KEY FOR THE IDENTIFICATION OF THE MORE IMPORTANT FRUIT INSECTS OF THE NORTHERN AND EASTERN UNITED STATES

THESIS FOR THE DEGREE OF M. S.

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1933

Insects
Tick Fruit insects

Entomology

T I T L E

Key for The Identification
of The More Important
Fruit Insects of The
Northern and Eastern United States

T H E S I S

Submitted To The Faculty of
Michigan State College
In Partial fulfillment of The
Requirements for The Degree
of Master of Science

Frederick A. Kuhn
June 1933

THESIS

ACKNOWLEDGMENT

I hereby extend credit where credit is due:

It is with an air of indebtedness that I mention the name of Professor Ray Hutson. At first he gave me but a bare peep of the task before me but gradually he broadened the scope and piloted me to the culmination of this volume. During my collecting and compiling his patient generosity was ever present.

I too acknowledge herein that Doctor E. A. Bessey extended to me full directions as to the procedure of reference citations and terminology as applied to bush fruits, vine fruits, and small fruits.

Introduction.

This theses, if it fulfills its intended purpose, is a tool which when placed in the hands of an amateur enables him to diagnose many of his own fruit injuries in relation to the insects doing the injury. With the knowledge at hand, he can turn to the other sources for control measures.

The key is graduated on the basis of convenience instead of importance and seven principal indications are used to that end as -

III. Foliage (Buds, Leaves, and Flowers)
B. Leaf Injury
7. Foliage Eaters
a. Single Defoliators
(5). Giant Caterpillars
(A). Cocoon Spinners
(I). _____Cecropia Moth

Where an insect is referred to more than once, the first reference is in detail plus references to literature at the end of the key. The second, third, or fourth reference to the same insect is referred to by page number to the first reference cited. The first time an insect is mentioned references are added, as follows (32, p. 83). The 32 indicates note 32 at the end of the key under the heading "Literature Cited". Then p. 83 indicated the page number.

At the end of the key is a complete list of literature cited; for ordinary references the key is sufficient.

Common and scientific insect names have been checked with the nomenclature of the American Association of Economin Entomologists of December 1931.

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KEY TO THE MORE IMPORTANT APPLE INSECTS

I. TRUNK, BRANCH AND TWIGS.

A. Trunk.

1. Mature trees.

a. "Shotholes" in bark the size of a pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles are in the burrows, adults are 1/8" long. (39, p. 540)*, (56, p. 550), (3, pp. 3-8). .....
Shot-hole borer Scolytus rugulosus.

b. Just under the bark and in sapwood 1 to 1½" deep, are irregular shallow burrows in trunk and larger branches of old and young trees. Above the burrows the bark turns a dark and dead color. Inside the burrows there is fine sawdust packed tightly; in the entrance is a packing of excelsior-like wood fibres. Large killed bark areas tend to girdle the tree. More often the sunny side of tree is the center of attack. Full grown grubs are 1¼" long, yellow or yellow-white, having a flattened and rounded body piece just behind the head. (4, pp. 1-12), (27, p. 27), (47, p. 83). .....
Flat-headed apple tree borer Chrysobothris femorata.

c. In crotches, cracked or wounded areas, are found borers just in the under bark and sometimes in the sapwood. Their presence causes deadened bark areas. The grubs are 3/5" long, yellowish-white in color, and have brown heads. (47, p. 87). .....
Apple crotch borer Aegeria pyri.

d. In trunks and larger branches are paired borers; the eggs from which they hatch are laid a half inch apart, laterally; as they hatch each grub begins its burrow just under the bark and travels around the limb or trunk in the opposite direction. Later the burrows extend more deeply into the hardwood. Exit holes are ¼" in diameter. The

*Figures in parenthesis refer to literature cited; see list of references at end of key.

grubs are about an inch long, whitish, having a brownish head and black jaws. (32, p. 85), (53, p. 193). .....
Spotted apple tree borer Saperda cretata.

e. Near the ground line or underground.
(1). Burrows from one to three inches below ground to one foot or over above ground. The burrows are within the inner bark and sapwood but extend right into the heartwood. Near the base of the tree the bark darkens, dies and cracks. Coils and reddish sawdust-like particles on the bark or ground below, reveal the grub's presence. If the grubs are anywhere, they are from one to three inches below ground, though they may be above. Eight to ten inches above ground are exit holes as large in diameter as a pencil. (47b, p. 80), (35, p. 527), (53, p. 185). .....
Round-headed apple tree borer Saperda candida.

(2). Large grubs bore in crown and roots. They are 2 to 3" long, white with a brown and black head and a lateral body row of oval spots. (32, p. 322), (38, p. 252).
.....
Giant grape root-worm Prionis laticollis.

2. Nursery stock or younger trees.
a. Borers.
(1). Branches and trunk full of "shotholes".
.....Shot-hole borer, page 1.

(2). Borers in crotches and cracked or wounded places. The grubs bore in inner bark, occasionally in sapwood.....
.....Apple crotch borer, page 1.

(3). Burrows are in inner bark and sapwood from between one to three inches below ground to one foot or over above ground. Exit holes are eight to ten inches above ground and are the diameter of a lead pencil.....
.....Round-headed apple tree borer, page 2.

b. Bark scales or coverings.
(1). Trunk, branches, and twigs covered with small brownish scales 1/16 to 1/8" long curved and resemblong an oyster shell; underneath are many minute eggs. Bark cracks and whole tree weakens or dies. (47b, p. 1), (23, p. 124), (47, p. 73).
.....
Oyster shell scale Lepidosaphes ulmi.

(2). Trunks, branches, twigs, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both fruit and bark, the area turns red. Under magnification the specks are disks having a raised central nipple-like blackish spot . Tree vigor decreases, foliage becomes yellowish and scant. (23, p. 165), (57, p. 70), (23, p. 126). .....
San Jose scale Aspidiotus perniciosus.

(3). Trunk, branches, and twigs are often coated with dirty-white scales 1/10" long. In the winter time, if the scales are flipped over, with the naked eye one can discern reddish-purple eggs. (59, p. 41), (47, pp. 7-11), (57, p. 73). .....
Scurfy scale Chionaspis furfura.

c. Aphids.
(1). Wounds in trunk and branches are crowded over with cottony masses of teltering purplish aphids. Wounds form gall-like knots in endeavoring to overcome the toxic stimulation. Underground trunk and roots are also subject to attack. Infested trees often grow adventitious fibrous roots. Roots die, the tree is stunted, or may even be killed outright. (11, pp. 5-12), (9, p. 21), (45, p. 55). .....
Woolly apple aphid Eriosoma lanigera.

B. Branches.
1. "Shotholes" in bark.
a. Branches and trunk bark full of "shotholes" the size of a pencil lead.....
.....Shot-hole borer, page 1.

2. Borers in branches.
a. Branches and trunk full of "shotholes" the size of a pencil-lead. The holes extend into the sapwood where sawdust-filled lateral galleries and runways follow the grain.....
.....Shot-hole borer, page 1.

b. Dead bark areas on sunny side of tree, under which are shallow, broad, irregular burrows under the bark and within the sapwood... .....
.....Flat-headed apple tree borer, page 1.

c. Burrows in inner bark and sapwood from one to three inches below ground to one foot or over above ground. Eight to ten inches above ground are exit holes the diameter of a pencil.....
Round-headed apple tree borer, page 2.

d. Branches and twigs have paired borers, apparently two eggs were laid close together, when they hatch each starts to bore in the opposite direction. They bore first in the sapwood then right into the heartwood. Exit holes are ¼" in diameter.....
.....Spotted apple tree borer, page 2.

e. In crotches or wounds in trunk or branches are borers within the inner bark, rarely in the sapwood. The grubs are 3/5" long, yellowish-white having brownish heads.....
.....Apple crotch borer, page 1.

3. Tree injuries having cottony coverings.
a. Injuries in trunk or branches are coated over with cottony masses sheltering purplish aphids.
.....Woolly apple aphid, page 3.

4. Bark scales or coverings on branches.
a. Scales.
(1). Branches, twigs, and leaves have large brown soft-bodied half-pea-shaped scales 1/8-3/16" long. They cluster together on one side of the twig or branch. They winter over on small branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations causes leaves to yellow, all growth ceases, followed by premature shedding of fruit and foliage. (53, p. 261), (32, p. 129), (23, p. 148), (2, p. 123). .....
European fruit lecanium Lecanium corni.

(2). Branches and twigs from May through July have undersurfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (35, p. 676), (25, p. 295), (2, p. 153).
.....
Cottony maple scale Pulvinaria vitis.

(3). During winter the bark on undersides of branches and twigs is nearly covered with shiny convex-shaped brownish scales 1/12" in diameter. In the summer the fruit is coated with honeydew masses growing sooty-black fungi which renders the fruit unsalable. (32, p. 129), (2, p. 153), (36, p. 603). .....
Terrapin scale Lecanium nigrofasciatum.

(4). Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. (53, p. 179), (25, p. 283), (32, p. 179). .....
Putnam's scale Aspidiotus ancylus.

(5). Minute grayish thin scales are massed together upon branches and twigs. Under magnification the specks appear to have a raised reddish area in the center; thus they are distinguished from the San Jose scale; otherwise, they are similar. (32, p. 128), (36, p. 617). .....
Cherry scale Aspidiotus forbesi.

(6). Branches and twigs similar to Putnam's and Cherry Scales (gray to nearly black scales with orange or reddish nipples, which are off-center) which in reality are distinguished only by microscopic characters. The individual scales are 1/12" in diameter. The central elevation is orange and off-center. (53, p. 260), (45, p. 58). .....
European fruit scale Aspiotus ostreaeformis.

(7). Branches and twigs are coated with 1/8" reddish-orange scales; the central spot of off-center. (53, p. 360), (25, p. 283). .....
Walnut scale Aspiodiotus juglans-regiae.

C. Small branches, twigs, and shoots.
1. Twig borers.
a. Pinkish or creamy-white larvae 1/2" long burrow in twigs causing the foliage to wilt and the shoot to die back. Earlier broods attack the shoots while later broods prefer the ripening fruits. Apples in close proximity to peaches are most severely attacked after the peaches are harvested. The internal worminess shows up as burrows and excrement as found in the pulp, in the core, or may even be exposed to the outside. (2, p. 132), (36, p. 608), (47, p. 10). .....
Oriental fruit moth Grapholitha molesta.

b. Twig tips and their foliage die back because of small burrowing beetles 1/8" long, cylindrical in shape. Twigs are attacked just below a leaf scar, from there the burrows lead into the sapwood in one main longitudinal burrow and numerous lateral ones, called brood chambers.

(15, p. 65), (53, p. 282), (3, p. 15).
.....
Pear blight beetle Anisandrus pyri.

c. Burrows from shoots to base of small branches widening out at base of shoots cause the twigs to wilt and drop off. The injury is most noticeable in the winter or early spring, indicating, the killed new growth. The whole tree is weakened, if injured in repeated years will die. The borings are lengthwise with the twig and contain ½" brown beetles. (50, p. 513), (15, p. 67), (51, p. 449). .....
Apple twig borer Amphicerus bicaudatus.

2. Twigs die-back.
a. Terminal growths die-back as if affected by borers, nursery stock is especially susceptible. The insect is ¼" long, coppery-brown, and ovular-shaped. (2, p. 139), (59, p. 43), (36, p. 611). .....
Tarnished plant bug Lygus pratensis.

3. Severed twigs.
a. Twigs from 2-3" long up to 2-3 feet long litter the ground beneath the tree. The twigs are smoothly cut off; the severed end has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a ¾" white grub. (53, p. 200), (25, p. 327), (25, p. 664). .....
Twig pruner Elaphidion villosum.

b. Twigs or small branches of ½" diameter are often cleverly girdled by having a complete ring gnawed out of the bark into the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurs in the severed parts, the egg hatches and the grub eats out all but the bark, as the twig lies on the ground. (53, p. 202), (57, p. 282). .....
Twig girdler Oncideres cingulatus.

4. Gnawed twigs.
a. Twigs badly gnawed so they droop, buds entirely eaten off. Injuries occur early in the season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. (56, p. 78), (36, p. 532), (47f, p. 37), (45, p. 8). .....
New York weevil Ithycerus noveboracensis.

5. Feeding punctures in twigs.
   a. Young trees and nursery stock have shoots and fruit stems punctured and sap withdrawn, as the insects do so they cause the twig or shoot to warp and curl, at time producing a complete loop. Curling up of leaves leads to premature defoliation. Also the leaves are coated with honeydew. The fruit likewise is punctured, when injured thus it takes on a dimpled and speckled appearance. (11, pp. 23-8), (47e, pp. 5-7), (45, p. 32). .....
   Apple plant lice Aphis pomi, sorbi, and fitchi.

   b. Shoots and stems are punctured early in the season, before and after buds burst; warpings and twistings disrupt the shoots. Opening buds are punctured by insects until they have access to succulent leaves. They suck sap from leaf and fruit stems; the leaves curl up and wilt, while the fruit stems droop, thus dwarfing or killing the fruit. Fruit spurs and inner tree-top portions are more subject to attack than terminal parts. (47e, p. 3), (45, p. 32), (47f, p. 25). .....
   Rosy apple aphid Anuraphis roseus.

   c. Twigs are sapped of their needed fluids during May by large bugs 5/8" long. Such punctures and robbed sap causes the twigs to warp, droop, and dry up, together with all foliage thereon. When growth is most active the injury becomes most severe. (53, p. 208). .....
   Ring-legged tree bug Brochymena annulata.

6. Oviposition punctures in twigs.
   a. Ugly roughened and ragged wounds in twigs with splinters reaching in the air; the injuries are in a row extending anywhere from one to four inches. Beyond the injury the twig dies, and the foliage turns brown. The scars are holes made so the female can oviposit. (36, p. 533), (23, p. 105), (47f, p. 78). .....
   Periodical cicada Cicada septendecim.

   b. Twigs, small and larger branches have series of cuts or incisions through the bark into the wood. The incisions are in rows, each single injury is a pair of convex-shaped incisions with the concave surfaces facing each other. In the center of each cuttings into the wood eggs are deposited, as many as twelve to each incision. Oviposition occurs usually in lower

branches. The tip part, beyond the injury, dries up and breaks off. If it does not break off its bark becomes rugged and the wood causes swellings in an irregular manner. The injury is done by a 3/8" hump-backed green insect. (47f, p. 77), (45, p. 57), (9, p. 25).
.....
Buffalo tree hopper Ceresa bubalus.

c. In the bark or sapwood rows of pinholes are punctured in one side of the twigs. There may be twenty-five to an inch, or fifty to seventy-five in a row, in each an egg 1/8" long is inserted. Each incision is not straight down but rather curved in. The infested twigs or branches break off beyond the injury or die back. (38, pp. 1-20), (59, p. 36), (45, p. 56). .....
Tree cricket Oecanthus sp.

7. Bark coatings on twigs.
   a. Grayish specks on bark and fruit, individually invisible to the eye, surrounded by a reddish area.....San Jose scale, page 3.

   b. Bark scales 1/16 to 1/8" long, resembling an oyster shell.....Oyster shell scale, page 2.

   c. Bark covered with grayish scales 1/10" long, In winter, if flipped over, they reveal very small reddish-purple eggs.....
   .....Scurfy scale, page 3.

   d. Large brown soft-bodied scales half-pea-shaped 1/8 to 3/16" long clustered together. Winter forms are flat, spindle-shaped, and immature.
   .....European fruit lecanium, page 4.

   e. The under-bark of twigs is covered with cottony masses from May through July.....
   .....Cottony maple scale, page 4.

   f. Bark on undersides of twigs is coated with shiny convex-shaped brownish scales 1/12" in diameter.....Terrapin scale, pate 4.

   g. Twigs and branches have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off-center.....
   .....Putnam's scale, page 5.

   h. Minute grayish specks massed together upon twigs and branches. Under magnification a raised reddish nipple is in the center of each. (Similar to San Jose scale, page 3).....
   .....Cherry scale, page 5.

i. Bark coated with 1/12" dark ashy-gray scales. .....European fruit scale, page 5.

j. Bark coated with 1/8" reddish-orange scales. .....Walnut scale, page 5.

II. UNDERGROUND (Roots and trunk).

A. Knob-like swelling and cracks in roots killing them, eventually culminating in death of entire tree. The knob-like swellings contain bluish-white or reddish-brown aphids 1/10" long. ....Woolly apple aphid, page 3.

B. Large white grubs feeding on roots of nursery stock and young trees. (25, p. 236), (32, p. 302), (36, p. 306). ..... White grubs Lachnosterna sp.

C. Large, long white grubs, 2-3" long; having a brown and black head and a lateral row of oval spots along the body. They bore around in roots. (32, p. 322), 37, p. 232). ..... Giant grape root-worm Prionis laticollis.

D. Roots from two inches below ground to a foot or so above ground have shallow burrows from the bark into the heart-wood. Eight to ten inches above ground are exit holes the size of a pencil..... .....Round-headed apple tree borer, page 2.

III. FOLIAGE (Buds, Leaves, and Flowers).

A. Bud injury.

1. Buds eaten off.

a. Caterpillar injury.

(1). Buds are entirely eaten off as they begin to swell early in the spring; later the fruit, leaves and shoots become seared and pitted, by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. Leaves are also rolled together and tied by silken strands, in which the creature and his house seeks shelter. Nursery stock is seriously attacked. (52, p. 68), (32, p. 313), (36, p. 560), (47, p. 54). ..... Leaf crumpler Mineola indigenella.

(2). At the time buds burst small caterpillars begin feeding on them. During a six weeks period they eat developing buds, injure unfolding leaves by rolling and binding them with silken strands, and by injuring the setting fruits which come amongst the leaf

rollings. The larvae are ¾" long by about the first of June. (12, pp. 1-41), (21, pp. 1-6), (45, p. 23).....
Fruit tree leaf roller Cacoecia argyrospila.

(3). Leaves are rolled up and tied together by leaf-eating larvae, which peel off the under leaf surfaces. They also eat off buds, flowers, and puncture fruit skins, then eat out their pulp. The first larval stage is as a leaf-miner; in the mature stage they devour the buds; there are two broods, May-June, and July-August. They winter over as eggs on the bark. (60, p. 63), (32, p. 230), (36, p. 716), (35, p. 73).
.....
Oblique-banded leaf roller Cacoecia rosaceana.

(4). Tiny gregarious caterpillars hatch out in time to lay waste expanding leaves; at first they eat out holes, later they consume the entire leaf except for the main veins. Complete defoliation is not uncommon. Mature caterpillars are two inches long, having ten pairs of dorsal blue tubercules and six reddish, separated by a yellow median line; otherwise the body is clothed with long black hairs. (5, pp. 1-23), (25, p. 273), (32, p. 200). .....
Gypsy moth Porthetria dispar.

(5). Buds, flowers, and leaves are often stripped overnight by an unseen visitor. Or, certain branches may be the center of attack, more often nursery stock or new trees. (53, p. 138), (2, p. 130), (45, p. 11). .....
.....
Climbing cutworms Noctuidae sp.

b. Beetles injury.
(1). Buds, leaves, and flowers are stripped or badly ruined early in the season, during a one-month period. Buds, flowers, and leaves are eaten off or are eaten ragged and tattered; newly set fruits become badly disfigured by having holes eaten into them. Adults are 1/3" long, yellowish-brown, and have long sprawling legs. They prefer porous sandy areas. (19, pp. 1-4), (59, p. 28), (9, p. 51), (45, p. 29). .....
Rose chafer Macrodactylus subspinosus.

(2). Buds are eaten off, twigs gnawed and drooping. Early spring injuries to young trees in close proximity to hickory or oak woodlots are especially serious..... .....New York weevil, page 6.

(3). During the early spring small jumping beetles 1/10 to 1/5" long puncture and eat out opening buds. The adults are shiny-metallic colored and eat out holes in the leaves resembling "shotholes". The larval stage is spent as leaf miners, which produce mines from near the center of the leaf to the margin terminating in blister-like cells. (45, p. 8), (36, p. 558). .... Apple flea weevil Orchestes pallicornis.

(4). Same as preceding, except the larvae are not leaf miners; they too perforate the leaves shothole-like. The larvae are 1/5" long light-brown with black spots. Adults are greenish-blue jumping beetles. (51, p. 451), (53, p. 403), (38, p. 264). ..... Grape flea beetle Haltica chalybea.

2. Buds eaten into.
   a. Caterpillar injury.
      (1). Opening buds are eaten into thus destroying all flowers and leaves. Inside the buds are brown caterpillars ½" long with a black head and shield eating and tunneling about. The fruit has its epidermis scooped out in places, causing blemishes in matured fruits. They also feed upon expanding foliage. Nursery stock is often destructively attacked. (51, p. 549), (45, p. 21), (47, p. 31). ..... Bud moth Tmetocera ocellana.

      (2). Opening buds are eaten into and tunnelled around in by small apple-green caterpillars which attain ¾" in length when full grown; on the lateral surfaces are three narrow yellowish-white stripes. The measuring worms feed for four or five weeks, preferring to feed on flower buds. (53, p. 93), (23, p. 108), (32, p. 207). ..... Bruce's span-worm Rachela bruceata.

(3). Unfolding buds have their scales eaten off and the flowers eaten into. The devastating insects are very small caterpillars residing in sheltered cases. The cases are pistol-shaped having a curl or bend in it; in all they are ¼" long and may be found attached to leaves, twigs, branches, or fruit, depending upon the season of year. (36, p. 561), (47f, p. 58), 45, p. 10). .....
Pistol-case bearer Coleophora malivorella.

(4). Same as preceding except that the case-bearer has a cigar-shaped case which is triangular at the tip. (32, p. 204), (51, p. 547), (57, p. 86). .....
Cigar-case bearer Coleophora fletcherella.

(5). Bud scales are eaten off by yellowish, greenish, or black measuring worms an inch long. Developing leaves are eaten tattered and skeletonized. The top half and center of tree is primarily the source of injury. The measuring worms are spinners, spinning threads wherever they travel, from top of tree to ground crosswise and sideways; in fact completely entangling the tree sufficiently to cause the foliage to die and drop prematurely. The fruit becomes badly dwarfed. (44, p. 20), (46f, p. 59), (30, p. 56). .....
Spring cankerworm Paleacrita vernata. (45, p. 20), (47f, p. 41), (30, p. 56). .....
Fall cankerworm Alsophila pometaria.

(6). Buds are fed upon by ¾" light-green caterpillars with head, legs, and thoracic shield varying from brown to black.. At first they feed on buds, then roll and tie leaves together to feed on the foliage or fruit within the tangle.....
.....Fruit tree leaf roller, page 10.

(7). Buds are fed upon by caterpillars which roll and tie leaves together, then, within twisted horn-like tubes or cases nearly an inch long, they reside in the enclosure.....
.....Leaf crumpler, page 9.

b. Beetles injury.

(1). Buds, blossoms, and new foliage in new orchards in close proximity to locust trees become badly devasted by small jumping beetles 1/10" long as they voraciously feed. (53, p. 205), (47f, p. 38). .....
Red-legged flea beetle Crepidodera rufipes.

(2). Opening buds are eaten into, leaf and fruit stems severed by gnawings. Injuries occur from May through June. (53, p. 371), (36, p. 533), (38, p. 167). ..... Imbricated snout beetle Epicaerus imbricatus.

(3). Buds are eaten off, twigs gnawed and drooping. Young trees early in the spring, in close proximity to oak or hickory woodlots, are especially hard hit..... .....New York weevil, page 6.

(4). Jumping beetles 1/10 to 1/5" long puncture and eat out opening buds. Adults are shiny-metallic colored and at first eat out buds, later eating out perforations in leaves similar to "shotholes". The larvae are leaf miners.....Apple flea weevil, page 11.

3. Buds rasped.
   a. Early in the season buds shrivel up and turn brown, on close examination the browned surfaces reveal raspings caused by feedings. Oviposition in stems of young fruit produces a wilting effect followed by premature fruit shedding. Heavy infestations appear as injuries caused by fire. (39, pp. 1-7), (32, p. 119), (36, p. 592). ..... Pear thrips Taeniothrips inconsequens.

4. Buds punctured.
   a. Swelling and expanding buds are punctured and sap withdrawn, resulting in slight injuries to buds. Their presence need not cause alarm, even though 15-20 may be upon a bud or flower; they are waiting for newly developed succulent leaves on which they feed a short time, to end of May, then migrate from the tree. Some of the leaves curl up and drop due to aphis feeding upon them. (47e, p. 8), (47f, p. 27), (45, p. 31). ..... Apple grain aphid Rhopalosiphum prunifoliae.

   b. Opening buds are punctured by aphid nymphs until they have access to succulent leaves. They draw the sap from leaf and fruit stems; the leaves curl up and wilt, while the fruit stems curl and droop, thus dwarfing or killing the fruit. Fruit spurs and inner tree-top portions are more subject to attack than terminal parts. .....Rosy apple aphid, page 7.

c. Opening buds are punctured by green aphids, so also are flowers and fruit stems. The punctures cause warpings which tend at times to wilting and killing of the terminal part beyond the incision. Infestations occur only early in the spring and in the fall. (53, p. 151), (32, p. 142). .....
Apple bud aphid Siphocoryne avenae.

B. Leaf injury.
1. Leaf miners.
a. During June leaf miners ½" long mine about in the leaves, then pupate therein, after causing the leaf to curl up and then tying it fast. The caterpillars are ½" long, olive or brownish-green, having a light brown head and two lateral and two dorsal white stripes. More often found in unsprayed orchards. They skeletonize leaves and eat out small cavities in apples. (53, p. 52), (23, p. 113), (36, p. 525). .....
Palmer worm Dichomeris ligulella.

b. Leaf mines less than one inch long which the miner deserts to build a flimpsy cocoon on the leaf surface close to the mine. From the cocoon the caterpillar comes forth to feed on the leaf surface, thus skeletonizing it. The cocoons may be found on twigs, leaves, or fruit. Attached leaves brown and shrivel up; the injury occurs early in the year, just as the first leaves unfold. The larvae are ½" long, greenish-yellow with a reddish tinge on anterior segments. (47, p. 62), (53, p. 56), (23, p. 115). .....
Apple bucculatrix Bucculatrix pomofoliella.

c. The first leaves in the spring are likely to be infested with leaf miners which mine about for about three weeks, then pupate within the mines for another three weeks. The second brood pupates in the leaf until it drops then holds over until spring. The second brood larvae lines its mine with silken threads, whereas, the first brood does not. (23, p. 117), (50, p. 616), (32, p. 235). .....
Apple leaf trumpet miner Tischeria malifoliella.

d. Irregular dark blotch mines ½" in diameter harboring a 1/8" long, legless, light yellow-brown caterpillar with a dark head. When fully matured the larva cuts off a piece of the mine

With which it forms an oval seed-like yellowish shield which it attaches to the bark. (53, p. 75), (32, p. 232), (50, p. 116). .....
Resplendent shield bearer Coptodisca splendoriferella.

e. Leaf miners which in the earliest stage mine about then bind the leaf in a roll and skeletonize its surfaces.....
.....Oblique-banded leaf roller, page 10.

f. Leaf mines from near the leaf center to the margin terminating in blister-like cells.. Adults are 1/10" long beetles which eat out round holes in foliage, giving it a "bird-shot" perforation.
.....Apple flea weevil, page 11.

g. Leaf miners in earliest stage, later they construct brownish-gray, tough, silken cases ¼" long, bent at the top to resemble a pistol, standing upright at right angles to whatever it is attached. Inside the cases are 1/8" caterpillars.
.....Pistol-case bearer, page 12.

h. Same as preceding except the case is cigar-shaped, having its tip triangular.....
.....Cigar-case bearer, page 12.

2. Leaves rolled and webbed together.
a. Late in June ½" greenish-yellow caterpillars fold over a portion of a leaf then sew it fast, within the enclosure the larva feeds on the upper epidermis. Its head is yellow, the cervical shield has a black spot near the outer hind corner. They are found only in neglected orchards. (47f, p. 56), (53, p. 61), (32, p.218).
.....
Apple leaf sewer Ancylis nebeculana.

b. Edges of leaves are drawn and tied together, then within the fold the caterpillars eat off the under epidermal layer; from a distance the injury appears as fire blight. Nursery stock is more often subject to attack. The caterpillars are ½" long, pale yellowish-green, with a yellow head and thoracic shield. (53, p. 59), (32, p. 231).
.....
Yellow-headed fireworm Alceris minuta.

c. Single leaves or grouped leaves are drawn together by silken strands, wherein caterpillars eat foliage, puncture fruit skins, and eat the pulp. Earliest larval stage is as a leaf miner. The caterpillars are ½" long, light yellowish brown to apple-green, having a brownish black head and thoracic shield; the thoracic shield is bordered with white or black.....
.....Oblique-banded leaf roller, page 10.

d. Leaves and fruit clusters are drawn together and bound with silken cords. Fruit within the tangle has cavities eaten out. The larvae are ½" long, green, with head and thoracic shield dark brown or black.....
.....Fruit tree leaf roller, page 10.

e. At foliation time leaves are rolled and tied together by threads; and, within the enclosure reside several twisted horn-like tubes or cases nearly an inch long used by caterpillars as shelters.....Leaf crumpler, page 9.

f. Buds and leaves are webbed together by silken threads wherever the worm is feeding. The caterpillars are ¼" long, brown, having black heads.
.....Bud Moth, page 11.

g. Single leaves are rolled so the upper and lower surfaces are tied together by silken threads. The earliest larval period is spent as a leaf miner, the latter part is spent as a semi-leaf miner partially buried and partially exposed.
.....Resplendent shield bearer, page 15.

h. Leaves curl up, then are tied by silk threads. The rolled leaves are those first burrowed about in by leaf miners. When inhabiting the enclosure they skeletonize leaves and eat cavities in the young apples. The caterpillars are ½" long, olive or brownish-green, having a light-brown head and two lateral and two dorsal white stripes.....Palmer worm, page 14.

3. Leaf protuberances.
a. Pistol-shaped protuberances on the underleaf surface ¼" long.....
.....Pistol-case bearer, page 12.

b. Cigar-shaped protuberances on the underleaf surfaces ¼" long, having a triangular tip.
.....Cigar-case bearer, page 12.

c. Slender, blackish, twisted horn-like tubes or cases nearly an inch long on twigs and leaves, within which reside reddish-brown caterpillars. .....Leaf crumpler, page 9.

d. Leaves which have been infested by leaf-miners have a mine less than an inch long; at the end is a flimpsy cocoon 1/4 to 2/5" long on the lower leaf surface.....Apple bucculatrix, page 14.

e. Sacks or bags 1/4 to 1 1/2" long hanging from underleaf surfaces, twigs, branches, or on the bark. Inside the bags are dark-brown shiny-bodied caterpillars. (26, pp. 1-11), (25, p. 215), (51, p. 503) (38, p. 679). ..... Bagworm Thyridopteryx ephemeraeformis.

4. Speckled leaves.
a. Mites or spiders.
(1). Yellowish spots are on the foliage. Around the spots on under leaf surface are numerous very fine silk threads. Inside the spots are tiny red spiders 1/50" long. (53, p. 315), (32, p. 367), (38, p. 207). .....
Red spider Tetranychus bimaculatus.

(2). Reddened, mottled leaves turn rusty, then black and fall. Around spots on lower leaf surface are silken threads and red spiders 1/16" long. (47f, p. 66), (25, p. 308), (22, p. 395). .....
Greenhouse red spider Tetranychus telarius.

(3). Brownish blisters 1/8" across or else in masses on under surface of leaves. Blisters have fine thread entanglements around them. Fruit cracks open. (21, pp. 1-6), (47f, pp. 1-6), (9, p. 42. .....
Pear-leaf blister mite Eriophyes pyri.

(4). Reddish or greenish galls or blisters 1/4" across on the under leaf surface. Leaves and fruit drop prematurely. Silken threads wrap about the blisters. Fruit of poor size, quality, and texture. (10, pp. 1-125), (2, p. 140), (47f, p. 67). .....
European red mite Paratetranychus pilosus.

b. Leafhoppers.

(1). During midsummer and early fall foliage becomes mottled with white; injured leaves fade and drop. Underleaf surfaces have numerous shy insects which walk sideways when startled or fly off in clouds. Adults are yellowish green and 1/8" long. (47f, p. 29), (32, p. 156), (45, p. 7). .....
Rose leafhopper Typhlocyba rosae.

(2). Pale greenish yellow leaves with white spots surrounding leaf punctures. Leaves drop prematurely. Adults insects are 1/8" long, yellowish, with irregular dark markings and black or red stripes. Similar to preceding. (23, p. 117), (51, p. 456), (38, p. 311). .....
Grape leafhopper Erythroneura comes.

(3). Edges of leaves turn white and curl up, or the surface is mottled with white spots. Tips of some leaves have a browned triangular surface; also tips of lateral veins have browned triangular areas. Adult insects are 1/8" long, pale yellowish-green having six or eight white spots on the front pronotum margin. Similar to preceding. (47f, p. 30), (23, p. 231), (45, p. 7). .....
Apple leafhopper Empoasca sp.

5. Leaves skeletonized.

a. Caterpillars.

(1). Late August or September trees are apt to be bereft of foliage due to complete skeletonization. The injury is done by worms spinning a single thread wherever they go. When one tree is stripped, in searching for food the caterpillars twine and entwine the base of trunk until it is one huge web. Mature caterpillars are 1" yellowish-green, with prominent numerous black spots. (46, pp. 247-64), (2, p. 126). .....
Apple and thorn skeletonizer Hemerophila pariana.

(2). Leaves which have leaf-mines within are later completely skeletonized on the outside. The larvae inhabit flimpsy cocoons attadhed to the leaves. Larvae are

greenish-yellow with a reddish tinge on the anterior segments; in all they are ⅝" long.....Apple bucculatrix, page 14.

(3). Late in June ½" greenish-yellow caterpillars fold over and tie leaves together then skeletonize the upper epidermis. The head is yellow, the cervical shield has a black spot near the outer posterior corner. .....Apple leaf sewer, page 15.

(4). During June larvae that mined inside of leaves roll and tie them together than skeletonize the rolled leaf. The caterpillars are ½" long, olive or brownish green, having a light brown head and two lateral and two dorsal white stripes. .....Palmer worm, page 14.

(5). Leaves having ¼" pistol-shaped protuberances on under leaf surfaces of leaves which are skeletonized .....Pistol-case bearer, page 12.

(6). Leaves having ¼" cigar-shaped protuberances on under leaf surfaces of leaves which are skeletonized.....Cigar-case bearer, page 12.

b. Beetles.

(1). Leaves are badly skeletonized, during a three months period, by metallic-green or greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of abdomen. They swarm together in great numbers. The fruit is either gouged or partly peeled in irregular shallow patches. (2, p. 127), (36, p. 605), (48, pp. 1-31).
.....
Japanese beetle Popillia japonica.

(2). Leaves are skeletonized early in the season by beetles 1/3" long, yellowish-brown, possessing long sprawling legs. They eat leaves ragged and tattered, devour buds and flowers; newly set fruit is badly injured by having holes eaten out.....Rose chafer, page 10.

(3). Leaves are skeletonized by jumping beetles 1/10" long, New orchards in close proximity to locust trees are most seriously injured. .....Red-legged flea beetle, page 12.

6. Leaves turn pale, dry up, curl, and drop prematurely.

a. Leaves curl shortly after unfolding then dry up and drop. Inside curling leaves are multitudes of aphids sucking sap from leaves, stems, and newly forming fruit. Petioles and fruit stems warp out of shape.....
.....Rosy apple aphid, page 7.

b. From spring to fall aphids puncture leaves and leaf stems causing them to wilt, dry up, and drop prematurely. The stems warp badly.....
.....Apple aphid, page 7.

c. Speckled leaves become browned and curled; from a distance they appear dust-laden. Leaves drop prematurely. Fruit is undersized, of poor quality and color.....European red mite, page 17.

d. Under leaf surfaces have brownish blisters $\frac{1}{4}$" in diameter, or masses of them; the blisters swarm with tiny mites. Leaves drop prematurely. Fruit skins crack open.....
.....Pear leaf blister mite, page 17.

e. Leaves turn pale yellow, curl up, and drop. Lower leaves are attacked first, then higher ones etc. Fruit is stunted. The injuries become most severe in dry seasons and in arid areas. Twigs and trunk have numerous pinkish or red eggs upon the bark sufficient to produce a reddish hue, during the dormant stage. Small six or eight - legged creatures inhabit the under leaf surfaces. (62, p. 11), (47f, p.66), (45, p. 36). .....
Clover mite Bryobia praetiosa.

f. Reddened mottled leaves turn rusty, then turn black and drop. Around the spots are wrapped silken threads encasing red spiders 1/16" long.
.....Greenhouse red spider, page 17.

g. Yellowish spots on undersides of leaves surrounded by silken webs encasing red spiders 1/50" long.....Red spider, page 17.

h. During midsummer and early fall leaves become mottled with white, injured leaves fade and then drop. Under leaf surfaces have 1/8" long, shy side-walking creatures.....
.....Rose leafhopper, page 18.

i. Pale greenish yellow leaves which have white spots surrounding leaf punctures. Leaves drop prematurely. Similar to preceding species. .....Grape leafhopper, page 18.

j. Edges of leaves turn white and curl up, or else the surface is mottled with white. Some leaf tips have a triangular brown spot, likewise at the end of lateral veins. Similar to preceding species.....Apple leafhopper, page 18.

7. Feeders on expanding foliage.
   a. Caterpillars.
      (1). Many tiny gregarious caterpillars hatch out in time to lay waste expanding leaves; at first they eat out holes, later they consume the entire leaf except for the largest veins. Complete defoliation is not uncommon. Mature caterpillars are two inches long having ten pairs of dorsal blue tubercles and six reddish, separated by a yellow median line; otherwise the body is clothed with long black hairs. (25, p. 275), (5, pp. 1-23), (47f, p. 48). .....
      Gypsy moth Porthetria dispar.

      (2). Webs are spun at terminal points where many caterpillars centralize. The August brood skeletonizes leaves, but the chief injury occurs when the over-wintering larvae revive in the spring to devour unfolding leaves as fast as they make their appearance. (5, pp. 24-32), (47f, p. 49), (25, p. 277). .....
      Brown-tail moth Nygmia phaeorrhoea.

      (3). From the time of bud opening to three weeks after petal-fall small caterpillars tie leaves and fruit clusters, then devour the leaves. Leaf parts which are not eaten dry up.....Fruit tree leaf roller, page 10.

      (4). When leaves begin to unroll they are eaten off by caterpillars, providing the buds were not eaten off by them. Later they scoop out holes in newly setting fruits. .....Bud moth, page 11.

      (5). Early in the spring leaf clusters are chosen by caterpillars which proceed to tie them fast to a twig for a shelter. Inside the shelter are tough, horn-like shaped cases enclosing caterpillars eating the leaves.....Leaf crumpler, page 9.

(6). Complete or partial defoliation of leaves, buds, and flowers may occur overnight by an unseen predator. The injury occurs very early in the spring. Nursery stock or young trees are more subject to attac.....Climbing cutworms, page 10.

b. Beetles.

(1). Leaves, buds, and flowers are eaten off by beetles early in the spring; some leaves are eaten ragged and tattered. The beetles are 1/3" long, yellowish-brown, possessing long sprawling legs.....Rose chafer, page 10.

(2). New leaves, buds, and blossoms are eaten off, especially when in close proximity to locust trees. The beetles are 1/10" long, and are high-jumpers.....Red-legged flea beetle, page 12.

(3). Unfolding leaves are eaten ragged and tattered. The beetle is 1/5" long, shining steel-blue and can jump freely.....Grape flea-beetle, page 11.

(4). Newly opened leaves are perforated as if shot full of tiny "shotholes". The beetle is 1/10" long, dull-black colored, and it is a jumping beetle.....Apple flea weevil, page 11.

8. Foliage eaters.

- a. Single defoliators.

(1). Beetles.

(A). Leaves, during the period of a month or 6 weeks, are badly eaten by beetles which appear in swarms. The beetles are 1/3" long, yellow-brown, possessing long sprawling legs.....Rose chafer, page 10.

(B). Leaves have the epidermis eaten off by congregating metallic-green beetles slightly larger than potato beetles. They are present during two or three months of the summer and cling together in swarms.....Japanese beetle, page 19.

(2). Caterpillars.

(A). Total defoliation of branches or entire tree may occur overnight by an unseen destroyer. Nursery stock or young trees are especially susceptible to defoliation.....
.....Climbing cutworms, page 10.

(B). Giant caterpillars, over two inches long. They feed for a month or so without seriously injuring the tree, due to their rarity. When through feeding they spin cocoons, then hibernate in them for the winter.

(I). Cocoon inside a rolled leaf. = Promethea moth (18, pp. 263-71).

(II). Cocoon 7/8" by 2½ or 3", partly wrapped in a leaf. = Luna moth (57, p. 282).

(III). Cocoon 7/8" in diameter, slightly longer than round, sort of ovular-shaped. = Polyphemus moth (57, p. 94).

(IV). Cocoon 1½ or 2" by 3 or 4" fastened to branches encasing leaves. =-Cecropia moth (57, p. 91).

b. Colonial defoliators.

(1). Web spinners.

(A). Thick webs are spun in forks or crotches and used as a shelter only, all feeding is done outside the web. Within the web leaves dry up and die; outside the web they are stripped. As the caterpillars grow they enlarge the web to accommodate the colony. Webs are spun early in the season, when buds and leaves are in development. The caterpillars are brown having a white dorsal line; sides are blue, and sparsely haired. (1, pp. 1-18), (2, p. 125), (45, p. 14).
.....
Eastern tent caterpillar Malacosoma americana.

(B). Dirty-white loosely woven webs, containing excrement everywhere, enclose branch tips late in the summer or early fall. The chief differences between this and the preceding species is that

this species feeds within the web, while the former does not; this species spins its web late in the summer, the former spins early in the spring. (45, p. 18), (25, p. 213), (47f, p. 44). .....
Fall webworm Hyphantria cunea.

(C). Webs are spun at terminal points where many caterpillars centralize. During the winter the webs are conspicuous, at which time the larvae are in hibernation. The August brood skeletonizes the leaves, but the principal injury occurs when the over-wintering caterpillars revive in the spring to devour unfolding leaves as fast as they develop.....Brown-tail moth, page 21.

(2). Non web-spinners.

(A). In midsummer colonies of caterpillars appear and completely defoliate branches or the whole tree. Nursery stock or young trees are most subject to attack. When not feeding they congregate on the trunk or branches. When at rest the caterpillars either have the rear end elevated or the fore and rear ends; when startled they elevate both ends suddenly and remain so. The caterpillars are two inches long, black and yellow striped, having a yellow ring around the neck. (52, p. 123), (38, p. 270), (23, p. 118).
.....
Yellow-necked caterpillar Datana ministra.

(B). Same as preceding species except the caterpillars are black and yellow striped with a coral-red hump just behind the head and a row of spines projecting from it. (53, p. 125), (38, p. 271), (23, p. 118).
.....
Red-humped caterpillar Schizura concinna.

(C). In the spring young caterpillars eat off the epidermal layer; later they eat off the entire leaf save for the midrib; some also gnaw small holes in the fruit. The 1½" larvae have three

pencil-like tufts of long black hairs, one at each side of the head and one at the dorsal posterior end. (30, p. 41), (57, p. 269), (36, p. 687).
.....
White-marked tussock Hemerocampa leucostigma.

(D). This insect resembles the preceding. It has a black head and the first two tussocks are black in young caterpillars, later turning white. Later an additional pencil of long black plume-tipped hairs project laterally from the second abdominal segment. (32, p. 203), (53, p. 105). .....
Rusty tussock moth Notolophus antiqua.

(E). Neglected orchards have leaf epidermis peeled off in midsummer, followed by consumption of all save the midrib. The caterpillar is 1½" long, covered with dense spreading tufts of white hairs, a row of eight black tufts on the back and two long slender black pencils on the fourth and tenth segments. Head, feet, and under body parts are black; upper body surface is white spotted with black. (47f, p. 53), (32, p. 183). .....
Hickory tussock moth Halisidota caryae.

(F). Caterpillars which spin one thread as a "gi-line" wherever they travel; when not feeding they congregate on trunk or branches. If food is scarce they go out after it in form like marching army worms. The caterpillars are 1¾" long, having a median row of white "lozenge-shaped" dots along the back. (25, p. 241), (30, p. 35), (45, p. 16).
.....
Forest tent caterpillar Malacosoma disstria.

(G). Early in the spring colonial caterpillars hatch out in time to consume opening buds and devour foliage as fast as it unfolds; at first holes are eaten in the leaves then all but the midrib is eaten away. The insect is two or three inches long; along the back are two rows of blue spots with a dim yellow stripe between; the body is clothed with long black hairs.
.....Gypsy moth, page 21.

(H). Leaves, buds, and flowers are stripped partially or totally overnight by an unseen enemy. The injury occurs early in the spring and is more likely to befall nursery stock or young trees.....
.....climbing cutworms, page 10.

9. Premature defoliation.
   a. Leafhoppers.
      (1). During midsummer and early fall foliage becomes mottled with white; injured leaves fade, then drop.....Rose leafhopper, page 18.

      (2). Edges of leaves turn white, curl up, and drop. Some leaves are white mottled. Tips of some have a browned triangular spot ; tips of lateral veins may also have browned triangular spots. "Hopper-burn" is caused by 1/8" pale yellowish-green leafhoppers. On the fore part of pronotum are six or eight white spots on the margin.....
.....Apple leafhoppers, page 18.

   b. Aphids.
      (1). Leaves turn pale, curl up, dry up, and drop prematurely. Amongst the dry curled leaves are multitudes of aphids secreting themselves. Leaf petioles are at times warped way out of line.....
.....Rosy apple aphid, page 7.

      (2). Similar to preceding species, except the preceding does its injury either in the spring or fall, whereas this species continues its injury from spring right through to late fall.....Apple aphid, page 7.

   c. Cankerworms.
      (1). During the spring greenish, brownish or black measuring worms about one inch long spin threads from which they dangle and so tangle up the tree that the leaves curl up, die and drop prematurely. Upper half of tree, especially the central portion, is the center of attack.....
.....Spring and Fall cankerworms, page 12.

   d. Spiders and mites.
      (1). Yellowish spots on foliage surrounded by silken webs on under surface encasing red spiders 1/50" long. Leaves drop prematurely.
.....Red spider, page 17.

(2). Reddened mottled leaves turn rusty, then turn black and drop. Around the spots, on lower leaf surface, are silken threads encasing red spiders 1/16" long. .....Greenhouse red spider, page 17.

(3). Speckled leaves become browned and curled, from a distance they appear dust laden, before dropping..... .....European red mite, page 17.

(4). Under leaf surfaces have brownish blisters 1/4" in diameter, or masses of them. The blisters swarm with tiny mites. Leaves drop before maturity..... .....Pear leaf blister mite, page 17.

(5). Leaves turn pale yellow then curl up and drop. Lower leaves are attacked first then the higher ones etc. Injury is worst during dry spells or in arid areas. .....Clover mite, page 19.

C. Flower injury.

1. Flowers and buds are eaten away by leaf rollers, when they are abundant the entire tree may become stripped of buds, flowers, and leaves. Larvae are 3/4" long, yellowish-green, head and thoracic shield being brownish-black; feed from May to August. .....Oblique-banded leaf roller, page 10.

2. Flowers, buds and leaves on branches or entire tree stripped overnight by an invisible pest. Nursery stock or young trees most liable to be attacked. .....Climbing cutworms, page 10.

3. Flower stems are punctured by yellowish-green aphids while in the process of feeding, the stems wilt and the flowers die.....Apple bud aphid, page 14.

4. Flowers are eaten into and destroyed by jumping beetles 1/10" long. Flowers and new leaves are eaten ragged. Trees in close proximity to locust trees are most seriously affected..... .....Red-legged flea beetle, page 12.

5. Blossoms, buds, and leaves are nearly entirely eaten off by large numbers of yellowish-brown beetles 1/3" long, possessing long sprawling legs. .....Rose chafer, pate 10.

6. Petals are eaten and blossoms riddled by shiny bronze-green beetles the size of a potato beetle. The beetles congregate in great swarms. .....Japanese beetle, page 19.

IV. FRUIT.

A. Fruit blemishes (outside).

1. Fruit is covered with honeydew masses growing sooty-black fungi which renders the fruit unsalable. During the winter bark on the undersides of branches and twigs is nearly covered with shiny convex-shaped scale 1/12" in diameter.....Terrapin scale, page 4.

2. Minute grayish specks on fruit and leaves surrounded by a reddish area.....San Jose scale, page 3.

3. Distorted fruits having honeydew masses over them and on leaves, the honeydew has sooty-black fungi on it.....Apple aphid, page 7.

B. Fruit blemishes (through the epidermis).

1. Crescent-shaped scars.

a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times the scars develop depressions instead of humps. Fruit becomes hard, knotty, and misshapen, usually dropping during May or June. Inside the fruit resides a grayish-white curved larva. (6, pp. 469-513), (53, p. 243), (63, pp. 1-51). .....
Plum curculio Conotrachelus nenuphar.

b. Misshapen, knotty, and undersized fruit. Small holes are eaten in ends or sides of fruit; when crescent-shaped holes are close together the skin between dries up and cracks. Infested fruit may or may not drop. The female oviposits, after digging out a hole in the fruit, then plugs the hole with excrement. (6, pp. 514-57), (23, p. 116), (47f, pl 21). .....
Apple curculio Tachypterellus quadrigibbus.

2. Round holes or round scars in fruit.

a. Round holes 1/8" deep eaten into apples. .....Apple curculio, page 28.

3. Shallow holes gouged, scooped, or eaten out of fruit.

a. Small holes scooped out of fruit.

(1). Shallow cavities scooped out of immature fruits. Around the fruit are rolled leaves and silken entanglements. .....Palmer worm, page 14.

(2). Fruit skins are gnawed and peeled, also small holes eaten into the fruit. Around the injured fruit are single and grouped leaves rolled together by leaf rollers. .....Oblique-banded leaf roller, page 10.

(3). Soon after setting, new fruit clusters and leaves are drawn together by leaf rollers, then tied together; in the meantime the fruit has small cavities eaten through the skin into the pulp. Mature fruits show deep, russeted, elongated scars. .....Fruit tree leaf roller, page 10.

(4). Small holes are eaten through the skin into the pulp. On the fruit are tiny, ¼" long, pistol-shaped protuberances inhabited by minute caterpillars. .....Pistol-case bearer, page 12.

(5). Same as preceding, except the protuberances on the fruit are cigar-shaped and have a triangular tip.....Cigar-case bearer, page 12.

b. Cavities eaten into the fruit.

(1). Holes are eaten through the skin and pits hollowed out in the pulp. The injury occurs during the latter part of May or June. Because the caterpillars cannot travel far they injure many fruits on a given branch. (45, p. 26), (47f, p. 22), (36, p. 574). .....
Green fruit worm Graptolitha sp.

(2). Fruit is scored and pitted early in the spring. Injured fruits are rolled in leaves enclosing caterpillars in twisted horn-like tubes or cases nearly an inch long, one caterpillar to each individual shelter.....Leaf crumpler, page 9

(3). Deep pits eaten into fruit.

(A). New fruits have deep pits scooped out of the pulp. The injurious pests are caterpillars 1½" long, yellowish-black, hairy, and striped. Each has three pencil-like tufts of long black hairs which project, one on each side of the head, and one from the dorsal

posterior. There are two bright red spots on the posterior dorsal surface.....White-marked tussock moth, page 25.

(B). Beetles 1/10" long eat through fruit skins, then hollow out cavities by continued eatings. Within the cavities oviposition occurs and grubs then infest the fruit. (53, p. 38), (36, p. 558). ..... Apple weevil Pseudanthonomus crataegi.

(C). Newly set fruits are badly injured by having the skins chewed off and deep holes scooped out of the pulp. Beetles 1/3" long, yellowish-brown, possessing long, sprawling legs, did the injury. .....Rose chafer, page 10.

(D). Injury same as preceding but much worse is performed by beetles about the size of a potato beetle. The head and thorax are shining bronze green, while the wing covers are tinged with green at the edges. The tip of abdomen with tufts of white.....Japanese beetle, page 19.

(4). Cracked fruit skins.

(A). Blister-like patches on fruit causing skins to crack open..... .....Pear leaf blister mite, page 20.

(5). Round exit holes in fruit.

(A). Exit holes are 5/16" in diameter having a sort of ring around them. Apples have burrows and heaps of excrement in the pulp, around and within the core. Often excrement and core parts are thrust out of the fruit via burrows in the calyx end. Seeds are often eaten out. The worm is $\frac{3}{4}$" long, pinkish-white, has legs, and has a brown head. They enter usually via the calyx opening into the pulp to the core. (9, p. 49), (45, pp. 40-44), (47f, p. 1). ..... Codling moth Carpocapsa pomonella.

~(6). Internal worminess.

(A). Worny apples.

(I). Apples have burrows and heaps of excrement in the pulp, around and within the core. Often excrement and core part are thrust out of the fruit via burrows in the calyx end. Seeds are often eaten out. The worm is ½" long, pinkish-white, has legs, and has a brown head. They enter usually via the calyx opening into the pulp to the core.....
.....Codling moth, page 30.

(II). Burrows and excrement are in the pulp and core, even excrement is forced out upon the outside. Late apples in close proximity to peaches are most seriously attacked after peaches are harvested. The worms are pinkish or creamy-white, ½" long.....Oriental fruit moth, page 5.

(III). Burrowing worms under the skin, traveling about in a winding circuit first just under the skin, then next to the core; sometimes they infest the core. The worms are ¼" long, legless, headless, and white in color. (23, p. 95), (45, p. 44), (47f, p. 15).
.....
Apple maggot Rhagoletis pomonella.

(IV). Burrows are under the skin of apples which entirely under-mine the calyx end. The mines are shallow but broad, seldom entering the core. The worm is 5/8" long, pinkish or nearly white. (53, p. 23), (23, p. 95), (45, p. 44).
.....
Lesser apple worm Laspeyresia prunivora.

(B). Grubby apples.

(I). Grubs 1/3" long, milky-white, legless, with a brown head, and strongly curved reside in the pulp or core.....
.....Plum curculio, page 28.

(II). Grubs nearly ½" long, brown or light-brown with four distinct humps on the back have no legs and are strongly curved bore about in the fruit.....
.....Apple curculio, page 28.

(C). Fruit seeds eaten out.
(I). Seeds have 1/5", spindle-shaped curved maggots which hollow out seeds, then hibernate therein for the winter. (32, p. 355).
.....
Apple seed chalcid Syntomaspis druparum.

(7). Misshapen fruits.
(A). Dwarfed fruits.
(I). Fruit is undersized, of poor color and quality. The foliage is speckled, then drops permaturely.
.....European red mite, page 17.

(II). Dwarfed fruit with a rough, uneven, more or less pitted and warty surface.....Rosy apple aphid, page 7
or Apple aphid, page 7.

(B). Fruit surfaces irregular.
(I). Fruit is normal on one side, on the other side there are skinless areas over which the fruit tries to grow new skin but by so doing the apple becomes warped out of shape.
....Fruit tree leaf roller, page 10.

(II). Same injury as above, but several apples on a given limb are so injured; sometimes half of the pulp is eaten out and the hole never is grown over.....
Green fruit worm, page 29.

(III). Dimpled and pitted fruit, causing a gnarled surface. (45, p. 47), (47f, p. 12), (53, p. 28).
.....
Apple red-bug Lygidea mendax.

(IV). Lumpy or knotty fruit somewhat dwarfed.....Rosy apple aphid, page 7
or Apple aphid, page 7.

(V). Depressions in fruit having numerous sting-like holes or healed scars. Between the stings the surface humps

up....Apple curculio, page 28.

(VI). Similar to preceding, but the depressions have crescent-shaped scars instead of rounding scars. The irregularity of the surface is much worse than in the preceding species. The surface is badly warped, humped, and pitted. .....Plum curculio, page 28.

(8). Premature fruit shedding.

(A). Tree weakness causing premature fruit shedding.

(I). Infested leaves turn yellow, all growth ceases. Branches and twigs have coverings of brown soft-bodied scales 1/8"-3/16" long, sort of half-pea-shaped..... ...European fruit lecanium, page 4.

(II). Speckled foliage, from a distance appearing dust laden, falls prematurely..... ....European red mite, page 20.

(III). During dry spells or in arid areas the foliage drops, followed by fruit dropping. Foliage turns yellow and curls before dropping. .....Clover mite, page 20.

(B). Wormy apples dropping prematurely.

(I). Apples have winding circuit burrows between the skin and core, in which is much excrment. The worms are white, legless, headless, 1/4" long..... .....Apple maggot, page 31.

(II). Apples have burrows and heaps of excrement in them, in the pulp, around the core, and in the core. If the worm made its escape there is an exit hole 3/16" round with a ring around it. .....Codling moth, page 30.

(III). Gnarled, knotty fruit which has crescent-shaped incisions or scars on the outside and grubs within. They are 1/3" long, milky-white, having a brown head, they are strongly curved and legless. .....Plum curculio, page 28.

(C). Fruit stems eaten, causing fruit to drop.

(I). Early in the spring fruit stems are gnawed and severed.
....Imbricated snout beetle, page 13.

(II). Apples leaves and fruit stems are severed, causing leaves and fruit to drop early in the summer or late spring. (59, p. 67), (34, p. 96), (53, p. 389).
.....
Fullers' rose beetle Asynonychus godmani.

KEY TO THE MORE IMPORTANT PEAR INSECTS.

I. TRUNK, BRANCHES, AND TWIGS.

A. Trunk.

1. Mature trees.

a. Burrows from 1-2" below the ground line to a foot or more above, they are within the inner bark and sapwood, extending into the heartwood. Darkened, dead, bark areas near the base of the tree or coils and piles of reddish sawdust-like particles on the bark and ground reveal the insects' presence. If present, they can be detected if the ground is scraped away from the tree at the ground line. Exit holes made by adults are ordinarily 8-10" above ground, the diameter of a pencil. Deadened bark areas cause a general tree weakness; a complete girdling kills the tree. (51, p. 185)*, (23, p. 87), (47f, p. 80). .....
Round-headed apple tree borer Saperda candida.

b. Shallow, broad, irregular burrows just under the bark and in the sapwood of trunk and large branches. Above the burrows the bark areas darken and take on a deadened appearance. Inside the burrows are fine sawdust and excelsior-like fibres. The injury is due to deadened bark areas girdling the tree. The sunny side of the tree is the principal center of attack. (44, p. 52), (4, pp. 1-12), (32, p. 300), (27, pp. 27-30). .....
Flat-headed apple borer Chrysobothris femorata.

c. Grubs bore in sapwood just under the bark causing the bark to swell and crack, thus killing the tree outright. They attack any tree from nursery stock to old trees, either the trunk or branches. (23, p. 153), (51, p. 230), (36, p. 588). .....
Sinuate pear tree borer Agrilus sinuatus.

d. Wounds on trunks and branches covered with cottony masses sheltering purplish aphids. Underground trunk and roots are knotted. Many adventitious fibrous roots make their appearance. The tree is likely to be stunted, seriously retarded, or entirely killed. Nursery stock is

*Figures in parenthesis refer to literature cited; see list of references at end of key.

often seriously affected. Wherever the insects feed galls are grown by the tree to overcome them; they kill branches; roots crack and die. Fruits become dwarfed and smeared with excretions from the insects, doubly causing the crop to be unsightly. (11, pp. 5-23), (23, p. 101), (2, p, 135), (47f, p. 88). .....
Woolly apple aphid Eriosoma lanigera.

e. "Shotholes" in bark the size of a pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles in burrows, adults are 1/8" long. (32, p. 340), (3, pp. 3-8), (36, p. 530). .....
Shot-hole borer Scolytus rugulosus.

2. Nursery stock or young trees.
   a. Trunk, branches, twigs, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both fruit and bark, the area turns red. Under magnification the specks are disks having a central raised nipple-like blackish spot. Tree vigor decreases, foliage becomes scant. (47c, pp. 1-13), (21, p. 165), (59, p. 70), (25, p. 126). .....
San Jose scale Aspidiotus perniciousus.

   b. Trunk, branches and twigs are covered with small brownish scales 1/16 to 1/8" long, curved and resembling an oyster shell; underneath individual scales are many minute eggs. Bark cracks and the whole tree weakens or dies. (47b, p. 1), (23, p. 124), (47g, p. 63). .....
Oyster shell scale Lepidosaphes ulmi.

   c. Branches and twigs from May through July have undersurfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (36, p. 676), (25, p. 295), (2, p. 153). .....
Cottony maple scale Pulvinaria vitis.

   d. Branches, twigs, and even the trunk may be coated with dirty-white scales 1/10" long. In the winter time if the scales are flipped over, with the naked eye one can discern reddish-purple eggs. (51, p. 176), (47b, pp. 6-11), (32, p. 125), (36, p. 675). .....
Scurfy scale Chionaspis furfura.

e. During the winter bark on undersides of branches and twigs is nearly covered over with shiny convex-shaped brownish scales 1/12" in diameter. In the summer the fruit is coated with honeydew masses growing sooty-black fungi which renders the fruit unsalable. (32, p. 129), (2, p. 55), (36, p. 603). .....
Terrapin scale Lecanium nigrofasciatum.

f. Branches, twigs, and leaves have large brown soft-bodied half-pea-shaped scales 1/8 to 3/16" long. They cluster together on one side of the twig or branch. They winter over on smaller branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow, all growth ceases, followed by premature shedding of foliage and fruit. (51, p. 261), (32, p. 129), (23, p. 148). .....
European fruit lecanium Lecanium corni.

g. Wounds in branches and trunk are crowded over with cottony masses sheltering purplish aphids. Wounds form gall-like knobs in endeavoring to overcome the toxic stimulation. Underground trunk and roots are also subject to attack. Infested trees often grow numerous adventitious fibrous roots. Roots die, the tree is stunted, or may even be killed overnight. .....
.....Woolly apple aphid, page 36.

B. Branches.

1. Dead bark areas on sunny side of tree.
   a. Exit holes through bark reaching into sapwood.
   .....Flat-headed apple tree borer, page 35.

2. Borers in branches.
   a. Narrow winding burrows from beneath the bark way into the heartwood. Bark areas above burrows darkened or dead. .....
   .....Sinuate pear tree borer, page 35.

   b. "Shotholes" in branches just above bud scars.
   .....Shot-hole borer, page 36.

   c. Shallow, broad, irregular burrows under bark and in sapwood on the sunny side of tree.
   .....Flat-headed apple tree borer, page 35.

3. Tree injuries having cottony coverings.
   a. Cottony masses over injuries, under which reside purplish aphids. .....
   .....Woolly apple aphid, page 36.

4. Bark scales or coverings of branches.

a. There are 1/12" dark ashy-gray scales on branches and twigs. The central elevation is orange in color and off center. Branches and twig scales similar to Putnam's Scale (page 5) and Cherry Scale (page 5) distinguished only by miscroscopic characters. (51, p. 201), (45, p. 58). .....
European fruit scale Aspidiotus ostreaeformis.

b. Minute thin grayish scales massed together upon branches and twigs. Under magnification the specks appear to have a raised reddish area in the center of each; thus they are distinguished from the San Jose Scale (page 3); otherwise they are similar. (32, p. 128), (36, p. 617). .....
Cherry scale Aspidiotus forbesi.

c. Branches and twigs have dark gray to nearly black almost circular scales, 1/12" in diameter. The raised orange tip is off center. (51, p.172), (25, p. 283), (32, p. 179). .....
Putnam's scale Aspidiotus ancylus.

d. Branches and twigs are coated with 1/8" reddish-orange scales; the central spot is off center. (51, p. 360), (25, p. 283). .....
Walnut scale Aspidiotus juglans-regiae.

e. Grayish specks on fruit and barks, individually invisible to the eye, surrounded by a reddish area. .....San Jose scale, page 36.

f. Oyster-shell-shaped scales 1/16 to 1/8" long. .....Oyster shell scale, page 36.

g. The under-bark of twigs is covered with cottony masses from May through July. .....
.....Cottony maple scale, page 36.

h. Large brown soft-bodied scales, half-pea-shaped 1/8 to 3/16" long. Winter forms are flat, spindle-shaped, and immature. .....
.....European fruit lecanium, page 37.

i. Bark on undersides of branches and twigs is coated with shiny convex-shaped brownish scales 1/12" in diameter. .....Terrapin scale, page 37.

j. Bark covered with grayish scales 1/10" long. In winter, if flipped over, they will reveal very small reddish-purple eggs. .....
.....Scurfy scale, page 36.

C. Small branches, twigs, and shoots.

1. Twig borers.

a. Twig tips and their foliage die back because of small burrowing beetles 1/8" long, cylindrical in shape. Twigs are attacked just below a leaf scar; from there the burrow leads into the sapwood in one main longitudinal burrow and numerous lateral one called brood chambers. (15, p.165), (51, p. 232), (3, p. 13). .....
Pear blight beetles Anisandrus pyri.

b. Shoots die-back and wilt because of small boring larvae. Pinkish or creamy-white larvae ½" long in twigs causing the foliage to wilt and the whole shoot die. Early and late varieties of pears are attacked by the larvae, earlier broods attack the shoots, later broods attack the fruit. Pears in close proximity to peach orchards are most severely injured after the peaches are harvested. The internal worminess shows up as burrows and excrement in the pulp, in the core, or may even be exposed to the outside. (2, p. 132), (36, p. 608), (47, p. 10).
.....
Oriental fruit moth Grapholitha molesta.

c. Burrows from shoots to base of main stem widening out at base of shoots causing the twigs to wilt and drop off. The borings are lengthwise with the grain and contain ½" brown beetles. The injury is most noticeable in winter or early spring indicating the killed new growth. The whole tree, if injured in repeated years, will die; otherwise it is badly weakened. (50, p. 513), (15, p. 67), (51, p. 449).
.....
Apple twig borer Amphicerus bicaudatus.

d. Twigs from two to three inches long to two to three feet long litter the ground beneath the tree. The twigs are smoothly cut off; the severed part has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a ½" white grub. (51, p. 200), (25, p. 327), (36, p. 664).
.....
Twig pruner Elaphidion villosum.

e. Twigs to small branches ½" in diameter are often cleverly girdled by having a complete ring gnawed out of the bark to the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurred in the severed part, the egg hatches and the grub eats out all but the bark, as it lies on the ground. (51, p. 202), (55, p. 282).

.....
Twig girdler *Oncideres cingulatus*.

2. Gnawed twigs.
   a. Twigs badly gnawed so they droop, buds entirely gnawed off. Injury occurs early in season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. The insect is a ¾" snout beetle grayish and black mottled. (55, p. 78), (36, p. 532), (47f, p. 37).
   .....
   New York weevil *Ithycerus noveboracensis*.

3. Twigs die-back.
   a. Twigs and shoots, especially on nursery stock, die back as if infested with borers. The insect is ¼" long, ovular-shaped, and coppery-brown. (36, p. 611), (32, p. 163), (2, p. 139).
   .....
   Tarnished plant bug *Lygus pratensis*.

4. Severed twigs.
   a. Twigs hollowed out, causing adjoining shoots to wilt and break off. .....
   .....Apple twig borer, page 39.

   b. Hollowed twigs from 2-3" long to 2-3 feet long litter ground under the tree. .....
   .....Twig pruner, page 39.

   c. Twigs or branches, less than ½" in diameter, litter the ground under the tree. The severed end shows it was gnawed off. .....
   .....Twig girdler, page 39.

5. Bark coatings on twigs.
   a. Scales.
      (1). Grayish specks on fruit and bark, individually invisible to the eye, surrounded by reddish areas. .....
      .....San Jose scale, page 36.

      (2). The bark on the lower side of twigs is covered with cottony masses sheltering purplish aphids, from May through July.
      .....Cottony maple scale, page 36.

      (3). Female scales are dirty-gray in color, irregularly pear-shaped. Male scales are much smaller, elongate, snowy-white, having three distinct keels extending longitudinally along the back. .....Scurfy scale, page 36.

      (4). Oyster-shell-shaped scales 1/16 or 1/8" long.
      .....Oyster shell scale, page 36.

(3). Bark on undersides of twigs is coated with shiny, convex, brownish scales 1/12" in diameter. .....Terrapin scale, page 37.

II. UNDERGROUND (trunk and roots).

A. Roots have galls, enclosing dark-blue aphids causing the roots to crack open and die, thus leading to ultimate death of the tree. .....Woolly apple aphid, page 36.

B. Trunk from 1-3" below ground to one foot or more above ground have shallow burrows from the bark to the heartwood. Dead bark areas overlie the burrows. 8-10" above ground are exit holes the size of a lead pencil made by the adult beetles. .....Round-headed apple borer, page 35.

III. FOLIAGE (Buds, Leaves, and Flowers).

A. Bud injury.

1. Buds eaten off.

a. Twigs badly gnawed so they droop, buds entirely gnawed off. Injury occurs early in season. Young trees set out in freshly cleared lands in close proximity to hickory or oak wood lots are seriously affected. .....New York weevil, page 40.

b. Complete or partial defoliation of buds, leaves, and flowers may occur overnight by an unseen predator. The injury occurs in the spring very early. Nursery stock or young trees are most subject to attack. (53, p. 158), (36, p. 488), (45, pp. 11-14). .....
Climbing cutworms Noctuidae sp.

c. Buds are entirely eaten off, as they begin to swell in the spring; later the fruit, leaves, and shoots become seared and pitted by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. Leaves are rolled together and tied by silken strands, in which the creature and his house seeks shelter. (32, p. 213), (36, p. 560), (47f, p. 54), (51, p. 68). .....
Leaf crumpler Mineola indigenella.

d. Buds, leaves, and flowers are stripped or badly ruined early in the season; buds and leaves are eaten off or eaten ragged and tattered; blossoms are nearly eaten off; newly set fruits are badly disfigured by having pits eaten into them. All the injury occurs during a one month or six week period. Adults beetles are 1/3" long, yellowish-brown and have long sprawling legs. (51, p. 454), (19, pp. 1-4), (45, p. 29). .....
Rose chafer Macrodactylus subspinosus.

e. Unfolding buds are entirely eaten off; unfolding leaves eaten tattered and ragged. (31, p. 400), (38, p. 264), (31, p. 451).
.....
Grape flea beetle Haltica chalybea.

2. Buds eaten into.
a. Opening buds are eaten into and destroyed consequently the future crop is injured or ruined. The epidermis of fruit is scooped out in places, which, of course, adds blemishes to the ripened crop. (31, p. 549), (45, p. 21), (47f, p. 31).
.....
Bud moth Choteosera ocellana.

b. Buds, unfolding leaves, and developing fruits are injured from the time buds open to three weeks after petal-fall. Several leaves and fruit clusters are tied together with silken strands; within the entanglements cavities are eaten into the fruit and the leaves are partially or entirely killed. Matured fruits have deep russeted, elongated scars badly deforming them. 21, pp. 1-6), (17, pp. 1-26), (38, pp. 3-5).
.....
Fruit tree leaf-roller Cacoecia argyrospila.

c. Buds, blossoms, and new foliage in new orchards in close proximity to locust trees become badly devastated by small beetles 1/10" long, as they voraciously feed. (31, p. 205), (47f, p. 38).
.....
Red-legged flea beetle Crepidodera rufipes.

d. Opening buds are eaten into, leaf and fruit stems severed by gnawings. The injury occurs from late May through June. The adults are 3/8-½" long, greenish-brown snout beetles. The wing covers are crossed by two irregular light lines. (31, p. 371), (36, p. 533).
.....
Imbricated snout beetle Epicaerus imbricatus.

e. In the spring buds are eaten off by caterpillars which travel about in twisted horn-shaped tubes or cases nearly an inch long. .....
.....Leaf crumpler, page 41.

3. Buds rasped.
a. Early in season buds shrivel up and turn brown, on close examination the browned surfaces reveal raspings caused by feedings of tiny black insects 1/20" long. Heavy infestations appear as injuries caused by fire. Oviposition in

stems of young fruit produces a wilting effect followed by premature fruit shedding. (33, p. 119), (56, p. 892), (50, pp. 1-7).

.....

Pear thrips Taeniothrips inconsequens.

4. Buds punctured.

a. Opening buds are punctured by aphid nymphs until they have access to succulent leaves. They suck sap from leaf and fruit stems; the leaves curl up and wilt, while the fruit stems curl and droop, thus dwarfing or killing the fruit. The aphids attract many ants by their honeydew secretions. Fruit spurs and inner tree-top portions are more subject to attack than terminal parts. (11, p. 31), (51, p. 532), (45, p. 32).

.....

Rosy apple aphid Anuraphis roseus.

b. Swelling and expanding buds are punctured and sap is withdrawn, resulting in slight injuries. Their presence need not cause alarm, even though 15-20 may be upon one bud or blossom; they are waiting for succulent leaves, on which they feed a very short time, to the end of May, then migrate from the tree. Some leaves, due to feeding punctures, will curl up. (47e, p. 8), (47f, p. 27), (45, p. 31). .....

Apple grain aphid Rhopalosiphum prunifoliae.

B. Leaf injury.

1. Feeders on expanding leaves.

a. Immature bugs feed, by their piercing and sucking mouth parts, on developing leaves, stems, blossoms, and fruits. The principal fruit injury occurs during the latter part of May when the fruit is setting; either the fruit drops or is misshapen. From the feeding punctures on new fruits exudes sap in continuous droplets. As the pear grows the punctures rupture the skin, exposing a yellowish pulp beneath. Mature fruit is irregularly shaped with humps and depressions. (40, pp. 1-7), (32, p. 164), (51, p. 221). .....

False tarnished plant bug Lygus invitus.

b. Many tiny gregarious caterpillars hatch out in time to lay waste expanding leaves; at first they eat out holes, later they consume the entire leaf except for the largest veins. Complete defoliation is not uncommon. Mature

caterpillars are two inches long, having ten pairs of dorsal blue tubercles and six reddish, separated by a yellow median line; otherwise the body is clothes with long black hairs. (25, p. 273), (5, pp. 1-23), (47, p. 49).
.....
Gypsy moth Porthetria dispar.

c. Unfolding leaves are injured by caterpillars which form a house out of leaf pieces and saliva in which they travel about; the caterpillars' cases are nearly an inch long. .....
.....Leaf crumpler, page 41.

d. Undeveloped foliage is badly eaten into and seriously injured. New orchards in close proximity to locust trees become injured the most.
.....Red-legged flea beetle, page 42.

e. Young trees and nursery stock are especially subject to early defoliation as the leaves first begin to unroll. The epidermis of fruits is scooped out. .....Bud moth, page 42.

f. Unfolding leaves are eaten into so they appear ragged and tattered. .....
.....Grape flea beetle, page 42.

g. From the time of bud opening to three weeks after petal-fall small caterpillars tie leaves and fruit clusters together, then eat the leaves. The leaf parts which are not eaten dry up.
.....Fruit tree leaf-roller, page 42.

h. Webs are spun at terminal points where many caterpillars centralize. The webs are conspicuous during the winter, while the larvae are in hibernation. The August brood tends to skeletonize leaves, but the principal injury occurs when the overwintering caterpillars revive in the spring to devour unfolding leaves as fast as they make their appearance. There is one generation each year; in the first stage the injury is by skeletonization; in the second stage it is by devouring leaves in the spring as rapidly as they appear. (5, pp. 24-32), (2, p. 128). .....
Brown-tail moth Nygmia phaeorrhoea.

2. Leaf miners.
   a. Leaves are rolled up and tied together by leaf-eating larvae which eat off the under leaf surfaces. The earliest caterpillar stage is spent as a leaf miner; then it rolls and ties leaves together and punctures fruit skins, eats out fruit pulp, eats off flowers, buds etc. (38, p. 63), (21, p. 550), (22, p. 760).
   .....
   Oblique-banded leaf roller Cacoecia rosaceana.

   b. Bark on trunk and branches have 1/10" seed-like protuberances within which reside small destructive pupating caterpillars. In the larval stage they are mobile leaf miners, making a mine 1/4" in diameter. (31, p. 75), (32, p. 232).
   .....
   Resplendent shield bearer Lepidisca splendoriferella.

3. Speckled leaves.
   a. Leaves become speckled, browned, and appear dust laden from a distance; the leaves drop prematurely. Feeding punctures in the leaves rob them of chlorophyll and at the same time poisoning the surrounding tissue. Very light spider webs on leaf undersurfaces. Fruit is undersized, of poor quality and color. (10, pp. 1-125), (2, p. 140), (47f, p. 67). .....
   European red mite Paratetranychus pilosus.

   b. Leaves have small reddish or greenish galls or blisters $\frac{1}{4}$" across on the underside which turns brown, spotting the leaves with dead areas; leaves are quite likely to drop when affected thus. (47a, pp. 1-6), (22, pp. 1-12), (2, p. 140). .....
   Pear leaf blister-mite Eriophyes pyri.

4. Leaves skeletonized.
   a. Leaves are badly skeletonized, during a three months period, by metallic-green or greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of the abdomen. They swarm together in great numbers. The fruit is either gouged or partly peeled in irregular shallow patches. (48, pp. 1-24), (2, p. 127), (23, p. 103).
   .....
   Japanese beetle Popillia japonica.

   b. Leaves are skeletonized, or buds, leaves and flowers badly ruined early in the season. Buds and leaves are just about eaten up, new fruit has holes eaten out. .....Rose chafer, page 41.

c. Buds and blossoms are eaten, foliage skeletonized in new orchards in close proximity to locust trees. .....
.....Red-legged flea beetle, page 42.

d. Unsprayed or neglected orchards are likely to become defoliated in late August or September because of severe leaf skeletonization. As the caterpillars go hither and yon they spin a single thread; whenever complete defoliation besets a tree the caterpillars twine their threads while in search of food until they have the whole base of trunk wrapped in one huge web. (2, p.126).
.....
Apple and thorn skeletonizer Hemerophila pariana.

e. Leaves in August become skeletonized by caterpillars inhabiting webs at branch tips.
.....Brown-tail moth, page 44.

f. Leaves show nothing more than a mere framework of veins. The pest is a dark-green slimy slug. (51, p. 240), (36, p. 616). .....
Pear slug Briocampoides limacina.

g. Identical in all respects to the preceding except the pest is blackish with a dark brown head. (51, p. 569). .....
Pear slug Caliroa cerasi.

5. Leaf protuberances.
a. Cone-like protuberances growing on undersides of leaves within which are hanging caterpillars. The growths are natural leaf resistances to the feeding larvae. (26, pp. 1-7), (26, p. 215), (51, p. 503). .....
Bagworm Thyridopteryx ephemeraeformis.

b. Caterpillars which travel about in a twisted horn-shaped tube or case, nearly an inch long, roll together and tie leaves to form a shelter. When feeding they may be upon the twig, a leaf, or on fruit. .....Leaf crumpler, page 41.

6. Leaves webbed together.
a. Edges of leaves are drawn and tied together, then within the fold the caterpillars eat off the under epidermal layer; from a distance the injury appears like fire blight. Nursery stock is more often subject to attack. (51, p. 59), (32, p. 231), (38, pl 306). .....
Yellow-headed fireworm Alceris minuta.

b. Early in spring leaf clusters are bound together as a cluster. If the shelter is torn apart it will be found to contain tough, horn-shaped cases inhabited by caterpillars. .....Leaf crumpler, page 41.

c. Early in season many leaf and fruit clusters are bound together; the damage occurs between bud opening and three weeks after petal-fall. .....Fruit tree leaf-roller, page 42.

d. Either single or grouped leaves are wound together by caterpillars which eat the under leaf surfaces. The earliest larval state is spent as a leaf miner. ....Oblique-banded leaf roller, page 43.

e. Single leaves are rolled so the lower and upper surfaces are tied together by silken strands. The larval period is nearly all spent as a leaf miner; during the latter part the caterpillar eats through one surface and after that remains as a semi-leaf-miner partially buried and partly exposed. ....Resplendent shield bearer, page 45.

7. Leaves curl up, turn pale, dry, and drop prematurely.

a. Early in season leaves turn brownish or black, dry up, and during midsummer fall prematurely. The fruit remains small and it too falls prematurely. Leaves and fruit on infested trees are more or less covered with unpleasant secretions which acquire a black sooty fungus growing thereon. The honeydew is usually the first indication of their presence. The insects are 1/10" long have sucking probosces, and hover on the undersides of leaves. (51, p. 218), (9, p. 41), (36, p. 588). .....
Pear psylla Psyllia pyricola.

b. Leaves turn pale yellow, curl up, and drop. Lower leaves are attacked first, then the higher ones, etc. The fruit is stunted. The injuries become most severe in dry seasons and in arid areas. Twigs and stems have numerous red or pinkish eggs upon the bark sufficient to produce a reddish hue, during the dormant stage. Small six or eight legged creatures in-

...bit the under leaf surface. (47a, p. 66), (21, pp. 1-9), (50, p. 88). .....
...Clover mite Bryobia pratensis.

c. Affected leaves become burned and from a distance appear dead. The leaves drop prematurely. The fruit is undersized, of poor quality and color. .....
.....Pure pear rust mite, page 45.

d. On under leaf surfaces are brownish blisters 1/8" in diameter or masses of them; under magnification the blisters are found to swarm with tiny mites. Eventually the tree becomes defoliated. Sometimes the fruit is injured by epidermal cracking. .....Pear leaf blister-mite, page 45.

e. Very early in the season leaves become curled up and drop; in reality they drop before attaining full development. This is the least injurious of apple aphid species. .....
.....Apple grain aphid, page 42.

f. As new leaves unfold they commence to curl, dry up, and drop. Inside the leaf curl are multitudes of aphids sucking sap from developing leaves, stems, and newly forming fruit.
.....Rosy apple aphid, page 43.

g. Same as preceding, except this species remains upon the tree the year-round instead of a short period early in the spring. Because they remain upon the tree the year-round they produce large quantities of honeydew bearing sooty-black fungi. (11, pp. 87-8), (2, p. 134), (31, p. 147). .....
Apple aphid Aphis, genl.

8. Foliage eaters.
a. Single defoliators.
(1). Beetles.
(A). Complete or partial defoliation, as if it occurred overnight. Injury occurs in mid or late spring, during May or June. Large beetles lying on the ground beneath the tree, or flying noisily about lights with a loud buzzing. (36, pp. 306-10), (2, p. 838), (22, p. 302). .....
June beetle Lachnosterna sp.

(B). Leaves may be either badly eaten ragged or may be skeletonized in spots by beetles slightly larger than a potato beetle; their size enables each to do a great amount of damage. They are metallic-green or greenish-bronze beetles having two distinct white spots near the tip of abdomen. .....Japanese beetle, page 45.

(2). Caterpillars.

(A). Complete or partial defoliation may occur overnight without leaving the least trace of the predator. ....Climbing cutworms, page 41.

(B). Giant caterpillars, over two inches long. They feed for a month or so without seriously injuring the tree, due to the rarity of them. They spin cocoons when through feeding, then hibernate over winter.
Promethea moth (25, p. 268).
Cecropia moth (25, p. 266), (57, p. 91).
Polyphemus moth (25, p. 267), (57, p.93).
Luna moth (25, p. 268).

b. Colonial defoliators.

(1). Web spinners.

(A). Thick webs are spun in forks or crotches and used as a shelter only; all feeding is done outside of the web. Within the web the leaves dry up and die; outside the web they are stripped. As the caterpillars grow they enlarge the web to accommodate the colony. The caterpillars are brown having a white dorsal line with blue sides and are sparsely haired. Early in the season, when buds and leaves are in development, the webs are spun. (46, ppl 1-9), (45, p. 14), (47g, p. 70), (47f, p. 42). .....
Eastern tent caterpillar Malacosoma americana.

(B). Dirty-white loosely woven webs, containing excrement everywhere, enclose branch tips late in the summer or early fall. The chief difference between this and the preceding species are that this species feeds within its web while the former does not, and

this species spins its web late in the summer, while the former spins early in the spring. The caterpillars are pale-yellow spotted with black and are very hairy. (45, p. 18), (47f, p. 44), (55, p. 265).

.....

Fall webworm Hyphantria cunea.

(C). Webs are spun at terminal points where many caterpillars centralize. The August brood skeletonizes the leaves quite badly but the greatest injury takes place in the spring when the hibernating caterpillars revive to devour new leaves as fast as they unfold.

.....Brown-tail moth, page 44.

(2). Non web spinners.

(A). During the spring greenish, brownish, or black measuring worms one inch long spin long threads from which they dangle and so tangle up the tree that the leaves curl up, dry, and may drop prematurely. The leaves are nigh complete destruction, the fruit is badly dwarfed. The defoliation is more common in the upper half of the tree, especially the center, (45, p. 20), (25, p. 222), (55, p. 87). .....

Spring cankerworm Pale acrita vernata. (45, p. 20), (25, p. 222), (55, p. 89).

.....

Fall cankerworm Alsophila pometaria.

(B). In midsummer colonies of caterpillars appear and completely defoliate branches or the whole tree; nursery stock or young trees are most likely to be attached. When not feeding they congregate on the trunk or branches. When at rest the caterpillars either have the rear end elevated or the fore and rear ends elevated; when startled they raise both ends suddenly and remain so. The caterpillars are two inches long, black and yellow striped, having a yellow ring around the neck. (55, p. 90), (23, p. 118), (38, p. 270).

.....

Yellow-necked caterpillar Dantana ministra.

(C). Same as the preceding species except the caterpillars are black and yellow striped with a coral-red hump just behind the head with a row of spines pro-

jecting from it. (55, p. 90), (23, p.118), (38, p. 271). .....
Red-humped caterpillar Schizura concinna.

(D). In the spring young caterpillars eat off the leaf epidermis but later the entire leaf save for the midrib; some also gnaw holes in the fruit. The 1½" larvae have three pencil-like tufts of long black hairs, one on each side of the head and one at the dorsal posterior end; also two bright-red spots on back of rear end. (38, p. 295), (55, p. 269), (2, pp. 207-13), (32, p. 202). .....
White-marked tussock Hemerocampa leucostigma.

(E). This insect resembles the preceding. It has a black head and the first two tussocks are black, in young caterpillars, but turn white later. Later an additional pencil of long black plume-tipped hairs project laterally from the second abdominal segment. (38, p. 295), (32, p.203) .....
Rusty tussock moth Notolophus antiqua.

(F). Neglected orchards have leaves stripped of the epidermis in midsummer, followed by consumption of all save the midrib. The injury is done by caterpillars 1½" long, covered with dense and spreading tufts of white hairs, a row of eight black tufts on the back and two long slender black pencil on the fourth and tenth segments. The head, feet, and under body surfaces are black; upper body surface is white spotted with black. (32, p. 183), (2, p. 246). .....
Hickory tussock moth Halisidota caryae.

(G). Caterpillars which spin one thread as a "gi-line" wherever they travel; when not feeding they congregate on trunk or branches. If food is scarce they go out after it in form like marching army worms. The caterpillars are 1¾" long, having a median row of white "lozenge shaped" dots along the back. (32, p.204), (55, p. 80), (32, p. 204). .....
Forest tent-caterpillar Malacosoma disstria.

(H). Early in the spring colonial caterpillars hatch out in time to consume opening buds and devour the foliage as fast as it unfolds; at first hole are eaten in the leaf, then all but the midrib is eaten away. The insect is two to three inches long; along the back are two rows of blue spots with a dim yellow stripe between; the body is clothed with long black hairs. .....Gypsy moth, page 21.

(I). Leaves, buds, and flowers may be stripped partially or totally overnight by an unseen enemy. The injury takes place early in the Spring and is more likely to center in nursery stock or young trees. .....Climbing cutworms, page 41.

9. Premature defoliation.

a. Early in season leaves turn brownish or black, dry up, and fall during midsummer. Leaves, as well as fruit, are covered with unpleasant secretions which acquire a black sooty fungus growing thereon. .....Pear psylla, page 47.

b. Early in season leaves become curled up and drop; in reality they drop before attaining maturity. .....Rosy apple aphid, page 43.

c. Shoots and leaves dry up, any time from spring to early fall, because of plant lice which do not migrate but remain on the host the year round. Large honeydew accumulations secreted by the lice attract multitudes of ants. Both leaves and fruit bearing honeydew black sooty fungi growing all over them. .....Apple aphid, page 43.

d. Green, yellowish, or black measuring worms one inch long, when abundant, spin so many single threads, from which they dangle, that the tree becomes entwined; the leaves dry up and drop prematurely.....Spring and fall worms, page 50.

e. Leaves turn pale yellow, curl up and drop. Lower leaves are attacked first; then the higher leaves, etc. Most severe injury occurs during dry seasons and in arid areas. Small six or eight-legged creatures inhabit under leaf surfaces.....Clover mite, page 48.

f. Speckled leaves become browned and drop prematurely. From a distance they appear dust-laden.....European red mite, page 45.

g. Brownish blisters one-eights of an inch in diameter on the under leaf surfaces swarming with tiny mites, visible only if a magnifier is used.....Leaf blister mite, page 45.

C. Flower injury.

1. Flowers injured by punctures.

a. Buds, stems of new leaves and flower stems are tapped by small sap-sucking insects. The flowers dry up and die. The injuring insect is a green aphid. (51, p. 151), (47g, p. 8), (32, p. 142). .....
Apple grain aphid Siphocoryne avenae.

b. Young nymphs puncture stems of flowers and leaves from which they rob sap; consequently the stems wilt and the flowers and leaves die. The injuring insect is ¼" long, light brown in color. .....False tarnished plant bug, page 43.

c. Unopened flower buds are punctured by mosquito-like insects 1/10" long. At the time of puncturing the female deposits 12-45 eggs; the eggs hatch and the larvae work into the developing ovary to destroy its entire central portion. The partly developed fruit drops shortly before or after setting. (37, pp. 1-7), (23, p. 152), (51, p. 225). .....
Pear midge Taeniothrips inconsequens.

d. Blossom stems are punctured by sap-sucking bugs which cause them to shrivel up. Before pears are ½" in diameter they are punctured by bugs ¼" long which cause them to drop or be dwarfed. At punctured places sap oozes out and lingers, later the spot turns black. As growth occurs the skin becomes ruptured exposing on inner layer of light yellow. As growth continues the punctured areas becomes depressed, while the surrounding areas hump up. (40, pp. 1-8), (51, p. 221), (32, p. 164). .....
False tarnished plant bug Lygus invitus.

2. Flowers eaten into or entirely eaten off.

a. Blossom clusters and clusters of new fruits are eaten into or entirely eaten off or later gnawed and gouged out.....Rose chafer, page 41.

b. Small beetles 1/10" long eat into and destroy flowers. Adult beetles have shiny-blue wing covers and reddish brown head, thorax, antennae, and legs.....Red-legged flea-beetle, page 42.

c. Flower ovaries are punctured and the insides eaten out or else oviposition occurs there and the milky-white larva begins its development within the center of the growing ovary and later developing core. (28, p. 187), (51, p. 271), (71, p. 590). .....
Plum gouger Anthonomus scutellaris.

d. Small insects 1/50" long rasp away the flower parts and work into the ovary. Their rasping is injurious but their oviposition in flower and fruit stems is worse; it causes the stems to lodge and the flower or fruit to die, then drop prematurely. (39, pp. 1-8), (9, p. 42), (22, p. 146). .....
Pear thrips Euthrips pyri.

e. Overnight a tree is stripped of its flowers, buds, and leaves by an unseen pest. Young trees and nursery stock are most liable to be preyed upon. In large trees a certain limb or limbs are attacked .....climbing cutworms, page 41.

IV. FRUIT.

A. Newly set or setting fruit injured.

1. As newly set fruit clustered begins to separate, plant lice in abundance begin feeding on the fruit stems robbing the fruit of its needed nutriment. As a result of the feeding the fruit stems warp and lodge or the fruit sap is so checked off that the fruit does not normally mature later, but remains stunted.....Rosy apple aphid, page 43.

2. Newly set fruit cracks and then drops prematurely. Upon examination the inside reveals the whole core eaten out by many tiny maggots. .....
.....Pear midge, page 53.

3. Newly set fruits are enclosed by silken strands and rolled leaves and they have the skins scored and the fruit pitted. Within the tangled mass of leaves and fruit reside many tough horn-shaped cases inhabited by the destroying caterpillar. .....
.....Leaf crumpler, page 41.

4. Green worms spin threads and tie together leaves and fruit clusters, the leaves are consumed but the fruits are russeted and deeply scarred in long streaks.....Fruit tree leaf roller, page 42.

5. Leaves are drawn together either singly or in groups and tied fast. The leaves show leaf miners infesting them. Caterpillars are 2" long and have brownish-black heads and thoracic shields. Fruits within the entanglement have gnawed holes through the epidermis. .....
.....Oblique-banded leaf roller, page 45.

6. Fruit in clusters become badly chewed up by beetles 1/3" long, yellowish-brown, and possessing long sprawling legs. .....Rose chafer, page 41.

B. Fruit blemishes (outside).

1. Fruits have coverings of honeydew bearing a sooty-black fungus. Under leaves and on the fruit are tiny reddish-brown cicada-like insects 1/10" long. .....Pear psylla, page 47.

2. Honeydew covered fruit harboring a scoty-black fungus. In the winter undersides of twigs and branches are nearly covered with shiny convex-shaped brownish scales 1/12" in diameter. .....Terrapin scale, page 37.

3. Minute grayish specks on the bark and fruit surrounded by a reddish area. .....San Jose scale, page 36.

C. Fruit blemishes (through the epidermis).

1. Crescent-shaped scars.

a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times the scars develop depressions instead of humps. The fruit becomes hard, knotty, and misshapen, usually dropping during May or June. Inside the fruit resides a grayish-white curved larva. (6, pp. 469-513), (9E, pp. 1-40), (47f, p. 6), (9, p. 40).
.....
Plum curculio Conotrachelus nenuphar.

b. Misshapen, knotty, and undersized fruit have small holes eaten in ends or sides; when the crescent-shaped or round holes are close together the skin between dries up. The female oviposits, after digging out a hole in the fruit, then plugs the hole with excrement. Infested fruit may or may not drop. (6, pp. 515-56), (47f, p. 21), (23, p. 116), (9, p. 50).
.....
Apple curculio Tachypterellus quadrigibbus.

2. Round holes or round scars.
   a. Round holes eaten out during feeding or oviposition. Infested pears contain a milky-white grub but do not drop before ripening. .....Plum gouger, page 54.

   b. Misshapen, knotty, and undersized fruit have small holes are eaten in ends or sides; when the crescent-shaped or round holes are close together the skin between dries up. The female oviposits, after digging out a hole in the fruit, then plugs the hole with excrement. Infested fruit may or may not drop. ....Apple curculio, page 55.

3. Holes gouged or eaten out.
   a. Yellowish or greenish naked caterpillars 1½" long have a creamy mid-dorsal stripe plus a similar but wider lateral stripe; in the latter part of May or June they eat holes in the fruit. They injure many fruits on a given branch because they can't travel far. Because they are large by the time codling moths orchards are sprayed they are able to resist the poisons and thrive. They injure by eating foliage and by scooping out holes in the fruit and eating into the pith. (44, p. 26), (56, p. 574), (51, p. 59). ..... Green fruit worms Graptolitha antennata and others.

   b. Newly set fruits are badly injured by having the skins chewed off and deep holes scooped into the pith. Beetles of a yellowish-brown color, having sprawling and long legs, and being 1/2" long. .....Rose chafer, page 41.

   c. Injury same as preceding performed by a beetle the size of a potato beetle. The head and thorax is shining bronze-green while the wing covers are tinged with green at the edges. The protruding abdomen has the tip and sides spotted with white. .....Japanese beetle, page 45.

   d. New fruits have deep holes scooped out of the pith. The injury was done by caterpillars 1½" long, yellowish-black, hairy, and striped. They have three pencil-like tufts of long black hairs that project, one on each side of the head, and one from the rear end. The posterior dorsal surface has two bright-red spots. .....White-marked tussock moth, page 51.

e. Matured fruit shows deep russeted elongated scars through the fruit skins into the pith. The injury takes place early in the season and is done by tiny caterpillars which are green with black heads, at first; later they become green entirely. .....Fruit tree leaf roller, page 42.

f. Caterpillars puncture the fruit skins and eat away the pulp. The injury happens early and to young fruits. Caterpillars ¾" long, with brownish-black head and thoracic shield do the damage.....Oblique-banded leaf roller, page 45.

g. New fruits are scooped into by feeding caterpillars. The feeders are ½" long, cinnamon-brown with a black head, thoracic shield, and legs. .....Bud moth, page 42.

h. Fruit skins blister, crack open, and the fruit is dwarfed or drops prematurely. Such is an extreme case of infestation. .....Pear leaf blister mite, page 45.

D. Premature fruit shedding.

1. Leaves of infested trees turn yellow, tree and fruit growth ceases, fruit falls prematurely. Branches have half-pea-shaped brown scales 1/8"-3/16" long which are soft-bodied. .....European fruit lecanium, page 37.

2. Young fruits crack and drop prematurely. Upon close examination of stems they will be found to contain nymphs of insects 1/20" long or their eggs.....Pear thrips, page 54.

3. Young fruit drop prematurely. Upon close examination 12-45 maggots will be found which have eaten out the core.....Pear midge, page 53.

4. Before pears are one-half inch in diameter they are tapped by bugs 1/4" long which cause them to drop, or else dwarfs the ones that do not drop. At places where punctures occurred sap oozes out and lingers; later the punctured place turns black. As growth occurs, the skin becomes ruptured exposing an inner layer of light yellow. As growth continues the punctured area becomes depressed while the other areas become humped.....False tarnished plant bug, page 43.

5. Fruit has crescent-shaped incisions in the skins and an irregularly humped and depressioned surface. Fruits drop before maturing, during May and June.....Plum curculio, page 55.

6. Fruit having crescent-shaped incisions may drop or else have growth partially arrested. (Very similar to preceding species except larvae within are milky-white instead of grayish-white). The larva is ½" long, footless and hump-backed.....Apple curcilo, page 55.

7. Many pears drop before ripening. Within the pear is a ½" larva, whitish or pinkish, having a brown head. The fruit may have a 3/8" round exit hole. The entrance is through the calyx end into the core, which it eats out, then makes its escape. (2, p. 49), (23, p. 85), (36, p. 568). .....
Codling moth Carpocapsa pomorella.

8. Foliage speckled and sickly looking, appearing dust laden at a distance. During dry spells leaves and fruit drop prematurely.....
.....European red mite, page 45.

9. During dry spells foliage turns yellowish and both leaves and fruit drop.....Clover mite, page 48.

E. Internal worminess.

1. Fruit is misshapen, undersized, turns a natural ripe color ahead of its time. One side is shrivelled and shrunken fast to the core, while the other side is normal. The injury takes place after mid July. Inside the fruit resides a ¼" maggot which is pointed at the head end. The burrows turn brown. (13, pp. 1-10), (9, p. 49), (36, p. 615), (51, p.304), 36, p. 573). .....
Fruit fly Rhagoletis cingulata and fausta.

2. Worms enter by the calyx end, sometimes burrowing around the entire calyx just beneath the skin. The mines are broad but shallow, seldom entering the core. (44, p. 44), (51, p. 23), (23, p. 110).
.....
Lesser apple worm Laspeyresia prunivora.

3. Burrows and excrement found in the fruit pulp, core, and even coming forth to the surface, revealing a badly ruined fruit.....Oriental fruit moth, page 39.

4. Milky-white grubs having a reddish tinge beneath, boring about in the core and pulp. .....
.....Plum curculio, page 55.

5. Grayish-white curved grubs boring about in fruit during May and June, either on the tree or on the ground. The grubs lack the reddish ventral tinge which is found in the Plum curculio.
.....Plum gouger, page 54.

6. The fruit has an entrance by way of the calyx end, inside, the whole core is badly eaten out and mixed with excrement. If the larva is out of the fruit, there is a 3/8" round exit hole. The caterpillar is pinkish but has a brown head and is ½" long.
.....Codling moth, page 58.

7. Small fruits having the entire core eaten out by 12-45 tiny maggots, before dropping.....
.....Pear midge, page 53.

F. Misshapen fruits.
1. Dwarfed fruits.
a. Fruit undersized, of poor quality and color.
.....European red mite, page 45.

b. Fruit growth stunted by being robbed of sap by plant lice.....Rosy apple aphid, page 43.

2. Fruits normal on one side.
a. Early scars on one side of the fruit producing bare skin-less areas that are partly grown over by humped or fenced skin from the normal part of fruit.....Fruit tree leaf roller, page 42.

b. One side of the fruit is wrinkled and depressed, nearly dried fast to the core, the other side is normal and attains a color of maturity in advance of the season.....
.....Cherry fruit fly, page 58.

3. Fruit surface has humps and depressions.
a. Feeding punctures retard growth in the place pierced; surrounding it the tissues become gritty and hard. As growth is retarded it causes a depression where the adjoining tissue continues to grow.....
.....False tarnished plant bug, page 43.

b. Dwarfed fruit which has dimpled or pitted appearance, sometimes also russeted side spots are the result of the insect's sucking mouth parts. The fruit itself is hard and the texture is woody. (45, p. 47), (23, p. 102), (36, p.582), (51, p. 28). .....
Apple red bugs Lygidea mendax and others.

c. Round holes are eaten into the fruit for feeding and oviposition; the punctured portion becomes a depression as the undisturbed part grows into humps. The larvae inside are milky-white and have brown jaws; in shape they are strongly curved.....Plum gouger, page 54.

d. Crescent-shaped incisions in fruit.
(1). Fruit falls shortly after oviposition within it. Grayish-white grubs infest the core.....Plum curculio, page 55.

(2). Fruit remains on the tree. Grub inside nearly ⅜" long, strongly curved.
.....Apple curculio, page 55.

KEY TO THE MORE IMPORTANT CHERRY INSECTS.

I. TRUNK, BRANCHES, AND TWIGS.
  A. Trunk.
    1. Mature trees.
      a. "shotholes" in bark the size of a pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles in burrows, adults are 1/8" long. (32, p. 540), (36, p. 530), (51, p. 291).
      .....
      Shot-hole borer *Scolytus rugulosus*.

      b. Galleries terminate in a "Y" shaped forking in trunk and branches; otherwise same as preceding species. (15, p. 3), (32, p. 540), (23, p. 143).
      .....
      Peach bark beetle *Phthorophloeus liminaris*.

      c. Gummy exudations at base of tree from 2-3" below the surface to one foot above. Exudations are mixed with frass, a sawdust-like materal, and excrement. Dying or dead bark areas indicate burrowing larvae in inner bark. Leaves yellow, tree vigor decreases, and trees may die. When borers are over abundant nursery stock becomes seriously affected. (32, p. 216), (23, p. 126), (36, p. 595). .....
      Peach borer *Aegeria exitiosa*.

      d. Gummy exudations where injuries have occurred in trunk and branches such as bark wounds or splittings between trunk and limbs. Injuries usually are up high. Gummy ooze is mixed with excreta and sawdust. Dark bark areas, dead or dying bark, are caused by larvae boring in inner bark. (27, pp. 399-443), (30, p. 217), (21, p. 141).
      .....
      Lesser peach borer *Aegeria pictipes*.

      e. In crotches, cracked or wounded areas are found borers just in the under bark and sometimes in the sapwood. Their presence causes deadened bark areas. The grubs are 3/5" long, yellowish-white in color, and have brown heads. (47f, p. 87). .....
      Apple crotch borer *Aegeria pyri*.

*Figures in parenthesis refer to literature cited; see list of references at end of key.

f. Large grubs bore in crown and roots; they are 2-3" long, white, with a brown and black head and a lateral body row of oval spots. (32, p. 522), (38, p. 252). .....
Grape root-worm Prionis laticollis.

2. Nursery stock or young trees.
a. Borers.
(1). Gummy exudations at base of tree from 2-3" below the surface to a foot above. Exudations are mixed with frass, a sawdust-like material, and excrement, Dying or dead bark areas indicate burrowing grubs in inner bark. When they are abundant nursery stock is seriously affected. .....Peach borer, page 61.

(2). Areas on branches and trunk full of gummy ooze, mixed with frass, issuing from injured places.. Underneath are burrows with or without borers. .....
.....Lesser peach borer, page 61.

(3). In crotches, cracked or wounded areas are found borers just in the under bark and sometimes in the sapwood. They cause deadened bark areas. The grubs are 3/5" long, yellowish-white, and have brown heads. .....Apple crotch borer, page 61.

(4). "Shotholes" in bark the size of a pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. .....Shot-hole borer, page 61.

(5). Galleries terminate in "Y" shaped forkings in trunk and branches; otherwise same as preceding species. .....
.....Peach bark beetle, page 61.

b. Bark scales.
(1). Trunks, branches, twigs, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both bruit and bark, the area turns red. Under magnification the specks are disks having a central raised nipple-like blackish spot. Tree vigor decreases, foliage becomes scant. (25, p. 165), (55, p. 70), (23, p. 126). .....
San Jose scale Aspidiotus perniciosus.

(2). Trunk, branches, and twigs are covered with small brownish scales 1/16" to 1/8" long, curved and resembling an oyster shell; underneath the disks are many minute eggs. Bark cracks and the whole tree weakens or dies. (47b, p. 1), (23, p. 124), (47f, p. 73). .....
Oyster shell scale Lepidosaphes ulmi.

(3). During the winter bark on the undersides of branches and twigs is nearly covered over with shiny convex-shaped brownish scales 1/12" in diameter. In the summer fruit is coated with honeydew masses growing sooty-black fungi. (32, p. 129), (2, p.153), (36, p. 603). .....
Terrapin scale Lecanium nigrofasciatum.

(4). Trunk, branches, and twigs may be coated with dirty-white scales 1/10" long. In the winter time, if the scales are flipped over, with the naked eye one can discern tiny reddish-purple eggs. (59, p. 41), (47b, pp. 7-11), (55, p. 73). .....
Scurfy scale Chionaspis furfura.

(5). Trunk, branches, and twigs appear whitewashed. Upon close examination small scales appear. Female scales are circular, convex, about 1/25" in diameter, and grayish-white in color. Male scales are larger, being shaped like long narrow shingles having an oblong dorsal surface at its narrowest end. (32, p. 128), (23, p. 137).
.....
White peach scale Aulacaspis pentagona.

B. Branches.

1. "Shotholes" in bark.

a. Branches and trunk perforated with "shotholes" the size of a pencil lead. .....
.....Shot-hole borer, page 61.

b. Similar to preceding except the galleries terminate in "T" shaped forkings. The bark perforations appear like "pinholes".
.....Peach bark beetle, page 70.

2. Borers.

a. Branches and trunk perforated with "shotholes" the size of a pencil lead. The holes extend into the sapwood where sawdust-filled lateral galleries and runways follow the grain.
.....Shot-hole borer, page 61.

b. Similar to preceding except the galleries terminate in "T" shaped forkings. The bark perforations look like "pinholes". .....
.....Peach bark beetle, page 61.

c. In crotches or wounds in trunk or branches are borers within the inner bark, rarely in the sapwood. The grubs are 3/5" long, yellowish-white, having brownish heads. .....
.....Apple crotch borer, page 61.

d. Gummy exudations at base of tree from 2-3" below ground to one foot above. Exudations are mixed with frass and excrement. Dying or dead bark areas indicate burrowing larvae in inner bark.
.....Peach borer, page 61.

e. Areas on branches and trunk full of gummy ooze, mixed with frass, issuing from injured places. Underneath are burrows with or without borers.
.....Lesser peach borer, page 61.

3. Bark scales or coverings.

a. Minute thin grayish scales massed together upon branches and twigs. Under magnification the specks appear to have a raised reddish area in the center of each; thus they are distinguished from the San Jose scale (page 62); otherwise they are similar. (62, p. 138), (36, p. 617).
.....
Cherry scale Aspidiotus forbesi.

b. Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. (55, p. 179), (25, p. 283), (32, p. 179). .....
Putnam's scale Aspidiotus ancylus.

c. There are 1/12" dark ashy-gray scales. The central elevation is orange and off center. Branches and twig scales similar to Putnam's (page 64) and Cherry scales (page 64) distinguished only by microscopic characters. (53, p. 360), (45, p. 58). .....
European fruit scale Aspidiotus ostreaeformis.

d. Branches and twigs are scaled with 1/8" reddish-orange scales; the central spot is off center. (53, p. 360), (25, p. 283). .....
Walnut scale Aspidiotus juglans-regiae.

e. Grayish specks on fruit and bark, individually invisible to the eye, surrounded by a reddish area. .....San Jose scale, page 62.

f. Oyster-shell-shaped scales 1/16 to 1/8" long. .....Oyster shell scale, page 62.

g. Bark on undersides of branches and twigs is coated with shiny convex-shaped brownish scales 1/12" in diameter. .....Lerrapin scale, page 63.

h. Bark covered with greyish scales 1/16" long. In winter, if flipped over, they will reveal very small reddish-purple eggs. .....Scurfy scale, page 64.

i. Whole tree or parts appearing white-washed. .....White peach scale, page 63.

C. Small branches, twigs, and shoots.

1. Twig borers.

a. Shoots die-back because of small boring larvae. Trees may be attacked at the shoots, or else the fruit may directly be attacked. Internal fruit worminess shows up as burrows and emergent in the pulp, in the core, or may even be exposed to the outside. The larvae are ½" long, creamy-white in color. (2, p. 132), (36, p. 608), (47f, p. 10). ..... Oriental fruit moth Grapholitha molesta.

b. Twigs to small branches ½" in diameter are often cleverly girdled by having a complete ring gnawed out of the bark to the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurred in the severed part the egg hatches and the grub eats out all but the bark, as it lies on the ground (53, p. 202), (57, p. 282). ..... Twig girdler Oncideres cingulatus.

c. Twig tips and their foliage dies back because of small burrowing beetles 1/8" long, cylindrical in shape. Twigs are attacked just below a leaf scar; from there the burrow leads into the sapwood in one main longitudinal burrow and numerous lateral ones called brood chambers. (15, p. 65), (53, p. 232), (3, p. 15). ..... Pear blight beetle Anisandrus pyri.

d. Burrows from shoots to base of main stem widening out at base of shoots cause the twigs to wilt and drop off. The borings are lengthwise with the twig and contain ½" brown beetles. (50, p. 513), (15, p. 67), (51, p. 449). ..... Apple twig borer Amphicerus bicaudatus.

2. Oviposition punctures in twigs.
   a. In the bark or sapwood rows of pinholes are punctured in one side of the twigs. There may be twenty-five to an inch, or fifty to seventy-five in a row; in each pit an egg 1/8" long is inserted. The incisions are not straight down but rather curved in. The infested twigs or branches break off beyond the injury or die back. (55, pp. 1-20), (59, p. 55), (45, p. 56).
   .....
   Tree cricket Oecanthus sp.

3. Gnawed twigs.
   a. Twigs badly gnawed so they droop, buds entirely gnawed off. The injury occurs early in the season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. (57, p. 78), (36, p. 552), (47f, p. 37), (45, p. 8).
   .....
   New York weevil Ithycerus noveboracensis.

4. Severed twigs.
   a. Twigs hollowed out, causing adjoining shoots to wilt and break off.....Apple twig borer, page 65.

   b. Twigs or branches, less than ½" in diameter, litter the ground under the tree. The severed end shows it was gnawed off. .....Twig girdler, page 65.

5. Bark coatings on twigs.
   a. Grayish specks on fruit and bark, individually invisible to the eye, surrounded by a reddish area. .....San Jose scale, page 62.

   b. Oyster-shell-shaped scales 1/16 to 1/8" long. .....Oyster shell scale, page 63.

   c. Bark covered with grayish scales 1/10" long. In winter, if flipped over, they will reveal very small reddish-purple eggs. .....Scurfy scale, page 63.

   d. Whole tree or parts appearing white-washed. .....White peach scale, page 63.

   e. Minute thin gray scales massed together upon branches and twigs. Each indivdual speck has a raised reddish area in the center. .....Cherry scale, page 64.

   f. Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. .....Putnam's scale, page 64.

g. There are 1/12" dark ashy-gray scales on branches and twigs. The central elevation is orange and off center. .....European fruit scale, page 64.

h. Branches and twigs are coated with 1/8" reddish-orange scales ; they central spot is off center. .....Walnut scale, page 64.

i. Bark on undersides of twigs and branches is coated with shiny convex-shaped brownish scales 1/12" in diameter. .....Terrapin scale, page 63.

II. UNDERGROUND (trunk and roots).

A. Large grubs bore in crown and roots. They are 2-3" long, white, with a brown and white head, and a lateral body row of oval spots.....Giant grape rootworms, page 62.

B. Gummy exudations at base of tree from 2-3" below the surface to one foot above. The exudations are mixed with frass and excrement. Dying or dead bark areas indicate the presence of burrowing larvae in the inner bark. .....Peach borer, page 61.

III. FOLIAGE (buds, leaves, and flowers).

A. Bud injury.

1. Buds eaten off.

a. Buds are entirely eaten off as they begin to swell in the spring; later the leaves, shoots, and fruits become seared and pitted by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. Leaves are rolled together and tied by silken strands, in which the creature and his house seeks shelter. (53, p.68), (32, p. 213), (36, p. 560), (47f, p. 54). .....
Leaf crumpler Mineola indigenella

b. Leaves are rolled up and tied together by leaf-rolling larvae which eat off the under leaf surface. The earliest caterpillar stage is spent as a leaf miner, after that it eats off buds, flowers, and after peeling off epidermis of new fruits and pulp is eaten into. The caterpillar is ¾" long, yellowish-green, head and thoracic shield brownish-black. Two broods carry on from May-June and July-August, respectively. (60, p.63), (32, p. 230), (36, p. 716), (35, p. 73). .....
Oblique-banded leaf roller Cacoecia rosaceana.

c. Complete or partial defoliation of buds, leaves, and flowers may occur overnight by an unseen predator. The injury occurs in the spring, very early. Nursery stock or young trees ore most subject to attack. Often when mature trees are attacked the pests concentrate on certain limbs, which they strip. (53, p. 138), (2, p. 130), (45, p. 11). .....
Climbing cutworms Noctuidae sp.

d. Twigs badly gnawed so they droop, buds entirely eaten off. All injury occurs early in the season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. The insect is a ⅜" snout beetle, grayish and black mottled. .....New York weevil, page 66.

e. Buds, leaves, and flowers are stripped or ruined early in the season; buds and leaves are eaten off or eaten ragged and tattered; newly set fruit are badly disfigured by having pits eaten into them. All the injury occurs during a month or six weeks. Adults are 1/3" long, yellowish-brown, and have long sprawling legs. They prefer porous sandy areas. (19, pp. 1-4), (19, p. 28), (9, p. 51), (45, p. 29).
.....
Rose chafer Macrodactylus subspinosus.

2. Buds eaten into.
a. Caterpillars eating into buds.
(1). Unfolding buds are eaten into, thus destroying opening flowers and leaves. Inside the bud is a ½" long brown caterpillar with a black head tunnelling about. The fruit has its epidermis scooped out in places, causing blemishes on matured fruits. (51, p. 549), (45, p. 21), (47f, p. 31).
.....
Bud moth Tmetocera ocellana.

(2). Buds, unfolding leaves, and developing fruits are injured from bud opening to three weeks after petal-fall. Several leaves and fruit clusters are tied together with silken strands; within the entanglement cavities are eaten into the fruit, and the leaves are killed. Mature fruits have deep russeted, elongated scars, badly deforming them. (12, pp. 1-40), (21, pp. 1-6), (45, p. 23).
.....
Fruit tree leaf-roller Cacoecia argyrospila.

(3). Buds are entirely eaten off as they begin to swell in the spring; later the fruit, leaves, and shoots become scored and pitted by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. The leaves are rolled and tied together, inside the enclosure reside the creatures in their shelters. .....
.....Leaf crumpler, page 67.

(4). Unfolding buds have their scales eaten off and flowers eaten into. The devastating insects are very small caterpillars residing in sheltered cases. The case is pistol-shaped having a curl or bend in it; in all it is $\frac{1}{4}$" long and may be found attached to leaves, twigs, branches, or fruit, depending upon the season of year. (36, p. 561), (47f, p. 58), (45, p. 10).
.....
Pistol-case bearer Coleophora malivorella.

(5). Same as preceding except that the case-bearer has a cigar-shaped case which is triangular at the tip. (32, p. 264), (51, p. 547), (57, p. 86). .....
Cigar-case bearer Coleophora fletcherella.

b. Beetles eating buds.

(1). During the early spring small jumping beetles 1/10 to 1/5" long puncture and eat out opening buds. The adults are shiny metallic beetles which eat out holes in leaves resembling shotholes. The larval stage is spent as leaf miners, which produce mines from near the center of the leaf to the margin terminating in blister-like cells. (45, p. 8), (36, p. 558).
.....
Apple flea weevil Orchestes pallicornis.

(2). Opening buds are eaten into, leaf and fruit stems severed by gnawings. The injury occurs from May through June. The insects are 3/8-1/2" long, greenish-brown snout beetles. The wing covers are crossed by two irregular light bands. (53, p. 371), (36, p. 533), (38, p. 167).
.....
Imbricated snout beetle Epicaerus imbricatus

(3). Buds are eaten into or eaten ragged and tattered as they unfold. The insects are 1/6" long, yellowish-brown and have long sprawling legs.....Rose chafer, page 68.

3. Buds rasped.

a. Early in the season buds shrivel up and turn brown. On close examination the browned surfaces reveal raspings caused by feedings. Ovipositions in stems of young fruit produces a wilting affect followed by premature fruit shedding Heavy infestations appear as injuries caused by fire. (39, pp. 1-7), (32, p. 119), (36, p. 592).
.....
Pear thrips Taeniothrips inconsequens.

4. Buds punctured.
   a. Pale greenish aphids puncture buds, shoots, leaves, and newly setting fruits; the shoots and leaves curl up and warp, the leaves turn yellow then drop, but the buds just brown and die. The injury is spring injury. (11, p. 32), (51, p. 587), (36, p. 610). .....
   Green peach aphid Myzus persicae.

   b. Opening buds are punctured and killed by shiny black aphids. Leaves and shoots are curled so badly that they die, the leaves dropping. The young fruit is stunted and sometimes rendered worthless. (16, p. 163), (11, pp. 42-44), (47e, p. 16). .....
   Black cherry aphid Myzus cerasi.

   c. Opening buds are punctured and the insides eaten out. The adults are 1/10 to 1/5" metallic jumping beetles; besides injuring buds they eat holes in leaves resembling shotholes. The larval stage is as a leaf miner. .....
   .....Apple flea weevil, page 69.

B. Leaf injury.
   1. Leaf miners.
      a. In the earliest larval state the caterpillars are leaf miners. They draw together single or grouped leaves, then tie them fast; inside the enclosure the caterpillars eat foliage, puncture fruit skins, and eat the pulp. .....
      .....Oblique-banded leaf roller, page 67.

      b. The larvae spend their earliest period in the leaf as a miner. Buds and blossoms are injured by very small caterpillars in twisted pistol-shaped protuberance $\frac{1}{4}$" long on twigs, branches, leaves, or fruit. As the bud begin to swell the caterpillars travel with their cases to buds and new leaves whereon they feed. Later in the year the protuberances are on leaves and fruit. .....Pistol-base bearer, page 69.

      c. Same as preceding except the protuberances are cigar-shaped, at the tip end the case is triangular. .....Cigar-case bearer, page 69.

      d. Leaf mines from near the leaf center to the margin terminating in blister-like cells. The insects are beetles 1/10" long, which eat out round holes in the foliage, giving it a "bird-shot" perforation. .....
      .....Apple flea weevil, page 69.

2. Speckled leaves.
   a. Leaves become speckled, browned, and appear dust laden from a distance; the leaves drop prematurely. On the under leaf surfaces are reddish or greenish galls or blisters $\frac{1}{4}$" across, enwrapped in fine silken webs. The fruit is of poor quality, size, and texture. (10, pp. 1-125), (2, p. 140), (36, p. 554). .....
   European red mite Paratetranychus pilosus.

   b. Leaves turn pale yellow, curl up, and drop. Lower leaves are attacked first, then higher etc. Fruit is stunted. Injury most severe in dry seasons or in arid areas. Under leaf surfaces are inhabited by 6 or 8 legged spiders. Twigs and stems have numerous red or pinkish eggs upon the bark sufficient to give the whole a reddish hue, during the dormant stage. (62, p. 1), (47f, p. 66), (45, p. 36).
   .....
   Clover mite Bryobia praetiosa.

3. Leaves skeletonized.
   a. Webs are spun at terminal points where many caterpillars centralize. The webs are conspicuous during the winter, while the larvae are in hibernation. The August brood tends to skeletonize leaves, but the principal injury occurs when the overwintering caterpillars revive in the spring to devour unfolding leaves as fast as they make their appearance. (5, pp. 24-32), (47f, p. 49), (17, p. 277). .....
   Brown-tail moth Nygmia phaeorrhoea.

   b. Leaves show nothing more than a mere framework of veins. The pest is a dark green slimy slug. (50, p. 642), (32, p. 348), (36, p. 616).
   .....
   Pear slug Eriocampoides limacina.

   c. Identical in all respects to the preceding, except the pest is blackish with a dark brown head. (51, p. 569), (23, p. 148). .....
   Pear slug Caliroa cerasi.

   d. Leaves are badly skeletonized by metallic greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of abdomen. The fruit is either gouged or partly peeled in irregular shallow patches. (2, p. 127), (35, p. 605), (47f, p. 35).
   .....
   Japanese beetles Popillia japonica.

4. Leaves full of "shotholes".
   a. The leaves are riddled as if full of "shotholes". The pest is a beetle 1/5" long, dull-red, and persists from May through July and August. (21, p. 165), (18, pp. 753-817), (44, p. 68). .....
   Cherry leaf beetle Galerucella cavicollis.

5. Leaf protuberances.
   a. Caterpillars which travel about in twisted horn-shaped tubes or cases, nearly an inch long, roll together and tie leaves to form a shelter. When feeding they may be upon the twig, a leaf, or on fruit. .....Leaf crumpler, page 67.

   b. Under leaf surfaces and fruit having bent pistol-shaped protuberances. .....
   .....Pistol-case bearer, page 69.

   c. Under leaf surfaces and fruit having cigar-shaped protuberances which are three cornered at the tip. .....Cigar-case bearer, page 69.

   d. Cone-like protuberances growing on undersides of leaves within which are hanging caterpillars. The growths are natural resistances to the feeding larvae. (26, pp. 1-11), (25, p. 215), (51, p. 503), (36, p. 679). .....
   Bagworm Thyridopteryx ephemeraeformis.

6. Leaves webbed together.
   a. Early in the spring leaf clusters are bound together as a shelter. If the shelter is torn apart it will be found to contain tough, horn-shaped cases inhabited by caterpillars.
   .....Leaf crumpler, page 67.

   b. Buds and leaves are webbed together by silken threads wherever the worm is feeding. The caterpillars are $\frac{1}{4}$" long, brown, having black heads.
   .....Bud moth, page 68.

   c. Leaves and fruit clusters are drawn together and bound with silken cords. Fruit within the tangle has cavities eaten out. The larvae are $\frac{3}{4}$" long, green, with head and thoracic shield brown or black. .....Fruit tree leaf roller, page 68.

   d. Single leaves or grouped leaves are drawn together by silken strands, wherein caterpillars eat foliage, puncture fruit skins, and eat the pulp. The earliest larval stage is as a leaf miner. The mature caterpillars are $\frac{3}{4}$" long, light yellowish-brown to apple-green, having a brownish black head and thoracic shield.
   .....Oblique-banded leaf roller, page 67.

e. Leaves are tangled together by silken strands enclosing numerous leaves which become eaten away. The larvae spend one month within the silken shelter, eating all the time. Severely infested trees appear as one huge web. The injury occurs in late spring. (58, p. 254), (72, p. 348), (36, p. 613). .....
Plum web-spinning sawfly Neurotoma inaena iena.

7. Premature defoliation.
a. Leaves curl, turn pale, dry up and drop.
(1). Speckled leaves become browned and from a distance appear dust laden. The fruit is undersized, of poor quality and color.
.....European red mite, page 71.

(2). Lower leaves are attacked first, then higher etc. The fruit is stunted. Injuries become most severe in dry seasons and in arid areas. Under leaf surfaces have tiny six or eight legged mites. .....
.....Clover mite, page 71.

(3). During the spring pale green aphids cause leaves and leaf stems to curl up out of shape. .....Green peach aphid, page 70.

(4). During the spring shiny-black aphids cause leaves to curl up, and cause the new fruit to be so stunted that often the crop is worthless. .....Black cherry aphid, page 70.

b. Leaf petioles gnawed off.
(1). Leaves severed from late May through June.
.....Imbricated snout beetle, page 69.

8. Foliage eaters.
a. Single defoliators.
(1). Leaves are stripped or eaten ragged, and tattered early in the season, during the period of a month or six weeks. The pest is a beetle 1/2" long, yellowish-brown having long sprawling legs. .....
.....Rose chafer, page 68.

(2). Giant caterpillars (over two inches).
(A). Caterpillars 2-2½" long, pale-green, edged with white on the sides, having many black-tipped branched spines. (25, p. 271), (37, p. 128).
.....
Io moth Automeris io.

(D). Caterpillars a little over two inches long, bluish-green, two coral-red tubercules on each side of second and third body segments, a single yellow tubercule on next to last segment. The body is decorated with numerous small, blue-black, slightly-raised tubercules. The caterpillars spins a cocoon wrapped in a leaf. (45, p. 269).

.....

Prometheа moth Callosamia promethia.

b. Colonial defoliators.

(1). Spinners.

(A). When leaves make their appearance in the spring young larvae hatch out and commence to spin webs around leaves on which they feed. As they grow they enlarge the web; about the time a brood matures the whole tree is in one huge web. The larva is 2" long gray above and pink or yellow below; the head is yellow; the thoracic shield is black. .....Plum web-spinning sawfly, page 73.

(B). Webs are spun at terminal points where caterpillars centraline. The August brood skeletonized the leaves, then hibernate in a semi-developed stage for the winter. In the spring they revive to consume developing leaves. ....Brown-tail moth, page 71.

(C). Dirty-white loosely woven webs, containing excrement everywhere, enclose branch tips late in the summer or early fall. Those caterpillars feed within the web. The caterpillars are pale-yellow, spotted with black, and very hairy. (45, p. 18), (25, p. 213), (47f, p. 44). .....
Fall webworm Hyphantria cunea.

(D). Thick webs are spun in forks or crotches and used as shelters only; all feeding is done outside the web. As they grow the web is enlarged to make the additional accomodations. Outside the webs the leaves are stripped. The webs are spun early in the spring.

The caterpillars are brown having a white dorsal line with blue on the sides. The whole insect is sparsely haired. (1, pp. 1-18), (2, pp. 1-25), 45, p. 14). .....
Eastern tent caterpillar Malacosoma americana.

(2). Nine spinners.

(A). In the spring young caterpillars eat off the epidermal layer; later they eat off the entire leaf save for the midrib; some gnaw small holes in the fruit. The larvae are 1-½" long, have three pencil-like tufts of long black hairs, one on each side of the head, and one at the dorsal posterior end. (36, p. 667), (40, p. 41), (57, p. 269).
.....
White-marked tussock Hemerocampa leucostigma.

(B). This insect resembles the preceding. It has a black head and the first two tussocks are black in young caterpillars, in later caterpillars they are white. Still later an additional pencil of long black plume-tipped hairs project laterally from the second abdominal segment. (32, p. 203).
.....
Rusty tussock moth Notolophus antiqua.

(C). Neglected orchards have leaf epidermis peeled off followed by consumption of all save for the midrib. The injury occurs in midsummer. The insect pest is a caterpillar 1½" long, covered with dense spreading tufts of white hairs, a row of eight black tufts on the back and two long slender pencils on the fourth and tenth segments. Head, feet, and under body parts are black; upper body surface is white spotted with black. (47f, p. 53), (32, p. 183).
.....
Hickory tussock moth Halisidota caryae.

(D). Many tiny gregarious caterpillars hatch out in time to lay waste expanding leaves; at first they eat out holes, later they consume the entire leaf except for the largest veins. Complete

defoliation is not uncommon. Mature caterpillars are 2" long, having ten pairs of dorsal blue tubercules and six reddish, separated by a yellow median line; otherwise the body is clothed with long black hairs. (25, p. 273), (5, pp. 1-23), (47f, p. 48). .....

Gypsy moth Lorthetria dispar.

(E). In midsummer colonies of caterpillars appear and completely defoliate branches or the whole tree; nursery stock or young trees are most likely to be attacked. When not feeding they congregate upon the trunk or branches. When at rest the larvae either have the rear end elevated or the fore and rear ends elevated; when startled they raise both ends suddenly and remain so. The caterpillars are 2" long, black and yellow striped, having a yellow ring around the neck. (53, p. 123), (38, p. 270), (23, p. 118).

.....

Yellow-necked caterpillar Datana ministra.

(F). Same as preceding species except the caterpillars are black and yellow striped, with a coral-red hump just behind the head and a row of spines projecting from it. (53, p. 125), (38, p. 271), (23, p. 118).

.....

Red-humped caterpillar Schizura concinna.

(G). Caterpillars which spin one thread as a "gi-line" wherever they travel, when not feeding they congregate on trunk or branches. If food is scarce they go out after it in form like marching army worms. The caterpillars are 1⅜" long, having a median row of white "lozenge-shaped" dots along the back. (25, p. 241), (45, p. 16), (23, p. 109).

.....

Forest tent-caterpillar Malacosoma disstria.

(H). Leaves, buds, and flowers may be stripped overnight by an unseen pest. The injury takes place in the spring and is more likely to center on nursery stock or young trees. .....

.....climbing cutworms, page 67.

C. Flower injury.

1. Flowers rasped.

a. Flowers are rasped and turn brown, the insect works right into the flower and eats away its vital parts. Oviposition occurs in flower and fruit stems, causing the stem to wilt and the flower to die or the setting fruit to drop. .....Pear thrips, page 69.

2. Flowers eaten into or entirely eaten off.

a. Buds and flowers are eaten off by leaf-rolling caterpillars. At first the larvae are leaf miners, then leaf rollers, then destructive bud, flower, and leaf eaters, besides puncturing fruit skins. .....Oblique-banded leaf roller, page 67.

b. Flowers are eaten off by large beetles, about the size of a potato beetle. They are metallic green and have two white spots on tip of abdomen. .....Japanese beetle, page 71.

c. Flowers are badly eaten by beetles 1/3" long, yellowish-brown, and possessing long sprawling legs. .....Rose chafer, page 68.

d. Flowers on branches of large trees or all flowers on small trees together with buds and leaves may be stripped overnight.....Climbing cutworms, page 67.

IV. FRUIT.

A. Fruit blemishes (outside).

1. Minute grayish specks on bark and fruit surrounded by a reddish area. .....San Jose scale, page 62.

2. Honeydew covered fruit harboring a sooty-black fungus. In the winter underside of twigs and branches are nearly covered with shiny convex-shaped brownish scales 1/12" in diameter. ....Terrapin scale, page 63.

B. Fruit blemishes (through the epidermis).

1. Crescent-shaped scars in fruit.

a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times the scars develop depressions instead of humps. Fruit becomes hard, knotty, and misshapen. Inside the fruit resides a grayish-white curved larva. (6, pp. 499-513), (33, p. 845), (63, p. 151). ..... Plum curculio Conotrachelus nenuphar.

2. Small slits or cracks in fruit.
   a. Within the fruit develop small brownish or black insects 1/20" long which rasp away the pulp and suck up the juices. .....Pear thrips, page 69.

3. Shallow holes gouged, scooped, or eaten out of fruit.
   a. Fruit skins are gnawed and peeled also small holes eaten into the fruit. Around the injured fruit are single or grouped leaves rolled and tied together. .....
   .....Oblique-banded leaf roller, page 67.

   b. Shortly after setting fruit has small cavities eaten through the skin into the pulp. Mature fruits show deep russeted, elongated scars. .....Fruit tree leaf roller, page 68.

   c. Fruit is scored and pitted shortly after setting. Injured fruits are rolled in leaves enclosing caterpillars in twisted horn-like tubes or cases nearly an inch long. .....Leaf crumpler, page 67.

   d. Pits are scooped out of the fruit; surrounding the injured fruits are leaves rolled and tied together. .....Bud moth, page 68.

   e. Small holes are eaten through the skin into the pulp. Upon the fruit are tiny ¼" long, pistol-shaped protuberances inhabited by minute caterpillars. .....Pistol-case bearer, page 69.

   f. Same as preceding, except the protuberances on the fruit are cigar-shaped and have a trisecular tip. .....Cigar-case bearer, page 69.

4. Cavities eaten into the fruit.
   a. In the spring deep holes are gnawed into the fruit, as the apple tries to heal over the wound it grows "lopsided". The injury was done by a caterpillar 1" long, yellowish-black, hairy, and striped. It has three pencil-like tufts of long black hairs that project, one on each side of the head, and one at the dorsal posterior end. The dorsal rear end has two bright-red spots. .....White-marked tussock, page 75.

   b. Newly set fruits are enclosed by silken strands and rolled leaves then their skins are scored and pitted. Inside the tangled mass are tough horn-shaped tubes or cases inhabited by caterpillars. .....Leaf-crumpler, page 67.

c. Fruits in clusters become badly chewed up, holes eaten out etc., by beetles 1/8" long, yellowish-brown, and possessing long, prancing legs. .....Rose chafer, page 68.

d. Same injury as done by preceding species. The beetle is about the size of a potato beetle, it has a shining bronze-green head and thorax and two white spots at the abdominal tip. ....Japanese beetle, page 71.

C. Internal worminess of fruit.

1. Wormy fruit.

a. Burrows in the pulp around the pit containing much excrement, some of it coming forth to the surface. The worms are ½" long, pinkish or creamy-white. .....Oriental fruit moth, page 65.

b. Burrowing worms under the skin, traveling about in a winding circuit, first just under the skin, then next to the pit. The worms are ¼" long, legless, headless, and white in color. (23, p. 95), (45, p. 44), (47f, p. 15), (48, pp. 1-8). ..... Apple maggot Rhagoletis pomonella.

c. The fruit is misshapen, undersized, turning a natural ripening color ahead of its time. One side is shrivelled and shrunken fast to the pit, while the other side is normal. The injury occurs during July. The burrows turn brown. Inside the cherry resides a ¼" maggot, which is pointed at the end. (13, pp. 1-10), (44, pp. 1-11), (66, p. 618). ..... Cherry fruit fly Rhagoletis cingulata and fausta.

2. Grubby fruit.

a. Inside the pulp are grubs 1/8" long, milky-white, legless, with a brown head, and strongly curved body. .....Plum curculio, page 77.

D. Misshapen fruit.

1. New fruits are stunted and distorted or else wilt and drop prematurely. .....Green peach aphid, page 70.

2. Fruit normal on one side but collapsed on the other side until it touches the pit. The other side attains its ripened color ahead of its time. .....Cherry fruit fly, page 79.

3. Fruit normal on one side. The other side had some of the skin eaten off when the cherry was small, then the skin from the uninjured surface attempted to grow over the injury, in so doing the cherry grew "lop-sided". .....Fruit tree leaf roller, page 68.

4. Fruit surface has humps and depressions on the outside and crescent-shaped incisions in the skin. .....Plum curculio, page 77.

5. Dwarfed fruit of poor quality and color. .....European red mite, page 71.

E. Premature fruit shedding.

1. Tree weakness causing fruit shedding.

a. Premature defoliation leads to premature fruit shedding. Foliage is speckled and sickly looking, appearing dust laden at a distance. .....European red mite, page 71.

b. Premature defoliation leads to premature fruit shedding. The leaves turn yellow and drop. The injury is worst during dry seasons. ....Clover mite, page 71.

2. Oviposition in fruit stems.

a. Upon close examination fruit stems will be found to contain nymphs of insects 1/20" long or their eggs. .....Pear thrips, page 69.

3. Fruit stems severed.

a. Early in the spring fruit stems are severed so the fruit drops before maturing. ....Imbricated snout beetle, page 69.

KEY TO THE MORE IMPORTANT PLUM INSECTS.

I. TRUNK, BRANCHES, AND TWIGS.

A. Trunk.

1. Mature trees.

a. "Shotholes" in bark the size of a pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles in burrows, adults are 1/8" long. (15, p. 6)*, (32, p. 340), (36, p. 530).
.....
Shot-hole borer Scolytus rugulosus.

b. Galleries terminate in a "Y" shaped forkings in trunk and branches; otherwise same as preceding species. (15, p. 8), (32, p. 340), (23, p. 143). .....
Peach bark beetles Ithorochloeus liminaris.

c. Gummy exudations at base of tree from 2-3" below the surface to one foot above. Exudations are mixed with frass, a sawdust-like material, and excrement. Dying or dead bark areas indicate burrowing larvae in inner bark. Leaves yellow, tree vigor decreases, and trees may die. When borers are abundant nursery stock is seriously affected. (32, p. 216), (23, p. 126), (32, p. 595). .....
Peach borer Aegeria exitiosa.

d. Gummy exudations where injuries have occurred in trunk and branches such as bark wounds or splittings between trunk and limbs. Injuries usually are high up. Gummy ooze is mixed with excreta and sawdust. Dark bark areas, dead or dying bark, are caused by larvae boring in inner bark. (29, pp. 399-448), (32, p. 217), (11, p. 141). .....
Lesser peach borer Aegeria pictipes

2. Nursery stock or young trees.

a. Bark scales.

(1). Trunk, branches, and twigs covered with small brownish scales 1/8 to 1/16" long, curved and resembling an oyster shell; underneath are many minute eggs. Bark

*Figures in parenthesis refer to literature cited; see list of references at end of key.

cracks and whole tree weakens or dies. (47b, p. 1), (25, p. 134), (47f, p. 73). .....
Oyster shell scale Lepidosaphes ulmi.

(2). Trunks, branches, twigs, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both fruit and bark, the area turns red. Under magnification the specks are disks having a central raised nipple-like blackish spot. Tree vigor decreases, foliage becomes yellowish and scant. (25, p. 105), (57, p. 70), (23, p. 126). .....
San Jose scale Aspidiotus perniciosus.

(3). Trunk, branches, and twigs appear whitewashed, upon close examination small scales appear. Female scales are circular, convex, about 1/25" in diameter and grayish-white in color. Male scales are larger, being shaped like long narrow shingles having an oblong dorsal surface at its narrowest end. (32, p. 128), (23, p. 128). .....
White peach scale Aulacaspis pentagona.

B. Branches.

1. Branches and trunk full of "shotholes". .....
.....Shot-hole borer, page 81.

2. Branches and trunk full of "pinholes" terminating in a "Y" shaped burrow. .....
.....Peach bark beetle, page 94.

3. Areas on branches and trunk full of gummy ooze, mixed with frass, issuing from injured places. Underneath the burrows with or without borers.....
.....Lesser peach borer, page 81.

4. Outer bark coverings.
   a. Minute thin gray scales massed together upon branches and twigs. Under magnification the specks appear to have a raised reddish area in the center of each; thus they are distinguished from the San Jose scale; otherwise they are similar. (32, p. 128), (30, p. 617).
   .....
   Cherry scale Aspidiotus forbesi.

b. Branches and twigs are coated with 1/8" reddish-orange scales; the central spot is off center. (52, p. 360), (25, p. 283). .....
Walnut scale Aspidiotus juglans-regiae.

c. Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. (53, p. 30), (25, p. 283), (32, p. 179). .....
Putnam's scale Aspidiotus ancylus.

d. Branches and twigs similar to Putnam's and cherry scales, distinguished only by microscopic characters, covered with 1/12" dark ashy-gray scales. The central elevation is off center and orange in color. (53, p. 261), (45, p. 58). .....
European fruit scale Aspidiotus ostreaeformis.

e. Branches and twigs from May through July have undersurfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (36, p. 676), (25, p. 295), (2, p. 153). .....
Cottony maple scale Pulvinaria vitis.

f. Branches, twigs and leaves have large brown soft-bodied half-pea-shaped scales 1/8 to 3/16" long. They cluster together on one side of the twig or branch. They winter over on smaller branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow; all growth ceases, followed by premature shedding of foliage and fruit. (52, p. 261), (32, p. 129), (25, p. 148), (2, p. 123). .....
European fruit lecanium Lecanium corni.

g. During the winter bark on undersides of branches and twigs is nearly covered with shiny convex-shaped brownish scales 1/12" in diameter. In the summer the fruit is covered with honeydew masses growing sooty-black fungi which renders the fruit unsalable. (32, p. 129), (2, p. 153), (36, p. 605). .....
Terrapin scale Lecanium nigrofasciatum.

h. Scales 1/16 to 1/8" long resembling an oyster. .....Oyster shell scale, page 81.

i. Grayish specks on bark and fruit, individually invisible to the eye, surrounded by a reddish area. .....San Jose scale, page 82.

j. Whole tree or parts appearing white-washed. .....White peach scale, page 82.

C. Small branches, twigs, and shoots.

1. Twig borers.

a. Pinkish or creamy-white larvae ½" long burrow in twigs causing the foliage to wilt and the whole shoot to die back. Early and late plum varieties are attacked by the larvae; earlier broods attack the shoots, later broods attack the fruit. Orchards in close proximity to peaches are most severely attacked after the peaches are harvested. The worminess shows up as burrows and excrement in the pulp, the pit, or even exposed to the exterior. (2, p. 132), (36, p. 608), (47f, p. 10). .....
Oriental fruit moth Grapholitha molesta.

b. Twigs tips and their foliage dies back because of small burrowing beetles 1/8" long, cylindrical in shape. Twigs are attacked just below a leaf scar; from there the burrow leads into the sapwood in one main longitudinal burrow and numerous lateral ones, called brood chambers. (12, p. 65), (53, p. 232), (3, p. 15). .....
Pear blight beetle Anisandrus pyri.

c. Burrows from shoots to base of small branches widening out at base of shoots cause the twigs to wilt and drop off. The injury is most noticeable in the winter or early spring, indicating the killed new growth. The whole tree, if injured in repeated years, will die; otherwise it is badly weakened. The borings are lengthwise with the twig and contain ½" brown beetles. (50, p. 513), (15, p. 67), (51, p. 449). .....
Apple twig borer Amphicerus bicaudatus.

d. During the spring borers work into terminal shoots causing them to wilt or die-back; the larvae winter over within the shoots. The larvae, during the early spring, also bore into buds. The larvae are 1/16-3/8" long, brown, black-headed, and pupate in inconspicuous cocoons on the tree. The first brood tunnels in buds and shoots; the second brood tunnels in shoots and fruit; the third brood infests only the fruit. (50, p. 580), (23, p. 130),

(32, p. 215), (33, p. 610). .....
Peach twig borer Anarsia lineatella.

2. Severed twigs.
   a. Twigs from 2-3" long up to 2-3 feet long litter the ground beneath the tree. The twigs are smoothly cut off, the severed end has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a ¾" white grub. (53, p. 200), (25, p. 327), (36, p. 664). .....
   Twig pruner Elaphidion villosum.

   b. From twigs to small branches of ½" diameter are often cleverly girdled by having a complete ring gnawed out of the bark into the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurred in the severed part, the egg hatches and the grub eats out all but the bark, as the twig lies on the ground. (53, p. 202), (57, p. 282). .....
   Twig girdler Oncideres cingulatus.

3. Gnawed twigs.
   a. Twigs badly gnawed so they droop, buds entirely gnawed off. Injury occurs early in season. Young trees set out in freshly cleared lands in close proximity to hickory or oak wood lots are seriously affected. (57, p. 78), (56, p. 532), (47f, p. 37). .....
   New York weevil Ithycerus noveboracensis.

4. Rows of twigs punctures.
   a. Rows of pinholes through outer bark into the cambium or sapwood. The punctures are in a row with the grain, each row may have 50-75 holes which are 25 to the inch. The punctures are holes made during oviposition and contains eggs 1/8" long. Perforated twigs become diseased or dry up and break off. (55, pp. 1-20), (36, p. 637), (54, p. 1). .....
   Tree cricket Oecanthus niveus and others.

5. Feeding punctures on twigs.
   a. Twigs are sapped of their needed fluids during May by large bugs 5/8" long. Such punctures and robbed sap cause the twigs to warp, droop, and dry up together with all foliage thereon. When growth is most active the in-

jury becomes most severe. (53, p. 208).
.....
Ring-legged tree bug Prochymena annulata.

b. Early in season, twigs, petioles, and fruit stems are injured by light green aphids having a mealy bluish-white powder on their backs. They get on undersides of leaves where they cause the leaves to turn yellow and drop. By the end of June they have all migrated away from the host plant. (11, p. 39), (51, p. 592), (57, p. 118). .....
Mealy plum aphid Hyalopterus arundinis.

c. Twigs and newly forming fruits are injured by being robbed of sap. Injuries occur shortly after blossom time, lasting until 2-3 generations are reared, then migrate from the host in late spring. (11, p. 32), (51, p. 587), (36, p. 610).
.....
Green peach aphid Myzus persicae.

6. Dark coatings on twigs.
   a. Scales.
      1. Oyster shell-shaped brownish scales 1/16 to 1/8" long. .....Oyster-shell scale, page 82.

      2. Grayish specks on bark and fruit, individually invisible to the eye, surrounded by reddish areas. .....San Jose scale, page 82.

      3. Whole tree or parts appearing white-washed. .....White peach scale, page 82.

      4. Grayish specks, invisible to the eye, surrounded by reddish areas. Under magnification each scale has a raised reddish center. .....Cherry scale, page 82.

      5. Dark gray to nearly black circular scales. .....Putnam's scale, page 83.

      6. Bark covered with 1/12" dark ashy-gray scales. ....European fruit scale, page 83.

      7. Twig under-bark covered with cottony masses from May through July. .....
.....Cottony maple scale, page 83.

      8. Large brown soft-bodied scales, half-pea-shaped 1/8-3/16" long. Flat spindle-shaped immature winter forms 1/25" long.
.....European fruit lecanium, page 83.

9. Bark on undersides of twigs coated with shiny convex brownish scales 1/12" in diameter. .....Terrapin scale, page 83.

10. Bark coated with 1/8" reddish-orange scales. .....Walnut scale, page 83.

II. UNDERGROUND (Roots and trunk).
A. Trunk from 2-3 inches below ground to one foot above.
1. Gummy exudations mixed with frass, sawdust, and excrement on outer bark. .....Peach borer, page 81.

III. FOLIAGE (Buds, Leaves, and Flowers).
A. Bud injury.
1. Buds eaten off.
a. Buds are entirely eaten off as they begin to swell in the spring; later the fruit, leaves, and shoots become seared and pitted by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. Leaves are also rolled and tied together by threads in which the creature and his lease seek shelter. (53, p. 68), (42, p. 213), (35, p. 560), (47f, p. 54). .....
Leaf crumpler Lineola indigenella.

b. Unfolding buds are entirely eaten off; unfolding leaves are eaten, tattered and ragged. (51, p. 451), (53, p. 403), (38, p. 264).
.....
Crape flea beetle Haltica chalybea.

c. Buds eaten off and twigs gnawed. .....
.....New York weevil, page 85.

2. Buds eaten into.
a. Opening buds are eaten into, thus destroying opening flowers and leaves; consequently the future crop is injured or ruined. Inside the buds are ½" long brown caterpillars with black heads, tunneling about. The fruit has its epidermis scooped out in places, causing blemishes on matured fruits. (51, p. 549), (45, p. 21), (47f, p. 31). .....
Bud moth Tmetocera ocellana.

b. Buds, unfolding leaves, and developing fruits are injured from bud opening to three weeks after petal-fall. Several leaves and fruit clusters are tied together with silken strands; within the threads cavities are eaten into the fruit, and the leaves are partially or entirely killed. Mature fruits have deep russeted,

elongated scars, badly deforming them. (12, pp. 1-41), (31, pp. 1-6), (45, p. 25).
.....
Fruit tree leaf-roller Archips argyrospila.

c. Buds, blossoms, and new foliage, in new orchards in close proximity to locust trees become badly ruined. (55, p. 305), (47f, p. 38).
.....
Red-legged flea beetle Crepidodera rufipes.

d. The larvae spend their earliest period in the leaf as leaf miners. Buds and blossoms are injured by very small caterpillars in twisted pistol-shaped protuberances on twigs and branches early in the spring. As the buds begin to swell the caterpillars travel with their cases to buds and new leaves whereon they feed. Later in the year the protuberances are found on leaves and fruit. (36, p. 561), (47f, p. 58), (45, p. 10), ...
Pistol-case bearer Coleophora malivorella.

e. Same as preceding, except the protuberances are cigar-shaped, at the tip end the case is triangular. (32, p. 234), (31, p. 547), (57, p. 86). .....
Cigar-case bearer Coleophora fletcherella.

f. Buds, leaves, and flowers are stripped or badly ruined early in the season; buds and leaves are eaten off or are ragged and tattered; blossoms are nearly eaten off; newly set fruits are badly disfigured by having holes eaten into them. All the injury occurs in about one month or six weeks. (55, pp. 397-402), (2, p. 128), (36, p. 625). .....
Rose chafer Macrodactylus subspinosus.

g. Opening buds and bark are gnawed into, leaf and fruit stems severed. (53, p. 371), (36, p. 533). .....
Imbricated snout beetle Epicaerus imbricatus.

3. Buds rasped.
a. Early in season buds shrivel up and turn brown, on close examination the browned surfaces reveal raspings caused from feedings. Oviposition in stems of young fruit causes them to wilt and its fruit drop prematurely. Heavy infestations appear as injuries caused by fire. (39, pp. 1-7), (32, p. 119), (35, p. 592).
.....
Pear thrips Taeniothrips inconsequens.

4. Buds punctured.
   a. Swelling and expanding buds are punctured and sap is withdrawn, resulting in slight injuries to buds. Their presence need not cause alarm, even though 15-20 may be upon a flower; they are waiting for newly developed succulent leaves on which they feed a very short time, to end of May, then migrate from the tree. Some of the leaves become curled up and drop due to aphids feeding thereon. (47e, p. 8), (47f, p.27), (20, p. 31). .....
   Apple grain aphid Rhopalosiphum prunifoliae.

B. Leaf injury.
1. Leaves rolled and webbed together.
   a. Leaves are tangled together by silken strands enclosing numerous leaves which become eaten away. The larvae spend one month within the silken shelter, eating all the time. Severly infested trees appear as one huge web. The injury occurs in late spring. (53, p. 254), (32, p. 548), (36, p. 612). .....
   Plum web-spinning sawfly Neurotoma inconspicua.

   b. Single leaves or grouped leaves are drawn together by silken strands, wherein caterpillars eat foliage, puncture fruit skins, and eat the pulp. In the earliest stage larvae are leaf miners. (60, p. 63), (32, p. 250), (36, p. 716). .....
   Oblique-banded leaf-roller Cacoecia rosaceana.

   c. Early in season many leaves and fruit clusters are bound together; the damage occurs between bud opening and three weeks after petal-fall. .....Fruit tree leaf-roller, page 88.

2. Leaves skeletonized.
   a. Leaves show nothing more than a frame-work of veins. The pest is a dark green slimy slug. (60, p. 642), (32, p. 548), (36, p. 616). .....
   Pear slug Eriocampoides limacina.

   b. Identical in all respects to the preceding except the pest is blackish with a dark brown head. (51, p. 569), (23, p. 148). .....
   Pear slug Caliroa cerasi.

c. Leaves are badly skeletonized by metallic-green or greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of abdomen. Also the fruit is either gouged or partly peeled in irregular shallow patches. (2, p. 127), (36, p. 605), (48, pp. 1-31).
.....
Japanese beetle Popillia japonica.

3. Speckled leaves.
a. Leaves become speckled, browned, and appear dust laden, from a distance; the leaves drop prematurely. Feeding punctures in leaves rob them of chlorophyll and at the same time poison the surrounding tissue. Very light spider webs on leaf under surface. Fruit is undersized, of poor quality and color. (10, pp. 1-125), (2, p. 140), (47f, p. 67).
.....
European red mite Paratetranychus pilosus.

4. Leaf miners.
a. Leaf miner in early larval period. Pistol shaped protuberances ¼" long on leaf.
.....Pistol-case bearer, page 88.

b. Leaf miner in early larval period. Cigar shaped protuberances ¼" long on leaf.
.....Cigar-case bearer, page 88.

c. Leaf miner in early larval period. .....
.....Oblique-banded leaf-roller, page 89.

5. Leaf protuberances.
a. Under-leaf surfaces and fruits having bent pistol-shaped protuberances. .....
.....Pistol-case bearer, page 88.

b. Under leaf surfaces and fruits having cigar-shaped protuberances which are three cornered at the tip. .....Cigar-case bearer, page 88.

c. Cone-like protuberances growing on the under sides of leaves in which are hanging caterpillars. The growths are natural leaf resistances to the feeding larvae. (26, pp. 1-11), (25, p. 215), (51, p. 503). .....
Bagworm Thyridopteryx ephemeraeformis.

6. Leaves curl, turn pale-yellow, dry up, and drop prematurely.

a. Leaves turn pale-yellow, curl up, and drop. Lower leaves are attacked first, then higher, etc. Fruit is stunted. Injury most severe in dry seasons and in arid areas. The 6 or 8 legged creatures are inhabitants of under leaf surfaces. Twigs and stems have numerous red or pinkish eggs upon the bark sufficient to give the whole a reddish hue, during the dormant tree stage. (62, p. 1), (47f, p. 66), (45, p. 36). .....
Clover mite Bryobia praetiosa.

b. Tips of branches have leaves curl up and drop prematurely, thus checking proper bud-making and fruiting. The branches are the center of attack. Chief injuries occur in spring and fall. (50, p. 662), (51, p. 592), (23, p. 159).
.....
Plum aphid Aphis prunifolia.

c. Same injury as above performed by bluish-white mealy powdered aphids 1/10" long and marked with three longitudinal green stripes.
.....Mealy plum aphid, page 86.

d. Large numbers of aphis on swelling buds, 15-20 per bud or flower, apparently doing no harm.
.....Apple-grain aphid, page 89.

e. Speckled leaves dropping prematurely.
.....European red mite, page 90.

7. Foliage eaters.
a. Single defoliators.
(1). Complete or partial defoliation, as if it occurred overnight. Injury early in season, during May and June. Large beetles lying on the ground or flying noisly about lights with a loud buzz. (25, p. 236), (32, p. 303), (36, p. 306).
.....
June beetles Lachnosterna and others.

(2). Foliage eaten and skeletonized by metallic-green or greenish-bronze beetles slightly larger than a potato beetle. Near the abdominal tip are two distinct white spots. Fruit is badly ruined by having the epidermis peeled off and holes eaten out of the pulp. .....Japanese beetle, page 90.

(3). Leaves are stripped partly or entirely skeletonized during a one-month or six weeks period early in the season. .....Rose chafer, page 88.

(4). Nursery stock and young trees are often stripped overnight of buds, leaves and flowers by an unseen predator, a nocturnal pest. (53, p. 133), (2, p. 130), (45, p. 11). .....
Climbing cutworms Noctuidae sp.

(5). Giant caterpillars (over 2" long).
(A). Cocoon spinners.
(I). Cocoon inside a rolled leaf. Promethea moth (25, p. 268).
(II). Cocoon 7/8" diameter and 2½ or 3 inches long, partly wrapped in a leaf. Luna moth (25, p. 268).
(III). Cocoon 7/8" diameter slightly longer than round, sort of ovular-shaped. Polyphemus moth (25, p. 267), (57, p. 93).
(IV). Cocoon 1½"-2" thick and 3-4" long, fastened to branches encasing leaves. Cecropia moth (25, pp. 263-71), (25, p. 266), (57, p. 91).

b. Colonial defoliators.
(1). Web spinners.
(A). Thick webs in forks or crotches used as a shelter when not feeding; the caterpillar inhabitants do their feeding outside the web. Within the webs the leaves dry up and die; outside the web they are stripped. As the caterpillars grow they enlarge the web. The webs are spun early in the season, while buds and leaves are unfolding. (1, pp. 1-18), (2, p. 125), (45, p. 14). .....
Eastern tent caterpillar Malacosoma americana.

(B). Leaves tangled together by silken strands enclosing numerous leaves which become the feeding center. Severely infested trees appear as one web. ....Plum web-spinning sawfly, page 89.

(C). Caterpillars that spin one thread as they come and go. When not eating they congregate on twigs or limbs. (23, p. 241), (32, p. 204), (45, p. 16). .....
Forest tent caterpillars Malacosoma disstria.

(2). Non spinners.
(A). Caterpillars having three pencil-like tufts of long black hairs, one on each side of head, and one at the dorsal posterior end; also two bright-red spots on back of rear end. (30, p. 41), (57, p. 269), (36, p. 687).
.....
White-marked tussock Hemerocampa leucostigma.

(B). Similar to the preceding species except the head is black instead of coral-red with a fringe of white arising from the cervical shield and extending over it from above. Young caterpillars have two black tussocks which later turn white; laterally they have long black plume-tipped hairs rising from the second abdominal segment. (33, p. 104), (32, p. 205).
.....
Rusty tussock moth Notolophus antiqua.

(C). At first holes are eaten out of leaves, followed by a complete leaf destruction except for the large veins. Complete defoliation is not uncommon. Caterpillars are two inches long, having ten pairs of dorsal blue tubercles and six reddish, separated by a yellow median line; otherwise, the body is clothes with long black hairs. (25, p. 273), (5, pp. 1-23), (47f, p. 48). .....
Gypsy moth Porthetria dispar.

(D). Branches and small trees are stripped of foliage by a colony of black and yellow striped caterpillars having a yellow neck ring. Sometimes their population gets congested. (33, p.123), (33, p. 123), (32, p. 118).
.....
Yellow-necked caterpillar Datana ministra.

(2). Branches and small trees are stripped of foliage by a colony of black and yellow striped caterpillars having a red hump just behind the head with a row of spines projecting therefrom. (58, p. 195), (38, p. 271), (23, p. 118).
.....
Red-humped caterpillar Schizura concinna.

8. Premature defoliation.
a. Leaves curl, turn pale, and drop.
1. Leaves turn yellow and drop early in the season. On under leaf surfaces are light green aphids, coated with a bluish-white powder. .....Mealy plum aphid, page 86.

2. During spring and fall leaves at branch tips curl up and drop prematurely. .....Plum aphid, page 86.

3. Speckled and browned leaves drop prematurely. Underleaf surfaces have very fine spider webs enclosing red mites 1/8" long. .....European red mite, page 90.

4. Lower then high-up leaves drop during dry spells until the tree is wholly bare. During the dormant stage the twigs and stems have the bark coated with tiny reddish eggs sufficient to produce a reddish hue. .....Clover mite, page 91.

b. Leaves severed from late May through June.
1. Petioles eaten off by beetles 3/8-1/2" long. .....Imbricated snout beetle, page 88.

C. Flower injury.
1. Stems of blossoms and new fruits wilt and die. The stem injury is from oviposition by minute insects 1/20" long. Heavily infected areas appear as blighted by fire. .....Pear thrips, page 88.

2. Early in season flowers have ovaries eaten away and newly set fruit is injured by oviposition and feeding. The larvae live within the pits of developing fruits; they are milky-white in color. (38, p. 384), (51, p. 590), (23, p. 157).
.....
Plum gouger Anthonomus scutellaris.

3. Flowers are eaten off by a yellowish-brown beetle about 1/4" long, having long sprawling legs. .....Rose chafer, page 88.

IV. FRUIT.

A. Fruit blemishes (outside).

1. Minute greyish specks on fruit surrounded by a reddish area. .....San Jose scale, page 88.

2. Shiny convex-shaped brownish scales 1/16" in diameter on undersides of twigs and branches. Honeydew covered fruit harboring a sooty-black fungus. .....Cherry scale, page 84.

B. Fruit blemishes (through the epidermis).

1. Crescent-shaped scars.

a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions developing into swellings or knots protruding from the fruit surface. At time the scars develop depressions instead of bumps. Fruit becomes hard, knotty, and misshapen, usually dropping during May or June. Inside the fruit resides a greyish-white curved larva. (6, pp. 488-513), (58, p. 243), (68, pp. 1-51). .....Plum curculio Anthonomus nenuphar.

b. Misshapen, knotty, and undersized fruit. Small holes eaten in ends or sides of fruit; when the crescent-shaped holes are close together the skin between dries up. Infested fruit may or may not drop. The female oviposits, after digging out a hole, in the fruit, then plugs the hole with excrement. (6, pp. 514-57), (68, p. 116), (47f, p. 21). .....Apple curculio Tachypterellus quadrigibbus.

2. Round holes eaten into the fruit.

a. Holes are 1/16" in diameter, some eaten way into the core. .....Plum gouger, page 94.

3. Holes gouged or eaten out.

a. Large deep holes eaten out, or just gouged and scaled in irregular channels. Leaves are skeletonized. The injury is done by a beetle slightly larger than a potato beetle. .....Japanese beetle, page 90.

b. Leaves have holes eaten into them or else they are entirely consumed. The injury occurs early in the season, lasting about one month or six weeks. .....see Chafer, page 90.

c. Caterpillars puncture fruit skins so they can get at the pulp for feeding. .....
.....Oblique-banded leaf-roller, page 89.

d. Mature fruit shows deep roisetted, elongated scars. .....Fruit-tree leaf-roller, page 88.

e. Fruit is scored and pitted. .....
.....Leaf crumpler, page 100.

f. Small holes eaten out of fruit. .....
.....Pistol-case bearer, page 88.

g. Small holes eaten out of fruit. .....
.....Cigar-case bearer, page 88.

h. Pits are gouged out of the fruit, surrounding the injured fruit are leaves rolled and tied together. .....Bud moth, page 87.

C. Premature fruit shedding.

1. Large soft-bodied half-gone-shaped scales on twigs and branches. Leaves turn yellow, growth ceases, and fruit falls prematurely. .....
.....European fruit lecanium, page 85.

2. Foliage speckled and sickly looking, appearing dust laden at a distance. During dry spells leaves and fruit drop prematurely. .....
.....European red mite, page 90.

3. During dry spells foliage turns yellowish, leaves, and fruit drop. .....Clover mite, page 91.

4. Wormy fruit drops before maturing. The worm travels about between the pit and skin in a railroad twisting circuit, sometime entering the pit. The larvae are footless, headless, having a pink body and brown head. (34, p. 95), (45, p. 44), (47f, p. 15). .....
Apple maggot Rhagoletis pomonella.

5. Fruit having crescent-shaped incisions in the skin and an irregularly bumped and depressioned surface. Fruit drop before ripening.
.....Plum curculio, page 95.

6. A brown or light-brown grub nearly ½" long with four distinct humps on the back burrows about in the fallen fruit. .....Apple curculio, page 95.

D. Internal worminess.

1. Worms enter by the calyx end, sometimes burrowing around the entire calyx end just beneath the skin. The mines are broad but shallow, seldom entering the pit. (53, p. 53), (55, p. 95), (47, p. 44). .....
Lesser apple worm Laspeyresia prunivora.

2. Worms traveling about under calyx end between skin and pit, possibly within the pit. Burrows are shallow and twisting. .....Apple maggot, page 109.

3. Burrows and excrement found in the fruit pulp, pit, and even coming forth to the surface, revealing a badly ruined fruit. .....Oriental fruit moth, page 84.

4. Milky-white grubs boring about in the pit and pulp. .....Plum curculio, page 95.

5. Grayish-white curved grubs in fruit during May and June, either on the tree or under the tree. The larvae lack the reddish tinge beneath, as the Plum curculio has. .....Plum gouger, page 94.

KEY TO THE MORE IMPORTANT PEACH INSECTS.

I. TRUNK, BRANCHES, AND TWIGS.

A. Trunk.

1. Mature trees.

a. Holes in bark size of pencil lead. Holes extending into sapwood join sawdust-filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles in burrows, adults are 1/8" long. (32, p. 340)*, (36, p. 530), (51, p. 475). .....
Shot-hole borer Scolytus rugulosus.

b. Galleries terminate in a "Y" shaped forking in trunk and branches; otherwise same as preceding species. (15, p. 3), (32, p. 340), (23, p. 143).
.....
Peach bark beetle Phthorophloeus liminaris.

c. Gummy exudations at base of tree from 2 to 3" below surface to one foot above. Exudations are mixed with frass, a sawdust-like material, and excrement. Dying or dead bark areas indicate burrowing larvae in inner bark. Leaves yellow, tree vigor decreases, and trees may die. When they are abundant, nursery stock are seriously affected. (32, p. 216), (23, p. 126), (36, p.595).
.....
Peach borer Aegeria exitiosa.

d. Gummy exudations where injuries have occurred in trunk and branches such as bark wounds or splittings between trunk and limbs. Injuries usually are high up. Gummy ooze is mixed with excreta and sawdust. Dark bark areas, dead or dying bark, are caused by larvae boring in inner bark. (29, pp. 399-448), (32, p. 217), (23, p.141).
.....
Lesser peach borer Aegeria pictipes.

e. Just under bark and in sapwood 1-½" deep, are irregular shallow burrows in trunk and larger branches. Above the burrows the bark turns a dark and dead color. Inside the burrows is fine sawdust packed tightly; in the entrance is a packing of excelsior-like wood fibres. Large

*Figures in parenthesis refer to literature cited; see list of references at end of key.

killed bark areas tend to girdle the tree, more often the sunnyside is the center of attack. In the burrows are grubs 1¼" long, yellow or yellowish white, having a flattened and rounded body piece just behind the head. (4, pp. 1-12), (45, p. 27), (47f, p. 83). .....
Flat-headed apple tree borer Chrysobothris femorata.

2. Nursery stock or young trees.
   a. Bark scales.
      (1). Trunk, branches and twigs covered with small brownish scales 1/16 to 1/8" long, curved and resembling an oyster shell; underneath are many minute eggs. Bark cracks and whole tree weakens or dies. (47b, p. 1), (23, p. 124), (47f, p. 73). .....
      Oyster shell scale Lepidosaphes ulmi.

      (2). Trunk, branches, twigs and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales on both fruit and bark, the area turns red. Under magnification the specks are disks having a central raised nipple-like blackish spot. Tree vigor decreased, foliage becomes yellowish and scant. (25, p. 165), (57, p. 126). .....
      San Jose scale Aspidiotus perniciosus.

      (3). Trunk, branches, and twigs appear white-washed, upon close examination small scales show up. Female scales are circular, convex, about 1/25" in diameter and grayish white in color. Male scales are larger, being shaped like long narrow shingles having an oblong dorsal surface at its narrowest end. (23, p. 137), (32, p. 128). .....
      White peach scale Aulacaspis pentagona.

      (4). During the winter, bark on under sides of trunk, branches and twigs is nearly covered with shiny convex-shaped brownish scales 1/12" in diameter. In the summer the fruit is covered with honeydew masses growing sooty-black fungi which renders the fruit unsalable. (2, p. 153), (36, p. 603), (32, p. 129). .....
      Terrapin scale Lecanium nigrofasciatum.

(5). Entire bark on trunk, branches and twigs may be covered with greyish or dirty-white scales 1/10" long. In the winter time if the scales are flipped over reddish-purple eggs show ... (59, p. 41), (47I, pp. 7-11), (37, p. 7). .....
Scurfy scale Diaspis pyrus.

D. Branches.

1. Borers in branches.

a. Branches and trunk perforated with "shotholes". .....Shot-hole borer, page 93.

b. Branches and trunk perforated with "pinholes" terminating in "I" shaped burrows. .....Lesser bark beetle, page 90.

c. Areas on branches and trunk full of gummy ooze mixed with frass, issuing from injured places. Underneath are burrows with or without borers. .....Lesser peach borer, page 98.

d. Just under the bark in large branches and trunks of tree are shallow, broad, irregular burrows. Bark above the burrows becomes darkened and dies. Sunnyside of tree is the center of attack. .....Flat-headed apple tree borer, page 99.

2. Dark scales on branches.

a. Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. (55, p.179), (25, p. 898), (22, p. 179). .....
Putnam's scale Aspidiotus ancylus.

b. Branches and twigs coated with 1/8" reddish-orange scales; the central spot is off center. (55, p. 860), (25, p. 895). .....
Walnut scale Aspidiotus juglans-regiae.

c. Branches, twigs and leaves have large soft-bodies half-pea-shaped scales 1/8 to 3/16" long. They cluster together on one side of the twig or branch. They winter over upon small branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow; all growth ceases, followed by premature shedding of foliage and fruit. (32, p. 281), (32, p. 139), (23, p. 148), (2, p. 122). .....
European fruit Lecanium Lecanium corni.

d. Branches and twigs, from May through July, have undersurfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (56, p. 676), (27, p. 295), (2, p. 158). .....
Cottony maple scale Pulvinaria vitis.

e. Shell-shaped brownish scales 1/16 to 1/8" long. .....Oyster shell scale, page 99.

f. Greyish specks on bark and fruit, individually invisible to the eye, surrounded by reddish areas. .....San Jose scale, page 99.

g. Bark on undersides of twigs coated with shiny convex brownish scales 1/12" in diameter. .....Terrapin scale, page 99.

h. Whole tree or parts appearing white-washed. .....White peach scale, page 99.

i. Entire branch and trunk bark may be covered with greyish or dirty-white scales 1/10" long. In the winter time if the scales are flipped over they reveal hidden reddish-purple eggs. .....Scurfy scale, page 100.

C. Small branches, twigs and shoots.
1. Twig borers.
a. Pinkish or creamy-white larvae ½" long burrow in twigs causing the foliage to wilt and the whole shoot to die back. Earlier peach varieties are practically immune to the worms because they attack the twigs, later broods attack both twigs and fruit, then still later broods attack only the fruit. The fruit worminess shows up as burrows and excrement in the pulp, in the pit or even exposed to the exterior. The larvae enter via the stem end; the fruit may have no indications of worminess whatsoever, when picked, and again it may already be ruined. (2, p. 132), (36, p. 608), (47f, p. 10). .....
Oriental fruit moth Grapholitha molesta.

b. Burrows from shoots to base of main stem widening out at base of shoots cause the twigs to wilt and drop off. The injury is most noticeable in winter or early spring indicating the killed new growth. The whole tree, if injured in repeated years, will die; otherwise it is badly weakened. The borings are lengthwise in the twig and contain ½" brown beetles. (50, p. 513), (15, p. 67), (31, p. 449). .....
Apple twig borer Amphicerus bicaudatus.

c. Cavities are eaten into the end of shoots, causing them to wilt and die back. Larvae of the first brood winter over in shoots, thus beginning their injury when they revive early in the spring. The first brood burrows in twigs; the second brood tunnels in twigs and fruit; third brood tunnels only in the fruit. The larvae are 1/16-3/8" long having a brown body and black head. When the larvae period is completed, they spin inconspicuous cocoons wherever they happen to be. (23, p. 140), (32, p. 215), (36, p. 601). .....
Peach twig borer Anarsia lineatella.

d. Twigs to small branches ½" in diameter are often cleverly girdled by having a complete ring gnawed out of the bark to the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurred in the severed part, the egg hatches and the grub eats out all but the bark, as it lies on the ground. (53, p. 202), (57, p. 282). .....
Twig girdler Oncideres cingulatus.

e. Twigs from two to three inches long to two to three feet long litter the ground beneath the tree. The twigs are smoothly cut off; the severed end has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a ½" white grub. (53, p. 200), (25, p. 527), (36, p. 664). .....
Twig pruner Elaphidion villosum.

2. Gnawed twigs.
a. Twigs badly gnawed so they droop, buds entirely gnawed off. Injury occurs early in the season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. (57, p. 78), (36, p. 536), (47f, p. 37), (25, p. 8). .....
New York weevil Ithycerus noveboracensis.

3. Severed twigs.
a. Twigs hollowed out, causing adjoining shoots to wilt and break off. .....
.....Apple twig borer, page 101.

b. Hollowed twigs from two to three inches long to two to three feet long litter the ground under the tree. .....Twig pruner, page 102.

c. Twigs or branches, less than ½" in diameter litter the ground under the tree. The severed end shows it was gnawed off. .....
.....Twig girdler, page 102.

d. Twigs and shoots irregularly gnawed so they droop or hang. Injury occurs during spring. .....New York weevil, page 102.

4. Feeding punctures in twigs.
   a. In the spring and early summer shoots, leaves, and roots are populated with black aphids, if they are found upon shoots and leaves it is evident they are also on the roots. They cluster on tender shoots about crotches and lower tree parts. The shoots become warped and wilted due to being fed upon, so also do the leaves, though they are more likely to curl up and drop. Honeydew is freely secreted over the leaves, rendering a scoty black mass upon them. During the summer the aphids primarily linger about the roots. Porous sandy soils are most susceptible to infestation. Nursery stock and young trees are severely attacked, they then take on a yellowish sickly foliage. (53, p. 585). .....
      Black peach aphid Anuraphis persicae niger.

   b. Pale greenish aphids puncture buds, shoots, leaves and newly setting fruit; the leaves and shoots curl up and warp, the leaves turning yellow before dropping. The injury occurs in the spring. (11, p. 52), (51, p. 587), (36, p. 610). .....
      Green peach aphid Myzus persicae.

   c. Shoots covered with light green aphids causing warped and stunted growth, leaves become badly curled and some fruit shriveled and misshapen. Leaves drop prematurely. (50, p. 662), (51, p. 592), (25, p. 12). .....
      Mealy plum aphid Hyalopterus arundinis.

   d. Terminal growth and some lateral growth dies back after distortion has occurred. Black spots indicate where feeding took place. Nursery stock and young trees are severely injured. The buds and developing fruits are pitted and dwarfed. The insect is $\frac{1}{4}$" long, brassy colored, black and yellow marked, possessing a red thorax. (35, p. 595), (59, p. 44), (36, p. 446), (32, p. 165). .....
      Tarnished plant bug Lygus pratensis.

5. Oviposition punctures in twigs.
   a. Twigs, small and large branches have series of cuts or incisions through the bark into the sapwood. The incisions are in rows and each single injury is a pair of convex-shaped in-

cisions with the concave surfaces facing each other. In the center of each cutting in the wood eggs are deposited, as many as twelve to each puncture. Oviposition occurs more often in lower branches. The tip portion, beyond the injury, dries up and breaks off. If it does not break off it becomes rugged and the wood causes swellings in an irregular manner. The injuring insect is a 3/8" long hump-backed green creature. From a dorsal view it is triangular, having the pointed end at the rear. (47f, p. 77), (23, p. 57), (9, p. 25).

.....

Buffalo tree hopper Ceresa bubalus.

b. In the bark or sapwood rows of pinholes are punctured in one side of the twigs. There may be twenty-five to an inch or fifty to seventy-five in a row, in each an egg 1/8" long is inserted. Each incision is not straight down but rather curved in. The infested twigs or branches break off beyond the injury or die back. (55, pp. 1-20), (59, p. 36), (44, p. 56).

.....

Tree cricket Oecanthus species.

6. Bark coatings on twigs.
   a. Scales.
      (1). Oyster-shell shaped scales on the bark 1/16-1/8" long. .....Oyster shell scale, page 99.

      (2). Grayish specks on fruit and bark, individually invisible to the eye, surrounded by a reddish area. ...San Jose scale, page 99.

      (3). Whole tree or parts appearing white-washed. .....White peach scale, page 99.

      (4). Bark on undersides of branches and twigs is coated with shiny convex-shaped brownish scales 1/12" in diameter. .....Terrapin scale, page 99.

      (5). Bark covered with grayish scales 1/10" long. In winter, if flipped over, they will reveal very small reddish-purple eggs. .....Scurfy scale, page 100.

      (6). Twigs and branches have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. .....Putnam's scale, page 100.

(7). Bark coated with 1/8" reddish-orange scales. .....Walnut scale, page 100.

(8). Large brown soft-bodied scales, half-pea-shaped, 1/8 to 3/8" long. Winter forms are flat, spindle-shaped, and immature. .....European fruit lecanium, page 100.

(9). The under bark of twigs is covered with cottony masses from May through July. .....Cottony maple scale, page 101.

II. UNDERGROUND (trunk and roots).

A. Borers in roots.

1. Gummy exudations at base of tree from 2-4" below the surface to one foot above. The exudations are mixed with frass, a sawdust-like material and excrement. Dying or dead bark areas indicate burrowing larvae in the inner bark. The borers are yellowish worms 1" long, with brown thoracic legs and five pairs of abdominal prolegs. When borers are abundant nursery stock is seriously affected. Leaves yellow, tree vigor decreases, and trees may die. ....Peach borer, page 98.

B. Aphids on roots.

1. Roots, especially during late summer, have a great infestation of black aphids. Sandy porous soil is most likely to attract the aphids. Leaves yellow and look sickly and are covered with black fungi, especially during the spring and early summer. .....Black peach aphid, page 103.

III. FOLIAGE (Buds, Leaves and Flowers).

A. Bud injury.

1. Buds eaten off.

a. Caterpillars eating off buds.

(1). Buds are entirely eaten off as they begin to swell in the spring; later the fruit, leaves and shoots become seared and pitted by caterpillars which travel about in twisted horn-like tubes or cases nearly an inch long. Leaves are also rolled together and tied by silken strands, in which the creature and his house seeks shelter. The caterpillars are 3/5" long, greenish-brown, head and thoracic shield dark brown. (53, p. 68), (32, p. 213), (36, p. 560), (47f, p. 54). ..... Leaf crumpler Lineola indigenella.

(2). From the time of bud opening to three weeks after petal-fall buds are eaten off, unfolding leaves and setting fruits are badly injured. Several leaves and fruit clusters are tied together with silken threads; within the entanglements cavities are eaten into the fruit and the leaves are partially or totally ruined. Matured fruits have deep russeted, elongated scars badly deforming them. (12, pp.1-41), (21, pp. 1-6), (45, p. 23). .....
Fruit tree leaf roller Cacoecia argyrospila.

(3). Leaves are rolled up and tied together by leaf-eating larvae, which peel off the under leaf surfaces. They also eat off buds, flowers, and puncture fruit skins, then eat out the pulp. The first larval stage is as a leaf-miner; the mature stage is when buds are eaten off. There are two broods, one from May through June, the other from July through August. They winter over as eggs on the bark. (59, p. 63), (30, p. 230), (36, p. 716). .....
Oblique-banded leaf roller Cacoecia rosaceana.

b. Beetles eating off buds.
(1). Twigs badly gnawed so they droop, buds are entirely gnawed off. Injuries occur early in the season. Young trees set out in freshly cleared lands in close proximity to hickory or oak woodlots are seriously affected. The snout beetle is 3/8" long. .....New York weevil, page 102.

(2). Buds, leaves, and flowers are badly ruined early in the season; buds and leaves are eaten off or ragged and tattered; blossoms are nearly eaten off; newly set fruits are badly disfigured by having pits eaten into them. All the injury occurs during a period of a month or six weeks. The pests are beetles 1/3" long, yellowish-brown and have long sprawling legs. (59, p. 28), (9, p. 31), (45, p. 29). .....
Rose chafer Macrodactylus subspinosus.

2. Buds eaten into.
a. Caterpillars eating into buds.
(1). Opening buds are eaten into thus destroying flowers and leaves. Inside the buds are brown caterpillars with a black

head and shield eating and tunnelling about. Nursery stock is most injuriously attacked. The fruit has its epidermis scooped out in places, causing blemishes in matured fruits. (51, p. 540), (45, p. 21), (47f, p. 31). .....
Bud moth Tmetocera ocellana.

(2). Leaves and fruit clusters are drawn together and bound with silken cords. Fruit within the tangle has cavities eaten in them. The larvae are ¾" long, green, with head and thoracic shield dark brown or black. ...Fruit tree leaf roller, page 106.

(3). At foliage time leaves are rolled and tied together; within the enclosure reside several twisted horn-like tubes or cases nearly an inch long used by caterpillars for shelter. ....Leaf crumpler, page 105.

b. Beetles eating into buds.
(1). Buds, blossoms and new foliage in new orchards in close proximity to locust trees become badly devastated by small jumping beetles 1/10" long when they voraciously feed. (53, p. 205), (47f, p. 38). .....
Red-legged flea beetle Orchidodera rufipes.

(2). Opening buds are eaten into, leaf and fruit stems covered by gnawings. Injuries occur from May through June. (53, p. 371), (36, p. 533), (39, p. 167). .....
Imbricated snout beetle Epicaerus imbricatus.

(3). Buds are eaten off, twigs are gnawed and drooping. Early spring injuries especially to young trees in close proximity to hickory or oak woodlots. .....
.....New York weevil, page 108.

3. Buds rasped.
a. Early in season buds shrivel up and turn brown, on close examination the browned surfaces reveal raspings caused by feeding. Oviposition within stems of young fruit produces a wilting effect followed by premature fruit shedding. Heavy infestations appear as injuries caused by fire. (39, pp. 1-7), (53, p. 119), (36, p. 592). .....
Pear thrips Taeniothrips inconsequens.

B. Leaf injury.

1. Leaf miners.

a. Leaves are rolled up and tied together by leaf eating larvae, which feed off the under leaf surfaces. They also eat off buds, flowers, and in mature fruit skins, they then eat out the pulp. The first larval stage is a leaf-miner; during the mature stage buds are eaten off. .....Oblique-banded leaf roller, page 106.

2. Leaves rolled and webbed together.

a. Leaves webbed together in a loose nest, in which reside dirty, yellowish-white caterpillars, 1/2" long, and reddish-brown striped with six long dorsal and lateral stripes. They eat out of the enclosed leaves and shred them. There are two broods, one appearing in July and the other in September. (FF, p. 287), ... The Striped leaf worm Cnephasia asseclana.

b. Buds and leaves are webbed together by silken strands wherever the caterpillars feed. Larvae are 1" long, brown, having black heads. .....Bud moth, page 107.

c. Single or grouped leaves are drawn together, wherein caterpillars eat out the foliage, sometimes fruit skins and eat away at the pulp. The caterpillars are 1" long, light yellowish-brown to pale-green, having a brownish-black head and thoracic shield. The thoracic shield is bordered with white or black. ....Oblique-banded leaf roller, page 106.

d. Leaves and fruit clusters are drawn together and bound with silken cords. Fruit within the tangle has cavities eaten out. The larvae are 3/4" long, green, with head and thoracic shield dark brown or black. ....Fruit tree leaf roller, page 106.

e. At foliage tips leaves are rolled and tied together by threads; within the enclosure reside several twisted horn-like tubes or cases nearly an inch long used by caterpillars as shelter. .....Leaf crumpler, page 105.

3. Leaf protuberances.

a. Caterpillars which travel about in a twisted horn-like tube or case, nearly an inch long. When at rest they are inside enclosures made by rolled and tied leaves. ....Leaf crumpler, page 105.

b. Cone-like protuberances, varying on undersides of leaves from which caterpillars are found hanging. The growths are natural leaf tissue grown as a resistance to the feeding caterpillar. (57, p. 217), (51, p. 503), (36, p. 579).
.....
Bagworm Psychidae Oiketicus abrasus.

4. Spotted leaves.
a. Yellowish spots on foliage. Around the spots on under leaf surfaces are numerous very fine threads. Inside the spots are tiny red spiders 1/50" long. Leaves drop prematurely. (57, p.218), (48, p. 207), (49, p. 207). .....
Red spider Tetranychus bimaculatus.

b. Reddish, or greenish fl" galls or blisters on the under leaf surface. Silk threads entangle the blisters. Leaves and fruit are shed prematurely. Fruit is dwarfed, of a poor quality and texture. (10, pp. 1-125), (2, p. 140), (36, p. 554).
.....
Euro.ean red mite Paratetranychus pilosus.

c. Leaves turn pale yellow, curl up and drop; lower leaves are attacked first then higher ones etc. Six or eight-legged creatures inhabit the under leaf surfaces. The injuries become most severe in dry seasons and in arid areas, then defoliation occurs. The leaves become black specked before dropping. Fruit is badly stunted. Twigs and trunk have numerous pinkish or red eggs upon the bark, during the dormant stage sufficient to produce a reddish hue. (62, p. 1), (47f, p. 66), (45, p. 36).
.....
Clover mite Bryobia praetiosa.

5. Skeletonized leaves.
a. Leaves show nothing more than a mere frame-work of veins. The pest is a dark green slimy slug. (49, p. 642), (32, p. 348), (36, p.616).
.....
Pear slug Eriocampoides limacina.

b. Webs are spun at terminal points where many caterpillars centralize; the webs are conspicuous during the winter, while the larvae are in hibernation. The August brood tends to skeletonize leaves, but the principal injury occurs when the overwintering larvae revive in the spring to devour unfolding leaves as fast as they make their appearance. There is one

generation each year; the first stage is as a skeletonizing larva, the second is the hibernating stage from which the destructive new foliage strippers appear in the spring.
(3, pp. 24-32), (47f, p. 49), (23, p. 277).
.....
Brown-tail moth Nygmia phaeorrhoea.

c. Orchards, early in the spring, if they are new orchards in close proximity to locust trees are apt to have their foliage skeletonized by small jumping beetles 1/10" long. .....
.....Red-legged flea beetle, page 107.

d. Leaves are badly skeletonized by metallic-green or greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of abdomen. They appear in great swarms and last for two or three months of the summer. They gouge out the fruit or partly peel off fruit skins in irregular patches.
(2, p. 127), (27, p. 605), (30, pp. 1-31).
.....
Japanese beetle Popillia japonica.

e. Leaves are skeletonized, or buds, leaves, and flowers badly ruined early in the season by eating beetles. Buds and leaves are just about eaten up, new fruit has holes eaten out. The injuries occur during a period of a month or six weeks. Worst injuries occur in porous sandy areas. The insects are beetles 1/3" long, yellowish-brown and have long sprawling legs.
.....Rose chafer, page 106.

6. Leaves full of "shotholes".
   a. Leaves are riddled full of holes quite early in the season, in early June. The pest is a beetle 1/5" long, dull red and has black antennae. (18, pp. 753-817), (23, p. 165), (41, p. 1-3). .....
   Cherry leaf beetle Galerucella cavicollis.

7. Leaves curl, turn pale, dry up, and drop prematurely.
   a. Aphid injury.
      (1). Tips of branches have leaves curl up and drop prematurely, thus checking proper bud making and fruiting. Injuries occur either in the spring or fall. .....
      .....Mealy plum aphid, page 103.

      (2). About crotches and lower tree parts leaves curl up then drop prematurely. The leaves which drop have coatings of sooty-black fungi; young trees are most severely injured. Porous sandy soils most susceptible to tree injuries...Black peach aphid, page 103.

(3). Pale green aphids puncture shoots and leaves causing the shoots to warp and curl up, consequently the leaves turn yellow, curl and drop. The injury occurs in the spring. .....
.....Green peach aphid, page 103.

b. Spider or mite injury.
(1). Yellowish spots on undersides of leaves surrounded by silken webs encasing red spiders 1/50" long. .....
.....Red spider, page 109.

(2). Speckled leaves become browned and curled; from a distance they appear dust laden. Leaves drop prematurely. Fruit is undersized, of poor quality and color.
.....European red mite, page 109.

(3). Black speckled leaves, speckled with droppings, underneath which are many six or eight-legged mites, the size of a pinhead. Lower leaves attacked first, then higher leaves, etc. The injury is at its peak during dry seasons or in arid areas. .....Clover mite, page 109.

8. Foliage eaters.
a. Single defoliators.
(1). Beetles.
(A). Leaves, buds and flowers are eaten off by beetles early in the spring; some leaves are eaten ragged and tattered. Injuries occur over a one month or six weeks period. The beetles are 1/3" long, yellowish-brown possessing long sprawling legs. .....
.....Rose chafer, page 106.

(B). Leaves have the epidermis eaten off by voracious metallic-green beetles slightly larger than potato beetles. They are present for two or three months of the summer and cling together in swarms. .....
.....Japanese beetle, page 110.

(2). Caterpillars.
(A). Complete or partial defoliation may occur over night without leaving the least trace of the predator, or else a few hairless cutworms may be found on the ground. .....
.....Climbing cutworms, page 92.

b. Colonial defoliators.
(1). Web spinners.

(A). Thick webs are spun in forks or crotches and used as a shelter only; all feeding is done outside the web. Within the web leaves dry up and die; outside the web they are stripped. As the caterpillars grow they enlarge the web to accommodate the colony. The webs are spun early in the season, when buds and leaves are developing. The caterpillars are brown having a white dorsal line and blue sides, being sparsely haired. (1, pp. 1-18), (2, p. 125), (45, p. 14). .....
Eastern tent caterpillar Malacosoma americana.

(B). Caterpillars which spin one thread as a "gi-line" wherever they travel; when not feeding they congregate on trunk or branches. If food is scarce they go out after it in form like marching army worms. The caterpillars are 1¾" long, having a median row of white "lozenge shaped" dots along the back. (25, p. 241), (33, p. 16), (32, p. 204). .....
Forest tent caterpillar Malacosoma disstria.

(C). Loose woven nests, enclosing several caterpillars, are spun around several leaves. Within the web the larvae feed upon and shred leaves. The larvae are 3/8" long, dirty yellowish-white marked on the back and sides by six longitudinal reddish-brown stripes.
.....Striped peach worm, page 108.

(2). Non-web spinners.

(A). Caterpillars which spin a single thread as a "gi-line" wherever they travel; when not feeding they congregate on trunk or branches. .....
...Forest tent caterpillar, page 112.

(B). In the spring ground caterpillars eat off the epidermal layer; later they eat off the entire leaf save for the midrib. The larvae are 1½" long and have three pencil-like tufts of long black hairs, one on each side of the head and one at the dorsal posterior end. In young caterpillars tussocks are black but turn white later on; the head is black. (32, p. 203).
.....
Rusty tussock moth Notolophus antiqua.

(C). Many tiny gregarious caterpillars hatch out in time to lay waste expanding leaves; at first they eat out holes, later they consume the entire leaf except for the largest veins. Complete defoliation is not uncommon. Adult caterpillars are 2-3" long; two rows of red spots and two rows of blue spots along the back with a dim yellow stripe between; the body is clothed with long black hairs. (5, pp. 1-23), (47f, p. 48), (25, p. 273). ..... Gypsy moth Porthetria dispar.

(D). Overnight a tree is stripped of its flowers, buds, and leaves by an unseen pest. Young trees and nursery stock are most liable to be preyed upon, then very early in the season. In large trees a certain limb or limbs are attacked. .....climbing cutworms, page 92.

(E). Early in the season leaves are eaten off or eaten ragged and tattered. The injury occurs for about a month or six weeks. The insects are beetles 1/3" long, yellowish-brown and have long sprawling legs. They gather together in swarms. ....Rose chafer, page 106.

9. Premature defoliation.
   a. Spiders or mites.
      (1). Dried leaves under the tree having yellow spots on them around which are very fine silken meshes. Amongst the spots are tiny red spiders 1/50" in length. ....Red spider, page 109.

      (2). Reddish or greenish galls or blisters $\frac{1}{4}$" across on the undersides of fallen leaves. Silken threads enmesh the blisters. .....European red mite, page 109.

      (3). Leaves turn pale yellow, curl up and drop during dry spells. Under leaf surfaces have six or eight-legged creatures enmeshed by silk threads. Twigs and trunk have many tiny red eggs sufficiently numerous to extend a reddish hue. ....Clover mite, page 109.

   b. Aphids.
      (1). Tips of branches have leaves curl up and drop prematurely. Branches are the center of attack. The injuries occur either in the spring or fall. ....Mealy plum aphis, page 103.

(2). Leaves that have honeydew upon which black fungi grows curl up and drop, most of the injury occuring in the spring. Porous sandy soils are most susceptible to infestation. The pest is a black aphis. .....
.....Black peach aphid, page 103.

(3). Fresh shoots and leaves in the spring curl up and warp, the leaves dropping prematurely. The injurers are pale green aphids. .....Green peach aphid, page 103.

c. Beetles.
(1). From late May through June leaf and fruit stems are gnawed so they droop or drop off entirely. ...Lubricated snout beetle, page 1[illegible]

C. Flower injury.
1. Yellowish-green aphids that attack the peach blossoms and blight them.....Green peach aphid, page 103.

2. Flowers are rasped, shrivel up, and turn brown. Blossom stems have eggs inserted within them, the insertion so weakens the stem that it collapses. Peach skins are blasted by the raspings. The insect is black and 1/20" long. .....
.....Pear thrips, page 107.

3. Blossoms are eaten off by small jumping beetles 1/10" long. The injuries are intensified if the orchard is a new orchard in close proximity to locust trees. .....Red-legged flea beetle, page 107.

4. Flowers are eaten into or off by caterpillars which roll and tie leaves together. The over-wintering larvae revive in the spring when buds begin to unfold, then they commence their depredations. .....Oblique-banded leaf roller, page 106.

5. Flowers are stripped overnight by an unseen visitor, either on the whole small tree, or on certain limbs of large trees. ....Climbing cutworm, page 92.

6. Swarms of 1/3" long yellow-brown beetles with long sprawling legs descent upon trees to strip them of their flowers and leaves. .....
.....Rose chafer, page 106.

7. Injuries very similar to preceding species performed by beetles slightly larger than potato beetles, metallic-green or greenish-bronze, having two distinct white spots near the tip of abdomen.
.....Japanese beetle, page 110.

IV. FRUIT.

A. Fruit blemishes (outside).

1. Honeydew covered fruit harboring a sooty-black fungus. In the winter, undersides of twigs and branches are nearly covered with shiny convex-shaped brownish scales 1/16" in diameter. .....Terrapin scale, page 99.

2. Minute grayish specks on fruit surrounded by a reddish area. .....San Jose scale, page 99.

B. Fruit blemishes (through the epidermis).

1. Crescent-shaped scars.

a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times the scars develop depressions instead of lumps. Fruit becomes hard, knotty and misshapen, usually dropping during May or June. Inside the fruit resides a grayish-white curved grub 1/3" long. (6, pp. 469-516), (53, p. 240), (63, pp. 1-51). .....
Plum curculio Conotrachelus nenuphar.

2. Holes gouged or eaten out.

a. Caterpillar injury.

(1). Pits scooped out of the fruit; surrounding the injured fruit are leaves rolled together and tied. ....Bud moth, page 107.

(2). Newly set fruit has cavities eaten out by caterpillars which roll up leaves and tie them with silken threads. Mature fruit shows deep russeted, elongated scars. .....Fruit tree leaf roller, page 106.

(3). Fruit is scored and pitted early in the season: Adjoining injured fruit leaves are rolled and tied together in leaf tangles, in which are caterpillars in twisted horn-like tubes or cases nearly an inch long. .....Leaf crumpler, page 105.

(4). Fruit skins are gnawed and peeled, also small holes are eaten in the fruit. Around injured fruits are single and grouped leaves rolled together by leaf rollers. .....Oblique-banded leaf roller, page 106.

b. Beetles injury.

(1). Newly set fruits are badly injured by having the skins chewed off and deep holes scooped out of the pith. The insects are beetles 1/8" long, yellow-brown, possessing long sprawling legs....Rose chafer, page 104.

(2). In many ways as preceding species but wings. The beetles are about size of potato beetles. The head and thorax are shining bronze-green while the wing covers are tinged with green at the edges. The tip of the abdomen has two white spots. .....Japanese beetles, page 110.

c. Adult moth injury.
(1). Adult moths having lacerating mouth parts which rasp and tear up the skins of ripening fruits late in the season. The moths have a 1¼" wing spread, they are olive-tan, with three more or less prominent wavy transverse bars on each fore wing. They migrate north from the cotton belt where the larval stage is spent feeding on cotton. (23, p. 393), (36, p. 416), (9, p. 50). .....
Cotton leaf worm Alabama argillacea.

C. Internal worminess.
1. Wormy fruit.
a. Burrows are under the fruit which entirely undermine the calyx end. The mines are shallow and broad, surrounding the pit. The worm is 3/8" long, pinkish or nearly white. (53, p. 83), (23, p. 95), (45, p. 44). .....
Lesser apple worm Laspeyresia prunivora.

b. The pulp of ripening or ripened fruit may have tiny borers within about 5/8 to 1/2" long, dull reddish-brown, with the head dark brown or almost black. .....Peach twig borer, page 102.

c. Peaches with holes eaten in the flesh of the fruit, the burrow generally running around the pit. Masses of dark castings often protruding from these holes, especially at the calyx. Pinkish-white brown headed worms about ¾" long, feeding inside the peach or resting in tough cocoons of white silk, spun under the bark on the trunk or in other shelters about the tree. Minute, flat, white, shiny eggs, three-fourths the size of a pinhead, on the leaves adjacent to the growing fruit or on the skin. (9, p. 49), (45, pp. 40-44), (47f, p. 1), (36, pp. 525 and 568-73). .....
Codling moth Carpocapsa pomonella.

d. Burrows and excrement in the pulp or around pit, even excrement is forced out upon the fruit. Early peach varities are immune to the pest

because early larvae broods are twig borers. Later peach varieties are attacked by later larval broods. The worms are pinkish or creamy-white, ½" long. .....
.....Oriental fruit moth, page 101.

2. Crubby fruit.
   a. Convex shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times the scars develop depressions instead of humps. Fruit becomes hard, knotty, and misshapen, usually dropping in early summer. Inside the fruit resides a grayish-white curved larva 1/3" long. .....
.....Plum curculio, page 115.

D. Misshapen fruits.
   1. Dwarfed fruits.
      a. Fruits punctures early in the spring tend to dwarf the fruit and give it a very irregular surface, spotted here and there by tiny round specks, indicating where punctures occurred.
.....Mealy plum aphid, page 103.

      b. Injury very similar to preceding species.
.....Green peach aphid, page 103.

   2. Irregular fruit surfaces.
      a. One side of the fruit is quite normal, the other side has patches of brown skinless areas over which the skin from the normal side is making a desperate effort to graft over. The scarred side is somewhat gnarled and caved in.
.....Fruit tree leaf roller, page 106.

      b. Very deep pits and very high humps scattered over the fruit surface, giving it a gnarled appearance. Over the surface are crescent-shaped scars. Fruit drops prematurely.
.....Plum curculio, page 115.

E. Premature fruit shedding.
   1. Entire tree affected.
      a. Leaves of infested trees turn yellow, tree and fruit growth ceases, fruit falls prematurely. Branches have half-pea-shaped brown scales 1/8 to 3/16" long and they are soft bodied.
.....European fruit lecanium, page 100.

      b. Premature foliage shedding and fruiting go hand in hand. The leaves have yellowish spots on the undersides surrounded by silken webs encasing red spiders 1/50" long. .....
.....Red spider, page 109.

c. Premature foliage shedding and fruiting go hand in hand, as in the preceding species. The injuries occur during dry spells. The pest is a red spider 1/4 the size of a pinhead. .....Clover mite, page 109.

d. Similar to two preceding species. The leaves become speckled before dropping; from a distance they appear dust laden. ....European red mite, page 109.

2. Wormy fruit dropping prematurely.
   a. Fruit which has burrowing larvae above the pit, which entered via the calyx are apt to be Codling Moth larvae. If so they are ¾" long, pinkish-white with brown heads. ....Codling moth, page 116.

   b. Peaches which drop during May or June have crescent-shaped scars on the outside with grayish-white curved larvae within. ....Plum curculio, page 115.

3. Fruit stems causing fruit to drop.
   a. Young fruits crack open and drop prematurely, upon close examination of the stems they will be found to contain nymphs of insects 1/20" long or their eggs. ....Pear thrips, page 107.

   b. Young fruits have stems gnawed, thus severing the fruit from the tree. The injury occurs through May or June. ....Imbricated snout beetle, page 107.

KEY TO THE MORE IMPORTANT FRUIT INSECTS.

I. TRUNK, BRANCHES, AND TWIGS.

A. Trunk.

1. Mature trees.

a. Burrows from 1-2" below the ground line to a foot or more above, they are within the inner bark and sapwood extending into the heartwood. Darkened, dead, bark areas near the base of the tree and coils and piles of reddish sawdust like particles on the bark and ground reveal the insects presence. If present, they can be detected if the ground is scraped away from the tree at the ground line. Exit holes made by adults are ordinarily 8-10" above the ground and the diameter of a lead pencil. Deadened bark areas cause a general tree weakness; a complete girdling kills the tree. (47f, p. 80)*, (36, p.527), (53, p. 185). .....
Round-headed apple tree borer Saperda candida.

b. Just under the bark within the sapwood 1-½" deep, are irregular shallow burrows in the trunk and larger branches of old and young trees. Above the burrows the bark turns a dark and dead color. Inside the burrows there is fine sawdust packed tightly; in the entrance is a packing of excelsior like wood fibres. Large killed bark areas tend to girdle the tree. More often the sunny side of the tree is the center of attack. Full grown grubs are 1¼" long, yellow or yellow-white, having a flattened and rounded body piece just behind the head. (4, pp. 1-12), (27, p. 28), (47f, p. 83). .....
Flat-headed apple tree borer Chrysobothris femorata.

c. "Shotholes" in the bark the size of a pencil lead. Holes extending into sapwood join sawdust - filled lateral galleries and runways; both in trunk and branches they follow the grain. Adult and larval beetles are in the burrows; adults are 1/8" long. (32, p. 340), (36, p. 530), (53, p. 291). .....
Shot-hole borer Scolytus rugulosus.

2. Nursery stock or young trees.

a. Borers.

(1). Burrows are in the inner bark from 1-3" below ground to one foot or over above ground. Exit holes are 8-10" above ground and the diameter of a lead pencil.
...Round-headed apple tree borer, page 119.

*Figures in parenthesis refer to literature cited; see list of references at end of key.

(2). Branches and trunk full of "shotholes. .....Shot-hole borer, page 139.

b. Bark scales or coverings.
(1). Trunks, branches, twigs, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both fruit and bark, the areas turns red. Under magnification the specks are disks having a raised central nipple-like blackish spot. Tree vigor decreases, foliage becomes yellowish and scant. (23, p. 165), (57, p. 70), (28, p. 126), (47c, pp. 1-11). .....
San Jose scale Aspidiotus perniciosus.

(2). Trunk, branches, and twigs covered with small brownish scales 1/16-1/8" long, curved and resembling an oyster shell; underneath the disks are many minute eggs. The bark cracks and the whole tree weakens or dies. (47b, pp. 1-6), (23, p. 113), (22, p. 124). .....
Oyster shell scale Lepidosaphes ulmi.

B. Branches.
1. "Shotholes" in bark.
a. Branches and trunk full of "shotholes" the size of a pencil lead. .....Shot-hole borer, page 119.

2. Bark scales or coverings on branches.
a. Branches, twigs, and leaves have large soft-bodied half-pea-shaped scales 1/8-3/16" long, which cluster together on one side of the branch or twig. They winter over on small branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow, all growth ceases, followed by premature shedding of fruit and foliage. (33, p. 261), (32, p.129), (28, p. 148), (1, p. 123). .....
European fruit lecanium Lecanium corni.

b. Branches and twigs from May through July have under-surfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (36, p. 678), (25, p. 295), (2, p. 153). .....
Cottony maple scale Pulvinaria vitis.

c. Minute grayish thin scales are massed together upon branches and twigs. Under magnification the specks appear to have a raised reddish area in the center; thus they are distinguished from San Jose scales (page 130); otherwise they are

similar. (32, p. 128), (36, p. 617). .....
Cherry scale Aspidiotus forbesi.

C. Small branches, twigs, and shoots.
1. Twig borers.
a. Pinkish or creamy white larvae ½" long burrow in twigs causing the foliage to wilt and the shoot to die back. Earlier broods attack the shoots while later broods prefer the ripening fruits. The internal worminess shows up as burrows and excrement as found in the pulp, in the core, or may even be exposed on the outside. (2, p. 132), (36, p. 608), (47f, p. 10).
.....
Oriental fruit moth Grapholitha molesta.

2. Twigs severed.
a. Twigs from 2-3" long to 2-3feet long litter the ground beneath the tree. The twigs are smoothly cut off; the severed end has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a ¾" white grub. (53, p. 202), (25, p. 327), (36, p. 664). .....
Twig pruner Elaphidion villosum.

b. Twigs or small branches of ½" diameter are often cleverly girdled by having a complete ring gnawed out of the bark into the sapwood; consequently the twig dries up and is broken off when a high wind blows. Oviposition occurs in the severed part, the egg hatches and the grub eats out all but the bark, as the twig lies on the ground. (53, p. 202), (57, p. 282).
.....
Twig girdler Oncideres cingulatus.

3. Feeding punctures in twigs.
a. Young trees and nursery stock, especially, have shoots and fruit stems punctured and sap withdrawn, as the insects do so they cause the twig or shoot to warp and curl, at times producing a complete loop. Curling up of leaves leads to premature defoliation. Before the leaves drop they become heavily coated with honey-dew. The fruit likewise is punctured, when injured thus it takes on a dimpled and speckled appearance. (49, pp. 130-36), (11, pp. 23-8), (47e, pp. 5-7).
.....
Apple plant lice Aphis pomi, sorbi, and fitchi.

b. Terminal growth and some lateral growth dies back after distortion has occurred. Black spots indicate where feeding took place. Nursery stock and young trees are severly injured. Buds, leaves, and developing fruit are pitted and dwarfed.

The insect is 1" long, bluish colored, black and yellow striped, flapping a red thorax. (50, p. 40), (4, p. 199). .....
Lives on plant bug Thyanta custator.

II. UNDERGROUND (trunk).

A. Bores from 1-2" below ground to one foot or over above ground leave shallow burrows from the egg to the heartwood. Dead bark scales overlie the burrows. 9-10" above ground are round exit holes the size of a lead pencil, made by the adult beetles. .....
.....Round-headed apple tree borer, page 92.

III. FOLIAGE (buds, leaves, and flowers).

A. Bud injury.

1. Buds eaten off.

a. Buds are entirely eaten off as they begin to swell in the spring; later the fruit, leaves, and shoots become stemmed and pitted by caterpillars which travel about in twisted leaf-like tubes or cases nearly an inch long. Leaves are rolled together and tied by silken strands, in which the caterpillar and its larger pupa shelter. (50, p. 60), (28, p. 413), (30, p. 500), (472, p. 54). .....
Leaf crumpler Lithocolletis salicella.

b. Unfolding buds are entirely eaten off; unfolding leaves are eaten ragged and tattered. (31, p. 451), (50, p. 408), (32, p. 304). .....
Large flea beetle Systena elongata.

2. Buds eaten into.

a. Opening buds are eaten into, thus destroying flowers and leaves. Inside the buds are brown caterpillars ½" long with a black head and shield eating and tunnelling about. The fruit has its epidermis scraped out in places, causing blemishes in matured fruit. Nursery stock is often destructively attacked. (31, p. 540), (45, p. 81), (47f, p. 51). .....
Bud moth Spilonota ocellana.

b. Unfolding buds have their scales eaten off and the flowers eaten into. The destroying insects are very small caterpillars residing in sheltered cases. The cases are pistol-shaped having a curl or bend in them; in all they are ¼" long and may be found attached to leaves, twigs, branches, or fruit, depending upon the season of year. (28, p. 274), (31, p. 547), (57, p. 96). .....
Pistol-case bearer Coleophora malivorella.

c. Same as preceding except--that the case-bearer has a cigar-shaped case which is triangular at the tip. (36, p. 561), (47f, p. 59), (48, p. 10). .....
Cigar-case bearer Coleophora fletcherella.

3. Buds rasped.
a. Early in season buds shrivel up and turn brown, on close examination the browned surfaces reveal rasping caused by feedings. Heavy infestations appear as injuries caused by fire. Oviposition in stems of young fruit produces a wilting effect followed by premature fruit shedding. (14, pp. 1-7), (32, p. 119), (36, p. 592). .....
Pear thrips Taeniothrips inconsequens.

4. Buds punctured.
a. Shoots are tapped by sap sucking bugs which cause them to droop. They also puncture buds and draw sap from them. The bugs are ¼" long, coppery-brown, and have ovular bodies.
.....Tarnished plant bug, page 122.

B. Leaf injury.
1. Leaf miners.
a. Bark on trunk and branches have 1/10" seed-like protuberances within which reside small destructive pupating caterpillars. In the larval stage they are mobile leaf miners, making a mine ¼" in diameter. (33, p. 73), (32, p. 582).
.....
Resplendent shield bearer Coptodisca splendoriferella.

b. Leaf miner in early larval period. Pistol-shaped protuberances ¼" long on under leaf surfaces. .....Pistol-case bearer, page 122.

c. Leaf miner in early larval period. Cigar-shaped protuberances ¼" long on under leaf surfaces.
.....Cigar-case bearer, page 125.

2. Leaf protuberances.
a. In the spring buds are eaten off by caterpillars which travel about in twisted horn-shaped tubes or cases nearly an inch long, most of the time they are attached to under leaf surfaces in tangles of rolled leaves. .....
.....Leaf crumpler, page 123.

b. Cone-like protuberances growing on undersides of leaves within which are hanging caterpillars. The growths are natural leaf resistances against the feeding larvae. (26, pp.1-11), (35, p. 215), (51, p. 503), (36, p. 679).
.....
Pagworm Pyrideoteryx ephemeraeformis.

c. Pistol-shaped protuberances ¼" long on underleaf surfaces. .....Pistol-case bearer, page 122.

d. Cigar-shaped protuberances ¼" long on underleaf surfaces. ....Cigar-case bearer, page 123.

3. Leaves rolled and webbed together.
a. Buds are eaten off by caterpillars which travel about in twisted horn-shaped tubes or cases. When at rest they reside in a shelter made of leaves rolled and tied together. .....
.....Leaf crumpler, page 122.

b. Young trees and nursery stock have leaves rolled and tied, then leaves are eaten and fruit skins scooped out. The caterpillars are ½" long with a black head and shield. .....Bud moth, page 122.

4. Skeletonized leaves.
a. Leaves show nothing more than a mere framework of veins. The pest is a dark-green slimy slug ½" long. (50, p. 642), (32, p. 548), (36, p. 616). .....
Pear slug Eriocampoides limacina.

5. Leaves curl and dry up, then drop prematurely.
a. As new leaves unfold they commence to curl, dry up, and drop. Inside the leaf curl are multitudes of aphids sucking sap from remaining leaves, stem, and immature fruit. They remain on the tree the year round. .....
.....Apple plant lice, page 121.

b. Pale-greenish aphids puncture buds, shoots, leaves, and setting fruit. The leaves curl up and warp, turn yellow then drop. The injury occurs in the spring. ...Green peach aphid, page 126.

6. Foliage eaters.
a. Colonial defoliators.
(1). Non-web spinners.
(A). In midsummer colonies of caterpillars appear and completely defoliate branches or the whole tree; nursery stock or young trees are most likely to be attacked. When not feeding

they congregate on trunk or branches. When at rest the caterpillars either have the rear end elevated or the fore and rear ends elevated; when startled they raise both ends suddenly and remain so. The caterpillars are two inches long, black and yellow striped, having a yellow ring around the neck. (53, p. 123), (38, p. 270), (23, p.118). .....
Yellow-necked caterpillar Datana ministra.

(B). Same as the preceding species except the caterpillars are black and yellow striped with a coral red hump just behind the head and a row of spines projecting from it. (53, p. 125), (38, p. 271), (23, p. 118). .....
Red-humped caterpillar Schizura concinna.

(C). In the spring young caterpillars eat off the leaf epidermis but later the entire leaf, save for the midrib; some also gnaw holes in the fruit. The larvae are 1½" long and have three pencil-like tufts of long black hairs, one on each side of the head, and one at the dorsal posterior end. On the back of the rear end are two bright red spots. (30, p. 41), (57, p. 269), (36, p. 687). .....
White marked tussock moth Hemerocampa leucostigma.

(D). Neglected orchards have leaves stripped of the epidermis in midsummer, followed by the consumption of all save the midrib. The injury is done by caterpillars 1½" long, covered with dense and spreading tufts of white hairs, a row of eight black tufts on the back and two long slender black pencils on the fourth and tenth segments. The head, feet, and under body surfaces are black; upper body surface is white spotted with black. (47f, p. 53), (32, p. 183). .....
Hickory tussock moth Halisidota caryae.

7. Premature defoliation.
   a. Leaves curl up and drop during the spring. Amongst the dropped and curled leaves are multitudes of aphids....Apple plant lice, page 121.

b. Leaves turn yellow, curl up, warp and drop. The injury occurs in the spring. (11, p. 32), (51, p. 587), (36, p. 610). .....
Green peach aphid Myzus persicae.

C. Flower injury.
1. Flower stems are punctured by yellowish-green aphids while in the process of feeding; the stems wilt and the flowers die. (53, p. 151), (32, p. 142).
.....
Apple bud aphid Siphocoryne avenae.

2. Small insects 1/20" long rasp away the flower parts and work into the ovary. Their rasping is injurious but their oviposition in flower and fruit stems is worse; it causes the stems to lodge and the flower or fruit to die, then drop prematurely. .....
.....Pear thrips, page 123.

IV. FRUIT.
A. Fruit blemishes (outside).
1. Minute grayish specks on fruit and bark surrounded by a reddish area. .....San Jose scale, page 120.

B. Fruit blemishes (through the epidermis).
1. Crescent-shaped scars.
a. Convex-shaped crescent scars sometimes having a hole in the convex side. The incisions develop into swellings or knots protruding from the fruit surface. At times scars develop depressions instead of humps. The fruit becomes hard knotty, and misshapen, usually dropping during May or June. Inside the fruit resides a grayish-white curved grub. (6, pp. 469-513), (53, p. 243), (63, pp. 1-51). .....
Plum curculio Conotrachelus nenuphar.

2. Round holes or scars.
a. The skin between scars dries up and cracks. The injury is by feeding or by oviposition. The female oviposits, after digging out a hole in the fruit, then plugs the hole with excrement. Infested fruit may drop but usually it does not. (6, pp. 514-57), (23, p. 116), (47f, p. 21).
.....
Apple curculio Tachypterellus quadrigibbus.

b. Roundish holes are eaten through the skin and pulp is eaten out beneath. There are two rows of deep punctures which indicate oviposition. The fruit grows gnarled and knotty, having a woody texture. Inside the fruit is a $\frac{1}{4}$" grub, white, and legless. (23, p. 166), (56, p. 236), (36, p. 593). .....
Quince curculio Conotrachelus crataegi.

3. Small holes eaten through the skin.
   a. Cigar-shaped cases on fruit, ½" long. .....
   .....Cigar-case bearer, page 133.

   b. Pistol-shaped cases on fruit ¼" long. .....
   .....Pistol-case bearer, page 132.

4. Deep cavities eaten into fruit.
   a. Holes gnawed in young fruit, in regular pits. The insect doing the harm is 1½" long, having three pencil-like tufts of long black hairs, one on each side of the head and one at the dorsal posterior end; on the rear dorsal surface there are two bright red spots. .....
   .....White-marked tussock, page 125.

   b. Fruit surrounded by leaves rolled and tied up silken threads, which act as a shelter for caterpillars in horn-shaped cases nearly an inch long, have deep pits eaten out. .....
   .....Leaf crumpler, page 122.

5. Round exit holes in fruit.
   a. Fruit has exit holes 3/16" in diameter having a sort of ring around them. The fruit has burrows and heaps of excrement in the pulp, around and within the core; often the seeds are eaten out. The entrance is via the core. The worm is 3/4" long, pinkish-white, has legs, and has a brown head. (9, p. 49), (45, pp. 40-44), (47f, p. 1), (56, pp. 525 and 536-73). .....
   Codling moth Carpocapsa pomonella.

C. Internal worminess.
1. Worm fruit.
   a. Burrows are under the skin of quinces which entirely undermine the calyx end. The mines are shallow but broad, seldom entering the core. The worm is 3/8" long, pinkish or nearly white. (53, p. 23), (23, p. 95), (45, p. 44).
   .....
   Lesser apple worm Laspeyresia prunivora.

   b. Whole apple full of burrows and excrement, often seeds are entirely eaten out. Outside either has a 3/8" round exit hole surrounded by a circle; or else has a ¾" long, pinkish-white worm which has a brown head. .....
   .....Codling moth, page 127.

   c. Burrows and excrement are in the pulp and core, even excrement is forced out upon the outside. Badly infested fruit has worms ¼" long, pinkish or creamy white. ...Oriental fruit moth, page 121.

2. Crubby fruit.
   a. Charled and knotty fruit drops prematurely, during May or June. In the fruit resides a ½" grayish-white curved grub. .....
   .....Plum curculio, page 126.

   b. Misshapen, knotty, undersized fruit with small holes eaten in the ends or side, the skin between dries and cracks. Fruit may fall, usually it clings to the tree. The grub within is ½" long, milky-white, and hump backed, but legless. .....Apple curculio, page 126.

   c. Charled and knotty fruit has woody texture. Round holes are eaten through the skin and pits scooped into the pulp from the outside. Two rows of deep punctures indicate oviposition. Within the fruit resides a grub or worm, ¼" long, white, and legless. .....
   .....Quince curculio, page 126.

D. Misshapen fruits.
   1. Charled, knotty, undersized fruit.
      a. Grayish-white grubs ½" long inside the fruit. Fruit drops prematurely. .....
      .....Plum curculio, page 126.

      b. Milky-white grubs ½" long inside of fruit which clings to the tree. ...Apple curculio, page 126.

      c. In the fruit remain ¼" white grubs, as the fruit clings to the tree. Round holes are eaten through the skin from which deep pits are eaten out of the pulp. .....
      .....Quince curculio, page 126.

   2. Uneven, dimpled fruit surface.
      a. Dwarfed fruit which has a dimpled and speckled surface. .....Apple plant lice, page 121.

E. Premature fruit shedding.
   1. Charled, knotty, and dwarfed fruit which have within them ½" long, grayish-white curved grubs.
   .....Plum curculio, page 126.

   2. Windfalls under the tree or worny apples on the tree either have a 3/8" exit hole surrounded by a ring, or else contains a 3/4" long pinkish-white worm which has a brown head. .....
   .....Codling moth, page 127.

KEY TO [illegible] INJURY TO [illegible].

I. MAIN STEM, LATERAL CANES, AND SHOOTS.

A. Main stem.

1. From the ground line up to the second year's growth the bark is coated with yellowish-brown scales which are elliptical, flat, and 1/15" in diameter. Each has the central spot off-center and the middle is whitish. Dark overwintering eggs attached. Encrusted vines may die. (34, p. 439). .....
Grape scale Aspidiotus uvae.

2. The main stem, lateral canes and shoots are coated over with small brownish scales 1/16 to 1/8" long, curved and resembling an oyster shell; underneath individual scales are many minute eggs. Bark cracks and the whole vine weakens or dies. (47b, pp. 1-6), (23, p. 113), (32, p. 124). .....
Oyster shell scale Lepidosaphes ulmi.

B. Lateral canes.

1. Canes severed.

a. Canes and shoots from two to three inches long to three feet long lie upon the ground beneath the vine. The growths are smoothly cut off; the severed part has a hollow center plugged with fine shavings and sawdust. The tunnel may be 10-15" long enclosing a 3/4" white grub. (33, p. 200), (25, p. 227), (36, p. 664). .....
Twig gruner Elaphidion villosum.

2. Cottony masses on undersides of canes and shoots.

a. Canes and shoots from May through July have undersurfaces covered with cottony masses beneath which soft-bodied scales live. Heavily infested vines have entire foliage turn a sickly yellow and die. (36, p. 676), (25, p. 295), (1, p. 158). .....
Cottony maple scale Pulvinaria vitis.

C. Shoots.

1. Borers in shoots.

a. Burrows from shoots to base of main stem, widening out at shoot base causing the shoots to wilt and drop off. The boring are lengthwise with the grain and contain ½" brown beetles. (50, p. 513), (15, p. 67), (31, p.449). .....
Apple twig borer Amphicerus bicaudatus.

b. During the spring terminal borers work into shoots causing them to wilt or die back; the larvae winter over within shoots. The larvae, during the early spring, also bore into buds.

*Figures in parenthesis refer to literature cited; see list of references at end of key.

The larvae are ½" long, brown, black headed, and pupate in incomspicuous cocoons on the vine. The first brood tunnels in buds and shoots; the second brood tunnels in shoots and fruit; the third brood infests only the fruit. In all broods they attack the roots causing them to die back. (23, p. 170), (33, p. 315), (36, p. 601). .....
Peach twig borer Anarsia lineatella.

c. Shoots are severed and lie on the ground beneath the vine. The severed part has a hollow center containing a ½" white grub and is plugged with fine shavings and sawdust. .....
.....Twig pruner, page 129.

2. Rows of shoot punctures.
   a. Rows of pinholes through outer bark into the cambium or sapwood. The punctures are in a row with the grain. Each row may have 50-75 holes which are 25 to the inch. The punctures are holes made during oviposition and contain eggs 1/8" long. Perforated twigs become diseased or dry up and break off. (55, pp. 1-20), (59, p. 36), (45, p. 56). .....
   Tree cricket Oecanthus nivous and others.

3. Cottony masses on under shoot surfaces.
   a. Bark is coated on under shoot surfaces with cottony masses sheltering aphids, from May through July. ...cottony maple scale, page 129.

II. UNDERGROUND (roots).

A. Large, long white grubs 2-3" long; having a brown and black head and a lateral row of oval spots along the body. They bore around in the roots. (32, p. 522), (10, p. 282). .....
Giant grape root worm Prionis laticollis.

B. Galls or nodules of soft tissue form on roots then decay sets in and girdles the roots. Leaves have spherical galls on the under leaf surfaces, in which are many small aphid-like insects. Five to seven aphid generations rise as leaf gall makers, all after the third generation migrate to the roots to produce galls. When the roots began to rot the leaves yellow, growth ceases, and the vine dies. (23, pp. 171-3), (51, p. 432), (36, p. 629).
.....
Grape phylloxera Phylloxera vitifoliae.

C. Small roots and rootlets are fed on by tiny grubs, some of which even eat bark off of larger roots. The grubs are 2/5" long, white, yellowish-brown head and thoracic shield. The adult beetles eat out chain-like holes in leaves or else entirely devouring them. The adults are ¼" long, reddish-brown covered with short gray hairs. Adults appear during June and July. Larvae are on the

roots from early fall to June. (23, p. 175), (51, p.451), (53, p. 448). .....
Grape root worm Fidia viticida.

D. Roots die-back because of small borers ½" long, they are brown with black heads. ...Peach twig borer, page 130.

III. FOLIAGE (buds, leaves, and flowers).

A. Bud injury.

1. Buds eaten off or eaten into.

a. Buds are eaten off and new foliage is eaten ragged and tattered. At first they feed upon the upper epidermis, later they eat out irregular holes in the leaves. The larvae are 1/8" long, dark brown, later yellowish-brown, and marked with regular rows of blackish tubercles, each bearing a small hair. The head, anal, and prothoracic plates, and legs are black. (51, p. 451), (53, p. 403), (39, p. 264). .....
Grape flea beetle Haltica chalybea.

b. Buds, leaves, and flowers may be partially or totally striped overnight by an unseen predator. The injury occurs very early in the season. (53, p. 138), (2, p. 130), (45, p. 11). .....
Climbing cutworms Noctuidae sp.

c. Early in the season buds shrivel up and turn brown. On close examination the browned surfaces reveal raspings caused during feeding. Heavy infestations appear as injuries caused by fire. Oviposition in stems of new fruit produces a wilting affect followed by premature fruit shedding. (32, p. 119), (36, p. 592). .....
Pear thrips Taeniothrips inconsequens.

B. Leaf injury.

1. Speckled leaves.

a. Very small whitish spots appear on grape leaves, turning them to a pale greenish-yellow; the leaves dry up and fall. The white spots are due to feeding punctures from which the chlorophyll was extracted. The injury occurs soon after the first foliage unfolds. The insects are 1/8" long, light-yellowish, with green markings on the wings. They have strong jumping legs and inhabit under leaf surfaces. (23, p. 177), (51, p. 456), (37, p. 311). .....
Grape leafhopper Erythroneura comes.

b. During midsummer or early fall grape leaves become stippled or mottled with white. The leaves do not curl but they fade and drop prematurely. The insects habits are identical to preceding species. The insect is 1/8" long, yellow-green in color. (47f, p. 29), (32, p. 156), (45, p.7), (31, p. 13). .....
Rose leafhopper Typhlocyba rosae.

2. Leaves skeletonized.
   a. During late spring sulphur-yellow caterpillars ½" long skeletonize the leaves, later they eat out holes and consume all but the larger veins. They are colonial insects and feed in a row, like soldiers in formation. The caterpillars are marked with four rows of black spots, visible from above; the body is clothes with long, bristly hairs. (53, p. 416), (57, p. 162).
   .....
   Grape-leaf skeletonizer Harrisina americana.

   b. Leaves are badly skeletonized, during a three months period, by metallic-green or greenish-bronze beetles slightly larger than potato beetles, having two distinct white spots near the tip of the abdomen. They swarm together in great numbers. The fruit is either gouged out or seriously peeled. (2, p. 127), (36, p. 605), (48, pp. 1-31).
   .....
   Japanese beetle Popillia japonica.

3. Leaf protuberances.
   a. Leaves have holes cut out of them on three sides and rolled together on the fourth side and tied by silken strands. The first leaf injury occurs early in the season. The first generation of larvae web together flowers and newly set or setting grape clusters. Later the larvae bore into green and ripening fruit where they eat out the seeds and pulp, producing purplish spots on outside. The worm causes decay within and fungi grows near the opening. Individual grapes are tangled up by silken threads which prevent their natural growth. The larvae are 3/8" long, dark-green to dark-purple with a light-brown head, and a black thoracic shield. (33, p. 130), (51, p. 462), (36, p. 619). .....
   Grape berry moth Polychrosis viteana.

   b. Leaves have spherical galls on the under leaf surfaces; inside the galls are many minute aphid-like insects. .....Grape phylloxera, page 130.

4. Grapes and leaves wrapped and tied in silken threads.
   a. Leaves and grapes, usually wormy grapes, are tied together by silk spinning caterpillars. .....Grape berry moth, page 132.

5. Foliage eaters.
   a. Epidermis eaten off of leaves.
      (1). Leaves are devoid of their epidermis as well as holes eaten through them. The grapes have great holes eaten in them sufficiently to spoil the bunch. The injury carries

over during a three months period when the pests congregate in swarms. They are beetles slightly larger than potato beetles, metallic-green or greenish-bronze, and have two distinct white spots near the tip of the abdomen. ....Japanese beetle, page 132.

(2). During late spring leaves are skeletonized by colonial caterpillars which eat off the leaf surfaces as they eat in rows like soldiers in formation. The caterpillars are ½" long, sulphur-yellow; marked with four rows of black spots, visible from above; the body is clothed with long bristled hairs. ....Grape-leaf skeletonizer, page 132.

b. Holes eaten into leaves.

(1). Colonial caterpillars eat holes in leaves, later consuming all but the main veins. The larvae are ½" long, sulphur-yellow, marked with four rows of black spots, visible from above. The body is covered with long bristled hairs. ....Grape leaf skeletonizer, page 132.

(2). During the spring small chain-like holes are eaten out of leaves by grayish-tan beetles ¼" long. ....Grape root worm, page 140

c. Single defoliators.

(1). Grape leaves are devoured by large caterpillars 2" long and have a horn-like-tail erected from the dorsal posterior end. The caterpillars are green covered with small yellow dots. Along the body are seven oblique stripes margined behind with a darker green. A white stripe with a deep green margin extends from behind the head to the horn; on either side of the back, and along the middle is a series of seven spots, varying from red to pale-lilac and set in a patch of pale-yellow. (56, p.161), (23, p. 178), (38, p. 272), (50, p. 528). ..... Grape vine hog sphinx Ampelophaga myron.

(2). During the summer leaves are devoured by caterpillars up to 3½" long. They are variable in color, some being yellowish-green with black eye spots along each side of the back with faint blackish stripes, while others are black with yellowish spots on the back. The caterpillars have a tail-like horn on the dorsal posterior end.

(37, p. 102), (30, p. 3[illegible]), (25, p. 183).
.....
White lined sphinx Sphinx lineata.

(3). From the first of June to the fore part of August naked caterpillars 1½" long feed upon grape leaves. They have a bright orange head, an orange band across each segment, on each side of the body is a wavy white longitudinal band which is more prominent near the rear end. (32, p. 183), (53, p. 420), (38, p. 275), (57, p. 167), (2, p. 157). .....
Eight-spotted forester Alypia octomaculata.

(4). Few or many large golden-yellow beetles an inch long may be found on grape leaves in the process of devouring them. Each wing cover is marked with three black dots and two on the prothorax. (38, p. 262).
.....
Eight-spotted pelidnota Pelidnota punctata.

(5). Early in the season new foliage is eaten ragged and tattered. The injury is done by adult jumping beetles 1/5" long of a dark metallic greenish-blue color. The larvae, which are 1/3" long and light-brown having black spots, also feed on unfolding leaves. ...Grape flea beetle, page 131.

d. Colonial defoliators.

(1). Dirty-white loosely woven webs, containing excrement everywhere, enclose lateral cane tips late in the summer or early fall. The colonial caterpillars feed within the web. The caterpillars are about 1" long, covered with black and white hairs projecting from numerous black tubercles. They are variable in color varying from yellowish with black and yellow tubercles, while others have a dark stripe down the back and are almost black. (45, pl. 18), (25, p. 215), (47f, p. 44). .....
Fall webworm Hyphantria cunea.

(2). Leaves may be stripped overnight and no trace of the predator be visible. .....
.....Climbing cutworms, page 131.

(3). During late summer leaves are entirely consumed save for the main veins. The devouring caterpillars feed in a row like soldiers in formation. They are ½" long, sulphur-yellow, marked with four rows of black spots, visible from above. The body is clothed

with long bristly hairs. .....
.....Grape leaf skeletonizer, page 132.

(4). Early in the spring and for about a six weeks period, leaves are stripped and other are eaten full of holes, ragged or tattered. The pest is a beetle about 1/3" long, yellowish-brown, possessing long sprawling legs. (19, pp. 1-4), (59, p.28), (9, p. 51), (45, p. 29). .....
Rose chafer Macrodactylus subspinosus.

e. Premature defoliation.

(1). In spring and fall the foliage curls up, browns, and falls prematurely. Underneath the leaf curls are numerous light-green aphids covered with a bluish-white mealy powder. Along the body are three longitudinal stripes somewhat darker than the other body color. (50, p. 662), (51, p. 592).
.....
Mealy plum aphid Hyalopterus arundinis.

(2). Stems of newly developed or developing leaves, flowers, and fruits are so injured by sap-sucking bugs that they wilt and drop prematurely. Fruit which has already set is punctured in many places causing an irregular surface on the ripened fruit and a toughened, tasteless pulp. The skins are apt to crack where punctures occur. The bugs are $\frac{1}{4}$" long and light-brown.
(40, pp. 1-8), (9, p. 58), (53, p. 221).
.....
False tarnished plant bug Lygus invitus.

(3). Pale greenish-yellow leaves which have very many small whitish spots on them drop shortly after leafing out. .....
.....Grape leafhopper, page 131.

(4). During midsummer leaves fade, become stippled or mottled with white, then drop.
.....Rose leafhopper, page 131.

C. Flower injury.

1. Overnight flowers are entirely stripped and no trace of the pest is at hand. .....
.....Climbing cutworm, page 131.

2. Flower stems wilt and dry up, upon close examination the stems will reveal nymphs infestation as a result of oviposition. The same injury occurs to new fruit causing premature fruit shedding. Flower parts are rasped as the tiny 1/20" long, insect feeds.
.....Pear thrips, page 131.

3. During blossom time small nymphs inject their proboscos into and feed on flowers, causing them to dry and curl up; thus killing them. Most of the injury is done at the latter part of May on new fruits as they puncture and produce an irregular surface on the outside and dry up pulp on the inside. .....False tarnished plant-bug, page 135.

4. Flowers are eaten off or eaten so they dry up without fruiting. The injurer is a beetle 1/3" long, yellowish brown, has long sprawling legs, and congregate in swarms over a six weeks period. ....Rose chafer, page 135.

IV. FRUIT.

A. Webs entangling grapes.

1. Individual grapes are fastened together by silken threads; the entangled grapes are wormy, having larvae 3/8" long, dark-green to light-brown head, and a black thoracic shield. .....Grape berry moth, page 132.

B. Grape blemishes (outside).

1. Minute grayish specks on the bark and grapes surrounded by a reddish area. ....San Jose scale, page 120.

2. Grape skins are lacerated late in the summer by adult moths with a 1¾" wing span, they are olive-tan and have three more or less prominent wavy transverse bars on each fore wing. (23, p. 393), (36, p. 416), (45, p. 50). ..... Cotton leaf-worm Alabama argillacea.

C. Deformed grapes.

1. Feeding punctures in young grapes cause a deformed and speckled, irregular surface. ....False tarnished plant-bug, page 135.

D. Small holes eaten into grapes.

1. Small holes are eaten into grapes by the female in which she oviposits. The eggs hatch into white, footless grubs, 1/3" long, the body tapers towards both ends, and the body is clothes with fine short hairs. The grubs can be easily distinguished from the Grape Berry Moth because the Grape Berry Moth has well developed legs and is a dark color. (50, p. 534), (23, p. 183), (32, p. 335). .... Grape curculio Craponius inaequalis.

E. Large holes eaten into the grapes.

1. During a six weeks period in the early summer large holes are eaten out of grapes or nearly the whole grape consumed. Swarms of beetles 1/3" long, yellowish-brown, and have long sprawling legs. .....Rose chafer, page 135.

2. During a three months period commencing early in the season, large holes are eaten out of grapes or else the entire grape is consumed. Swarms of beetles slightly larger than a potato beetle do the damage. They are metallic greenish-bronze and have two distinct white spots at the abdominal end. .....Japanese beetle, page 132.

F. Wormy grapes.

1. Worms infesting the fruit as larvae 1/16-3/8" long, brown, and black headed. ....Peach twig borer, page 130.

2. Worms 3/8" long in the fruit which have well developed feet and in color are dark-green to purplish. .....Grape berry moth, page 132.

3. Grubby fruit with grubs 1/3" long, white, footless, and the body which tapers towards both ends is clothed with fine short hairs. ....Grape curculio, page 136.

G. Premature fruit shedding.

1. Main stem and lateral canes, on the undersides, clothed with cottony appearing masses sheltering soft living scales. ....Cottony maple scale, page 129.

2. Oviposition in stems of newly set fruit by tiny insects which are black and 1/20" long produces a wilting affect of the stem which caused early shedding. .....Pear thrips, page 131.

3. New fruit has the stem of the grape bunch punctured by sap sucking bugs which cause the fruits to be stunted or growth cease entirely and then drop. .....False tarnished plant bug, page 135.

4. Fallen fruit which has white grubs 1/3" long, legless, and has a tapering body clothed in fine short hairs. .....Grape curculio, page 136.

KEY TO THE MORE IMPORTANT BLACKBERRY AND RASPBERRY INSECTS.

I. **MAIN STEM** (cane & shoots).

A. Canes.

1. Bark coverings on canes.

a. Undersides of canes and shoots have large soft-bodied half-pea-shaped scales 1/8-3/16" long which cluster together. They winter over as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow, all growth ceases, followed by premature shedding of foliage and fruit. (53, p. 261), (32, p. 129), 23, p. 148), (2, p. 123). .....
European fruit lecanium *Lecanium corni*.

b. Bushes are weakened by the presence of snowy-white scales which from a distance make the bush appear white-washed. Individual scales are nearly circular, thin and flat, and 1/12" in diameter; at the margin are two light yellow exuviae. (32, p. 128), (38, p. 260). .....
Rose scale *Aulacaspis rosae*.

2. Cane galls.

a. A pithy swelling in the cane from one to three inches long and nearly an inch in diameter. It is red or reddish-brown, with the surface divided by deep longitudinal furrows forming four or five ridges or parts. In the gall reside larvae 1/10" long, having reddish mouth-parts and oval spots of the same color along the lateral surface. (51, p. 411), (38, p. 247). .....
Blackberry gall-maker *Diastrophus turgidus*.

3. Cane punctures.

a. Through the bark into the pith rows of pinholes are punctured in one side of the cane. There may be twenty-five to an inch, or fifty to seventy-five in a row; in each pit an egg 1/8" long is inserted. The incisions are not straight down but rather curved in. The infested canes or shoots break off beyond the injury or die back. (55, pp. 1-20), (59, p. 36), (45, p. 56).
.....
Tree cricket *Oecanthus sp.*

4. Cane borers.

a. From April to early June shoot tips wilt because of small gall-like swellings. As soon as shoots appear above ground they are attacked. Within the swelling hatch maggots which began to burrow downwards then completely girdles the inner bark causing the cane to dry up and break off.

*Figures in parenthesis refer to literature cited; see list of references at end of key.

The maggots continue to bore downwards in the pith to the ground level where they pupate for the winter. The eggs are laid in axils of young leaves at shoot tips, from which the maggots bore downwards. (32, p. 277), (23, p.207), (53, p. 329). .....
Raspberry cane maggot Hylemyia rubivora.

b. Young shoots wither, die, and break off as the canes below them girdled twice, an inch apart. Between the girdles an egg is deposited, upon hatching the grub bores down in the pith to the ground line which it reaches in time to hibernate for the winter. At intervals the burrow makes an exit to the outside. The grubs are 1" long, dull-yellow, small dark-brown head. (28, p. 267), (23, p. 202), (32, p. 322). .....
Raspberry cane-borer Oberea bimaculata.

c. Swellings occur in the canes, as they continue to grow they crack open longitudinally. The swellings in raspberries cause the canes to die but in blackberries they merely prevent fruiting. Just under the bark the grubs make spiral tunnels in the sapwood. Within the tunnels are pale-yellow larvae 3/5" long, small brown head, black jaws. The anterior segments are enlarged and flattened; the tip of abdomen has two long slender dark-brown horns, each with three blunt teeth on the inner edge. (32, p. 30), (36, p.639), (23, p. 205), (28, p. 267). .....
Red-necked cane borer Agrilus ruficollis.

d. Borers tunnelling about in the lower portion of the cane and in the upper root parts, sometimes completely girdling the crown. The larvae are 1½" long, white, and have a brown head. (23, p. 204), (32, p. 218). .....
Raspberry root borer Bembecia marginata.

B. Shoots.
1. Shoot borers.
a. Shoot tips wilt because of gall-like swellings near the shoot base. From the swelling downwards is a tunnel through the pith.
.....Raspberry cane maggot, page 139.

b. Shoots wilt and dry up because of two girdles below, one inch apart. .....
.....Raspberry cane borer, page 139.

2. Shoots wilting (containing no borers).
   a. Early in the seasons shoots are punctured and sap withdrawn resulting in deformed shoots; the same occurs to fruit and leaf stems, causing fruit to die and leaves to curl up and drop. Buds too are killed by being punctured. Later the fruit is pitted, or dwarfed if it wasn't previously to seriously hampered. The pests are ¼" bugs, having a black and yellow marked thorax, and a brassy color otherwise. (59, p. 43), (2, p. 139), (36, p. 611), (35, p. 48). .....
   Tarnished plant bug Lygus pratensis.

3. Shoots gnawed so they droop.
   a. Buds are eaten into and thus destroyed, others are used by the female as a source for oviposition. In either case the shoot is partly gnawed off and left hanging. (23, p. 194), (32, p. 332), (36, p. 643). .....
   Strawberry weevil Anthonomus signatus.

II. UNDERGROUND (roots and crown).
   A. Borers in roots.
      1. Large grubs bore in crown and roots; they are 2-3" long, white, with a brown and black head and a lateral body row of oval spots. (32, p. 322), (37, p. 232). .....
      Giant grape root-worm Prionis laticollis.

      2. Boring larvae in the crown and upper root portions, sometimes completely girdling the crown. They are 1½" long, white, and have a brown head. .....
      .....Raspberry root borer, page 139.

III. FOLIAGE (buds and leaves).
   A. Bud injury.
      1. Wormy buds.
         a. Unfolding buds are eaten into, thus destroying opening flowers and leaves. Inside the bud resides a ½" long brown caterpillar with a black head tunnelling about. The fruit is likewise gnawed into thus causing blemishes. (51, p. 549), (45, p. 21), (47f, p. 31). .....
         Bud moth Tmetocera ocellana.

      2. Buds eaten into.
         a. Opening buds are punctured and the insides eaten out by small jumping beetles 1/lo to 1/5" long, metallic in color. They also eat holes in leaves like "shot" perforations. The larvae are leaf miners. (45, p. 8), (36, p. 558). .....
         Apple flea weevil Orchestes pallicornis.

3. Oviposition in buds.
   a. Buds are eaten into and thus destroyed, others are used by the female as a source for oviposition. In either case the shoot is partly gnawed off and left hanging. .....
   .....Strawberry weevil, page 140.

4. Buds eaten off.
   a. Buds are eaten off and developing leaves skeletonized by small beetles ¼" long, reddish-yellow or reddish-brown, having a thick coat of pale tawny hairs. Larvae are ¼" long, plump, cylindrical, white grubs; each segment is crossed with a brood yellow band and has many short white hairs, they appear in June and July to feed into the fleshy head of the berries. Infested berries are dwarfed and ripen prematurely. (23, p. 201), (56, pp. 91-99), (14, pp. 173-85).
   .....
   Raspberry fruit worm Byturus unicolor.

   b. Opening buds are eaten into, leaf and fruit stems severed by gnawings. The injury occurs from May through June. The injury is done by snout beetles 3/8-½" long, greenish-brown; the wing covers are crossed by two irregular light bands. (53, p. 371), (36, p. 533), (38, p. 167).
   .....
   Imbricated snout beetle Epicaerus imbricatus.

   c. Buds, leaves, and flowers are stripped or ruined early in the season; buds and leaves are eaten off or eaten ragged and tattered; berries are just about eaten off. All the injury occurs during a month or six weeks. Adult beetles are 1/3" long, yellowish-brown, and have long sprawling legs. They prefer porous sandy area. (59, p. 28), (9, p. [illegible]), (45, p. 29). .....
   Rose chafer Macrodactylus subspinosus.

   d. Leaves are rolled up and tied together by leaf rolling caterpillars which later eat off under leaf surfaces. The earliest stage is spent as a leaf miner, after that it eats off buds, flowers, and eats into the fruit. The larvae are ¾" long, yellowish-green, head and thoracic shield are brownish black. Two broods carry on May-June and July-August respectively. (35, p. 73), (36, p. 716), (32, p. 230),
   .....
   Oblique-banded leaf roller Cacoecia rosaceana.

   e. Complete or partial defoliation of buds, leaves, and flowers may occur overnight by an unseen predator. The injury occurs in the spring, very

early. Nursery stock is most susceptible to attack. (53, p. 138), (2, p. 130), (45, p. 11).
.....
Climbing cutworms Noctuidae sp.

B. Leaf injury.
1. Leaf miners.
a. Leaves are rolled up and tied together by leaf rolling larvae which eat off the under leaf surfaces. The earliest caterpillar stage is spent as a leaf miner, after that it eats off buds, flowers, and eats into the fruit. The caterpillar is ¾" long, yellowish-green, head and thoracic shield brownish-black. Two broods carry on May-June and July-August respectively.
.....Oblique-banded leaf roller, page 141.

b. Lower leaves have large brown blisters, near edge of leaf, with mines in the center of them and flattened, active larvae 1/3" long feeding therein. (7, pp. 3-37), (24, pp. 10-15), (52, p. 69), (23, p. 137). .....
Blackberry leaf miner Metallus rubi.

c. Leaf mines from near the leaf center to the margin terminating in blister like cells. Adults are beetles 1/10" long which eat out ground holes in the foliage, giving it a "bird-shot" perforation. .....
.....Apple flea weevil, page 140.

2. Leaf rollers.
a. Leaves are rolled up and tied together by leaf rolling caterpillars which later eat off the under leaf surfaces. The earliest stage is spent as a leaf miner, after that it eats off buds, flowers, and eats into the fruit. The larvae are ¾" long, yellowish-green, head and thoracic shield are brownish-black.
.....Oblique-banded leaf roller, page 141.

b. Leaves are rolled up by spinning caterpillars after that the leaves turn brown and die; infested bushes appear whitened or grayish. The caterpillars inside the rolls are 1/3-1/2" long, light-brown, dark olive-green, or brown; and they have a brown head. (8, pp. 1-8), (58, pp. 235-56), (23, p. 197). .....
Strawberry leaf roller Ancylis comptana.

3. Spotted leaves.
a. Yellow spots on lower leaf surface which show through the upper part of the leaf, if examined turn out to be spots of oviposition or the earliest larval period of a sawfly. Young larvae are ¾" long, green covered with barbed spiny tubercules, brown on the back and white on the

sides. At first, during early summer, the larvae eat soft leaf parts later consuming all but the veins. (32, p. 347), (23, p. 203).
.....
Raspberry sawfly Monophadnoides rubi.

b. Large brown blisters near the edge of leaf with mines in the center of them occupied by larvae 1/3" long. .....
.....Blackberry leaf miner, page 142.

c. Pale spots or blotches showing through the leaves giving them a mottled appearance, after that they brown, blacken, then drop prematurely. Under leaf surfaces have silk entanglements sheltering red spiders 1/16" long. (47f, p. 66), (25, p. 308), (23, p. 395). .....
Greenhouse red spider Tetranychus telarius.

d. Yellow spots on leaves, very similar to preceding species, cause premature defoliation. Under leaf surfaces have silken entanglement sheltering red spiders 1/50" long. (28, p.191), (38, p. 207), (32, p. 367), (53, p. 315).
.....
Red spider Tetranychus bimaculatus.

e. During midsummer and early fall foliage becomes stippled or mottled with white then drops. On the under leaf surfaces are numerous jumping insects 1/8" long and yellow-green in color. Their habit of walking is laterally and very rapid. (47f, p. 29), (32, p. 156), (45, p. 7), (31, p. 13). .....
Rose leafhopper Typhlocyba rosae.

4. Leaves curl up.
a. Leaves curl up and shoots are dwarfed. The injury is due to the presence of reddish-brown jumping plant lice 1/8" long which have three yellowish-brown wing bands. (32, p. 152), (23, p. 208). .....
Blackberry Psyllid Triozoa tripunctata.

b. Leaves curl up and deform because insects with sucking mouth parts withdraw sap from leaf petioles. Fruit stems are likewise attacked causing the fruit to be dwarfed. The bugs are ¼" long, brassy colored, black and yellow marked, having a red thorax. ....Tarnished plant bug, page 140.

c. Leaves curl up and berries are pitted by short oval black bugs 1/8" long, each side of the body has a white stripe. (32, p. 167), (36, p. 511).
.....
Negrobug Corimelaena pulicaria.

d. Leaves curl up, dry, and drop prematurely. Infested leaves show up as pale unhealthy foliage covered with flowery dust. Under the leaves are silken meshes sheltering red spiders 1/50" long. .....Red spider, page 143.

5. Holes eaten through leaves.
   a. During early summer holes are eaten through the leaves, later all is consumed except the veins. .....Raspberry sawfly, page 143.

   b. Holes are eaten in leaves or else the entire leaf eaten off early in the season, during the period of a month or six weeks. The injury occurs due to swarming beetles 1/3" long, yellowish-brown, having long sprawling legs. .....Rose chafer, page 141.

   c. Early in the season holes are eaten into leaves making them appear like "shotholes". ....Apple flea weevil, page 140.

6. Skeletonized leaves.
   a. During the summer leaves are entirely skeletonized, leaving but the bare veination. Upon the leaves are found 1/12" yellow-white or pale-green larvae, covered with spiny white or brown tubercules. .....Raspberry sawfly, page 143.

   b. Unfolding leaves are skeletonized, flowers eaten into, and berries have cavities eaten in them. .....Raspberry fruit worm, page 141.

   c. Leaves are skeletonized during a three months period of the summer and fruit has large holes eaten into them or else eaten right off. The injury is due to beetles slightly larger than potato beetles; they are metallic-green or greenish-bronze with two distinct white spots on the tip of the abdomen. They congregate in great swarms. (2, p. 127), (36, p. 605), (48, pp. 1-31). ..... Japanese beetle Popillia japonica.

7. Severed leaves.
   a. Leaves and fruit stems are severed during May and June by beetles gnawing at the stems. The beetles are 3/8-1/2" long, greenish-brown snout beetles; the wing covers are crossed by two irregular light bands. ....Imbricated snout beetle, page 141.

8. Premature leaf shedding.
   a. During early summer leaves yellow in patches then drop prematurely. Upon the leaves are found slimy slugs $\frac{3}{4}$" long, green, covered with barbed

spiny tubercules, brown on back and white on the sides. .....Raspberry sawfly, page 143.

b. At dry summer periods lower leaves turn pale and drop, followed by higher leaves until all are shed. On the leaves are many black specks, droppings. The pests are brown mites the size of a pinhead. Shoots and canes have, during the dormant period, numerous red or pinkish eggs upon the bark sufficient to give the whole a reddish hue. (47f, p. 66), (45, p. 36).
.....
Clover mite Bryobia praetiosa.

c. Mottled appearing leaves brown then blacken and shed prematurely. Under leaf surfaces have silken entanglements sheltering red spiders 1/16" long. .....Greenhouse red spider, page 143.

d. Yellow spots on leaves, very similar to preceding species, cause premature shedding. Under leaf surfaces have silk entanglements sheltering red spiders 1/50" long. .....Red spiders, page 143.

C. Flower injury.

1. Flowers are eaten off or parts of them eaten off by caterpillars ¾" long, having brownish-black heads and thoracic shields. .....
.....Oblique-banded leaf roller, page 141.

2. Early in the spring flowers are entirely stripped from bushes, the stripping occurs overnight by an invisible pest. .....Climbing cutworms, page 142.

3. Flower stems are eaten off or eaten so they lodge. The injuring insect is a snout beetle 3/8-½" long, greenish-brown.....Imbricated snout beetle, page 141.

4. Small holes eaten into flowers by light brown beetles 1/8" long. .....Raspberry fruit worm, page 141.

IV. FRUIT.

A. Insects upon the berries.

1. The outside of berries are often disfigured by small black oval bugs 1/8" long. They make feeding punctures which produce a drying up. They are of the stink bug family and are too quickly recognized when accidentally eaten. .....
.....Negrobug, page 143.

B. Berries eaten into.

1. The berries have the crown of their caps eaten into, the berries consequently are dwarfed and ripen prematurely. The troublesome larvae often burrow

well into the berries, thus spoiling them for table use. They cling fast to the berry cap and are not easily shaken off. The larvae are ¼" long, plump, cylindrical, white grubs; each segment is crossed with a broad yellow band and has many white hairs.....Raspberry fruit worm, page 141.

2. From late May through June pits are eaten out of the berries shortly after setting. The injuring insect is a snout beetle 3/8-½" long and grayish brown in color. .....
.....Imbricated snout beetle, page 141.

3. During a month or six weeks immature berries have deep holes eaten into them and lots of them. The insect pests are beetles which gather together in swarms. They are 1/3" long, yellowish-brown, and have long sprawling legs. ....Rose chafer, page 141.

4. Feeding habits similar to preceding species except they are present for about a three months period. Each is a metallic greenish-bronze beetle slightly larger than a potato beetle, having two distinct white spots near the abdominal tip. .....
.....Japanese beetle, page 144.

C. Wormy berries.
1. Inside the berries are imbedded grubs, each being ¼" long, plump, cylindrical, and white; every segment is crossed with a broad yellow band and has many short white hairs. .....
.....Raspberry fruit worm, page 141.

D. Premature fruit shedding.
1. The stems of newly set berries are punctured, weakened, and lodge so the berries hang down and soon drop. If the lodging is not complete they become dwarfed and ripen prematurely. Other berries are pitted by the insect's sucking tube.
.....Tarnished plant bug, page 140.

2. Shoot tips and berry stems are gnawed so they break off, hang, or lodge resulting in premature shedding of the berries. The injuring insects are snout beetles 1/10" long, black to dull-red, with a dark spot just behind the center of each wing cover.
.....Strawberry weevil, page 140.

3. Injury identical to preceding species except the injuring insect is different. It is a greenish-brown or gray snout beetle 3/8-½" long. .....
.....Imbricated snout beetle, page 141.

KEY TO THE MORE IMPORTANT CURRANT AND GOOSEBERRY INSECTS.

I. MAIN STEM (canes and shoots).

A. Canes.

1. Bark coverings on canes.

a. Canes, shoots, and occasional fruits are coated with minute grayish specks, barely visible to the eye. Around the scales, on both fruit and bark, the area turns red. Under magnification the specks are disks having a raised central nipple-like blackish spot. The tree vigor decreases, foliage becomes yellowish and scant. (25, p. 165), (57, p. 70), (23, p. 186), (47c, pp. 1-11). .....
San Jose scale Aspidiotus perniciosus.

b. Canes and shoots from May through July have undersurfaces covered with cottony appearing masses beneath which soft scales live. Heavily infested trees have entire foliage turn a sickly yellow and die. (36, p. 676), (25, p. 295), (2, p. 153). .....
Cottony maple scale Pulvinaria vitis.

c. Trunk, branches, and twigs covered with small brownish scales 1/16 to 1/8" long curved and resembling an oyster shell; underneath are many minute eggs. The bark cracks and the whole tree weakens or dies. (47b, pp. 1-6), (23, p. 113), (32, p. 124). .....
Oyster shell scale Lepidosaphes ulmi.

d. Trunk, branches, and twigs are often coated with dirty-white scales 1/10" long. In the winter time, if flipped over, with the naked eye one can discern reddish-purple eggs. (59, p. 41), (47b, pp. 7-11), (57, p. 73). .....
Scurfy scale Chionaspis furfura.

e. Branches, twigs, and leaves have large soft-bodied half-pea-shaped scales 1/8-3/16" long. They cluster together on one side of the twig or branch. They winter over on small branches as flat spindle-shaped brown scales 1/25" long and immature. Infestations cause leaves to yellow, all growth ceases, followed by premature shedding of fruit and foliage. (52, p. 261), (32, p. 129), (23, p. 148), (2, p. 123). .....
European fruit lecanium Lecanium corni.

f. Branches and twigs have dark gray to nearly black almost circular scales 1/12" in diameter. The raised orange tip is off center. (53, p.179), (25, p. 283), (32, p. 179). .....
Putnam's scale Aspidiotus ancylus.

*Figures in parenthesis refer to literature cited; see list of references at end of Key.

g. Minute thin grayish scales are massed together on branches and twigs. Under magnification the specks show a raised reddish central area; thus they are distinguished from the San Jose scale, otherwise they are similar. (32, p. 128), (36, p. 617). .....
Cherry scale Aspidiotus forbesi.

h. Branches and twigs similar to Putnam's and Cherry Scales (gray to nearly black scales with orange or reddish nipples, which are off center) which in reality are distinguished only by microscopic characters. The individual scales are 1/12" in diameter. The central elevation is orange and off center. (53, p. 260), (45, p. 58). .....
European fruit scale Aspidiotus ostreaeformis.

i. Branches and twigs are coated with 1/8" reddish-orange scales; the central spot is off center. (53, p. 360), (25, p. 283). .....
Walnut scale Aspidiotus juglans-regiae.

2. Cane punctures.
a. Through the bark and into canes or shoots are rows of pinhole punctures in one side, there may be twenty-five to an inch or fifty to seventy-five in a row; in each hole an egg 1/8" long is inserted. Each incision is not straight down but rather curved in. The infested canes or shoots break off beyond the injury or die back. (55, pp. 1-20), (59, p. 36), (45, p. 56). .....
Tree cricket Oecanthus sp.

3. Cane borers.
a. Around the latter part of June young borers bore through the outer bark and into the pith then tunnel out the inside. They descent downward where in a half-grown state where they hibernate at the ground line. Next May they become full grown and gnaw out an exit then return to the burrow to pupate. The grubs are a little over 1/2" long, yellowish, brown head, and numerous small tubercles over the body. Affected canes have stunted and sickly foliage, then later the whole bush dies and breaks off. (57, p.145), (38, p. 243), (53, p. 339). .....
Currant borer Synanthedon tipuliformis.

B. Shoots.
1. Severed shoots.

a. In late spring, after the young shoots have reached a growth of several inches, two or three inches of the tips sometimes wilt, and fall or hang suspended. Examination shows the tip has been girdled by several sharp cuts. Full grown larvae are ½" long, glistening straw-yellow, having a darker head; the thoracic segments are wider than others and bear rudimentary feet; the abdominal tip has a horny, stout, bifid spine. (23, p. 189), (53, p. 357), (32, p. 345). .....
Currant stem girdler Janus integer.

2. Shoot punctures.
a. Small slits are cut into shoots, lengthwise, and half way into the pith. In each slit a half dozen eggs are inserted, each being 1/16" long. The slits are between two and six inches from the shoot tip. Shoot growth often crowds the eggs half way out of the incision. A peculiar brown depressed spot forms on tender terminal leaves, in early summer. Later whole leaves turn brown, curl up, and drop. Growth of shoots ceases and they die. The pest is a bug 3/10" long, greenish-yellow, two black spots on thorax, and four black stripes down the back. (36, p. 635), (23, p. 188), (60, p. 70). .....
Four-lined plant bug Poecilocapsus lineatus.

3. Wilting shoots.
a. During late spring shoots wilt or break off and fall. Examination shows sharp cuts which girdled the cane below. The cane also has a longitudinal tunnel in the pith. .....
.....Currant stem girdler, page 149.

b. Small slits lengthwise in shoots from two to six inches from the tip, in each slit are about six eggs 1/16" long; continued cane growth partly crowds out the eggs. .....
.....Four-lined plant bug, page 149.

II. FOLIAGE (buds, leaves, and flowers).
A. Bud injury.
1. Buds eaten off.
a. Opening buds are eaten into or eaten off, leaf and fruit stems are severed by gnawings. The injury occurs from May through June. The injury is done by snout beetles 3/8-1/2" long, greenish-brown; the wing covers are crossed by two irregular light bands. (53, p. 371), (36, p. 533), (38, p. 167). .....
Imbricated snout beetle Epicaerus imbricatus.

b. Leaves are rolled up and tied together by leaf rolling caterpillars which later eat off the under leaf surfaces. The earliest stage is spent as a leaf miner, after that they eat off buds, flowers, and eat into the fruit. The larvae are ¾" long, yellowish-green, head and thoracic shield are brownish-black. Two broods carry on May-June and July-August, respectively. (60, p. 63), (32, p. 230), (36, p. 716), (35, p. 73). .....
Oblique-banded leaf roller Cacoecia rosaceana.

c. Complete or partial defoliation of buds, leaves, and flowers may occur over night by an unseen predator. Small trees are entirely stripped, whereas, on large trees certain branches are stripped. The injury occurs in the spring, quite early. No trace of the pest is evident, except possibly for a few naked nocturnal caterpillars under the trees. (53, p. 138), (2, p. 130), (45, p. 11). .....
Climbing cutworms Noctuidae sp.

B. Leaf injury.
1. Leaf miners.
a. The earliest stage is spent as a leaf miner followed by a leaf rolling period wherein the caterpillars eat of the under leaf epidermis. The larvae are ¾" long, yellow-green, head and thoracic shield are brownish black. .....
.....Oblique-banded leaf roller, page 150.

2. Leaf rollers.
a. First stage is spent as a leaf miner, then the caterpillars roll leaves together and eat off the lower leaf epidermis. The larvae are ¾" long, yellowish-green, head and thoracic shield are brownish-black. .....
.....Oblique-banded leaf roller, page 150.

3. Spotted leaves.
a. Undersides of leaves become spotted, puffed up, and distorted. Upper sides turn red, then the leaves wither and drop. Badly infested bushes are apt to become defoliated. The injury begins early in the spring and continues throughout the season. The insects have wingless light yellow females, some are winged yellow or pale green with a disky-brown head and thoracic shield. The body bears transverse capitate hairs and long slender cornicles which are slightly enlarged at the distal ends. (23, p. 187), (36, p. 634), (32, p. 145).
.....
Currant aphid Myzus ribis.

b. Tender terminal leaves and others are punctured by plant bugs as they suck up the sap. The leaves become spotted, wither, turn brown and die. The eggs are laid in slits in soft stems in late June or July. Usually six to eight eggs are placed in a slit causing the shoot to wither and die, then break off. The bugs are 1/3" long, orange-yellow, with four black stripes lengthwise of the wing covers and thorax, and an apple green area between the stripes. .....Four-lined plant bug, page 149.

c. During midsummer and early fall foliage becomes stippled or mottled with white then drops. On the under leaf surfaces are numerous jumping insects 1/8" long and yellow green in color. Their habit of walking is laterally and very rapid. (47f, p. 29), (32, p. 156), (45, p. 7), (31, p. 13). .....
Rose leafhopper Typhlocyba rosae.

d. Pale spots or blotches showing through the leaves giving them a mottled appearance, after that they brown, blacken, then drop prematurely. Under leaf surfaces have silken entanglements sheltering red spiders 1/16" long. (47f, p. 66), (25, p. 308), (23, p. 395). .....
Greenhouse red spider Tetranychus telarius.

4. Leaves curl up.
a. Irritation caused by numerous feeding punctures in leaves cause the leaves to become badly curled and distorted so that pocket-like cavities are formed on the under sides. The upper surface turns a bright red variegated with yellow and green. .....Currant aphid, page 150.

b. Early in the season shoots are punctured and sap is withdrawn resulting in deformed shoots; the same occurs to fruit and leaf stems, causing fruit to die when the stem lodges. As the shoots lodge leaves curl up and drop. Buds too are killed by being punctured. Later the fruit is pitted or it is dwarfed, if previously it wasn't too seriously hampered. The pests are ¼" bugs, having a black and yellow marked thorax, and a brassy color otherwise. (2, p. 139), (36, p. 611), (35, p. 48). .....
Tarnished plant bug Lygus pratensis.

c. Yellow spots on leaves, similar to preceding species, curl up and drop prematurely. Under leaf surfaces have silken entanglements sheltering

red spiders 1/50" long. (52, p. 315), (32, p. 367), (38, p. 207), (28, p. 191).
.....
Red spider Tetranychus bimaculatus.

5. Leaves skeletonized.
   a. Leaves skeletonized by pale green slugs that at first have black heads which later turn green. (53, p. 344), (50, p. 487). .....
   Native currant sawfly Gymnonychus appendiculatus.

6. Leaves devoured.
   a. At first tips of leaves are eaten away, if the pests are abundant all the leaves are entirely devoured; sometimes, tender shoots become badly chewed. The insects are measuring worms about an inch long which spin single threads from which they dangle. They are whitish with a wide yellow stripe down the back and one on each side; each segment has several black spots. The underside has a pinkish tinge with a brood median yellow stripe which is also black spotted. (52, p. 345), (51, p. 428), (32, p. 206).
   .....
   Currant span worm Cymatophora ribearia.

   b. Sawflies in large numbers strip the foliage shortly after the leaves unfold. At first they skeletonize the leaves, then consume all but the midrib. When mature the slugs are ¾" long, when very young they are white ornamented laterally by black spots; when they begin to feed the white color changes to green and the head becomes black, the body retains the black spots. (53, p. 341), (51, p. 426), (57, p. 146).
   .....
   Imported currant-worm Pteronus ribesii.

   c. Leaves stripped overnight, during early spring, by an invisible nocturnal pest. The only clew to the predator is a few hairless caterpillars on the ground under the bushes. .....
   .....Climbing cutworm, page 150.

7. Severed leaves.
   a. Leaf stems are gnawed so the leaf hangs by an injured stem or else drops. The injury occurs early in the spring. .....
   .....Imbricated snout beetle, page 149.

8. Premature defoliation.
   a. Badly curled and distorted leaves turn bright red above, variegated with yellow and green. Under surfaces have pocket-like cavities.
   .....Currant aphid, page 150.

b. During midsummer or early fall foliage becomes stippled or mottled with white then drops. .....Rose leafhopper, page 151.

c. Tender terminal leaves or all leaves become spotted, wither, turn brown, and drop. Shoots have slits in which eggs are inserted causing them to die-back and break off. ....Four-lined plant bug, page 149.

d. Leaf stems gnawed off early in the season. .....Imbricated snout beetle, page 149.

e. Leaves turn pale yellow then curl up and drop. Lower leaves are attacked first then higher ones etc. Injury is worst during dry spells or in arid areas. .....Clover mite, page 145.

f. Yellowish spots on foliage surrounded by silken webs encasing red spiders 1/30" long. Leaves drop prematurely. .....Red spider, page 152.

g. Reddened mottled leaves turn rusty then turn black and drop. Around the spots, on lower leaf surface, are silken threads encasing red spiders 1/16" long. .....Greenhouse red spider, page 179.

C. Flower injury.

1. Flowers are eaten off or parts of them eaten off by caterpillars ¾" long, having brownish black heads and thoracic shields. ....Oblique-banded leaf roller, page 150.

2. Early in the spring flowers are entirely stripped from bushes; the stripping occurs over night by an unseen pest. .....Climbing cutworms, page 150.

3. Flower stems are eaten off or eaten so they lodge. The injuring insect is a snout beetle 3/8-½" long, greenish-brown. ....Imbricated snout beetle, page 149.

III. FRUIT.

A. Berries eaten into.

1. Immature berries are drawn together and tied by silken threads which enmesh the new fruits, within the web reside ¾" greenish caterpillars that have a brownish head. The larvae usually feed on the outside of the fruit though sometimes they enter therein. They cause the berries to discolor, wither, and drop prematurely; others merely ripen prematurely. (53, p. 353), (38, p. 326).

.....

Gooseberry fruit-worm Zophodia grossulariae.

2. Berries and leaves are rolled together and tied in a webby mass within which reside caterpillars that eat into the fruit. The caterpillars are ¾" long, yellowish-green, head and thoracic shield are brownish black. .....
.....Oblique-banded leaf roller, page 150.

3. Fruit stems are gnawed off so they lodge, or the berries are gnawed into. .....
.....Imbricated snout beetle, page 149.

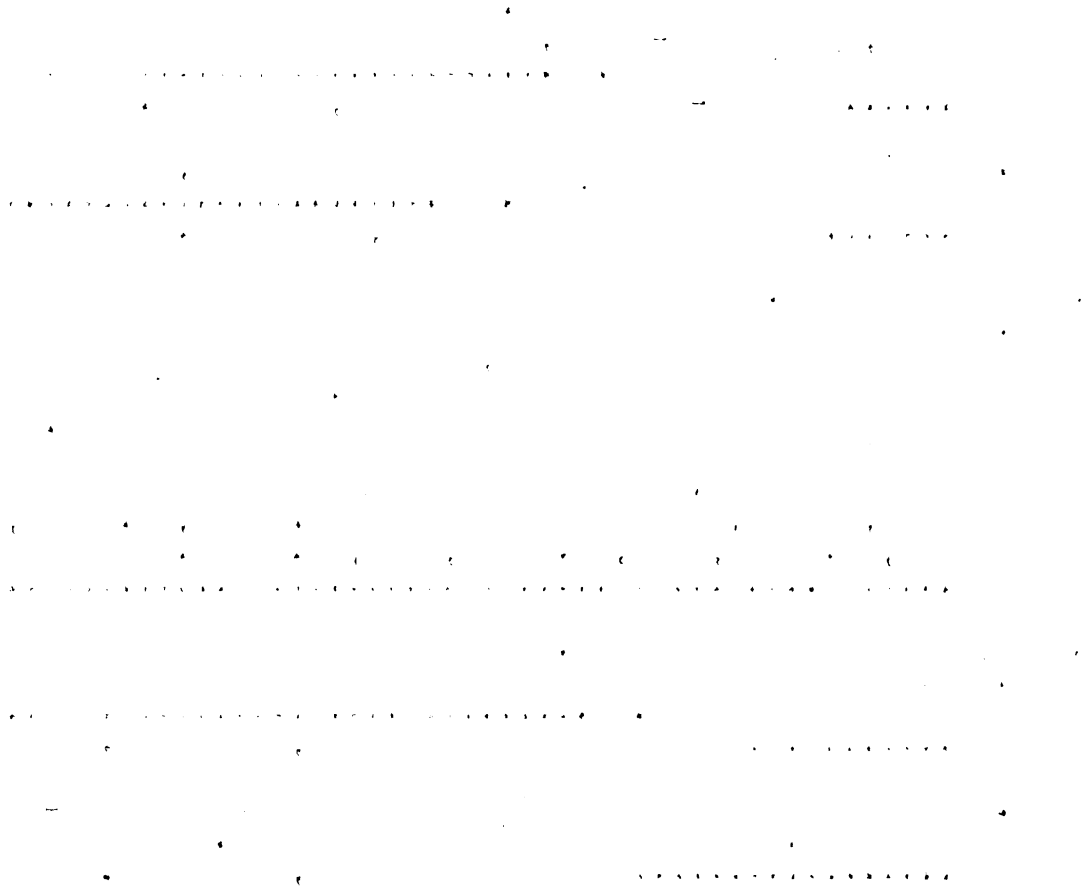
B. Wormy berries.

1. During the summer currants and gooseberries turn red and drop prematurely, upon close examination small white maggots will show up. At first they burrow about in the pulp then consume the seeds. Berries on the bush or on the ground have exit holes in them. When full grown the maggots are ¼" long, white, with black mouthparts. (32, p. 265), (33, p. 190), (51, p. 429), (53, p. 355).
.....
Currant fruit fly Epochra canadensis.

C. Premature fruit shedding.

1. Stems of berries gnawed off so developing fruit is prematurely shed. .....
.....Imbricated snout beetle, page 149.

2. During the summer berries turn red and drop prematurely. Inside are ¼" white maggots.
.....Currant fruit fly, page 154.



KEY TO THE MORE IMPORTANT STRAWBERRY INSECTS.

I. ROOTS AND CROWN.

A. Roots devoured and crown bored into.

1. Curved white grubs 1/3" long devour roots and burrow about in the crown. Whole plant takes on a weakened condition, later dying. (60, p. 67), (35, p. 96), (53, p. 389). .....
Fuller's rose beetle Asynonychus godmani.

2. Curved white grubs one inch or less in length feed upon roots and burrow in the crown causing a general plant weakness and then the plants death. The grubs have brown heads and slender legs and are present throughout the season. (25, p. 236), (32, p. 302), (36, p. 306). .....
White grubs Lachnosterna sp.

3. Whitish grubs 4/5" long that have reddish-brown heads burrow in larger roots and the crown. Portions of the plant wilt and die off. (53, p. 384). .....
Strawberry crown moth Sesia rutilans.

4. Black to dull red snout beetles 1/10" long with a dark spot on each wing cover feed upon buds, leaves, and pollen. The snout is slender, curved, and half as long as the body. The female ovipositis in buds then makes an incision in the stem below so it will lodge. The tiny grubs eat out the inside bud or flower parts. (23, p. 194), (32, p. 332), (86, p. 643). .....
Strawberry weevil Anthonomus signatus.

B. Crown borers.

1. White, legless, yellow-brown beetles ¼" long bore out the crown so as to weaken or kill the plant. New growth and runners are entirely checked. (20, pp. 1-8), (51, p. 391), (32, p. 334). .....
Strawberry crown borer Tyloderma fragrariae.

C. Root worms.

1. During May to July several species of white brown-spotted grubs 1/8" long eat off the roots of strawberry plants. Adults are 1/8" long, bronze-brown or copper colored beetles which destroy the foliage. (36, p. 643), (51, p. 393), (39, p. 313). .....
Strawberry root worms Paria canella, Colaspis brunnea and Graphops pubescens.

D. Plant eaten off at the ground line.

1. During spring until late summer plants often are severed by 1/5", light colored brown-headed grubs.

*Figures in parenthesis refer to literature cited; see list of references at end of Key.

Around the base of the plant lie 1/6" short and blunt snout beetles that are black colored and feed upon the leaves. (36, p. 644), (23, p. 195), (35, pp. 102-5). .....
Strawberry crown girdler Brachyrhinus ovatus.

E. Root aphids.
1. Pear-shaped blue-green or blue-black aphids 1/20" long on leaves and roots accompanied usually by small brown ants. Infested plants become stunted and dry up. (52, p. 389), (58, p. 134), (32, p. 148). .....
Strawberry root louse Aphis forbesi.

II. BUDS.
A. Buds punctured by feeding and oviposition.
1. Buds have tiny beetles 1/10" long puncture them while feeding or eat out holes for egg laying. After the eggs are laid the female makes an incision in the stem causing it to lodge and hang down. .....
.....Strawberry weevil, page 155.

B. Buds eaten off.
1. Buds, blossoms, leaves, and fruit are badly ruined early in the summer, or during late spring. Buds and blossoms are eaten off; leaves are eaten ragged and tattered; fruit is partially or entirely consumed. The injuring insects are 1/3" long, yellow-brown, possessing long sprawling legs, and gather together in swarms. (19, pp. 1-4), (60, p. 28), (9, p. 51), (46, p. 29). .....
Rose chafer Macrodactylus subspinosus.

III. FLOWERS.
A. Flower parts browned and wilted.
1. Tiny 1/20" brownish-yellow insects appear on strawberries in the early spring, as soon as flower buds open. They rasp or chafe away the epidermis of flower parts then suck up its juices. The lower calyx and ovary are the sources of oviposition by the female, the flower stem may also be a source of egg-laying. Fruits take on a "button" appearance. The injuries are worst during dry spells. (32, p.122), (54, p. 379). .....
Strawberry thrips Euthrips tritici.

B. Flowers eaten off.
1. Flowers are gnawed into ruin by 1/3" yellow-brown beetles having long sprawling legs. .....
.....Rose chafer, page 156.

C. Lodged flower stems.
1. Flower stems lodge and hang down, other flowers have pollen eaten away.....Strawberry weevil, page 155.

IV. LEAVES.
A. Leaf rollers.
1. One half of a leaflet is lapped over the other half and fastened by silken threads. Inside the

folded leaflet resides a caterpillar 1/3 to ½" long, light-brown to olive-green or brown. Infested foliage appears whitened. The injury is prevalent throughout the season. (8, pp. 1-8), (59, pp. 235-55), (23, p. 197). .....
Strawberry leaf roller Ancylis comptana.

2. Several leaves are rolled and tied together by leaf rolling caterpillars, within the entanglement is a ½" green or reddish caterpillar. The earliest period is spent as a leaf miner, after that as a leaf roller. Rolled leaves dry up, die, and drop thus defoliating whole patches. From within the rolled leaves the caterpillars go out to eat into and injure the berries. There are two broods May-June and July-August. (61, p. 63), (32, p. 230), (39, p. 716), (36, p. 73). .....
Oblique-banded leaf roller Cacoecia rosaceana.

3. Leaflets have the under epidermis peeled off by small caterpillars that later roll up the leaflets and tie them fast with silken threads. At first they feed within the small shelter but soon include other leaves, blossoms, and fruit which they tangle together in a mass. The rolled leaves not eaten up dry up and die. (54, p. 364). .....
Obsolete-banded leaf roller Archips obsoletana.

B. Holes eaten in leaves.
1. Leaves riddled with small holes.
a. Tiny round holes eaten in leaves so they fall early in the spring. About the plants are many very small metallic jumping beetles. (37, p.645), (32, p. 317),.....
Flea beetles as Typophorus canellus, Phylotrella vittata and Altica ignita.

b. Pale greenish slugs 3/5" long having sixteen prolegs riddle leaves with holes. When at rest they curl up on the under leaf surface. (54, pp. 366-8). .....
Strawberry slugs Empria maculata, fragrariae, and ignita.

c. New leaves have holes eaten into them by ½" long, slug-like worms, that have twenty legs and a pale yellow stripe down the back. When they are at rest they coil up on the under leaf surface. (52, p. 395), (32, p. 347), (58, p.450), (39, p. 288). .....
Strawberry sawfly Emphytes maculata.

C. Leaves stripped.
1. Leaves are devoured overnight by nocturnal pests without making their presence known except possibly

for a few naked caterpillars upon the ground. (54, p. 138), (2, p. 130), (46, p. 11). .....
Climbing cutworms Noctuidae sp.

D. Leaves eaten off.
1. The plants have the leaves stripped during the spring by grayish snout beetles 3/8-½" long, with two irregular light bands upon the wing covers. (54, p. 371), (37, p. 533), (39, p. 167). .....
Imbricated snout beetle Epicaerus imbricatus.

E. Spotted leaves.
1. Oval wax specks 1/30" long on the leaf. About the leaves are mealy white tiny flies fluttering about. Black fungus and honeydew secretions are abundantly about the whole plant. (54, p. 369). .....
Strawberry whitefly Aleyrodes packardi.

2. Yellowish spots on foliage, around the spots on under leaf surface are numerous very fine silken threads enclosing tiny red spiders 1/50" long. The leaves fall prematurely. (54, p. 315), (32, p. 367), (39, p. 207). .....
Red spider Tetranychus bimaculatus.

F. Premature defoliation.
1. Leaves gnawed off.
a. From May through June leaves are eaten off from the plant, causing them to drop prematurely. .....Imbricated snout beetle, page 158.

2. Yellow-spotted leaves, prematurely shed.
a. On under leaf surfaces are minute silken threads encasing red spiders 1/50" long. .....
.....Red spider, page 158.

3. Holes in leaves, prematurely shed.
a. Irregular holes eaten into leaves causing their early defoliation. Amongst leaves not yet shed are ½" slug-like worms curled up on the under leaf surfaces. ....Strawberry sawfly, page 158.

4. Leaves dry up and fall.
a. Leaflets that have one half lapped over the other half and tied by silken strands. .....Strawberry leaf roller, page 157.

b. Several leaves rolled and tied together enclosing a ½" green or reddish caterpillar. Some of the leaves show leaf miners burrowed about in them. ....Oblique-banded leaf roller, page 157.

c. Partially skeletonized leaves are rolled up and tied with silken threads. The webs include blossoms and fruit. .....
.....Obsolete-banded leaf roller, page 157.

V. FRUIT.

A. Black bugs on fruit.

1. Black bugs 1/8" long that have a lateral white stripe, when eaten with berries they give a very unpleasant taste. (32, p. 167), (37, p. 511), ... Negrobug Corimeloena pulicaria or some other stink bugs.

B. Dried up fruit on the plant.

1. Dried up fruit on partly severed stems. ....Strawberry weevil, page 155.

C. Deformed fruits.

1. Fruit has a "buttoned" appearance. Injuries worst during dry spells. The insects are brownish-yellow, 1/20" long. .....Strawberry thrips, page 156.

2. In the spring knobbed-like growths occur upon strawberries sometimes called "buttoning". The berries become darkened and hard due to being punctured during sap withdrawal. The insects are ¼" long bugs, having a black and yellow marked thorax and otherwise a brassy color. (2, p. 139), (60, p. 43), (37, p. 611), (35, p. 48). ..... Tarnished plant bug Lygus pratensis.

D. Fruit eaten off.

1. Ripe berries have their seeds and pulp eaten out or else so badly eaten that the remaining part rots. The entire crop may be ruined in a day or two. The pests are flat, black ground beetles ½-1" long. They are nocturnal and conceal themselves under stones or other objects during the day. (54, p. 380), (52, pp. 15 and 264). ..... Ground beetles Harpalus caliginosus and pennsylvanicus

2. Berries eaten off or ruined by swarming beetles 1/3" long, yellow-brown, and have long sprawling legs. .....Rose chafer, page 156.

E. Premature fruit shedding.

1. Stems of green fruit gnawed off.

a. Immature fruits are severed from the plant by being gnawed off. ....Imbricated snout beetle, page 158.

2. Leaf shedding stimulating fruit shedding.

a. Large holes eaten in leaves, fallen shortly thereafter. .....Strawberry sawfly, page 158.

b. Leaflets have one half lapped over the other half and tied by silken threads. ....Strawberry leaf roller, page 157

c. Several leaves are rolled and tied together by silken threads. Some of the leaves have been mined in by leaf miners. ....Oblique-banded leaf roller, page 157.

d. Leaves, blossoms, and fruit are drawn together and tied by silk threads. Some of the leaves are skeletonized. .....
.....Obsolete-banded leaf roller, page 157.

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Insect List.

The following insect list considered in this thesis coincides with the nomenclature of the American Association of Economic Entomologists, as of December 1931, the latest revision.

	Common Names	Scientific Names
1.	Apple and thorn skeletonizer	Hemerophila pariana
2.	" aphid	Aphis pomi
3.	" bud aphid	" siphocoryne
4.	" crotch borer	Aegeria pyri
5.	" curculio	Tachypterellus quadrigibbus
6.	" flea weevil	Orchestes pallicornis
7.	" grain aphid	Rhopalosiphum prunifoliae
8.	" leaf trumpet miner	Tischeria malifoliella
9.	" maggot	Rhagoletis pomonella
10.	" red bugs	Lygidea mendax
11.	" seed chalcid	Syntomaspis druparum
12.	" twig borer	Amphicerus bicaudatus
13.	Bagworm	Thyridopteryx ephemeraeformis
14.	Black peach aphid	Anuraphis persicae-niger
15.	" cherry	Myzus cerasi
16.	Bruce's spanworm	Rachela bruceata
17.	Brown-tail moth	Nygmia phaeorrhoea
18.	Buffalo tree hopper	Ceresa bubalus
19.	Cecropia moth	Platysamia cecropia
20.	Cherry fruit fly	Rhagoletis cingulata " fausta
21.	Cherry leaf beetle	Galerucella cavicollis
22.	" scale	Aspidiotus forbesi
23.	Cigar-case bearer	Coleophora fletcherella
24.	Clover mite	Bryobia praetiosa
25.	Cotton leaf worm	Alabama argillacea
26.	Codling moth	Carpocaspa pomonella
27.	Common red spider	Tetranychus telarious
28.	Cottony maple scale	Pulvinaria vitis
29.	Currant aphid	Myzus ribis
30.	" borer	Synanthedon tipuliformis
31.	" fruit fly	Epochra canadensis
32.	" spanworm	Itame ribearia
33.	" stem girdler	Janis integer
34.	Eastern-tent caterpillar	Malacosoma americana
35.	Eight-spotted forester	Alypia octomaculata
36.	European fruit scale	Aspidiotus ostreaeformis
37.	" " lecanium	Lecanium corni
38.	" red mite	Paratetranychus pilosus
39.	Fall cankerworm	Alsophila pometaria
40.	Fall webworm	Hyphantria cunea
41.	False tarnished plant bug	Lygus invitus

42.	Flat-headed apple tree borer	Chrysobothris femorata
43.	Forest tent caterpillar	Malacosma disstria
44.	Four-lined plant bug	Poecilocapsus lineatus
45.	Fruit tree leaf roller	Cacoecia argyrospila
46.	Fuller's rose beetle	Asynonychus godmani
47.	Giant grape root worm	Prionis laticollis
48.	Gooseberry fruit worm	Zophodia grossulariae
49.	Grape flea beetle	Haltica chalybea
50.	" berry moth	Polychrosis viteana
51.	" curculio	Craponius inaequalis
52.	" leaf skeletonizer	Harrisina americana
53.	" phylloxera	Phylloxera vitifoliae
54.	" rootworm	Fidia viticida
55.	" scale	Aspidiotus uvae
56.	" leafhopper	Erythroneura comes
57.	Green fruit worm	Graptolitha sps.
58.	Greenhouse red spider	Tetranychus telarius
59.	Green peach aphid	Myzus persicae
60.	Gypsy moth	Porthetria dispar
61.	Hickory tussock moth	Halisidota caryae
62.	Imbricated snout beetle	Epicaerus imbricatus
63.	Imported currant worm	Pteronidea ribesi
64.	Japanese beetle	Popillia japonica
65.	Lesser apple worm	Laspeyresia prunivora
66.	Leaf crumpler	Mineola indigenella
67.	Lesser peach borer	Aegeria pictipes
68.	Luna moth	Tropaea luna
69.	Mealy plum aphid	Hyalopterus arundinis
70.	Negrobug	Corimelaena pulicaria
71.	New York weevil	Ithycerus noveboracensis
72.	Oblique-banded leaf roller	Cacoecia rosaceana
73.	Oriental fruit moth	Grapholitha molesta
74.	Oyster shell scale	Lepidosaphes ulmi
75.	Palmer worm	Dichomeris ligulella
76.	Peach bark beetle	Phthorophloeus liminaris
77.	Peach borer	Aegeria exitiosa
78.	" twig borer	Anarsia lineatella
79.	Pear leaf blister mite	Eriophyes pyri
80.	" midge	Contarina pyrivora
81.	" psylla	Psyllia pyricola
82.	" slug	Eriocampoides limacina
83.	" thrips	Taeniothrips inconsequens
84.	Pistol-case bearer	Coleophora malivorella
85.	Plum curculio	Conotrachelus nenuphar
86.	" gouger	Anthonomus scutellaris
87.	" web-spinning sawfly	Neurotoma inconspicua
88.	Polyphemus moth	Telea polyphemus
89.	Promethea moth	Callosamia promethia
90.	Putnam's scale	Aspidiotus ancylus
91.	Quince curculio	Conotrachelus crataegi
92.	Raspberry cane borer	Oberea bimaculata
93.	" cane maggot	Hylemyia rubivora
94.	" fruit worm	Byturus unicolor

95.	Raspberry root borer	Bembecia marginata
96.	" sawfly	Monophadnoides rubi
97.	Red-necked cane borer	Agrilus ruficollis
98.	humped caterpillar	Schizura concinna
99.	Resplendent shield bearer	Coptodisca splendoriferell
100.	Rosy apple aphid	Anuraphis roseus
101.	Rose chafer	Macrodactylus subspinosus
102.	" leafhopper	Typhlocyba rosae
103.	Rose scale	Aulacaspis rosae
104.	Round headed apple tree borer	Saperda candida
105.	Rusty tussock moth	Notolophus antiqua
106.	San Jose scale	Aspidiotus perniciosus
107.	Scurfy scale	Chionaspis furfura
108.	Shot-hole borer	Scolytus rugulosus
109.	Sinuate pear tree borer	Agrilus sinuatus
110.	Spring canker worm	Paleacrita vernata
111.	Strawberry crown borer	Tyloderma fragariae
112.	" " girdler	Brachyrhinus ovatus
113.	" " moth	Aegeria rutilans
114.	" leaf beetle	Haltica ignita
115.	" leaf roller	Ancylis comptana
116.	" root aphid	Aphis forbesi
117.	" weevil	Anthonomus signatus
118.	" whitefly	Trialeurodes packardi
119.	Tarnished plant bug	Lygus pratensis
120.	Terrapin scale	Lecanium nigrofasciatum
121.	Tree cricket	Oecanthus sp.
122.	Twig girdler	Oncideres cingulatus
123.	Walnut scale	Aspidiotus juglans-regiae
124.	White grubs	Lachnosterna sp.
125.	" -lined sphinx	Sphinx lineata
126.	" -marked tussock	Heterocampa leucostigma
127.	" peach scale	Aulacaspis pentagona
128.	Woolly apple aphid	Eriosoma lanigera
129.	Yellow-necked caterpillar	Datana ministra
130.	Yellow-headed fireworm	Alceris minuta

Additional Insect List.

1.	Apple bucculatrix	Bucculatrix pomifoliella
2.	" flea beetle	Haltica punctipennis
3.	" leaf sewer	Ancylus nebeculana
4.	" plant lice	Aphis fitchi and sorbi
5.	" weevil	Pseudanthonomus crataegi
6.	Io moth	Automeris io
7.	Blackberry gall maker	Diastrophus turgidus
8.	" leaf miner	Metallus rubi
9.	" psyllid	Triozoa tripunctata
10.	Bud moth	Tmetocera ocellana
11.	Climbing cutworms	Noctuidae sps.
12.	Eight-spotted pelidnota	Pelidnota punctata
13.	Gooseberry spanworm	Cymatophora ribearia
14.	Green currant worm	Gymnonychus appendiculatus
15.	Grape vine hog sphinx	Ampelophaga myron
16.	Ground beetles	Harpalus caliginosus " pennsylvanicus
17.	Plum aphid	Aphis prunifolia
18.	Pear blight beetle	Anisandrus pyri
19.	" slug	Caliroa cerasi
20.	Peach twig borer	Anarsia lineatella
21.	Periodical cicada	Cicada septendecim
22.	Red-legged flea beetle	Crepidodera rufipes
23.	Ring-legged tree bug	Brochymena annulata
24.	Spotted apple tree borer	Saperda cretata
25.	Strawberry thrips	Euthrips tritici
26.	" slugs	Empria maculata " fragrariae " ignita
27.	" rootworms	Paria canella Colaspis brunnea Graphops pubescens
28.	" sawfly	Harpiphorus maculatus
29.	Striped peach worm	Gelechia confusella
30.	Twig pruner	Elaphidion villosum

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