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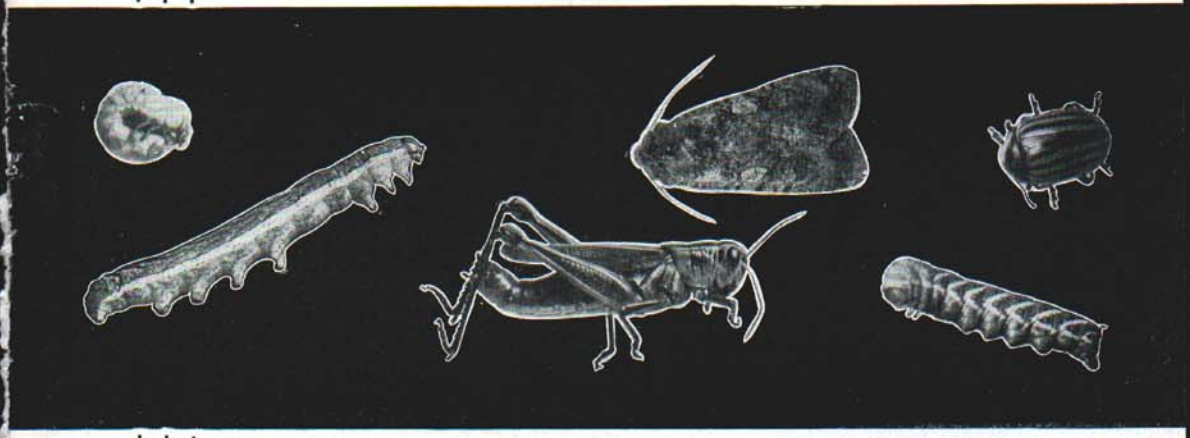

CHEWING INSECTS

Affecting FIELD AND GARDEN CROPS

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RAY HUTSON

The prevalence of insects, harmful and otherwise, is governed by many factors.

Climate is the most important single item, for climate largely determines the kinds of insects that occur in any region. High or low temperatures and prevalence or absence of moisture affect various insects in different ways. In other words, some insects, cutworms for example, seemingly prefer cool, moist conditions, while thrips and chinch bugs flourish under dry, hot conditions. In addition, the effect of climate upon plants exerts an indirect influence upon insects as in the last analysis, insects depend upon plants for their food. Climatic fluctuations also encourage or discourage insect diseases which often, in turn, determine the number of insects.

Crop practice is another factor of importance. It exerts influence by furnishing food and by providing shelter. Everyone has noticed the prevalence of white grubs in newly plowed sod. Almost everyone can recall some insect which passes the winter upon crop remnants or in trash, leaves, or rubbish. While some insects, for instance grasshoppers, eat almost any plant, most insects feed upon limited groups of plants.

The influence of the foregoing factors, which are in a measure interdependent upon insect control measures, cannot be over-estimated in any consideration of insect control upon field and garden crops. The net per acre value of the crops affected is in many cases such as to necessitate careful planning to insure a profit without any expenditure for insect control. Consequently, consideration of a crop in relation to the probable insect pests is good business. Plowing sodlands without thinking of white grubs and wireworms and permitting squash bugs to get into good condition for the winter upon the stumps of the vines left after harvest are examples of poor practices.

Many farm practices are recommended in this bulletin for insect control, and in every case an effort has been made to make such practices harmonize with practices that are considered good farming from other standpoints. It should be apparent that any insect control problem which can be anticipated or solved by modification of the usual practices is more economically done in this way since ordinarily the modifications recommended do not cost a great deal.

Insect outbreaks sometimes occur under circumstances that cannot be met by modification of crop practices. Insecticidal treatment then is the only way to avoid threatened loss. However, the greatest success in insect control comes to those who use good practices and de-

Fig. 1. Grasshopper eggs at grass roots.

pend upon insecticides in situations where insect outbreaks occur despite good practices as sometimes happens when conditions fluctuate widely.

GENERAL FEEDERS

While many insects confine their feeding to a few plants, several insects feed upon almost any plant material.

Grasshoppers

Melanoplus femur-rubrum, M. mexicanus, Agenotettix deorum and *Camnula pellucida.*

These four species of grasshoppers are always to be found in Michigan. Sometimes only a few are present, but always there are enough to multiply quickly whenever the weather conditions are favorable. Their ability to destroy a wide variety of crops is too well-known to need comment.

In northern Michigan conditions are just suited to their needs, with occasional resulting infestations of great size, followed by periods marked by almost negligible quantities of the pests. Large areas of "wild land," which have not yet been brought under cultivation, furnish suitable places for the hoppers to multiply during the production of a "wave" and migrate to cultivated land.

The grasshoppers under discussion lay their eggs in the soil, choosing sodland, wherever it is to be found. Each female may deposit several pods of eggs, each pod containing a score or more of eggs. The eggs hatch in the spring and the hoppers live and FEED until fall. The number deposited in an acre of "cut-over pasture" is almost unbelievable.

If the grasshoppers are left to nature, their destruction is certain enough, but usually too slow to be of much aid to the farmer.

Rainy or damp weather at the time the eggs are hatching will stop an outbreak sometimes by killing the young grasshoppers. Rainy, cloudy, cool weather during August and September will prevent extensive egg laying. On the other hand, dry, bright, hot weather during hatching time and the egg-laying season will result in grasshopper increase. Hatching is a critical time in the life of the grasshopper because young, small grasshoppers drown readily, are susceptible to disease, and do not feed normally at temperatures below 65° F.

Extremely hot, dry weather sometimes affects grasshoppers adversely through its effect upon vegetation. Grasshoppers consume large amounts of food, sometimes denuding an area and starving.

Weather conditions also affect grasshoppers through influence upon their enemies. Wild birds, skunks, mice, shrews, turkeys, hairsnakes, mites, flies, blister beetle larvae, and other animals and fish feed on grasshoppers.

Under weather conditions favorable to grasshoppers, outbreaks sometimes cause great crop losses. However, grasshopper damage is preventable.

Control—Grasshopper eggs may be destroyed by plowing or by other methods of working the egg-infested areas. Old sods may be plowed and alfalfa fields and meadows can be harrowed, which will break and destroy many of the egg clusters.

In areas where such methods are impractical, the use of poison bait is the only satisfactory solution of the problem. Bait is used by scattering it thinly over the area where the hoppers are feeding. The application should be made in the morning on warm, sunny days. Young hoppers are more quickly killed than older ones, and economy demands that bait be used on young hoppers before they leave the areas from which they hatched. Older grasshoppers will be killed if bait is used late in the season, but much damage has already been

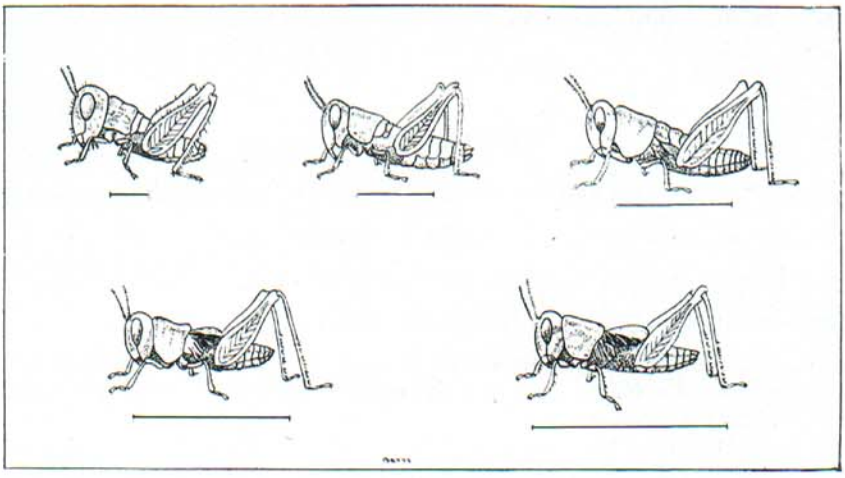

Fig. 2. Young grasshoppers. The line indicates actual size.

done at this time and more bait is required to cover the larger areas and to satisfy the greater appetites of the adults.

About 10 pounds of wet bait are sufficient to treat successfully an acre of ground for young hoppers. The bait may be spread by machinery where practical. Machines costing very little have been designed and used for this purpose and will treat as many as 50 acres an hour when drawn over the infested area behind an auto or truck. The most common method of spreading bait in Michigan is by hand. The bait is carried in a sack, pail, or basket and is scattered by a man walking or riding a horse, back and forth over the area, throwing the bait to either side as he progresses. The bait is crumbled in the hand and thrown with considerable force to scatter it thinly without lumps and bunches. The greatest difficulty is in making the bait "stretch" so that 10 pounds will cover an acre completely.

A garden or other small plat can be protected sometimes by broadcasting and maintaining a barrier of bait about it two or more rods wide, but protection is more certain if the grasshoppers are poisoned in their breeding places.

Poison bran bait (Page 39), is properly spread in the heat of the day for grasshoppers since they feed little, if any, when the temperature is below 65° F.

On Mint and in Alfalfa Seed Fields—It sometimes happens that grasshoppers attack mint fields and fields of alfalfa grown for seed; in such cases the use of poison bran bait sprinkled on the ground to attract grasshoppers living in the tops is ineffective. The hoppers can be checked, however, in such cases by dusting with calcium arsenate around the edges of the threatened fields just before the attack is made, or to a less degree by dusting the field with a dust containing 10 per cent of calcium arsenate and 90 per cent of hydrated lime. The hay from such fields must, of course, be kept away from livestock, and should be plowed under. Fields of fresh mint in the vicinity of recently cut-over land have been given adequate protection in this way.

Blister Beetles

STRIPED BLISTER BEETLE (OLD-FASHIONED POTATO BEETLE) *Epicauta vittata*

ASH-GRAY BLISTER BEETLE, *Macrobasis unicolor*

BLACK BLISTER BEETLE, *Epicauta pennsylvanica*

MARGINED BLISTER BEETLE, *Epicauta marginata*

Four common kinds of blister beetles are in Michigan; the ash-gray, the margined, the black, and the striped or old-fashioned potato beetle. All of them feed on beets and on various other plants. Some species seem to prefer members of the clover family—sweet clover, vetches—which they attack during the latter half of July and August. The black species is found in great number, late in the season, on golden rod.

The appearance of the blister beetle is shown in Fig. 3. It is long and slender, has graceful legs and form, and is a little more than half an inch in length. The species differ markedly in color. The one figured is known as the old-fashioned potato beetle, because of its well-known love for that plant. It is striped, yellow and black, with black legs. Those of the black and gray species look much like the striped one except for the color, while the margined beetle is dead black with the margins of the wing-covers gray. They all eat the foliage of beets when adult and often cause serious damage.

Fig. 3. Old-fashioned potato beetle. (Enlarged.)

The larval stages, in all common species, except the steel-blue ones, are passed in devouring the eggs of grasshoppers. The young blister beetles of this group are not known to feed on anything else. Inasmuch as grasshopper eggs are laid in pods of 20 to 30 eggs, it is possible for the beetles to do a great deal of damage to the contents of the pods by devouring part of the eggs. If all are not eaten, fermentation and the consequent loss of the rest of the batch is sure to follow. From this we see that it is possible for the beetle to attain its maturity only at the expense of many grasshopper eggs. The beetles, then, are valuable if they occur in anything like moderation, but, lest growers be overrun by those well-meaning but hungry allies, it is often desirable to get rid of them.

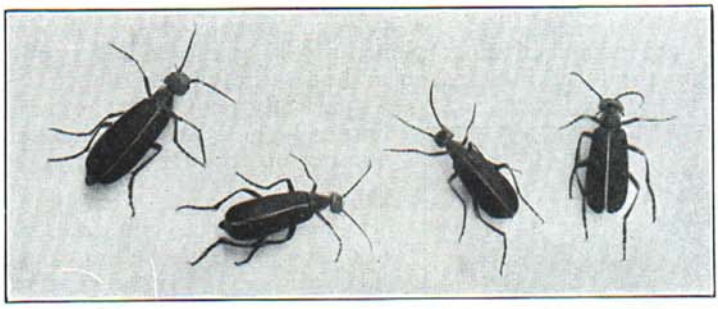

Fig. 4. Margined blister beetles.

Control—Before the days of arsenical poisons, it was the custom of growers when the beetles came in droves, to drive the insects into windrows of dry straw by brushing with the branches of trees and then burn them. Today spraying or dusting with calcium arsenate is relied upon to dispose of the beetles.

Cutworms and Armyworms

Noctuidae spp.

Cutworms are naked caterpillars which are the larvae of medium-sized night-flying, winged moths or "millers". These larvae or "worms" have a habit of cutting off food and eating it after it has wilted. They

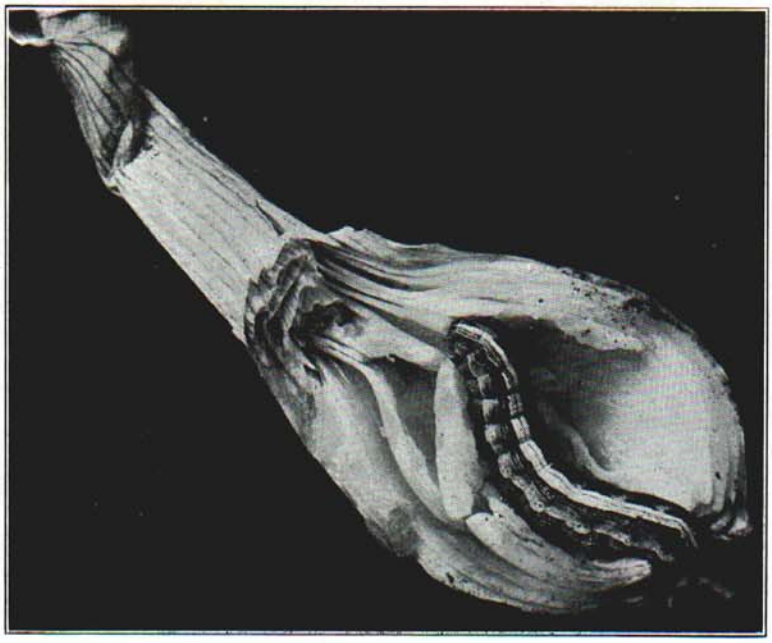

Fig. 5. Cutworm feeding inside of onion bulb.

normally are produced most plentifully in grass sod, several generations being produced in a season and pass the winter for the most part as partially grown larvae, ready when spring comes to attack plants just coming up from the ground.

Fig. 6. Adult moth of cutworm.

Control—Except for climbing cutworms, which ascend trees and vines and feed on the swelling and opening buds, the pests can be kept from such plants as tomatoes, cabbage, and cucumbers by encircling each plant or hill of plants by a paper barrier, sometimes called a paper collar. This protector is merely a round collar of stiff paper placed about the plant and projecting into the soil for about one and one-half inches. It is effective because the common cutworms do not readily climb over such barriers. Empty tin cans can be made into efficient collars by cutting out the bottoms.

Collars do well on a small scale for the protection of tomatoes, cabbage, and similar plants, but when whole fields of onions, celery or corn are to be protected, collars are, of course, inadequate. In such cases, use may be made of poison bran bait, (p. 38), recommended for use in combating grasshoppers, merely omitting the salt.

Fig. 7. Tomato plant with collar of stiff paper for cutworms.

The bait works best when broadcast in the evening in small particles, at the rate of 20–40 pounds per acre, and allowed to lie on the surface.

Fall plowing of grass sod is destructive to cutworms. For the climbing species, use poison bran bait (p. 38) and, in addition, place a band of tree-tanglefoot or some similar material about the trunk of the tree. In the case of grape vines, the wires near the posts must be similarly treated.

The armyworm, *Cirphis unipuncta*, is a special kind of cutworm which at intervals appears in unusual numbers. This creature has all the habits of other cutworms. It works at night and on overcast days. It cuts its food and wilts it. The worm passes through the four stages common to insects of its group: egg, larva or "worm," pupa, and winged moth.

However, its powers of reproduction are very great, and, consequently, when favorable conditions arrive it has a way of appearing in enormous numbers, sometimes sufficient to destroy completely the crops in which it happens to be at work. The armyworm is always to be found in Michigan to a greater or less degree. It produces three generations a year; one in early spring, one in mid-summer, and one in the autumn. Occasionally, the spring generation is well-represented, and occasionally mild attacks occur in September, but usually serious attacks occur in July or August if they develop at all.

A low-lying oats field is ideal for rapid development of the armyworm. The young larvae work at night, cutting off leaf after leaf until only the naked straw and the head remain. Meantime, the larvae are growing and the food supply is getting dryer and less plentiful. The heads are attacked, and, true to the pest's habit of cutting off its food, the heads are lopped off and fall to the ground. Now comes the march to new fields, and, because of the orderly drive in which practically all individuals start and continue in one general direction, the name "armyworm" is suggested. The individuals do not scatter radially, but they march, frequently covering the ground. New fields are invaded and occupied—most often fields of corn, where the larvae complete their growth and change to pupae, each in its earthen cell. Later, the pupa changes to a winged moth, which flies and provides for the next generation.

During the long intervals between outbreaks, armyworms are kept in check by natural enemies, the most important of which are Tachina flies and Hymenopterous parasites, both internal parasites which lay

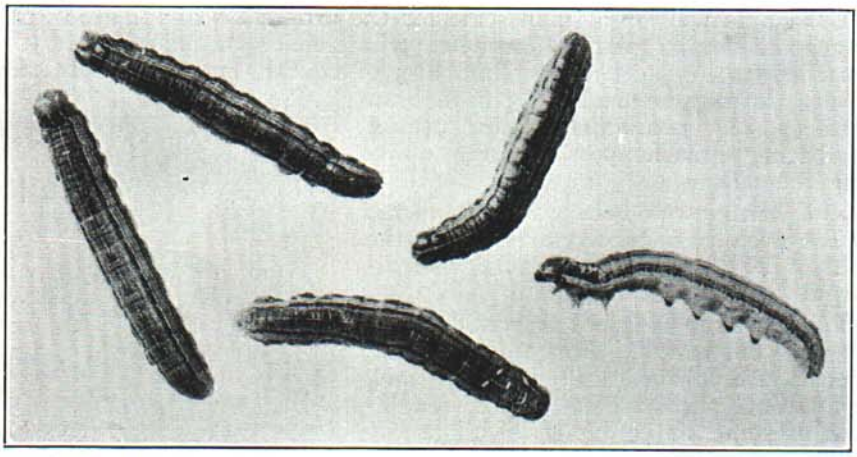

Fig. 8. Armyworms, slightly enlarged, showing eggs of parasites.

their eggs on or in the bodies of the larvae. The parasites are influenced greatly by temperature conditions, and so, as in the case of cutworms, an attack is most likely to occur after a cold, wet, late spring.

Control—When a farm or a field is found to be infested, it is necessary to take measures to prevent the spread of armyworms to uninvaded areas at once. To do this, place barriers in the line of march. Usually, three deep, clean-cut furrows placed parallel, 10 or 12 feet apart, will stop the worms. Turn the furrows toward the advancing worms, and when each furrow fills turn it under, leaving a fresh furrow, burying the "worms" already in the furrow, and making ready a new one at the same time. The furrow method does not work well on sandy or mucky land and if it is used the affected area is abandoned to the armyworms.

A better method is that of spreading poisoned bran bait (p. 38) over the infested area at the rate of about 40 pounds of wet poison bait per acre. The bait used against other cutworms may be used to advantage against armyworms. The bait is properly spread in the evening.

Fall Armyworm

Laphygma frugiperda

Once in a number of years, ears of corn are found late in the season with a number of larvae present—larvae which resemble those of the ear-worm closely. Usually, such larvae belong to another species of moth, the fall armyworm, which also attacks all sorts of crops besides corn. In Michigan, beans are likely to be eaten. Attacks by the fall armyworm come at long intervals in Michigan, and the best control seems to be the use of poison bran bait (.p 38), a control which at the very best is unsatisfactory.

Common Stalk Borer

Papaipema nebris nitela

Perhaps no other insects are sent to the Michigan Agricultural Experiment Station for examination more often than the stalk borers, and of all the stalk borers one known as the common stalk borer is ten-fold more common than all of the rest. As the name suggests, this little naked caterpillar tunnels in plants having pithy or hollow stems. Corn, dahlia, ragweed, potato, tomato, rhubarb, aster, pigweed, and a host of other plants are included in the weekly quota mailed in for examination. For the last several years, many of the samples have been mistaken by the sender for corn borer, because of the recent great interest in the latter comparatively new pest.

The common stalk borer is a slender, naked, soft-skinned caterpillar which sometimes attains a length of one and one-half inches and is striped longitudinally with chocolate and cream-colored lines, except for the middle third, which is dark chocolate. This active, small larva pupates in its burrow and produces a winged moth late in the summer. The moth spreads about an inch and a quarter across its expanded olive wings. It lays its eggs on grass and common weeds and passes the winter in the egg stage. In the spring the eggs hatch and produce the larvae which are the cause of all the damage. There is but one annual generation.

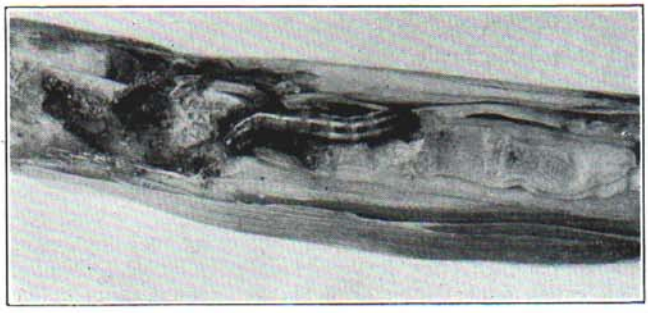

Fig. 9. *Papaipema nebris* in cornstalk, one of the borers easily mistaken for the European corn borer. (Slightly enlarged.)

Control—Up to the present time, no adequate, insecticidal control measures have been discovered. Cutting and destruction by fire of all weeds, either late in the fall or early in the spring, will do away with the over-wintering eggs. No other means of control is feasible, except the destruction by hand of such larvae as can be found working in their burrows but if the weeds are destroyed for at least 2 rods about the area to be protected, few stalk borers will be found in the area.

Pale Striped Flea Beetle

Systena blanda

Flea beetles, as the name implies, have strongly developed jumping hind-legs, by means of which they are able to take long leaps after the manner of the common flea. They all belong to the family of leaf-beetles, and feed on vegetation. The one described, "the pale, striped flea beetle," is very small, measuring about one-eighth of an inch in length, and is yellowish-brown in color. Down each wing-cover extends a yellow stripe. The prothorax is also yellow, the head brownish-red, the legs yellowish-red, and the under side of the body black.

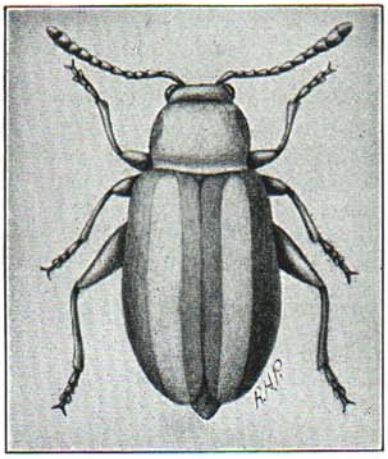

Fig. 10. Pale striped flea beetle. (Enlarged.)

While preeminently a pest of the sugar beet in Michigan, this beetle makes its presence felt forcibly on the garden beet, as well as on corn, beans, and potatoes. It is fond of sorrel (ordinary red or horse-sorrel), pigweed, lambsquarters, ragweed, and a great variety of other plants.

The slender, thread-like larvae of this beetle are said by Chittenden to feed on the roots of corn, lambsquarters, and probably also on the roots of Jimson or Jamestown weed. The larvae are white in color with a moderate number of hairs.

A brownish flea beetle (the potato flea beetle, *Epitrix cucumeris*) is also a general feeder and is controlled in the same way.

Flea beetles are pests during dry seasons, rarely doing serious injury during wet weather. The worst damage is done to beets while the beets are small, usually when they have about two leaves. Under such conditions, the beetles sometimes spoil large areas, usually in sandy regions. When the beets are larger, the insects eat out the soft tissue in patches, either on the upper or under surfaces of the leaves, after which the remainder of the patch dries and falls out, leaving unsightly holes which increase in size as the leaf expands.

Control—Spray or dust with an arsenical, or better still, spray with half-strength bordeaux mixture and calcium arsenate at the rate of two pounds to 100 gallons of water. A dust of calcium arsenate and gypsum or hydrated lime (p. 29) is satisfactory, and in the garden will be, probably, the favorite treatment, because dusts are so easily applied, and the operation can be repeated periodically without much preparation. Clean culture, including the burning of fallen leaves, and the destruction of all ragweed, pigweed, and related plants, will help to starve this pest, in common with some other flea beetles.

A method which has come into general practice on sugar beets in Michigan is to roll the field with a roller or cultipacker while the beets are small and before blocking time. The rolling should be done dur-

ing the heat of the day and not while the dew is on, because the plants are more brittle during early morning and more likely to be broken after they attain any size. Rolling should not be done after the plants get more than four leaves.

Dipping tomato, and other plants before they are set out in half-strength bordeaux plus lead arsenate (p. 41) is good protection against this flea beetle. Cabbage plants must not be dipped in bordeaux.

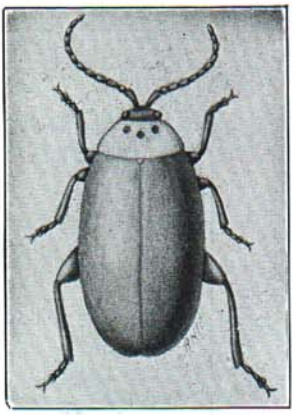

Fig. 11. Triangle flea beetle. (Enlarged.)

Triangle Flea Beetle

Disonycha triangularis

The triangle flea beetle is so named because of the three dark, round spots placed in a triangular position on the orange prothorax. This beetle varies from about three-sixteenths to one-fourth of an inch in length. It is blue-black in color, with the exception of the orange prothorax before mentioned. It has the strong, jumping hind legs of its family. It works on the same plants and is controlled by the same measures as the pale, striped flea beetle (p. 12).

White Grubs or June Beetles

Phyllophaga spp.

The common June beetle, June-bug, or May beetle is familiar to all. This large, clumsy, dark-brown beetle is to be observed, usually every third year, flying at dusk about shade trees, notably oak trees. It is the common large beetle that bumps into illuminated windows, buzzing and scrambling about and creating a disturbance. The larva of this creature lives underground and feeds on the roots of grasses, strawberries, corn, beans, and other plants, often burrowing in the tubers of potatoes, in which stage it is known as the white grub. Like all beetles, it passes through four stages, starting with the egg which is laid underground by the adult June beetle. From this egg, the white grub hatches, and the grub, after attaining its full size, changes to a pupa, still underground; this in turn produces a winged June beetle,

Fig. 12. June beetles *(Phyllophaga fusca)*.

in the manner of most common injurious species, during the spring of the third year from the time that the egg was laid.

To go back to the tiny larva just hatched from the egg—its small size during the summer of birth prevents it from destroying much vegetation in the form of roots.

When fall comes, the grub goes down below the plow-line and passes the winter. In the spring (just about a year after the egg is laid) the grub comes up to feed on the roots of plants. This is the year that the grub gets its growth, and the injury to vegetation may be very serious, indeed, at this time.

Fig. 13. White grub, larva of June beetle.

Late in the fall, the grub descends once more to a deep level and comes up again just about two years after the egg is laid. The season of feeding is a short one in this case. By early July the grub once more has dug down and built a cell in which it changes to a pupa and later to the "hard shell" beetle (the adult), ready to come up in April and May of the third year, to fly, to feed on the leaves of trees, and to lay the eggs for the next generation. Therefore, in any one brood of June beetles there is a flight of adult beetles and the laying of eggs one year, an attack on the roots of vegetation the year following, and a short period of feeding, which may pass unnoticed, in the third year. To complete our data for planning to avoid loss by this pest, we know that the eggs are laid by choice in grass sod or strawberry beds, or in some field covered with vegetation. Clover seems to be less frequently chosen for this purpose. It is therefore, unsafe to put corn, beans, potatoes, strawberries, hops, or young nursery stock in land that was in timothy or other grass or in strawberries the previous year, if that happened to be a June beetle year. In selecting a crop for such a case, one may be guided by the fact that small grains suffer less loss than cultivated crops.

Control—Trees on which the beetles are feeding may be sprayed with an arsenical (p. 40) or the beetles may be shaken off the trees onto sheets spread on the ground.

Deep plowing during mid-summer of the second year after the eggs are laid is effective, the object being to break up the cells in which the grubs are changing to pupae—and later to adults. The plowing should be done about the middle of July. In the case of golf links and extensive lawns where the land is never plowed, the grubs are likely to congregate, attracted by the broad expanse of grass sod; and in such places, many grubs are dug out and eaten by birds and skunks.

From the foregoing it will be seen that in the case of any one brood of white grubs, an attack may be expected every third year, and it will also be apparent that there is nothing to prevent two or more broods occupying any given area simultaneously, so that in such areas white grub attacks are to be expected two out of every three years.

Three broods now exist in Michigan—brood A occupying districts which include the Thumb and adjacent areas, and a large district including much of southwestern Michigan. This area is due to suffer from white grubs in 1942.

Brood B is of little importance.

Brood C is due to appear in destructive numbers over a smaller area in southern Michigan and in the extreme southeastern parts during 1941.

For a more complete discussion of white grubs, including the use of lead arsenate in bringing about their control in permanent sod see Circular Bulletin 132 of the Michigan Agricultural Experiment Station.

Wireworms

Agriotes mancus

Wet ground, and especially wet, mucky ground recently in sod may be inhabited by slender, hard-bodied larvae which are usually smoothly polished and yellow. These larvae tunnel into potatoes, young corn, and other crops, their presence often seriously interfering with the raising of crops in such soil.

Fig. 14. Wireworms, larvae of snapping-beetles.

The particular wireworm most common in Michigan, the one which causes more trouble than all the other species combined, has sometimes been called the wheat wireworm, although its operations are by no means confined to grains. It is one of the "click-beetles" or "skip-jacks"—beetles that have the power to throw themselves into the air when placed on their backs on a flat surface.

The larva requires three years for the completion of its growth, and at the end of that period it changes into a pupa in a little cell in the soil, coming out the following season as an adult snapping-bug or snapping-beetle.

Control—Grass sod is preferred by the beetle to everything else for egg-laying purposes, and for this reason, grass sod should be avoided for a period of years on soils where wireworms accumulate. It happens, furthermore, that the beetles seem to avoid to a marked degree, fields in either clovers or buckwheat when the time comes to deposit their eggs. For this reason, it is good practice to get land infested by wireworms into clover or into buckwheat as much of the time as possible, avoiding grass at all times. Wireworm-infested soil is usually somewhat acid in reaction, and it may be necessary to use lime in order to bring the soil into good condition for clover or other legumes. Several years are required to starve wireworms out of a field by this method because of the slow development of the individuals.

Fall plowing breaks up some of the cells in which the larvae and pupae pass the winter and is, therefore, an aid, although not a very effective one, in clearing the land of the pest.

A crop such as onions may be saved sometimes by drilling wheat between the rows. Wireworms attracted by the germinating wheat leave the onions and thus give the onions a chance to become established. The wheat can then be destroyed.

There are a number of wireworms which are serious enemies to agriculture and which are not to be controlled in the manner just described, but those wireworms are more or less negligible in Michigan.

Gray Field Slug

Limax agrestis

This is not an insect but is considered here because its work is so often confused with that of insects.

True slugs differ from land snails in that they lack shells. In Michigan there are four species of true slugs, which dwell out-of-doors. Two of them were introduced from Europe. Of these latter, the giant slug is to be found in some cellars and in root-cellars, as well as in a few greenhouses and forcing houses. It is, by no means, common here as yet.

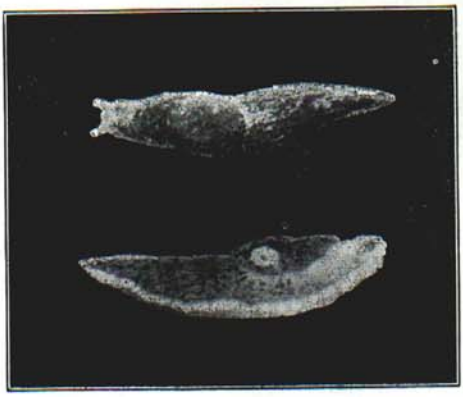

Fig. 15. Gray field slugs. (Enlarged.)

The gray field slug, on the other hand, has managed to distribute itself over the state and to make itself felt wherever there are forcing houses, or where celery or lettuce, and, in some places potatoes, are grown. That is especially true in damp locations.

The slugs collect under boards or other shelter and attack plants at night, scooping out cavities that often result in decay. In one case

they even burrowed down into the hill of potatoes and attacked the tubers underground.

Control—Spread poisoned bran bait among the plants affected by slugs at the same rate and in the evening as for cutworms (p. 10).

INSECTS OF RESTRICTED FEEDING HABITS

In contrast with those insects which feed upon a large number of crops, many insects confine their feeding to one plant or a few related plants.

Alfalfa Weevil

Hypera postica

Alfalfa weevil is established in parts of Utah, Idaho, Oregon, Nevada, California, Wyoming, Nebraska, and Colorado. Originally it came from the eastern hemisphere, being found in Europe, Asia, and northern Africa. It appeared in the United States in 1904. The beetles are from 1/8–3/16 inch long, and are dark brown, with short, black, and gray hairs which give the insects a mottled appearance. The weevils hibernate on alfalfa plants or under rubbish.

When excessively plentiful, the beetles will work also on garden truck. The greatest damage is done by the larvae, which feed on the leaves. They do not often destroy a stand, but reappear year after year, devouring the foliage during the first half of the season, there being but one brood each year.

As they pass the winter in hibernation, the destruction of their winter quarters under rubbish will help materially in their control.

It is to be remembered that thus far the alfalfa weevil is confined to a few of the western states and that it has not as yet reached the central states. It is well to be on the lookout, but probably many years will elapse before the weevil becomes a serious problem in Michigan.

Fig. 16. Clover root curculio. (Enlarged.)

Alfalfa and Clover Snout-beetles

Now that alfalfa has become of widespread importance, the grower is forced to consider an array of snout-beetles which find alfalfa attractive. Of those, three species are present in appreciable numbers in Michigan. One of those, the clover root curculio, *Sitona hispidula,* is an introduced species. It winters as an adult under rubbish, the adult beetle being about 1/8 inch in size and feeds on leaves. The larvae feed on the roots, eating cavities in the large roots and devouring the finer roots entirely.

The clover sitones, *Sitona flavescens,* is about 1/4 inch long, and dark brown in color. It eats U-shaped cavities from the sides of the leaves of clover and alfalfa, the larvae feeding on the crown and roots. It is probably also an introduced species.

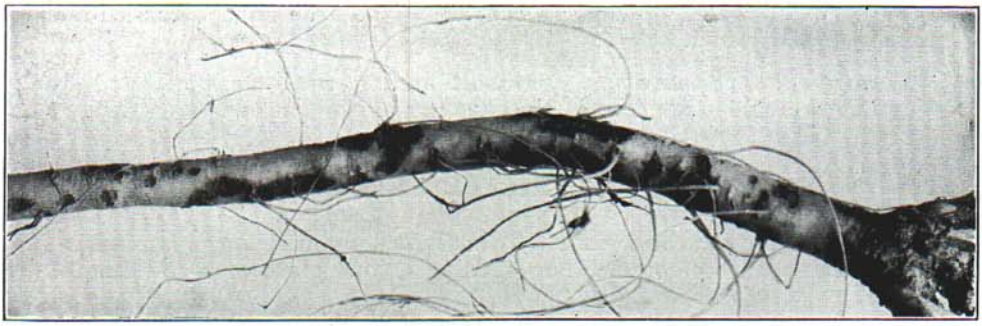

Fig. 17. Work of clover root curculio on alfalfa root.

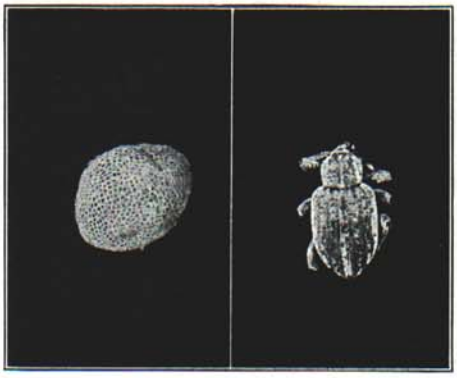

Fig. 18. Clover leaf beetle, cocoon and adult beetle.

The third species, the clover leaf weevil, *Hypera punctata,* which originally came from Europe, has been in Michigan for many years. It is much larger than the other two species, being almost ⅓ inch long. It is heavy-bodied and brownish in color, striped longitudinally with gray. The larvae feed during the night on the leaves, and if not attacked by a fungous disease they would, no doubt, prove destructive. However, there is a fungous disease that usually attacks the weevils as soon as they become plentiful, impelling the larvae to climb up to the tips of grass leaves, where they die. Those larvae, killed by the fungous disease, are poisonous if sufficient quantities are eaten by stock.

None of those three snout beetles have called for active control measures in Michigan thus far, the last named one usually being naturally controlled by its fungous disease.

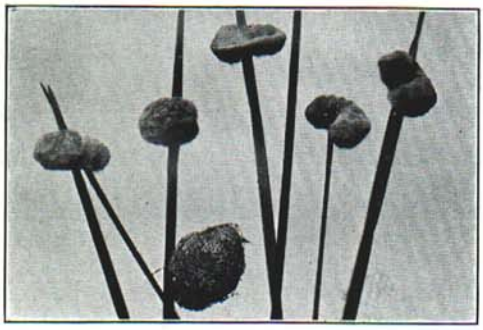

Fig. 19. Mummified bodies of clover leaf beetles, killed by fungous disease.

Asparagus Beetle

Crioceris asparagi

The asparagus beetle, which was originally introduced from Europe, is a dainty little beetle, brightly colored and highly polished. It is about ¼ inch in length, the wing-covers being reddish-yellow and cream colored, marked with black; and the thorax reddish-yellow with black dots. The larva is olive-gray, with blackish head and legs. The elongate black eggs, about 1/10 inch in length, stand on end on the young shoots of asparagus. They hatch in about 8 days, and the young grubs or larvae excavate pits, which become discolored and impair the value of the stalks. In about two weeks, these larvae become full-

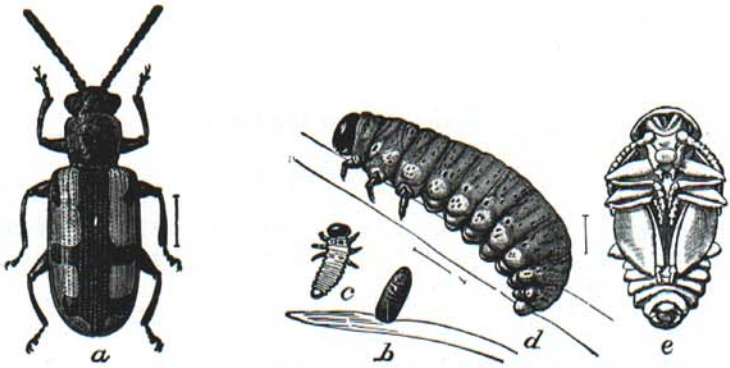

Fig. 20. Asparagus beetle (enlarged). A, adult beetle; d, larva; c, young larva; b, eggs; e, pupa. (Chittenden, year book, Dept. Agr. for 1896.)

grown and burrow into the ground to pupate, emerging as winged beetles after about 8 days, the entire time required for the completion of the life-cycle being about a month. Several generations are produced each year, and the winter is passed in the adult winged condition, under rubbish.

Control—Fields from which the shoots are being cut should never be treated with arsenical poison, because of the danger of poisoning. The practice of trapping the beetles on selected rows of shoots is one that has become nearly standard in commercial fields, having been practiced for many years. Leave some young shoots for the beetles to lay their eggs upon, and cut and burn these shoots before they are a week old, in order to destroy the eggs. If patches or rows of such trap plants are systematically left over the patch, and if the shoots in those trap plots are carefully cut and burned just before the eggs hatch early in the season, there is usually little trouble. As soon as the cutting season is over, the whole patch should be sprayed or dusted with an arsenical. All seedlings and feathery plants should be included in this general treatment.

If the beetles and their larvae become so troublesome during the cutting season that the foregoing practices are inadequate for their

control, the use of a derris dust (p. 42) offers good protection if the plants are kept covered. This will necessitate several frequent dustings as new plants are constantly appearing.

12-Spotted Asparagus Beetle

Crioceris duodecimpunctata

The 12-spotted asparagus beetle, a red-orange beetle, a little larger than the common species and having in general, similar habits, often accompanies the common asparagus beetle. The 12-spotted beetle, late in the season, feeds inside the berries of the mature feathery plants and is therefore, somewhat safe-guarded against sprays. However, the remedies suggested for the common asparagus beetle are recommended for this species also.

Mexican Bean Beetle

Epilachna corrupta

The Mexican bean beetle attacks all sorts of cultivated bean plants and, if left unchecked, is likely to prove a serious enemy, particularly to string beans or snap beans.

The beetle is a ladybird. It is larger than the commoner ladybirds with which everyone is familiar, being about ¼ inch in length. It is oval in form and its highly arched, yellowish, or orange-brown wing covers are each ornamented with eight irregular black spots, arranged in three rows across the back, making 16 spots in all. The larva, or immature feeding form, attains a length of about ⅓ inch. It is elongate, elliptical in form, yellowish in body color, and its back is decorated with branching blackish spines (Fig. 21).

Fig. 21. Larvae and adults of Mexican bean beetle, with their work. Natural size (from Bureau of Entomology, U. S. D. A.).

Fig. 22. Work of larvae on underside of bean leaf, with pupae, (slightly enlarged).

Like so many destructive pests, the adults pass the winter sheltered under dead plants or hidden in trash and rubbish, notably in woodland or other places in the vicinity of bean fields. The beetles are strong fliers and drift on the wind for miles.

They commence to leave their winter quarters early in the spring, in time to feed on the young bean plants, and to lay their eggs in loose clusters on the under surfaces of the bean leaves, sometimes as many as 50 being found in a cluster. Other individuals delay their operations for a month or more, so that the egg laying occupies an extended period, beginning when the bean plants first appear above ground and continuing for several weeks.

Control—It is unsafe to use bean hay for stock feed if the plants have been sprayed with an arsenical.

After the pods have appeared the only safe materials to use are pyrethrum or derris (p. 42).

Bean Weevil

Acanthoscelidus obtectus

The beetle lives over the winter in stored beans and sometimes in peas. It flies to the young bean plants (unless one carelessly plants infested beans, and then the pest does not even have to fly) and feeds

Fig. 23. Eggs of bean weevil (enlarged 50 times) and adult bean weevils (enlarged 9 times).

on the young plants until the pods are formed. At this time, eggs are laid upon the pod, the grub boring a hole through the pod, entering the young seeds, feeding therein and remaining there until the beans are harvested. In due time the grubs change to beetles and bore their way out, sometimes several from one bean. If the weather is warm, or if the beans are stored in a warm place, the new crop of beetles

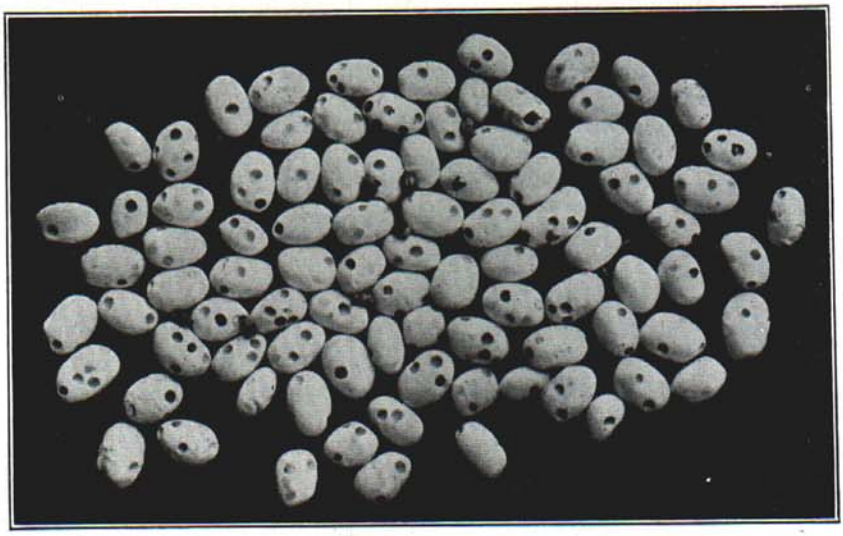

Fig. 24. Weevily beans.

soon lays eggs, and fresh seeds are attacked, the process going on until nothing remains but a worthless, evil-smelling powder. Clean beans stored near infested ones are practically sure to become infested, since the pests work in stored seeds as well as in the field.

Control—Perhaps some beans will escape treatment, but **seed beans** should always be free from weevils. In order to make sure, all seed beans that contain weevils should be fumigated.

The treatment can be made at little cost. Propylene dichloride mixture will kill the weevil efficiently. Use about 1 pound for 50 bushels, in a tight bin. (For fumigating directions see page 43.)

Small quantities of seed beans are efficiently protected by shaking them in a container with half as much lime or other fine dust as there are beans.

Cabbage Worms

Pieris rapae

White butterflies, the adults of the cabbage worm may be seen fluttering wherever there are plants of cabbage, cauliflower, rape, radish, turnip, mustard, or any member of the mustard family. Three species are found in Michigan—two native species; the northern white and the southern checkered white; and the imported white cabbage butterfly, which in numbers surpasses both of the other species.

Fig. 25. Imported cabbage worm larva, pupae and adult (slightly enlarged).

The yellow butterfly of about the same size is not to be confused with the "whites", since its caterpillar feeds on clover and not on plants of the mustard family. One sees the white butterflies laying eggs on cabbage and its relatives, and soon afterward the well-known green or bluish-green larvae are to be found on the plants, where they are commonly called "cabbage worms". They eat holes in the plants, sometimes tunneling deeply into the heads, and changing to naked pupae, which are fastened by loops of silk to the undersides of leaves or on nearby objects. In a few days or weeks, those pupae, in turn, give rise to winged butterflies, except, of course, in the case of the over-wintering generation. Both adult butterflies and "worms" or larvae are to be found at most any time during the growing season.

Control—Before the cabbage heads form, apply lead arsenate or calcium arsenate, either as a dust or spray (p. 40). If arsenates are used as sprays a gallon of skimmilk will serve as a good spreader.

After the heads form it is unsafe to use arsenicals. Use hellebore and hydrated lime, or hellebore and cheap flour in the proportion of about 1 part of the hellebore to 3 or 4 of lime, or flour.

Pyrethrum and derris sprays and dusts (p. 42) are entirely effective against cabbage worms. Several dusts and sprays containing those materials are on sale. Dust applications of 25 to 50 pounds per acre will control cabbage worms.

Fig. 26. Cabbage plant riddled by cabbage worms.

Pyrethrum and derris sprays have not been so satisfactory for cabbage worm control as dusts where hand equipment has been used but are very satisfactory with power equipment.

Cauliflower is especially liable to show arsenical residue (p. 40). Never use arsenic on cauliflower.

Diamondback Moth

Plutella maculipennis

This small greenish caterpillar is sometimes called a "pinworm" by cauliflower growers.

The adults live over winter in trash. The larvae feed upon the leaves.

Control—Derris or pyrethrum dusts or sprays should be used against this insect when it appears.

Cabbage Looper

Autographa brassicae

Inconspicuous in its work, but, nevertheless, of some importance, is the cabbage-looper, so named because of the looping or measuring gait of the larvae. This pale-green, almost translucent larva reaches a size slightly larger than that of the common "cabbage worm". It is rather obscurely striped longitudinally. The larva walks with a looping gait, because there are no legs for the middle region of the body.

When full-grown, the larva spins a white, silken cocoon, sometimes under a leaf blade, often on some other nearby object. After a time, the adult makes its way out of the cocoon and is a winged moth or miller, which spreads about 1½ inches from tip to tip of the wings. The moth is brownish-gray in color, the front-wings being more or less transversely mottled, each front-wing bearing a small silver-white, well-defined spot, the hind-wings being lighter in color and without mottlings.

The same remedies that apply to the common cabbage worm (p. 24) will serve for the looper.

Cabbage Snakes

Mermis spp.

Alarming stories relative to the poisonous properties of "long, slender, hair-like 'snakes'," which are found in cabbage, are commonly circulated. Those fearful "snakes" are the same creatures that are often found in watering-troughs and pools. They are known as "hair-snakes" and are believed by the uninformed to be animated horse hairs. They really are parasites from the bodies of grasshoppers, crickets, and similar insects which pass part of their existence in the soil, the young gaining access to the bodies of grasshoppers or crickets early in their careers. When a grasshopper is about to die from the drain put upon its strength by the parasite, the latter crawls out. Some fall among the cabbages on which the hoppers happen to be feeding at the time when their strength fails. Such hair-snakes find refuge in the cabbage heads, finding a moist place wherein they manage to live for some time.

It is not at all likely that harm would result from eating a piece of hair-snake, but their presence in cooked food is naturally undesirable.

Striped Cabbage Flea-beetle

Phyllotreta vittata

Like all of the flea-beetles, the cabbage flea-beetle is small and inconspicuous, though very active, jumping long distances when disturbed. It is less than 1/10 inch in length and black in color, with a well-marked yellowish stripe on each wing-cover. The larva is long and slender, and mines in the leaves of young cabbage plants.

Control—The worst damage is inflicted by those little pests when the plants are young, and long before the heads are formed. At that time a spray of an arsenical with bordeaux mixture (p. 41) will serve

to check the pest, the bordeaux acting as a repellent. It will be necessary to add a spreader, such as skimmilk (p. 40) to get a good coating on cabbage leaves. After the heads appear, it is unsafe to use any of the arsenicals.

Corn-borer

Pyrausta nubilalis

The European corn-borer is one of the most undesirable alien insects that has ever come to this country. It is a first-class destroyer of corn. Sorghum, broom-corn, and a number of vegetables having fleshy stalks, such as celery, bean, rhubarb, and many others, are attacked by the two-brooded eastern corn-borer. Worst of all, it will feed, when forced to do so, on a long list of less important crops and on many weeds, notably on the smartweed (Polygonum). The two-brooded form was first noticed in this country in 1917, when it appeared in the vicinity of Boston, since which time it has spread over New England. In the vicinity of the Great Lakes, both in the United States and in Canada, a single-brooded type is well-established. The insect is so well-established at this time that one must forego all hopes of ever exterminating it.

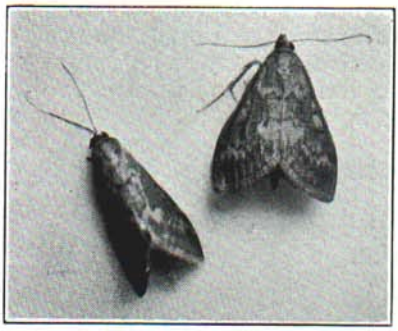

Fig. 27. Adult moths of European corn-borer (slightly enlarged).

When working in corn, the larvae tunnel through the stalks and the ears, sometimes, however, boring into roots, tassels, and leaf-ribs. The presence of the pest is often revealed by the breaking over of the tassel, which has been weakened by the tunneling of larvae.

Fig. 28. Larvae or "worms" of corn-borer (enlarged twice).

Similarly, other plants are pierced by tunnels, and such plants are always likely to serve as distributors of individuals to new localities when carried from place to place. Thus, the carrying of cut-flowers, such as asters, chrysanthemums, and gladiolus, or of such plants as chard, celery, beets, spinach, or a host of similar plants, is to be discouraged when they are to be taken from an infested district to one in which the pest is not already established.

Fig. 29. Corn-borers tunneling in stalk.

The corn-borer passes the winter as a full grown larva or "worm" about an inch long, in a tunnel burrowed in the plant on which it is working. Here it rests until about the middle or last of May, when an exit hole is prepared, after which a flimsy cocoon is spun in which the change to a pupa takes place. During June, the adult moth emerges from the cocoon—a moth capable of flying to a distance of many miles. Eggs are placed in groups of 15 or 20 on the undersides of the leaves or stems of the plants, some females producing more than 1,000 eggs each. From those eggs come the larvae, which tunnel through the plants during the summer and autumn.

The most important control measures developed, up to the present time, consist in the disposal of crop remnants, most important of which are corn stalks, in such a way that they cannot harbor the larvae nor serve as retreats during the period preceding pupation. The ensiling

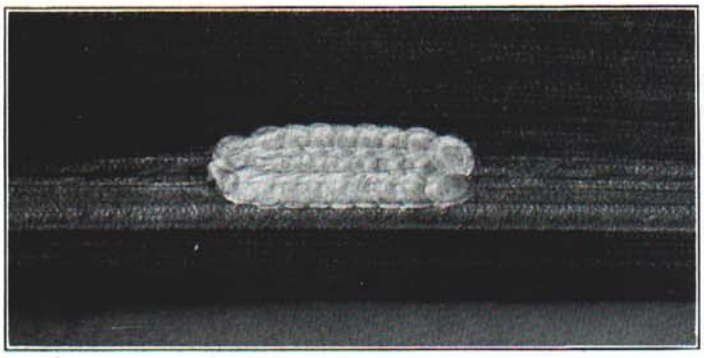

Fig. 30. Egg-cluster on corn-leaf (greatly enlarged).

of corn plants disposes of the contained larvae perfectly, and the shredding of the stalks kills almost all of them. The complete burial by plowing of all stalks, stubble, and bits of the corn plant, in such a manner as to leave the surface of the ground entirely bare, is probably the most important measure yet developed. Such measures, to be successful, must be taken before the adults emerge and should be taken before the larvae spin their cocoons in the spring. If all debris is cleaned up by June 1, few borers will emerge.

The maintenance of an effective quarantine aimed toward preventing the spread of the pest to hitherto uninfected districts has proved of value.

Corn Ear-worm

Heliothis obsoleta

The corn ear-worm is by no means a new pest in the United States. Working in corn as a principal host-plant in the north, it is well known and regarded as a troublesome enemy to this important crop. When the European corn-borer made its appearance, the two were and still are too often regarded as identical.

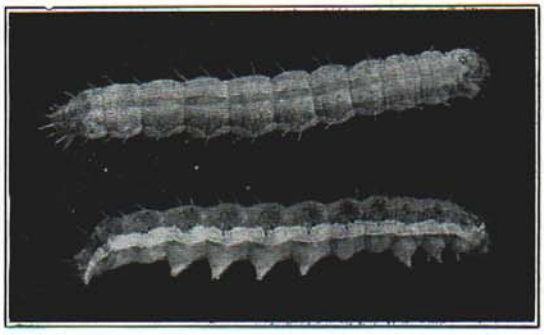

Fig. 31. Corn ear-worms.

It is practically useless to try to forecast years in which the corn-ear worm will be abundant in the north. In some seasons, one finds 75 per cent or more of the sweet corn invaded by the striped larvae or "worms," working on the kernels when they are "in the milk," or later until they become hard. The entrance is almost always made at the tip of the ear, but when the husk is removed the larvae may be found almost anywhere. Usually, only one larva is found, due to a well-known cannibalistic habit.

An ear of sweet corn is sometimes ruined by a single larva, since the space left by the destruction of the kernels is almost sure to become the medium for fungous growth, one species of which produces a dark stain, ruining the ear for table purposes.

Field corn is also attacked, and likewise popcorn, but in the case of field corn the uneaten kernels mature and, when shelled and cleaned, they are practically undamaged. The corn ear-worm is found as well in all the continents of the world. In the southern states it is known as the "cotton-boll worm". It is, also, a serious enemy of tomatoes, and of less importance, of a long list of other vegetables. In the south, there are several generations each year, fewer generations appearing as one progresses northward. Each female is said to be capable of

laying several hundred eggs, even up to 2,500. When corn is attacked, the eggs are likely to be laid on the fresh silk, the newly hatched larvae eating their way down to the kernels. When full-grown, the larva leaves the ear and buries itself underground, where it changes to a pupa in an earthen cell. Later the pupa produces a clay-colored moth.

Control—The number of infested ears of corn may be greatly lessened by dusting the silk, just after it is pushed out, with powdered calcium arsenate and hydrated lime or sulphur, mixed about half and half. The dusting may be accomplished with a hand duster, and the application should be repeated once or twice before the corn is ready for market. Such a dusting would seem to be warranted in fields of sweet corn and in fields of pedigreed field corn—in fact, wherever the value of the crop will pay for the treatment. It may be regarded somewhat in the light of insurance, and, while protection of the crop is not likely to be complete, the number of perfect ears is certain to be greatly increased.

Success in controlling this pest has been attained by snipping off the tips of the ears as soon as the silks start drying. Growers who practice this control are well-satisfied with the results and report that the cost of the repeated clippings necessary is no greater than for arsenical treatment. There will be no arsenical residue on corn treated in this way.

Cucumber-beetle

Diabrotica vittata

The striped cucumber-beetle is a small, black and yellow striped beetle that feeds on the leaves of cucumber, cantaloup, and related plants, attacking them as they come up and continuing to feed on them until the vines begin to run.

Not only do the beetles feed on the plants, but they also lay their eggs on the stems, and the grubs from those eggs burrow in the stems and roots. Furthermore, it is known that the adults are largely responsible for the spread of wilt disease, a serious disease which destroys vines of cucumber, squash, cantaloup, and their allies. The ravages of those little beetles, which often appear in swarms, and the annoyance resultant upon their depredations in the garden, have led to the adoption of many remedies.

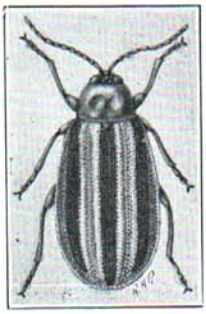

Fig. 32. The striped cucumber - beetle (greatly enlarged).

Control—The best treatment for cucumber beetles consists of dusting the plants with a mixture of calcium arsenate 1 part and finely ground gypsum 19 parts.

Gypsum does not go on well in a duster, consequently a shaker made from a friction-top can or pail is commonly used for applying

Fig. 33. A friction-top can or a piece of burlap may be made into a good shaker.

it. Punching small holes in the bottom of such a pail and improvising a handle will transform a cheap container into an efficient shaker. A piece of burlap can also be used for a shaker by gathering the edges together in the hand. The application will have to be repeated after each rain and to keep new growth covered.

Mint Flea-beetle

Longitarsus waterhousei

Aside from the attacks of cutworms, grasshoppers, and a small jumping beetle, known as the mint flea-beetle, neither the peppermint nor the spearmint crops are frequently attacked by insect enemies.

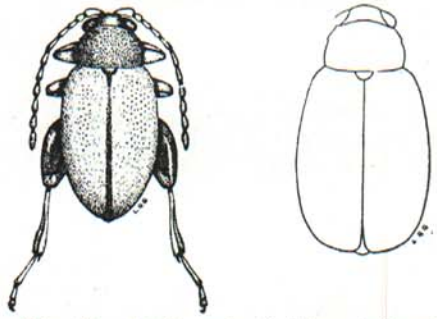

Fig. 34. Adult male (left) and female (right) of mint flea-beetle (greatly enlarged).

The last named insect is tiny, about 1/12 inch long, and in color a very pale brown. As the name suggests, the beetle is provided with strong hind legs, fitted for jumping. This jumping habit has become so fixed as the habitual method of locomotion that the male beetles have lost the power of flight, the membranous wings being entirely lacking. The larger females still possess wings but seldom if ever use them, preferring to jump or crawl, as do the more active males.

The eggs of the mint flea-beetle are laid in the soil, during the summer. Here they remain until the following May, when they hatch out into slender larvae each about 1/5 inch in length and white, with a shining pale-brown head. These larvae feed on the rootlets and tunnel in the roots and underground stems, sometimes working up above the ground level for an inch or more. Peppermint plants take on a deep purple color, and the destruction of much of the root system of the plant loosens its hold on the soil, so that the plants are easily pulled up.

The larvae feed for about a month and then change to pupae, which in turn produce the winged beetles. Fortunately, there is but one generation each year.

Early in August, the beetles crawl and jump to new fields, gradually working their way into the fields and continuing to advance until late fall. During their lives, the adult beetles feed freely on the leaves of the plants, resulting in serious injury to the crop.

Fig. 35. Injury to mint leaves by adults of mint flea-beetles (about natural size).

Control—Plant mint on land that has not grown mint for at least two seasons—not even volunteer mint on the ditch banks — or on ground that has been clean-cultivated or summer-fallowed. The roots for propagation should be dug from fields having as light an infestation as possible, and preferably from those well-dusted the previous year.

Before the transplants are removed from the fields they should be thoroughly shaken, in order to loosen and disengage the dirt and eggs before the transplants are carried to the new fields.

Aside from cultural practices, the most important control measure used against the mint flea-beetle is dusting. Much of our information concerning the selection of dusts has come through the efforts of E. L. Woodhams and Richard F. Stroud, of the A. M. Todd Company, at Mentha, Mich., where large acreages of peppermint are grown. In a recent letter from Mr. Stroud, he states that, of all dusts thus far tested for the early applications on standing mint, the first choice is 95 per cent calcium arsenate with 5 per cent bentonite. The mixture should be applied at the rate of 12 pounds to the acre between July 15–25 at the latitude of Mentha. This dusting is sometimes repeated

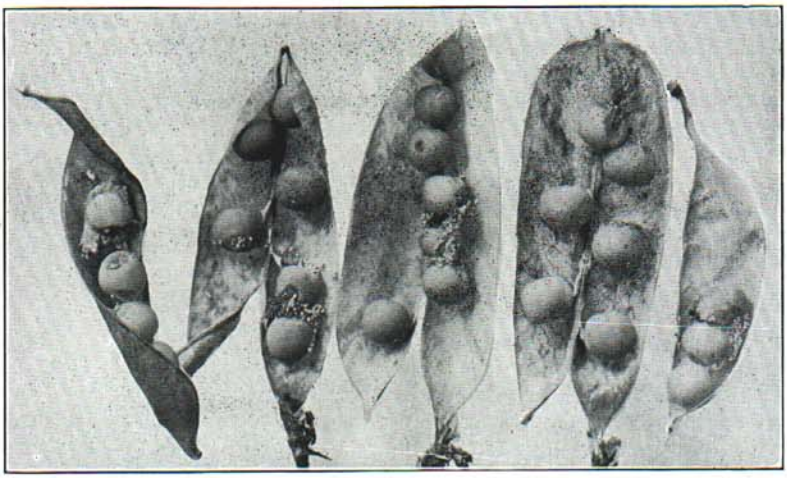

Fig. 36. Work of pea moth showing frass and injured peas in pods.

if the necessity arises. After cutting the mint, the fields should be dusted immediately, before the females migrate, and that means **just as soon** as the field has been cut, with a dust consisting of common flour with 8 per cent of the finest dusting paris green. This is applied to the stubble to kill the females that would otherwise migrate to other fields. Hay from mint so dusted should not be used either for bedding or for fodder.

Pea Moth

Laspeyresia nigricana

The larva of the pea moth attacks growing peas in the pod. The small yellowish caterpillar, about ½ inch long, is found in certain localities, where it attacks growing peas in the pod and works on nothing else. It comes from eggs usually laid on the sepals of the young "sets". The larvae pierce the pods and scoop out pits in the soft growing peas, besides partially filling the hollow in the pod with frass and webbing. This insect has been destructive in Wisconsin and in the maritime provinces of Canada. It occurs in Michigan in Chippewa, Ontonagon, and Delta counties. The insect was introduced from abroad into Canada about 1893.

About the time that the young pods are nicely formed, the winged moths come from their underground cocoons and lay their eggs singly, usually on the sepals of the young pods. From those eggs, come tiny caterpillars, which bore into the pod and attack the soft peas forming inside. This continues until early in September, when the larvae emerge and bury themselves, either in the soil or under debris. Here, each larva spins its cocoon and remains in a dormant condition until some time in July of the following year at which time the moths

emerge and lay eggs. It will thus be seen that, except for about two months, the pea moth is to be found the year round in its cocoon on or under the surface of the ground. During the two months of activity—that is, part of July and all of August—the attack is made and the injury is done to growing peas in the pod.

Control—No sprays yet discovered have proved effective.

Furthermore, vines sprayed with arsenicals could not be fed with safety to stock. However, deep fall plowing which will bury the larvae in the cocoons has afforded some relief. As many of the larvae do not leave the pods until the vines are removed from the field, it is recommended that the vines be threshed within a day or two after harvest, which will result in the death of many larvae. The pods and straw in such case should also be burned immediately which will account for most of the remainder.

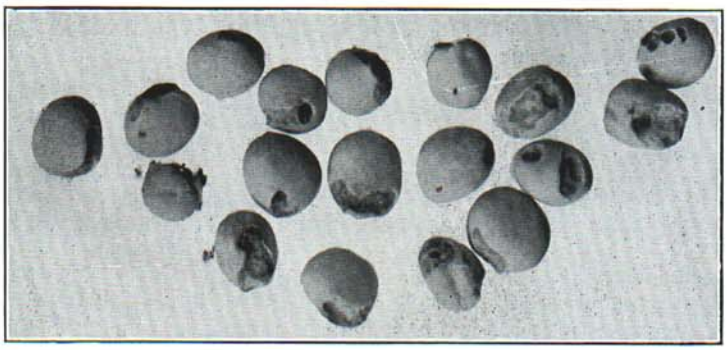

Fig. 37. Work of pea moth. Injured peas not removed from crop by repeated cleaning (slightly enlarged).

Early varieties suffer less from the pea moth than those which mature later. It is desirable to plant as early in the spring as the weather permits.

Pea Weevil

Bruchus pisorum

Pea weevil work looks much like that of the bean weevil. However, a single pea weevil develops in a pea. The bean weevil is smaller and works both in peas and in beans. Often several bean weevils develop in one seed.

Pea weevil control in Michigan is a question of planting clean seed. Pea weevil may be killed by fumigation in a tight container. (See page 43.)

Where practical, holding the seed for two years will permit practically all of the weevils, to emerge from the seeds, which may then be planted with the assurance that danger of infestation by weevils is no longer present.

Potato Beetle

Leptinotarsa decemlineata

The Colorado potato beetle is a native of the Rocky Mountain highlands, where it ranges on wild plants belonging to the potato family. Late in the nineteenth century, this potato pest worked its way across the continent, and, finding an abundance of potato fields in the East, it created such a disturbance in farming communities that the necessity of devising new and effective methods for poisoning insects at once became apparent.

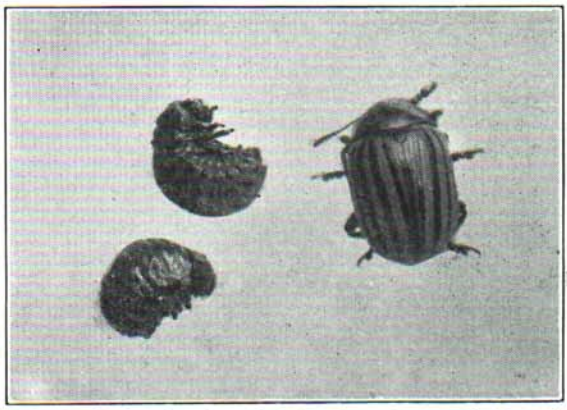

Fig. 38. Potato beetle; adult beetle and larva (enlarged).

The oval, highly arched beetle with its wing-covers decorated by 10 alternate, yellow and black lines, is commonly known. Two generations develop each year, and from the eggs laid by those beetles come the equally familiar red slugs. Both the adult striped beetles and the slugs devour potato plants. During the winter, the adults hibernate underground, or, less often, underneath fallen leaves and rubbish. They come out in the spring, and, after feeding for a short time, lay their orange-colored eggs on end in groups usually on potato plants. The larvae or slugs burrow underground when full grown, and those hatched early in the season mature in time to become the parents of a second generation in late summer.

Control—A spray or dust of an arsenical will easily control potato beetles. Such a spray or dust is applied to the potato plants and freely eaten by both larvae and adults. There remains, however, some choice as to which arsenical to use. The poison is practically always applied in standard 8-12-100 bordeaux, or if a dust is used, something that takes its place. If a spray is to be used, the first choice would be calcium arsenate, using 2 pounds to 100 gallons of bordeaux mixture. The next choice would be paris green at one-half that strength, and last of all would be lead arsenate used twice as strong as calcium arsenate.

A 5-per cent calcium arsenate, a 10-per cent lead arsenate dust, or the commonly used potato dust may be used successfully (p. 40). Lime is used as a diluent.

Early application is necessary to poison the adult beetles.

Rhubarb Curculio

Lixus concavus

The stems and large leaf-veins of rhubarb sometimes bear reddish-purple patches, more brilliantly colored than the natural purple and green of the stem. The wounds are usually caused by a slender, black snout-beetle approximately ½ inch long, the beetle being covered with a rusty powder easily wiped off. Such colored patches, if caused by the curculio, will show a wound usually near the center of the splash of color, and not infrequently a gummy exudate. On splitting the wound, it is sometimes possible to find an egg or a young grub buried beneath the surface.

Rhubarb stems mutilated in this way, either for the purpose of egg-laying or by beetles which are merely feeding, are, of course, less valuable for table use, although the eggs and grubs are easily cut away. Eggs placed in rhubarb seldom if ever produce grubs which reach maturity, but eggs placed in dock and burdock do produce beetles. Furthermore, it is said that sunflower and thistle furnish suitable food for the normal development of the beetle. Aside from hand-picking, the destruction of those natural food-plants in the vicinity of rhubarb beds is the most that can be done to keep the beetles in check.

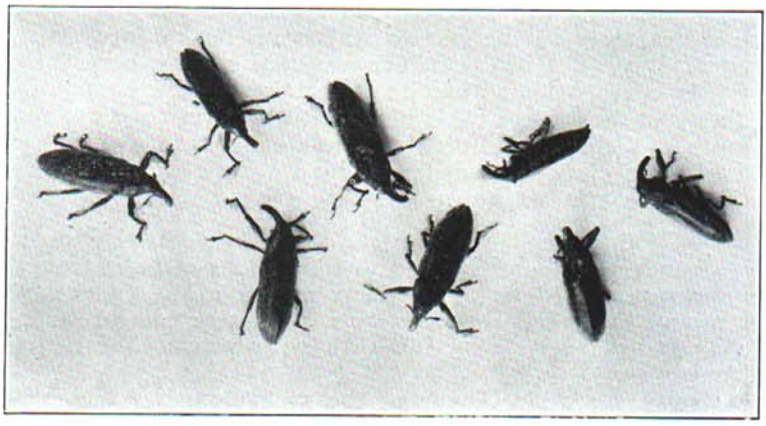

Fig. 39. Adult rhubarb curculios. (About natural size.)

Squash-vine Borer

Melittia satyriniformis

The squash-vine borer is becoming more common in western Michigan. One finds the larvae or grubs tunneling and feeding on the inner walls of either stems or the bases of the leaf stems, usually near the root, but occasionally at other points.

The larva is a naked, white grub-like caterpillar, which sometimes

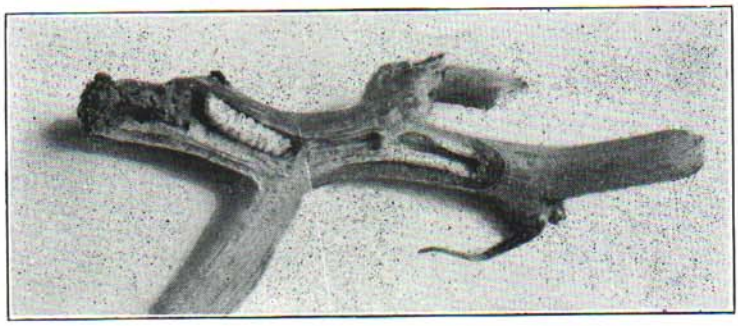

Fig. 40. Squash-vine borer in tunnel in squash-vine.

reaches the length of an inch, with a diameter of ¼ inch. This caterpillar has a brown head with brown thoracic and anal shields. When full-grown, it burrows about 2 inches below the surface of the soil, where it spins its cocoon to remain during late summer and winter. There is believed to be but one generation in Michigan each year, and those caterpillars are reported to infest both summer and winter squash as first choice, but are also found in cymlings, pumpkins, gourds, muskmelons, cucumbers, and wild balsam apples.

The tiny brownish eggs, which measure about 1/25 inch in length, are glued separately on the vine or leaf stems during late June or the first half of July. The larvae, which are at first tiny, bore their ways to the hollow stems and continue to feed there for about a month, after which they cut their ways out and bury themselves for pupation. The adult moth, which comes forth the following spring, has brownish front wings and almost transparent hind wings. It measures about 1½ inches across the expanded wings.

Control—Good control of this pest has been reported from the use of three pounds of arsenate of lead to 100 gallons of half strength bordeaux mixture, applied to cover the vines from the time they start running, about the middle of June, until the latter part of July. One's success depends largely upon the care with which the treatment is carried out.

Many growers practice covering the vine along its length with a few hoefuls of soil at the joints. Most of those vines when covered with earth in this manner will strike root at the points covered, thus materially aiding the plant to withstand the strain put upon it by the mutilations occasioned by the borer.

It is obvious that a thorough cultivation of the soil after an infested crop has been harvested will destroy a large proportion of the pupae that are located an inch or two beneath the surface of the soil. It is also obvious that a thorough clean-up involving the destruction of all crop remnants immediately after the first killing frost or after the crop has been harvested, will help to reduce the number of borers that would otherwise survive and attack the vines the following year.

Tomato Worm

Phlegethoutius spp.

The white marked green caterpillars, as long as three inches, often seen upon tomato plants are usually called tomato worms, although they often feed on any other plants belonging to the potato family. A southern species resembling the common form in appearance and habits sometimes occurs.

These insects are capable of defoliating large plants almost over night. They also feed upon the fruit. Tomato and potato plants are usually partially defoliated before the caterpillars are noticed. Tomato worms are then hard to kill, because of their size. However, tomato worms are no different than other insects and hatch as small caterpillars from eggs and grow as a result of their feeding. When they reach maturity they go into the ground where large, brown vase-like pupae are formed which are characterized by the fact that the tongue makes a large loop or handle, characteristic of this species. The adults are large moths which fly at twilight when they are often mistaken for humming birds as they hover feeding from petunias and similar plants.

Sometimes tomato worms are attacked by a small wasp-like parasite which is seen as egg-like, white cocoons covering the back of the insect. An affected tomato worm is no longer capable of eating. Such worms serve as breeding places for parasites and should be left alone to permit the parasites to emerge.

Fig. 41. Tomato worm.

Control—Control of tomato worms is usually complicated by the fact, previously noted, that the insects are seldom seen until they are full grown when they are extremely hard to kill with poisonous materials. However, spraying tomatoes with half-strength bordeaux plus calcium arsenate, 2 pounds in 100 gallons, or dusting with a 5 per cent calcium arsenate dust will take care of them. Such treatment should be a routine practice while the plants are small.

After the worms are full grown the only way to take care of them is by some variation of hand picking, such as snipping them with a pair of shears. This, at first hand, seems an expensive way of controlling them, but if the matter is considered, it will be seen that it is the only way to destroy the full grown worms.

Fig. 42. Tomato worm showing cocoons of wasp-like parasite.

COMMONLY USED INSECTICIDES

No effort has been made to list insecticides other than those recommended in the bulletin. In addition, the formula for bordeaux, commonly considered as a fungicide, is given because of the repellent action and because it is so commonly used with insecticides.

Attention is directed to the danger from residues following the use of arsenicals.

Poison Bran Bait for Cutworms, Armyworms and Grasshoppers

CAUTION!

Bran bait is POISONOUS. Broadcast all bait as soon as mixed.

Bran bait when properly used is not dangerous.

Livestock and poultry are never killed except where carelessness prevails.

Burn all sacks, and BURY the ashes.

Wash hands and tools thoroughly after handling bran bait.

(No authentic cases of poisoning song or game birds are known.)

How to Make Poison Bran Bait

The following bait formula is the most satisfactory and economical for large quantities:

5 lbs. white arsenic (not lead arsenate) or paris green. (When available use 2 qts. 4 pound test or 1 qt. 8 pound test sodium arsenite.)
5 lbs. common salt (when used for grasshoppers).
2 gals. cheap molasses.
About 10 gallons of water.
100 lbs. bran.
3 ounces banana oil.

The amount of water stated is **about** 10 gallons, because bran varies in water-holding capacity. The arsenic and molasses should be added to 6 gallons of the water and the bran mixed with the resulting solution. Water is then added to make the finished bait "form" when squeezed tightly, but never wet enough to drip when subjected to the above test. The banana oil is added last. Mixing may be done by hand or with machinery, such as cement mixers. Hand mixing can be done by shovelling on a cement floor or in a mixing box. Clean all mixing tools thoroughly before using them for other purposes.

For grasshoppers: Spread **in the forenoon** at the rate of 10 to 20 pounds per acre for grasshoppers.

For cutworms or armyworms: Spread in the evening at the rate of 20–40 pounds per acre. For small plats, use a teaspoonful near each plant or hill of plants. For small quantities of poison bran bait use:

5 lbs. bran.
4 ounces white arsenic or paris green (not arsenate of lead).
(Salt 4 ounces if for grasshoppers.)
Molasses—one pint.
Water—to moisten.

One orange or lemon finely chopped, skin and all. Mix molasses and poison with 2–3 pints water and add to the bran and stir thoroughly with more water.

Homemade Sodium Arsenite

Sodium arsenite is the best poison for making poison bran bait. It is treacherous material to store, consequently few dealers stock it. The commercial sodium arsenite usually sold contains 4 pounds of arsenic per gallon (4 pound test); whereas the homemade sodium arsenite described in the next paragraph contains 8 pounds of arsenic per gallon (8 pound test).

Sodium arsenite containing 8 pounds of white arsenic per gallon (8 pound test) is made according to the following formula:

Water (7 pounds)	7 pints
Caustic soda or lye	3 pounds, 4 ounces
White arsenic	10 pounds

Use a container that will hold at least 3 gallons. Dissolve the lye in the water, which will become warm. When the lye is dissolved, stir in the arsenic gradually.

With the addition of the arsenic the solution will become hot. No external heat is needed but the mixture must be constantly stirred.

The yield of sodium arsenite will be about 5 quarts or sufficient for 500 pounds bran or 1,000 pounds of wet bait.

Keep away from the fumes while making this material.

For large quantities, use a container that will have a capacity of at least 15 gallons. Measure 8½ gallons of water and pour into the barrel. Dissolve in the water 32 pounds of caustic soda or lye (the ordinary household grade of lye obtained in grocery stores). When the lye dissolves, it will be noticed that the water becomes warm. After all the lye is dissolved, stir in the powdered white arsenic a little at a time, as fast as it is dissolved, until the 100 pounds of arsenic has been added.

The addition of the arsenic generates more heat and no external heat is required. This will make about 12 gallons of a clear, thick, sirupy liquid, containing 8 pounds of arsenic per gallon. It is important to stir the solution constantly while the arsenic is being added.

Occasionally the solution will be cloudy. By adding some more lye this condition will usually disappear. Lye should be added in small quantities using only enough to clear the liquid.

Stay away from the fumes while making this material.

The chief advantage in using liquid sodium arsenite is that it is completely soluble, coating every particle with poison. In addition it is more poisonous to the insect because it is soluble in the digestive juices and therefore quicker acting.

Lead Arsenate

Lead arsenate is a heavy, white powder. It is commonly used as a spray at the rate of 3 pounds in 100 gallons of water or bordeaux; or 1 ounce in 2 gallons of water or bordeaux. When used with water, either 1 pound of powdered skimmilk or 2 gallons liquid skimmilk in 100 gallons of spray will improve the spreading on foliage.

Lead arsenate, when used as a dust, is mixed one part lead arsenate with nine parts of lime.

Lead arsenate is safer on tender foliage than calcium arsenate. It leaves a poisonous residue on plants and should be used according to directions on pages 13, 14, 19, 24, 25 and 26. Lead arsenate should not be used when there is danger of residue.

Calcium Arsenate

Calcium arsenate is a white powder but is not so heavy as lead arsenate. It is commonly used as a spray at the rate of 2 pounds in 150 gallons of water or bordeaux; or 1 ounce in 3 gallons of water. Calcium arsenate is used also as a dust. One part calcium arsenate plus 19 parts lime makes a good general-purpose arsenical dust for beetles and caterpillars on many crops.

Cucumber plants do not tolerate lime particularly well, hence calcium arsenate when used on cucumbers is mixed with gypsum. The correct mixture consists of gypsum 19 parts, calcium arsenate 1 part. Gypsum does not flow well in a duster and as a consequence is frequently used in a shaker.

Calcium arsenate should not be used where there is danger from residue.

Paris Green

Paris green is not used as much as formerly since there is danger of burning. When available it is effective for chewing insects on those plants which tolerate paris green. It should never be used on cauliflower because of residue.

A spraying of paris green should be put on as a fine fog, and the spraying should be stopped short of the dripping point. On potatoes, 8 ounces to 50 gallons of water or bordeaux is used, but one must be careful to stop spraying before the plants drip, or many of the large, heavy particles of poison will drop off.

Bordeaux Mixture

Bordeaux mixture is a standard fungicide. It also serves a useful purpose by repelling many insects, especially flea-beetles.

Bordeaux mixture is made by combining lime and copper sulphate in water. There are many kinds of bordeaux and many ways of making it. References in this bulletin are to half-strength (4-6-100) bordeaux, which may be made conveniently in 100-gallon lots by:

1. Dissolving 4 pounds of copper sulphate (bluestone) in 8–10 gallons of water.
2. Mixing 6 pounds hydrated lime with 3–5 gallons water.
3. Adding the copper sulphate solution prepared in (1), to 50–60 gallons of water and mixing.
4. Adding the lime prepared in (2), to the solution made in (3), and stirring.
5. Diluting the mixture to 100 gallons.

Three gallons of half-strength (4-6-100) bordeaux-arsenate are made by:

1. Dissolving 2 ounces copper sulphate (bluestone) in 1 gallon water.
2. Mixing 3 ounces hydrated lime in 1 gallon water.
3. Pouring the copper sulphate (1) solution and lime mixture (2) together.
4. Add enough water to make 3 gallons.

Bordeaux is compatible with all arsenicals. Half-strength bordeaux is especially valuable for dipping the tops of transplants. It is excellent for controlling flea-beetles just after plants are set out if calcium arsenate is added at the rate of 2 pounds to 100 gallons. This is at the rate of 1 ounce in 3 gallons.

Full-strength bordeaux (8-12-100) may be made by the procedure outlined if the amounts of lime and copper sulphate are increased. However, if large quantities are needed, Extension Bulletin 154, *The Spraying Calendar,* may be consulted.

Proprietary bordeaux sprays are as satisfactory as the amounts of copper they contain.

Copper-lime dust: Many growers use copper-lime dust instead of bordeaux spray. For small acreages with hand dusters this dust is effective. Where power spraying equipment is available, dusting is inferior to spraying.

There are many formulae for a satisfactory copper-lime dust. The following are typical:

4 pounds monohydrated copper sulphate.
16 pounds hydrated lime.

or for larger quantities:

20 pounds of monohydrated copper sulphate.
80 pounds hydrated lime.

An arsenical may be added to this dust for controlling chewing insects, such as potato beetle, by substituting the arsenical for the lime. One pound of calcium arsenate in 20 pounds of dust is the proper amount.

Pyrethrum

Pyrethrum is made from the dried floral parts of a plant resembling the oxeye daisy. The active principles of pyrethrum are known as pyrethrins and constitute less than 1 per cent of most commercially ground pyrethrum.

A good pyrethrum dust for control of insects such as those infesting celery usually contains 30 to 50 per cent of finely ground pyrethrum or its equivalent pyrethrins mixed with one of the inert mixing materials.

Effective pyrethrum dusts contain between one-tenth and one-fourth of one per cent of killing agent.

Pyrethrum preparations vary in pyrethrum content so widely that the sprays are best made from commercial extracts according to the manufacturer's recommendation.

Derris

Derris insecticides are prepared from the roots of a tropical shrub. One of the toxic principles in derris is rotenone, which is mentioned because most assays of derris are based upon the rotenone present; in making dusts from ground derris it is convenient to adjust the amounts of ground derris and the mixing material to obtain a given percentage of rotenone. Ground derris is commonly sold containing 4 per cent rotenone. A good insecticidal dust contains ½ to ¾ per cent rotenone.

A good derris dust can be made by thoroughly mixing 1 pound of ground derris root of 4 per cent rotenone content with 6 pounds talc, clay, bentonite, chalk, tobacco dust, flour, or sulphur. Such a mixture will contain a little more than ½ of 1 per cent rotenone and can be stored for 2 or 3 months. Good dusts can be made from derris assaying more or less than 4 per cent rotenone, but the amount of mixing material will be different. Applied at the rate of 15 to 25 pounds per acre, the dust will control cabbage worms, Mexican bean beetle, currant worms, slugs, and most caterpillars.

Five pounds ground derris with 1 pound powdered skimmilk, 2 gallons of skimmilk, 3 pounds of thoroughly dissolved soap or 3–6 ounces of one of the sulphated alcohols make 100 gallons of effective spray.

Derris is ineffective, however, against celery leaf tier and corn ear worm.

FUMIGATION OF STORED GRAINS AND SEEDS FOR INSECTS WITH PROPYLENE DICHLORIDE AND CARBON TETRACHLORIDE MIXTURE

The development of a cheap fumigating agent, which would eliminate the fire hazard always present when using carbon disulphide has been the subject of study for years among entomologists. Such fumigating agents have been developed and consist of a mixture of propylene dichloride and carbon tetrachloride or ethylene dichloride and carbon tetrachloride. (Inquire of your county agent for local sources of supply.) This material is effective for insects infesting grains or seeds commonly stored on Michigan farms.

All insect fumigants work best during warm weather. A temperature of 70 degrees F. is desirable, but not absolutely necessary. When the temperature falls below 60 degrees F., the fumigation should be postponed. Furthermore, seeds and grains must be **dry** if the operation is to be successful—that is, if the insects are to be killed without injuring the viability of the seeds.

Measure the inside of the bin, counting in the "air-space" above the grain and allowing 2 pounds avoirdupois of the liquid for each 100 cubic feet of space. If it becomes necessary to fumigate at a temperature lower than that stated, then the dose must be increased.

After the bins are made tight, arrange for covering the top. Smooth off the grain or other seed and, if wooden covers are lacking, then cover with two or three thicknesses of blankets with newspapers placed between them. Lift the blankets here and there and throw the fumigant directly on the grain.

If the bin is more than 4 feet deep, it is well to thrust a good sized pipe down into the grain in several places and to pour one-third of the liquid through this pipe in order to get it down near the bottom of the bin. Replace the covering blankets and paper, close up the place and leave.

The gas from propylene dichloride and carbon tetrachloride is heavier than air and, therefore, it settles down between the seeds. When properly applied, it kills most of the insects, excepting the eggs. This failure to kill the eggs may necessitate the repetition of the fumigation after a period of a month or so.

It is non-inflammable and non-explosive, although it is poisonous if breathed.

Experiments have shown that 2 pounds are necessary for each 100 cubic feet of air space.

NOTE

Before putting the grain into the bins, make sure that the bins are clean and tight. Sweep out the bin with a broom and dust-pan and remove sweepings in some covered receptacle, where they may be immediately burned. If the sweepings are merely thrown out on the ground, there are sure to be grain beetles, larvae of grain moths, and probably one or two species of mites left uninjured and which will be sure to escape and find their ways back into the new grain.

After the bins have been thoroughly dry-cleaned, they should be scrubbed with an old broom and boiling hot lye and water. Use about 1 pound of ordinary crystal lye, obtained at any grocery store, in each gallon of boiling water. Work this down into the cracks and crevices if the bin happens to be made of wood, after which line the inside of the bin, not only the floor but the sides as well, with several thicknesses of building paper or newspapers over-lapped at the edges and held by paste.

Never place new grain upon old grain or in the close vicinity of old grain if it is possible to avoid doing so.

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