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Injurious Corn Insects

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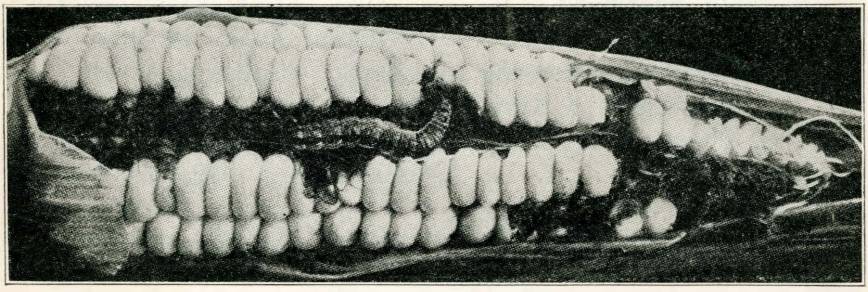

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INJURIOUS CORN INSECTS

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INJURIOUS CORN INSECTS

By
H. C. SEVERIN

Reliable estimates of the average yearly loss of growing corn (not including stored corn) thru insect attack in the United States is placed at 10 to 15 per cent of the total value. In South Dakota the loss is less than 10 per cent, but nevertheless it is a considerable yearly tax upon the farmers of our state and one which can be greatly reduced thru proper application of control measures based upon a thoro knowledge of the life of these harmful insects and methods of their work.

It is our aim in this bulletin to discuss briefly only the most important and common insects which reduce the corn yield in this state. Many other insect pests may be found, at times, working upon or within the corn leaves, stems, roots, husks, silk, pollen and ears, and occasionally these insects may do considerable harm, but for information regarding these, the farmer should write to the Entomology Department of the South Dakota State College.

ARMY WORM.

INJURY.

The army worm (*Cirphis unipuncta* Haw.), altho notorious for the injury it may cause, usually does not visit the same region in exceptionally large numbers during successive years. While the insect prefers to breed and feed in grass or small grain growing in low and moist parts of fields, at times the caterpillars become so abundant and the food material so scarce, that the worms are forced to seek elsewhere for their food. On such occasions the caterpillars migrate in vast armies and should a cornfield be in their path, they will enter this and begin to destroy it. The migrating worms climb the corn plants and strip these of their leaves, leaving only the midrib, but later as more and more caterpillars invade the field, not only is the midrib eaten but the

whole plant may be devoured as well. Feeding takes place usually at night, the worms hiding during the daytime under clods of dirt and rubbish, in the heart of corn plants or in the rank, thick growth of grass and grain. Migration also takes place usually at night, but feeding and migration often occur during the daytime, especially when the day is cloudy. When the caterpillars are not very abundant in a low area near a cornfield, some of the worms may attack the corn and these may then be found in the heart of the plants of the first three or four rows bordering the low area.

LIFE CYCLE.

Like many of our insects, the army worm passes thru four stages during its life, the moth or miller, the egg, the caterpillar or army worm stage and finally the pupa. The moth is a night flying insect and is often attracted in large numbers to light. The forewings of the moth are yellowish brown in color and are marked with a small white speck near their center (Fig. 1, a). When the wings are spread, the insect measures from one and one-half to one and three-fourths inches in width. The moths usually fly to distant fields to lay their eggs, and for this purpose they choose low areas where plant growth is rank. The eggs (Fig. 1, d) resemble glass beads smaller than the head of an ordinary pin and are laid mostly at night in patches or rows in a gummy material between the folded blades of leaves or between the leaf sheaths and stems of grasses and grains. Each female moth ordinarily is capable of laying about 700 eggs, a fact which accounts for the enormous numbers of worms that may be present in a field during an army worm outbreak. In about 8 or 12 days, the eggs hatch into small green caterpillars. These young worms eat but little and since they feed close to the ground, they may be present by the hundreds of thousands and still escape detection by the farmer unless

a careful examination is made. It is only after the worms have acquired considerable growth that the injury which they cause becomes serious. Three to five weeks are required by the caterpillars to become full grown, the worms then measuring one and one-half inches long and one-eighth of an inch wide. In general appearance, the army worms resemble cutworms, the body being smooth and practically free from hair. The color varies considerably, ranging from greenish yellow to brown or even black. Looking at the caterpillar from the side, one sees three stripes, a middle black one and an upper and lower yellowish one (Fig. 1,b).

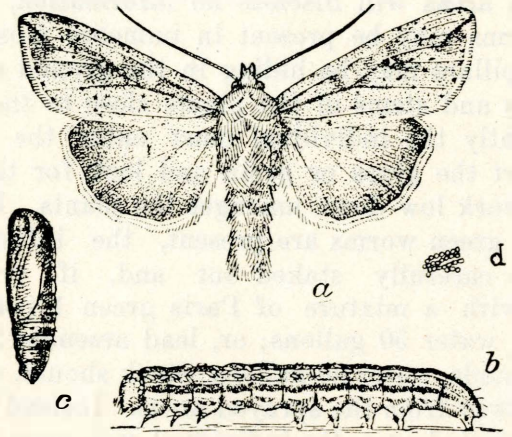

Fig. 1.—Life history of army worm; a, Moth; b, army worm with eggs of parasite attached to back; c, pupa; d, eggs. After F. M. Webster and modified by H. C. Severin.

When the army worms are full grown, they usually enter the ground to a depth of an inch or so, hollow out a chamber and pupate. The pupa (Fig. 1, c) at first brown in color, but later, black, gives rise in 10 to 20 days to a moth.

Two generations of army worms occur in South Dakota in a year, with a possiblity during some years of a partial third generation in the extreme southern part of the state. The insect hibernates as a caterpillar and possibly also as a moth, but regarding the latter

point, definite information is still lacking. The serious injury which results from army worm attack is due to the generation of worms present in July and August.

CONTROL.

SPRAYING AND BURNING OF INFESTED AREAS.—To discover outbreaks of army worms before they have had time to do serious injury, a farmer should examine carefully and frequently during the latter part of June and during July, all grass and grain growing in low areas. A casual glance or two from a distance over such areas will disclose no information, even tho army worms may be present in immense numbers, for the caterpillars may be hiding in the ground or among the leaves and stems of the plants close to the ground. Consequently the individual must enter the breeding areas, part the grass or grain and look for the worms or their work low down amongst the plants. If numerous small green worms are present, the infested area should be carefully staked out and, if practicable, sprayed with a mixture of Paris green 1 pound, soap 2 pounds, water 50 gallons; or, lead arsenate 2 pounds, soap 2 pounds, water 50 gallons. Stock should, of course, be kept away from the sprayed areas. Instead of spraying the infested area, the individual may mow the same, cover it with straw and burn it over.

DESTROYING MIGRATING WORMS.

When the worms have begun to migrate, they may be destroyed by spraying, by scattering poisoned bait or by trenching.

SPRAYING FOR MIGRATING WORMS.—If spraying is to be effective, the foliage into which the worms migrated and are working must be fairly dense. A strip four or five rods wide should then be sprayed. If corn is being invaded and if spraying is relied upon to control the worms, the lead arsenate spray should be

used, but if it is necessary to spray with Paris green, then 2 pounds of freshly slaked lime should be added to each 50 gallon lot of spray.

POISONED BAIT.—Where spraying is not practicable, a poisoned bait may be profitably used instead. The bait should be prepared carefully according to the following formula:

Bran or shorts or alfalfa meal 50 pounds
White arsenic 2 pounds, or Paris green 2 pounds
or lead arsenate paste 4 pounds
Low grade molasses such as black strap 2 gallons
Water, as much as the bait will hold without becoming sloppy.

The effectiveness of the bait will depend in large measure upon the length of time it remains moist. Salt added to the bait at the rate of 5 pounds to 50 pounds of the bran will increase the length of time the bait remains moist and should be added whenever the soil is dry and hot. The juices and finely chopped peelings of 6 oranges has made the bait more attractive to the worms in some portions of the United States.

The poisoned bait is to be scattered broadcast by hand late in the afternoon wherever the army worms are found, and if the caterpillars are migrating, the bait should be sown in their path. The amount of bait prepared according to the formula is sufficient to treat 7 or 8 acres. If the worms are already in the corn, the bait should be dropped into the heart of the plants and a small amount also placed on the ground near each hill of corn.

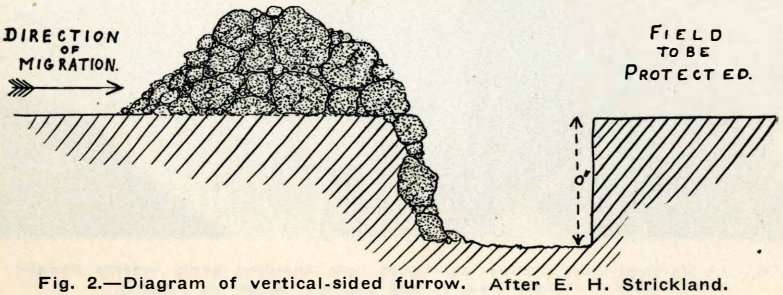

Fig. 2.—Diagram of vertical-sided furrow. After E. H. Strickland.

TRENCHING.—When the army worms are on the march, they may be stopped by means of a trench placed across their path. The trenches used are of two kinds, the vertical-sided trench, and the dusty trench. The vertical-sided trench is the more difficult to make and may be constructed in soil which is rather moist, while the dusty trench requires less labor to make and is to be used in dry soil.

VERTICAL-SIDED FURROW.—The vertical-sided furrow (Fig. 2) should be at least 10 inches deep and the side of the ditch toward the crop that is to be protected should be as vertical as possible. After the ditch has been plowed, it will be necessary to trim up the vertical side with a spade and should the soil here become hard instead of crumbly, it will be necessary to loosen it with a rake. At intervals of 15 or 20 feet, post holes

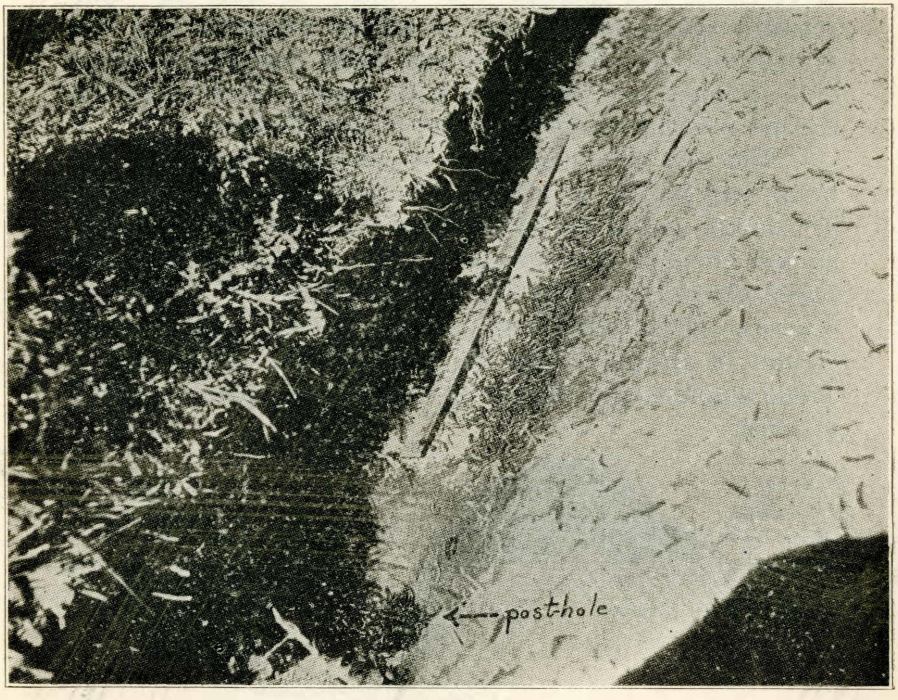

Fig. 3.—Vertical-sided furrow and post hole showing army worms caught in both. A yard rule in the trench. After A. Gibson.

one or two feet deep should be dug. The worms in attempting to pass over the ditch, will not be able to climb the dusty vertical side, and will consequently travel along the ditch, only to fall into a post hole (Fig. 3) where they may be destroyed by crushing them with a post or by pouring water and a small amount of kerosene over them.

DUSTY FURROW.—If the soil is dry and labor scarce, a dusty furrow may be constructed instead of a vertical-sided trench. According to E. H. Strickland, such a furrow may be made as follows: "Turn as deep a furrow as possible with a walking plow, throwing the earth *toward 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 (Fig. 4)."

Immediately after plowing the furrow, drag a heavy log down the trench. The man who is in charge of the horses should stand on the back of the log to weight it

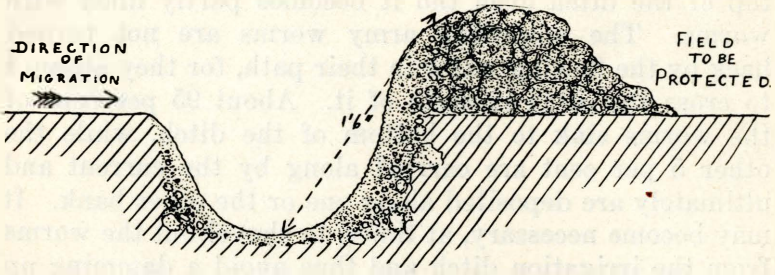

Fig. 4.—Diagram of dusty-sided furrow. After E. H. Strickland.

down. This operation will crush all of the large clods and leave a smooth, dusty, sloping side to the furrow."

Post holes one or two feet deep may then be dug at intervals of 15 or 20 feet in the bottom of the ditch. The worms caught in the holes may then be killed as

directed in the vertical-sided trench. If no post holes are dug, the worms may be destroyed by dragging a log back and forth thru the furrow whenever live worms are to be found in it.

TRENCH POISON BAIT.—Poisoned bait should, if possible, be used in connection with the trench system of control. If this is done, the bait should be applied thinly to the bottom of the trench toward evening whenever the worms are migrating. If a rain occurs and packs the soil so that the worms are able to cross the trench, a log should be dragged several times thru the furrow and the bait replenished.

RUNNING WATER.—Running water in irrigation ditches may be used to stop the advance of migrating army worms. Such a ditch, according to E. V. Wilcox, should have a regular fall and no sharp bends. The sides should be steep and smooth and the width of the bottom should not be less than a foot. The water flowing thru the ditch must be at least six inches deep, but there must be no danger that the water will reach the top of the ditch even tho it becomes partly filled with worms. The migrating army worms are not turned back by the flowing water in their path, for they attempt to cross the ditch in spite of it. About 95 per cent of the worms sink to the bottom of the ditch, while the other 5 per cent are carried along by the current and ultimately are deposited along one or the other bank. It may become necessary, at times, to shovel out the worms from the irrigation ditch and thus avoid a damming up of the stream and a consequent overflow. Whenever the worms are removed from the water (Fig. 5), they should be destroyed, for many of the caterpillars will recuperate even after having been in the water 24 or even 48 hours. Irregular currents due to an unevenness in the pitch of the ditch or to sharp bends may cause the worms to collect in certain spots and ultimately dam up the

water. This will lead to an overflow and a possiblity that several bushels of army worms will be carried with the water and deposited on the field that is to be protected.

Fig. 5.—Heap of dead army worms shoveled out of an irrigation ditch. After E. V. Wilcox.

CUTWORMS.

INJURY.

Cutworms (*Noctuidae*) do more harm to corn in South Dakota than any other insect. The name "cutworm" is applied to these caterpillars because of the instinct which they have of cutting off the stems of plants close to the surface of the ground or a trifle beneath it. But the insect may also injure plants by gnawing into the stem without severing it or by eating

out holes in the leaves. Oftentimes a cutworm will pull the stem of a severed plant into its burrow and there feed upon it, but at other times the destructive caterpillar may cut off several plants in one night and not feed to any great extent upon any single one.

Cutworms feed principally at night and remain concealed in the daytime under clods of earth or rubbish or in the soil, buried at a depth of one-half to two inches. The worms may usually be found in the soil near the injury which they caused during the preceding night, but should the food material become scarce and the caterpillars abundant, they may move out of the field in vast armies similar to the true army worms.

LIFE CYCLE.

When the cutworms (Fig. 6, b, d) are full grown, they are thick, cylindrical, soft-bodied caterpillars, varying in length from one and one-half to two inches. The body is smooth and almost entirely free from hair and varies in color from a glossy transparent green or white to grey, dark brown or black. The worms may be marked with dots, blotches and longitudinal stripes, but they all possess there pairs of legs on that part of the body immediately back of the head and five pairs of legs on the remainder of the body. When disturbed, the caterpillars at first make no effort to escape, but curl up in the form of a small snail shell and remain perfectly quiet (Fig. 6, c).

Most of our injurious cutworms become full grown in the months of June and July, at which time they enter the ground, hollow out a chamber and inside of this, change to the pupa (Fig. 6, g). At this time injury in the field stops, for in the pupa stage, the insect does not feed. In two, three or four weeks, the pupa gives rise to a moth or miller. These millers (Fig. 6, a) are the common greyish or brownish moths which enter our houses during the spring and summer and fly about the lights. A few weeks later, the moths are ready for egg-laying, and at this time are attracted to grassy or weedy fields. The

eggs (Fig. 6, e, f) are deposited singly or in clusters on vegetation, or rubbish, or directly on the ground. The number of eggs laid by a single moth varies with the species, but in one case, at least, over 1,000 eggs were produced. The eggs hatch a few weeks after they are laid and the young cutworms to which they give rise, feed upon the vegetation and the roots of grasses and weeds until cold weather sets in. The young worms then go into hibernation, seeking protection in the soil, under rubbish, etc. The following spring the worms are ready to attack such vegetation as may be on hand and to their liking, and if it be corn instead of grass that is available, the injury may be very severe.

There are many species of cutworms in South Dakota, but not all of them have a life cycle as outlined. Some may pass thru more than one generation each year, and others may hibernate in the egg, pupa or moth stage instead of the caterpillar.

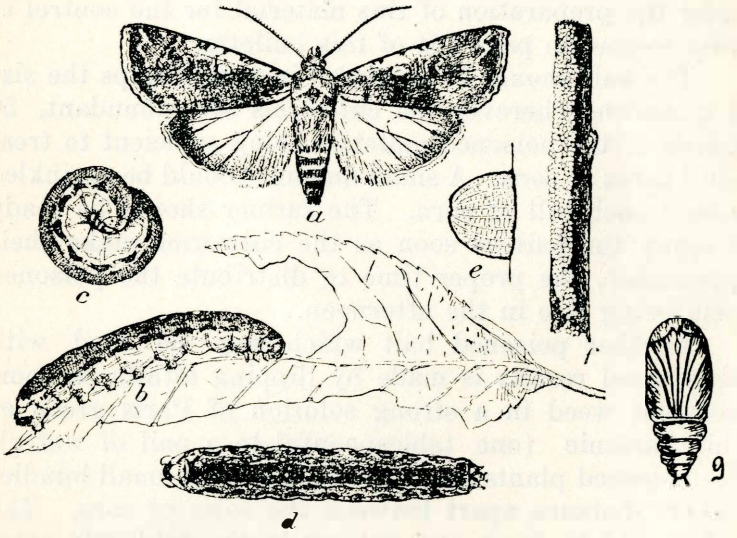

Fig. 6.—Variegated Cutworm (Peridroma margaritosa): a, Moth; b, side view of caterpillar extended; c, side view of curled-up caterpillar; d, top view of caterpillar; e, egg enlarged; f, egg mass on twig; g, pupa. After L. O. Howard and modified by H. C. Severin.

CONTROL.

CULTURAL.—To avoid cutworm injury next year,

fall plow as early as possible this year, all land liable to harbor cutworms. Grass lands, timothy fields, weedy stubble fields, in fact any field which has green vegetation upon it during August and early September may serve as an attractive area for egg-laying. The object of early fall plowing is to remove the green growth and thus make the field less attractive for egg-laying. If early plowing is not practicable, then plow late in the fall and follow this by thoro disking and harrowing in the spring. Late fall plowing has for its object the burial and destruction of the eggs and the young cutworms, while the spring disking and harrowing will keep down the vegetation and thus tend to starve out the young worms.

POISONED BAIT.—If cutworms are abundant in the spring in corn land, the injury may be considerably lessened by applying a poisoned bait to the field. This bait should be made according to the directions given under the preparation of this material for the control of army worms on page 784 of this bulletin.

The bait should be scattered in small lumps the size of a marble wherever the cutworms are abundant, 50 pounds of the poisoned material being sufficient to treat 4 or 5 acres of corn. A small amount should be sprinkled around each hill of corn. The farmer should be ready to apply the bait as soon as the cutworms make their appearance, the proper time to distribute the poisoned mash being late in the afternoon.

Another poisoned bait which may be used with fairly good results is made by dipping alfalfa or some succulent weed in a strong solution of Paris green or white arsenic (one tablespoonful to a pail of water). The poisoned plants should be scattered in small bundles a short distance apart between the rows of corn. The bait should be fresh and put out in the field only after sundown.

CONTROL OF MIGRATING CUTWORMS.—If the cutworms assume the migrating habit, as the true army worms often do, then the control measures out-

lined under "army worm control" should be adopted.

At times, cutworms enter a cornfield from neighboring fields such as meadows, pastures, etc., but without assuming the army habit. These cutworms may be destroyed by scattering poisoned bait over a narrow strip of ground on that side of the cornfield which is being invaded.

POULTRY, WILD BIRDS AND HOGS.—Poultry, wild birds and hogs may be advantageously used to reduce the number of cutworms in a field that is planted to corn. Poultry may be used to advantage chiefly while the field is being plowed, and at the same time, wild birds, such as gulls, blackbirds, grackles and robins should be given every encouragement to visit and work in the field. Hogs may be pastured in fields infested with cutworms, for these animals will root up and devour soil insects such as cutworms, white grubs, etc.

EAR WORM.

INJURY.

The corn ear worm (*Heliothis obsoleta* Fabr.) does its greatest amount of injury by working into the ears of corn and there devouring the kernels. As the caterpillars make their way into an ear, they usually feed upon the silk, then upon the kernels at the top of the ear, and later they may eat a broad channel down the ear, leaving a path of refuse behind (see title-page). In most instances more injury is done to the ear thru water and molds that follow up the invading caterpillar than is actually done thru the jaws of the worm. Such moldy corn when fed to stock may cause cases of severe illness and even death. A generation of worms may attack corn before the ears have formed and if such is the case, the caterpillars may be found feeding in the axils of the leaves and stems, or in the heart of the plant among the rolled-up leaves.

LIFE CYCLE.

There are four stages in the life cycle of this insect,

namely, egg, caterpillar pupa and moth. The eggs (Fig. 7, f) may be laid upon the leaves of the corn plant, but should the plant be in silk, the eggs are then usually glued to the silk. Within a few days the eggs hatch into caterpillars, and these feed by eating the silk or by gnawing away the surface tissue of the leaves. As the worms get larger they will be found feeding in the heart of the corn plant or on the kernels of the ear. When the caterpillars are full grown, (Fig. 7, b, c) they measure one and one-half inches in length, and they vary in color from green to pink, brown or almost black and in markings from a plain to spotted or even striped appearance. The caterpillars when full grown, usually cut a circular opening thru the husks of the ear and thru this make their escape. They now burrow into the ground one-half to six inches deep, hollow out a chamber and within this change to the pupa. The pupa (Fig. 7, d) is an oval, brown or blackish body, three-fourths of an inch in

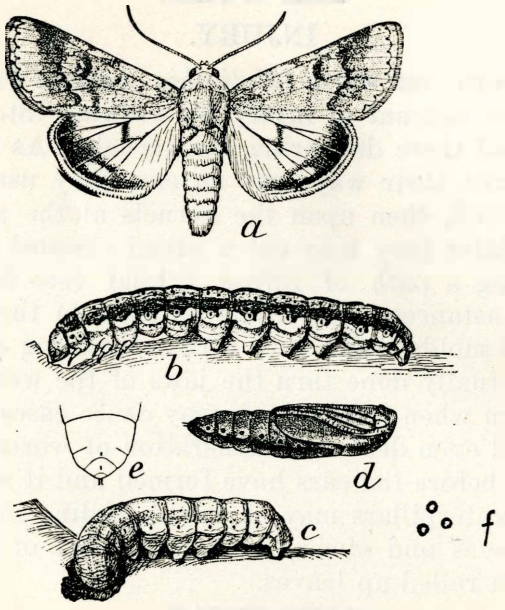

Fig. 7.—Life history of corn ear worm; a, Moth; b, ear worm; c, light colored ear worm; d, pupa; e, back end of pupa; f, eggs. After L. O. Howard and modified by H. C. Severin.

length. The moth which emerges from the pupa is a yellowish, olive green or drab colored insect with an expanse of wings of one and three-fifths inches (Fig. 7, a). Each female moth is capable of laying several thousand eggs, as many as 3,000 having been obtained from one insect.

In South Dakota there are at least two generations of this insect per year, with a possibility of a third generation in some years. The winter is passed in the ground as a pupa.

CONTROL.

Fall plowing of cornfields and their edges, followed by thoro harrowing, will destroy many of the hibernating pupae and thus aid in controlling this pest. However, since the moth is so very prolific, the next summer may find many ears of corn again infested.

During the past few years an attempt to control the ear worm was made by dusting growing ears of corn with powdered lead arsenate 75 per cent and sulphur 25 per cent. This process, however, is very laborious, for after the powdered lead arsenate and sulphur are thoroly mixed, they must be carefully applied as a dust to the silk of each ear at intervals of 3 or 4 days. The dusting may be done through a cheese cloth bag or thru a powder gun; the first application of the poison is to be made when the silk first makes its appearance and the last when the silk has become dry. Owing to the large amount of labor necessary to carry on the dusting process, this method of control becomes practicable only on corn grown in small amounts, such as sweet corn and show corn, and on corn which will bring a big price, such as seed corn.

GRASSHOPPERS.

INJURY.

Grasshoppers do not breed ordinarily in cornfields, but may invade such fields from neighboring areas

where alfalfa, grain or grass is grown, or from unplowed edges of fields and roads, railroad right of ways, etc. When locusts first enter a cornfield, they injure the outer rows of corn by eating away all tender parts of the plants, such as the silk, husks and kernels of the ears as well as the blades of the leaves. Later as the hoppers increase in number, the injury becomes more severe and then the entire plants may be stripped so that nothing remains but the stalks. As still more grasshoppers appear, the insects spread through the entire cornfield and ruin it (Fig. 8).

Fig. 8.—Corn ruined by grasshoppers. After Dean.

LIFE CYCLE.

The more seriously injurious grasshoppers of South Dakota lay their eggs during the fall of the year and then die. The eggs are laid in masses (Fig. 9, A, B) in the ground at a depth of one to one and one-half inches, as many as 127 eggs having been found in a single egg mass laid by one of the larger species of our hoppers (*Melanoplus differentialis*). The smaller species of grasshoppers lay a considerably smaller number of eggs than do the larger species, but both the large and small species of hoppers normally produce two egg

masses. Firm ground is chosen by the female insect for egg-laying, such places as roadsides, uncultivated edges of grainfields, grasslands, railroad right of ways, alfalfa fields, etc., serving as attractive areas. The eggs remain unhatched over winter, but the following spring during May and June, they give rise to young hoppers measuring one-eighth to three-sixteenths of an inch in length (Fig. 9, C 1). The young insects feed and grow and at intervals shed their hard skin. After the skin has been molted for the fifth and last time, the insect is fully winged and shortly after this the females are ready to lay eggs (Fig. 9 D. E.)

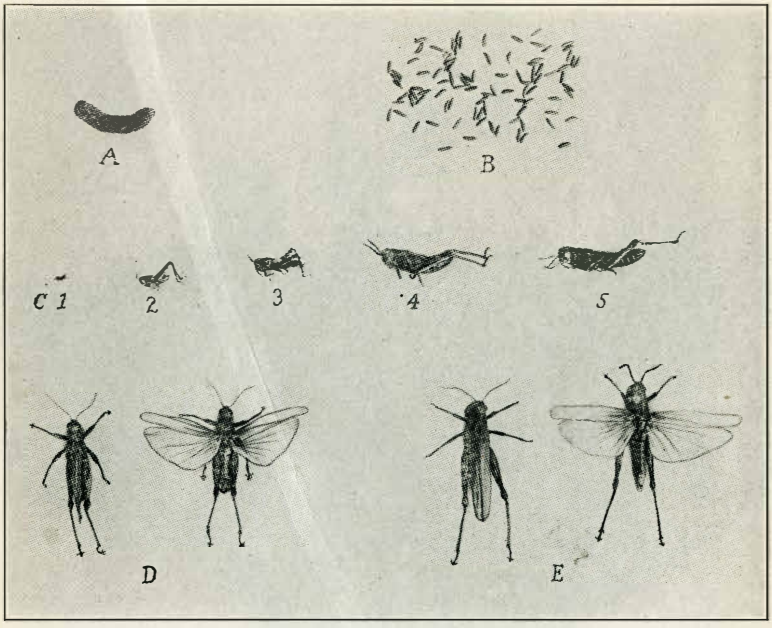

Fig. 9.—Life history of Differential grasshopper; A, Egg pod; B, Eggs taken from one egg mass; C, 1, 2, 3, 4, 5, stages of immature grasshoppers; D, male grasshoppers; E, female grasshoppers. After H. C. Severin.

CONTROL.

Grasshopper control measures may be divided into two divisions: 1st, those which deal with the destruction of the eggs and, 2nd, those employed in destroying

the hoppers, both young and old.

DESTRUCTION OF EGGS—A farmer who has been troubled with grasshoppers during the year, should examine his fields at the end of October for hopper eggs. Special attention should be paid to the areas which are favorable spots for egg-laying. Such fields as were badly overrun with grasshoppers during the summer, and over which are scattered numerous dead hoppers in the middle of October, will usually contain a large number of eggs. To locate the eggs, soil which is suspected of harboring them, should be scraped to a depth of 1 or 2 inches with a trowel, spade or other in-

Fig. 10.—Clump of grama grass showing grasshopper egg masses among the stems and roots. After H. C. Severin.

strument. If eggs are present, small yellowish oval bodies one-sixteenth of an inch in diameter and three-sixteenths of an inch in length will be exposed. Grass clumps in these areas should be pulled up and broken

open in order to find out if these contain hopper eggs (Fig. 10). If an alfalfa field is to be examined, not only should the soil in bare spots be gone over, but clumps of grass, alfalfa plants, and the edges of large ant hills should also be investigated.

Such areas as contain eggs should be plowed in the fall of the year (after October 15) and in the spring the soil should be disked, harrowed and, if possible, rolled so as to pack the ground. If the ground cannot be plowed in the fall and if spring plowing is to be practiced, then this should be done before May 15. The plow should be followed by the disk, harrow and roller, if possible. If the ground is not to be plowed, then it should be disked, harrowed or cultivated in the fall, and in the spring it should be thoroly harrowed. If in the spring there are numerous grass clumps in the field, and if these clumps contain uninjured grasshopper egg masses, the field must be thoroly worked with a brush harrow or plank drag.

Alfalfa fields which are badly infested with eggs should be cultivated late in the fall with an alfalfa renovator or with a spring tooth harrow. The following spring, a straight tooth harrow should be used to work the alfalfa field. If, however, there are numerous grass clumps in the field at this time and if these clumps contain eggs, then a brush harrow or plank drag must be used to break them up.

DESTRUCTION OF THE GRASSHOPPERS.—If the eggs of the locusts were not destroyed and the hoppers have hatched, then these insects should be killed with poison bait or caught by means of a hoppercatcher or a hopperdozer. Whichever method is used, however, the farmer should not put off killing the insects any longer than is necessary because the injury becomes more severe each day.

POISONED BAIT METHOD OF CONTROL.—The poisoned bait is a cheap and very effective agent for destroying young and adult hoppers. This should be prepared carefully according to the following formula:

[1] Bran, coarse flaked, if possible .....25 lbs.
White arsenic or Paris green ..... 1 lb.
Lemons or oranges 6
Cheap molasses, such as sorghum, black strap or glucose sirup ..... 2 qts.
Water .... 4 gal.

The dry bran and poison are placed in a large tub or box and mixed with a hoe, wooden stick or other implement. The sirup or molasses should be dissolved in three gallons of water, and to this is added the lemon or orange juice, followed by the finely grated pulp and peel of the fruit. The resulting mixture is poured slowly over the poisoned bran, and at the same time the entire mixture should be stirred so that every particle of bran is thoroly dampened.

The poisoned bait is attractive and efficient when it is fresh and moist, and when it is in this condition, the locusts prefer to feed upon it rather than upon their natural food plants. Consequently the bait should be distributed at a time of day when it will remain moist the longest period of time. In South Dakota, the distribution of the poisoned material should take place after sundown or before sunrise. The efficiency of the bait is destroyed by rains and consequently the poisoned bran should not be applied on a day when there is liable to be a rainfall.

The bait should be thinly sown by hand or by a broadcast seeder over such parts of fields and gardens as contain grasshoppers. A convenient method of scattering the bait over a large area is to sow it from the rear end of a light wagon. Where the locusts are very numerous, the amount of bait prepared by using 25 pounds of bran should be sufficient to cover 5 or 6 acres, but where the hoppers are only moderately numerous, this amount will treat 10 to 12 acres.

When the locusts are very abundant, it may be necessary to repeat the application of the bait a second or even a third time at intervals of 4 or 5 days. Under

[1] Alfalfa meal or shorts may be substituted if bran cannot be obtained.

no circumstances should the poisoned material be sown thickly or placed in heaps in a field or garden. The efficiency of the bait should be judged 3 or 4 days after the material was applied, for many of the poisoned hoppers die only after such a period has elapsed.

If the grasshoppers are leaving their breeding ground and invading a neighboring cornfield, the poisoned bait should be sown in a strip several rods wide between the breeding ground and the corn. The treatment should be repeated as often as is necessary at intervals of two days or more.

If the hoppers have already invaded one edge of the cornfield, the poisoned bait may be used to stop their progress. In this case, however, 3 or 4 times the amount of molasses called for in the formula should be used. The bait is to be applied by sowing it over the ground as usual, but it should also be thrown in small amounts among the tops of the plants.

HOPPERCATCHER AND HOPPERDOZER METHOD OF CONTROL.—Hoppercatchers and hopperdozers may be used with considerable success in reducing the numbers of grasshoppers in an alfalfa field, grainfield or other breeding area, but these machines cannot be used in cornfields. For instructions regarding the manufacture and operation of these machines, the farmer should write for Bulletin 172, South Dakota Agricultural Experiment Station.

To control locusts successfully, co-operation among neighboring farmers is oftentimes necessary.

CORN ROOT APHIS.

INJURY.

The corn root aphis or louse (*Aphis maidiradicis* Forbes) does its principal damage to corn while the plants are still small. In some cases the young plants may be killed outright before they break thru the ground, but usually the injury is not so severe. The root lice have sucking mouthparts somewhat similar to those

of a bedbug, and it is thru this beak, the sharp needle-like parts of which the animal forces into the roots of plants, that nourishment in the form of sap is obtained. Consequently, the characteristic injury of badly infested corn plants is their lack of strength, expressed in a dwarfing of the entire plants and accompanied by a yellowing or reddening of the leaves. If, upon an examination of dwarfed and weak corn, it is found that the roots are infested with small mealy bluish green lice, either winged (Fig. 11) or wingless (Fig. 12) and that these aphids are attended by numerous small brown ants, then there is evidence sufficient that the corn root louse is present and doing serious injury. The greatest injury in the field occurs in patches which were especially weedy in early spring.

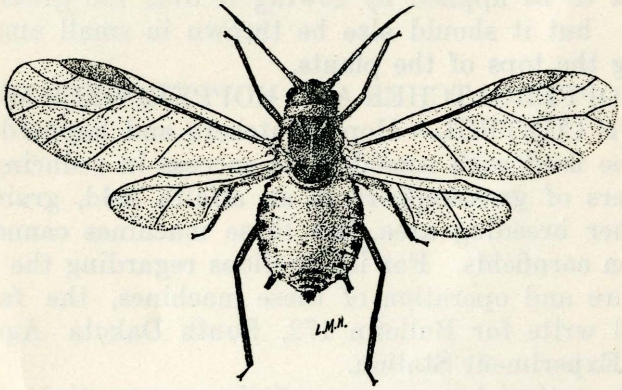

Fig. 11.—Winged female root louse enlarged 16x. After Forbes.

LIFE CYCLE.

The corn root louse lives thru the winter in the egg stage. The eggs were laid by female lice during the preceding fall, were gathered up by little brown field ants so common in cornfields and were stored in their underground burrows. In the spring the eggs hatch into young root lice and these young are seized by the ants and placed upon the roots of pigeon grass, smartweed, ragweed, crabgrass and other common grasses growing in cornfields. The lice feed upon the roots of the weeds

by sucking out the sap, but they make suitable return to the ants by producing a sweet fluid, the honey dew, which is eagerly eaten by the ants. The root lice which hatch from the eggs are all wingless females and these give birth to living young in about two or three weeks. The second generation of lice feed and grow and are ready to give birth to the third generation of female aphids in about two or three weeks. The fourth generation and generations following are produced like the second and third, but as the ground becomes warmer, a shorter interval of time is required to mature the lice, until only a week to 11 days is necessary. In central Illinois as many as 22 generations of lice may be produced in a year, but the average is 16. The number of young which each female louse is able to produce averages 44.

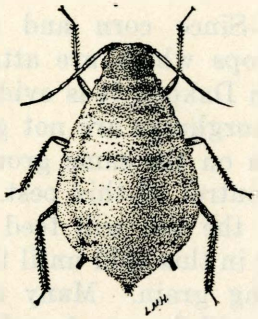

Fig. 12.—Wingless female root louse enlarged 14x. After Forbes.

If a field infested with the corn root louse is planted to corn, the ants remove the lice from the roots of weeds and transfer them to the roots of corn. Beginning with the second generation, some of the aphids of each generation become winged and these leave the roots of the plants upon which they were feeding, make their way to the open air thru the burrows of the ant nests and migrate. If they happen to fly to another cornfield and are found by the little brown field ants, they are seized and carried underground, to be placed upon the roots of corn or weeds. In this manner new fields may become

stocked with root lice. In the fall of the year, true male and female lice appear. These are wingless and after leading a life somewhat similar to the wingless females which preceded them, they mate and die, the female having deposited her eggs in the meantime.

Thus it is seen that a close association exists between the ants and the lice. The lice cannot exist without the ants, for the ants collect and care for the eggs of the aphids in fall, winter and early spring, carry the newly hatched young lice in the spring to the roots of weeds, transfer the aphids from the roots of weeds to the roots of corn and from one corn root to another when overcrowding takes place or when the roots become dry and hard, take the migrating lice underground and place them upon their proper feeding material, etc.

CONTROL.

ROTATION.—Since corn and sorghums are the only cultivated crops which are attacked by the corn root louse in South Dakota, it is evident that a rotation in which corn or sorghums are not grown two or more years in succession on the same ground will be an efficient aid in the control of this pest. If a small grain crop follows corn, the lice will feed upon the roots of the weeds growing in this field until the weeds are killed out by the growing grain. Many of the winged lice reared in this field will fly over to neighboring cornfields and become established there. In this manner a field which was in corn last year and in which the lice were not destroyed, may act as a center of distribution of root lice even tho a rotation of crops is practiced.

However, it should be borne in mind that a cornfield suffers its most serious injury from root lice, not so much because of the aphids that migrated into it this year, as because of the lice that were in that field when the corn was planted.

CULTIVATION.—Proper cultivation is undoubtedly the most important method of control for the corn root louse. Late fall or early spring plowing to a depth

of six inches, followed by repeated diskings in the spring has for its object the breaking up of the ant nests, the scattering of the eggs and young of the root lice and ants and the destruction of the young weeds upon which the young root lice must feed. Plowing in the fall, followed by a single disking in the spring is much more effective than spring plowing and no disking. Plowing to a depth of four inches is not nearly so effective as six-inch plowing, for the ant nests extend six inches beneath the surface of the soil. For the same reason deep disking is more effective than shallow disking.

Corn which is grown on fertile soil and soil that is well cultivated will suffer less thru corn root lice than corn grown on poor soil or on soil which does not receive the proper cultivation.

REPELLANTS.—Until further experiments have been conducted, it is not advisable to soak seed in repellants with the idea of avoiding corn root louse injury, nor is it advisable to add a repellant to fertilizer to bring about this result.

CO-OPERATION.—Co-operation among farmers for mutual protection against the corn root louse is highly essential. Every farmer should do his share to eliminate thru cultural methods the lice in his fields, even tho he practices rotation. If this is not done, the lice may become so abundant in the future that rotation of crops then will not give us the protection that it does at the present time.

WHITE GRUBS.

INJURY.

Among the serious enemies of corn are the larvae of May beetles or common white grubs or grubworms (*Lachnosterna sp.*). These insects are readily distinguished by their large white soft body and brown head and by the fact that they nearly always lie curled up in the form of a semicircle (Fig. 13, e). The grubs found at the base of manure heaps and other decaying vegeta-

tion are not the insects we are discussing, for the May beetle larvae are not known to breed in such places. The white grubs feed upon the roots and underground stems of certain plants, corn, potatoes, timothy and strawberries suffering the greatest amount of damage. Land which is in sod may become so thoroly infested with white grubs and so badly injured, that the sod may be rolled up like a carpet (Fig. 14). On the other hand, alfalfa and clover are practically immune from attack, while the small grains are only moderately injured. When the grubs are very abundant in a cornfield, every hill of corn may be destroyed, but usually the destruction is not so severe (Fig. 15). In many instances, the grubs may not be abundant enough to kill the corn plants outright, but they may destroy the roots to such an extent as to cause the plants to blow over in a moderately strong wind.

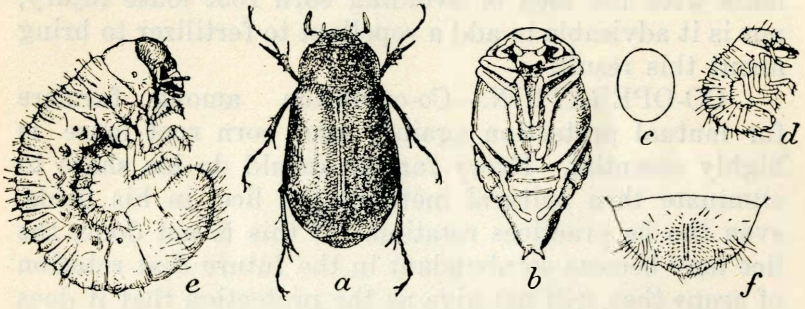

Fig. 13.—Life history of May Beetle (Lachnosterna arcuata): a, Beetle; b, pupa; c, egg; d, newly hatched larva; e, mature larva or grub; f, anal or last segment of larva from below. a, b, and e Enlarged one-fourth; c, d, and f more enlarged. After Chittenden.

LIFE CYCLE.

The life cycle of a white grub is made up of four stages, namely, the May or June beetle, the egg the larva or grub and the pupa. To pass thru these stages, the injurious species of white grubs require three years, altho later research may prove that some of our species complete their cycle only after a lapse of four years. A general summary of the three-year life cycle as it occurs in South Dakota is given in the following short discussion.

First Year. The beetles (Fig. 13,a) first appear at the end of April, but usually they do not become abundant until the latter part of May and early June. After the beetles have fed for a time, they lay their eggs and

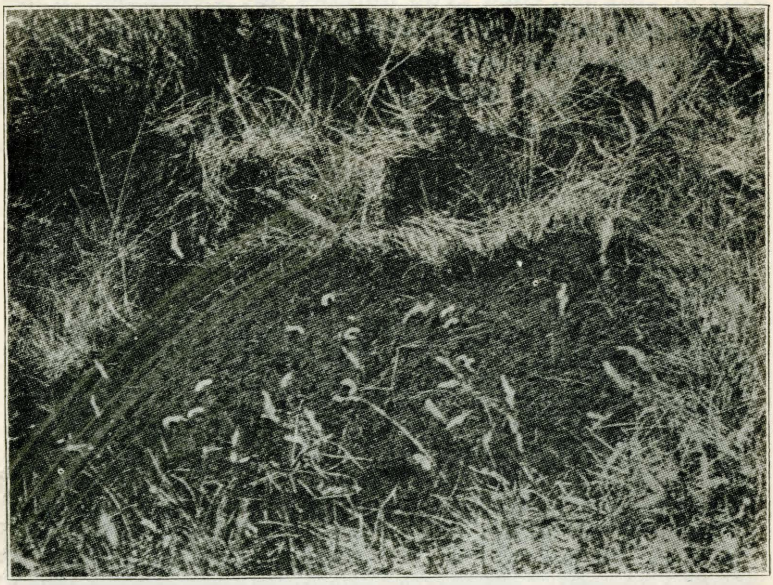

Fig. 14.—Piece of sod overturned to show white grubs underneath. After J. J. Davis.

die. The eggs (Fig. 13, c) hatch into young grubs or larvae in a few weeks and these feed on live or decaying vegetation that is found in the soil. However, since the grubs are rather small during their first year, they do not cause very much harm. On the approach of cold weather, the young larvae burrow into the soil to a depth of 7 to 14 inches and hibernate.

Second Year. As soon as the soil warms up in the spring, the hibernating worms burrow upward thru the ground and resume feeding. If now corn or some other cultivated crop that is susceptible to grubworm injury is put into a field that is badly infested with these insects, the injury that results to the crop is very severe. In fact, it is chiefly during the second year of the grub's existence that most of the harm is done by grubworms.

In the fall of the year, the larvae again burrow deeper into the ground and hibernate.

Third Year. In the spring of the third year, the insects return to the surface soil to feed, but in June, July or August, each grub hollows out a chamber in the ground and within this changes to the pupa (Fig. 13, b). A few weeks later, the pupae change to beetles, but these, instead of making their way into the open air, remain in the pupal chambers until the following spring.

Fig. 15.—Cornfield injured by white grubs. After J. J. Davis.

While it is true that there may be some white grubs in our fields every year, a serious outbreak of the pest occurs usually only once every three years. If a farmer had a serious loss of corn in 1915 due to grubs, he may again expect trouble in 1918 unless he has practiced the proper control measures. Further, if the May beetles were abundant in 1917, in the following year the grubs may be expected to be abundant and highly injurious in those fields which were attractive to the May beetles at

the time of egg-laying.

The beetles prefer to feed upon the leaves of trees, willow, poplar, ash, boxelder, maple, hackberry and elm being chosen food plants, altho corn and grass are also eaten. During the daytime, the beetles remain hidden, buried in grass or sod land, but during the evening they leave their places of concealment and fly to the feeding grounds. Here the beetles remain during the night and here also mating takes place. Upon the approach of dawn, the insects return to grass or sod land. The beetles, especially the males, are attracted to lights during the evening and are the familiar large brown or black insects which enter our houses thru an open window, fly noisily about, bump against the wall and then fall heavily to the floor. During a year when the beetles are abundant, thousands upon thousands of trees may be entirely stripped of their leaves thru these insects during the months of May and June.

For egg-laying, the beetles prefer high ground covered with sod, timothy, small grains or weedy corn. If such areas are situated close to timber, the conditions are ideal for the insect, for then no extended flights are necessary to pass from the feeding grounds to the fields in which concealment takes place, or to the breeding areas. The eggs are laid in the soil to a depth of 1 to 8 inches, and are white in color, oval in shape and one-tenth of an inch long (Fig. 13, c).

CONTROL.

When white grubs are working in a field of corn, nothing practicable can be done to lessen the injury to that particular crop. However, thru fall plowing, proper rotation, and the use of wild birds and farm animals, injury to corn thru these insects during the following years may be avoided or so reduced as to be negligible.

FALL PLOWING.—Fall plowing followed by thoro harrowing is of considerable value in ridding a field of white grubs. To be most effective, the plowing should be done early in October or even before this, for then the ground has not yet chilled sufficiently to cause the

grubs to burrow deep into the soil. If the grubs have changed to the pupa or the beetle stage, deep plowing at any time in the fall, followed by disking or harrowing, will destroy myriads of the pest.

USE OF WILD BIRDS AND FARM ANIMALS.—Wild birds such as gulls, robins, blackbirds, grackles and crows should be encouraged to visit fields that are being plowed, for these birds are very fond of grubworms. Poultry, likewise, can be used to destroy the grubs in a field that is being plowed, for our feathered friends soon learn to follow a plow.

Hogs, whenever given the opportunity, will practically free a field from grubs provided they are allowed to root it up between the months of May and October. One objection to this method of control, however, should be mentioned. The giant thorn-headed worm (*Echinorhynchus gigas*) is an intestinal parasite of the hog, but also requires to pass a portion of its life in the body of a May beetle or a grubworm. Should a hog swallow a grub or beetle infested with this parasite, the body of the grub or beetle is digested, and the worms liberated in the food tube of the hog. When the worms are mature, the females deposit eggs and these, together with the feces of the hog, pass out of the intestine. The grubworms, in turn, become infested with the parasite by eating the eggs.

To protect hogs from the thorn-headed worms, the folllowing information and directions should be carefully read and followed: Hogs that have never been pastured or allowed to root around manure piles, old straw stacks or other decaying vegetation, are free from these worm parasites, and likewise fields that have not been pastured by hogs during the last three years are uninfested. Consequently, in pasturing, use only hogs free from worms and turn them into fields that are not infested with the thorn-headed worm.

ROTATION.—In a year when grubworms are scheduled to be very injurious, corn or potatoes should not be planted in land which was in sod, timothy, small

grain or other uncultivated crop the year before. White grub injury may be expected to be severe in South Dakota in 1918, but the injury will probably be most marked in the south eastern corner of the state, because here the beetles were very numerous in the spring of 1917 and because here the loss in 1915 due to white grubs was especially serious. The three year interval between successive recurrences of injury is explained thru the fact that three years are required by the insect to complete its life cycle and the same length of time, therefore, must elapse before two year old grubs are again found in the soil. In planning a rotation, it should be remembered that clover, alfalfa, peas, flax and small grains suffer less injury from white grubs than do corn and potatoes, and that fields next to timber land or tree claims will harbor more grubs, all other conditions being equal, than land farther away.

WIREWORMS.

INJURY.

Wireworms (*Elateridae*) are classed among the most seriously injurious of the corn insects in South Dakota. The injury to corn is done early in spring and is confined to the seed, to the roots or to the stem beneath the ground. When the seed is attacked, the wireworms gnaw away the outside, bore into and sometimes thru it, or eat away the entire inner part, leaving only the hard outer shell. If the young plant is being attacked, the wireworms may devour the smaller roots, they may bore into and tunnel thru the larger ones or they may burrow thru the stem beneath the ground. Failure of the seed to give rise to plants should not be attributed, without investigation, to weak or dead seed, for this condition may be due to wireworms or some other underground insect. Should corn a foot or two in height suddenly wilt, wireworms may logically be suspected as the cause of the damage, especially if the corn in question is growing on land that was in sod a year or two ago. Normally, wireworms live in sod land and because of the

immense numbers of grass roots present, they may feed upon these without producing any noticeable effect, but if corn is put into such a field, the roots are correspondingly reduced in number and the wireworm injury consequently becomes serious.

LIFE CYCLE.

Wireworms vary in color from a yellow to a reddish brown and in size from three-quarters of an inch to an inch and a half. The body of a wireworm is either flattened or rounded, smooth and segmented, the three segments directly back of the head bearing six short legs (Fig. 16, b). When the worms are taken into the hand, they bend their body back and forth with wonderful strength.

The length of time that it takes these insects to complete their life cycle varies with the species, but the stages thru which they pass are more or less similar in all. When a worm is full grown, it hollows out a little chamber in the ground, and inside of this it changes to a pupa (Fig. 16, d). This usually takes place in July and August and the insect, after remaining in the pupal stage for two, three or four weeks, transforms to a beetle (Fig. 16, a). The beetles of our injurious species of wireworms measure in length from slightly over a quarter of an inch to not quite an inch. They are popularly known as snap or click beetles, jumping jacks, etc., on account of their habit of springing into the air with a snap when they are laid upon their backs. Most of the beetles remain in the pupal chamber during the fall and winter, but some leave this chamber shortly after they have transformed to beetles and after flying about and feeding during the favorable weather of fall, they seek suitable hibernating quarters. Any protected nook large enough for the insect to enter may serve as a place to pass the winter; such things as loose bark of trees, loose boards on buildings, boards and rubbish on the ground, etc., offer attractive shelter for hibernation. In the spring, the beetles come out of their hibernating quarters and in a short time lay their eggs, prefering

for this purpose, grass or sod land. The eggs hatch into young wireworms, and these feed and grow, some of the worms spending three years in the soil, while others remain there for five or even six years.

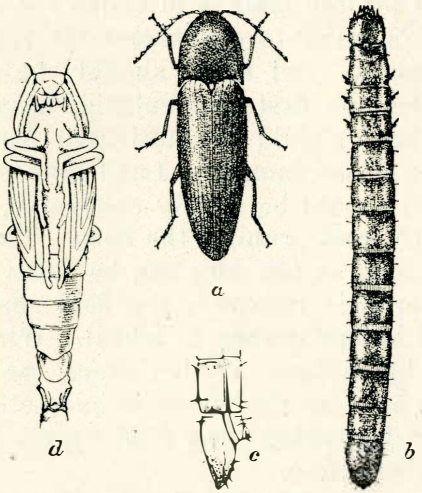

Fig. 16.—One of the corn wireworms: a, Adult or beetle; b, larva or wireworm; c, last segments of larva; d, pupa. All enlarged. After Chittenden.

CONTROL.

Wireworms are very difficult to control; 1st, because the worms are underground workers and therefore difficult to reach; 2nd, because the worms cling to life very tenaciously; 3rd, because there are several injurious species of wireworms in our state, some of which inhabit one type of soil and others another type, and consequently require different methods of control; and 4th, because so many useless remedies are to be found in literature and in the minds of farmers. Among some of the useless or impracticable control measures which are often recommended are the following: 1st, coating the seed with various poisons, repellants, etc., some of the more notable being Paris green, strychnine, lead arsenate, tar, kerosene, kerosene emulsion, copper sulphate, sulphur, tobacco preparations, formaldehyde, etc.; 2nd, treating the soil with salt, fertilizer, patented preparations, etc.; 3rd, using traps and poisoned baits; and 4th

plowing late in fall.

J. A. Hyslop makes the following recommendations for the control of the wheat wireworms (*Agriotus mancus*), a species which raises havoc with corn in South Dakota: "When the land is intended for corn the following year, in order to counteract the ravages of the wheat wireworm, sod land should be plowed immediately after the first hay cutting, usually early in July. This land should be cultivated deeply thruout the remainder of the summer. Land that is in corn and badly infested should be deeply cultivated, even at the risk of slightly root-pruning the corn. This should be continued as long as the corn can be cultivated, and as soon as the crop is removed, the field should be very thoroly tilled before sowing to wheat. Where wheat is not followed by seeding to other crops, the field should be plowed as soon as the wheat is harvested; this kills the worms by destroying their food supply and preventing proper hibernation.

"A thoro preparation of the corn land and a liberal use of barnyard manure or other fertilizer will often give a fair stand of corn in spite of the wireworms, a vigorous stand often being able to produce roots enough to withstand the depredations of several wireworms. Tho not always practicable, the interposing of crops not severely attacked by wireworms, such as field peas and buckwheat, between sod and corn would materially reduce the number of wireworms in the soil at the time the crop is planted."

Regarding the corn wireworms (*Melanotus* sp.) Hyslop writes as follows: "The corn wireworms are almost exclusively confined to poorly drained and heavy soils. Heavily liming and thoroly tile-draining land infested with these wireworms would undoubtedly prove beneficial. The thoro cultivation of waste land, especially along drainage ditches and creeks, during midsummer, and the deep cultivation of crops and fallow land at the same time would destroy large numbers of them."