POTATO INSECTS
THEIR BIOLOGY AND BIOLOGICAL AND CULTURAL CONTROL

AGRICULTURE HANDBOOK NO. 264

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
The biology and brief descriptions of insect pests of Irish potatoes are presented in this handbook. It is intended primarily as a reference for agricultural workers who are responsible for suggesting control measures. With more than 100 known pests of potatoes in this country, it is essential that the pests most commonly found in each production area be recognized and their life histories and habits known. This information will be useful not only in advising growers when to use insecticides but also in suggesting alternative or supplemental cultural and biological control measures, including maximum utilization of natural enemies.

Recommendations for controlling potato insects in commercial plantings are given in Farmers' Bulletin 2168, Controlling Potato Insects. To control these pests in home gardens, refer to Home and Garden Bulletin 46, Insects and Diseases of Vegetables in the Home Garden.

Caution: Insecticides are poisonous. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the container label.
POTATO INSECTS
THEIR
BIOLOGY AND
BIOLOGICAL
AND CULTURAL
CONTROL

By W. A. SHANDS
and B. J. LANDIS

AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURE
HANDBOOK NO. 264
CONTENTS

Page

Aphids.......................... 2
Armyworms........................ 10
Blister beetles.................... 12
Carrot beetle..................... 14
Caterpillars....................... 15
Colorado potato beetle.......... 15
Cucumber beetles............... 17
Cutworms......................... 19
Earwigs.......................... 20
European corn borer............. 21
False chinch bug............... 22
Flea beetles..................... 23
Garden symphylan................. 26
Grasshoppers and field crickets 28
Leafhoppers...................... 29
Leaf miners...................... 31
Mealybugs........................ 32
Millipedes........................ 33
Mites............................. 34
Mole crickets.................... 34
Mormon cricket................ 36
Plant bugs....................... 37
Potato psyllid................... 39
Potato scab gnats.............. 41
Potato tuberworm.............. 42
Seed-corn maggot............... 44
Shield-shaped bugs............ 45
Slugs and snails............... 46
Springtails.................... 47
Stalk borers.................. 47
Three-lined potato beetle.... 48
Thrips.......................... 49
Tortoise beetles.............. 49
Vegetable weevils............. 50
Whiteflies........................ 51
White-fringed beetles........ 53
White grubs..................... 54
Wireworms........................ 56
List of potato insects......... 59
White, or Irish, potatoes are attacked and damaged by many kinds of insects and other small animals. The feeding damage caused by these pests or the diseases they transmit may affect the growth and health of the potato crop and frequently reduce the yield, size, or quality of the tubers. Where damage is severe, the crop may be killed outright or become unmarketable unless timely and adequate control measures are taken.

Some insects bite out and swallow parts of the leaf, stem, or tuber of the potato plant. Certain biting insects, such as blister beetles and grasshoppers, feed on the leaves where they can be easily seen and their damage realized. Other biting insects, such as stalk borers, wireworms, or flea beetle larvae, feed while concealed in the plant or in the soil and their damage may not be noticed until sometime later, or not until harvest.

The damage caused by sucking insects, which include aphids and leafhoppers, also is not readily noticed and often becomes extensive before control measures are started. Virus and certain viruslike diseases of potatoes are transmitted or caused chiefly by sucking insects. Depending on the disease, yield and quality of subsequent crops may be reduced markedly from planting seed potatoes saved from virus-infected plants.

The Colorado potato beetle, flea beetles, leafhoppers, aphids, the potato psyllid, and grasshoppers are injurious in both the adult and immature stages, whereas wireworms, cutworms, and stalk borers cause damage only as larvae.

This handbook contains descriptions and information about the life histories, habits, and damage caused by many pests of potatoes. These pests are listed alphabetically but are not of equal economic importance. Some are generally distributed and are present in varying degrees of abundance each year in most areas. Al-

1The authors are indebted to W. J. Reid, Jr., of this Division for reviewing sections concerning pests of major economic importance.
though not all of them are economically important in all areas every year, they are a potential threat annually in most areas. Insects of this category include aphids, the Colorado potato beetle, flea beetles, grasshoppers, and wireworms.

Other pests, although widely distributed, vary greatly in economic importance from place to place and from year to year. Some of them, such as armyworms, cutworms and other caterpillars, and blister beetles, may not seriously attack potatoes for years, and then they will appear suddenly in numbers so large as to require immediate control for protection of the potato crop. Others may be present or cause serious damage in limited parts of fields or under particular conditions. Spider mites are usually most abundant along dusty roads. Slugs and snails do most damage in wet parts of fields or during wet seasons. Some plant bugs infesting hay crops may move into potato fields when the hay is cut.

Another group includes insects of economic importance in certain restricted areas. In this category are the potato psyllid in parts of Colorado, Utah, and Nebraska; the white-fringed beetles in certain parts of the South; the potato tuberworm near the coast in restricted parts of the East and the West; and the Mormon cricket and the iris whitefly in parts of the intermountain region of the West. The Mormon cricket occurs in the States west of the Missouri River and is most destructive in Oregon, Washington, Nevada, Utah, Idaho, Montana, Wyoming, and Colorado. The iris whitefly is generally distributed in the Pacific Northwest from southern California to British Columbia, especially in arid sections.

Various other pests occasionally attack potatoes. Although most of them are ordinarily of minor economic importance, some may cause appreciable damage at times or in very limited areas. In this group are mole crickets, shield-shaped bugs, earwigs, millipedes, and the garden symphylan.

APHIDS

Aphids, or plant lice, are small soft-bodied insects usually found feeding on the underside of leaves. The several kinds that propagate on potatoes are about the size of the head of a pin and either yellowish or leaf green. The immature stages, called nymphs, closely resemble the adults. Most species have two cylindrical appendages, or cornicles, which arise laterally near the tip of the abdomen. Ordinarily the cornicles lie rather close to the abdomen. When disturbed, some species of aphids are able to raise them in a defensive position. The cornicles are sometimes called "honey tubes," but they have no connection with honeydew—a sweetish, glossy coating found on leaves of plants heavily infested by aphids. The cornicles secrete small globules of a liquid thought by some to possess defensive properties. The shiny deposits of honeydew frequently found on aphid-infested plants are excretions from the aphid's digestive tract.

Most aphids are wingless throughout their lives. However, in some generations vary-
ing numbers of the immature forms develop slight swellings on the sides of the thorax that later enlarge to become wing pads. Such individuals are winged at maturity. In some species the winged aphids only vaguely resemble the wingless forms because of the larger thorax, which bears two pairs of narrow, triangular, transparent wings. The winged aphids may also be darker or a different color from the wingless forms.

Four or more species of aphids attack potato foliage, but the green peach aphid and the potato aphid usually cause most damage. These two aphids are rather generally distributed over the United States and propagate on many weeds, ornamentals, and food crops. The buckthorn aphid is a pest of potatoes chiefly in the Northeastern States. The foxglove aphid infests potatoes in the Northeast, Southeast, and the Pacific Northwest States.

The abundance of aphids varies greatly from year to year and from one region to another. During a 20-year period the buckthorn aphid was the most abundant species on potatoes in the Northeast and the green peach aphid in the Northwest. Both the green peach and potato aphids occur commonly on potatoes in the Southeast. Epidemics of the foxglove aphid have occurred less frequently throughout the country than those of other species, but occasionally it is the predominant species on potatoes in some fields in the Southeast.

The green peach aphid (fig. 1, A) is about one-fourteenth inch long. The wingless form (fig. 1, B) during most of the summer may vary from light to dark green and some have a yellowish tint; in late summer and fall some may vary from pink to red. The winged form (fig. 1, A and C) is usually dark brown except for a yellowish abdomen, which is partly covered by an irregular dark patch on the anterior two-thirds of its dorsal part.

The potato aphid is about one-ninth inch long. The winged and wingless forms are similar in color and may be light to a medium green, pink, or mottled green and pink. Many of the green ones have a darker green stripe that runs longitudinally on top of the abdomen. In some localities it is known as the pink and green tomato aphid.

The buckthorn aphid is one-seventeenth to one-twentieth inch long. It varies from yellowish green to a dark green or almost black depending on the season. The winged form generally resembles the wingless
except for its dark head and thorax.

The foxglove aphid is about one-twelfth inch long. The winged and wingless forms superficially resemble the green peach aphid. However, they are slightly larger and the body is not so round as that of the green peach aphid, but more like a milk bottle. Also, the head and thorax of the winged form are usually brownish yellow. The wingless forms are either yellowish green or apple green. On the foxglove aphid there often is a dark circular area around each cornicle.

**Feeding Damage**

Aphids feed by inserting their needlelike mouth parts, or stylettes, into plant tissues and withdrawing the juices. They frequently congregate along the midrib and veins on the underside of the leaves and feed on the nutritious sap contained in the bundles of phloem tubes. When exceptionally abundant, the potato aphid will congregate and feed near the growing tips of stalks and branches (fig. 2). The sap is forcibly removed from young plants by means of the insect’s pharyngeal pump, but after the plants have become full grown, the sap pressure is so great that aphid feeding is almost involuntary. Under optimum conditions a green peach aphid will suck one-third of its weight in plant sap per hour. It has been estimated that a moderate population of aphids will remove more than a

**FIGURE 2.**—Potato aphids feeding on stem of potato plant. (Courtesy of Maine Agricultural Experiment Station.)

**FIGURE 3.**—Crinkled, cupped potato leaves resulted from feeding of large numbers of potato aphids.
half ton of sap per acre from a field of potatoes during a 3-week period.

Moderate aphid infestations cause the younger potato leaves to crinkle, cup, or curl downward (fig. 3) and cause the lower older leaves, which are usually most heavily infested, to wilt, become yellow, and die. By the time these symptoms appear, most of the damage has been done. The hotter the weather and drier the soil, the more likely are certain contributing factors, such as excessive transpiration, sunscald, and wind damage, to be associated with the loss of a given quantity of sap from aphid feeding. However, 3 or 4 days of maximum temperatures that exceed 95° F. will either greatly reduce or exterminate the aphid population in the potato fields.

Considerably more plant sap is ingested at times than the aphids can utilize. The excess material is excreted as honeydew. It contains approximately 85 percent of carbohydrates and 3 percent of proteins. Frequently entire plants will be coated with honeydew, which presumably interferes with normal transpiration, respiration, and photosynthesis and also serves as an excellent medium for the growth of yeasts and molds. Heavy aphid populations either stunt the plants or kill them prematurely and thus prevent the production of a full crop of potatoes.

Transmission of Virus Diseases

All four of the common species of aphids that infest potatoes are capable of spreading several virus diseases. These diseases may reduce either the quality or quantity of the crop produced or both. Aphidborne diseases are usually more severe in plants grown from infected tubers than in newly infected plants. However, this is not entirely so for leaf roll or for spindle tuber in some sections of the country. In some varieties, such as Green Mountain or Russet Burbank, the tubers produced by plants newly infected with leaf roll may show an objectional internal discoloration known as net necrosis. The yield of marketable tubers may be reduced 50 to 100 percent in the case of plants growing from tubers infected with leaf roll. The virus disease known as spindle tuber may result in misshaped tubers and reduced yield of newly infected plants as well as of plants growing from infected tubers. Since all the potato viruses are transmitted through the tubers, effective ways to retard their spread include rotating potato fields annually, planting disease-free seed, roguing out and destroying diseased plants early in the season, and controlling aphid vectors.

One species of aphid may be more important than another as a vector of a particular virus disease. The green peach aphid is of most importance in the transmission of rugose mosaic and of leaf roll. The latter is one cause of a necrotic condition of the tubers of some varieties known as net necrosis. The potato aphid is the most important vector of mild mosaic. The buckthorn aphid is effective in spreading rugose mosaic and also is reported to spread leaf roll. The foxglove aphid can transmit mild mosaic and leaf roll. Several other potato viruses are spread by one or
more of these aphids. Recent studies have indicated that aphids may be much less important as vectors of spindle tuber than they were formerly thought to be and that mechanical spread of this disease may be of much greater consequence than aphid transmission.

Seasonal History and Habits

Over much of the Temperate Zone winged forms of several kinds of potato-infesting aphids fly to overwintering host plants late in the summer or fall. In the North or at high elevations, where winters are usually cold, the wingless progeny of the migrant aphids that infest perennial, or woody, host plants deposit a few small elongate, oval eggs beside or behind buds or in crevices of bark of old or new growth wood. The eggs are olive green when laid, but soon change to a shiny black. Early in the spring or when the buds start swelling, the eggs hatch and the stout-beaked grayish aphid nymphs, called stem mothers, start feeding on the buds. The green peach aphid successfully winters in the egg stage on peach in central Washington and on Canada plum (fig. 4) in northeastern Maine. The potato aphid deposits overwintering eggs chiefly on wild roses, the buckthorn aphid on alder-leaved buckthorn (fig. 5), and the foxglove aphid on hawkweed and several other plants in the Northeastern States.

Fall flights of the green peach aphid are not restricted to perennial plants. When some of these winged forms infest young annual plants, aphid nymphs are deposited, which do not develop into egg-laying adults. Instead, they mature as adults and continue to reproduce parthenogenetically as long as the weather permits. Most northern winters are too rigorous for survival of these aphids, but some are able to survive some winters in the intermountain region of the Pacific Northwest. In many southern regions the green peach aphid does not lay eggs in the fall, and the summer forms reproduce on annual plants the year round.
Winged forms of the aphids, known as spring migrants, develop on the winter host plants starting in the second or third generation after egg hatching. In central Washington, where 15 generations of the green peach aphid were bred in cages on peach trees, nearly 50 percent of all aphids in the last 13 generations were winged. It was estimated that, starting with a single egg, 400 spring migrants were produced in the third generation. In northeastern Maine spring migrants are produced chiefly in the second, third, and fourth generations.

The spring-migrant aphids fly from overwintering host plants to weeds, potatoes, and other crops. After one or more generations of wingless aphids, some winged forms may be produced and these fly to and infest potatoes or other crops and weeds. After one or more generations on the summer host plants, the largest numbers of winged aphids—the summer dispersal forms—may be produced starting in midsummer. They disperse in enormous numbers from the plants on which they develop, including potatoes infected with leaf roll and other virus diseases, and scatter over the countryside to alight on potato, other food crops, and weeds. In general, the greatest field-to-field dispersal of some virus diseases occurs during this period.

Throughout the potato-growing season the aphids reproduce parthenogenetically and deposit living young. All the aphids are females except a few small winged males that develop late in the summer and fall, when the wingless egg-laying generation of females is produced on woody host plants.

During the summer an aphid may deposit from 50 to 100 young aphids during a 2- to 3-week period. Since the nymphs mature in 1 to 2 weeks, a very rapid increase in population is possible. In the State of Washington as many as 19 generations of the green peach aphid are possible on winter and summer host plants. In the South there may be even more.

The green peach aphid, the foxglove aphid, and the buckthorn aphid ordinarily infest the underside of leaves on the middle and lower parts of potato plants more abundantly than at the top and thus they may not be readily noticed. The potato aphid also feeds on the lower leaves, but during the flowering period it may become especially
abundant on the blossoms and tender terminal growth of the potato plants. To determine aphid abundance, be sure to examine the underside of the leaves, especially those at the middle and near the bottom of the plants.

**Control**

**Insecticides**

Usually complete control of aphids with insecticides is not so important in potatoes grown for table use as for seed purposes. However, in several varieties, among them Green Mountain and Russet Burbank, a serious tuber defect known as net necrosis frequently develops in the tubers produced by plants newly infected with leaf roll. When these varieties are grown for winter storage, efficient aphid control is necessary for production of a satisfactory crop. Infection of potatoes of all varieties with virus diseases often results in reduced yields in the year following initial infection. In the Northwest, Russet Burbank crops have been reduced 50 percent because of infection with leaf roll during the current season.

A much higher degree of aphid control is required in potatoes grown for seed than for eating purposes. The feeding of a single viruliferous aphid on a plant for a short time may be sufficient to infect it with some of the virus diseases.

Under ordinary conditions small numbers of nonviruliferous aphids can be tolerated on a crop of potatoes without causing noticeable reduction of yield from the feeding activity alone. Best all-seasonal control of aphids, however, can be obtained in areas with short growing seasons by killing the aphids on the plants early in the season while the population is small and the foliage is sparse and can be well covered with insecticide. In areas with long seasons it is usually uneconomical to apply insecticides before the summer migration starts. Watch the potato plants closely and apply an appropriate insecticide when required. Keep the aphid population low by repeating applications when needed or as recommended by your county agricultural agent or Extension Service entomologist. When using ground application equipment, direct the insecticide dusts or sprays to the underside of the potato leaves, where most aphids are located, especially that of the lower leaves.

**Natural Control**

Many natural agencies tend to hold down aphid numbers on their host plants, including potatoes. Sometimes these agencies are so effective that aphid populations never become large enough to affect potato yields. When this occurs, the use of insecticides is unnecessary in fields of table-stock potatoes of many varieties. Keeping close watch of aphids on the potato plants can reveal when application of insecticides is undesirable because of the operation of natural controls.

The effect of natural agencies in the control of aphids on potatoes can be increased by withholding insecticides except when needed, and by selecting for use an insecticide that will provide good control of the aphids while, at the same time, doing least harm to the agencies of control.
operating within the potato field. Among the more important natural controls are parasitic and predatory insects, fungus diseases, and certain weather conditions. Sometimes any one or more of these agencies provide adequate control of the aphids in fields of potatoes.

The most important parasites of aphids are tiny, four-winged, wasplike insects. Females lay their eggs inside the aphids. The eggs hatch into larvae that devour the inside of the aphids' bodies (fig. 6).

Lady beetles are important predators. Both larvae and adults of lady beetles eat large numbers of aphids (fig. 7). Other beneficial predators that feed on aphids are spiders, soldier bugs, assassin bugs,
syrphid flies, and green lacewings (fig. 8).

Several species of fungi are known to kill aphids. In fact, when suitable weather conditions prevail, any one or more of these kinds of entomogenous fungi are capable of virtually eliminating the aphid population on potatoes within a few days. Fungus enemies of aphids are more effective in humid than in arid potato-producing areas.
Cultural Practices

Cultural practices can restrict the number of aphids on the crop. In sections where overwintering occurs on wild host plants, the destruction of these plants over a large area should reduce the size of the population likely to be established on potatoes in the spring. In sections where overwintering of the green peach aphid takes place chiefly on peach trees, thorough treatment of the trees with insecticides either in the fall or prior to the spring migration also is beneficial. To make these practices effective, the kinds and locations of the winter host plants of the aphids should be recognized and a thorough program of eradication or treatment should be practiced over a wide area.

Weeds, whether growing in uncultivated or crop land, often support large populations of aphids. Frequently these weeds become infested before potato plants come up. They should be destroyed early in the season. Weeds in potato fields can be destroyed by early, thorough cultivations or by applications of certain herbicides just prior to emergence of the crop plants.

Other cultural practices are helpful in keeping the aphid populations at low levels on potatoes in some sections. In central Washington, potatoes planted by April 1 are less likely to be damaged by aphids or leaf roll than crops planted much later in the season. In northeastern Maine the proper timing of planting and of hilling greatly reduces the size of the aphid population. Consult your agricultural experiment station as to what cultural-control measures are practical.

ARMYWORMS

The larvae, or caterpillars, of several kinds of night-flying moths are frequently present in potato fields throughout the country, but they are usually unobserved because of their small numbers and seclusive habits. However, when for some reason the natural enemies of these larvae become abnormally scarce, or favorable weather conditions prevail in connection with a plentiful food supply, these pests multiply rapidly. When armyworms have exhausted their food supply in one field, they move in hordes, like armies, to attack crops in other fields nearby. They have voracious appetites and rapidly consume the tender parts of plants, leaving only the bare stems. Primarily they attack grains and grasses, but they also destroy potatoes and many other annual crops.

The armyworm and the fall armyworm (fig. 9) are the most destructive of this group of insects. Although they look alike and have many similar habits, the armyworm appears in early spring and the fall armyworm in late summer and in the fall. Both insects are generally distributed over much of the United States east of the Rocky Mountains and occasionally the

![Figure 9. - Fall armyworm.](G&F-3979)
armyworm occurs in damaging numbers in Arizona and California. The yellow-striped armyworm and the southern armyworm are occasional pests of potatoes. Many species of caterpillars may assume certain armyworm habits and become serious pests when very abundant and when food plants are scarce. The white-lined sphinx caterpillar often assumes the armyworm habits in the West.

**Life History and Habits**

Destructive outbreaks of the armyworm may occur in northern regions if the preceding September was warm followed by average temperature and light snowfall during the winter. Cool, dry weather in the spring is also favorable for its survival and development. Other kinds of armyworms have different temperature and moisture requirements and some may develop in damaging numbers following cold, backward springs.

The fully developed parent of the armyworm is a moth or "miller." Like other armyworm and cutworm moths, it has a small white spot near the center of each front wing. The armyworm moth is brownish gray and the wings are about 1⅛ inches across when fully expanded. The female moths lay their eggs at night on leaves of various plants. The eggs are laid in rows or masses and resemble little white beads. A single moth may lay 800 or more eggs during her lifetime.

Armyworm eggs hatch in 8 to 10 days into pale-green larvae. Full-grown larvae are greenish brown or reddish brown except for three dark, often nearly black, stripes along the back and sides. They are about 1½ inches long. Armyworm larvae complete their feeding in 3 to 4 weeks. Then they burrow 2 or 3 inches into the soil, where they change into pupae. Moths emerge from the pupae in 2 or 3 weeks.

The armyworm usually has three broods each year, but there may be only one in more northerly areas. It overwinters in the larval stage in all areas, and in the extreme South all stages of the insect may be present during the winter.

The fall armyworm moth is about the same size as the armyworm moth. It is mottled gray with a noticeable whitish streak near the tip of each front wing. The full-grown larva is about 1½ inches long, practically hairless, and ranges from light tan or green to nearly black. Extending down the back are three yellowish-white hair lines. These are bordered on each side by wider and darker stripes and next to these by an equally wide, slightly wavy, yellow stripe splotched with red. On the front of the head is a prominent white inverted Y.

The fall armyworm overwinters in all stages in the South, but it cannot survive where the ground freezes. In the spring, swarms of adults fly northward, sometimes covering hundreds of miles in a single flight. By midsummer they may be distributed over most of the Northern States. Only one generation of larvae is usually abundant in any locality in the North, but in the South there may be five to six generations.

The yellow-striped armyworm adult has a wing expanse of 1½ inches and the front wings are mottled gray and brown. The
moth lays her eggs in masses on plants and elsewhere and covers them with scales from her body. The caterpillars are greenish brown, with fine longitudinal gray lines and a double row of velvety green or black spots on the back. This insect is most abundant in the South. It is most abundant in the late summer and overwinters in the pupal stage.

The southern armyworm is a pest of potatoes in the South. The full-grown larva is dark gray to nearly black and is marked with median, subdorsal, and lateral yellow stripes. The adults are moths. There are four or more generations.

The larvae of the white-lined sphinx may become migratory, leaving Russian thistle and other weeds to damage potatoes, tomatoes, peas, and crested wheatgrass. The full-grown larva is about 3 inches long and either bright green or black, with yellow head and yellow spiny horn at the rear of the body. The adults are large night-flying moths. There are probably two generations a year.

Control

The best way to control armyworms is to apply recommended insecticides to nearby vegetation before these insects reach potato fields. If this is not possible, a large proportion of the marching armyworms can be destroyed by plowing furrows 8 to 10 inches deep across their line of march and dragging a post or log through them. The straight side of the furrow should face these caterpillars. If postholes are dug 20 feet apart in the furrow, the worms will collect in them and can be killed by spraying with kerosene or some other petroleum oil.

You can kill many pupae and expose others to weather and their natural enemies by shallow cultivation after the larvae have entered the soil. You can also reduce breeding places of the fall armyworm and prevent serious infestation by keeping fields free of grass.

Fields of grain or grasses should be carefully watched and the heaviest growth of plants in several areas of fields known to be infested should be examined frequently to determine the extent of infestation. If caterpillars are abundant in only a small area, cutting, drying, and burning the straw of the infested area may be sufficient. Large areas should be treated with insecticides. See Farmers' Bulletin 2168, Controlling Potato Insects.

BLISTER BEETLES

Many kinds of beetles feed on potato foliage from time to time over much of the United States. These insects are rather soft bodied, long, and slender, about four times as long as wide, with the head distinctly set off from the thorax and the pointed tip of the cylindrical abdomen exposed beyond the end of the cutaway wing covers. Adult blister beetles contain an oil, cantharidin, which is a powerful skin irritant. Handling or brushing against them often causes the formation of large water blisters. The most important kinds of blister beetles are the striped blister beetle, the ebony blister beetle (fig. 10), the margined blister beetle, the
ash-gray blister beetle, and the spotted blister beetle.

Adult blister beetles vary between one-third and 1 inch in length. They also vary from dull red to gray, black, blue, or green. Some are striped or spotted and others are a solid color. Certain kinds have a metallic luster.

Blister beetles are very restless, active insects that tend to feed and fly together in swarms. They feed on many field and truck crops, ornamentals, and weeds from July to September in the North and for a much longer period in the South. They are not a constant pest of potatoes, but sometimes hungry hordes appear in the fields, strip the young tender leaves down to the midrib, and disappear as suddenly as they came. Their damage chiefly checks plant growth temporarily, although they can reduce yields and also spread a bacterial wilt known as brown rot.

**Life History and Habits**

Blister beetles lay their eggs in masses of 50 to 300 about an inch deep in the soil. The eggs are elongate, cylindrical, and yellow. They hatch in 10 days to 3 weeks into a larval form called a triungulin.

The larvae of all blister beetles are predatory. Those of some kinds feed on grasshopper eggs and may become troublesome following the years of grasshopper outbreaks. The larvae of other blister beetles feed on bee larvae or as inquilines on provisions of bee nests. In either case the life history is very complex.

In species predacious on grasshoppers, the blister beetle larva burrows through the soil seeking out and entering grasshopper egg pods where it feeds. When this stage of the insect is full grown, it molts and changes to a sedentary form. The larva also molts several more times, but it retains its same general form and habitat. When fully grown, the larva burrows a short distance farther into the soil and molts for the sixth time into a nonfeeding, coarctate form not usually found in the beetle family. Usually the winter is passed in this stage. The next summer the insect again molts two more times and at last the pupa is formed. The adult appears a few weeks later. Triungulins of blister beetles that are dependent on bees or stored bee food crawl into flowers, where they become attached to bees and are thus transported to the nests. Some blister beetles require 1 or 2 years to complete their life history, whereas others may complete two generations a year.
Control

Because blister beetles appear suddenly and may do considerable damage before being detected, insecticides are generally applied as an emergency measure after they have been found in the crop. Failure to obtain adequate control usually may be attributed to applying insecticides too sparingly, too late, or without reference to the habits of the beetles.

Infested areas should be treated quickly. Spot treatment is usually adequate, but the insecticide should be applied directly to the beetles. Aircraft application to large areas is feasible, whereas row-crop or hand-operated machines are adequate for small infestations. If a hand machine is used, applying the insecticide in an ever-tightening circle around the infestation will gradually drive the beetles to the center, where they are more likely to be hit with insecticide.

CARROT BEETLE

Several scarab beetles, of which the carrot beetle is best known, occasionally attack potatoes. Adults and larvae feed on the roots and tubers and the adults also feed on the foliage. The true carrot beetle probably occurs in all States east of the Rocky Mountains, except Florida, Maine, New Hampshire, and Vermont. Several other very similar beetles may occur in Florida and the Western States. Favored host plants include red-root, sunflower, wheat, corn, and oats.

Adults of the carrot beetle and related species are all robust, oblong-oval, rather shiny, and reddish brown (fig. 11). The carrot beetle is approximately a half inch long and related species slightly shorter or longer. They may be found from April to August and are strongly attracted to light.

Life History and Habits

The adults overwinter in the soil, sometimes several feet below the surface. They start emerging in April or May. After feeding for several days, they reenter the soil and lay their eggs, usually near satisfactory host plants or in soil rich in humus. The white round eggs enlarge slightly with age and hatch in 1 to 3 weeks. The full-grown larvae are slightly more than 1 inch long. They resemble the common white
grub. They have reddish-brown heads and rather prominent legs, but their curved bodies are bluish white. The larvae are cannibalistic.

**Control**

Plowing early in the fall may break up and destroy many of the pupal cases, but this measure is only partly effective. These insects are easily controlled by applying certain chlorinated hydrocarbon insecticides in the soil prior to planting a crop.

**CATERPILLARS**

In addition to armyworms and cutworms (pp. 10, 19), there are several other species of caterpillars that have a wide range of host plants and occasionally damage potatoes. Among them are the corn earworm, the yellow woollybear, the zebra caterpillar, the cabbage looper (fig. 12), the tomato hornworm (fig. 13), the tobacco hornworm, the garden webworm, and some other webworms. All are potato-foliage feeders. The beet webworm and the alfalfa webworm may be injurious to potatoes and other crops from the Mississippi Valley to the Continental Divide. Sometimes where these or other species of caterpillars are especially abundant on their normal host plants near potatoes, they may, after exhausting their food supply, assume armyworm habits and move into the potato field, where considerable damage can be done. Volunteer host plants in a potato field also may serve as a source for chance infestation by caterpillars. Clean culture will eliminate this source.

**COLORADO POTATO BEETLE**

The Colorado potato beetle is one of the most widespread and destructive pests of potato in this country (fig. 14 and p. 1). Both adults and larvae, or immature young, feed by chewing the leaves. When the insects are
abundant, plants may be completely defoliated and even the stalks gnawed. Severe feeding damage appreciably reduces the yield. This insect also helps spread several potato diseases, including brown rot or bacterial wilt, spindle tuber, and ring rot.

The adult beetle is rather stout, oval, strongly convex, and hard backed (fig. 14, C). It is yellowish brown except for five narrow black stripes on each of the two off-white wing covers, about a dozen small black spots on the top of the head and thorax, and dark brown or black on the tips of the legs. The beetle is about three-eighths inch long and one-fourth inch wide.

**Life History and Habits**

The eggs are yellow or light orange, long-oval, and about one-fourteenth inch long (fig. 14, A). The beetles deposit the eggs perpendicular to the surface of the potato leaves in masses of several orderly rows. From 10 to 30 or more eggs may be laid together, usually on the underside of the leaves. One female may lay 300 or more eggs in 4 or 5 weeks. The eggs hatch in 4 to 9 days, and the tiny humpbacked grubs, or larvae, start to feed immediately (fig. 14, B). They seldom stop feeding except to shed their skins. They molt four times and become full grown in 2 or 3 weeks, when they are about three-fifths inch long. The newly-hatched larvae are cherry red except for the glistening black heads and feet. As the larva increases in size, the body changes to yellowish red or orange. The line of several small black dots on each side of the body of the larva marks the location of the spiracles, which are the breathing pores.

When full grown the larvae enter the soil, where they pupate in smoothly lined cells a little larger than the body. Here they transform into the pupal stage and then the adult. The beetles emerge above ground about 2 weeks after the larvae have entered the soil, or about 4 to 5 weeks after the eggs are deposited. Over most of their range the adult beetles spend the winter in the soil. Either one or two generations develop where the season is short, but three may occur in the South. Over most of the Temperate Zone first-generation larvae may appear in April, May, or June and first-generation adults in May, June, or July depending on the location. Where the weather becomes very hot in July or August, either egg laying stops or the eggs are killed by the sun. Several common plants and weeds of the potato family serve as hosts for this insect. Buffalo-bur, native to the Southwest and parts of the West, is the most widely distributed one, but a similar solanaceous plant is an important economic host in the Southeast. In the Northwest the beetles feed on common nightshade and groundcherry early in the spring and persist on these plants throughout the summer under some conditions. In addition to potatoes, they are particularly destructive to eggplant and tomato plants.

**Control**

The Colorado potato beetle has a large number of natural
enemies. Many kinds of birds, including the rose-breasted grosbeak, robins, starlings, thrushes, crows, and sparrows, feed on the larvae and adults.

Several kinds of gray, brown, or bright-colored bugs prey on the eggs and larvae of the beetle. The most common one, sometimes called the potato-beetle destroyer, is shield shaped in the adult stage and black with either red or pale-yellow markings, the most prominent of which is an inverted triangle on the back. The young, or larvae, are cherry red when small, but the abdomen becomes pink with marginal rows of black dots as they grow larger. They are most commonly observed in August or September, with host eggs or larvae impaled on their long beaks.

Two kinds of gray and black tachinid flies parasitize the larvae. The flies lay one or more glistening white oval eggs on the nearly mature larvae and occasionally on the adults. These hatch in a few days and bore into the hosts where they feed. This does not prevent the full-grown larva from entering the ground and preparing the usual pupal cell, from which it does not emerge. Instead, adults of the parasite emerge from the soil in about 2 weeks and have been known to live for 70 days. There are at least two generations each year. Although these parasitic flies usually destroy only a small percentage of the Colorado potato beetle, they have at times practically exterminated their host throughout a 5-mile-square area.

CUCUMBER BEETLES

Several kinds of cucumber beetles feed on the foliage and the larvae feed on the roots of potatoes, other crops, and weeds. The shallow or deep larval feeding holes in the tubers may resemble those caused by either wireworms or flea beetle larvae. In the South they are sometimes called healed holes. Neither the eggs nor the larvae of these insects can survive in dry soil; in fact the greatest damage is likely to develop on low land or during wet seasons. The species most destructive to potatoes are the spotted cucumber beetle, the western spotted cucumber beetle, and the banded cucumber beetle (fig. 15). The adults are either bright green marked with 11 black spots on the wings or yellowish green with 3 black stripes or bands. All of them have narrow bodies with a conspicuous collar that tapers forward from the wings to the dark head. The spotted cucumber beetle is one-fourth inch long, whereas the other species are slightly smaller.
Life History and Habits

The spotted cucumber beetle, or Southern corn rootworm as it is known in the South, is widely distributed east of the Rocky Mountains and feeds on a great variety of plants. Adults are active throughout the year in the South. They seek cover in any kind of vegetation, particularly at the base of plants, where they overwinter in the North. The beetles become active when the temperature reaches about 70° F. on warm winter days or in the spring. Large numbers of this insect migrate north and south with the seasons, often traveling 500 miles in 3 or 4 days.

The females of the first generation lay their eggs in the soil around various host plants in the spring and those of the second generation in midsummer. One female may lay as many as 500 eggs, often 100 in a day.

The eggs are yellow, oval, and about the size of a pinhead. They hatch into larvae in about 3 weeks in the spring and 1 week to 10 days in midsummer. The larvae, or grubs, are yellowish white except for brown heads. They are slender and about one-half inch long. They become full size in 2 to 4 weeks and then form cells about 1 inch below the soil surface in which they transform to pupae. In a week or two the pupae change into adults. There are two or more generations in the South and either one or two in the North.

The western spotted cucumber beetle has essentially the same life history as the spotted cucumber beetle. It occurs in the more humid and warmer parts of the country west of the Rocky Mountains. Deficient precipitation in the spring is detrimental to the larvae, and a minimum of 5° F. in the winter, without snow cover, is sometimes fatal to overwintering adults.

The adults have voracious appetites and may feed on more than 50 different plants. Under certain conditions they become gregarious. In some years after native host plants dry up, they swarm into cultivated crops in tremendous numbers. The beetles tend to congregate in caches for overwintering in both the North and the South. However, some individuals remain active throughout the winter in most infested areas.

The females are long lived and each may lay a thousand eggs or more. They are laid just below the surface of the soil and hatch in from 8 to 22 days. The larval feeding period is about 3 weeks and the total period from egg to active adult is 50 to 75 days. There is only one generation in the North.

The banded cucumber beetle occurs in the Southern States from coast to coast. The adults are active throughout the year, but they are most abundant in

![Figure 16: Spotted cutworm: A, Adult moth; B and C, larvae.](TC-3668)
the fall. The larvae bore into the stems as well as the tubers.

Control

Early plowing and frequent cultivation to prevent weed growth before planting the crop help to prevent egg deposition in the soil. In some areas less damage occurs in late than in early plantings.

CUTWORMS

The larvae of more than a dozen different kinds of night-flying moths, or millers, damage potatoes chiefly by cutting off the stems at or slightly below the ground surface; hence, the name cutworm. Although resembling armyworms, they are less prolific and seldom travel in hordes. They feed during the cooler part of the day or at night and have the distinctive habit of curling the body tightly when disturbed. Usually they are most numerous in newly-plowed grassland, which follows a rye cover crop, or in spring-flooded bottom lands. The most economically important species are the variegated cutworm, the black cutworm, and the spotted cutworm (fig. 16), which are generally distributed throughout the United States. Regionally important are the granulate cutworm in the South, the glassy and dingy cutworms in the North, and the pale western cutworm in the West.

Most cutworms eat only a little of the stem they have cut off and then move on to attack other stems. Consequently, a few worms may destroy many small plants in one night. The variegated and dingy cutworms may climb the plants and eat the leaves, the black cutworm feeds at or just below the surface of the ground, and the pale western cutworm moves entirely underground and cuts off the stem 1 to 2 inches below the surface. Cutworms occasionally damage potato tubers (fig. 17).

Adult cutworm moths are mostly a somber yellow, tan, brown, or gray. However, a few have bright-colored hindwings and are sometimes called owlet moths. The moths are attracted to electric lights and often become a nuisance.

Life History and Habits

The female moths lay their eggs late in the afternoon or at night. In the East and South the eggs are laid on leaves and stems of various plants, including grasses, but in the West many eggs are laid on trash or in the soil. The small hemispherical eggs are laid singly or in small groups, as by the dingy cutworm, or in large masses of closely packed rows of 650 or more eggs, as by the variegated cutworm. The incubation of cutworm eggs ranges from 2 to 14 days depending on
the species and the temperature.

Cutworm larvae vary in color. The variegated cutworm is grayish brown and lightly mottled with darker brown, with single rows of pale-yellow dots along each side of the body. The black cutworm is greasy gray or brown, with faint lighter stripes and numerous small and large granules on the body. The spotted cutworm has a dark stripe along each side and several pairs of wedge-shaped black dashes on the rear part of the back. The granulate cutworm is dark gray, with many black granules covering the body. The glassy cutworm is a shiny greenish white except for the reddish head. The dingy cutworm is dull brown, with a broad buff-gray center stripe subdivided into many triangular areas and bordered by a narrow dark stripe on each side. The pale western cutworm is grayish, unmarked by spots or stripes, but the skin has fine, flat, pavementlike granules. Full-grown cutworms are plump and may be 2 inches long.

All cutworms have the same general life cycle, but one of the developmental stages may take longer to complete in some species than in others. All stages of the variegated cutworm develop rather rapidly and three or four generations may be produced each year. In certain single-brooded species the larval and pupal stages are greatly extended, and a rise in temperature appears to delay the transformation of larvae to pupae. Eggs of the dingy cutworm hatch in 6 to 14 days, whereas those of the pale western cutworm may require only 3 weeks in the fall but about 4 months for those that overwinter.

Cutworms are usually most abundant in the spring, probably because the most abundant species overwinter as partly grown larvae and resume feeding early. Exceptions include the pale western cutworm, which usually overwinters in the egg stage, and the black cutworm, which may overwinter in either the larval or pupal stage. Although the larvae are active at cool temperatures, they grow most rapidly when it is warm. Soil-infesting species may have to cope with extremely high temperatures. For example, larvae of the pale western cutworm may become distributed in a thin evaporation-cooled layer of the soil just above the moisture line, which is a continually fluctuating area separating moist from dry soil.

Control

Damage to potatoes by some kinds of cutworms may be avoided by early fall plowing and clean cultivation. Larvae left in a clean field become cannibalistic or starve. Potatoes should not be planted immediately following stubble, grass, or sod.

EARWIGS

Earwigs are furtive, foul-smelling insects that obtained their name from an old superstition that they crawled into the ears of sleeping persons. More characteristic, however, is the formidable pair of forceps that extends backward from the body. Although equipped with short wings folded under a pair
POTATO INSECTS

21

of leathery covers, earwigs rarely fly. They thrive best in heavily shaded damp places, where they hide by day and forage at night. Of the seven or more species in the United States, the European earwig is most widely distributed and also most likely to damage potatoes. It is a brown leathery insect about a half inch long and one-third as wide (fig. 18).

Life History and Habits

The European earwig lays small, oval, off-white eggs in masses of 20 to 65 in cells formed by the female an inch or more below the surface of the soil. Egg laying starts in January or later depending on the locality, and hatching may start in April. The female guards her young solicitously, gathering them about her at any alarm. The young earwigs molt four times during their nymphal growth period of approximately 65 days. Only one brood develops annually.

The European earwig feeds on the leaves, flowers, and fruit of many cultivated plants and also on small insects, particularly plant lice. Although normally avoiding tilled areas, it is occasionally found in irrigated potato fields in parts of the West. The adults and nymphs chew lacelike holes in the leaves, frequently skeletonizing an entire plant. This insect occurs in many New England and Atlantic Coast States and in nearly all States west of the Rocky Mountains.

Control

Earwigs are easily controlled with insecticides. However, if injured plants occur in the headlands, further injury may be greatly reduced by disk ing up or otherwise removing weeds or debris, which provides the diurnal hiding places of the insects. Earwigs have various natural enemies, of which the most effective is a fly parasite introduced from Europe many years ago.

EUROPEAN CORN BORER

The European corn borer is one of the most destructive pests ever to invade this country. Although corn is its favored host and receives by far the greatest damage, the borer also infests potatoes and many other vegetables, as well as flowers, field crops, and weeds. The general area over which it is established extends from Georgia to Maine and westward to eastern Montana.

The adult borer is a moth. It usually has two zigzag lines across the wings and a wing expanse of about 1 inch. The
female moth is pale yellow to light brown, with a robust body about one-half inch long. The male moth is smaller, has a more slender body, and is darker.

The full-grown borer, or larva, has a dark-brown or black head and is about 1 inch long and one-eighth inch thick (fig. 19). The upper part of the body is gray to light brown or pink, with a row of dark-brown spots on each segment and several brown or pink lines extending lengthwise on the body. The underside of the larva is flesh colored without markings.

Larvae of the European corn borer damage potatoes by feeding in the stalks or on the tubers. The tubers are subject to attack when exposed by heavy rains or if the infested potato stalks are killed by the borers. The developing larvae leave the dead stalks in search of food, and they will feed on any potato tubers that can be found.

**Life History and Habits**

The female moth lays her eggs in masses of 15 to 20 on the underside of the leaves. The average female will deposit about 400 eggs, but some have been known to lay as many as 1,900. The eggs are nearly white when first laid, but they turn pale yellow and then darker just before hatching.

The larva molts five or six times as it grows. When full grown, it constructs a flimsy cocoon and transforms to the pupal stage. Later it emerges as the moth.

The insect overwinters as a full-grown larva in the stalks of corn and stems of other crop plants and weeds. It pupates in the spring. The European corn borer has from one to three generations each year— one in the northerly areas, two over most of the infested area, and three in the southern part of its range.

The insect spreads in two ways. The adults may fly long distances, or the larva may be carried in cornstalks or other plants by flood waters, tidewaters, or other means.

**Control**

Destroying overwintering borers in the cornstalks or other infested plants in the fall, winter, or early spring by burning, shredding or cutting, and removing the stalks are effective means of preventing infestation and damage by the European corn borer.

**FALSE CHINCH BUG**

The false chinch bug is widely distributed, but usually it causes severe damage only in the western half of the country. The adults and nymphs overwinter in plant litter and may propagate in enormous numbers in the spring in some semiarid regions on Russian thistle, lambsquarters, redroot, mustards, and grasses. When the weeds dry up, the nymphs and adults migrate to potatoes and other crops. Potato leaves at-
tacked by the false chinch bug show small, round, rusty specks, or feeding punctures where the beak has been inserted. If the bugs are numerous, they may cause the plants to wilt and die within a few days.

The adults are very active, becoming alarmed and rising in swarms when disturbed. They are about one-eighth inch long, one-third as wide, and light to dark gray, with small black spots on top and black on the bottom. The top of the insect is flat and the head tapers to a prominent point between the bases of the thick, irregularly bent antennae. The nymphs are also gray, but much paler than the mature insects. The front of the body of last-stage nymphs is marked with distinct red and brown lines, and the abdomen is brownish or mottled with pink.

**Life History and Habits**

The crescent-shaped pink eggs are laid throughout the growing season in cracks in the soil, on foliage of low-growing plants, and even in the blossoms. The eggs hatch in about 4 days, and the nymphs feed for 3 to 4 weeks before changing to adults. There are from three to seven generations a year depending on the locality.

**Control**

Burning field litter and weeds in the fall and eliminating weed growth on abandoned land in the spring help to keep the insect in check. Wet weather is unfavorable for its development and increase. Insecticide applications are more effective when made following cool nights with some dew because they inhibit flight.

**Flea Beetles**

Many kinds of small leaf-feeding beetles are called flea beetles, because they have well-developed hindlegs that allow them to jump like fleas. Several attack potatoes, but four similar-appearing species are of considerable economic importance. Adults of these species are about one-sixteenth inch long, oval, and dark. The two most important species are sooty black and hard to differentiate. Fortunately they are widely separated. The potato flea beetle (fig. 20) occurs from mid-Nebraska to Maine and the Carolinas and the tuber flea beetle from western Nebraska and Colorado into the intermountain and coastal regions of the Pacific Northwest. The western potato flea beetle, a shiny black insect, occurs west...
of the Great Plains States, and the tobacco flea beetle, which is brownish black, occurs in varying numbers throughout much of the southern, central, and western parts of the country. The pale-striped flea beetle is slightly larger, a shining pale yellow, brown, or blackish, with a reddish-brown head and two widely separated pale stripes along the back. It is generally distributed throughout the southern part of the country, but it does not seem to attack potatoes in the Southwest. The eggplant flea beetle, very similar to the potato flea beetle, also is reported to injure potatoes.

**Nature of Injury**

Adult flea beetles chew out small round holes in the potato leaves. When these are numerous, the leaves appear sievelike (fig. 21). Badly chewed leaves wither and die. Usually only the potato flea beetle becomes sufficiently abundant to defoliate the plants, but in some areas this is also true of the tobacco flea beetle. Tubers of badly damaged plants may stop growing or become irregular shaped. Adult flea beetles also carry and transmit several serious bacterial diseases.

Flea beetle larvae attack the underground parts of their host plants (fig. 21). Larvae of most potato-infesting species may attack the tubers as well as the roots. However, the tuber flea beetle is especially destructive, because the larvae scar the tuber surface badly and also bore deep into the flesh (fig. 22). The larval feeding tunnels are long, gray or black, and cork-like. They are very objectionable and there is considerable waste in removing them. Larvae of other flea beetles bore only a short distance into the tubers. Ordinarily, shallow
blemishes can be removed with normal paring. However, in processing potatoes, where only the skin is removed in the lye bath, many flea beetle scars remain embedded in the flesh and must be removed with knives. It is important, therefore, to know what kinds of flea beetles are in the area and also how the crop is to be used in order to grow it satisfactorily and economically.

Life History and Habits

The adult flea beetles overwinter chiefly in or near fields in which they matured. Adults of the potato flea beetle and the tuber flea beetle usually burrow a few inches into the ground, but some may burrow downward 18 inches or more. In light soils approximately half of the tuber flea beetles hibernate below normal plow depth. Adults of the tobacco flea beetle and of some other species overwinter in woods litter, hedgerows, or on sodded ditchbanks. Winter survival of some species may exceed 50 percent when hibernation occurs in a moist but not excessively wet environment.

Several species of flea beetles do not actually hibernate during the winter; they merely become motionless under plant litter at or near the soil surface. On sunny days when the ground is bare of snow, the adults may crawl or fly about if the temperature rises above 50°F.

Adults of the potato and tobacco flea beetles leave their hibernation quarters as soon as the activation temperature is reached. This may vary from early February to early May in the South and from April or May to early June in the North. The first feeding occurs principally on various weeds and also on tomato and tobacco seedlings in plant beds. Adults are usually present in fair numbers by, or soon after, the time the first potato plants come up. One to four or more generations develop each year depending on the locality. The western potato flea beetle becomes active in April and the tuber flea beetle in May in the Pacific Northwest. Two or more generations of these insects occur each year depending on the length of the growing season.

Flea beetle eggs are deposited in cracks in the soil, chiefly near suitable host plants. They are slightly oval and white and are rarely seen because of their size. Eggs of most species hatch within a week or 10 days. The threadlike larvae attack the old seed pieces, large and small roots of the potato plants, and eventually the developing tubers. The larvae are about one-third inch long when full grown and at times may be found hanging part way out of their feeding tunnels in recently harvested potatoes.

The mature larvae leave the tubers or roots on which they have fed and prepare small smooth earthen cells a short distance away in which pupation takes place. The entire life cycle usually is completed in 4 to 6 weeks, although 8 or 9 weeks may be required under less favorable conditions. The newly formed adults crawl to the surface of the soil before their bodies are fully hardened or deeply colored.
Fields will help hold the beetles in check, since flea beetles feed and breed on many species of weeds.

GARDEN SYMPHYLAN

The garden symphylan (fig. 23) is a pest of major economic importance in some parts of this country. In the West it attacks several field crops and vegetables, including potatoes, ornamentals, and nursery and specialty crops. In the East it is primarily a greenhouse pest, although in recent years it has spread to the field in parts of the Northeast, where it appears to be increasing in its attacks against potatoes and several other food crops.

The garden symphylan inhabits soil primarily, but under favorable conditions it may emerge and attack low-lying parts of plants. The most common damage is from feeding on planted seeds and on the underground parts of growing plants. Where the creatures are abundant, the damage from feeding on the root hairs and rootlets is severe enough to stunt the growth of many crops, even potatoes. Besides causing a reduction in yield, they also attack and damage potato tubers (fig. 24). This damage is unsightly. It resembles somewhat that from potato scab disease or from feeding of flea beetle larvae. Actually, it consists of tiny holes in the skin, with a fairly large undercut cavity in which the symphyllans move about and feed.

The garden symphylan is not an insect, but it belongs to a more primitive group of animals related to millipedes and centipedes. At one time it was

Control

Clean culture to keep down weeds in and around potato
known as the garden centipede. It occurs throughout the northern half of the country and in Texas and California.

Adult symphylans are white active creatures that constantly run in and out of holes in the soil and disappear when exposed to light. They are not able to make their own burrows for migrating through the soil, but they must depend on other passageways, such as earthworm burrows and openings left by decaying roots. The adult symphylans are about one-fourth inch long and one-fiftieth inch wide. There are 14 visible body segments on which there may be as many as 12 pairs of legs and 2 long, beadlike antennae, which are constantly in motion. Since the creatures are blind, the antennae may take the place of eyes as well as other sensory organs. Two small appendages located on the rear end of the body produce a silklike material used to line the galleries and probably serve to guide the creatures.

Life History and Habits

The eggs are about one-fiftieth inch in diameter, spherical, and white, but they turn darker as the time of hatching approaches. The eggs are laid in groups of 5 to 25 in cavities in the soil. Egg laying takes place mostly in the spring or early summer. They are deposited in the top soil if moist or in the subsoil. Male symphylans have been reported to deposit in the soil spermatophores consisting of a pedicel, on which is attached a spherical head containing spermatozoa. The investigators believe that the female consumes this head and in some manner accomplishes the fertilization of her eggs. The eggs hatch in from 1 to 3 weeks.

The hairy larva escapes through a narrow opening in the egg and at first resembles a footless grub. A few minutes later the antennae are moved forward and the legs extruded. The larvae are very sluggish but become more active after each molt. The larvae molt seven times. Starting with the first molt the original 6 pairs of legs are increased by 1 pair at each consecutive molt until there are 12 pairs. For some peculiar reason the adults also molt, some as many as 50 times. Under favorable conditions broods may occur at regular intervals of about 3 months. Symphylans may live for 4 or more years.

Symphylans are very sensitive to changes in their environment, and there may be daily as well as seasonal differences in their vertical distribution within the soil profile. Optimum activity
occurs between 50° and 70° F. and feeding will continue at 85°. They die quickly when the temperature approaches 100°. They often come to the soil surface after rains in the late summer or fall. In late spring or summer they migrate downward 24 to 36 inches in non-irrigated soils to escape heat or drought. They become sluggish at low temperatures and overwinter outdoors as well as in greenhouses.

Control

Flooding level fields continuously for approximately 3 weeks when the temperature is at least 50° F. will reduce the populations to such an extent that damage to crops may not occur for a few years.

GRASSHOPPERS AND FIELD CRICKETS

The many kinds of grasshoppers are among the most injurious insect pests of American agriculture. Usually several species of these hardy insects may be found together. Their damage is most severe in the Plains States and mountainous areas of the West. Their greatest damage to potatoes is that of chewing holes in the leaves, although certain species of grasshoppers are able to transmit spindle tuber and unmottled curly dwarf. Field crickets, which are closely related to grasshoppers, feed on potato foliage also and cause damage when abundant.

Grasshoppers and field crickets are alike in that both have large, strong, biting jaws and also strong hindlegs adapted for jumping. The true crickets have rather robust, short, flat bodies and long, slender antennae, or feelers. The female has a long sword-shaped ovipositor, or egg-laying appendage. Most crickets are wingless, but a few have short wings.

Most grasshoppers have relatively short antennae. The body is elongate, slightly cylindrical, and partially sheathed by long, slender membranous wings topped by outer leathery wings. Five species are responsible for most of the damage to potatoes. The migratory grasshopper is about 1 inch long and reddish brown, with an irregular-shaped black patch on the neck or collar. The differential grasshopper is nearly 1½ inches long and yellow, with black chevronlike stripes on the “thighs” of the hindlegs. The two-striped grasshopper is about 1¼ inches long and greenish yellow, with black or brown markings and two lighter stripes extending the length of the body. The red-legged grasshopper is about three-fourths inch long, reddish brown above and yellow beneath, with tinges of bright red on the legs. The clear-winged grasshopper is about 1 inch long and yellow or brown, with large brown blotches on the horny outer wings.

Life History and Habits

Most grasshoppers lay their eggs late in the summer or early in the fall. The female thrusts her abdomen into the soil to a depth of 1 to 2 inches and starts laying eggs at the bottom of the tunnel. From 15 to 75 eggs, depending on the species, are laid at one place. These are held together by a gelatinous substance and form a sac, or
POTATO INSECTS

Each female may lay from 8 to 21 pods. Strange as it may seem, hard uncultivated ground is preferred for egg laying, although some pods may be found along the edges of cultivated fields, in ditchbanks, pastures, and hayfields. Grasshoppers that attack potato fields frequently have hatched in wasteland nearby.

The egg pods are very resistant to cold and moisture. Hatching starts in the spring, when the air temperature has been above 75° F. for a few days, and may continue for some time. The young, or nymphs, are active and able to hop almost immediately upon emerging from the egg. They require from 40 to 60 days to mature and develop wings. The adults mature during the summer or early in the fall. Usually there is but one generation a year, but some species may have two in southern areas.

Control

Potato fields may be best protected from grasshoppers by locating the young hoppers in hatching areas and treating them with insecticides before they move to potato fields. If a nearby alfalfa field is infested with large numbers of grasshoppers, it may be economical to cut the hay before applying insecticides. Some of the eggs of the grasshoppers may hatch even after the first cutting. Control measures for range grasshoppers should not start before hatching of the dominant species has been completed.

Wild and domestic bees are essential for seed production of legumes. If such seed crops become infested with grasshoppers, do not apply insecticides during the blossom period or treat late in the evening when the bees are inactive.

LEAFHOPPERS

Leafhoppers are small, narrow, wedge-shaped insects (fig. 25). They feed by sucking the sap mostly from the underside of the leaves. When the plants are disturbed, the adults hop or fly away and the long-legged nymphs scamper sidewise like crabs for cover.

Several kinds of leafhoppers attack potatoes (fig. 26). Most of these are approximately one-eighth inch long and yellowish or greenish; some have brown markings. Some species, because of their abundance, consume a great amount of plant sap and also remove the chlorophyll from the leaves, leaving them with a blotched appear-
ance. Others, although less numerous, can be more destructive because they transmit virus or viruslike diseases. The pale-green intermountain leafhopper becomes extremely abundant on potatoes in the Pacific Northwest, but it is not known to transmit viruses. Hopperburn, a viruslike "disease" resulting in extensive stippling, curling, and browning of the leaves (fig. 27), may be caused by the potato leafhopper throughout much of the eastern part of the country and in California. This condition is also caused by the southern garden leafhopper, which occurs throughout much of the southern half of the United States. The arid leafhopper and the western potato leafhopper also attack potatoes in parts of the West. Both species occur in low altitude and low relative humidity areas—the arid leafhopper in California, Arizona, and Utah and the western potato leafhopper from Texas to Oregon.

The six-spotted leafhopper is yellow or yellowish green with six very small black spots on the head. It is generally distributed throughout the country. Although seldom extremely abundant, it is likely to be the most abundant of 23 known leafhopper vectors of aster yellows or purple-top wilt disease. Although some eggs of the six-spotted leafhopper may overwinter in grain and other plants in the Northern States, this species also migrates from the lower Mississippi River area each spring. Many of the leafhoppers that reach the northern potato seed-growing areas are already infected with the aster yellows virus. Aster yellows occurs in more than 175 different kinds of plants. Tubers harvested from infected potato
plants may be flabby and make poor seed because of the lack of sprouts or because of weak sprouts. Foliage symptoms of the disease resemble leaf roll, psyllid yellows, and rhizoctonia. Even if not infected with the aster yellows virus, when abundant the leafhopper can cause direct feeding damage to the potato foliage (fig. 28).

The beet leafhopper varies from pale green in the spring to dark brown in the hibernating adults. It occurs in the western half of the United States. The adults transmit a virus, causing a disease known as curly top, to many crops including potatoes. Affected potato plants produce smaller abnormally formed leaves.

The short but relatively wide clover leafhopper is gray mottled with brown. It is reported to carry the potato yellow dwarf virus. The life cycle requires 2 to 4 weeks depending on the temperature. There are two generations annually in the Northern States and more in the South.

**Life History and Habits**

The leafhopper eggs are small, whitish, elongate, and slightly curved. They are inserted into tender parts of the plants in the spring and sometimes in the fall and require 10 days to 2 weeks to hatch. The nymphs become full grown in about 16 days. There are three to four generations of the intermountain leafhopper, two to three generations of the potato leafhopper, one to three generations of the beet leafhopper, and two or more generations of the six-spotted leafhopper.

![Figure 28.—Curled leaflets on this potato plant resulted from feeding or sucking damage of the six-spotted leafhopper.](P.1-49A)

**LEAF MINERS**

The larvae of two species of small gnatlike flies feed and mine in the soft tissue between the upper and lower surface of leaves of potato and many other plants. A few to more than 50 gray, narrow, and curiously entwined mines or one to several large blisterlike mines may be found in a single leaflet. The injury weakens the leaves and also is a convenient point of entry for disease and decay organisms.

Adult leaf miners that attack potatoes are either shiny black or black with yellow markings on the legs and each side of the abdomen. They drink the sap from small holes chewed in the leaves and, curiously, the female may turn about after laying an egg in the leaf and drink from the wound made by the ovipositor.

**Life History and Habits**

The small white eggs hatch in 3 to 8 days. The yellowish larvae rasp away the plant tissue
rather continuously with their sickle-shaped mouth hooks for 3 to 12 days. The full-grown larva is about one-eighth inch long. If the air is dry, the small brown puparium may be formed in the mine, but usually the larva crawls out and enters the soil. The pupal period is from 8 to 28 days. The average time required for one generation is about 23 days. These insects may overwinter in the pupal stage or propagation may continue in warm climates. There may be from three to six generations each year.

Leaf miners occur throughout much of the United States but are most likely to injure potatoes only in the southernmost States.

**MEALYBUGS**

Mealybugs that occasionally attack potatoes include the grape mealybug, the citrus mealybug, the apple mealybug, and the solanum mealybug.

Mealybugs are oval, scalelike, soft-bodied insects, about one-eighth inch long (fig. 29). Their bodies are covered with a whitish powdery wax.

Mealybugs damage potatoes by sucking their food from foliage, roots, or tubers. In Oklahoma, Nebraska, and Florida they feed on the roots or the stored tubers, but in California they may infest any part of the plant. In the Northeast they may occasionally infest potato leaves. When they feed on the foliage, circular chlorotic areas develop at the point of feeding. When large numbers of the mealybugs are present, the leaves become speckled with yellow.

**Life History and Habits**

The adult female mealybugs deposit their eggs in a compact, cottony, waxy sac at the rear end of their bodies. One of these little white cases contains 300 to 600 eggs. Although mealybugs may be found at many places on the plants, they are usually located on the trunk and at the axils of branching stems. In the field the eggs hatch in the spring. The young mealybugs remain for a short time in the egg case and then crawl over the plants. In the Northeast the tiny crawlers will travel considerable distances from apple trees into a nearby field of potatoes. There is evidence that strong winds also may carry them some distance from apple trees. Shortly
after they begin to feed, a white waxy material begins to exude from and cover the body. Female nymphs change little except to become larger as they grow. The male nymphs pupate in small white sacs and eventually emerge as two-winged flylike insects. In the North there is probably but one generation each year. However, in greenhouses a generation is completed in about 1 month.

**MILLIPEDES**

Several species of millipedes occasionally damage tubers. Millipedes are worm-like animals 9/4 to 11/4 inches long. Their brownish to grayish bodies are fairly glossy, thick, and leathery. They may have 50 to 75 pairs of legs, and the head is equipped with jaws capable of feeding on plant tissues that are not too hard. One species that infests potatoes in the West has rows of bright red dots on each side of the body.

Millipedes normally feed on decaying organic matter, but they may damage potatoes. In feeding on the tubers some species make rather large, shallow, irregular cavities, with no overhanging skin (fig. 30). They frequently feed inside cavities made by slugs and snails, insects, or the potato scab disease. One species makes cylindrical clear-cut tunnels, which slightly resemble those made by wireworms or flea beetle larvae. These tuber injuries facilitate the invasion of bacteria and fungi. The damage to potato seed pieces is especially noticeable during cool, wet springs in parts of the Northwest. In table-stock potato fields the damage is usually greatest near harvesttime. The millipede is particularly annoying as a contaminant of fresh produce.

**Life History and Habits**

The eggs of millipedes are laid in the soil or on the surface, usually in clusters of 20 to 100. They hatch in about 3 weeks and the larvae feed mostly on decaying vegetable matter. They grow slowly, gradually acquiring the appearance of the adult. The millipedes overwinter in the soil, sometimes in large clusters within potato tubers left in the field.

**Control**

Millipedes and their damage are usually most common in wet soils or in soils high in organic matter. Heavy applications of stable manure tend to increase the numbers of
millipedes. Cultural control and soil treatments for scab disease and scab gnats reduce damage by millipedes.

**MITES**

Several kinds of mites, especially the two-spotted spider mite (fig. 31), attack potatoes in the Western States. These mites rarely become a problem until the plants are more than half grown or after the weather has become very hot and dry. They overwinter on clover and other plants and frequently build up to enormous numbers on some other host before migrating on strands of silk to potatoes and other crops. First evidence of injury consists of very small brown stipplelike spots, most frequently in the basal lobes of the leaflets. Within a few days the small dead areas coalesce and the entire leaflet may be killed within a short time. Infestations invariably start on the underside of leaves near the top of the plants.

![Figure 31. Adult of the two-spotted spider mite.](TC-7278)

The very minute six-legged creatures are nearly leaf green, with two separate or partly coalescing nearly black spots on the body. The water-clear spherical eggs are extremely difficult to see.

**Life History and Habits**

All stages of the pest may be rather obscured by a protective webbing of silk. The eggs hatch after about a week. Egg laying stops near the end of summer, and the mites starting the winter become orange. There are several generations each year.

**Control**

The two-spotted spider mite has become highly resistant to insecticides in some areas. It is also particularly hard to control after becoming webbed in. Best control can be obtained by treating the crop before injury appears with an insecticide having a long residual life expectancy.

**MOLE CRICKETS**

Mole crickets occasionally feed on the roots, stems, and tubers of potato plants, in addition to a wide variety of other plants. These weird-looking light-brown to black crickets (fig. 32) burrow just beneath the surface of the soil and uproot plants, cut off roots, and eat shallow holes in the underground parts of stalks. The relatively shallow holes they eat in potato tubers are much like those made by white grubs or cutworms (fig. 33).

Mole crickets have robust bodies adapted for burrowing through the soil. The adult may be up to 1 1/2 inches long.
and its body is covered with fine velvety hairs. The rake-and-shovellike front legs are stout and the hind legs are large. Although the front wings are short, the hind wings are long.

There are several species of mole crickets, including the southern mole cricket, the changa or Puerto Rican mole cricket, the short-winged mole cricket, and the northern mole cricket. They occur throughout the Southern States from North Carolina to Texas, and one or more kinds may be found as far north as Nebraska, Indiana, and even Massachusetts.

**Life History and Habits**

The life history and habits of the common species of mole crickets are rather similar. The life history of the Puerto Rican mole cricket is summarized here because it is one of the most destructive species of mole crickets. This insect lays small greenish oval-shaped eggs in earthen cells at the end of its tunnels—generally 40 to 50 eggs in each cell. The eggs hatch in about 3 weeks, and hatching continues until early August. The small nymphs that emerge grow rapidly for awhile, but this rate slows as maturity is approached. When about two-thirds grown, the nymphs develop wing pads, which become longer with each molt. Altogether there are eight molts before the winged adult stage is reached.

Although some adults mature and can be seen in late October, the insect overwinters most commonly in the nymph stage. It completes development in the spring. Adult mole crickets are most commonly seen from May to July. The normal food of the Puerto Rican mole cricket consists largely of decaying organic matter. It frequents compost piles and often congregates there in large numbers.
MORMON CRICKET

The Mormon cricket is not a true cricket (fig. 34). It is closely related to the katydids and long-horned grasshoppers. Other pests of this group that have the same general life history and habits include the coulee cricket and the Jerusalem, or sand, cricket. These pests are native to the deserts of the intermountain region and are distributed from New Mexico to Washington. The coulee and Jerusalem crickets are found chiefly in the northern part of this region.

Damage occurs from biting and chewing by the adults and nymphs. When abundant, they consume the foliage of many plants, including potatoes. In 1939, 19,074,900 acres of land were infested by the Mormon cricket and crops were damaged on 62,977 acres. Serious crop damage by this pest is an annual threat, although its abundance may not reach such levels yearly or over large areas. Infestations of the coulee cricket appear every 5 or 6 years in the western part of the Yakima Valley. The Jerusalem cricket occasionally attacks potato tubers in newly farmed soil in the Western States.

Life History and Habits

The adult female of the Mormon cricket may lay as many as 150 chocolate-brown eggs that later turn gray. They are placed loosely in cracks or small holes in hard, bare ground during the fall. They are 1.5 mm. wide and 6 mm. long. The eggs hatch in the spring into nymphs that resemble the adults in general appearance but are smaller. The insects mature in 75 to 100 days during June and the first half of July and live until early fall. Few live after the middle of October.

Mormon crickets are active by day and rest by night. They are gregarious, and bands have been known to travel—by crawling—10 to 20 miles during a season. Bands of these insects have destroyed a field of potatoes within a few hours. Migrations of the Mormon cricket across highways or railway tracks have stopped automobiles and trains because of the slippery mass made by their crushed bodies.
PLANT BUGS

Various species of plant bugs frequently attack and damage many kinds of plants, including potatoes. The most widely distributed and generally the most common of these is the tarnished plant bug (fig. 35). The western plant bug (cotton dauber or legume bug) and the pale plant bug are also destructive in many Western States. Among other plant bugs of some economic importance are the four-lined plant bug, the rapid plant bug, the leaf-footed bug, the garden fleahopper, and the cotton fleahopper.

The adults of the tarnished plant bug, the western plant bug, and the pale plant bug are about one-fourth inch long and one-eighth inch wide, flat, and oval, with a small triangular area at the base of the wings. They may be brown, yellow, or mahogany, usually with white or black blotches. Although adults of the three species usually differ in color, this difference alone is unreliable for determining the species. The distinctive four-lined plant bug is one-fourth to one-third inch long and about half as wide as long. It is greenish yellow to dark green, with four black stripes extending about two-thirds the way down the wing covers. It is primarily a pest of currant and gooseberry but also of other plants, including potatoes.

The rapid plant bug is very active, about one-fourth inch long, and brown except for a narrow yellow border. It has long, slender, light-colored legs. It is a common pest of cotton and occasionally feeds on potatoes in the Mississippi Valley.

Adults of the leaf-footed bug, even though much larger and more clumsy appearing than other species of plant bugs attacking potatoes, will also fly away when disturbed. The adults are three-fourths to 1 inch long, dark brown, with a lighter marking across the wings in the middle of the body, and the last joint in each hind-leg is flattened into the shape of a leaf. This pest occurs in the Southeast.

The garden fleahopper and the cotton fleahopper are about the same size and look somewhat alike. They are small soft-bodied insects that resemble flea beetles in appearance as well as in the habit of jumping when disturbed.

All these plant bugs have piercing mouth parts equipped...
for sucking out the plant juices. Some of the nymphs and adults feed largely on the thin parts of leaves, whereas others feed on the veins, midribs, and tender tips of the stalks and branches. Usually the immediate evidence of injury to potatoes is wilting of the tender new growth or that part of the leaf beyond the point of the vein or midrib injury (fig. 36). The wilted, drooped parts of potato leaves usually die. Sometimes several leaflets per leaf will die, whereas at other times practically all leaflets of a leaf will sustain some damage but will not die immediately. The four-lined plant bug makes closely grouped feeding punctures in the leaves (fig. 37). The damaged sections turn brown, die, and sometimes fall out of the leaf and give the appearance of feeding damage by insects with chewing mouth parts.

The tarnished plant bug and closely related bugs also transmit a virus disease of potatoes known as spindle tuber, which causes misshaped tubers.

**Life History and Habits**

The life histories of the several species of plant bugs differ materially but are similar in that all species deposit eggs that hatch into nymphs. The nymphs and adults of a species somewhat resemble each other except for size and the nymphs have no wings. Some species overwinter in plant litter, trash, under the bark of trees, and in similar environments only as adults or as adults and nymphs. The four-lined plant bug and the cotton fleahopper overwinter as eggs. Depending on the
species and the location there are one to five generations each year. Some species breed on weeds, crop plants, and woody perennials such as wild roses, gooseberry, and currant. Several species, including the tarnished plant bug and other species of plant or lygus bugs, occur in enormous numbers on alfalfa, clover, and other crops and migrate to potatoes when the hay is cut or other nearby host plants mature.

**Control**

A general cleanup of weeds and plant litter in the fall prevents overwintering of bugs near fields in which susceptible crops may be grown the following year. Hoarycress is a favorite overwintering or early-spring host of lygus bugs and should be destroyed wherever found. Fields of alfalfa or clover are sources of lygus bugs in June and July. After each cutting of hay, the potato fields nearby should be examined to determine whether insecticides should be applied.

**POTATO PSYLLID**

The potato psyllid is a very destructive pest of potatoes in Colorado, Nebraska, New Mexico, Utah, Wyoming, and Montana. It also occurs in most other Western States except Oregon and Washington. In feeding on potatoes this tiny insect injects a substance into the plants that causes a curling and yellowing of the leaves known as psyllid yellows.

The adult psyllid is a narrow insect about one-tenth inch long (fig. 38, A). Its clear wings fold together rooflike over the abdomen. A broad white band extends across the middle of the gray body and an inverted white Y occurs on the back side at the tip of the abdomen. The legs of the adults are suited for jumping. In fact the potato psyllid belongs to the group of insects sometimes called jumping plant lice because of their close relationship to aphids, which have jumping habits. The adults are seldom seen on the potato plants by a casual observer, because they jump or take flight at the least disturbance.

Psyllid yellows resembles leaf roll and aster yellows but is caused only by the feeding of the nymphs of the potato psyllid. The first symptoms in an affected potato plant are an upward rolling of the basal part of the terminal leaflets and a change in color from the normal green to light green or yellow (fig. 39). In some varie-
ties of potatoes the rolled parts and sometimes other parts of the plants turn reddish or purplish. In the advanced stage the rolling extends to the older primary leaves. The leaf rolls over the midrib, becomes yellow, develops necrotic areas, and degenerates rapidly. The leaves feel harsh and leathery. Before long the plant appears to consist principally of primary stems. It becomes stunted and may turn brown and die. The growth of tubers is materially checked. The set of tubers is substantially increased, but they never reach marketable size. Aerial tubers may also form in the leaf axils.

Life History and Habits

The potato psyllid lays its spindle-shaped yellowish-orange eggs along the margins of the leaves on both the upper and lower surfaces. The eggs are suspended on small stalks (fig. 38, B), frequently in rows. They are most abundant on young apical leaves. A fertilized female may deposit up to 800 or more eggs during an oviposition period of about 3 weeks, with an average of 300 to 400. The eggs hatch into nymphs in 3 to 9 days in warm weather, but more time is required at lower temperatures.

The light-green, flat, scale-like nymphs are relatively immobile and resemble nymphs of the iris whitefly (fig. 38, C). They usually have five instars. They secrete small pellets of a white wax-coated substance containing honeydew. The pellets fall upon the top of the lower leaves and on the ground at the base of the plants and can be readily seen. Approximately 2 weeks in warm weather is required for the nymphs to complete development. There may be as many as 10 generations during a season in some areas. High summer temperatures, especially in July, hold down psyllid populations on potatoes and on other summer host plants.

The potato psyllid does not overwinter in the more northerly potato-growing areas. Instead, in autumn it moves into southerly desert areas, continuing to breed there throughout much of the winter. In the spring enormous numbers may develop on the host plants in these areas. The adult psyllids then move northward in large numbers. The psyllid reaches western Colorado and eastern Utah from late April to the end of June and the potato areas on the eastern slope of the Rocky Mountains during May and June.

Severity of psyllid damage in potatoes is dependent largely on the size of psyllid infestations on the plants. Large psyllid populations do not develop when temperatures are high. In the Plains areas where potatoes are grown during hot weather, the damage is likely to be much less than at high elevations where summer temperatures are lower.

Control

One adult psyllid per 100 sweeps of an insect net across the top of the potato plants may cause as much loss as 10 bushels of potatoes per acre. The application of insecticides should be started when one or more adult psyllids can be caught in 100 brisk sweeps of a standard
insect net, with the net opening held two-thirds below the top of the plants. Four or five sets of 100 sweeps each should be taken in different sections of each field. The sweep-net sampling should be done at intervals of 10 to 14 days. If the psyllid populations are not determined, start insecticide applications when the potato plants are 6 inches tall. A high degree of control of the psyllid nymphs on potatoes is required to prevent loss from psyllid yellows.

Do not leave piles of cull potatoes where they will sprout and provide a breeding place for the potato psyllid. Destroy the cull potatoes or spread them out in the sun to rot or dry up.

POTATO SCAB GNAT

The larvae of several small gnats live on soil fungi and decaying organic matter, but some kinds, particularly the scab gnat, also attack potato seed pieces and tubers under favorable conditions. They feed on tubers either in the field or in storage.

The potato scab gnat is present in many of the Northern States, but it causes most trouble from Missouri to West Virginia and New York. This insect is very tolerant of alkaline soil conditions, and infestations have been found in soils of desert origin in the Pacific Northwest. Scab gnat infestations are frequently associated with common scab infections, partly because both pests thrive in soils having a pH of more than 5.5 and partly because scab gnat larvae enter potato tubers through lesions caused by other pests, including scab.

Scab gnat larvae damage potatoes in several ways. Damage in storage may take place at temperatures as low as 35°F and entails enlarging old wounds started by other larvae, bacterial scab, or other agencies in the field. A few larvae entering a cut side of a potato seed piece in the soil may cause no direct damage, but their activity facilitates the entry of disease organisms or other insects. Heavy infestations in the seed pieces result in weak sprouts and correspondingly low yields or in missing hills. Sometimes stands have been reduced 25 percent. The larval pits and deeper wounds produced in developing tubers during the summer can be of particular concern because they affect the grade of the crop.

Scab gnat lesions may resemble common scab. However, scab lesions are surrounded by corky ridges arranged in concentric circles, whereas the potato skin surrounding scab gnat wounds is smooth to the edge of the wound (fig. 40). Scab gnat wounds also are deeper than scab lesions and usually contain a characteristic granular brown or black refuse. The wounds may be small and very shallow, resembling scab, or they may be large and 1 inch deep. In its more advanced stage scab gnat injury may be mistaken for wireworm feeding near the surface of the tuber.

Adult scab gnats are dusky brown, which, together with their habit of hiding under particles of soil, makes it difficult to observe them. Only the males have wings. The females are slightly larger than
to 14 days, are white with black heads, and are approximately one-sixth inch long. Pupation takes place within a fragile silk cocoon. The pupal stage requires 4 to 5 days. Mating takes place almost immediately after emergence and egg deposition starts within a few hours. Overwintering takes place in the soil and in potato storage houses. It is possible for 12 generations to be produced annually under optimum conditions.

POTATO TUBERWORM

The potato tuberworm may attack both foliage and tubers of potato plants in the field. It may also infest and damage the tubers in storage. The damage to the potato foliage is caused by the mines made in the leaves and stems, the webbing together of the leaves, and the feeding beneath the protective covering thus formed. If the foliage of infested plants dies, the larvae will enter soil cracks and attack the tubers. Tubers exposed by heavy washing rains in infested fields also are subject to such attacks. However, in most areas the tuberworm does greatest damage to the stored potatoes. The unsightly feeding tunnels choked with excrement are made throughout the flesh of the tubers (fig. 41) and the tubers become unfit for food.

Life History and Habits

The potato tuberworm is the larva or immature stage of a gray moth not over one-fourth inch long. It has minute dark-brown or black markings on the wings. The female moth
deposits her pearly-white eggs on the leaves and stems of the plants or in the eyes of exposed tubers in the field or in storage. The moths are seldom seen because they hide during the daytime but are active at night. The female lays from 150 to 200 eggs. In warm storage places the tuberworm may continue to breed and be a pest throughout the winter. In the field it overwinters as a larva or pupa in the soil. The life cycle may be as short as 2 weeks in the summer or as long as 7 months in the winter. In the field there are five or six generations in the South, but probably not more than two or three in more northerly areas.

The full-grown larva of the potato tuberworm is about one-half inch long (fig. 42). Its head is brown and its pinkish green or white body sometimes has a reddish-purple band down the back.

The potato tuberworm is spread over wide areas of the country through the shipment of infested potato tubers. It has become established in 22 States from the Atlantic to the Pacific Ocean. However, damage rarely occurs in the field except in California and in the coastal sections of Virginia. Besides potato, the insect attacks tomato, eggplant, and other plants of the nightshade family.

**Control**

Preventive measures usually are effective in controlling the potato tuberworm on the mainland of the United States. Plant only seed pieces that are not infested. Cultivate so as to hill the soil against the plants and keep at least 2 inches of soil over the developing tubers. Plant early and late crops of potatoes as far apart as possible. Harvest as soon as the crop is mature. During harvest do not leave the dug tubers in the field overnight, and do not cover piles of potatoes with potato tops. Use as feed or destroy all infested or cull potatoes. Store the potato tubers at temperatures below 52° F.

Prepare the storage or handling rooms for the potatoes well in advance of harvest. Two weeks beforehand thoroughly clean and spray the sorting sheds and grading rooms with an effective insecticide. Uninfested potatoes should not be
put in or near a storage place that has contained potatoes until it is cleaned and fumigated. If the tubers are stored in burlap bags, steam-clean the bags first.

**SEED-CORN MAGGOT**

The seed-corn maggot is the most destructive of several species of maggots occasionally attacking potato seed pieces (fig. 43). It is the larval stage of a species of fly slightly smaller than the common house fly (*Musca domestica* Linnaeus). The seed-corn maggot occurs throughout most of the United States. It is chiefly a pest of sprouting seeds or seedlings and is found on the decaying parts of plants, such as corn, beans, and peas, and of potato seed pieces. Sometimes in limited areas the decay of potato seed pieces resulting from the feeding of heavy infestations of the maggot is so severe that it is necessary to replant the fields. The maggots also spread the bacteria that cause the blackleg disease of potatoes.

The dirty-looking yellowish-white maggots are about one-fourth inch long when full grown. They do their greatest damage in cool, wet seasons and in soils containing large amounts of decaying vegetation or organic fertilizer. The insect is a problem in some parts of the West, even where the organic matter has been worked into the soil. The maggots enter the potato seed piece through cut, injured, or diseased surfaces not adequately healed over.

Both the adults and larvae of the seed-potato maggot resemble those of the seed-corn maggot. Damage to seed potatoes by the larvae also is similar. Although widely distributed, the seed-potato maggot generally is not as important a pest of potatoes as the seed-corn maggot.

**Life History and Habits**

The adult flies are about one-fifth inch long and grayish. The wings are held closer to the body than those of the house fly. Adults of the seed-corn maggot emerge in the spring and deposit their eggs in soil where there is an abundance of decaying organic matter. In coastal areas of the Southeast the insect breeds throughout the winter and attacks early-spring plantings of potatoes. In interior areas later plantings are subject to

---

**FIGURE 43.**—Seed-corn maggots feeding within a potato seed piece, a part of which has been cut away to show them.
injury. In the central part of the country there are three to five generations a year.

**Control**

The best way to prevent damage by the seed-corn maggot is to plant well-suberized, or healed, potato seed pieces. The first step toward getting the seed pieces to heal properly after cutting is to treat the whole potato tuber, before cutting, with a chemical to destroy surfaceborne disease organisms and then to dry the seed pieces. Cut the seed potatoes about 10 days or more before planting them to allow adequate time for suberization, which is the formation of scar tissue over the cut surfaces. Use a sharp, thin-bladed knife to insure clean-cut surfaces. Sterilize the knife before and at frequent intervals during cutting by dipping it in a suitable chemical solution. Do not cut the seed potatoes in bright sunlight.

Disinfect the walls and floors of the holding rooms where the cut seed will be kept while suberizing, as well as those of storage bins. The temperature of holding and storage rooms should be about 60°F. Keep the humidity high during suberization by wetting the floor frequently or by hanging up clean wet sacks on the walls daily. Pour the seed pieces from one container to another 24 hours after cutting and again in 48 hours.

Under these conditions the seed pieces can be held safely for 10 days. If necessary to hold longer, lower the temperature to about 40°F. to retard sprouting. Remove the seed pieces from storage to an airy place about 2 or 3 days before planting to allow the cut surfaces to dry and toughen.

**SHIELD-SHAPED BUGS**

Several kinds of large shield-shaped bugs occasionally attack potatoes, including several species of stink bugs, the big-footed plant bug, and the leaf-footed bug. All kinds feed by piercing the stalks, branches, or leaf petioles and sucking the sap. The part of the plant beyond the point of injury wilts and sometimes dies. Some kinds of shield-shaped bugs may also inject a toxic substance into the plant when feeding.

Damage by the Say stink bug in some sections of the Rocky Mountain States is known as big-bug blight. The southern green stink bug (fig. 44), the leaf-footed bug, and the big-footed plant bug cause appreciable damage to potatoes in some fields in the South. Although their damage in the Southeast is usually spotty, it is likely to be most common in potato fields planted near hammocks in which they overwinter.

Shield-shaped bugs may vary from bluish green to light green, to brown, and even to reddish

![Figure 44. Two nymphs (left) and adult (right) of the southern green stink bug. (Courtesy of South Carolina Agricultural Experiment Station.)](image-url)
brown depending on the species. The two largest kinds may be an inch or more long. Although both are rather spectacular and look slightly alike superficially, the yellow line running across the wing covers and the peculiar leaflike expansion of the hindtibia are characteristic of the leaf-footed bug. The legs of the big-footed plant bug also are expanded, but they do not resemble a leaf.

**SLUGS AND SNAILS**

Several kinds of slugs and snails may feed on foliage or stalks of potatoes, but their most serious damage is to the tubers. These pests are mollusks rather than insects. They are slimy, legless, soft bodied, and slow moving. They are one-half to 8 inches long. Snails have shells; slugs are closely related but have no shells.

Damage by slugs is much more common than that by snails. Tuber damage by slugs is readily recognized by the uneaten tissue-thin potato skin left hanging over the large feeding cavities (fig. 45). The holes made by snails in the tubers are smoothly round, one-fourth to one-half inch in diameter, and usually rather shallow. Both pests eat large irregularly shaped holes in the leaves. Damage to the tubers or foliage is most likely to occur in wet seasons and in low, wet spots in the field. Tubers may also be damaged when stored in damp, dark places.

These pests travel and feed mostly at night or during dark, damp days. They ordinarily hide under stones, clods of earth, and rubbish during the day. In moving about they leave a slimy trail that glistens in the daytime. Their jellylike eggs are laid in the fall and

---

**FIGURE 45.** - External and internal damage to potato tubers by slugs. Note the thin layer of skin over the cavity eaten out by the slug (left) and the presence of the slug in the cavity (right).
spring in the soil or under clods, sticks, and stones. Slugs and snails are widely distributed. Common slugs are the gray garden slug, the spotted garden slug (fig. 46), and the tawny garden slug.

SPRINGTAILS

Springtails, or snow fleas, are variously colored tiny insects. They have a forked furcula, or spring, attached beneath the abdomen, which when released propels the insect into the air. The damage they cause is often attributed to other insects because of their rapid disappearance when disturbed.

Among the several species, the garden springtail is most likely to attack potatoes. This nearly spherical dark-purple and yellow-spotted insect is only one twenty-fifth of an inch long and has a very distinct head. It may occur in swarms, feeding on the roots of potatoes and other crops, or it may attack the foliage, making characteristic pits by chewing on the underside of leaves or feeding in injuries made by other insects. Another species of springtail, nearly white, may occasionally be found in cavities in potato tubers.

STALK BORERS

The larvae of several insects bore into the stalks of potato, corn, and many other plants. Among these, the two most destructive and widely distributed throughout the United States are the stalk borer and the potato stalk borer.

The adult of the stalk borer is a moth having a wing expanse of a little over 1 inch. The front wings have small white spots and, depending on the variety, may vary from mouse colored to dark grayish brown. The hindwings are a pale gray brown. There is much variation in the appearance of the adults.

Larvae of the stalk borer are slender, naked, soft-skinned caterpillars (fig. 47). They are brownish with five whitish longitudinal stripes. The two stripes on each side of the body are broken in the middle and give the larva the appearance of being injured. The full-grown larva, 1 to 1½ inches long, may lose the striping and become a plain dirty gray.
The adult of the potato stalk borer is a blackish snout beetle about one-fifth inch long. The beetle is covered with flattened gray hairs or scales that give it a frosted appearance. There are three black dots at the base of the wing covers. The larva is a yellowish-white, legless, wrinkled grub with a brownish head and ranges up to one-third inch long. A similar insect, the tobacco stalk borer, attacks potatoes in Arizona and southern California.

The chief damage by stalk borers to potatoes is that, in feeding, they bore up and down the stems or stalks. This causes the leaves and stems beyond the point of injury to wilt. Frequently a stalk or an entire plant will die. When abundant, the larvae may seriously injure or even destroy entire fields of potatoes, particularly the potato stalk borer. Unfortunately the presence of borers usually is not recognized before considerable damage has been sustained.

Life History and Habits

The stalk borer moth lays its eggs in large numbers on grasses and various weeds, particularly ragweed, during late summer and fall. Although the insect is thought to hibernate in the egg stage, there is some evidence that small larvae may also survive the winter in some sections. Most of the borer eggs hatch very early in the spring. After feeding for a while, the small larvae move to young plants of potatoes, corn, or other crops and bore into the stalks. They may feed for a while in a stalk, then come out and move to other stalks. The worms become full grown in midsummer and then pupate in the soil or rarely in the stems of their food plant. The pupa is bare as it has no case. The adult emerges in late summer and fall. There is but one generation each year.

The potato stalk borer eggs, deposited singly in deep stem or petiole cavities, hatch in about 10 days. The larvae bore into and then up and down the stem as they feed and grow. The mature larva pupates in the stem after chewing an exit hole nearly through to the outside. The adult beetle matures in a week or two but ordinarily does not emerge from the larval burrows until the following spring. There is but one generation each year.

Control

Borers infesting potatoes can be controlled by destroying the vegetation on or in which they overwinter. This includes grasses in and around potato fields as well as large-stemmed weeds, such as giant ragweed, jimpsonweed, horsenettle, and groundcherry. Infested potato stalks should be raked and burned or plowed under after harvest.

THREE-LINED POTATO BEETLE

Both adult and larval stages of the three-lined potato beetle feed on potato foliage. The adult is a yellowish beetle about one-quarter inch long with three black stripes on the wing covers. It resembles somewhat the common striped cucumber beetle (Acalymma vittata (Fabricius)), but it is slightly larger. The grayish-yellow larva is readily distinguishable from the other insect pests of potato
because it is covered with a wet mass of its own excrement.

The three-lined potato beetle occasionally feeds on potatoes in the central and eastern parts of the United States and in Texas and California. In recent years it has increased in abundance and economic importance as a pest of potatoes in some sections of the Northeast.

**Life History and Habits**

The lemon-yellow eggs of the three-lined potato beetle may be distinguished because they are usually laid in rows of 4 to 50 along the midrib on the underside of the leaf, whereas those of the Colorado potato beetle are laid in bunches. The eggs hatch in 4 to 7 days, the larvae complete their development in 10 to 12 days, and the pupal period is about 25 days. There are two generations of the beetle each year. It overwinters as an adult. The three-lined potato beetle reproduces on several cultivated and weed hosts of the potato family.

**THRIPS**

Several kinds of thrips, or oat bugs, feed on the foliage of potatoes. These small slender insects, rarely one-eighth inch long (fig. 48), might escape detection were it not for their rapid serpentine movement. They feed chiefly on the underside of potato leaves and often leave the entire surface a mass of scar tissue.

Their eggs are deposited in the plant. The young are usually greenish yellow, but the adults may be gray, yellow, brown, or reddish. There may be from one to six generations of thrips each year depending on the species and the location. Potatoes are attacked by onion thrips in the West and South, the bean thrips in the Southwest, and the tobacco thrips in the South. Small potato plants heavily infested with thrips may become stunted. Extensive leaf injury by the onion thrips in the Pacific Northwest may reduce yields.

**TORTOISE BEETLES**

Several species of small rather flat beetles have a prominent marginal flange around the body, which gives them a tortoiselike appearance. Three species of tortoise beetles occasionally attack potatoes. The adults and larvae chew rather circular-shaped holes in the leaves and damage may be severe at times. The holes made by young larvae are small, but larger ones are made as the insects grow. These beetles occur from Connecticut through the Southern and Southwestern States.

The eggplant tortoise beetle is the most common tortoise beetle on potatoes. The adult is about one-fifth inch long and dull
green or greenish yellow. Adults of two other species are reddish brown and one has translucent areas on the marginal flange.

**Life History and Habits**

The adults of the eggplant tortoise beetle hibernate in debris and emerge early in the spring. One to four elliptical white or brownish eggs are laid on various parts of the host plant and are covered with a thin membrane. The eggs hatch in 4 to 5 days. The flattened larvae are greenish white or yellowish and may match the color of the plant so closely that they may not be seen. A gradually increasing pile of excrement is carried on top of the body by a pair of appendages known as an anal fecal fork. The larvae become full grown in 12 to 20 days. The shiny pupa is attached to the plant. The pupal period requires 2 to 7 days. There may be five generations in the South, where larvae are present from May through October.

**VEGETABLE WEEVILS**

Two species of vegetable weevils attack potatoes as well as several other kinds of vegetable crops. The most widespread and destructive of these is the vegetable weevil (fig. 49). The other one—the banded vegetable weevil (fig. 50)—is similar in appearance and in the kind of damage it inflicts, but it is smaller, has slightly different markings on its body, and has a much more limited distribution. The vegetable weevil occurs over much of the southern part of the country including some parts of California. The banded vegetable weevil is found chiefly from Louisiana to Georgia.

Damage to potatoes by the vegetable weevil is chiefly from feeding by the adults. It consists largely in cutting off the stalks of young potato plants near the soil surface—much like that by cutworms—and in feeding on the buds and leaves and thus stunting the plants. Feeding injury by the larvae of the weevil is similar to that by the adult weevils.
The adult of the vegetable weevil is about three-eighths inch long, dull grayish brown, with a pale gray V near the tip of each wing cover. When disturbed, the adults feign death by falling on their backs, drawing in the antennae and legs, and remaining motionless for several minutes. This habit and their grayish-brown color make them hard to see on the soil. The adults are long lived; they have been observed to live for nearly 2 years.

Life History and Habits

The adults—all of which are females—lay their eggs from late in September until late the following April. The eggs are laid in the buds or elsewhere on the plants and on or in the soil nearby. Hatching occurs in 15 to 20 days. The young larvae, feeding on the foliage and in the roots of some plants, require about 40 days to become full grown. Just before pupation in an earthen cell in the soil, the larva is slightly over one-half inch long, slender, and strongly convex. The pupa usually is found at depths of one-half to 2 inches, but it may occur at depths of 6 to 9 inches. The pupal period ranges from 13 to 41 days depending on the temperature. Total development requires from about 1½ to 4 months. There is but one generation each year. The young adult weevils are voracious feeders.

Control

The vegetable weevil has a wide variety of host plants. In addition to potatoes and several other kinds of vegetable crops, it feeds or breeds on 43 species of plants, mostly weeds. Consequently, clean cultivation of cropland so as to kill all weed hosts is an effective means of controlling the weevil. Crop rotation is another. Do not plant preferred host crops in the same field or adjacent fields in successive years. Clean up during the summer, by burning or other means, the dead grass, rubbish, or any host plants that might be along fence rows, ditch-banks, or the edges of infested fields.

WHITEFLIES

Three kinds of small mostly white insects, aptly known as whiteflies, attack potatoes in certain parts of the country. The iris whitefly most frequently damages potatoes. It is present only west of the Rocky Mountains. The abutilon whitefly is primarily a pest of cotton, but it also attacks potatoes from Arizona to Washington. The greenhouse whitefly occasionally infests potatoes throughout the country. The true whiteflies should not be confused with leafhoppers, which sometimes are erroneously referred to as whiteflies.

Whiteflies are very prolific and gradually increase in numbers on potatoes during the growing season. Damage is caused only by the larvae, and these infest the underside of the leaves, where they suck the juices from the plant. When heavy populations are present, the foliage becomes sticky with honeydew excreted by the larvae. Honeydew attracts other kinds of insects to the field and encourages growth of certain
molds. Heavily infested plants wilt abnormally during hot weather.

The adult iris whitefly is about one-eighteenth inch long and slightly triangular (fig. 51). The head and wings are covered with very small scales, and these are white except for two faintly gray spots on each wing. The underside of the body is gray. During egg laying the female’s wings vibrate against the leaf, and enough scales are shed to leave white spots around each group of eggs. Only adults survive the winter in the North, but reproduction is continuous in the South.

**Life History and Habits**

Egg laying starts in March or April in the North. Eggs are approximately one-sixteenth inch long, oval, and supported by short stalks. One to three eggs are laid at one place. They are white at first, but turn gray before hatching. The incubation period is 1 to 3 weeks. From 100 to 1,000 eggs may be counted on a single leaflet in some fields late in the summer.

Newly hatched whitefly larvae are thin, flat, and transparent, but later they become slightly oval, opaque, and off-white (fig. 52). Newly hatched larvae crawl a short distance and then become stationary, completely sealed under a coat of wax during the remainder of the larval and pupal stages. The larval stage is completed in approximately 10 to 15 days. The pupa resembles the larva, except that two red eye spots develop late in this stage. The period from egg to adult may require 32 to nearly 60 days.
WHITE-FRINGED BEETLES

Both the larvae and the adults of white-fringed beetles feed on potatoes and many other plants. The adults do little, if any, damage. The larvae may feed on the potato seed pieces, the stems and roots of the young plants, or in the developing tubers (fig. 53). When numerous, the larvae may almost completely destroy entire fields of potatoes (fig. 54).

White-fringed beetles, of which there are three species, were first discovered in this country in Florida in 1936. The current distribution includes 10 Southern States, from Louisiana to Florida to Virginia to Arkansas.

The adult beetles are approximately one-half inch long, one-sixth inch wide, and dark gray, with a lighter band along the margins of the wing covers (fig. 55). The full-grown larva is about one-half inch long and legless. Its body is yellowish white, fleshy, and curved.

Life History and Habits

All white-fringed beetles are females; there are no males. The females lay fertile eggs in masses of 15 to 20, usually at the point of contact between the soil and such objects as sticks, gravel, and stems of plants. The insect spends most of its life as a larva in the soil. There is but one generation each year.

Control

Infestation and damage of white-fringed beetles can be suppressed through crop rotation. Avoid planting potatoes following infested peanuts, soy-
beans, or velvetbeans, as the larvae tend to build up in soils planted to these crops. Also, do not plant the same land to any of these three crops more often than once in 3 or 4 years. After one of these crops, plant a grass or grain crop before potatoes. The addition of organic matter to the soil by turning under winter-grown cover crops will reduce damage by the larvae.

**WHITE GRUBS**

The larvae of May beetles, known as white grubs, may be serious soil pests of potatoes in many parts of the country, especially in the north-central and northeastern sections. Numerous species of white grubs are widely distributed over the United States. They have soft, curved, white abdomens, bony brown heads, and six rather prominent legs. They may be as long as 1 inch when full grown.

The posterior end of the abdomen is smooth and shiny, with dark body contents showing through. Two rows of minute hairs on the underside of the last abdominal segment distinguish white grubs from other larvae that look rather similar.

White grubs feed on the underground parts of many plants, including the roots, stems, and tubers of potatoes (fig. 56). They eat out large, shallow, circular holes in the potatoes (fig. 57). The affected plants do not reveal the injury. If there is a heavy infestation of the grubs when the field is planted, serious damage to the potatoes can result before the grower realizes their presence. It is important, therefore, to know whether a field is infested before it is planted to potatoes.

Adults of most species of May beetles are oval, light to dark brown, and one-half to seven-eighths of an inch long (fig. 58). A larger species, the ten-lined June beetle, is present in the West. Its adult has 10 narrow white stripes on the wing covers and is 1 to 1¼ inches long (fig. 59). The beetles emerge from the ground in the spring and fly clumsily about early in the evening during May or June, buzzing and scrambling about window screens or against light bulbs. They feed at night on

---

**FIGURE 56.**—White grub uncovered from sod where it was feeding.

**FIGURE 57.**—Injury to a potato tuber by a white grub.
leaves of trees. One species, which occurs in the South, is wingless and crawls from field to field.

**Life History and Habits**

The adult females lay their pearly-white eggs below the surface of the ground, most commonly in sod or grassland. One female may lay from 1 to 200 eggs. The eggs hatch in 2 or 3 weeks, and the young grubs feed on roots and underground parts of plants until fall, when they may be as long as one-half inch. They burrow deep into the soil and pass the winter as larvae.

The following spring the grub works its way up toward the surface, where it feeds throughout the summer on dead vegetation and underground parts of plants. The larvae become full grown in the fall of the second or third year. Most of them are 1 inch long, but larvae of the ten-lined June beetle are nearly 2 inches. Some species pass another winter in the soil as larvae and then return near the surface the following spring and feed until late spring or early summer. They then pupate in earthen cells 6 to 8 inches below the surface. During the last part of the summer the pupa changes to an adult beetle, remaining in the soil until the following spring.

The species of May beetles in the South generally have a 2-year life cycle. Most species in the Northern States require 3 years to complete a generation, but a few in the extreme North require 4 years.

**Control**

White grubs' damage to potatoes can be largely avoided by proper crop rotation. A suitable rotation in some sections of the country is oats or barley followed by clover and then potatoes. There should be a

---

**FIGURE 58.**—May beetle, or adult of a white grub.

**FIGURE 59.**—Adult of the ten-lined June beetle.
minimum acreage in small grains and a maximum in deep-rooted legumes, such as clover or alfalfa, during the peak of May beetle flight. Ordinarily the beetles do not deposit many eggs in pure stands of clover or in clean-cultivated land planted to row crops except sugarbeets.

White grub populations in pastureland can be greatly reduced without plowing or destroying the grasses by establishing a good stand of a dry-weather legume, such as biennial white sweetclover.

Pasturing hogs on grub-infested land will reduce the infestation. Chickens will also eat many grubs if allowed on the land during plowing.

**WIREWORMS**

Wireworms are serious pests of potatoes, many other field and truck crops, and flowers over much of the country. As their name implies, wireworms are slender larvae with jointed, wirelike bodies, rather flattened on the underside. Wireworm larvae are immature forms of a large group of insects belonging to a family of which the adult forms are known as click beetles or “skipjacks.” When these reddish-brown to black beetles are placed on their backs or held gently but firmly by the abdomen, they make a clicking sound. Beetles of destructive species in this country are from one-fourth to three-fourths inch in length. When full grown, the wireworms may be up to 1 1/4 inches long, depending on the species.

Many species of wireworms are injurious to potatoes. Some of the more economically important ones include the wheat wireworm and the eastern field wireworm in the Northeastern and Midwestern States; the community wireworm and corn wireworms in the Northeastern, Eastern, and Midwestern States; the prairie grain wireworm in the Northwestern States; the sugarbeet wireworm, the Pacific Coast wireworm, and the Great Basin wireworm in the Pacific Northwest; and the Gulf wireworm, the southern potato wireworm (fig. 60), the tobacco wireworm, and the sand wireworm in the Southern States.

The greatest amount of damage to potatoes from wireworms is caused by their feeding on the developing tubers. They may also cause damage by feeding in the planted seed pieces or on the roots and in the stalks of growing plants. Sometimes the last two types of damage are severe enough to make replanting necessary.

Wireworms damage the developing tubers in several ways. They chew shallow pits, deep pits, or deep holes (fig. 61).
Misshaped tubers may result when pits are made in the young tubers. Such injury to the tubers permits or even favors entrance of the fungus disease rhizoctonia, or black scurf, which also may cause serious damage. Feeding damage to the potato seed pieces affords a means of entrance and shelter for the seed-corn maggot, which spreads the blackleg disease of potatoes. The wireworm's pits or holes in tubers are very objectionable, irrespective of whether the tubers are intended for the processing industry or the fresh market, and a small amount of this kind of damage will downgrade or even prevent marketing of the crop. Damage caused directly or indirectly by wireworms is frequently considered to be the most serious of all tuber injuries.

**Life History and Habits**

Wireworms are largely soil-inhabiting insects, although the adult beetles are capable of sustained flight and do move around. Their small oval or spherical white eggs are deposited in moist soil, usually during the summer. The tiny white larvae generally hatch in about 2 weeks. As the wireworms feed, shed their skins, and become larger, they gradually become darker. The older hard-jointed wireworms vary from pale yellow to dark orange or mahogany brown depending on the species and the stage of growth. When fully grown, the wireworm may be up to 1 1/4 inches long. It then changes to a pupa in the soil and emerges within a week or two as an adult beetle. Usually the beetles emerge in the spring and mate. Each female deposits from 100 to 300 eggs in the soil.

Most kinds of wireworms require from 1 to 4 years or longer to reach adulthood, but the southern potato wireworm has at least two generations each year. The larvae of most species feed and move about within the top 3- or 4-inch layer of soil, but they go deeper for the winter. Some have been found as deep as 30 inches. Freezing temperatures ordinarily do not affect the winter survival of wireworms, but high mortality of the southern potato wireworm has been observed following sudden severe freezes.

**Control**

Cultural practices and crop rotations can affect the abundance of wireworms, because the larvae feed on grasses, weeds, and many crops in addition to potatoes. Wireworms usually cause most severe dam-

---

**Figure 61**.—External and internal feeding damage in potato tubers by the southern potato wireworm.
age on the lighter sandy loams. The wheat wireworm increases in abundance in fields planted for several years to hay crops. Its numbers are gradually reduced by clean cultivation. The southern potato wireworm does not become very abundant in land kept clean fallow or planted to row crops that are free of weeds and grasses during the egg-laying period. However, the opposite is true of the Pacific Coast wireworm. It becomes more abundant in fields under intensive cultivation and gradually decreases in fields planted to pasture grasses and alfalfa. An infestation of this wireworm can be greatly reduced by growing alfalfa for 3 or 4 years consecutively. Solid stands of alfalfa create a dry, compact soil unfavorable for wireworm development. In some sections of the country wireworms increase in abundance in sod land. Under these conditions, growing for 1 or more years an intervening crop that would be less affected by wireworms would result in less damage when such fields are planted to potatoes. Fall plowing destroys many wireworms. Other cultural practices may also be helpful. Ask your county agent or Extension Service entomologist about cultural practices best suited to your locality.

Experiments have shown that excessive damage to the potato crop may result if there is one wireworm, on an average, per square foot of soil. Sample your field for wireworms before planting a potato crop if you suspect their presence. If you find one or more, on an average, per square foot to a depth of 6 inches, do not plant potatoes, or else treat the field with recommended insecticides before planting. Consult your county agent for the best technique to use in sampling and sifting the soil for wireworms.
<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>abutilon whitefly</td>
<td><em>Trialeurodes abutilonea</em> (Halderman)</td>
</tr>
<tr>
<td>alfalfa webworm</td>
<td><em>Loxostege commixtalis</em> (Walker)</td>
</tr>
<tr>
<td>apple mealybug</td>
<td><em>Phenacoccus aceris</em> (Signoret)</td>
</tr>
<tr>
<td>arid leafhopper</td>
<td><em>Empoasca arida</em> DeLong</td>
</tr>
<tr>
<td>armyworm</td>
<td><em>Pseudaleitia unipuncta</em> (Haworth)</td>
</tr>
<tr>
<td>ash-gray blister beetle</td>
<td><em>Epichroma fabricii</em> (LeConte)</td>
</tr>
<tr>
<td>banded cucumber beetle</td>
<td><em>Diabrotica balteata</em> LeConte</td>
</tr>
<tr>
<td>banded vegetable weevil</td>
<td><em>Listoderus apicalis</em> Waterhouse</td>
</tr>
<tr>
<td>bean thrips</td>
<td><em>Hercothrips fasciatus</em> (Pergande)</td>
</tr>
<tr>
<td>beet leafhopper</td>
<td><em>Circulifer tenellus</em> (Baker)</td>
</tr>
<tr>
<td>beet webworm</td>
<td><em>Loxostege sticticalis</em> (Linnaeus)</td>
</tr>
<tr>
<td>big-footed plant bug</td>
<td><em>Acanthocephala femorata</em> (Fabricius)</td>
</tr>
<tr>
<td>black cutworm</td>
<td><em>Agrotis ipsilon</em> (Hufnagel)</td>
</tr>
<tr>
<td>buckthorn aphid</td>
<td><em>Aphis nasturtii</em> Kaltenbach</td>
</tr>
<tr>
<td>cabbage looper</td>
<td><em>Trichoplusia ni</em> (Hübner)</td>
</tr>
<tr>
<td>carrot beetle</td>
<td><em>Bothynus gibbosus</em> (De Geer)</td>
</tr>
<tr>
<td>changa</td>
<td><em>Scapteriscus vicinus</em> Scudder</td>
</tr>
<tr>
<td>citrus mealybug</td>
<td><em>Pseudococcus citri</em> (Risso)</td>
</tr>
<tr>
<td>clear-winged grasshopper</td>
<td><em>Camnula pellucida</em> (Scudder)</td>
</tr>
<tr>
<td>clover leafhopper</td>
<td><em>Aceratagallia sanguinolenta</em> (Provancher)</td>
</tr>
<tr>
<td>Colorado potato beetle</td>
<td><em>Leptinotarsa decemlineata</em> (Say)</td>
</tr>
<tr>
<td>community wireworm</td>
<td><em>Melanotus communis</em> Gyllenhaal</td>
</tr>
<tr>
<td>corn earworm</td>
<td><em>Heliothis zea</em> (Boddie)</td>
</tr>
<tr>
<td>corn wireworms</td>
<td><em>Melanotus</em> spp.</td>
</tr>
<tr>
<td>cotton fleahopper</td>
<td><em>Psallus seriatus</em> (Reuter)</td>
</tr>
<tr>
<td>coulee cricket</td>
<td><em>Peranabrus scabricollis</em> (Thomas)</td>
</tr>
<tr>
<td>differential grasshopper</td>
<td><em>Melanoplus differentialis</em> (Thomas)</td>
</tr>
<tr>
<td>dingy cutworm</td>
<td><em>Feltia subgothica</em> (Haworth)</td>
</tr>
<tr>
<td>eastern field wireworm</td>
<td><em>Limonius agonus</em> (Say)</td>
</tr>
<tr>
<td>ebony blister beetle</td>
<td><em>Epicauta funebris</em> Horn</td>
</tr>
<tr>
<td>eggplant flea beetle</td>
<td><em>Epitrix fuscula</em> Crotch</td>
</tr>
<tr>
<td>eggplant tortoise beetle</td>
<td><em>Nuzonia pallidula</em> Boheman</td>
</tr>
<tr>
<td>European corn borer</td>
<td><em>Ostrinia nubilalis</em> Hübner</td>
</tr>
<tr>
<td>European earwig</td>
<td><em>Forficula auricularia</em> Linnaeus</td>
</tr>
<tr>
<td>fall armyworm</td>
<td><em>Laphygma frugiperda</em> (J. E. Smith)</td>
</tr>
<tr>
<td>false chinch bug</td>
<td><em>Nysius ericae</em> (Schilling)</td>
</tr>
<tr>
<td>field crickets</td>
<td><em>Gryllus</em> spp.</td>
</tr>
<tr>
<td>four-lined plant bug</td>
<td><em>Poecilocapsus lineatus</em> (Fabricius)</td>
</tr>
<tr>
<td>foxglove aphid</td>
<td><em>Myzus solani</em> Kaltenbach</td>
</tr>
<tr>
<td>garden fleahopper</td>
<td><em>Halticus bracteatus</em> (Say)</td>
</tr>
<tr>
<td>garden springtail</td>
<td><em>Bourletiella hortensis</em> Fitch</td>
</tr>
<tr>
<td>garden symphylan</td>
<td><em>Scutigerella immaculata</em> (Newport)</td>
</tr>
<tr>
<td>garden webworm</td>
<td><em>Loxostege similalis</em> Guenée</td>
</tr>
<tr>
<td>glassy cutworm</td>
<td><em>Crymodes devastator</em> Brace</td>
</tr>
<tr>
<td>granulate cutworm</td>
<td><em>Feltia subterranea</em> Fabricius</td>
</tr>
<tr>
<td>grape mealybug</td>
<td><em>Pseudococcus maritimus</em> Ehrhorn</td>
</tr>
<tr>
<td>gray garden slug</td>
<td><em>Deroceras reticulatum</em> Müller</td>
</tr>
<tr>
<td>Great Basin wireworm</td>
<td><em>Ctenicera pruinina</em> Horn</td>
</tr>
<tr>
<td>greenhouse whitefly</td>
<td><em>Trialeurodes vaporariorum</em> Westwood</td>
</tr>
<tr>
<td>Common name</td>
<td>Scientific name</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>green peach aphid</td>
<td><em>Myzus persicae</em> (Sulzer)</td>
</tr>
<tr>
<td>Gulf wireworm</td>
<td><em>Conoderus amplicollis</em> (Gyllenhal)</td>
</tr>
<tr>
<td>intermountain leafhopper</td>
<td><em>Empoasca filamenta</em> DeLong</td>
</tr>
<tr>
<td>iris whitefly</td>
<td><em>Aleyrododes spiraeoides</em> Quaintance</td>
</tr>
<tr>
<td>Jerusalem cricket</td>
<td><em>Stenopelmatus fuscus</em> Haldeman</td>
</tr>
<tr>
<td>leaf-footed bug</td>
<td><em>Leptoglossus phyllopus</em> (Linnaeus)</td>
</tr>
<tr>
<td>leaf miners</td>
<td><em>Liriomyza</em> spp.</td>
</tr>
<tr>
<td>margined blister beetle</td>
<td><em>Epicauta pestifera</em> Werner</td>
</tr>
<tr>
<td>migratory grasshopper</td>
<td><em>Melanoplus sanguinipes</em> (Fabricius)</td>
</tr>
<tr>
<td>millipedes</td>
<td><em>Blaniulus guttulatus</em> (Bosc), <em>Julius</em> spp., and <em>Diploius londinensis</em> var. caeruleocinctus (Wood)</td>
</tr>
<tr>
<td>Mormon cricket</td>
<td><em>Anabrus simplex</em> Haldeman</td>
</tr>
<tr>
<td>northern mole cricket</td>
<td><em>Gryllotalpa hexadactyla</em> Perty</td>
</tr>
<tr>
<td>onion thrips</td>
<td><em>Thrips tabaci</em> Lindeman</td>
</tr>
<tr>
<td>Pacific Coast wireworm</td>
<td><em>Limonius canus</em> LeConte</td>
</tr>
<tr>
<td>pale plant bug</td>
<td><em>Lygus elisus</em> Van Duzee</td>
</tr>
<tr>
<td>pale-striped flea beetle</td>
<td><em>Systena blanda</em> Melsheimer</td>
</tr>
<tr>
<td>pale western cutworm</td>
<td><em>Agrotis orthogonia</em> Morrison</td>
</tr>
<tr>
<td>potato aphid</td>
<td><em>Macrosiphum euphorbiae</em> (Thomas)</td>
</tr>
<tr>
<td>potato flea beetle</td>
<td><em>Epitrix cucumeris</em> (Harris)</td>
</tr>
<tr>
<td>potato leafhopper</td>
<td><em>Empoasca fabae</em> (Harris)</td>
</tr>
<tr>
<td>potato psyllid</td>
<td><em>Paratrioza cockerelli</em> (Sulc)</td>
</tr>
<tr>
<td>potato scab gnat</td>
<td><em>Pnyxia scabiei</em> (Hopkins)</td>
</tr>
<tr>
<td>potato stalk borer</td>
<td><em>Trichobaris trinotata</em> (Say)</td>
</tr>
<tr>
<td>potato tuberworm</td>
<td><em>Gnorimoschema opercula</em> (Zeller)</td>
</tr>
<tr>
<td>prairie grain wireworm</td>
<td><em>Ctenicera aeripennis destructor</em> (Brown)</td>
</tr>
<tr>
<td>rapid plant bug</td>
<td><em>Adelphocoris rapidus</em> (Say)</td>
</tr>
<tr>
<td>red-legged grasshopper</td>
<td><em>Melanoplus femurrubrum</em> (De Geer)</td>
</tr>
<tr>
<td>sand wireworm</td>
<td><em>Horistonomus uhleri</em> Horn</td>
</tr>
<tr>
<td>Say stink bug</td>
<td><em>Chlororhoo sayi</em> Stål</td>
</tr>
<tr>
<td>seed-corn maggot</td>
<td><em>Hylyema ciliicrus</em> (Rondani)</td>
</tr>
<tr>
<td>seed-potato maggot</td>
<td><em>Hylyema florilega</em> (Zetterstedt)</td>
</tr>
<tr>
<td>short-winged mole cricket</td>
<td><em>Scapehriscus abbreviatius</em> Scudder</td>
</tr>
<tr>
<td>six-spotted leafhopper</td>
<td><em>Macrostes fascifrons</em> (Stål)</td>
</tr>
<tr>
<td>slug</td>
<td><em>Arion hortensis</em> Ferussac</td>
</tr>
<tr>
<td>snails</td>
<td><em>Mollusca</em></td>
</tr>
<tr>
<td>solanum mealybug</td>
<td><em>Phenacoccus solani</em> (Cockerell)</td>
</tr>
<tr>
<td>southern armyworm</td>
<td><em>Prodenia eridania</em> (Cramer)</td>
</tr>
<tr>
<td>southern garden leafhopper</td>
<td><em>Empoasca solana</em> DeLong</td>
</tr>
<tr>
<td>southern green stink bug</td>
<td><em>Nezara viridula</em> (Linnaeus)</td>
</tr>
<tr>
<td>southern mole cricket</td>
<td><em>Scapehriscus acletus</em> Rehn &amp; Hebard</td>
</tr>
<tr>
<td>southern potato wireworm</td>
<td><em>Conoderus falli</em> Lane</td>
</tr>
<tr>
<td>spotted blister beetle</td>
<td><em>Epicauta maculata</em> (Say)</td>
</tr>
<tr>
<td>spotted cucumber beetle, or</td>
<td><em>Diabrotica undecimpunctata howardi</em> Barber</td>
</tr>
<tr>
<td>southern corn rootworm</td>
<td></td>
</tr>
<tr>
<td>spotted cutworm</td>
<td><em>Amathes c-nigrum</em> (Linnaeus)</td>
</tr>
<tr>
<td>spotted garden slug</td>
<td><em>Limax maximus</em> Linnaeus</td>
</tr>
<tr>
<td>stalk borer</td>
<td><em>Papaipema nebris</em> (Guenee)</td>
</tr>
<tr>
<td>Common name</td>
<td>Scientific name</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>striped blister beetle</td>
<td>Epicauta vittata (Fabricius)</td>
</tr>
<tr>
<td>sugarbeet wireworm</td>
<td>Limonius californicus (Mannerheim)</td>
</tr>
<tr>
<td>tarnished plant bug</td>
<td>Lygus lineolaris (Palisot de Beauvois)</td>
</tr>
<tr>
<td>tawny garden slug</td>
<td>Limax flavus Linnaeus</td>
</tr>
<tr>
<td>ten-lined June beetle</td>
<td>Polyphylla decemlineata (Say)</td>
</tr>
<tr>
<td>three-lined potato beetle</td>
<td>Lema trilineata (Olivier)</td>
</tr>
<tr>
<td>tobacco flea beetle</td>
<td>Epitrix hirtipennis (Melsheimer)</td>
</tr>
<tr>
<td>tobacco hornworm</td>
<td>Protoparce sexta (Johannson)</td>
</tr>
<tr>
<td>tobacco stalk borer</td>
<td>Trichobasis mucorea (LeConte)</td>
</tr>
<tr>
<td>tobacco thrips</td>
<td>Frankliniella fusca (Hinds)</td>
</tr>
<tr>
<td>tobacco wireworm</td>
<td>Conoderus vespertinus (Fabricius)</td>
</tr>
<tr>
<td>tomato hornworm</td>
<td>Protoparce quinquemaculata (Haworth)</td>
</tr>
<tr>
<td>tuber flea beetle</td>
<td>Epitrix tuberis Gentner</td>
</tr>
<tr>
<td>two-spotted spider mite</td>
<td>Tetranychus telarius (Linnaeus)</td>
</tr>
<tr>
<td>two-striped grasshopper</td>
<td>Melanoplus bivittatus (Say)</td>
</tr>
<tr>
<td>variegated cutworm</td>
<td>Peridroma saucia (Hübner)</td>
</tr>
<tr>
<td>vegetable weevil</td>
<td>Listroderes costirostris obliquus (Klug)</td>
</tr>
<tr>
<td>western plant bug</td>
<td>Lygus hesperus Knight</td>
</tr>
<tr>
<td>western potato flea beetle</td>
<td>Epitrix subcrinita (LeConte)</td>
</tr>
<tr>
<td>western potato leafhopper</td>
<td>Empoasca abrupta (DeLong)</td>
</tr>
<tr>
<td>western spotted cucumber beetle</td>
<td>Diabrotica undecimpunctata (Mannerheim)</td>
</tr>
<tr>
<td>wheat wireworm</td>
<td>Agriotes mancus (Say)</td>
</tr>
<tr>
<td>white-fringed beetles</td>
<td>Graphognathus spp.</td>
</tr>
<tr>
<td>white grubs (May beetles)</td>
<td>Phyllophaga spp.</td>
</tr>
<tr>
<td>white-lined sphinx</td>
<td>Celerio lineata (Fabricius)</td>
</tr>
<tr>
<td>yellow-striped armyworm</td>
<td>Prodenia ornithogalli (Guenée)</td>
</tr>
<tr>
<td>yellow woollybear</td>
<td>Diacrisia virginica (Fabricius)</td>
</tr>
<tr>
<td>zebra caterpillar</td>
<td>Ceramicia picta (Harris)</td>
</tr>
</tbody>
</table>