, Hastings, Prince Edward, Lennox, Renfrew, Lanark, Leeds, Grenville, Carleton and Temiskaming. In this latter district the worms were first noticed on July 11. They were reported to have caused great damage to hay, oats and wheat. This is the most northern record of injury in Ontario which we received.

The outbreak in Carleton county was investigated by me. The chief infestations were near Carp and Kinburn, Ont., where near the former place on July 21, the caterpillars were numerous in a beautiful stand of 16 acres of Banner oats. At Carp, the worms were first observed on July 20. At this time the larvæ were from an inch to an inch and a half in length. Near Kinburn, Ont., the worms were present in large numbers in a 10-acre field of corn, about 2 acres of which had been eaten at the time of my visit. I made counts of worms present on individual corn plants and these gave 16, 17, 15, 28, 20, etc., the highest count being 28 and the lowest 15. Near Carp, deep furrows had been ploughed around corn fields, and on our return here at 5.15 p.m., hundreds of larvæ had collected in the post-holes which had been dug in the trenches. At this time the worms were becoming active, and the road was covered with thousands of them. In the ditches alongside of the roads the worms were present in countless numbers. Under date of September 2, Mr. J. Waterman, Assistant District Representative, Ontario Department of Agriculture, Carp, Ont., informed me that one oat field which he visited and which appeared to be a 65-bushel yield to the acre was reduced owing to the attack of the worms to a 15-bushel yield per acre.

The 1914 outbreak of the army-worm in Ontario was very similar to that which occurred in the same province in 1896. It would appear, however, that the recent outbreak was more destructive than that of 1896. In this latter year 39 counties and 118 townships were infested; in 1914, 42 counties and districts reported army-worms, 234 townships being infested.

The following is the list of the townships in Ontario in which the army-worm occurred in 1914:—

ESSEX COUNTY.

Anderdon
Colechester South
Colechester North
Gosfield North
Mersea
Malden
Pelee
Rochester
Sandwich South

KENT COUNTY.

Camden
Chatham
Dover
Harwich
Howard
Romney
Tilbury East
Zone

LAMBTON COUNTY.

Brooke
Dawn
Enniskillen
More
Windsor
Sarnia

ELGIN COUNTY.

Aldborough
Bayham
Dorchester South
Dunwich
Malahide
Southwold
Yarmouth

MIDDLESEX COUNTY.

Biddulph
Caradoc
Delaware
Dorchester
Ekfrid
London
Mosa
Nissouri West
Westminster

HURON COUNTY.

Ashfield
Colborne
Grey
Hay
McKillop
Morris
Tuckersmith
Usborne
Wawanosh

BRUCE COUNTY.

Atinabel
Albermarle
Arran
Brant
Carriek
Culross
Eastnor
Elderslie
Greenock
Huron
Saugeen

PERTH COUNTY.

Blanshard
Downie
Ellice

NORFOLK COUNTY.

Charlotteville
Midleton
Townsend
Walshingham
Windham
Woodhouse

OXFORD COUNTY.

Blandford
Blenheim
Dereham
Nissouri East
Norwich North
Oxford East
Oxford North
Oxford West
Zorra East
Zorra West

WATERLOO COUNTY.

North Dumfries
Waterloo
Wilmot
Woolwich

WELLINGTON COUNTY.

Eramosa
Guelph
Nichol
Puslinch
West Garafraxa
West Luther

GREY COUNTY.

Derby
Egremont
Glencol
Keppel
Proton
Sullivan
Sydenham

DUFFERIN COUNTY.

Amaranth
East Garafraxa
Melancthon

SIMCOE COUNTY.

Flos
Innisfil
Orillia
Sunnidale
Tecumseh
Tiny
Vespra

PEEL COUNTY.

Chinguacousy
Toronto
Toronto Gore

HALTON COUNTY.

Nelson
Trafalgar

WENTWORTH COUNTY.

Ancaster
Barton
Beverley
Binbrooke
Flamboro East
Flamboro West
Glanford
Saltfleet

BRANT COUNTY.

Brantford
Burford
Dumfries South
Oakland
Onondago
Tuscarora

HALDIMAND COUNTY.

Cayuga North
Dunn
Moulton
Oneida
Rainham
Seneca
Walpole

WELLAND COUNTY.

Bertie
Humberstone
Stanford
Thorold
Wainfleet

LINCOLN COUNTY.

Grantham
Niagara

YORK COUNTY.

East Gwillimbury
King
Markham
Scarboro
Vaughan
Whitchurch

ONTARIO COUNTY.

Mara
Pickering
Reach
Thorah
Uxbridge
Whitby

DURHAM COUNTY.

Clarke
Darlington
Hope

VICTORIA COUNTY.

Eldon
Emily
Fenelon
Laxton
Mariposa
Orps
Verulam

NORTHUMBERLAND COUNTY.

Brighton
Haldimand
Hamilton
Murray
Seymour

PETERBORO COUNTY.

Dummer
Galway
Otonabee
Smith

MUSKOKA DISTRICT.

Chaffey
Draper
Macaulay
Monk
Stisted

PARRY SOUND DISTRICT.

Armour
Hagerman
Hinsworth
McMurrich
Ryerson

NIPISSING DISTRICT.

Chisholm
Glackmeyer
Lamarehe
Maisonville
Papineau
Springer

ALGOMA DISTRICT.

Korah
Laird
Macdonald
Tarentorus

HASTINGS COUNTY.

Madoc
Rawden
Sidney
Thurlow
Tyendinaga

PRINCE EDWARD COUNTY.

Ameliasburg
Athol
Hallowell
Hillier
Marysburg
Sophiasburg

LENNOX COUNTY.

Adolphustown
Ernesttown
Fredericksburg North
Fredericksburg South
Kaladar
Richmond

RENFREW COUNTY.

Admaston
Alicc
Bromley
Horton
Ross
Westmeath

LEEDS COUNTY.

Landsdowne

GRENVILLE COUNTY.

Edwardsburg

LANARK COUNTY.

Pakenham
Sherbrooke South

CARLETON COUNTY.

Fitzroy
Huntley
Torbolton

TEMISKAMING COUNTY.

Armstrong
Daek
Dymond
Evanturel
Harley
Hilliard
Henwood
Hudson
Ingram
Kerns
Marter
Whitney

MANITOULIN DISTRICT.

Assignack
Barrie Island
Carnaroon

It is pleasing to record here the co-operative nature of the work in the control of the army-worm in Ontario in 1914, between the Entomological Branch and the Ontario Department of Agriculture. In Mr. Hudson's investigations he was much assisted by Mr. A. W. Baker, of the Ontario Agricultural College, and the following Ontario Agricultural Representatives: Messrs. Green and Sutton (Oxford county), R. Schuyler (Brant county), R. L. Vining (Wentworth county), Messrs. Whale and Noble (Middlesex county). In my own investigations in Carleton county I received valuable help from Mr. J. Waterman, the Assistant District Representative.



Fig. 14.— General view of trench beside gravel road, near Cathcart, Ont. (Original).

IN THE PROVINCE OF QUEBEC.

In this province injury was reported from the following counties: Pontiac, Wright, Richelieu, Quebec, Portneuf, and Champlain. The outbreak in the province of Quebec, however, was not, on the whole, a serious one, but in certain districts, fields of oats, barley, wheat, corn, and timothy were devastated, and the insect caused considerable alarm. At La Tuque, in Champlain county, the worms were discovered in large numbers in the last week of July. Fields of hay and oats were devastated in two and three days. In Pontiac county, Mr. J. K. King, Macdonald College Demonstrator, Shawville, informs us that the outbreak of the army-worm was more or less general throughout the central section of the

county, where wheat, barley, and oats were chiefly attacked. In the municipality of Clarendon, on the western boundary, a serious infestation occurred on the farm of Mr. John Stewart. In Portneuf county, the worms were reported from Rivière à Pierre. In the region of Maniwaki, Wright county, the worms invaded six farms, but no serious results were reported. In Richelieu county, township of St. Pierre de Sorel, one farmer reported that 20 acres of hay were destroyed 10 acres of which were not even mowed.

IN THE PROVINCE OF NEW BRUNSWICK.

Outbreaks of the army-worm in this province were investigated by Mr. R. P. Gorham, Assistant Horticulturist, Department of Agriculture, Fredericton, and Mr. Wm. McIntosh, of St. John. The following counties were infested: Kings, Queens, Sunbury, York, Albert, and St. John. Mr. Gorham has kindly given us the following statement:—



FIG. 15.—Traction ditcher used in digging ditches near Sussex, N. B., to check advancing army of worms. (Original).

"The army-worm was first reported from Sussex, Kings county, on August 7. Investigation showed that the whole of the military ground just north of the village was affected. This comprised something over 150 acres, and was covered with short grass of not much economic value (the growth that came up after the annual drill of the militia in June). The grounds were bounded on the south and east by a small stream, Sussex creek, on the west by the I. C. R. railway embankment, and on the north by a pasture field largely grown up to bushes. The general movement of the caterpillars was toward the west, where there were large fields of oats and vegetables just across the track. Ditches were dug around two sides of the field by means of a traction ditcher (see figures 15 and 16) and the caterpillars killed in the ditch by spraying with kerosene. This outbreak was all on low land of a sandy nature.

"About 5 miles west of the military grounds about 2 acres of oats and wheat were infested. On August 10 an infestation was found on the low marsh lands along the St. John river in Kings county, and an assistant was sent to make an examination of all the wild meadows and marsh lands along the river from Fredericton to St. John. He found no trace of the army-worms until reaching Upper Musquash island, 35 miles below Fredericton, in Queens county. On the central and lowest part of this island he found a strip of something over 10 acres in extent that was entirely eaten over by the caterpillars. This was on the lowest ground, having an elevation of not more than 3 feet above water level. The higher banks on the sides of the island were not affected.

"On Lower Musquash island, a few miles south, Le found a small amount of grass on the low ground, and evidences of slight damage over nearly the whole of the island. No caterpillars were found.



FIG. 16.—Ditch near Sussex, N. B., dug by traction ditcher. (Original).

"On the next two islands, Long island and Spoon island, no trace of army-worms were found. These islands are considerably higher than the others, probably 12 feet above water level.

"On Pig island, Kings county, Le found a quite general infestation over the whole of the small island of about 40 acres. About one acre was completely destroyed, and a slight amount of damage caused on the other parts.

"On Pickett's marsh, a small area of low land connected with the parish of Kars, he found a bad infestation, between 20 and 30 acres of grass completely destroyed, and as much more slightly damaged. This was all on the lowest part of the marsh.

"On Hog island he found an infestation extending over about 100 acres of the lowest land. Of this 20 acres were completely eaten over, and the damage on the remainder consisted of more or less general stripping of the leaves, leaving the main stems standing.

"On the Mistake, a strip of marsh land a . . . 5 miles long connected to the mainland of the parish of Greenwich, he found an area of about 40 acres badly damaged, the tender grasses eaten off and the weeds and coarser grasses left.

"On Grassy island, a large area of wild meadow belonging to the municipality of Kings, he found a slight infestation extending over about 100 acres, only serious on a few small areas, not amounting to more than 3 or 4 acres.

"Chancing to go back on the hills near Brown's Flats, Kings county, he found an area of several acres of grass land showing frass on the ground and evidence of feeding. Digging in the soil revealed considerable number of pupæ and a few larvæ; thirty larvæ and pupæ in a space 4 feet square. This was at an elevation of 300 feet, and the injury had not been noticed by the farmers.

"One thing especially noticeable about these outbreaks on marsh lands was that they were almost wholly confined to the lowest parts, to areas not more than 2 or 3 feet above the water level. The higher banks showed little or no



FIG. 17.—Area of lowland in western Ontario: grasses entirely eaten by armyworms, only weeds left standing. (Original).

injury, even when immediately adjoining the infested portions. All these marsh lands are submerged during the annual spring freshets to a depth of from 3 to 8 feet of water, this submersion lasting from the end of April to the middle of June.

"These marsh lands along the St. John river are valuable grass areas and normally give from two to three tons of hay per acre, which many of the farmers depend upon for winter stock feeding.

"An examination was also made of the low lands between Sussex and Perry's Point along the Kennebecasis valley, but beyond the finding of a few caterpillars in grass at Bloomfield it did not disclose any infestation."—R. P. GORHAM.

In the Nerepis valley, Queens county, various farms were infested, the worst damage being to oats. In nearly every case the infested area was close to the Nerepis stream on low intervale lands that were covered by the spring freshet. In St. John county, oats and grass were severely damaged in places. On one farm 15 miles east of St. John city, about 5 acres of oats were stripped of leaves and grain. Poisoned bran had been placed around the outside of the

field, and the farmer reported that the mixture had been very successful. At Fairfield the worms were noticed in early September. On one farm the oats were cut for hay but the farmer neglected to rake them up immediately. The result was, of course, that the caterpillars at once ate off the heads and leaves, practically destroying the whole crop. They then turned into a nearby meadow and destroyed a small area of grass land and a small patch of corn before changing to the pupal state.

Near Loch Lomond, in St. John county, Mr. R. G. Murray reported that in a seven-acre field of oats it was difficult to find a plant which had not been defoliated. Thousands of stalks standing 3 and 4 feet high were stripped bare of leaves and grain. Although too late, poisoned bran was distributed and innumerable numbers of the worms killed.

Mr. W. McIntosh, Curator of the Natural History Society of New Brunswick, St. John, N. B., who investigated outbreaks of the army-worm in New Brunswick, reports as follows:—

"Army-worms were first noticed to be unusually plentiful from the middle of July onward. The first complaint received was from Mr. J. D. McKenna, Sussex, July 6. The worms were reported from or found on eleven farms in the Nerepis valley, considerable loss being caused on the Lyons farm. There were eighteen records between St. John and Westfield Beach, the most serious damage being done to oats on the Quinton farm and on the farm of the Provincial Hospital, Lancaster. East of St. John city the greatest damage was done on the farm of R. G. Murray, Loch Lomond road, and in the Red Head district, the worms being recorded as far east as St. Martins and Penobscus. North, in the valley of the St. John river, the hay crops on some of the islands were ruined, and the oats attacked in some places on the mainland. The army-worm was reported from or found on seventy-one farms in southern New Brunswick."

IN THE PROVINCE OF NOVA SCOTIA.

Almost every county in Nova Scotia reported more or less injury by the army-worm, namely, Yarmouth, Digby, Queens, Annapolis, Lunenburg, Kings, Hants, Halifax, Colchester, Pictou, Antigonish, Guysborough, Cumberland, Cape Breton, and Inverness. The counties in which the most serious outbreaks occurred are Lunenburg, Digby, and Yarmouth. The first outbreak was located at Mahone Bay, Lunenburg county, on July 30, where the worms were found to be injuring garden corn. From this date until August 17 the worms were active, and reports of injury were received from many places. Mr. Geo. E. Sanders, in charge of the Entomological Field Station at Bridgetown, N.S., visited many farms where the worms had injured oats, barley, wheat, corn, and grass. Nowhere in his investigations did he find the caterpillars abundant enough to destroy the entire crop, although in some fields 90 per cent of the leaves were eaten off oats and barley. The average injury he placed at from 5 to 20 per cent. In the second week of August, I was present in Digby county, Nova Scotia, and observed the conditions on several farms between Bear River and Digby. In addition to the crops above mentioned, I found the worms doing injury to clover and rape, and to a slight extent to turnips. In many fields, particularly of oats and barley, conspicuous areas could easily be seen where the worms were at work, in such areas nothing being left but the stems of the plants. In fields of oats, in many instances, the grain in the hull had been severed from the plants and was lying on the ground. In the district around Marshalltown, Hill Grove, and Bay View, it was estimated that about 400 bushels, mostly oats, were destroyed. In one small field (about an acre) at Bear River, the worms had entirely eaten the second crop of timothy. Near Saulnierville, also in Digby county, five acres of wheat were practically destroyed.

Prof. W. H. Brittain, the Provincial Entomologist for Nova Scotia, states in correspondence: "Our records show that the insect was present in practically

every section of the province, and while the distribution is fairly complete, serious damage was done only in comparatively few localities. Lunenburg county was the first visited and serious injury to corn and grain was noticed in the vicinity of New Germany and other sections. In some cases 75 per cent and upwards of the crop was destroyed. Portions of Yarmouth and Digby counties were visited by Mr. C. A. Good, our Assistant Entomologist, who reported the loss to the oat crop to be 50 and 60 per cent. The grain on seventeen farms out of twenty-eight visited in Digby county was practically a total loss; in the remaining eleven the damage was of varying severity. The caterpillar



FIG. 18.—Individual corn plant eaten by army-worms.
(Original).

seems to prefer oats and barley in most cases, the beard of the barley being always cut off first. Corn was a favourite food and suffered severely where the insect was numerous. In quite a number of cases we were able to protect non-infested fields by the use of trenches or deep furrows. Few farmers could be induced to use poisoned bran, so that this preparation was given a trial in only a few places. Some secured good results, where corn was affected, by the use of lime and Paris green, while many who used this reported burning of the foliage. Many oat fields were cut green to escape destruction from the army-worm, and in many cases the damage continued after the grain was cut."

At Newcombe (Lunenburg county) Mr. Banford West reports seven farms on which serious injury was done to oats, barley, and wheat. On his own farm they were first noticed on a small patch of oats about one-third of an acre. In two days they stripped all the leaves off and a large part of the grain. A deep furrow was ploughed around the piece and post-holes 18 inches deep dug about 2 feet apart. When the worms started to leave this land they filled these holes full four times in an afternoon. The poisoned bran formula was forwarded to Mr. West, and the day he received our letter he applied the mixture in a field of oats into which the worms were beginning to migrate. He reported later that the application "made a finish" of the worms. In an area 2 miles square he estimated the damage to be \$600.

The Superintendent of Lighthouses on Sable island made collections, at our request, of moths which were attracted to the lights, and it is of interest to note that the collection forwarded to the department consisted largely of the adults of *Cirphus unipuncta*, the army-worm moth. The specimens of these moths were collected from August 17 to August 28. Sable island is about 140 miles due east of Guysborough county in Nova Scotia.



FIG. 19.—Oat field, showing complete stripping of stems. (Original).

IN THE PROVINCE OF MANITOBA.

No reports of injury in 1914 were received from Manitoba. In the locality near Treesbank, where a local outbreak occurred in 1913, Mr. Norman Criddle reported the finding of only a single caterpillar. The moths, however, were numerous in the latter part of June, and again in August and September, which would, of course, indicate that the caterpillars had been abundant in the district. If the worms had been present in numbers to cause damage to crops, the infestation would doubtless have been reported to the Branch at Ottawa, or to our Field Officer at Treesbank, Man.

IN THE PROVINCES OF SASKATCHEWAN, ALBERTA, AND BRITISH COLUMBIA.

As far as we know, no injury took place in these provinces in 1914. From Saskatchewan, reports of damage by the army-worm were received, but upon investigation the insect proved to be the Sugar-beet Webworm, *Loxostege sticticalis*. In British Columbia, the Alfalfa Looper, *Phylometra (Plusia) californica* was abundant in some districts during the past year, and was referred to by farmers as the "army-worm."

ESTIMATE OF THE LOSS IN 1914.

From a study of the outbreak in the various provinces we estimate, all things being considered, such as the actual destruction of crops, the time required to fight the pest with consequent neglect of important work at such time, the cost of hiring extra labour, sale of live stock in some districts owing to the threatened shortage of food, the cost of Paris green, etc., that the total loss in Ontario, Quebec, New Brunswick, and Nova Scotia will exceed at least \$300,000. The important outbreak of the army-worm occurred in Ontario, and of the above total loss fully five-sixths should refer to that province. In arriving at this estimate we received valuable assistance from the Census and Statistics Branch of the Department of Trade and Commerce. At our request a special circular was sent out to the Crop Correspondents of that Branch and the replies were filed in the Entomological Branch. Information of a reliable nature was obtained through this source, and also by our own Field Officers, those resident in Ontario receiving assistance from the Ontario Department of Agriculture District Representatives.

ACKNOWLEDGMENTS.

The writer is grateful for information received from officers of the provincial Departments of Agriculture, giving details of the outbreak of the army-worm in their respective districts or provinces. He also desires to thank Mr. J. P. Henderson, of Toronto, Ont, who kindly donated the negatives from which figures 12, 13, 14, and 17 have been made. These photographs were taken by Mr. Henderson under the direction of Mr. H. F. Hudson, Field Officer of the Branch, and Mr. A. W. Baker, of the Ontario Agricultural College. The photographs from which figures 6, 10, 18 and, 19 were made were taken at my request by Mr. J. Waterman, Assistant District Representative, Ontario Department of Agriculture, Carp, Ont.; and Mr. R. P. Gorham, of the New Brunswick Department of Agriculture, sent to me the photographs from which figures 15 and 16 were made. Figures 3, 4, 5, 7, 8, and 9 were made from photographs taken in the Branch by Mr. A. E. Kellett, Artist Assistant. Fig. 1 was made from a photograph taken by the writer.

The hymenopterous parasites were determined by Mr. A. B. Gahan, of the U. S. Bureau of Entomology, and the tachinid parasites by Mr. J. D. Tothill, of the Dominion Entomological Service.

