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THE CONNECTICUT AGRICULTURAL

CONTROL *of* APPLE INSECTS

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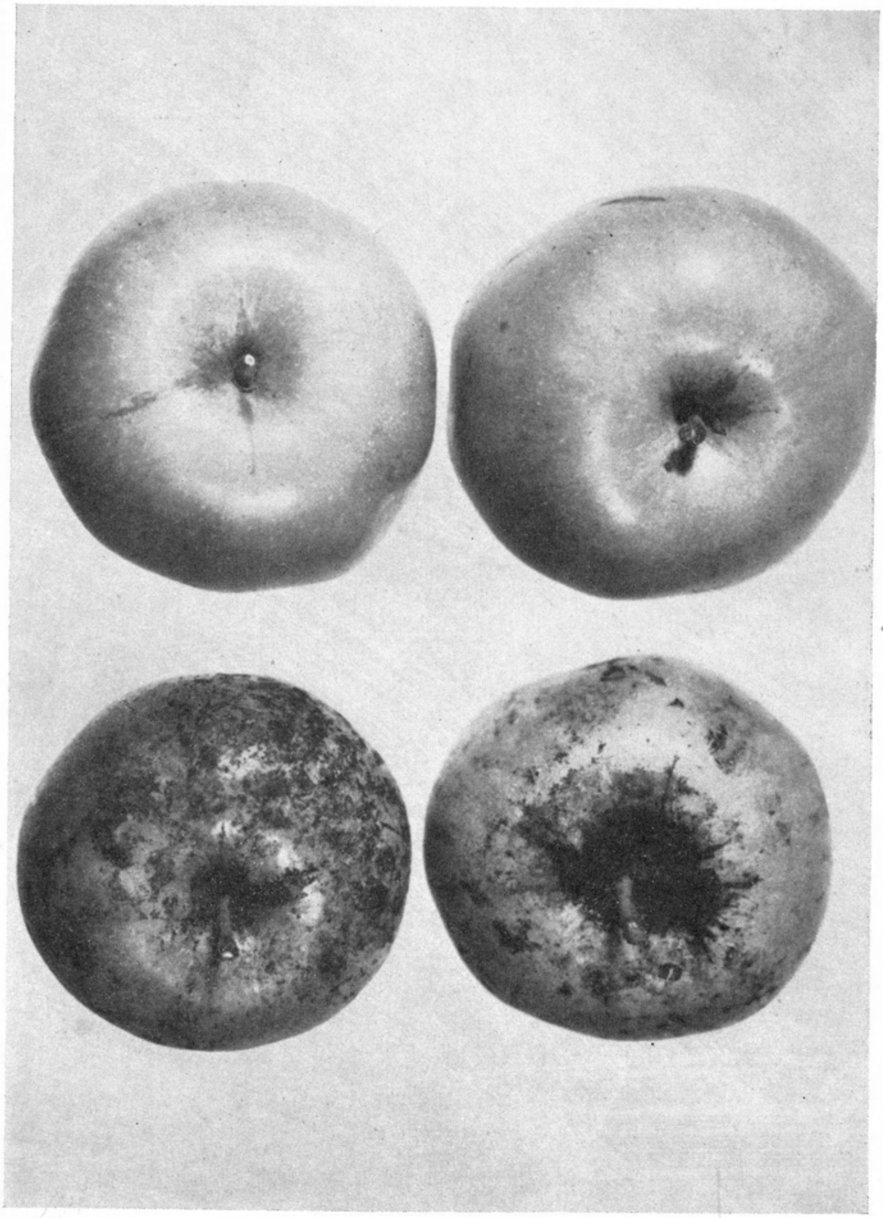

Figure 1. Work of green apple aphids. Apples from infested tree (below), uninfested (above).

Control of Apple Insects

by Philip Garman and J. F. Townsend

INTRODUCTION

Insects attacking tree fruits are numerous in Connecticut and research has uncovered many new facts about their control during the last two or three decades. Horticultural sprays have been improved and will continue to be improved from time to time as new methods of application, improved machinery and new materials become available. The change from lime sulfur to wettable sulfur in Connecticut during the early 1930's was probably responsible for an increased production of apples. At the same time the general use of wettables throughout the State was also responsible in part for increased trouble with mites. The fungicide, ferric dimethyl dithiocarbamate, changed the picture again and the general use of DDT brought to the fore many species of mites and insects not hitherto encountered in injurious numbers. All such developments necessitated widespread adjustments in the spray program. Advances in the art of chemical warfare against insects and diseases is now progressing so rapidly that present spray programs may be out of date in a few years. On the other hand, what we know of the life history and biology of fruit pests does not change radically from year to year, in spite of the fact that insects sometimes become adjusted to a spray program after years of application. A collection of field data on this subject, therefore, will probably be useful for a long time in spite of the rapid changes occurring in materials and application.

In presenting this bulletin it has been our idea to make the biological information as complete as possible without extending it unduly. These data plus summaries of control measures past and present will, it is hoped, enable those interested to map a satisfactory plan of campaign against any of the fruit tree pests described herein. A short description of the more important insecticides including strengths commonly used is given on pages 78 to 81. Figures of early bud stages (Figure 71) will partially fix the periods for timing spray operations.

Acknowledgements

The photographs presented in this bulletin are the work of B. W. MacFarland or his predecessor, B. H. Walden. They deserve full credit.

APPLE MAGGOT

Rhagoletis pomonella Walsh

Damage

Connecticut's number one apple pest, the apple maggot, is a native of the United States. Damage consists entirely of maggoty or wormy fruit which frequently reaches 100 per cent in unsprayed orchards. Owing to its habit of tunnelling near the skin, the insect is sometimes called "railroad worm." Infested fruit drops prematurely and the orchardist may be fooled into believing the uninfested fruit is more nearly ready to harvest than it is. The more susceptible varieties are Gravenstein, Wealthy, Cortland, Delicious and early sweet or sub-acid varieties. The apple maggot is not known to attack other fruits, although structurally there is no known difference between it and the blueberry maggot. The cherry maggot is recognized to be another species.

Life History

The apple maggot winters in the soil as a puparium, less than an inch below the surface. Flies begin to emerge about 30 days after petal fall but do not reach a peak in this area until July (Figure 2). In most years emergence is 90 per cent complete 60 days after petal fall. Egg laying does not begin immediately (10 days, sometimes less, after emergence), but in the field peak egg laying occurs about two weeks after peak emergence (Figure 3). In favorable years it may continue until harvest. During the egg-laying period there is frequently much migration of the flies within and from without the orchard; they travel at least 300 yards and probably much farther with favorable winds. Maggots leave the fruit during August, September and October and enter the soil where they remain over winter. There is not much tendency towards cycles, but there is often a one-year rise and fall probably due to bearing habits of many apple varieties.

Factors Affecting Abundance

Apple maggots withstand any type of weather that occurs in New England. Dry cool periods with considerable dew seem to favor long life on the part of the flies.

Rainfall following a dry period may bring a rush of flies from the soil, but towards the latter part of their emergence, moisture does not seem to have much influence. Cold limits for the puparia have not been established, but low temperatures definitely limit development of the larvae (Chapman, 1933).

The main factors affecting abundance are the proximity of uncared-for apples, infested drops from the previous season and attractive early varieties mixed in with late. In the latter case flies emerge from the soil, remain in the early variety fruit trees until harvest, then migrate to later varieties, frequently after it is too late to spray.

Predators and Parasites

The principal parasite observed in this area is *Opius melleus* Gahan, an insect which lays its eggs in the eggs of the apple maggot. It has been known to parasitize up to 30 per cent of the blueberry maggot, but 15 per cent is the highest parasitization of the apple maggot recorded. The curculio egg parasite, *Patasson* (*Anaphoidea*) *conotracheli* Gir., also attacks apple maggot eggs. Ants, spiders and other predators kill adult flies, but have not exerted much influence in recent years.

Control Measures

Destruction of "wild" apple trees in the vicinity of the orchard was frequently recommended in past years and is still a valid practice. Lead arsenate sprays, 3 pounds to 100 gallons, have been depended upon for a long time. Removal of drops from the orchard at harvest time or a little before is still valuable and some authorities think it more useful than sprays. In some years in Connecticut the labor problem has not allowed growers to use this measure, but its value cannot be questioned.

Recently, chemicals such as rotenone, DDT, DDD, methoxychlor, chlordane and parathion have demonstrated considerable killing power for apple maggot flies. Their ultimate usefulness will depend somewhat on residual action and the danger of leaving objectionable deposits. Thus, parathion, while effective, has a relatively short life, cannot be used too late in the season because of possible fruit injury and, if used earlier, allows rapid reinfestation from outside the orchard. DDT is effective but with somewhat shorter residual action than lead arsenate.

DDD-chlordane combinations have been used successfully in our experiments, and methoxychlor and dieldrin are equal if not superior in killing power to DDT.

Apple Maggot

Combination of several of the newer compounds appears desirable because of the necessity for combined controls for codling moth, European red mite and red-banded leaf roller.

Apple maggots within the fruit may be killed by placing in cold storage at 32 degrees F. for about one month. Thus, if an infestation is discovered too late to spray, the fruit may be partially salvaged if it is put in cold storage as soon as picked.

Spray dates commonly recommended for most Connecticut varieties are during the first and last 10 days of July and the first half of August. Later treatments should be either dusts or reduced dosage sprays and no application except rotenone appears desirable within two weeks of picking.

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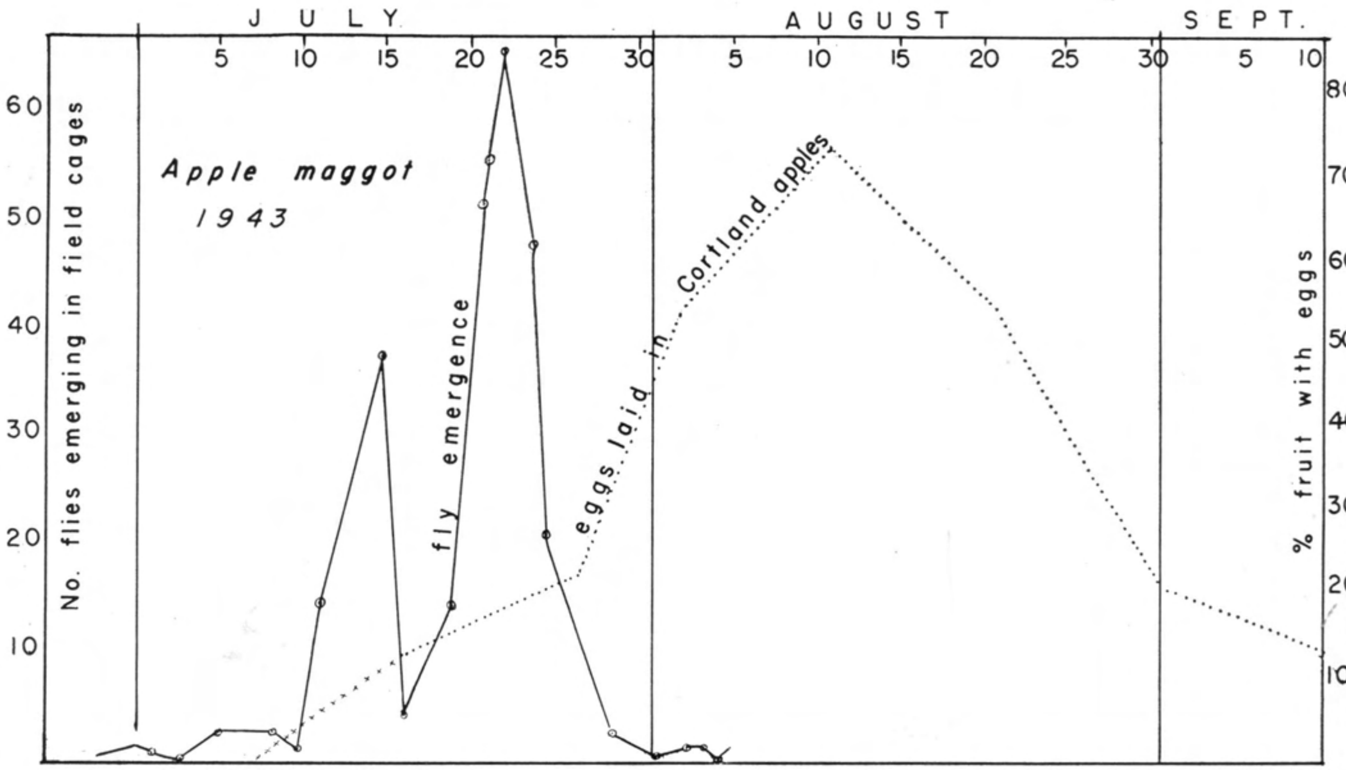

Figure 2. Chart showing apple maggot emergence in relation to egg laying in Cortlands.

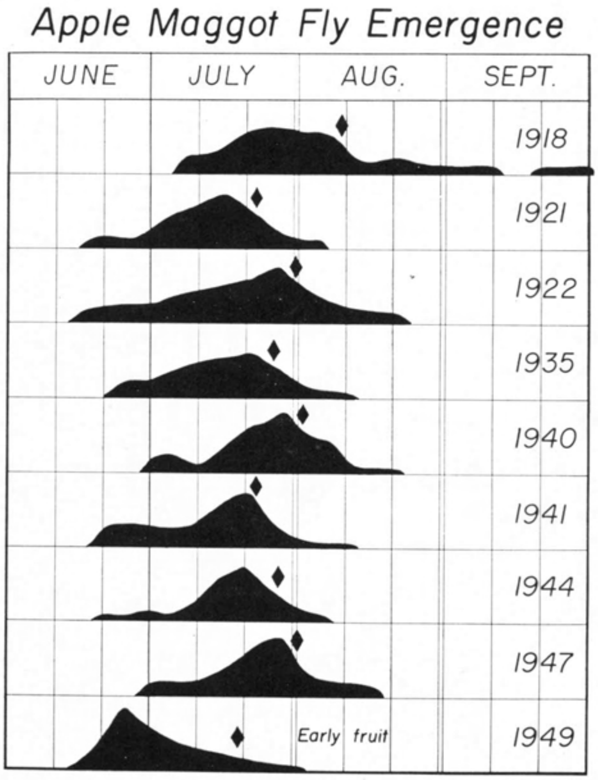

Figure 3. Apple maggot, chart of emergence. Diamonds represent time when 90 per cent have emerged. (First three years courtesy B. A. Porter.)

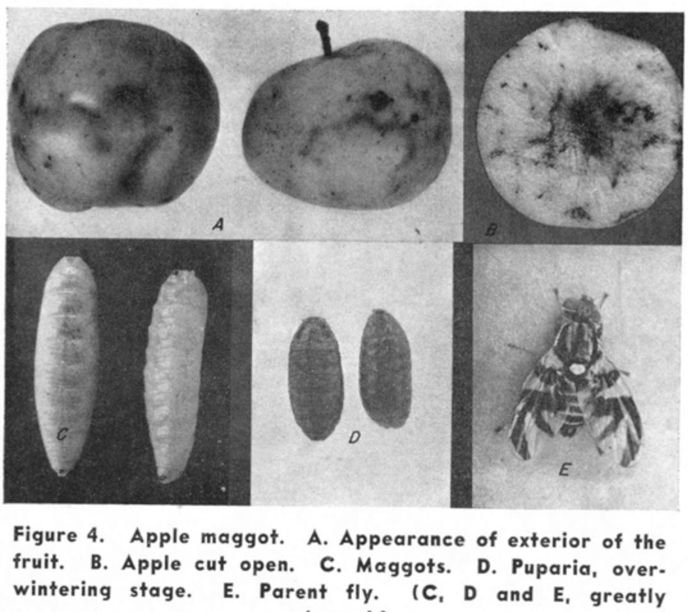

Figure 4. Apple maggot. A. Appearance of exterior of the fruit. B. Apple cut open. C. Maggots. D. Puparia, overwintering stage. E. Parent fly. (C, D and E, greatly enlarged.)

ROSY APPLE APHID

Anuraphis roseus Baker

Damage

Rosy aphids are small plant lice that have a pinkish tint when mature (Figures 6, 7, 11, 12). They produce curled leaves and deformed fruit (Figure 7). After being fed upon, the apples remain small and are worthless commercially. The insect may appear to become *suddenly* abundant in spring, but this phenomenon is usually due to the progressively increasing rate of reproduction which, given favorable temperatures, soon reaches a point where the trees may be literally covered over night. Gravenstein, Cortland and Baldwin are especially susceptible varieties. McIntosh is rarely damaged severely, partly because the fruits are well spaced so the aphids do not find them readily. The amount of damaged fruit may vary from a small percentage to practically 100 per cent.

Life History

Eggs are laid on the trees (Figure 6) during November and December and hatch in late April or early May. Following the hatching period the aphid population may decline only to become numerous later. The period of greatest activity extends from mid-May to July when the insects migrate to plantain (rib grass). In May and June reproduction is asexual, but a winged form appears during the latter part of June and this migrates to plantain. After several generations on plantain, a winged female is produced which returns to the apple in late fall. Progeny of these females mate with winged males from plantain and lay eggs during October, November and December.

Rosy aphids are not abundant every year. The cycle varies and peak seasons may be two, four or even more years apart. Cycles seem to depend in large part on abundance of natural enemies.

Factors Affecting Abundance

In the fall there may be limiting temperatures before many eggs are laid. This temperature according to Reed (1935) is 10 degrees F., at which point the females are killed. In spring, the most favorable periods are those when temperatures are between 55 and 70 degrees and there is abundant moisture and rapid twig growth. Natural enemies will not work efficiently at such temperatures, but the aphid reproduces with enormous speed.

Any condition promoting rapid plant growth will start the insect off on its round of destruction. Heavy fertilization may produce suitable foliage. Very rich soils are equally favorable.

Nearby waste lands may provide an abundance of natural enemies which sometimes move into the orchard and check the pest. Spacing and pruning influence outbreaks only as they provide rapid growth or rich succulent food.

Predators and Parasites

Many parasites and other enemies attack the rosy aphid. Several species of syrphus flies, lady beetles and lace-wing flies are most important (Figures 5, 8, and 10). A small hymenopterous wasp works as an internal parasite in hot weather and often reduces populations.

Eggs of some of the species mentioned are frequently seen in or near aphid colonies. The eggs of lady beetles are yellow, placed on end in compact groups; those of lace-wing flies are white and usually seen in groups, each egg with a slender hair-like stalk. Eggs of syrphus flies are laid singly and are usually white with a delicate surface netting.

Control Measures

Older methods consisted mainly in the use of dormant oils and delayed dormant lime-sulfur applications with nicotine sulfate. The later pre-bloom sprays were aimed at killing the stem mothers after hatching but before the rapid asexual reproduction got under way. These controls were reasonably effective with good spraying, but modern practice makes use of much more efficient chemicals. Dinitro compounds such as dinitrophenol, dinitro-*o*-cresol and various salts have been used recently. DN-289 and Elgetol 318 are triethanolamine salts of dinitro-*o*-*sec*butylphenol. They have been successful on both mites and rosy aphids. They are not quite so effective against mites as dormant oils but are useful nevertheless. Lauryl thiocyanate is also effective, but is not used much today.

Formerly, it was thought that once the leaves were curled, which begins while the tree is in bloom, it was useless to attempt control measures because the aphids were so well protected within the curled leaves. Modern experiments and orchard trials have proved that the insects can be killed within the curled portion with organic phosphates. Even after the trees have become heavily infested, it is now possible to save the apples with one of these phosphates. Organic phosphates act only partly by contact. There may be some penetration into the leaf tissues—enough to poison, since the insect takes its food from inside the leaf.

As a result of these developments it is no longer difficult to control rosy aphids. Experiments have shown that the application of one of the DN's at the dormant period, or tetraethyl pyrophosphate (TEPP) during the pre-bloom or immediately after bloom will keep the pest in check.

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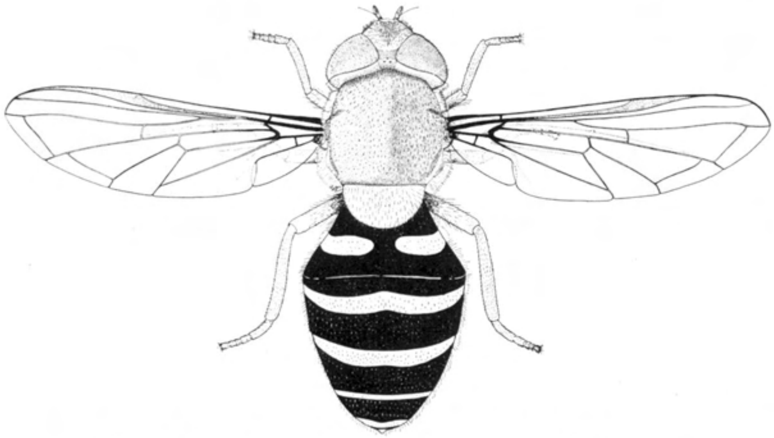

Figure 5. Adult syrphus fly enlarged about 5 times.

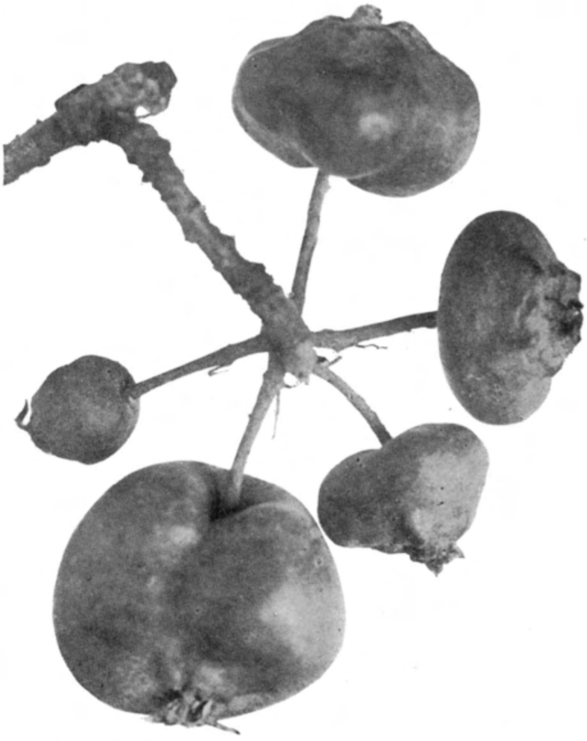

Figure 7. Apples, stunted by feeding of the rosy aphid.

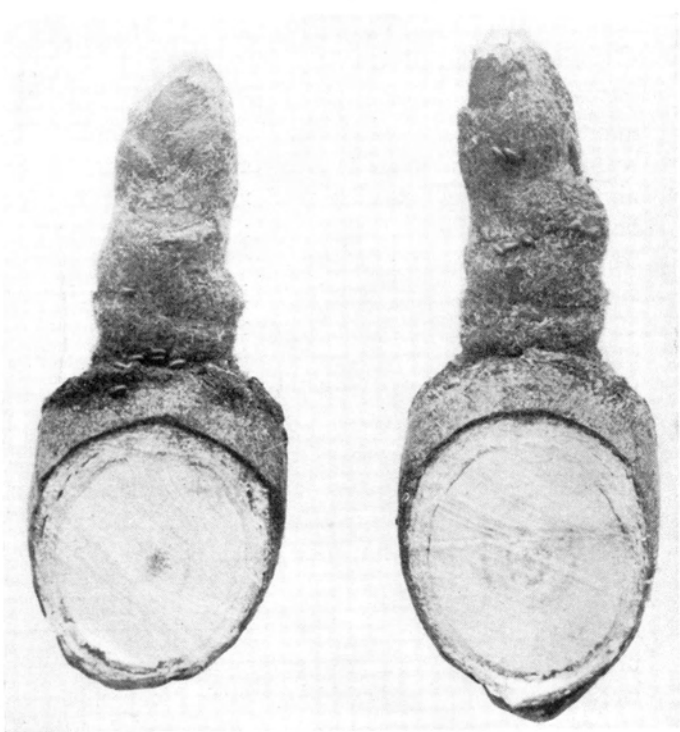

Figure 6. Eggs of the rosy aphid on small twigs.

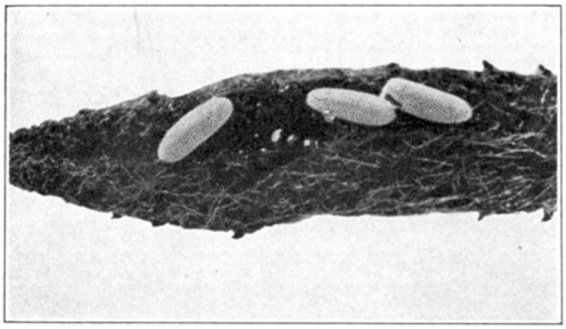

Figure 8. Eggs of the syrphus fly *(Syrphus toruus)*.

Rosy apple aphis—diagrammatic life history

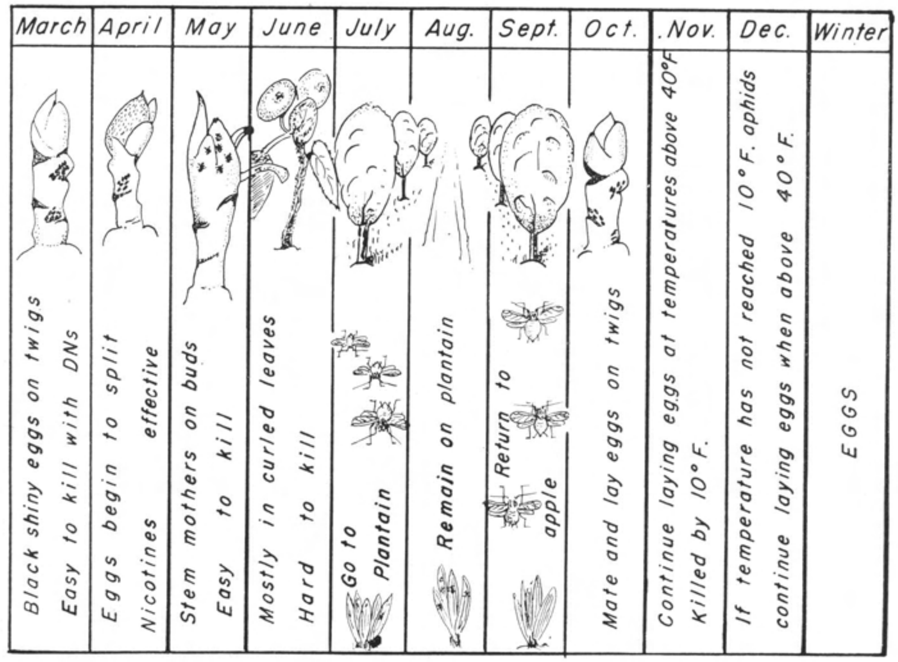

Figure 9. Chart showing life history of the rosy apple aphid.

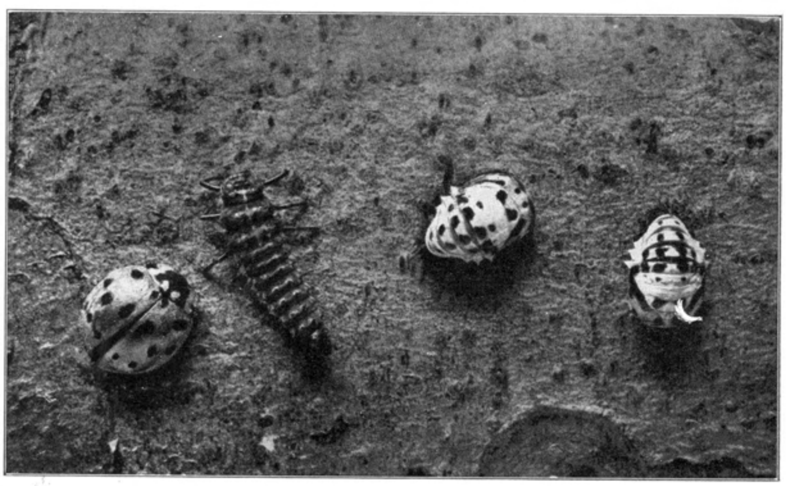

Figure 10. Adult beetle, larva and pupae of the lady beetle (*Anatis quindecimpunctata*).

Figure 12. Rosy aphids go from blossom or leaf buds to opening leaves. Note how the leaves are curling.

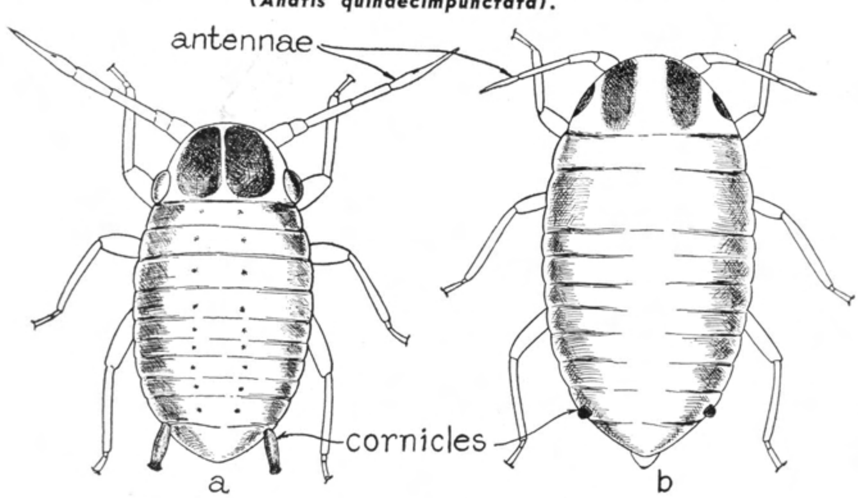

Figure 11. Early stages of the rosy apple aphid (a), and of the green apple aphid (b). Distinguishing features are the differing lengths of the antennae and cornicles.

GREEN APPLE APHID

Aphis pomi **DeG.**

Damage

Commonly known in Connecticut as "green aphis," this insect infests rapidly growing terminals of apples but during the average season does not harm the fruit. In some years and, in some locations, almost every year, it becomes numerous enough to get on the fruit during mid and late season. The fruit harvested from trees infested by the green aphis may be only slightly damaged or severely affected as in Figure 13. Frequently the fruit is covered with a sooty black deposit at harvest. Damage to the terminals is usually of minor importance, but a certain amount of defoliation often occurs in other parts of the tree, an injury which is of considerable importance from the standpoint of production. Likewise, leaves blackened with aphis soot do not function properly and this probably affects fruit quality.

There is another species, the apple-grain aphis, sometimes called "oat" aphis, which does little damage. It is less abundant than the green aphis but is indistinguishable in the egg stage and first instars.

Life History

The green apple aphid winters on twigs as a black shiny egg indistinguishable from that of the rosy apple aphid. Generations appear to be continuous on apple shoots throughout the summer, and there is continual migration from other plants in or near the orchard. The sexual form does not appear until late fall when eggs are deposited. However, the species is more or less omnivorous in habits, feeding on many other plants in and around the orchard. Destruction of the egg stage on the tree, therefore, does not necessarily control it.

No general cycles of abundance have been observed in Connecticut, although the pest is more troublesome in some years than in others.

Factors Affecting Abundance

Temperature and moisture relationships are the same as for the rosy aphid. Low temperatures of 55 to 70 degrees F. and frequent rains promote reproduction and may give rise to severe infestations.

Heavily fertilized and very rapidly growing trees sometimes support large green aphis populations. Drastic pruning which produces many vigorous water sprouts may give the same results.

Predators and Parasites

Parasites, predators and disease profoundly affect this pest. The same species that attack the rosy apple aphid attack this one. In years when syrphus flies and lady beetles are abundant, very little damage from green aphis may be experienced, but in other seasons when these predators are not present, considerable effort is needed to control the pest. Abundance of natural enemies may depend in large part on their abundance on other species of aphis on plants in or near the orchard.

Control Measures

Older methods consisted of spraying with oil and/or nicotine sulfate and removal of water sprouts by hand before general distribution of the aphids over the tree occurred. The latter method of control is still practiced. Usually no attempt at control was made in the summer until the aphids began to attack the fruit. No control method is completely effective, but some are distinctly beneficial. Best results have been obtained with the organic phosphates which are of great value in keeping aphids from the fruit. Failures have been reported, however, which may be tied up with climatic conditions at the time of spraying, or may be caused by other factors. Some aphids on the outer terminals may escape the effects of the sprays so that complete elimination appears difficult. Repeat applications appear to be necessary.

Sprays of TEPP or nicotine sulfate at standard dilutions, put on whenever the aphids appear to be numerous enough to damage the tree or fruit, have given good control.

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HODGKISS, H. E. Control of green apple aphis in bearing orchards. N. Y. (Geneva) Agr. Exp. Sta. Bul. 461. 1919.

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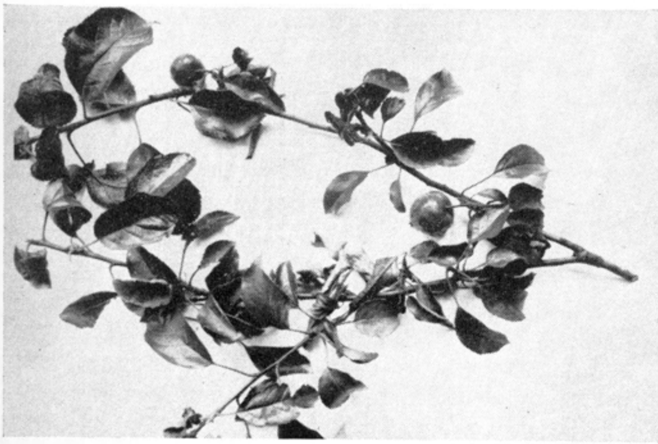

Figure 13. Apple branch heavily infested by green apple aphid.

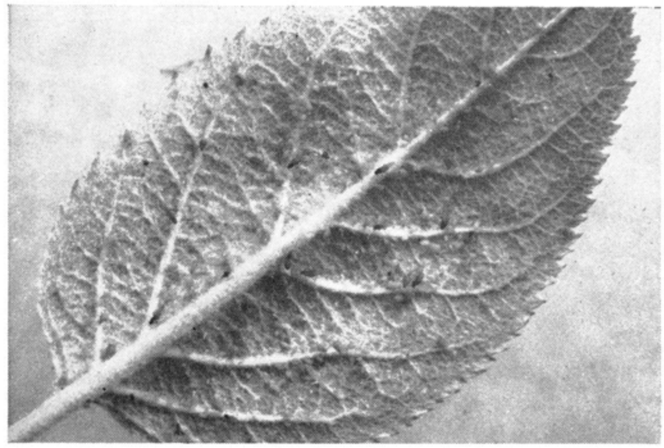

Figure 14. Aphids clustered on lower surface of leaf.

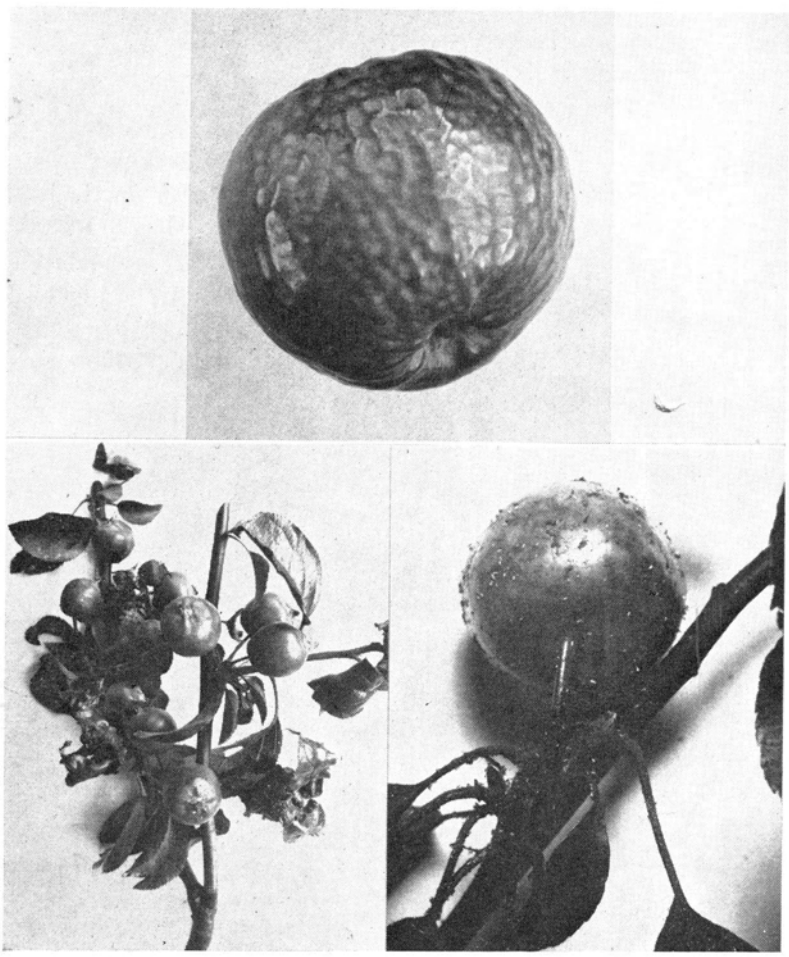

Figure 15. Aphids collected on fruit (right) and curling the leaves (left). Effect on fruit at harvest (top).

WOOLLY APPLE APHID

Eriosoma lanigerum (Hausm.)

Manifestations of woolly aphid infestations are usually seen in white patches of cottony material around buds and pruning scars. The insect is a purple to nearly black aphid which secretes the cottony substance for protection. It is sometimes mistaken for the mealy bug (see page 29).

Damage

Damage to the upper parts of the tree, usually evidenced by warts or nodules at the feeding points, is not severe unless the insect becomes very abundant. On the other hand, the root-infesting forms may cause great damage, particularly to nursery stock. Removal of sap lowers the tree's vitality and may possibly affect it in other ways. The woolly aphid occurs on elm, hawthorn and mountain ash, as well as on apple. Distribution is almost world wide, its occurrence having been noted in Australia, Palestine and many other countries.

Life History

The winter is passed either in the egg stage on elm or as an immature nymph on the roots of apple. Activity apparently begins when temperatures reach 40° F. and generations follow the usual course of aphids. Eggs are usually laid in the fall on elms in the immediate vicinity. The latter hatch in early spring, produce several generations without wings and then a winged generation which migrates to apple. After several generations on the apple, a winged stage is produced which then returns to the elm where eggs are laid for the winter.

Factors Affecting Abundance

From the life history sketch above, it is apparent that elms in the neighborhood of apple orchards are important factors in abundance. Temperature and humidity also play an important part. The optimum temperatures for outbreaks are between 60 and 70° F.; the most favorable humidity range is from 50 to 70 per cent (Bodenheimer, 1947). Cold limits are not known. Sprays of DDT have been reported by many to increase infestations.

Predators and Parasites

The most important parasite is *Aphelinus mali* (Hald.), which is so effective that it has been distributed in many countries outside the United States where woolly aphids are a problem. Its most effective temperatures, as well as the threshold at which it begins to work, are higher than those of the aphid itself. As a result, outbreaks are more likely to occur when temperatures are optimum for the aphid (60 to 70° F.) and unfavorable for the parasite. The main reason for increases of woolly aphids, as established by entomologists in many localities, lies in the destruction of Aphelinus by spray treatments. This was confirmed in Connecticut by our 1951 experiments.

Control Measures

Nicotine preparations have been used extensively in the past, as well as paradichlorobenzene for the root forms. As long as Aphelinus is abundant, however, there is little need for spray controls for woolly aphids in Connecticut.

Of the newer chemicals, it will be surmised from the above that DDT cannot be depended upon. In fact, in almost every case where this chemical has been used, increases in population rather than decreases have been noted. Action of methoxychlor and DDD are similar to DDT. On the other hand, parathion and TEPP are very effective.

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Figure 16. Galls formed by woolly aphid on roots of young nursery trees.

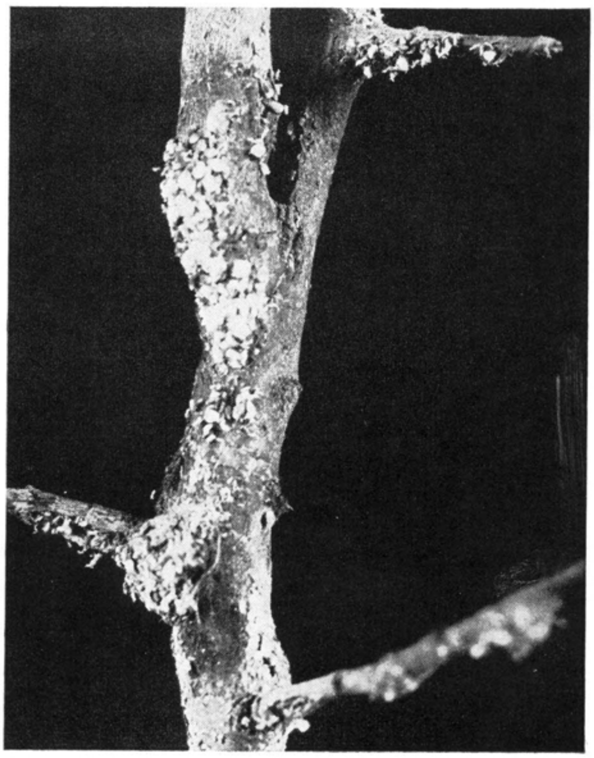

Figure 17. Woolly aphids on apple branch.

APPLE LEAF-CURLING MIDGE

Dasyneura mali **Kieff**

The parent insect is a minute fly and the young are small orange-colored maggots living in the curled edges of the leaves.

Damage

This insect was first found in Connecticut during 1943. The damage consists of curled leaves, particularly those of rapidly growing shoots (Figure 18). So far it has not become a serious pest in Connecticut.

Life History

For complete information, the reader should refer to the two Massachusetts bulletins listed below. There are three generations a year in this area.

Control Measures

The apple leaf-curling midge is easily killed with DDT, nicotine sulfate or parathion. Sprays at or near petal fall are suggested.

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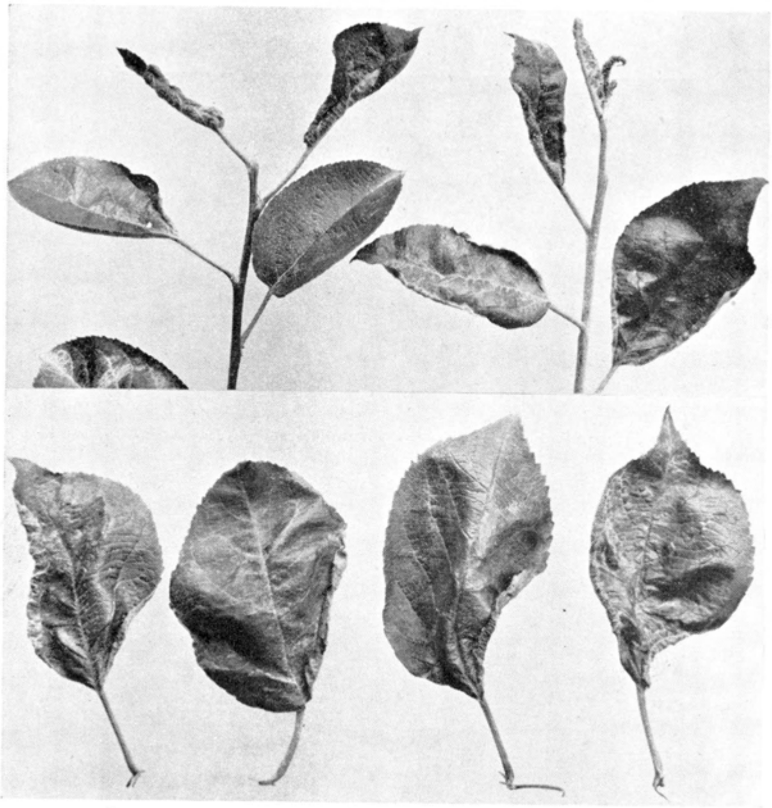

Figure 18. Work of the apple leaf-curling midge.

APPLE AND THORN SKELETONIZER

Anthophila pariana (Clerck)

The parent moth is a small insect about the size of the codling moth but somewhat darker in color. The larvae are small active greenish worms that skeletonize the leaves.

Damage

Damage consists mainly of skeletonizing with subsequent defoliation. Since its appearance in Connecticut in the 1920's, the insect has practically disappeared and has been of no importance. It continues to be a pest in other areas, notably Canada. In view of the relative unimportance, no attempt will be made to describe it in detail. Figure 19 shows the life history as determined when it first became abundant.

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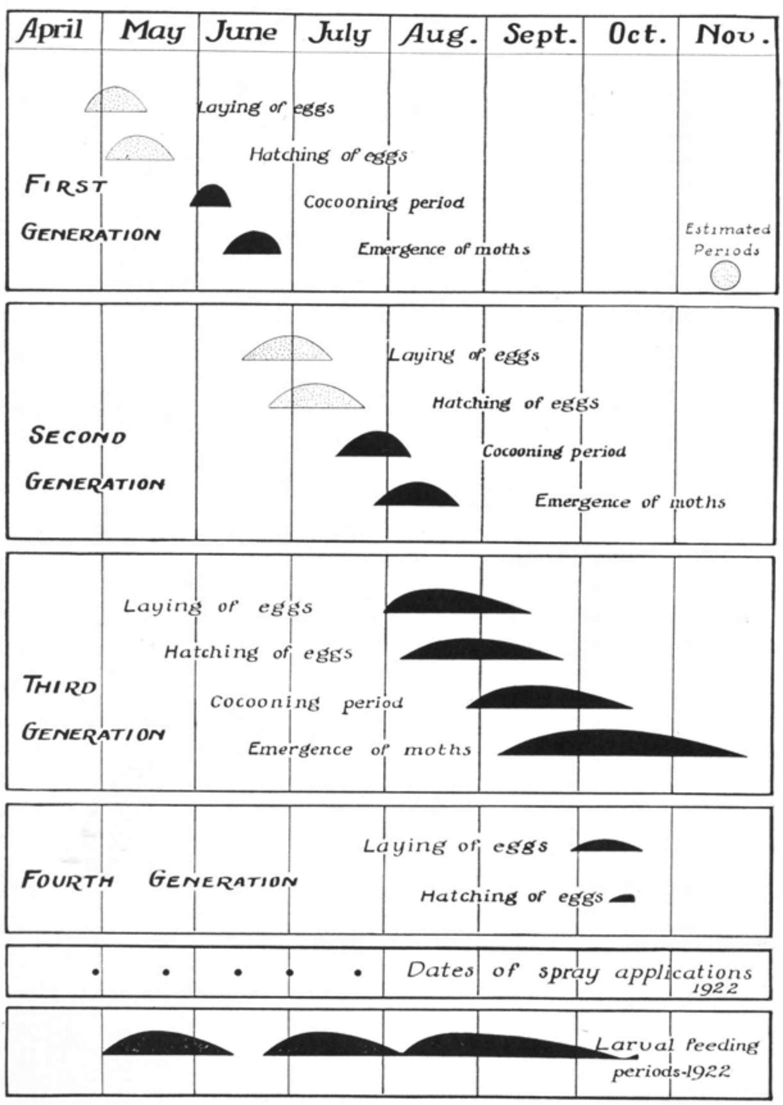

Figure 19. Chart of the life history of the apple and thorn skeletonizer. Stippled areas are estimated periods.

FLAT-HEADED APPLE TREE BORER

Chrysobothris femorata **Oliv.**

Damage

The larva of this borer, which may be recognized by the large flat thorax and curled U-shaped body, commonly damages trees by feeding on the inner bark. In young trees it produces an elongated gallery which may girdle the tree and kill it. On older trees the tunnel is more often circular and is gradually enlarged as the insect grows. The injury is not marked by castings as in the case of the round-headed borer, but may be detected by the sunken or slightly depressed areas where the larvae are feeding.

The beetles themselves are not known to do any serious damage in Connecticut, although they do feed on the leaves.

Life History

The life cycle is usually one year (occasionally more). Adults issue from wounds shortly after bloom; they live several weeks. They are very active during egg laying. Eggs are laid in suitable openings or cracks in the sunny side of all sorts of bark and logs. Each female produces about 100. The yellow flattened disc-like eggs hatch in 15 to 25 days in this climate. Mature larvae burrow into the wood for several inches where they pass the winter. Pupation occurs in spring.

There is no evidence of cyclic abundance.

Factors Affecting Abundance

Warm sunny weather promotes activity. Cold mortality limits for the larvae have not been determined but presumably are very low.

The flat-headed apple tree borer is said to infest many kinds of trees, attacking among others the larger shade and forest trees. Drought-weakened trees or trees damaged by the cultivator, other insects, scald or disease are readily attacked.

Predators and Parasites

Woodpeckers, crows, king birds and red-eyed vireos are among the more important predators. Insects such as ants destroy borers in the wood. Six species of hymenopterous parasites are known: *Bracon charus* Riley, *B. pectinatus* Say, *Spathius pallidus* Ashm., *Labena apicalis* Cr., *L. grallator* Say and *Phasgonophora sulcata* Westw.

Control Measures

Maintenance of tree vigor is considered of utmost importance. Shading of trunks by wrapping with paper or burlap has been found effective. Another method consists of placing an upright board about six inches wide close to the trunk on the south side to shade it. This discourages the parent beetles from laying eggs since they show strong preferences for sunny locations.

There is little information available on the efficacy of the newer insecticides. The use of such standard insecticides as lead arsenate has not proven effective nor have the repellents tried been of much use.

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ROUND-HEADED APPLE TREE BORER

Saperda candida F.

Damage

This insect infests apple, quince, pear, plum and peach. It has also been found in shad bush, crab apple, mountain ash (frequently attacked), red chokecherry and hawthorn. Its general preference seems to be for young apple trees.

It girdles young trees and weakens them. It is not unusual to find up to five borer larvae per tree in uncared-for plantings, but it only takes one or two to kill a small tree. Young trees are preferred because of the thinner bark. Some feeding by the beetles themselves takes place on foliage and fruit, although damage therefrom is not usually severe.

Life History

Beetles emerge from trunk galleries during the last of May or first of June; emergence may continue until July. Eggs are laid in the early morning from the last of June to the last of August. Twenty-five eggs per female is about average. They are placed in slits made in the bark near the ground level. The life cycle averages three years, but may vary from two to four. Larvae work first in the cambium, then penetrate the heart wood. There is a tendency to work down to the ground level or below during the winter. Pupation occurs during full bloom of the final year.

There is no definite information on cyclic abundance.

Factors Affecting Abundance

Flights of beetles occur and they seem to be most active generally in hot, damp periods. Otherwise, they are not affected except to be forced to ground levels by cold.

Cold limits of survival have apparently not been determined.

The insect travels relatively short distances in spite of well-developed wings. Most of the trouble may therefore be expected to arise from *within* the orchard, but nearby sources of infestation should nevertheless be considered and removed, if possible.

Predators and Parasites

There are more enemies of the round-headed apple tree borer than formerly suspected. Among them are the parasitic wasps, *Monogonogastra agrili* Ash., *Microbracon sp.*, *Cryptoideus luctuosus* Prov., *Melitobia chalybii* Ash., and a fly, *Sarcophaga sp.* Mites, hairworms, nematodes, spiders, ants and carabid beetles destroy the larvae.

Birds, however, are more important. Woodpeckers, including flickers, are known to remove large numbers of the larvae from apple trunks.

Control Measures

Among measures formerly considered, removing the worms by hand was probably the most effective. Clean cultivation or orchard sanitation was valuable in making the way clear for removal of the larvae by birds. Wrapping the trunks to force the beetles higher on the trunk where they could be more easily detected is mentioned, as is fertilization to enable the trees to recover from attacks.

Arsenate of lead, 3 pounds to 100 gallons, is not a new remedy; however, only within the last 10 years was it demonstrated by experiment to be effective. Cryolite, though not much used in Connecticut, is said to do a good job. The procedure calls for at least two sprays, the first two to three weeks after petal fall, the second two to three weeks after that. These sprays destroy the parent beetles. Best results are obtained when foliage and nearby weeds or grass are sprayed as well as the tree trunks.

For trees already infested, injection guns have given good control. Ten grams of paradichlorobenzene in 10 c.c. carbon disulfide, or rotenone or pyrethrum extract (1.5 to 2.5 per cent pyrethrins) mixed in a small amount of alcohol are effective. A pressure of 20 to 30 pounds per square inch in the gun is desirable.

Applications of the above materials may be made with an oil can but are not quite so effective. The can may be fitted with a small bore copper tube the right size to be inserted into the burrows.

To date, there are no records of control attempts with DDT, chlordane or other recently developed insecticides. Although it has not been proved, it is probable that some of them will work as well as lead arsenate.

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Figure 20. The round-headed apple tree borer. Larva.

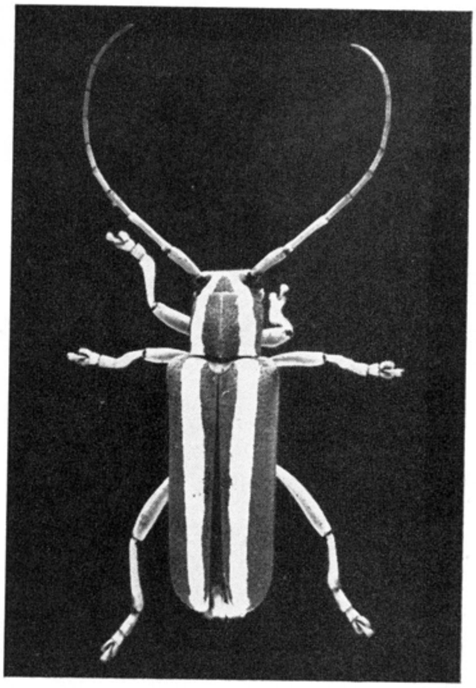

Figure 21. The round-headed apple tree borer. Adult beetle.

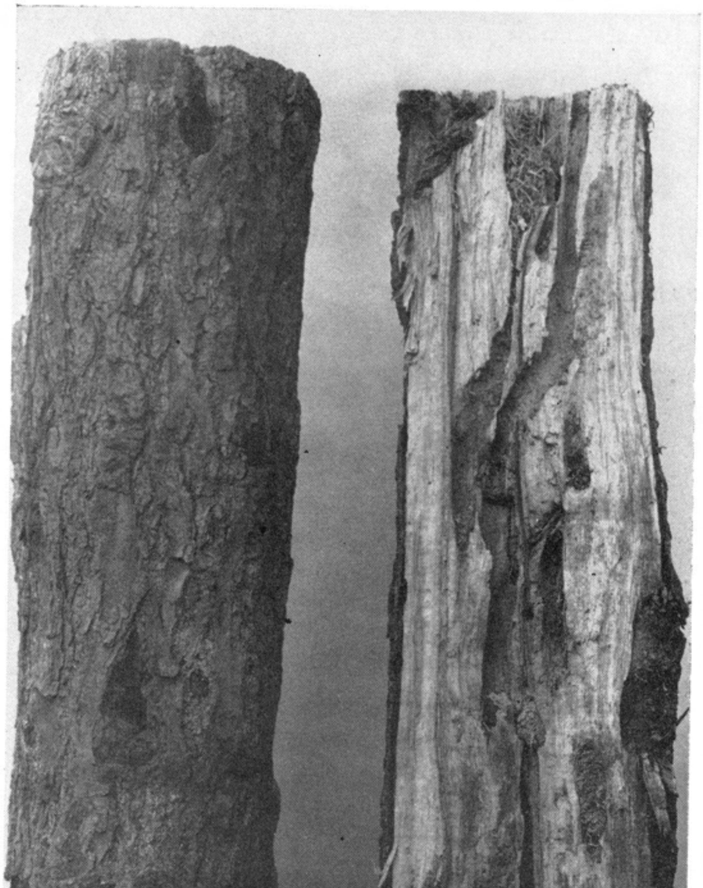

Figure 22. Work of the round-headed apple tree borer.

BUFFALO TREE HOPPER

Ceresa bubalus (F.)[1]

Damage

Tree hoppers are a serious problem in the Midwest and on occasion have produced considerable damage in the East. Young trees are severely injured, mainly by egg punctures in the bark of twigs and smaller branches. Scars resulting from them seriously weaken the tree.

Host plants are many. The adults use forest and fruit trees for egg laying, while the immature stages live on succulent plants, such as alfalfa or sweet clover and bindweed. Many other weeds serve the purpose but most damage in Connecticut has been in orchards planted to alfalfa or with an abundance of bindweed.

Life History

The winter is passed in the egg stage from which the insect hatches as a nymph in April (Hodgkiss, 1910). The nymphs drop to the ground and begin feeding on the cover crop. Adults appear in mid-July and may live until frost. Egg laying starts in the bark about August 1, and ceases the last of August.

Variations in abundance have been recorded but there is no definite information on cycles.

Factors Affecting Abundance

Weather conditions favorable for egg hatching include fairly high humidity for softening the wood, but this is evidently not a limiting factor. Cold limits for survival are not known.

Ground cover, alfalfa, sweet clover and bindweed are most important as mentioned. Nearby woodlands may also be a factor.

Predators and Parasites

Predator mites (*Iphidulus sp.*) are known to attack the buffalo tree hopper but very little is known about parasites or predators in Connecticut.

Control Measures

Until recently no sprays were known which would give satisfactory control of the adult hopper. All practices centered on weed removal in and around the orchard and avoidance of cover crops such as alfalfa and sweet clover. Judicious pruning to remove the eggs was thought to be of some benefit.

DDT is reported to be effective against the adult but DDT did not give practical control in Wisconsin (Fluke, 1948). The most successful control seen in Connecticut resulted from the use of parathion. Applications were made in July before the adult began egg laying, and at least part of the spray was directed at the ground cover. The dilution used was 1 pound 15 per cent parathion to 100 gallons.

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MARLATT, C. L. The buffalo tree hopper. U.S.D.A. Cir. 23 (2nd. series). 1897.

[1] The species most commonly encountered in Connecticut is *C. bubalus*. Two other species, *Stictocephala inermis* and *Ceresa taurina*, are associated with the same type of injury produced by the buffalo tree hopper (Hodgkiss, 1910).

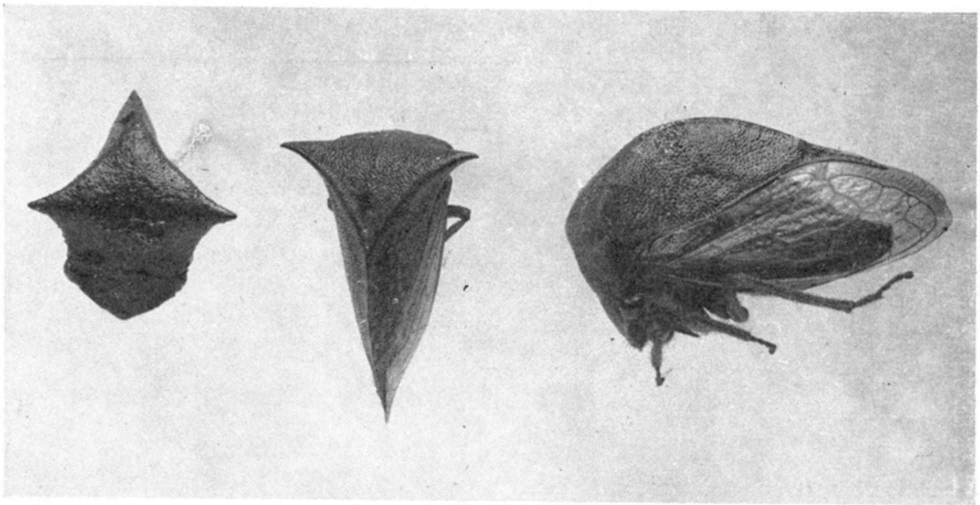

Figure 23. The buffalo tree hopper. Five times natural size.

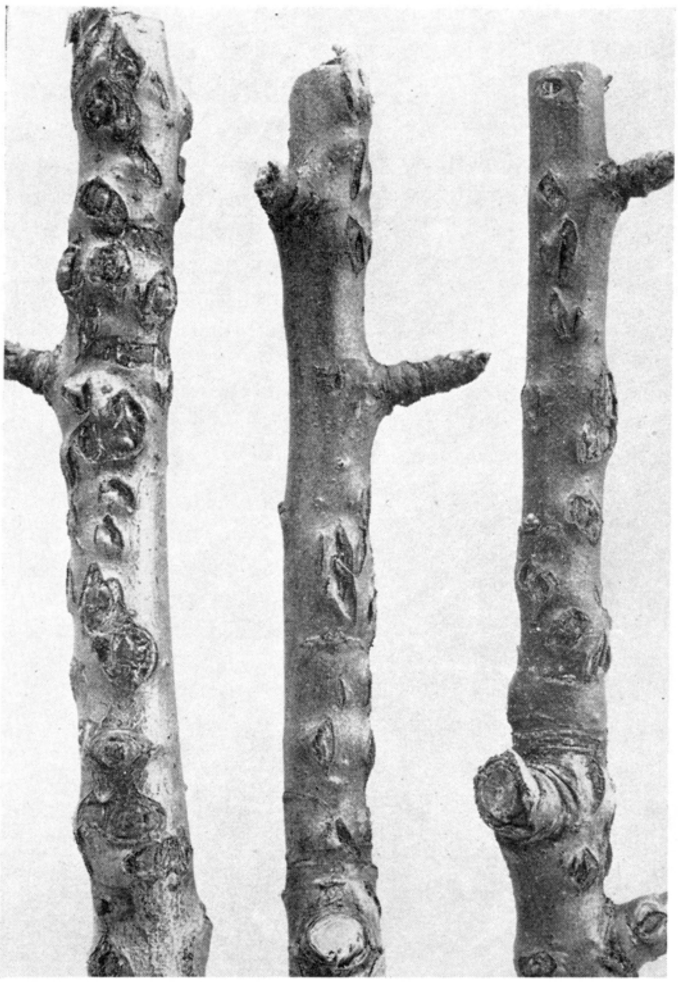

Figure 24. Egg-laying scars of the buffalo tree hopper on young apple twigs.

FALL CANKER WORMS

Alsophila pometaria (Harr.)[1]

Canker worms are small green or black loopers often occurring in large numbers on unsprayed trees. The female moth is a gray wingless creature, but the male has normal wings and is able to fly readily. This moth has a wing spread of about one inch with a few white spots and wavy lines.

Damage

The damage from leaf-feeding larvae may be extensive, but varies considerably from year to year. Unsprayed orchards are sometimes completely defoliated and, if early insecticides are omitted, the fruit may also be damaged. Defoliation results in the loss of two years' crops since fruit buds generally will not form for the following year if the leaves are eaten.

Damage is likely to be localized and erratic, but wherever allowed to go unchecked is serious and may be devastating.

Many kinds of forest, shade and fruit trees are attacked, but elm, linden and apples seem to be preferred.

Life History

The eggs are laid in small groups or bands. They hatch about the time apple buds are pink, and the small green or black loopers continue to feed until mature in June. They then drop to the ground and pupate. During November or early December the moths emerge, mate, and the wingless gray female crawls up the trunk and lays eggs on trunk, branches or twigs, usually as far out on the tree as possible. There is a definite trend towards cycles of abundance, probably connected with parasites and predators. There are about 10 years between peaks. The period of greatest destruction from the insect may last from three to five years.

Factors Affecting Abundance

Weather usually has little influence on this insect. Porter and Alden (1924), however, state that late cold spells after the larvae have hatched are known to be disastrous to them.

Infestations in nearby woodland areas are of great importance. Pruning, type of soil or other factors within the orchard appear to have little influence. Starvation from exhaustion of food supply often gives the larvae a severe setback, though rarely serving as an important factor in control.

Predators and Parasites

Fungous and bacterial diseases have been noted from time to time, but the insect does not seem to be especially subject to them. Birds of many species feed readily on canker worms. Carabid beetles, pentatomid and mirid bugs, soldier bugs and wasps destroy many. Numerous parasitic wasps and Tachinid flies have also been reported (Porter and Alden, 1924). Spiders may destroy canker worms on occasion.

Control Measures

Older methods consisted of banding the trees in the fall to prevent the moths reaching the tops of the trees. Success of this measure depended in part in keeping the bands sticky in spring in order to prevent larvae from eggs laid below the bands from reaching the tops. Bands should also be in place early enough in the fall to prevent females from ascending the trunk.

Spraying with arsenate of lead about the time of the spring hatch has been very successful.

Modern treatments consist mainly of substituting DDT for arsenate of lead since the insect is very sensitive to even small amounts of this insecticide. Controls have been obtained with high pressure hydraulic rigs, mist blowers and air borne equipment. The best time for orchard applications is at pink, calyx or first cover periods.

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PORTER, B. A., and ALDEN, C. H. The canker worms. U.S.D.A. Bul. 1238. Plates I and II. 1924.

[1] There are two species, *Poleacrita vernata* and *Alsophila pometaria.* The former has a slightly different life history, but is controllable with the same methods. The latter is more abundant in Connecticut.

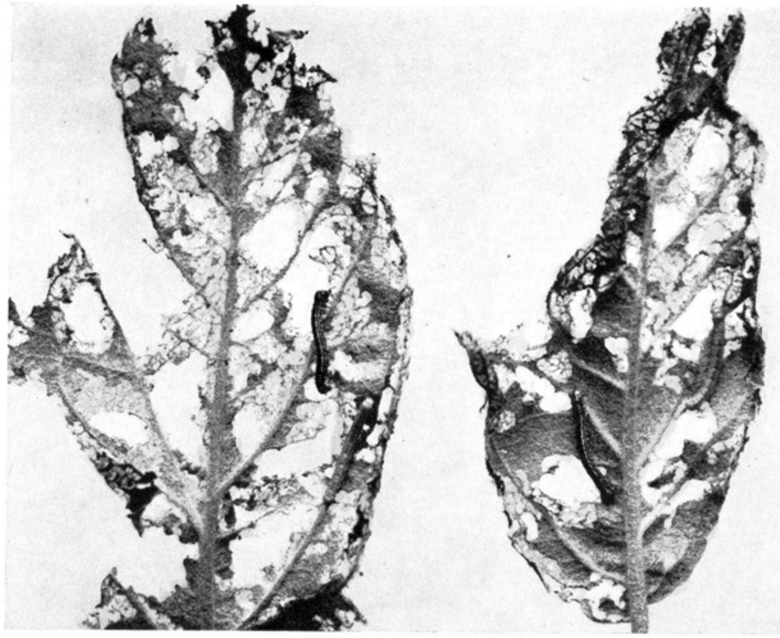

Figure 25. Canker worms feeding on apple foliage.

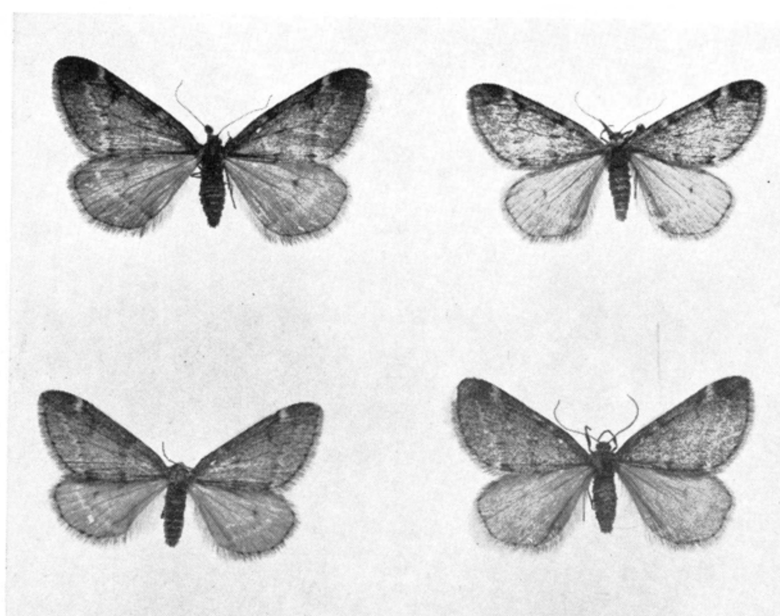

Figure 26. Male moths of the canker worm.

CODLING MOTH

Carpocapsa pomonella (L)

Damage

A native of Europe, this insect infests principally apples, pears and quinces in the Northeast, but has been recorded on peaches, cherries, plums and apricots. The only damage is from the larva entering the fruit and feeding therein. The larva bores directly into the center of the apple, its preferred food. Here it differs from the larvae of Oriental fruit moths or lesser apple worms which mine near the surface or wander extensively in the flesh. Codling moth larvae also differ from the fruit moth and others in being distinctly spotted in the earlier stages. When mature, however, the larva becomes pink, the same as that of the Oriental fruit moth, but it is usually much larger. The codling moth, until the discovery of DDT, did more damage to apples throughout the United States than any other insect. It still is of primary importance.

Life History

According to Bourne and Whitcomb (1927), there is much irregularity in the pattern of first brood larvae, due probably to irregularities in moth emergence and effect of temperature on egg laying. There are two generations in Connecticut, though sometimes the second is only partial. Moths emerge about the time apples are in bloom, live two to three weeks, and lay an average of 30 to 40 eggs per female. For the most part young larvae do not begin to enter the fruit until several weeks after petal fall (Figure 29). Depending somewhat on weather conditions, this stage may continue into July. The second generation begins to enter fruit about the first of August and continues into September. In Connecticut the size of the second generation may be reduced by cool weather which forces some larvae of the first generation into hibernation so that they do not emerge until the following year. The larvae are practically all in cocoons for winter by the middle of September. Moths emerge from packing sheds much later and the life cycle for these moths may be as much as three weeks later than given.

There is no evidence of cycles of abundance.

Factors Affecting Abundance

The insect is strongly affected by temperatures, with high sundown temperatures stimulating egg laying. Egg laying stops when temperatures are below 62 degrees F. and the number laid per female increases as the mean temperature rises (Isely and Ackerman). There are nearly four times as many eggs laid per female at 75 degrees as at 64. It may be reasoned, therefore, that if temperatures after sundown and before total darkness fall below 62° F., few eggs will be laid, and that if unfavorable conditions prevail during the two to three weeks life span of the moth, infestations may be reduced.

Other conditions favoring abundance are poor tree conditions, such as might be caused by a lack of pruning, lack of a crop the preceding season, or an inadequate spray program. Debris on the ground under the trees gives the pest favorable hibernating quarters. The presence of used field crates or nearness to unscreened packing sheds are other important influences. The rapidity with which drop fruits decay on the ground has also been mentioned (dry versus wet seasons).

Predators and Parasites

The most common parasite in the Northeast is *Ascogaster carpocapsae* Viereck. This parasite, however, has rarely been found in numbers large enough to affect codling moth populations significantly. There are other predators of minor importance. Woodpeckers are known to destroy many larvae and, together with predator beetles of several species, reduce the number of overwintering larvae considerably. Ants, Trichogramma egg parasites and thrips have been mentioned. All insect predators and parasites appear to be reduced by the spray programs employed in commercial orchards. DDT and related chemicals are probably more destructive than chemicals formerly used.

Control Measures

Before DDT became available, important control measures included (1) spraying with lead arsenate properly timed to kill the young larvae entering the fruit; (2) scraping all loose bark from the tree and banding with corrugated paper treated with beta-naphthol to kill cocooning larvae; (3) spraying the later generation with fixed nicotines, and (4) screening packing sheds to prevent escape of moths into the orchard. All of these measures were valuable and reasonably successful in the production of clean fruit. In spite of the methods employed, however, infestations were often high, due in part to the development of a strain of

Codling Moth

codling moth larvae in the Northwest known to be partly resistant to lead arsenate.[1] To overcome this condition, sprays allowing very heavy deposits to be placed on the apples and including stickers to prevent weathering came into prominence.

Tests of natural control versus insecticides (Jaynes and Marucci, 1947) seemed to indicate better control for insecticides.

With the discovery of DDT, most of the above practices have been largely abandoned. The problem in the Northwest became much less acute so that investigations and discussions dropped off noticeably in grower meetings and reports. Whether resistance to DDT will eventually necessitate a shift to still other sprays is not yet clear, but we do know that the need for mite control has been intensified, following the use of DDT. Thus, it would appear that growers have simply traded one problem for another. Results with DDT for codling moth have been so outstanding, however, that instead of returning to lead arsenate, there has been increased research to discover efficient miticides. These efforts have met with considerable success.

It has been found recently that moths can be killed readily with parathion. Since parathion is also a miticide, the codling moth problem appears to be considerably simpler than it was 10 to 15 years ago.

Timing sprays continues to be important. Baits to attract the moths is developing into an important supplementary measure; they tell *when* to spray. Our experiments have shown that, for the first generation, there should be continuous protection for about a month after calyx.

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[1] Not proved for Connecticut.

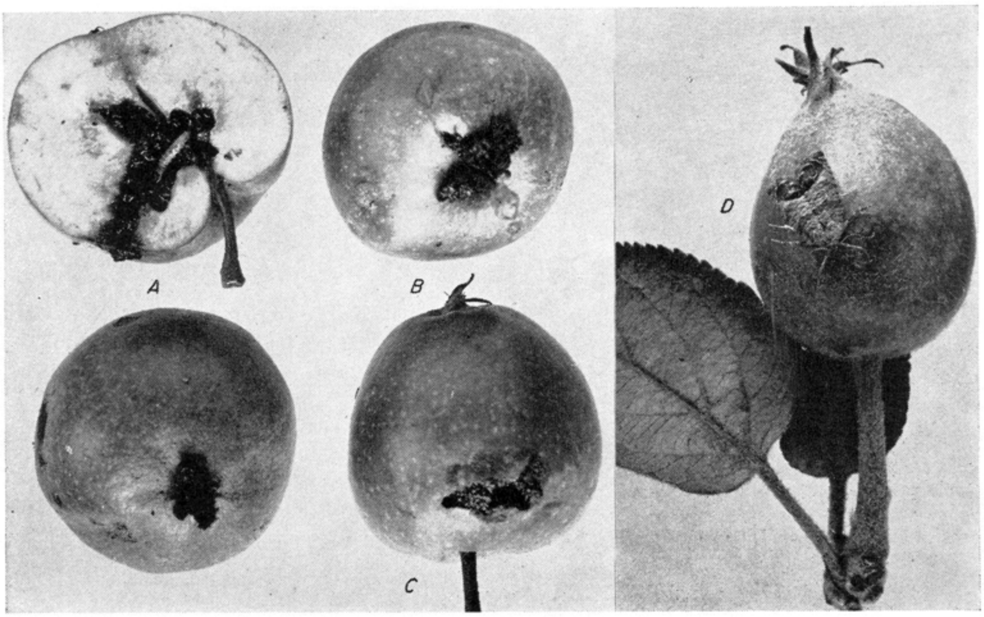

Figure 27. A. Larva at core of the apple. B. Entrance at calyx end. C. Entrance at side. D. Moth in position for laying eggs.

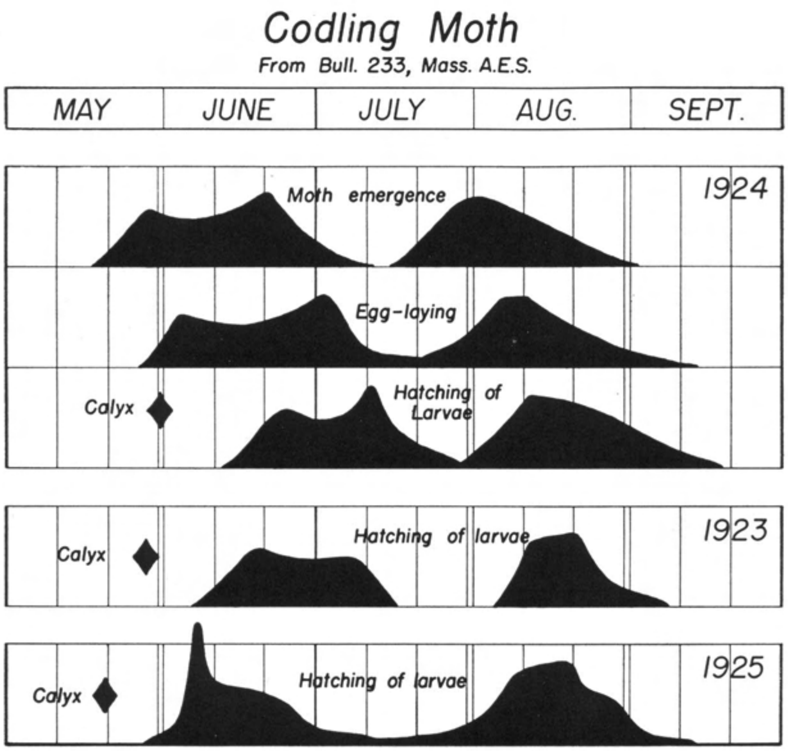

Figure 28. Codling moth life history (from Massachusetts Agr. Exp. Sta. Bul. 233).

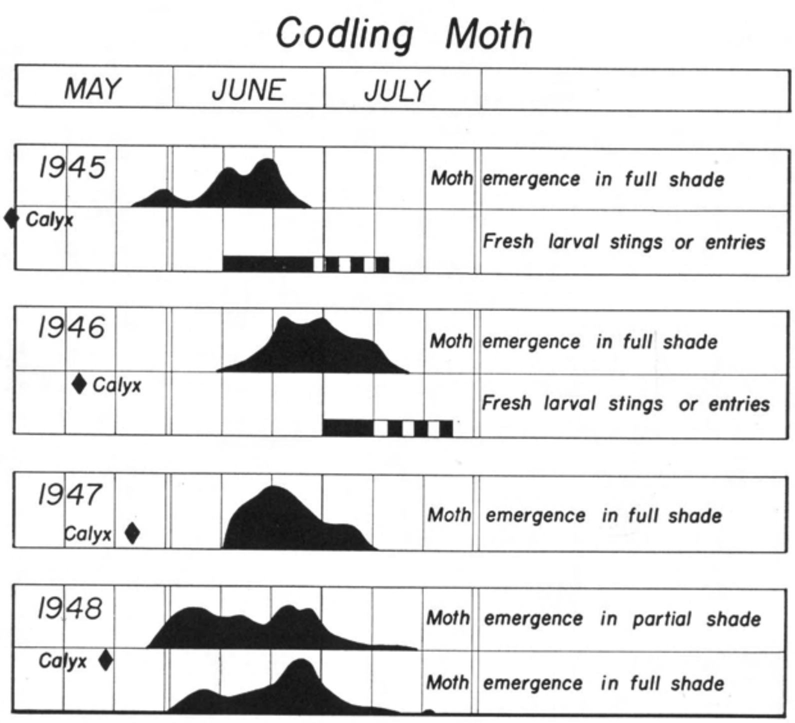

Figure 29. Codling moth life history in Connecticut.

COMSTOCK'S MEALY BUG

Pseudococcus comstocki **(Kuw.)**

Comstock's mealy bug is often confused with the woolly apple aphid. It can usually be distinguished by the flat shape of the bug (Figure 30), its long tail and the fact that the woolly aphis is purplish or nearly black when mature. Moreover, wooly aphids tend to cluster together and produce much larger quantities of cottony secretions.

Damage

Damage by Comstock's mealy bug results largely from removal of the juices from twigs and terminals and from the soot which collects in the gummy exudates on the fruit itself. This damage is very similar to that produced by green aphids and may be mistaken for it. Comstock's mealy bug most frequently attacks older vigorous trees. It is known to infest apples, peaches, pears and grapes.

Prior to 1936, this insect had been primarily a pest of catalpa and other shade trees. Since that time it has attracted attention from Virginia to New England as a pest of fruit trees. Thus far, it is most abundant in central and southwest Connecticut.

Life History

The winter is passed in the egg stage. Hatching occurs the last 10 days of May or the first week in June (about the time of the calyx or first cover spray). The bugs mature in one to one and one-half months and egg laying starts shortly thereafter, usually about July 15. The first nymphs of the second generation have been observed about August 1.

The second generation matures in the latter part of September or October when eggs are laid again. These remain in the egg stage throughout the winter.

Factors Affecting Abundance

The exact effect of weather on abundance is unknown. The cold tolerance has apparently not been determined.

Outside sources of infestation are not known to have much influence on the abundance of the mealy bug. As already noted, trees in full vigor are most commonly attacked.

Predators and Parasites

Natural control is thought to be accomplished by parasites, unfavorable weather and soil practices (Driggers, 1943).

The parasitic wasp, *Allotropa convexifrons,* is one of the most important parasites in Connecticut. It has been observed to reduce an infestation to harmless status within a year. *Pseudaphycus sp.* has been observed by Brigham to parasitize up to 36 per cent of the bug in Connecticut, and was the most important species in 1950. *Clausenia purpurea* is present but usually occurs in limited numbers.

Control Measures

DDT appears to be the most successful among insecticides tried by Connecticut growers to date; the usual concentration is 2 pounds (50 per cent) to 100 gallons. Parathion has been observed to destroy parasites without controlling the pest. So far only a few growers have had to spray for mealy bugs.

Applications should be made either the first of June when the first generation eggs are hatching, or about the first of August when the second generation eggs hatch.

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———, Clancy, D. W., and Pollard, H. N. DDT and its effect on the Comstock mealy bug and its predators. Jour. Econ. Ent. 38:422-425. 1945.

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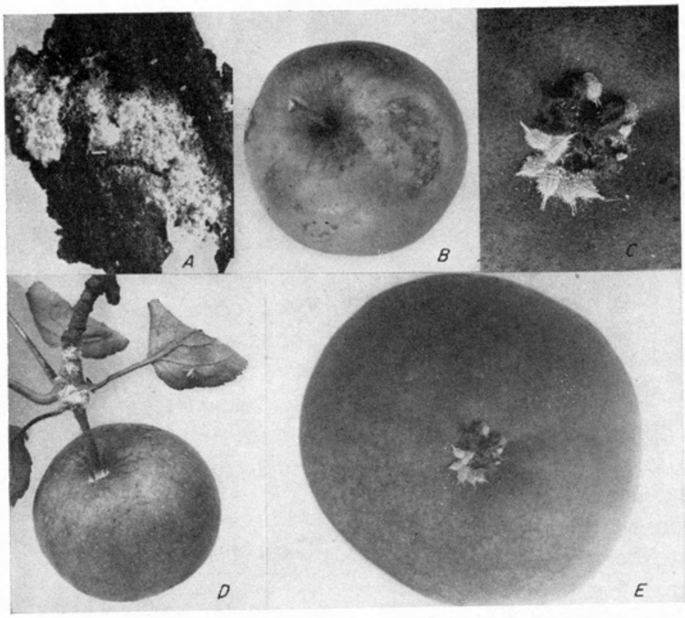

Figure 30. Comstock's mealy bug. A. Egg mass under bark scale. B. Sooty fruit. C. Mature bugs clustered around calyx. D. Bugs clustered on stem of apple. E. Cluster of mealy bugs at calyx end of a pear.

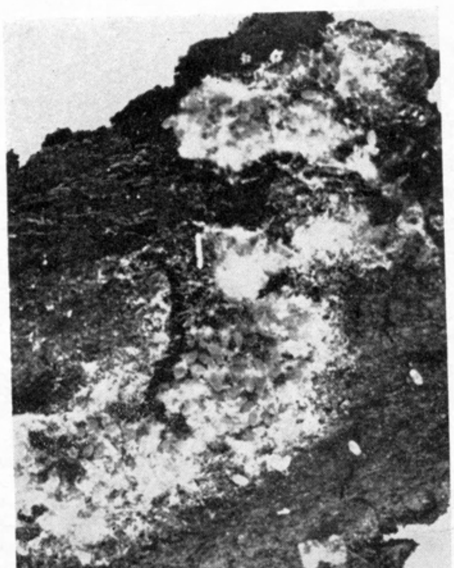

Figure 31. Egg masses of Comstock's mealy bug under apple bark scale.

EYE-SPOTTED BUD MOTH

Spilonota ocellana D. & S.

The larvae are easily distinguished from other larvae seen on the apple tree because they are dull brown in contrast to the customary green or yellow. The summer mines[1] usually are classed as "dirty" mines, and differ from the mines[1] of the red-banded leaf roller which are clean by comparison. The mines also contain shelter tubes which hide and protect the larvae. The moths somewhat resemble those of the codling moth but are smaller and the band across the wings has no wavy lines (Figures 32 and 33).

Damage

The first signs of injury from the eye-spotted bud moth occur in spring after the larvae leave their winter shelters. They bore into fruit and leaf buds and, if numerous, cause considerable damage. The summer generation feeds mainly on the lower surfaces of the leaves and may attack the apples to a limited extent (Figure 34). Damage here consists mainly of small shallow feeding punctures through which rot organisms may enter, often reducing the apple to cull grade.

Life History

There is only one generation a year and the insect passes the winter in small cocoons on the twigs as a partly grown larva. The larvae are stimulated to activity by temperatures over 60 degrees F. With continuous warm weather, they leave the shelters and migrate to growing buds. This migration may continue for more than a month and occasionally even longer. Emergence begins when the apples are in the green tip stage. After leaving winter quarters, the larvae feed on buds, constructing shelters after the buds break open. The insect pupates in these shelters. Moth emergence takes place during mid-June. After emergence, the moths may remain in the orchard only a few weeks or they may continue there until late August. Eggs are laid on the undersides of the leaves, beginning three to five days after moth emergence. They hatch in seven to ten days, averaging nine days (Porter). They have been noted in Connecticut June 20, July 2 and 13. The hatching period may extend into September.

There are great variations in the appearance of spring and early summer broods and also in the moth flight periods. There are also marked cycles of abundance which may last for four or five years at rather wide irregular intervals. There are records of outbreaks in 1841, 1869, 1891, 1907-1911 and 1944-1949.

[1] Not mines in the true sense but skeletonized areas covered with webbing.

Factors Affecting Abundance

The effect of weather on this insect appears to be slight. Except for data on temperatures required to bring the larvae out of hibernation, little useful information is available.

Nothing definite is known about sources of infestation, although the insect feeds on many kinds of fruit and native woodland trees. Increases are apparently favored by conditions within the orchard which make it difficult to secure good insecticide coverage. Crowded trees, tall and dense trees, and wet ground which prevents spring applications make control difficult. In some localities (Ontario, Gilliatt) the bud moth is most injurious in well-cared-for orchards, especially those in good growing condition.

Poor timing of sprays is another factor of considerable importance, as well as lack of thoroughness. The larval habit of protecting itself with shelter tubes and boring into buds out of reach of insecticides should also be mentioned.

Predators and Parasites

In view of the cyclic features of bud moth activity, there must be the usual number of natural enemies that attack it. According to Porter, many of the early records are open to question, but he lists a total of about 14 parasites. Among the more important ones are the egg parasite, *Trichogramma minutum* Riley, species of Secodella, several species of Bassus, *Epiurus indagator* and *Itoplectis conquisitor*. Among predators may be mentioned birds of various species, wasps (particularly *Odynerus catskillensis* Sauss), *Triphleps sp.*, the predator bug, and the mite, *Anystis agilis*, a general feeder. *Pediculoides ventricosus,* also a general feeder, has been reported recently.

Control Measures

Older methods of control were based largely on the use of lead arsenate and nicotine. Much emphasis was placed on thoroughness and timeliness. For control of the summer generation feeding under webs on the lower surfaces of the leaves, it was important to spray from beneath in order to obtain contact with nicotine or place the lead arsenate where it would be consumed by the larvae.

Control of the larvae in spring was thought to be best accomplished by delaying applications until prepink or until the larvae began to wander from bud to bud and were more easily reached by the spray.

Recently, emphasis has shifted more and more to the use of the so-called DN dormant sprays which are very effective against the overwintering larvae. To be effective, this spray must be applied before the temperatures rise above 60 degrees or before the larvae leave winter cocoons. In Connecticut the time is relatively short and usually falls between the 15th of March and the first week in April. The butylphenols are regarded as more effective than the dinitro-*o*-cresols or their salts. Dinitrocresol sprays should contain three quarts of the solution or an equivalent of 1.2 pounds per 100 gallons.

Parathion has been demonstrated to be a satisfactory control for the larvae feeding on the undersurfaces during the summer. It is apparently not necessary to spray the undersides with this material because of penetration into the leaf tissue. Knowing the general efficiency of parathion in killing moths of closely related species, it seems probable that part of its effectiveness in controlling the summer generation of bud moth resides in that property. The suggested dose is ¾ to 1 pound of 15 per cent parathion to 100 gallons.

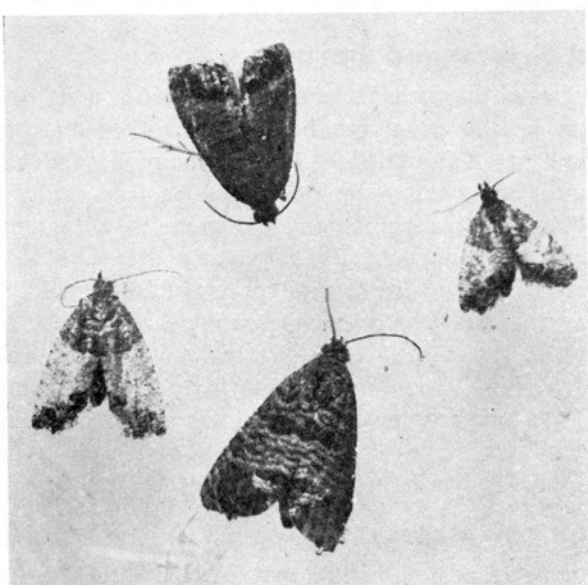

Figure 32. Codling moths and eye-spotted bud moths as they appear in bait pails. Right and left, bud moths; top and bottom, codling moths.

Figure 33. Recently emerged eye-spotted bud moth.

Our most successful treatments with parathion have been made in July.

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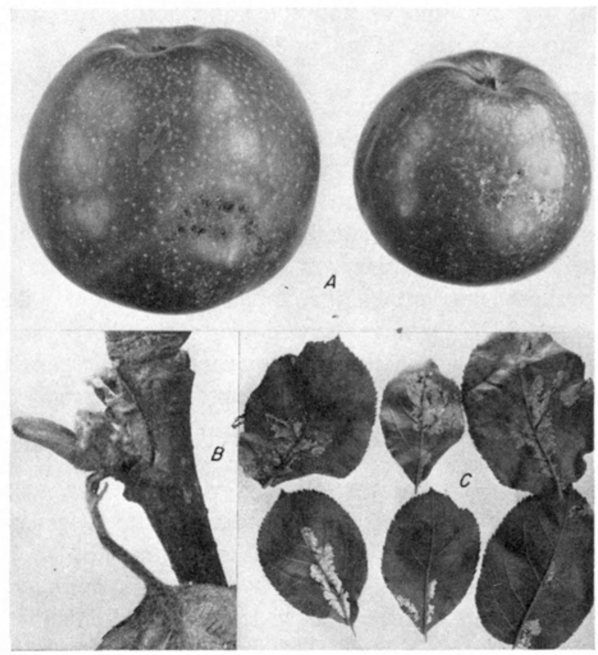

Figure 34. Work of the eye-spotted bud moth. A. Fruit punctures. B. Overwintering cocoon. C. Leaf feeding of the summer generation.

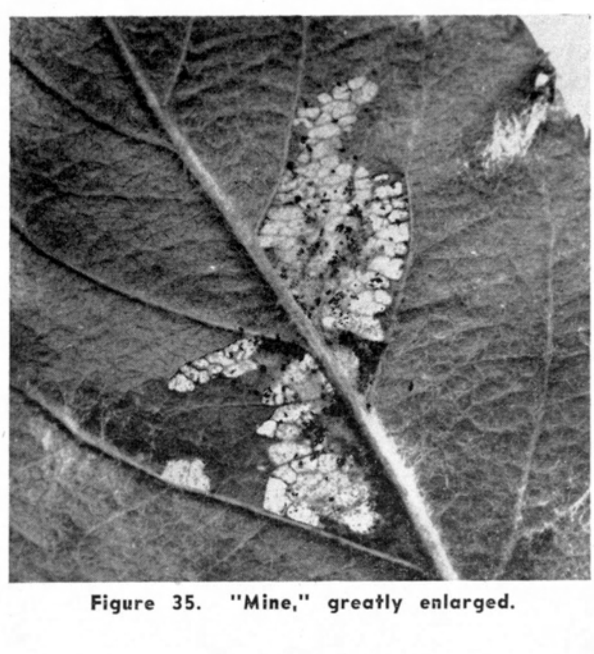

Figure 35. "Mine," greatly enlarged.

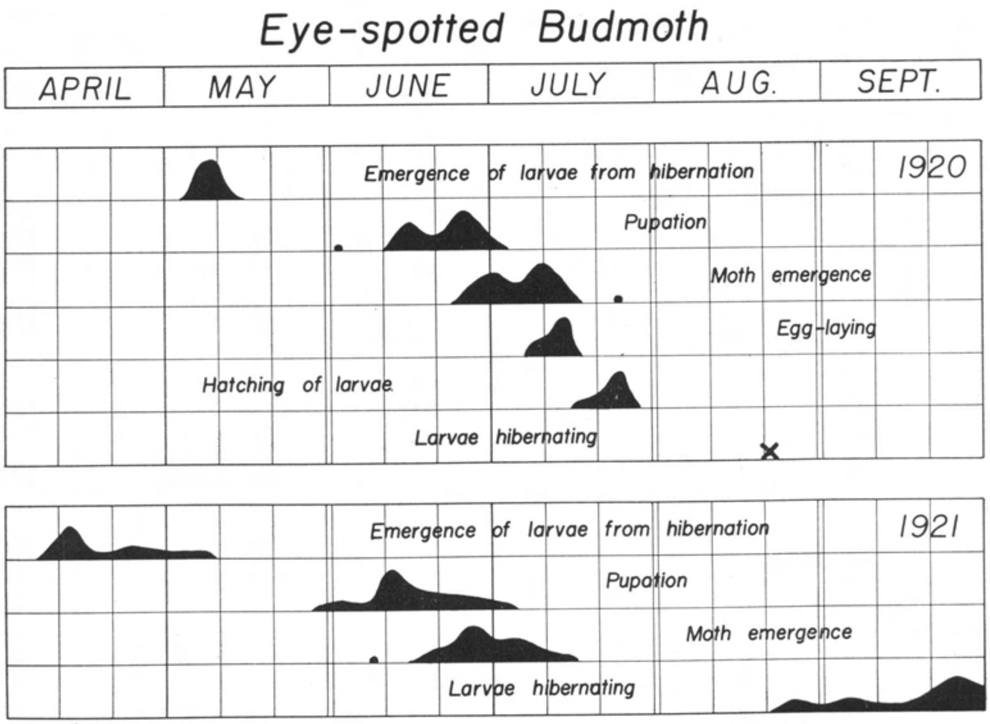

Figure 36. Life history of the eye-spotted bud moth, 1920-1921. Data courtesy B. A. Porter.

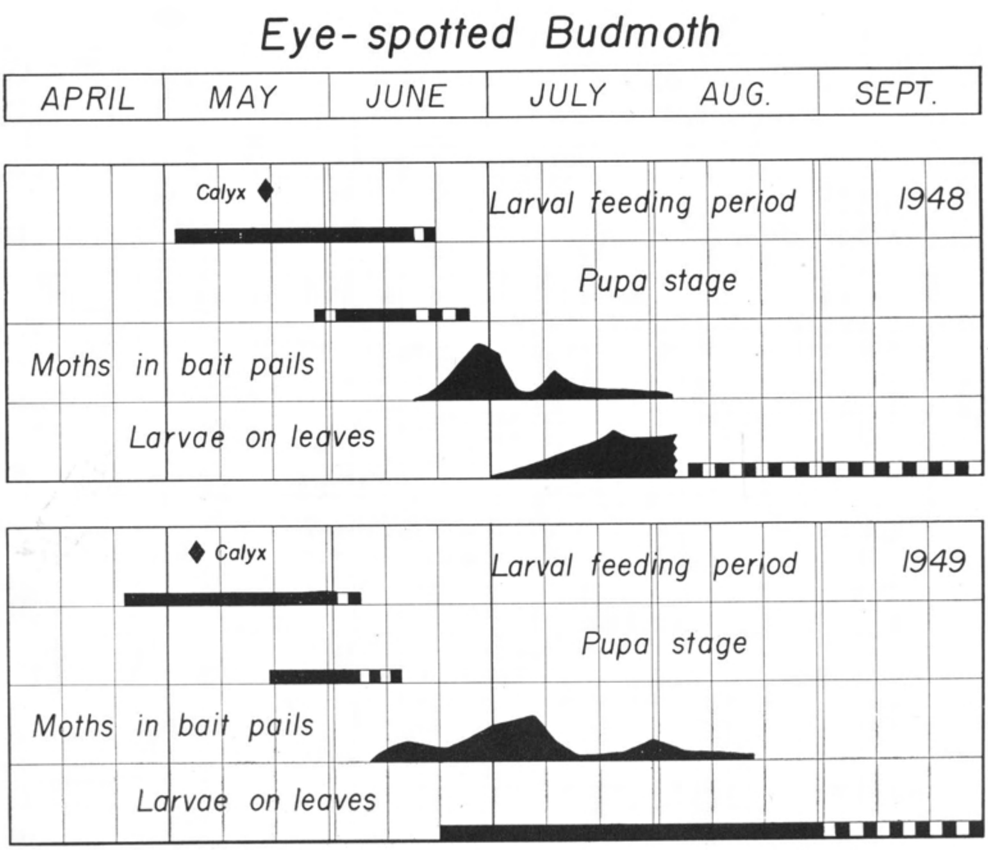

Figure 37. Life history of the eye-spotted bud moth, 1948-1949.

EASTERN TENT CATERPILLAR

Malacosoma americanum (F.)

The moth is brown with a wingspread of 1¼ to 1½ inches, the front wings each with two diagonal white lines. The caterpillar is a medium-sized hairy "worm" with a white mid-dorsal line and white spots along the sides set off by black in front of each one.

Damage

The principal damage results from feeding of caterpillars in early spring. They are gregarious, the colony spinning a conspicuous web in which the larvae remain except when feeding. Leaves may be stripped from a tree if the tents are numerous. There is also another species, the forest tent caterpillar, *Malacosoma disstria* (Hbn.), found occasionally in orchards. It does not spin a web like the eastern tent caterpillar, but the larvae congregate in masses on the bark. Most of the feeding of the tent caterpillars is done at night.

The favorite food of the Eastern tent caterpillar is wild cherry, with apple possibly the second choice.

Life History

There is only one generation a year. Winter is passed in the egg stage, the eggs being deposited in a compact band around small twigs (Figure 38) and cemented in a glassy glue-like substance. They are laid during the last of June or first of July, remain over winter, and hatch the following spring.

Cycles of abundance are very pronounced, probably as a result of natural or biological control. In Connecticut, the tents become conspicuous about every 10 years, varying from 8 to 12.

Factors Affecting Abundance

Extremely damp weather promotes disease among the caterpillars, particularly if they are crowded. Infestations occasionally come to an abrupt end following wet spells with abundant rainfall.

Inasmuch as tent caterpillars feed on many forest and shade trees, the presence of woodlands or favorite tree hosts near orchard areas results in migration into the orchard.

Predators and Parasites

Several egg parasites (Britton, 1935) and a total of 12 primary larval parasites are known. Besides these there are predatory insects, a bacterial disease and birds which feed on the larvae. Complete credit is usually given to the natural enemies of the tent caterpillar for its spectacular decline after a period of abundance.

Control Measures

Removal of the tents by hand is an easy and practical measure if the trees are not too large. Burning with a torch was practiced at one time, but was abandoned in orchards because of tree injury. Collection of the egg masses in heavily infested areas was also advocated, but is not practiced today. Such efforts depended largely on school children. Spraying with lead arsenate as soon as the tents appeared has been used for a long time as a practical control measure.

Tent caterpillars are easily and quickly killed with several of the newer insecticides. Both DDT and parathion are effective. Others will probably do the work equally well. Pre-bloom applications are effective.

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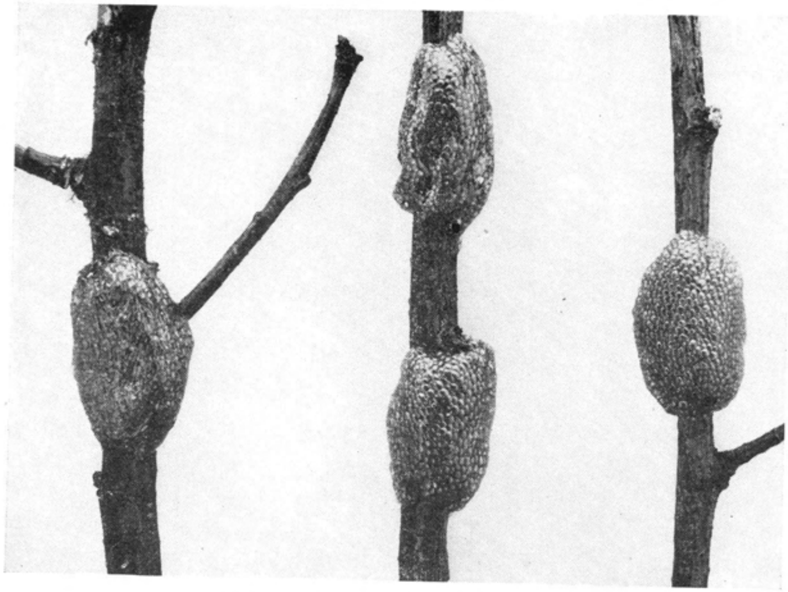

Figure 38. Egg masses of the eastern tent caterpillar.

Figure 39. Tent constructed by the larvae of the eastern tent caterpillar.

JAPANESE BEETLE

Popillia japonica **Newm.**

The larva is a typical white grub which infests lawns and meadows. The beetle is about ½ inch long with bright green body, brown wing covers and a row of white tufts of hair around the abdomen below the wings. It is of common occurrence throughout Connecticut.

Damage

Little or no damage is done to apple trees by the grubs but considerable injury results from feeding of the beetles on leaves or fruit.

Life History

In most areas the beetle requires one full year to complete its life cycle but there is some indication that it lives over a second year under some conditions. The winter is spent as a curled larva or grub in the soil, pupation takes place in late spring and the beetles emerge during June and July (Figure 42). Peak emergence is usually reached in central Connecticut shortly after the first of August but there is frequently a secondary peak about September 1. Eggs are laid soon after emergence; peak egg laying occurs about August 1.

There has been no evidence as yet of any tendency towards cycles of abundance.

Factors Affecting Abundance

About the only condition which seems to check abundance is drought during the egg-laying period, since dry soil at that time apparently prevents the larvae from developing. Severe cold during the winter does not usually affect the larvae in the soil, especially if there is a blanket of snow.

Nearness of apple or fruit trees to meadow or large turf areas is a distinct menace. Grass cover crops within orchards themselves are not especially important since the soil is usually sufficiently poisoned from sprays to kill the grubs feeding therein.

Predators and Parasites

Many parasites and natural enemies have been introduced from Japan and elsewhere. At present the most important insect parasites are probably *Tiphia vernalis, Tiphia popilliavora* and *Centeter cinerea.* The first two of these are digger wasps which enter the ground and prey upon Japanese beetle grubs in the soil. These wasps have become established in Connecticut and are doing much good. Another rather spectacular parasite is the fly, Centeter, which lays its eggs on the beetle's thorax. When the egg hatches, the fly larva bores through the thoracic shield and kills the beetle, usually before it can lay eggs.

Besides insect parasites, there is the disease known as "milky disease" because of the milky condition of the insect's blood when infected. The causal bacillus, known as *Bacillus popilliae* Dutky, has been distributed extensively in Connecticut. Where the soil is warm enough this disease is effective, but for the most part it does not seem to operate at top efficiency in Connecticut. It gives better control farther south.

Skunks, moles, blackbirds, starlings and crows feed extensively on the grubs in the soil. Probably other animals and birds could be added to this list.

In addition, the nematode parasite, *Neoplectana glaseri,* has been studied extensively in New Jersey where it is thought to be of considerable benefit.

Control Measures

Standard arsenate of lead as ordinarily used in the orchard will control Japanese beetles sufficiently to prevent damage. July or early August sprays for apple maggots usually give enough protection. Lead arsenate was formerly also applied to the soil of infested areas, but has now been largely replaced by more effective materials.

Baits containing geraniol or an allied chemical were widely used at one time and there has been considerable effort to develop satisfactory traps for their use. The method, while successful in catching beetles, did not give complete control of the insect.

Of the newer insecticides, DDT, 2 pounds to 100 gallons, and methoxychlor, 3 pounds to 100 gallons, should be mentioned as giving excellent control of the beetles. Several chlorinated compounds, such as chlordane and DDT, applied to the soil for grub control, give relief at very low doses (200 pounds 5 per cent dust to the acre). For late sprays on trees where there is danger of undesirable residues at harvest, methoxychlor is preferable to DDT or lead arsenate because of its low poison hazard.

Japanese Beetle

Parathion and related compounds, while effective killing agents, do not control the beetle efficiently because of their short residual life. Beetles may migrate in soon after treatment and start feeding again. On the other hand, the phosphates are useful as emergency sprays for quick reduction of heavy beetle populations, without danger of objectionable residues at harvest.

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Figure 40. Apple leaves partially skeletonized by Japanese beetles. Natural size. (After Bureau of Entomology and Plant Quarantine, U. S. Dept. of Agriculture.)

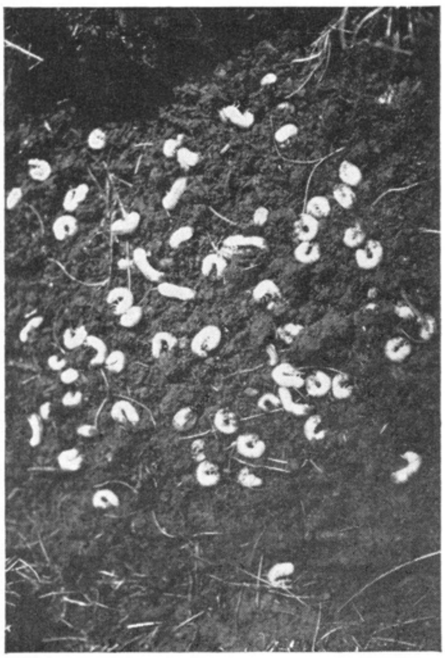

Figure 41. Larvae of the Japanese beetle. In the badly-infested turf area where the picture was taken, there were 585 grubs per square yard.

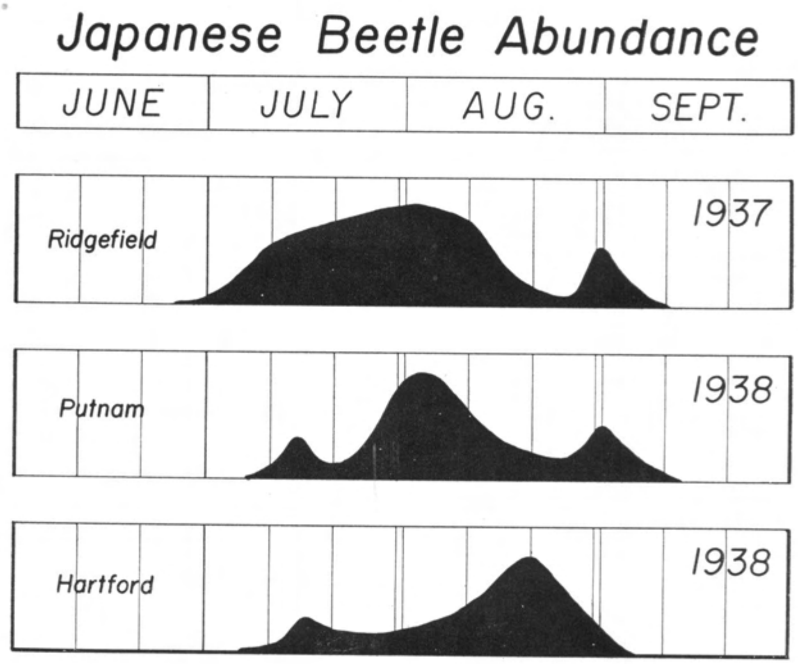

Figure 42. Chart of Japanese beetle abundance in Connecticut, determined from bait pail records.

WHITE APPLE LEAFHOPPER

Typhlocyba pomaria McA.

Several species have been confused, but the white apple leafhopper is most abundant in Connecticut. The nymphs are small, greenish insects that stick close to the undersurface of the leaves. When they are numerous, the leaf becomes mottled or sometimes completely gray in appearance. The adults fly readily and may annoy pickers by getting into eyes, ears or throat.

Damage

The damage consists of removal of chlorophyll by the nymphs and adults, preventing proper functioning of the leaves. Spotting of the fruit at harvest by the second generation is important and the fruit often drops too early when trees are heavily infested. The worst damage appears to be caused by interference with photosynthesis, which produces a low quality apple, and premature drop.

Life History

Winter is passed in the egg stage just underneath the bark of smaller branches, and the young nymphs hatch at or near the pink stage of most varieties. Adults begin to appear about the first of June, mate during the latter part of that month, and begin laying eggs in the midribs of the leaves or in the larger veins about the first of July. The second generation nymphs begin to appear on the leaves in early August but reach their peak of abundance about the first of September. Adults are most numerous during the latter part of September and the first of October, in the height of the harvest season (Figure 43).

The insect appears to have periods of increased abundance at irregular intervals, presumably due to natural causes rather than changes in control measures. Weather plays an important role and the insect is more troublesome in warm dry periods than in cool wet ones. The periods of abundance in Connecticut appear to have varied from three or four years to ten. In some localities infestations are reported to be serious every year, but this has not generally been the case in Connecticut.

Factors Affecting Abundance

As already stated, the principal climatic conditions promoting leafhopper abundance are dry, warm periods. Heavy rains near harvest wash the fruit free of specking left by leafhoppers, and during mid-summer may depress the population. Cold survival limits are not known.

Trees with low-hanging branches afford conditions where adults congregate in hot, dry weather, for while they thrive in dry weather, they are apt to seek humid conditions close to vegetation. Dense trees that cannot be sprayed thoroughly favor reproduction and prevent reduction of hopper populations through the action of insecticides.

Predators and Parasites

The egg is parasitized by *Anagrus armatus* Ash., and the adult by *Aphelopus sp.* There are a number of predatory bugs that feed on the nymph, and certain diseases have been recorded. Natural controls are so effective in Connecticut that unsprayed trees rarely have a serious outbreak. So far, however, we have not become aware of increases in hopper populations due to destruction of natural enemies by insecticides.

Control Measures

No dormant sprays were known that were effective against the white apple leafhopper, hence the main reliance was on summer sprays of nicotine sulfate. The customary dilution was 1 pint of 40 per cent nicotine sulfate in 100 gallons for heavy infestations, and ½ pint for light infestations. Applications were required from May 25 to June 7 for the first generation nymphs and August 25 to September 7 for the second. No recommendations were generally made for the adult hopper, and no sprays were advised for nymphs unless the population reached one per leaf in June or two per leaf in late August or early September.

Both DDT, 2 pounds 50 per cent to 100 gallons, and parathion, ½ pound 15 per cent to 100 gallons, are so effective against the nymph and adult that the insect is now much less of a problem than formerly. Likewise, accurate timing is not so necessary with the new insecticides because they control both nymphs and adults. It is not uncommon today to find the insect practically eliminated in commercial orchards by DDT sprays in late June and July, and it appears possible to kill enough to prevent development of the second generation at harvest. Leafhoppers apparently pick up DDT

White Apple Leafhopper

from leaf surfaces so that it is not necessary to obtain actual contact when spraying. It is, of course, advisable to include a miticide in mid-summer applications of DDT. Other chlorinated compounds similar to DDT have not been sufficiently tested against the white apple leafhopper to deserve comment. DN-111 has been found by Cox and others to be very effective against the nymphs. Since it is also a miticide, it would have decided advantages wherever it can be used successfully. In our experiments, however, DDT was much more effective against the hopper. (See combination used against the Japanese leafhopper.)

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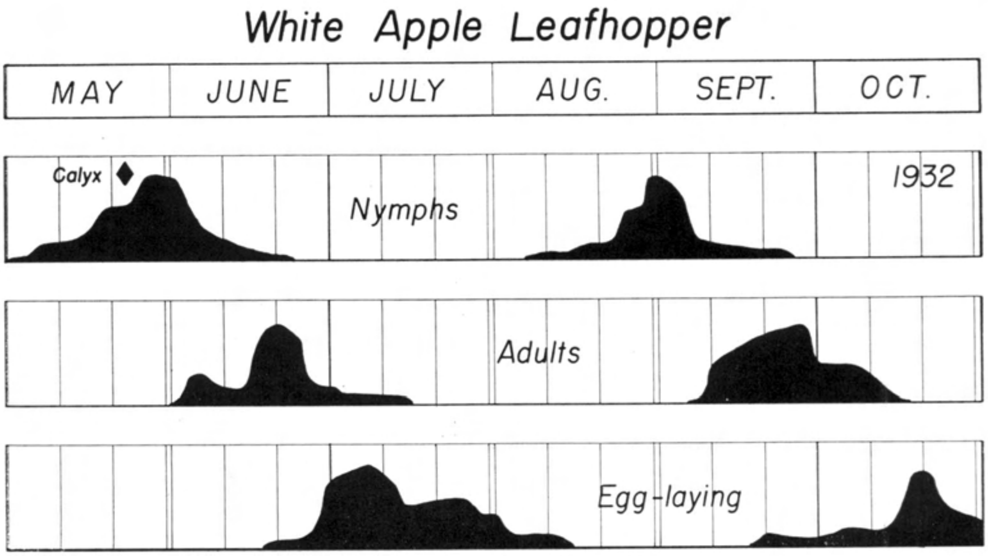

Figure 43. Life history of the white apple leaf hopper.

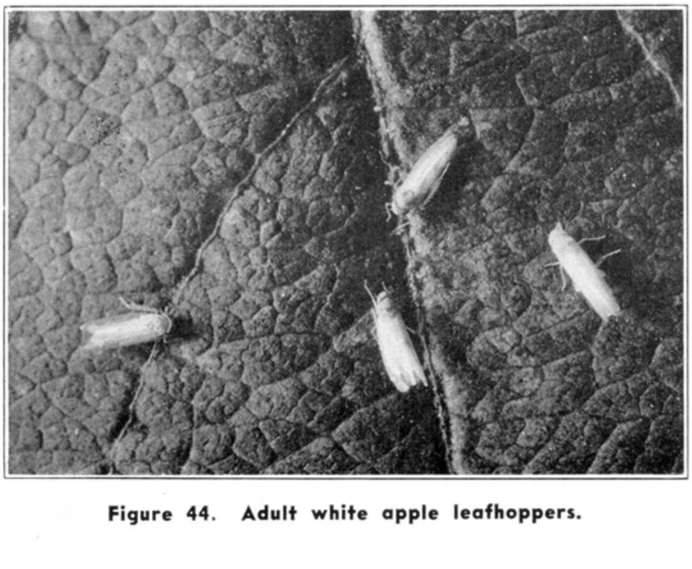

Figure 44. Adult white apple leafhoppers.

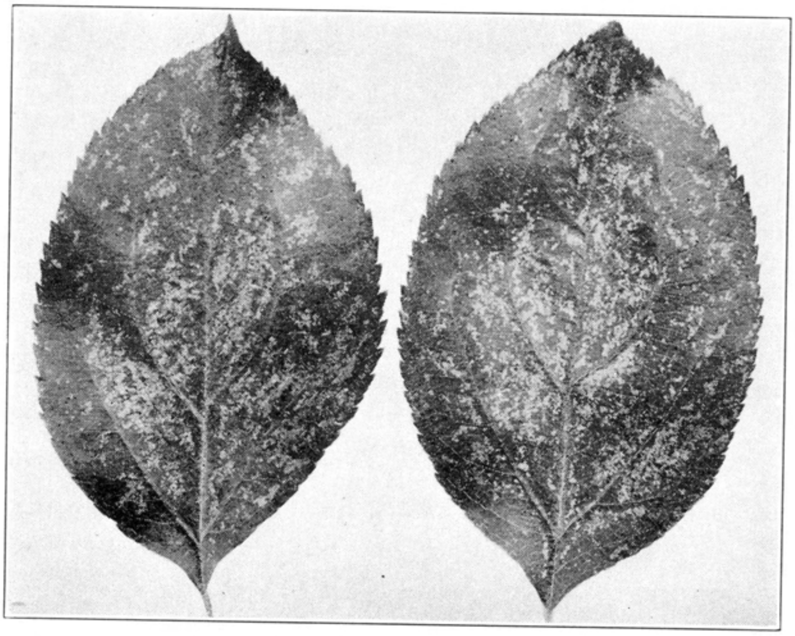

Figure 45. Apple leaves spotted as a result of leafhopper feeding.

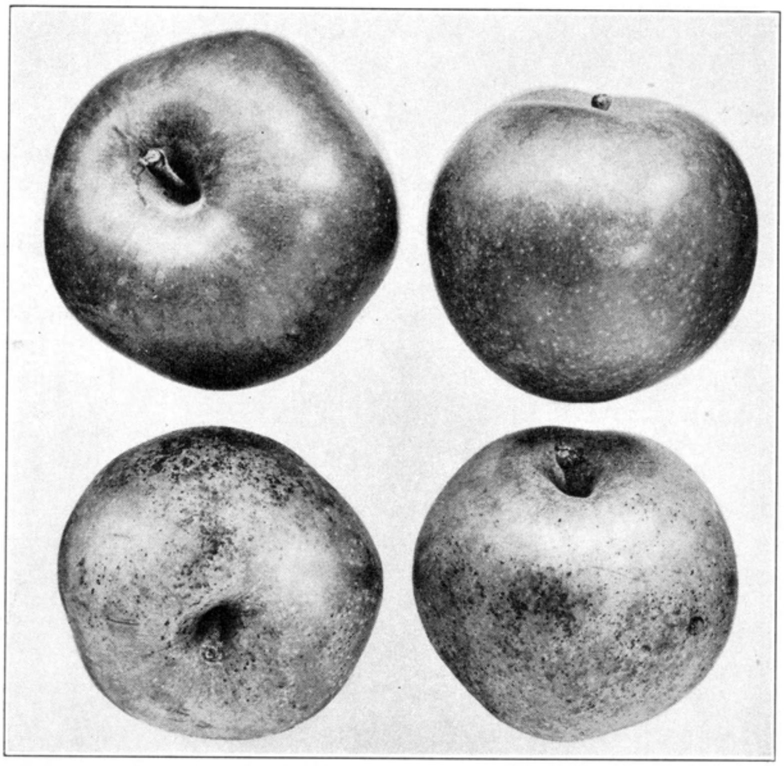

Figure 46. Spotting of fruit by the white apple leafhopper. Upper apples free.

JAPANESE LEAFHOPPER

Orientus ishidae (Matsumura)

An introduced pest first reported in 1919, the Japanese leafhopper is now well distributed over the northeastern fruit districts. It was first recognized in Connecticut in 1948.

In general appearance the adult hopper is dark gray but on closer inspection the wings are seen to be milky with brownish veins. It is 5 to 6 mm. in length (about 1/5 in.) and much larger than the more common white apple leafhopper. The legs are black except for the tarsi which are white with a dark median band. The nymphs are brown with white spots and have the habit of turning up the tail end as they walk over the leaf.

Damage

Early damage consists of a yellowing of leaves where young nymphs first congregate, especially on water sprouts in the center or base of the tree. Subsequent damage appears on the outside branches near the ground and later may be well distributed over the tree. A triangular area or sector of the leaf is usually killed (Figure 48). When the damage is extensive, general weakening of the tree results, a condition which may indirectly affect the fruit.

Life History

Presumably the insect passes the winter in the egg stage, somewhere near the base of the trunk either in coarse bark or in water sprouts near the ground. In some years hatching begins by May 21, in others not until June; it may continue for two or three weeks after the start. Nymphs are present until the last of July or first part of August. Adults appear the last of June or first of July. They may live well into September (Figure 47).

There is no information on cycles of abundance, if any.

Factors Affecting Abundance

Adults fly actively on warm, quiet days, are quiet in cool weather. They also seem to be active on very hot days. Extremely hot, dry weather as occurred in 1949 may shorten the life span of the insect.

Since the first nymphs to emerge seek out water sprouts at the base or center of the tree, it may be assumed that abundance of sprouts may aid the insect in getting a foothold. Trees with heavy canopies of foliage appear to have smaller populations than those which have been well pruned and where the canopy is thinner.

Predators and Parasites

Very little is known at present about natural enemies. Spiders and ants, however, have been observed to destroy Japanese leafhoppers on occasion.

Control Measures

Because the insect gets its start in life on water sprouts, it can be reasoned that removal of the sprouts before migration to other parts of the tree takes place is a logical procedure. This has been done in at least one orchard with some success.

Both nymphs and adults are killed by sprays of DDT or parathion. The latter kills at a very low dose. By giving special attention to water sprouts and low-hanging branches, very good control may be secured without spraying the whole tree. One of our best combinations in 1949 consisted of 50 per cent DDT and 50 per cent DDD, 1½ pounds each, plus 15 per cent Aramite, ½ pound in 100 gallons, applied July 6.

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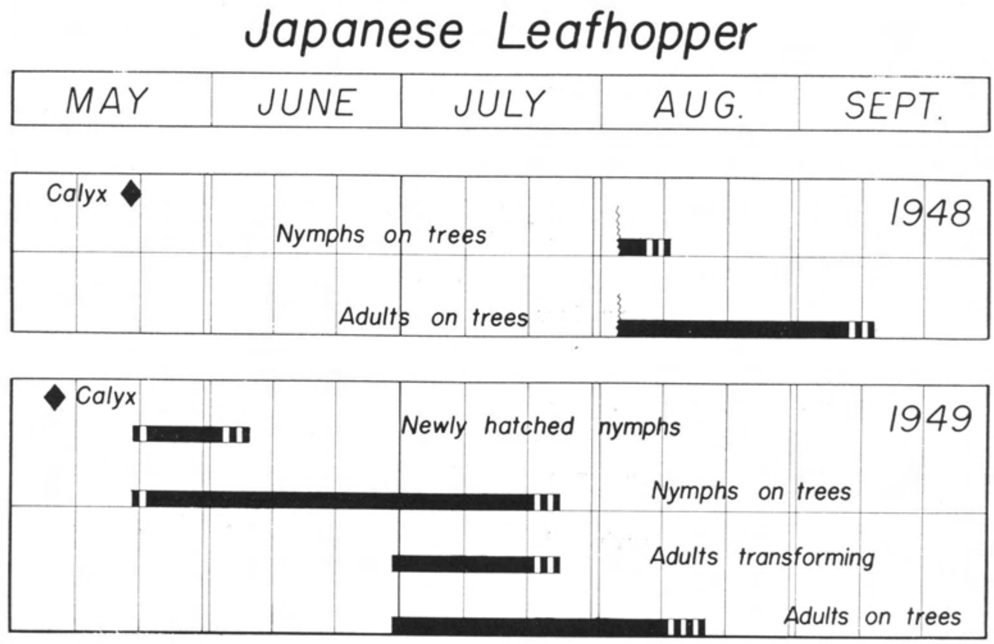

Figure 47. Life history chart of the Japanese leafhopper determined from Connecticut records.

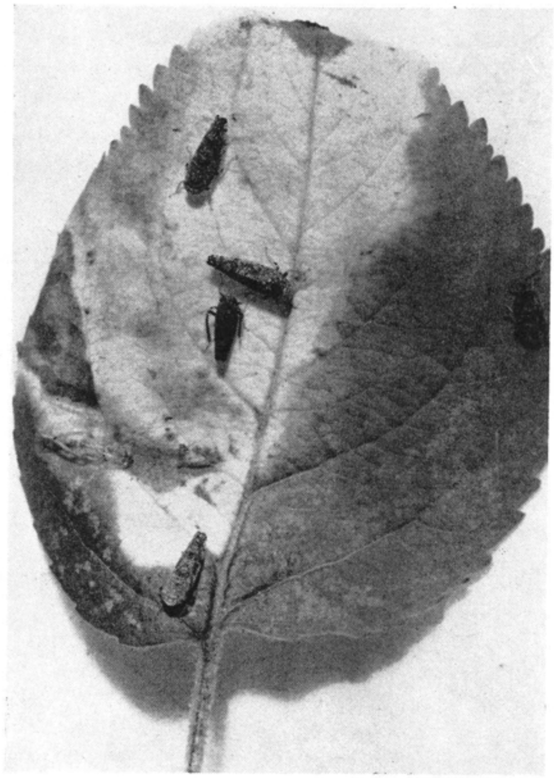

Figure 48. The Japanese leafhopper and the effect of its feeding on an apple leaf.

POTATO LEAFHOPPER

Empoasca fabae **(Harr.)**

This pest is similar to the white apple leafhopper but both nymphs and adults have a greenish tint.

Damage

Occasionally abundant in Connecticut, this insect does little actual damage. The main effect of its attack consists of curled and distorted leaves on terminal growth. The injury is somewhat similar to that of the apple leaf-curling midge, but the leaves are not rolled as tightly. In color the adult hopper is pale green in contrast to the white apple leafhopper (which is white or pale yellow) and the Japanese leafhopper which is gray.

The potato leafhopper winters in the adult stage, but probably perishes for the most part except when the winters are mild. Whenever the insect is eliminated by climatic conditions, reinfestations take place through migrations from farther south.

Control measures are the same as for the white apple leafhopper.

Altogether, there are 13 species of leafhopper known to attack apple, but not all are reported from Connecticut. No attempt will be made here to discuss the different forms. If the reader is interested, he should refer to DeLong's paper in Journal of Economic Entomology 24:1214-1222. 1931.

SPOTTED TENTIFORM LEAF MINER

Lithocolletis sp.[1]

The moth is a minute delicate insect with spotted wings measuring 1/5 inch from tip to tip.

Damage

Damage consists entirely of mining of the leaves, which upsets the normal functions to the extent the leaf is mined. Combinations of drought and excessive mining have been reported from time to time as particularly destructive. The mine, when complete, buckles the leaf like a small tent—hence the name of the pest.

The miner is known to infest apple, quince, plum, wild cherry, wild haw and sweet-scented crab.

Life History

There are three generations in Connecticut. The insect overwinters as a pupa within the mine in fallen leaves. Moths emerge about May 5 to 22, with the peak from May 8 to 12 (1950). They have been found in orchards just before bloom. The first generation completes its development by the first of July and moths may be found again during July. Mines begin to appear again in July (on July 21 in 1950) and the larvae and mines are present throughout August. The third generation larvae appear again in the leaves by September 15; the larvae complete their development by the last of October and begin to pupate, ready for hibernation.

The insect appears to be very irregular in occurrence, but a bad period occurred in Connecticut and Massachusetts from 1943 to 1946. When an outbreak occurs, other species of miners may also be involved.

Factors Affecting Abundance

Not much is known about weather or other conditions favoring abundance.

Predators and Parasites

A number of parasites have been found in Connecticut but these have not yet been identified.

Control Measures

Not many entomologists writing on apple insect control in the past have been willing to admit enough damage on the part of leaf miners to justify control measures. However, we do find mention of such controls as sprays of kerosene emulsion and nicotine sulfate, or clean cultivation to destroy the overwintering pupae in the leaves.

Among the newer chemicals, sprays of parathion or DDT appear to have been effective in Connecticut orchards.

Life history studies suggest that the best time for control is (1) during pre-bloom periods with TEPP, etc., or (2) during mid-summer with parathion.

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[1] *blancardella* of some authors.

OTHER LEAF MINERS

There are several other species of miner which may be found on apples, none of which deserves more than brief comment. A serpentine leaf miner is frequently seen, both on the bark and fruit, but does little actual damage.

UNSPOTTED TENTIFORM LEAF MINER

Callisto geminatella **Packard**

Moths of this species are steel gray, the larvae greenish gray and about the same size as the spotted tentiform miner.

Damage is about the same as that of the spotted tentiform leaf miner, and plants infested are apple, pear, crab apple, haw, plum and wild cherry.

Life History

Hibernation takes place in the pupa stage in the folded edges of the leaf. The unspotted tentiform leaf miner differs in this respect from the spotted leaf miner which pupates within the mine.

Controls are the same as for the spotted leaf miner.

Reference

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TRUMPET LEAF MINER

Tischeria malifoliella **Clem.**

The damage is about the same as that produced by the two previous species, but the mine is gradually enlarged at the tip as the insect grows so that it eventually assumes the shape of a trumpet. The host plants are apple (preferred), blackberry, raspberry and haw.

Life History

The trumpet leaf miner overwinters as a caterpillar within the mine. Adults appear in May, and again about the first of August. The second generation larvae mature about September 1 and the final generation hibernates as a larva.

Controls consist of destruction of overwintering forms by cultivation, or other methods as given for the spotted leaf miner.

Reference

Jarvis, C. D. The apple leaf miner, a new pest of the apple. Storrs Agr. Exp. Sta. Bul. 45. 1906.

RED-BANDED LEAF ROLLER

Argyrotaenia velutinana (Wlkr.)

Several related species have occasionally been associated with this one. The larva is green with a brown head. The skeletonized area is clean as compared with that of the bud moth which is dirty (Figure 34C).

Damage

The red-banded leaf roller is widely distributed in the Northeast causing light to severe fruit damage whenever it becomes abundant. Young larvae skeletonize the leaf, working on the lower surface, and thence move to apples, continuing into the harvest season. Larvae may be found on the apples even in storage. Removal of the skin in feeding (Figure 52) creates entrance points for disease, thereby increasing danger of rots of various kinds. The maximum percentage of injury in Connecticut on record is about 36 per cent, but the percentage reported from other apple-growing districts has been even higher.

The red-banded leaf roller has a wide variety of host plants, including forest trees, ornamentals, fruit trees, small fruits, truck crops and weeds. As an apple pest, it began to be noticed about 1920, as indicated in Connecticut and Pennsylvania reports. Infestations have subsequently become more serious.

There is no apparent explanation for the gradual rise of this insect as an orchard pest in the 1920's. Neither is there any apparent explanation for greater abundance in New York and other states as compared with Connecticut.

Life History

The red-banded leaf roller hibernates as a pupa in trash on the ground. Moths emerge soon after apple buds break and are most abundant when the buds are pink. The preoviposition period is only a few days and eggs of the first generation are laid on the smooth bark of twigs and branches. Incubation may require up to four weeks, reduced for the second generation to about 10 days. Larvae of the first generation begin to feed, usually on water sprouts in the center of the trees, about the middle of the blooming period. Larvae and pupae are present until the last of June. Moths of the second generation are present until about the middle of July, eggs from the first week to last week of that month, laid this time on the leaves (Figure 53). Larvae of the second generation begin to appear again about the middle of July and continue on the trees until harvest as indicated. See Figure 54 for comparison with the bud moth and fruit tree leaf roller. Definite cycles of abundance occur, the peak usually lasting two years or so. We have had at least one outbreak in each decade since 1920.

Factors Affecting Abundance

Infestations, including influx of second brood moths, have come from surrounding areas in some cases. This is natural because of the rather wide variety of host plants. Experiments conducted in New York in 1947 showed that infestations were heavier near woods (Harman, 1948; Chapman and Glass, 1949; Steiner *et al.*, 1948). If pruning is neglected and the trees are allowed to become too thick, adequate spray coverage may be difficult and the degree of control may be reduced. Water sprouts in centers of trees are favorite breeding places for the first brood (see references).

Predators and Parasites

There are many natural enemies of great importance in connection with red-banded leaf roller abundance. Action of these natural enemies within the reservoir of leaf rollers outside the orchard may easily explain the rise and fall of the pest within the orchard.

Control Measures

Arsenate of lead (3 pounds to 100 gallons) has provided the standard control for this insect for a long time. Controls have apparently become more difficult with the introduction of modern machinery which, except for mist blowers or other air blast machines, does not provide under-leaf cover equal to older outfits. DDT definitely does *not* provide satisfactory control. It is thought to destroy too many natural enemies without sufficient mortality of the insect itself. However, the exact reasons remain somewhat obscure. DDD, the dichloroethane analog, is much better and has provided good control where tried.

Control is possibly affected by larval habits. Thus, Steiner *et al.* (1948) mentioned the habit of the larvae, when disturbed, of seeking new terminal foliage. This was cited as a control factor in the early season when foliage is rapidly outgrowing the insecticide coverage. In the second brood, when there is little new terminal growth, the control with arsenate of lead is better, provided that the underparts of the leaves have been thoroughly covered. This may be a partial explanation of the better control obtained in New York State (Chapman and Glass, 1949) with DDT in the first brood and arsenate of lead in the second. In our own experiments we have had no difficulty wherever "efficiency mixes" have been used. As with other insecticides, however, the more cover on the undersurfaces of the leaves the better.

In general, control secured with arsenate of lead in tank-sprayed orchards has been remarkably good wherever pruning was adequate and the spray could penetrate to all parts of the trees. (See table at right.)

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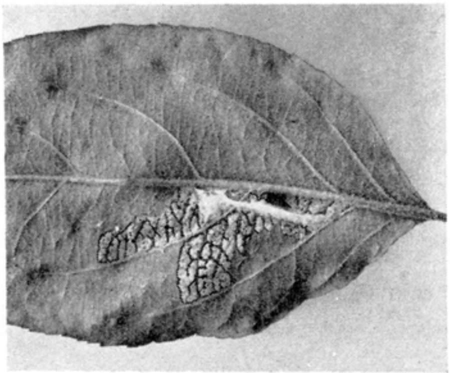
RED-BANDED LEAF ROLLER CONTROL—1948

Treatment	Per cent injured
Mt. Carmel - Variety Baldwin	
Lead arsenate and sulfur	.5
Parathion and sulfur	8.4
Chlordane, DDT and sulfur	16.7
Wallingford - Variety Greening	
Lead arsenate, fermate	3.3
Chlordane, DDT, fermate	10.3
Benzene hexachloride, DDT, fermate	36.0

NOTE: Materials given were used throughout the season at the customary dilution in a regular spray schedule.



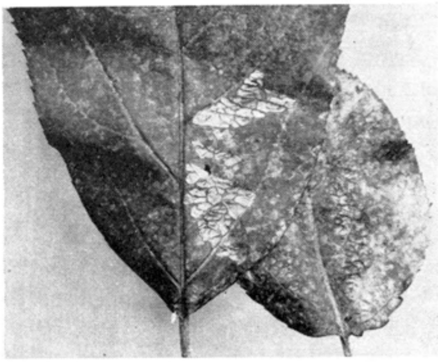


Figure 49. Feeding and pupa of the red-banded leaf roller (left). Appearance of the leaf fed upon from above (right).

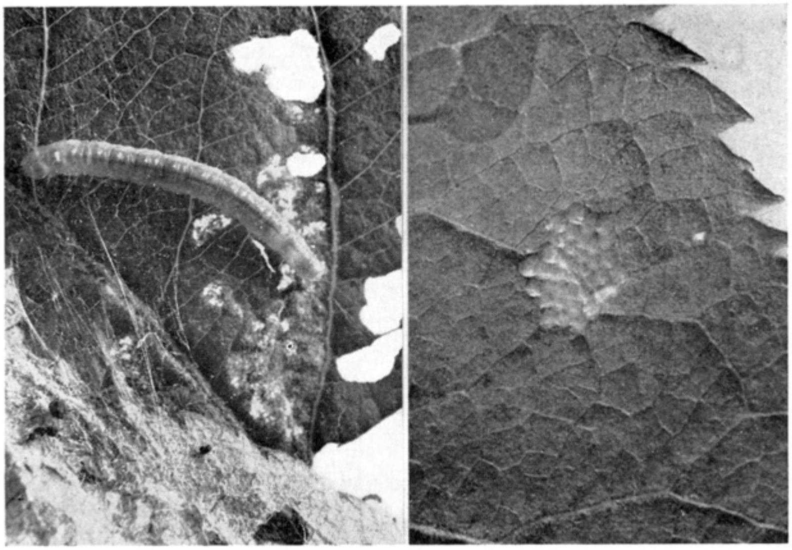


Figure 50. Larva of the red-banded leaf roller (left); egg mass on underside of a leaf (right).

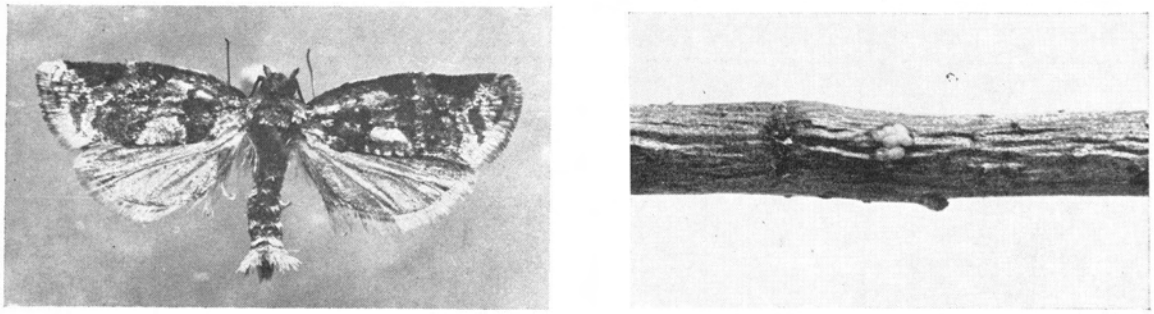


Figure 51. Adult moth of the red-banded leaf roller (left), egg mass (right).

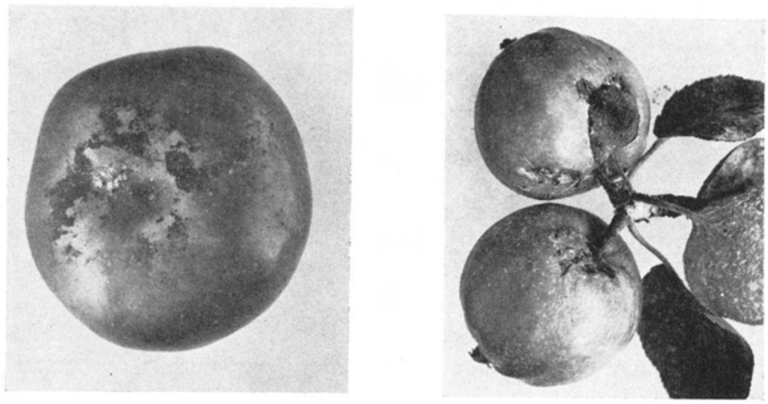


Figure 52. Feeding of the red-banded leaf roller on mature apple (left) and half-grown fruit (right).

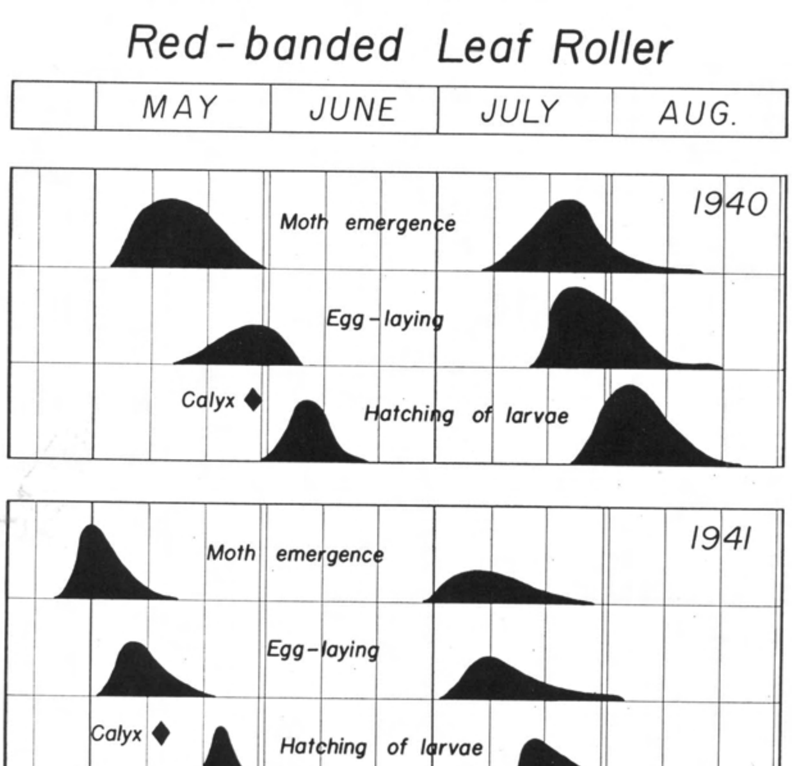


Figure 53. Life history of the red-banded leaf roller in Connecticut.

FRUIT TREE LEAF ROLLER

Archips argyrospila (Wlkr.)

The larva of this insect is a green worm with a black head. Egg masses are laid on the branches and smaller twigs and turn white during the winter.

Damage

After hatching, the larva bores into buds where it remains protected from sprays until it gets old enough to wander from bud to bud or fruit to fruit. The most important damage results from feeding on the fruit.

The fruit tree leaf roller infests apples, pears and other fruits, doing much damage when abundant.

Life History

Hibernation takes place in the egg stage; hatching occurs between the green tip and pink stages, requiring 10 to 12 days to complete. Caterpillars from a single egg mass all hatch at about the same time. The larval stage lasts about one month, the pupal stage begins (in New York) the first half of June. Moths emerge the latter half of June, and throughout July or even into August. Eggs are laid within a few days after emergence and this activity begins the middle of June, the greatest numbers being laid the last of June and first of July. (See Figure 54 for comparison with red-banded leaf roller and bud moth.)

There is little evidence of regular cycles although, if carefully studied, some definite patterns might emerge. Over a period of years, the history of important outbreaks has been somewhat as follows: First, there is a period of relative inactivity on the part of the leaf roller which may continue indefinitely. Damage in such years is probably less than 5 per cent. Secondly, there is a period of rapidly increasing injury covering three or four years during which the actual damage may reach well above 50 per cent of the crop. Finally, there appears a period of declining importance lasting two or three years after which the pest resumes its original status.

Harman (1928) says "The insect may appear suddenly in alarming numbers within a limited area. A grower may lose over 50 per cent of his crop while his neighbor will be unmolested. In general, the damage does not diminish until the applications are made under conditions that will insure more efficient results."

An outbreak in the Midwest from 1938 to 1942 appeared to be initiated in woodlands, and caused infestations in orchards requiring more than usual thoroughness in sprays. The widespread outbreaks in nearby woodlands were evidently dominant factors, providing alternate hosts for the insect.

While the heavy infestations in New York and Connecticut have appeared to be local, it is quite possible that they occurred in periods of greater than normal populations in nearby woodlands.

Factors Affecting Abundance

Weather apparently has little effect on the fruit leaf roller, though Haseman noted that Missouri outbreaks followed droughts.

As stated above, woodlands near apple orchards are a dominant factor. Pruning is important since well-pruned orchards are more easily sprayed and can be be more thoroughly covered.

Predators and Parasites

Many parasites have been reared from the fruit tree leaf roller. The most important or active is *Trichogrammatonyia tortricis*.

The combined effect of parasites has been reported by some authors to have been insufficient to control the fruit tree leaf roller, while others say "with the fruit tree leaf roller as with other insect scourges, forces entirely beyond man's control have much to do with making and eventually breaking such scourges."

Control Measures

The egg masses can be killed with dormant oil applications. Ordinarily, 2 or 3 per cent emulsions are not sufficiently strong. The recommendations called for in older publications included 6 per cent oil at the green tip or delayed dormant period. Chapman and Dean in 1935 found that lead arsenate would kill newly hatched larvae readily, if adequate coverage was maintained throughout the hatching period. The coverage and probably persistence was found to be better where summer oils were included.

DDT in the early (pre-bloom to first cover) sprays has been reported helpful. Doubtless other chlorinated insecticides will be found to destroy the fruit tree leaf roller larvae. Also, it may be found that parathion applied during the summer when the moths are in flight will reduce their numbers substantially.

Dinitro dormant sprays apparently have little effect on the egg masses.

Fruit Tree Leaf Roller

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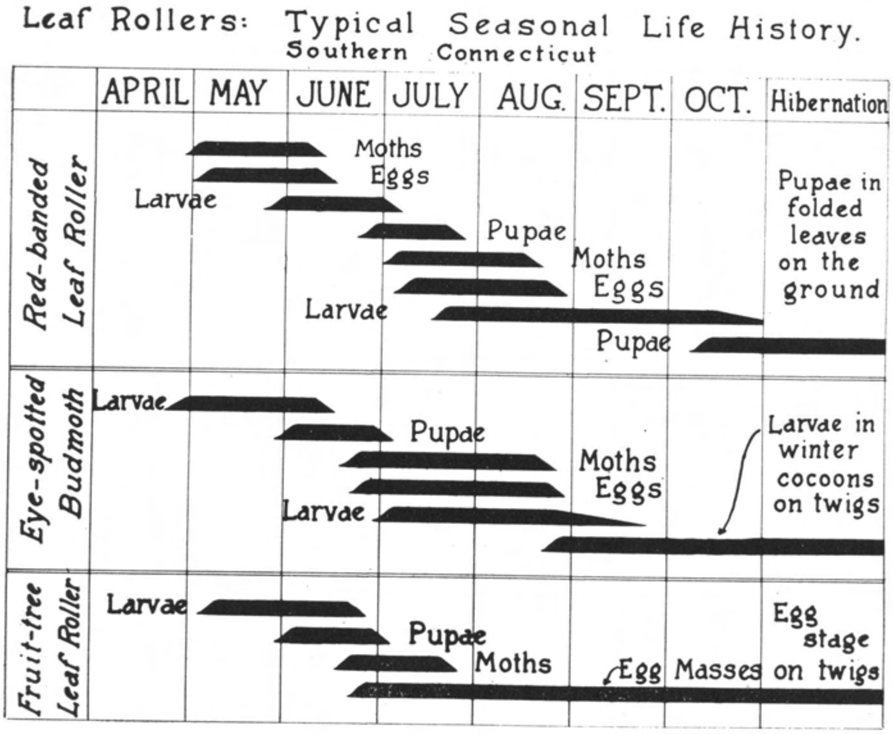
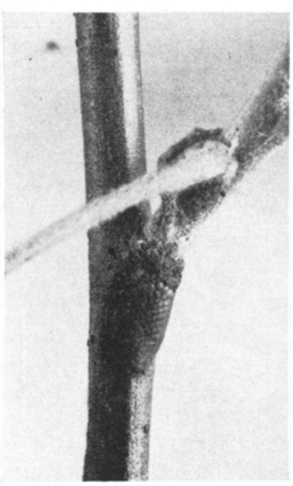


Figure 54. Seasonal life histories of the red-banded leaf roller, the eye-spotted bud moth and the fruit tree leaf roller.



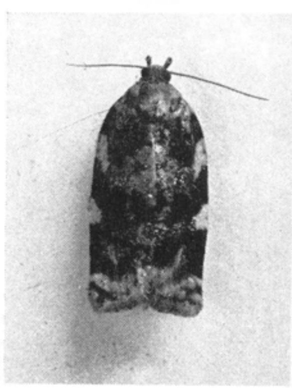


Figure 55. The fruit tree leaf roller. Left, overwintering egg mass newly deposited. In late spring the egg mass becomes almost white. Right, adult moth.

APPLE RED BUG

Lygidea mendax **Reuter**

These are bright red bugs about ¼ inch long when mature. They are very active and the adults fly readily from tree to tree.

Damage

Leaves of apple trees are spotted and puckered and the fruit itself becomes pitted and deformed as a result of punctures. Two species were formerly thought to be involved but now only one, *Lygidea mendax* Reuter, is considered important. The leaf damage is relatively unimportant except as an indicator of the bug's presence, but the fruit injury may be severe. Variation in fruit damage from 0 to 46 per cent has been observed; it may go as high as 75 per cent.

Host plants are apple and wild crab. Nearly all varieties of apples are affected, Rome Beauty and Red Delicious perhaps least.

Life History

The insect overwinters in the egg stage in lenticels of the bark on smaller branches and water sprouts. They are usually laid in pairs, the tips just showing at the surface. Hatching takes place in the early pink stage and is complete before McIntosh bloom. Young nymphs puncture young tips when the leaves are about 1 inch long. Third or fourth instar nymphs feed on the fruit as soon as it gets to be about ¼ inch in diameter. The adult stage is reached in June. When the season is late, it may be late June before the adults appear. Eggs are laid beginning about 10 days after emergence and may continue until mid-July or later. Adults are not seen after July. The adult flight is strong but usually only from tree to tree. The nymphs, when disturbed, dodge around a leaf or twig so they are rarely seen. Foci of infestations are apt to remain in one place year after year.

No regular cycles of abundance occur but marked variations have been noted from year to year; sometimes declines are rather abrupt.

Factors Affecting Abundance

There is little or no information on the effects of weather, temperature or humidity. Also, no low temperature limits are available.

Thick, unpruned trees full of sucker growth offer ideal conditions for this insect.

Predators and Parasites

Few natural enemies are known, although the abrupt declines noted from year to year indicate that there may be strong natural controls about which we have little knowledge.

Control Measures

Dormant or delayed dormant oils were formerly employed against the egg, and nicotine sulfate against the nymphs and adults. Pyrethrum sprays and dusts have been used.

Of the newer chemicals, DDT and parathion appear to be effective. Summer applications are best timed for the calyx spray since it is easier to get a good clean-up then than later.

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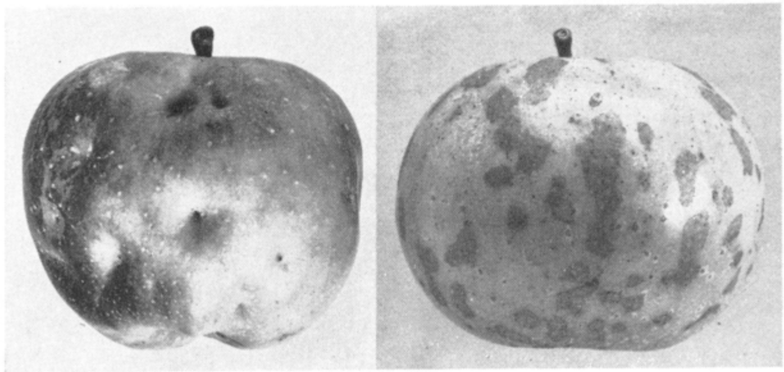

Figure 56. Red bug damage to apples.

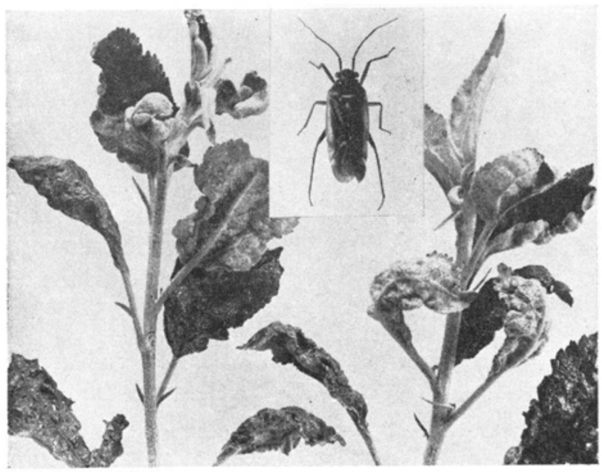

Figure 57. Red bug and damage to terminals.

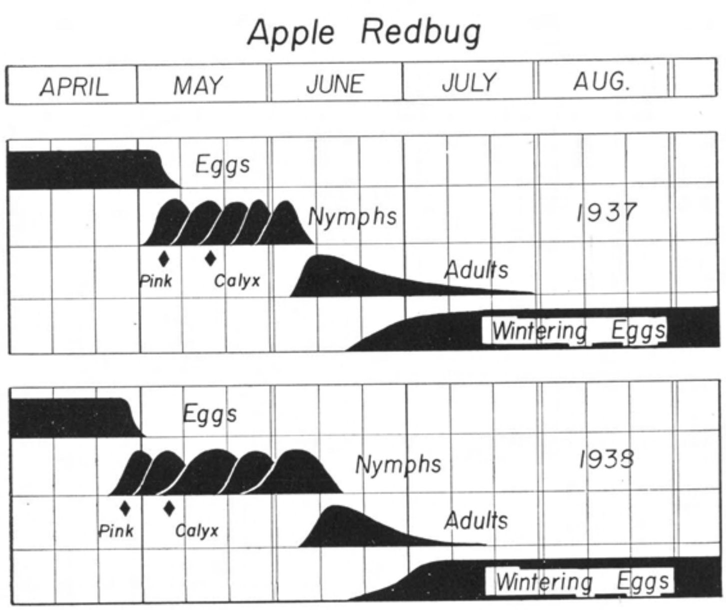

Figure 58. Life history of the apple red bug.
Redrawn from N. Y. Agr. Exp. Sta. Bul. 716

EUROPEAN RED MITE

Paratetranychus pilosus (C. & F.)

The first stage (larval) is bright red, but the second and third nymphal stages are usually dull green or brown. The adult female is a velvety red with conspicuous white spots at the base of the dorsal setae. Adult mites are about ½ millimeter in length (1/50 inch). Winter eggs are dull red, summer eggs brown.

Damage

A vicious enemy of the apple, the damage resulting from European red mite attack is seen in off-colored foliage in mid-season, premature leaf and fruit drop, and undersized and off-colored fruit. Attacks in June may result in a light set of fruit the following year. Varieties preferred in Connecticut are Baldwin and Delicious, but many others are infested.

Transportation from tree to tree is mainly by air currents but within the tree the mite crawls readily from leaf to leaf or twig to twig. After the first generation matures in early spring, there is a strong tendency for the females to disperse generally over the tree.

Life History

Winter is passed in the egg stage on the smaller twigs or medium-sized branches. Hatching occurs at or slightly before the pink stage, and from then on generations are continuous with a tendency to overlap in mid-summer. Winter eggs are usually deposited in late August or early September, but the mites may continue to be active much later, if favorable weather prevails.

From six to eight generations a year have been reported, but field counts have established the fact that there is a definite peak in abundance regardless of generations (Figures 59 and 61). This peak frequently falls near the first of July, but may be delayed by spray operations until the last of that month. From season to season, there are marked variations for the State as a whole, or for even larger areas. Such variation is often accompanied by rise and fall of natural enemies. Declines have also been noted following severe leaf bronzing by the pest the previous year.

Factors Affecting Abundance

Temperatures influence rapidity of development as with other mites. Heavy dashing rain storms wash many mites from the leaves and ice storms have been reported to remove winter eggs from the twigs. Neither does more than check development temporarily. Observations in Connecticut indicate that warm, dry spells are distinctly favorable to development and that most outbreaks occur during such periods. Cold limits for the overwintering eggs are not known, but must be very low.

Pruning affects development only inasmuch as lack of it prevents thorough spraying. Other plants in surrounding areas have sometimes been suspected as sources of infestation but, of this, little is known. The mite infests elm and mountain ash, as well as apple, and these could easily be a source of supply. Since European red mites are transported by winds, it is natural to suspect that they will be more abundant to the windward side of prevailing infestations than in the lee. Outbreaks frequently follow heavy DDT or sulfur-lead arsenate spray programs.

Predators and Parasites

There are a large number of predators including Iphidulus mites, Stethorus lady beetles, thrips, mirid bugs and others. So important are they in Connecticut that rarely do infestations develop in trees which have not been sprayed with insecticides that encourage mite populations.

Control Measures

Dormant or delayed dormant oils have been used in Connecticut for control of the European red mite since it became abundant in the early 1920's. Lime sulfur commonly used at that time was shown to have little effect. White, highly refined, summer oils next came into prominence and were recommended to keep populations of mites down if they became abundant in mid-summer. It was found that dormant oils only delayed the peak of abundance about a month in summer so it became important to have other insecticides. Summer oils were also limited to a short period in mid-summer in Connecticut. Their use results in changed appearance of the harvested fruit if they are applied too late, and they are incompatible with other materials if used earlier. DN-111 was next developed because of these disadvantages of summer oil, but its usefulness was also limited because of its phytotoxicity or leaf-burning qualities. In addition to all these problems, the use of DDT and wettable sulfurs for other

European Red Mite

pests seemed to counteract almost any mite control that was applied. Recent researches have revolved around the improvement of dormant oils to give more complete elimination of the eggs on the tree. Specifications for the so-called superior type oils have been reported upon by Chapman, and these seem to have relieved the situation somewhat. However, outbreaks still occur even in the best-sprayed orchards. The modified DN's (dinitro-*o-sec*butylphenol) appear to be slightly less efficient than the superior oils but have the advantage of killing aphis eggs at the same time, which oils do not, or at least not very efficiently. Still more recently there have come into use a number of very efficient summer miticides, such as the phosphates and Aramite, an organic sulfite. These are still not completely out of the experimental phase, but both TEPP and Aramite have been used with some success. Double applications of both are needed to give good clean-ups, seven days to two weeks apart. Applications between pink and first cover stand a good chance of killing enough mites to provide at least as good control as dormant oil. Omission of sulfur and substitution of ferbam has in our experience relieved some of the pressure of mites, provided dormant oil was omitted, but others have not reported any beneficial effects from the use of ferbam at all. However, the fungicide, dinitrophenylcrotonate, seems to combine both fungicide and miticidal properties, a distinct advance in this field. The same is claimed for "Crag 341" (glyoxalidine acetate).

There are indications here that it may soon be possible to combine miticidal, aphicidal and fungicidal properties all in one chemical and it is expected that future research in insecticides will proceed in this direction.

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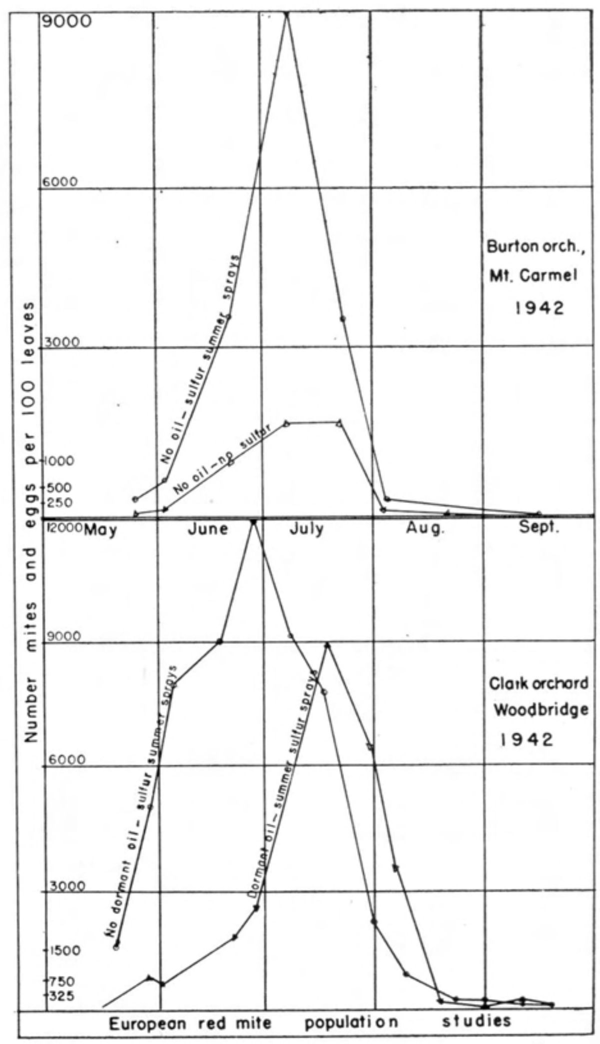

Figure 59. European red mite population studies at Mt. Carmel and Woodbridge.

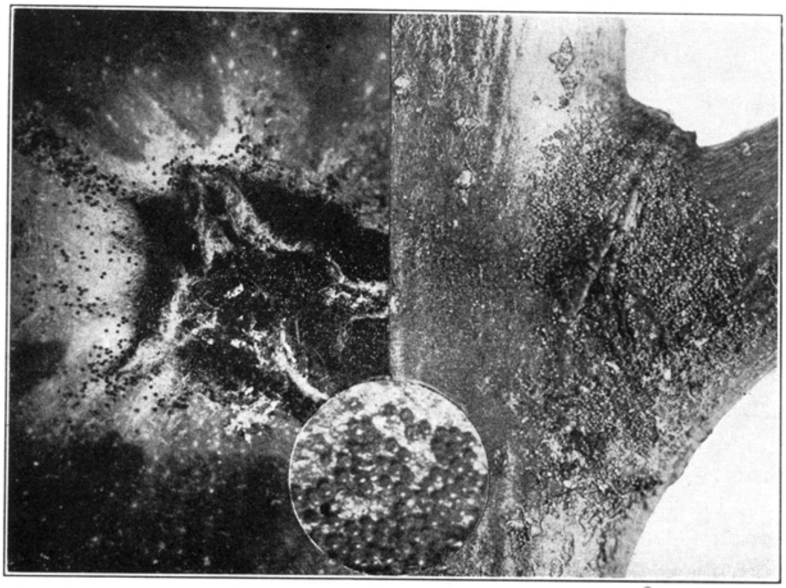

Figure 60. European red mite winter eggs.

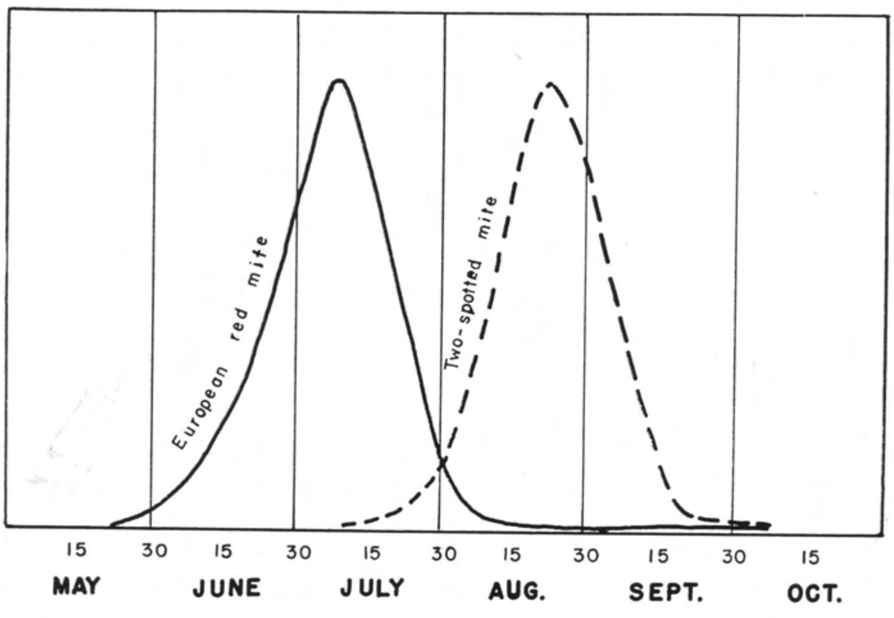

Figure 61. Abundance curves for the European and two-spotted mites in central Connecticut.

TWO-SPOTTED MITE

Tetranychus bimaculatus Harvey

There is very great variation in coloration of the two-spotted mite, from the common flesh color, usually with two spots, to a brilliant carmine. Overwintering females are pinkish with no spots. Authorities are not in complete agreement regarding the existence of more than one species passing under the name *bimaculatus* because of the close similarity of structure. If there does happen to be more than one species within the group, similarity of habits will make controls essentially the same.

Damage

Injury to fruit trees is due entirely to leaf feeding, which of course affects the fruit indirectly. Leaves may turn yellow and drop prematurely.

The two-spotted mite attacks a wide variety of plants, both herbaceous and woody. It has apparently become a pest of fruit trees, however, only since the use of DDT. It has been recorded from apples, peaches and cherries, but has not been a serious problem on pears.

Life History

The insect passes the winter as an adult female under bark scales. As soon as spring comes, the mites move down to the cover crop where they usually remain until late in the summer when drought may force them up into the trees. The peak abundance occurs much later than that of the European red mite as shown in Figure 61. Generations follow one another in rapid succession and may be complete from egg to egg in as little as five to seven days.

Factors Affecting Abundance

Drastic declines in early summer have been observed (Chapman, 1950) due to cool, rainy weather, followed by increases later when the weather has become hot and dry. Favorable conditions thus seem to be about the same as for the European red mite. Since the mite feeds on so many host plants, increased populations on any of them in or around the orchard are potential sources of infestation.

Besides DDT or similar sprays as causes of increase, it should be mentioned that the two-spotted mite thrives best on well-fertilized plants, and may be affected by excessive stimulation. The type of cover crop does not seem to make much difference.

Predators and Parasites

Natural enemies are essentially the same as for the European red mite and, like the European red mite, the two-spotted species is usually held in check by them in unsprayed trees.

Control Measures

Because of the fact that the two-spotted mite has only recently become a pest of apples and other fruits, no controls were necessary in the past.

Recent methods employed include the use of organic phosphates, an organic sulfite, and other compounds wherever the mite becomes abundant. There is some indication that resistance is developing in some areas where the phosphates have been employed. Resistance builds up rather rapidly in the two-spotted mite because of the extremely rapid rate of reproduction and the quick replacement of injurious populations from only a few survivors. Several workers mention the necessity of repeating applications of such materials as parathion or TEPP within a short interval since these controls do not affect the egg. Spray repetition intervals would depend, however, on the temperatures at the time since it takes much longer to complete the life cycle from egg to egg in cool weather than in hot (Cagle, 1949). In extremely hot weather it is necessary to repeat within a week.

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There is an extensive literature on the two-spotted mite, and the following are only a few references selected from it.

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CLOVER MITE

Bryobia praetiosa Koch

The first nymph or larval stage of the clover mite is light reddish in color; later nymphs and adults are dark brown. Examination of the adult with a lens shows it to be strongly flattened above and rather coarsely wrinkled. The egg is distinguishable from that of the European red mite by the absence of a central hair or papilla, and the eggs when seen in groups have a brownish tint rather than red.

Damage

The clover mite occasionally damages apple trees in Connecticut, the injury being quite similar to that of the European red mite. It is reported to be worse in dry seasons. In some cases the infested leaves become yellow and drop prematurely (Bourne, 1943).

Life History

On apple trees, the mite is reported to have three or four generations (Venables, 1943), and the winter is passed in the egg stage on twigs, bark, or other locations. Hatching apparently occurs earlier than the European red mite, but there are not as many generations. Recently hatched mites have been observed in Connecticut in February on bark near the ground on the south side of the tree.

Unlike the European red mite, summer eggs are laid mainly on the bark or twigs instead of the leaves and some investigators report abandonment of the tree for the ground cover after a period of feeding. Other reports indicate continuous generations on the apple from spring until harvest. Mites have been seen on apple foliage throughout the season in Connecticut.

In general, the life history of this mite has been inadequately studied and there are many important points yet to be cleared up.

Factors Affecting Abundance

Ground cover is probably the most important factor affecting abundance. In addition, the clover mite, like the European red mite, seems to be profoundly affected by applications of DDT, i.e., populations are increased by it. Weather relationships are about the same as for the European red mite.

Predators and Parasites

Very little is known about the natural enemies of the clover mite, though it is assumed that some of the same predators that attack the European red mite also attack this species.

Control Measures

Oil for control of clover mites on fruit trees has been recommended for a long time and is found in 1951 spray calendars. Organic phosphates, such as TEPP, have given gratifying results where they have been used. Complete control with oils is doubtful owing to the mite's habits of placing eggs under bark scales.

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YELLOW MITE

Eutetranychus uncatus G.[1]

This mite is closely related to the Willamette mite of the Pacific coast. It is also similar in general appearance to the two-spotted mite, but paler, and the dormant stage is lemon yellow instead of pink.

Damage

The yellow mite is a new species discovered several years ago in New Hampshire and Massachusetts; it has also been found in Connecticut (1950). The mite feeds on young leaves in spring causing damage similar to that of the two-spotted mite. So little of it has been found to date in Connecticut that it would be unwise to comment further. The localities where it has occurred include Glastonbury, Somers, Lebanon and Norwich.

About the only difference in the type of injury caused by this species and the two-spotted mite is that the yellow mite causes more puckering of the leaves, particularly early in the season. It does not bronze foliage like the European red mite and does not spin a web as does the two-spotted mite.

Life History

The yellow mite hibernates as a female under bark scales, from where it moves out to the foliage as soon as weather and growth permit. Eggs from the overwintering females were found in 1950 on May 17. From mid-May on, there seems to be a succession of generations similar to the two-spotted mite.

Control Measures

In general, the same control measures that apply to the two-spotted mite are also effective against this one. Dormant oils are of little use because the overwintering females are beneath bark scales. Summer miticides are effective but double applications are advisable because of their generally low toxicity for the eggs.[2] Treatments are necessary somewhat earlier in the season (calyx or first cover) than for the two-spotted mite.

Reference

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[1] Scientific description not yet published.
[2] At least one of the newer miticides has ovicidal properties.

PLUM CURCULIO

Conotrachelus nenuphar (Hbst.)

Damage

Damage results from egg and feeding punctures of the beetles and feeding of the legless brown-headed larvae within the fruit. Fruits injured are apple, pear, peach, plum, nectarine and quince. Plums and nectarines are the preferred fruits, but beetles develop readily in peaches and prefer them to apples. Pears and quinces are even lower on the curculio's menu than apples; they appear to be attacked only when other foods are not available.

Egg punctures are crescents when first made, but take on a shield-shaped appearance as the apple grows and becomes mature. Feeding punctures often result in warts (Figure 62D) of considerable size on apples, especially in such varieties as Cortland. Heavy feeding by the adult may produce grossly misshapen fruit (Figure 62C). The infested fruit drops to the ground soon after the egg hatches and the larva begins to feed. If the infestation is heavy, practically all of the fruit may be lost. Damage over the country as a whole has been estimated at 17 million dollars in a single year.

Life History

The winter is passed as an adult in or around the orchard. In spring, the adults begin to be active when the temperature reaches 60 degrees F. and they appear on apples and other fruits soon after. On apples they show up when the buds are pink, and the eggs are laid after petal fall as soon as the apples are of sufficient size (about ¼ inch in diameter). Larvae developing within the fruit complete their growth by mid-summer and enter the ground to pupate (Figure 63). After a short period in the ground where they pupate, the beetles of the next generation emerge, feed for a short time, and then seek hibernating quarters. The amount of fall feeding is usually small, although it depends considerably on prevailing temperatures. The insect has only one generation a year in Connecticut.

There is little evidence of cyclic abundance.

Factors Affecting Abundance

There is a graduated response to temperatures between 65 and 75 degrees F. and both egg laying and feeding are strongly increased as the temperatures rise. High mean temperatures (above 70° F.) have been shown to result in severe damage; serious losses generally result whenever these conditions prevail shortly after petal or calyx period. Heavy rains that wash off the spray may increase these losses. Stone walls, woods and heavy orchard cover allow the curculio beetles to overwinter in large numbers. Apples or pears near peach plantings are often severely injured; rows next to such plantings are nearly always the first to be attacked in spring. Wild apples or uncared-for plantations near commercial orchards are distinct menaces.

Predators and Parasites

Several parasites affect the plum curculio. Ants, ground beetles, lace wing flies, thrips and others attack the larvae and eggs, while birds and moles destroy the larvae. The most abundant parasite in Connecticut is *Triaspis curculionis* F., which has been recorded as destroying 18 to 33 per cent. The egg parasite Patasson (*Anaphoidea*) *conotracheli* Gir. is also important. Many of the parasites and predators are apparently destroyed by the newer sprays, which may account in part for increasing difficulty of control in some areas.

Control Measures

Up to about 1940, the standard insecticide for curculio control was acid lead arsenate. Jarring trees was practiced extensively at one time for peaches. Various chemicals have been tried, such as nicotine sulfate, fluorides and fluosilicates and others. All work since 1920 stresses the importance of clean-up or sanitation, such as burning over woodlands near the orchard, removal of stone walls and dense fence rows and cultivation within the orchard to destroy the larvae. This last measure is chiefly applied in peach orchards.

The increase in number of sod-mulch apple orchards since 1930 made it necessary to depend largely on sprays for control. Since 1918, with more and more knowledge of curculio habits, control measures centering around the use of lead arsenate became more effective, at least on apples, due to increases in the number of applications immediately following the calyx period. Use of stickers has been shown to be of benefit in reducing the amount of weathering that frequently occurs at that time of year in Connecticut.

Since 1940, the newer insecticides, such as DDT, methoxychlor, DDD (TDE), chlordane, benzene hexachloride, aldrin and dieldrin, as well as various organic phosphates, have come into use experimentally. Chlordane and methoxychlor have given good results in experiments and growers are now beginning to use them. Which one is the best is still to be determined but, so far, control appears to be at least as good as lead arsenate and in some cases better.

Timing depends somewhat on temperatures following the calyx period (Figure 64). Thus, if high temperatures and abundant rainfall occur at that time, much more difficulty will be experienced than if the weather is dry and cool. With high temperatures, it is advisable to spray at seven-day intervals but, if cool, the interval can be longer—ten days to two weeks.

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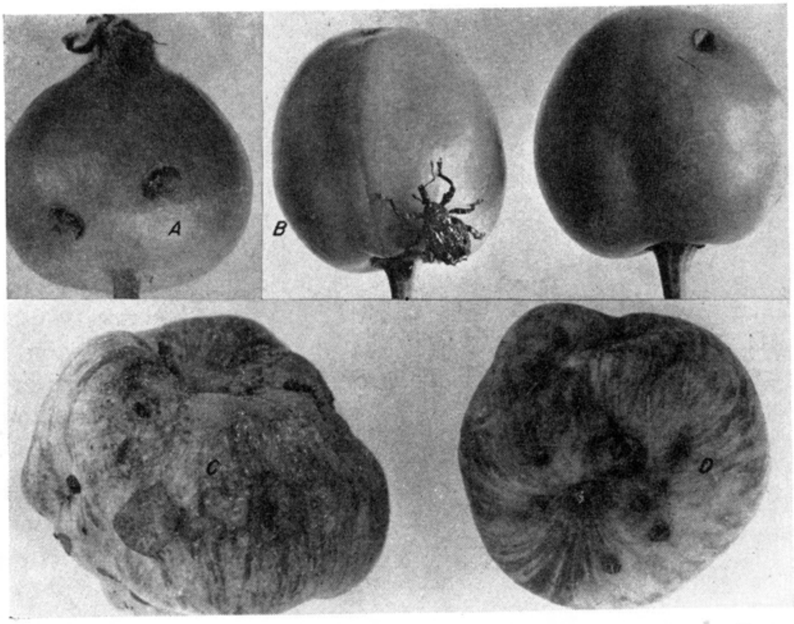

Figure 62. A and B. Egg and feeding punctures of the plum curculio. Adult beetle shown in B. C and D. Severely deformed fruit.

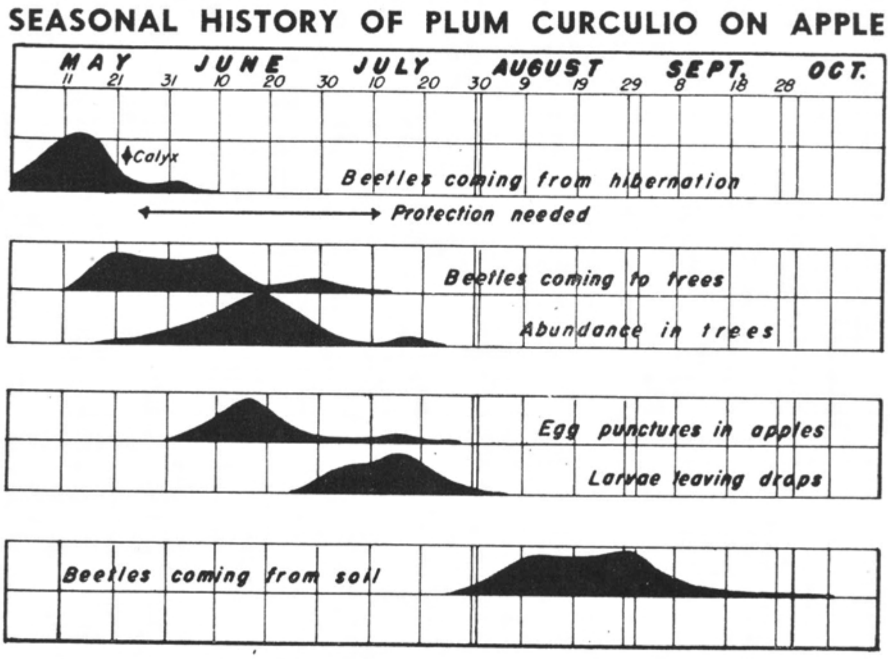

Figure 63. Seasonal life history of the plum curculio in Connecticut.

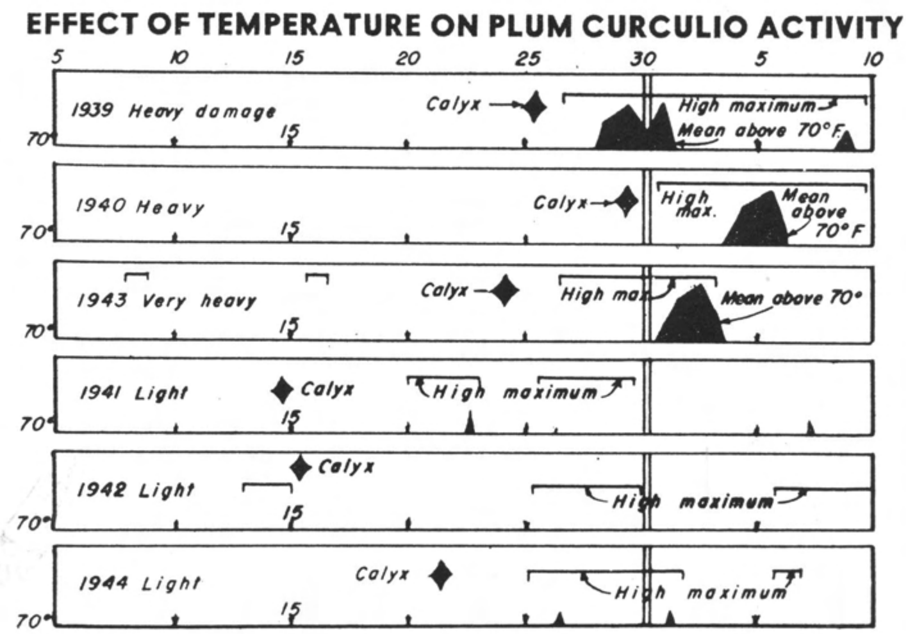

Figure 64. Chart based on apples showing effect of temperature on seasonal activity of the plum curculio. Diamonds indicate time of calyx spray; heavy horizontal black lines, periods of high maximum temperatures (about 75° F.); blacked in portions, periods when the mean temperatures reached 70° or above.

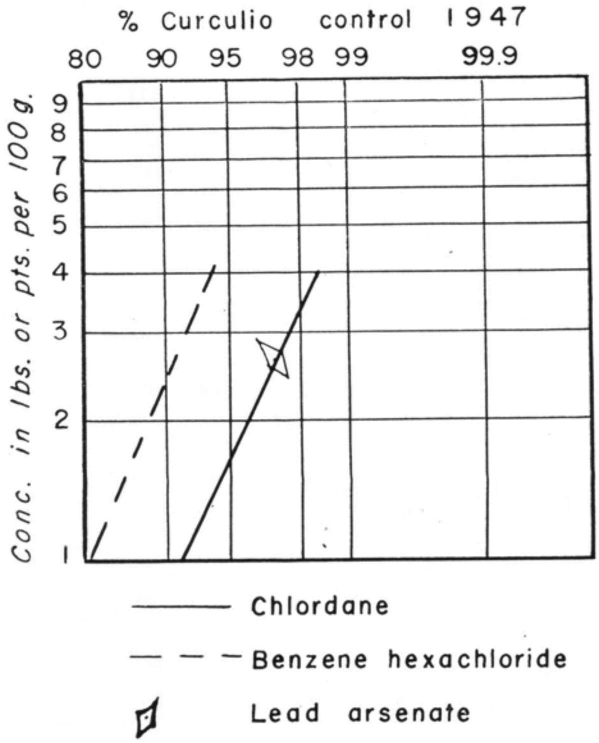

Figure 65. Comparison of chlordane, benzene hexachloride and lead arsenate for control of the plum curculio. Field experiment, 1947.

Figure 66. Plum curculio with freshly made egg puncture. Enlarged about one-third. Apples ½ inch in diameter or slightly less.

EUROPEAN APPLE SAWFLY

Hoplocampa testudinea (Klug)

The parent sawfly is a clear-winged "fly" about ¼ inch long, dark brown above and yellowish brown below. The larva (Figure 68, 2) is never pinkish like the older codling moth, oriental fruit moth, or lesser apple worm, and has a total of seven abdominal legs instead of five. It is further distinguishable by the increased number of transverse striations, as compared with the codling moth.

Damage

As the name implies, the insect is an introduction from Europe where it is a serious problem in the northern areas. Discovered in Long Island in 1939 by Pyenson, it has since spread to southern Connecticut and several counties in southeastern New York. It is not yet a serious problem in commercial orchards here, but is very destructive to apples in the home garden, particularly if unsprayed. It has persisted in well-managed orchards, however, and populations appear to be increasing as of 1951. The sawfly is also present in British Columbia.

Only apples, including crabs, are known to be attacked in America, but similar species also attack pears and plums in Europe. Many varieties are infested, though strong varietal preferences are reported for Hyslop crab, Wealthy, Dutchess, Gravenstein and King. Wealthy, Early McIntosh and Golden Delicious, all varieties with long bloom and heavy set of fruit, seem to have been preferred so far in Connecticut. A lot depends on the weather during bloom.

Life History

The apple sawfly hibernates as a mature larva in a puparium in the ground. Pupation takes place in early spring and adult sawflies emerge when the apple trees first come into bloom. Egg laying occurs during full bloom, the eggs being inserted in the flesh of the calyx cup. Newly hatched larvae tunnel under the surface of the skin and later bore directly into the apple, depositing a kind of chocolate-colored sawdust on the surface. A single larva may feed on several fruits in turn, damaging each. When mature, the larva drops to the ground or remains in the fruit until the apple drops. Then it enters the ground, constructing a cell or puparium where it remains until the following spring.

The seasonal history is represented graphically in Figure 67. In England the sawfly is reported to have two generations a year, occasionally. In Connecticut there is considerable variation in abundance in the same blocks from year to year but no evidence yet of cycling.

Factors Affecting Abundance

During cool, cloudy weather the flies are sluggish and often take shelter underneath the foliage. Mating and egg laying have been observed at temperatures of 60 degrees F. or below but the greatest activity takes place at higher temperatures in sunny weather. The fact that the sawfly is active at lower temperatures indicates a northern point of origin in Europe.

Damage appears heavier wherever there is a heavy set of fruit, especially in clusters. This may be partly due to the nearness of one apple to another when larvae are migrating. It could also be due in part to difficulty of spraying clusters thoroughly.

Predators and Parasites

There is as yet little or no information on natural enemies of the European apple sawfly.

Control Measures Against the Various Stages

Hibernating stage. There is little data or practical experience available to indicate that ground applications are effective.

Adult stage. After the newly emerged adults leave the soil, they remain in grass for a time, and often climb stems before taking flight. The possibility of killing them at this time with an insecticide of contact residual action is very good. DDT tried for this purpose, however, appeared to have too short a period of effectiveness, only two or three days. Owing to the habit of the flies in taking moisture from the leaves, it would seem that insecticides should be applied for their control. Applications would have to be made before bloom to protect bees. Derris (rotenone) dusts have been tried (Hey and Steer, 1934) with partial success. Any insecticide applied against the adult would have to be quick acting because of the short preoviposition period, and of good residual action because of the extended emergence period. Trees sprayed in 1951 with chlordane were well protected.

European Apple Sawfly

Egg stage. Eggs are laid largely during bloom. They are protected by their point of deposition within the calyx cup. It is not surprising that there should be differences of opinion regarding effectiveness of sprays against this stage. In experiments at New Haven, using rotenone, newly hatched larvae were killed within the calyx cup, before they could enter the fruit.

Larval stage. The effectiveness of lead arsenate, which presumably acts as a larvicide, may depend on unusually thorough coverage, because of the importance of getting it into the calyx cup. Timing may also be important. The habit of a substantial number of newly-hatched larvae (as observed in Connecticut) of entering the fruit without contact with the outer surface would seem to reduce the effectiveness of the most thorough lead arsenate spray.

Sprays against the larvae in shallow burrows just under the skin have been tried, but there is no definite information as to their effectiveness.

On the older stages, half grown or more, rotenone sprays have given good control. Lead arsenate has been of benefit in some cases, although some workers think it is worthless.

Of the chemicals reported to give best results for sawfly control, lead arsenate, nicotine sulfate and summer oil have been reported to give excellent control in British Columbia (Downes, 1944) and the English (Davies and Eaton, 1949) have had good results with parathion, gamma benzene hexachloride and chlordane (see Connecticut results under "adult stage").

Downes' formula consisted of summer oil emulsion, 2 gallons; nicotine sulfate, 1¼ pints; lead arsenate, 4½ pounds, and powdered skim milk as the emulsifier, all in 100 gallons. Spraying was done immediately after petal fall. In the English experiments, nicotine alkaloid, 95 to 98 per cent, was used at the rate of approximately ½ pint to 100 gallons, while chlordane was used at approximately 1 pound actual chlordane to 100 gallons, and parathion at approximately ½ pound actual to 100.[1] As of 1950, nicotine was being recommended in England. Two sprays, one at petal fall and one about a week later, were suggested. In this country two sprays of rotenone at the above periods have given good control. They can be used in the home garden. In Connecticut tests both chlordane and methoxychlor have given indications that they may be effective under our conditions.

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[1] Nicotine, .05%; parathion, .05%; benzene hexachloride, .01%, and chlordane, .1%.

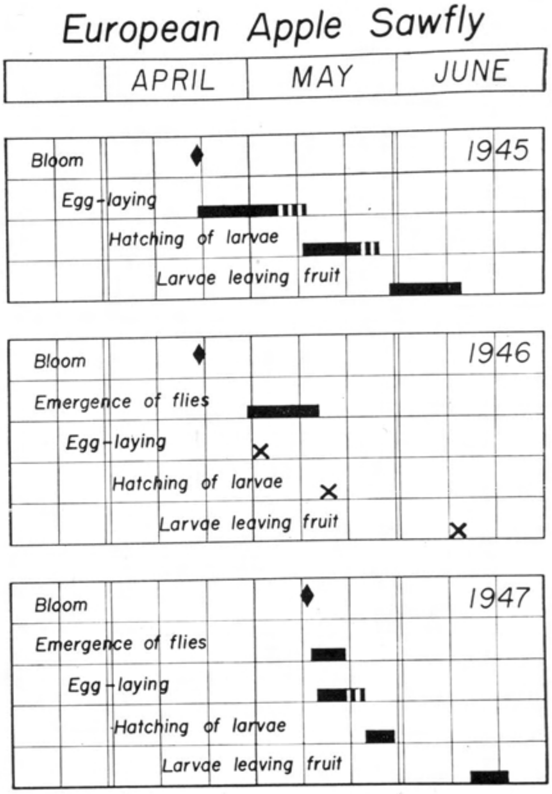
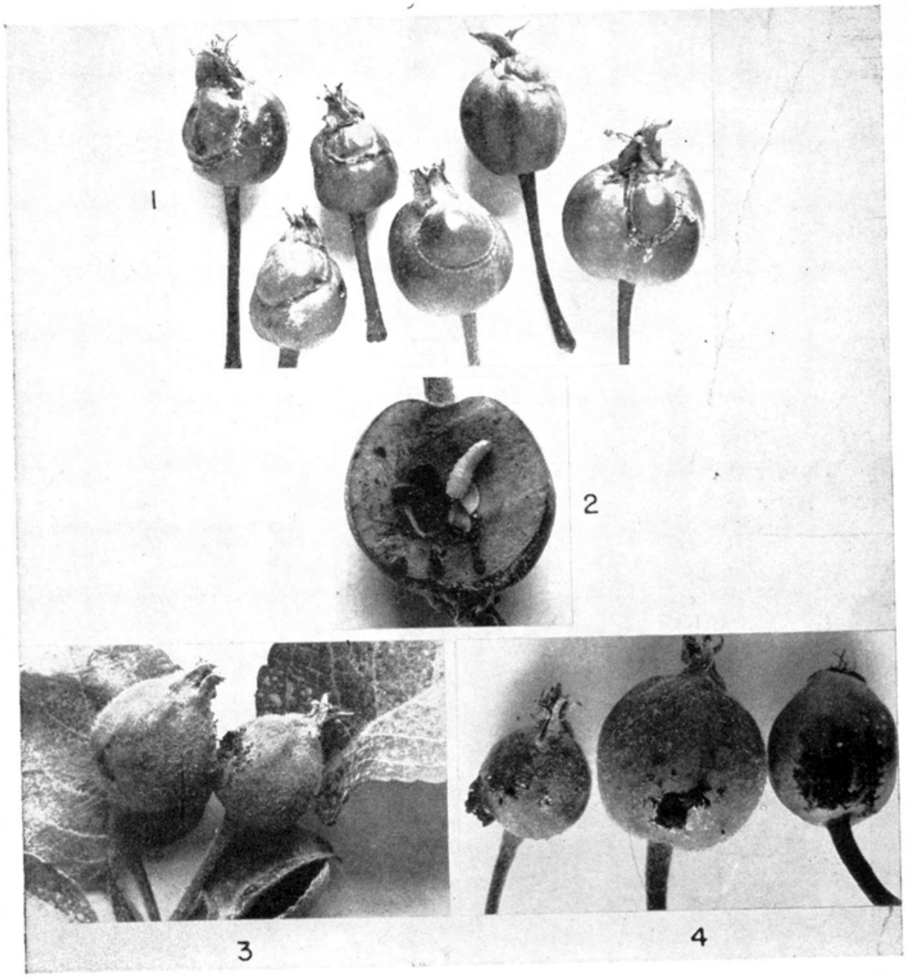


Figure 67. Life history of the European apple sawfly in Connecticut.

Figure 68. Work of the European apple sawfly. 1. Scars produced by young larvae feeding just beneath the skin. 2. Nearly mature larva in center of apple. 3 and 4. External appearance of young fruits after being tunnelled by larvae of the European apple sawfly.



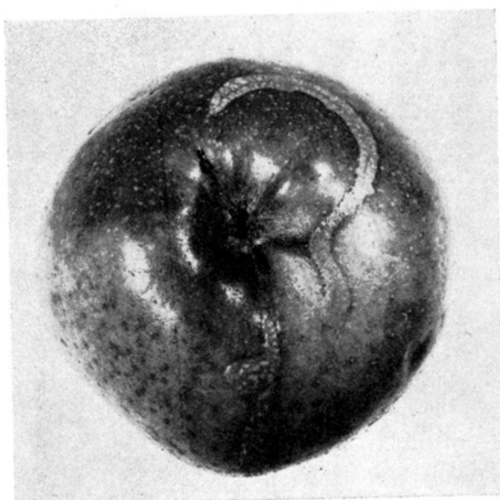


Figure 69. The European apple sawfly. Scar on mature apple.

OYSTER-SHELL SCALE

Lepidosaphes ulmi (L.)

This scale differs from the San Jose or scurfy scale in shape. The overwintering eggs are white in contrast with those of the scurfy scale which are purple. Three strains are thought to occur, one on lilac, one on fruit trees, and one on birch and poplar (Schuder, 1951).

Damage

A European insect, the oyster-shell scale has been present in this country for possibly 150 years. In early years, it was seldom very destructive (U.S.D.A. Bul. 1270, 1922) but, recently, it has presented a serious problem in Maine, Wisconsin and Nova Scotia. Widely distributed geographically in the United States, it occurs on most fruits, and many shrubs and woodland trees. In Connecticut it is common on lilac. The oyster-shell scale rarely kills entire fruit trees but often destroys many seedlings and sprouts.

Life History

The winter is passed as an egg beneath the scale. There may be as many as 50 eggs under a single scale. Hatching occurs the last week in May but the duration of the period is apparently not known. The young wander around for a few hours and then settle down, becoming mature in September or late August. Egg laying begins about the first of October, or earlier.

There is only one generation known to occur in Connecticut, but two have been suggested for New York in a long season.

There is no reliable information on cycling in Connecticut.

The pest is transported from plant to plant in several ways. It may be carried by wind, on the feet of birds, on other insects, or by man. The youngest stage moves readily from one part of the plant to another.

Factors Affecting Abundance

Weather is not known to affect abundance of the oyster-shell scale. Low temperatures of 32 degrees below zero have been reported fatal, but are not likely to affect the populations here; temperatures that low are infrequent in Connecticut.

In Nova Scotia there seems to be a close connection between abundance and the type of fungicide used. An increase in Maine paralleled the use of mild sulfurs. Also, the use of dormant oils is thought to increase the trouble from oyster-shell scale because of the destruction of natural enemies and failure to kill many of the eggs beneath the scales. Thiocyanates are also reported to be effective destroyers of parasites.

Predators and Parasites

Because of the scarcity of oyster-shell scale on unsprayed apple trees in Connecticut, it may be assumed that there is a fairly vigorous assortment of natural enemies which keep it in check. These have not been carefully studied but it is quite possible that we have the parasite, *Aphelinus mytilaspidis* LeB., and it is established that the predator mite, *Hemisarcoptes mali,* is present. At least five other mites have been found associated with the oyster-shell scale, although how important they are in reducing populations is not clear. All of these species are present in Connecticut.

Seven species of birds are reported to feed on the scale, mostly small creepers, several tits and one nuthatch.

Control Measures

Probably the best of the older remedies was lime sulfur and serious outbreaks did not occur where this spray was used. Dormant oils were tried as they became available, but were not satisfactory. Tar distillates have also been used (Hartzell, 1934).

O'Neal and Fluke (1948) have found DDT to be effective against young crawlers, if applied about June 1. In 1946 one application was needed, but in 1947 two were required because of the prolonged hatching period.

There is not much information available on other chlorinated compounds or the organic phosphates. Presumably some of them will do as good a job as DDT.

DN's of the butylphenol type are reported to be effective against moderate infestations.

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SAN JOSE SCALE

Aspidiotus perniciosus Comst.

This pest is a small brown circular or nearly circular scale as shown in Figure 70.

Damage

The San Jose scale was introduced from China about 1880, and reached Connecticut in 1895. The first damage occasioned was very severe in nurseries and elsewhere and the losses resulted in the passage of the nursery inspection laws by the State legislature. If unchecked by natural enemies or sprays, the San Jose scale kills trees outright. When the population is of low density, fruit growers no longer worry about it since the only damage may be a few reddish spots on apples or other fruit. It is, however, always a potential threat and must be watched continually to prevent it from getting out of hand.

Life History

The winter is passed as a partly mature scale on twigs and branches. Young active "crawlers" appear the last of June, and again at intervals of about four weeks. This would make possible a total of four generations each year and Britton reports three for Connecticut, with sometimes a fourth. There appear to be fluctuations in abundance of considerable magnitude, but the interval between peaks has not been definitely determined. Flurries of abundance occurred in 1922-3 and again in 1942-3, indicating a cycle of about 20 years.

Distribution is mainly by crawling (the young are free moving) from one part of the plant to another. They are carried from one plant to another on the feet of birds.

Factors Affecting Abundance

Cold limits are not known and other weather factors seem to have little influence. In some areas increases have been observed following the use of DDT and this scale has shown resistance to sprays of lime sulfur (Webster, 1933; Flint, 1923).

Predators and Parasites

Probably the most important enemy of the San Jose scale is *Prospaltella perniciosa* Tower, a widely distributed parasite in the Northeast. Parasitism up to 90 per cent has been reported. Action of this valuable enemy of the scale, together with others such as *Aphelinus diaspidis* Howard and *Aphelinus fuscipennis* H. and several of lesser importance, has, since 1915, apparently reduced the San Jose scale from a major to a minor pest in New England. Other parasites mentioned are *Signiphora nigrita* Ashmead, *Perissopterus pulchellus* Howard and *Anagrus spiritus*. In addition to the above, at least two lady beetles are mentioned in Connecticut reports: *Chilocoris bivulnerus* Muls. and *Microweisea* (*Pentilia*)*misella* LeC.

Control Measures

Dormant strength lime sulfur, one of the early pesticides developed, was designed primarily as a control for the San Jose scale. Following lime sulfur, dormant oil sprays of various kinds were invented and shown to be even more effective. Use of lime sulfur has gradually declined in the last three or four decades and now very little is used as a dormant spray.

Elimination of infested nursery stock was, of course, widely advocated.

Modern spray development has followed the line of improving oil sprays, or in testing some of the newer compounds, such as parathion, which was shown to have value for controlling San Jose scale. Dormant oils are still used, however, and the superior types are known to hold down the pest with very low concentrations and little or no plant injury. They will kill scale at 2 per cent actual oil and are far safer than the ones first used.

DN's of the butylphenol type are reported effective (Hammer, 1949; reference under scurfy scale).

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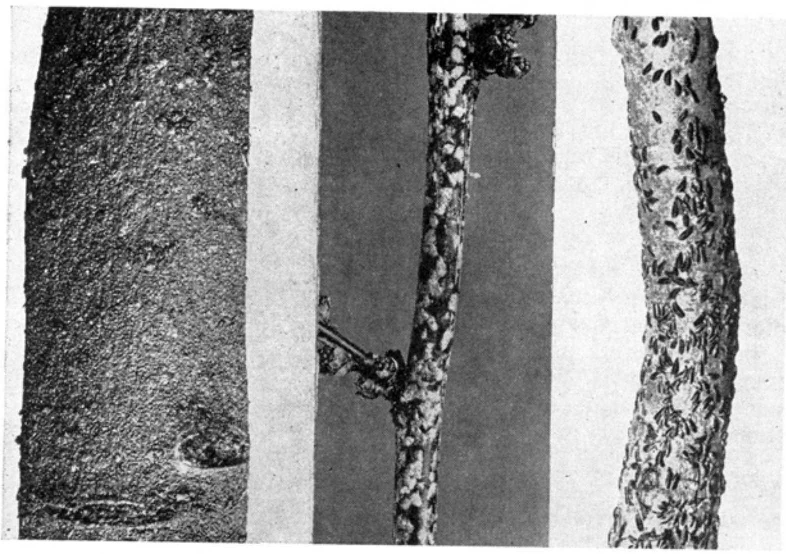

Figure 70. Left, San Jose scale; middle, scurfy scale; right, oyster-shell scale.

SCURFY SCALE

Chionaspis furfura Fitch

The scale is white, the "crawlers" yellow, and the eggs under old scales purplish. These features readily distinguish the scurfy from the oyster-shell scale (Figure 70).

Damage

The scurfy scale is a native insect similar in many ways to the oyster-shell scale and widely distributed in the United States. It is apparently more destructive in New England and the Middle Atlantic States than elsewhere. In Connecticut and most of New York scurfy scale has not been a serious pest. It has been reported from time to time, but not in great numbers. The chief injury is to young apple and pear trees. A colony established in Dutchess County, New York, between 1906 and 1909 (Brann, 1944) appears to have done more than the usual damage. The colony is spreading gradually but so far as we are aware has not reached Connecticut. This strain has two generations a year instead of one, as commonly reported here.[1]

Life History

The winter is passed in the egg stage under old scales. Hatching takes place the latter part of May, and young scales mature during September. The New York strain hatches about the same time, but there are two generations as noted, the first maturing by July 1. Egg laying for the single generation strain takes place in October, for the two generation strain in September.

No information is available on cycles of abundance.

The insect is said to be able to travel only a few inches by itself, but may be distributed by wind and birds the same as the oyster-shell scale.

Factors Affecting Abundance

Orchard conditions suitable or unsuitable for thorough spray coverage would appear to be important, particularly for the Dutchess County strain. In Connecticut so little trouble has been experienced and so little information concerning the pest is available that it would be unwise to comment further.

Predators and Parasites

Very little information is available on parasites or predators of this insect. Quaintance (1910) reported that the insect is apparently not so subject to attack as the oyster-shell scale, or else has not been as carefully studied. Probably there are effective parasites and predators able to depress the population sufficiently to prevent outbreaks except where the generations have doubled as with the New York strain. Parasites and predators reported by Brann (1945) are: *Chilocoris stigma Say* (*bivulnerus* Muls.), *Microweisea* (*Pentilia*)*misella* LeC., *Phycus raricornis* How. and *Aphytes fuscipennis* How. The first two are lady beetle predators. These natural enemies are known to destroy up to 30 per cent of the scale; mites were reported to destroy 40 per cent.

Control Measures

Both lubricating and tar oil emulsions appear to be reasonably effective in killing the eggs of the scurfy scale, differing somewhat from their action on the eggs of the oyster-shell scale.

While very little information is available regarding the effect of the newer insecticides, it is probably safe to assume that DDT or the organic phosphates will kill the crawlers the same as those of the oyster-shell scale.

Sprays applied about June 1 are most effective.

DN's of the butylphenol type are reported effective against moderate infestations.

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1 The two-brooded strain develops scales on the fruit at harvest, whereas the single-brooded one does not.

MISCELLANEOUS PESTS

Besides the species already described, there are a number of injurious insects which occasionally become important. Most of them are easily controlled, both with old and new insecticides. No attempt has been made to list all the species known to feed on the apple, but the following table will serve as a guide to at least some of them.

Pest	Season and kind of activity	Suggested control
Apple curculio *Tachypterellus quadrigibbus* Say	Small snout beetle. Injury same as plum curculio; lives in fruit in young stages. No crescents in young fruit as for plum curculio.	Same as plum curculio.
Brown-tail moth *Nygmia phaeorrhoea* (Donov.)	Leaf feeder in May and June. Brown hairy caterpillar with white spots along the sides.	Early sprays.
Shot-hole borer *Scolytus rugulosus* Ratz.	Mostly in weak or diseased trees. Small round exit holes. Damage often severe near wood piles.	Remove and burn affected parts. Treat or remove wood piles.
Cigar casebearer *Coleophora fletcherella* Fern.	Early spring foliage. Builds small cocoon resembling a cigar, about ¼ inch long when complete.	Early sprays. Lead arsenate, etc.
Fall web worm *Hyphantria cunea* Drury	Loose tents in August and September. Medium-sized brown hairy caterpillar; most serious in northeastern Connecticut.	Apple maggot sprays.
Gypsy moth *Porthetria dispar* (L.)	Leaf feeder in May and June. Large hairy caterpillar.	Early cover sprays.
Grasshoppers *Melanoplus sp.*	July, August.	Chlordane, aldrin. July.
Green fruitworm *Lithophane antennata* (Walk.)	Large green worm with white stripes. Feeds on fruit and foliage in May and June.	Lead arsenate or DDT. May or June.
Leopard moth *Zeuzera pyrina* (L.)	White, yellowish or pinkish larva with brown spots. Tunnels in smaller twigs and branches.	Prune off infested branches and destroy.
New York weevil *Ithycerus noveboracensis* (Forst.)	Large beetle feeding on bark.	No control usually necessary.
Oriental fruit moth *Grapholitha molesta* Busck.	Three generations; apples infested mostly in late summer. Small greenish larva with a black head, pink when mature, but without conspicuous brown spots. Wanders around in the flesh more than codling moth larva and does not bore directly to the core and seeds.	No control usually necessary. DDT or parathion.
Palmerworm *Dichomeris ligulella* Hbn.	Abundant about once in 60 years. Medium-sized green caterpillar.	Usual spray program.
Pear leaf blister mite *Eriophyes pyri* (Pgst.)	Small blisters on the leaves in early season. Mites are inside the blisters. Diameter of blister not over 1/16 inch.	Dormant sprays. DN or oils.
Pistol case bearer *Coleophora malivorella* Riley	Larvae live in small cocoons curled at end. Feed on foliage. Length not over ¼ inch.	Usual sprays.

Miscellaneous Pests

Pest	Season and kind of activity	Suggested control
Lesser apple worm *Grapholitha prunivora* (Walsh)	Larvae produce shallow blotch mines on surface of apple. Two generations a year. Larvae are brighter pink than codling moth or oriental fruit moth.	Same as for codling moth.
Red-humped caterpillar *Schizura concinna* (A. & S.)	Eggs laid in June and July. Larvae feed on foliage in August and September. Brown caterpillar 1-2 inch long with red hump.	Lead arsenate or DDT in usual spray mixture.
Rose chafer *Macrodactylus subspinosus* (F.)	Slender brown beetles with long legs. Feed in June on foliage and fruit.	DDT or chlordane. June.
Seventeen-year locust *Magicicada septendecim* (L.)	Young feed on roots in ground. Adults injure trees by excessive egg laying. Last outbreak 1945; next due 1962. Smaller than dog-day harvest fly and with more red.	TEPP or HETP most effective; parathion suggested.
Spotted apple tree borer *Saperda cretata* Newn.	Same kind of beetle as apple tree borer but with spots instead of stripes.	Same as round-headed apple tree borer.
Tussock moth, white-marked *Hemerocampa leucostigma* (A. & S.)	Leaf feeder in May and June. Brown caterpillar with tufts of white hair.	Usual early sprays. Maggot sprays for late feeders.
Yellow-necked caterpillar *Datana ministra* (Drury)	Leaf feeder in August and September.	Apple maggot sprays. July, August.

SPRAY PROGRAMS

For the last thirty years, apple spray programs have followed a similar pattern consisting of the following: (1) *dormant,* as buds begin to swell, (2) *delayed dormant,* when first leaf has turned back in the cluster (Figure 71), (3) *prepink,* just before the blossom buds separate, (4) *pink,* after blossom buds have separated but before blossoms open, (5) *full bloom,* when blossoms are out (fungicide only), (6) *calyx or petal fall,* when most of the petals have fallen, and (7) *cover sprays,* beginning 5 to 14 days after petal fall, and comprising up to five separate sprays during the summer. The cover sprays include the so-called maggot sprays usually applied in July or early August.

From the table below, it will be seen that, since 1920, the number of sprays in Connecticut has increased from 6 to 11, and the number of materials from 5 to 14 or more. A few, such as lime sulfur, Bordeaux mixture and nicotine sulfate, have been largely replaced by supposedly more effective compounds. There is now also a tendency to combine fungicides and insecticides in "efficiency" or all-in-one preparations, several of which are on the market. Likewise, there is an extensive movement to apply sprays in semi-concentrated form instead of dilutions formerly used, largely because of labor shortages or inconvenient or scarce water supplies. In many of our experiments, controls have been just as good with concentrates and alternate insecticides as with the usual methods and materials, but in view of the rapid changes now going on it would be unwise to try to formulate a spray program which might be out of date in a few years. For complete programs it seems best, therefore, to refer the grower of apples to current spray calendars, which may be readily obtained from Experiment Station and Extension Services.

ANALYSIS OF SPRAY CALENDAR CHANGES SINCE 1921

Growth stage	1921	1932	1940[1]	1950[2]
Dormant	Lime sulfur or miscible oil	. . . .	. . . .	DN or butyl-phenol DN
Delayed dormant	. . . .	Oil	Oil	Oil
Prepink	. . . .	Lime sulfur. Nicotine sulfate	Wettable sulfur or dry lime sulfur or liquid lime sulfur. Nicotine sulfate	Ferbam and/or wettable sulfur. Phygon
Pink	Bordeaux mixture or lime sulfur. Nicotine solution	Lime sulfur. Lead arsenate	Same as prepink	Same as prepink
Full bloom	. . . .	. . . .	. . . .	Ferbam
Calyx	Lead arsenate. Fungicide	Lime sulfur or dry lime sulfur or dry mixture. Nicotine sulfate. Lead arsenate	Same as pink	Ferbam or wettable sulfur. Lead arsenate, DDT, or methoxychlor. TEPP
Cover sprays	Lead arsenate. Fungicide (2-3 covers)	Same as calyx with or without nicotine sulfate (4 covers)	Same as calyx (4 covers)	Same as calyx (5 covers)

[1] Alternate dust schedules available.
[2] Alternate concentrate spray programs appearing in 1951.

Total sprays: 1921 — 5-6
1932 — 8
1940 — 8
1950 — 11

Total materials: 1921 — 6
1932 — 6
1940 — 8
1950 — 14 or more
(not all listed above)

NOTES ON CHEMICALS

Dormant Sprays

Mineral oils. Several kinds available; most generally used today are superior oils, dilution 2 to 4 per cent actual oil. Effective against scale and red mite at the delayed dormant stage, but only partially effective against aphis. "Superior" type oils are paraffin base oils of the following specifications: viscosity (Saybolt at 100 degrees F.), 90-120 secs.; viscosity index (Kinematic), 110 minimum; gravity (A.P.I. degrees), 32 minimum; unsulfonated residue, 90-92; pour point not greater than 30 degrees F.; homogeneity, a relative narrow boiling distillate portion of petroleum.

DN. Dinitro-*o*-cresol, sodium or other salt. Marketed usually as a 19 per cent solution, sometimes as a 40 per cent dry mixture. Useful against aphid eggs and hibernating bud moth larvae (2 to 4 quarts per 100 gallons). Also used to some extent for spraying the ground against scab; not 100 per cent effective, but of some value.

Butyl DN. Triethanolamine salt of dinitro-*o*-*sec*butylphenol. More effective against mites than DN, but not quite as good as oil. Kills both aphis and mites which ordinary DN does not; promising for scale insects. Use 2 quarts to 100 gallons.

Lime sulfur. No longer used extensively. Effective against scale. Requires nicotine for aphis; of little value for mites. Formerly used at 8 to 10 gallons per 100 as a dormant spray, the dilution depending in part on the specific gravity. Lime sulfur is also a fungicide.

Summer Sprays

These are stomach poisons, contact poisons or combinations.

Lead arsenate. Standard insecticide until the discovery of DDT. Now being replaced to some extent, but still used extensively. Dilution 2 to 3 pounds per 100 gallons. Most common form is acid lead arsenate, the basic lead arsenate being less effective.

DDT. Dichlorodiphenyltrichlorethane. Marketed as a 50 or 75 per cent wettable powder, also in emulsions, pastes and solutions. Powder is most used in orchards. Valuable for codling moth and Japanese beetles, but influx of mites following full schedules demands caution. Also, failure to control red-banded leaf roller necessitates partial substitution of other compounds or continued use of lead arsenate. Kills apple maggot flies readily but generally used in combination with lead arsenate for that insect. Dilution 2 pounds (50%) to 100 gallons.

TDE or *DDD.* Dichlorodiphenyldichloroethane. Very similar to DDT and marketed also as a 50 per cent wettable powder, but more effective against red-banded leaf roller. Has about the same killing power for apple maggot flies as DDT. Only partially effective against the plum curculio. Dilution usually 2 to 3 pounds per 100 gallons.

Chlordane. 1,2,4,5,6,7,8,8-Octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane. Marketed as a 40 to 50 per cent wettable powder and useful against the plum curculio and early leaf feeders. Especially useful for interplanted peaches and apples where it is necessary to avoid lead arsenate (this is true under our conditions). Dilution 2 to 3 pounds to 100 gallons. Not safe on all varieties of plums.

Methoxychlor. 2,2-bis-(*p*-methoxyphenyl)-1,1,1-trichloroethane. Generally marketed as a 50 per cent powder. Much less toxic to man than DDT, DDD or chlordane. Effective against plum curculio. Very effective against Japanese beetles and kills maggot flies readily. Useful as a late season spray because of its low poison hazard. Dilute 3 pounds to 100 gallons.

Aldrin and *Dieldrin.* Two very promising chlorinated compounds. Effective against plum curculio and others. Experimental phase not yet complete.

Nicotine sulfate. Still a valuable contact for aphis, leafhopper and others. Commonly diluted to 1 pint of the 40 per cent to 100 gallons.

Parathion. See below under "Miticides."

Summer Miticides

Many different products are being offered for mite control but their relative efficiencies have not been fully determined.

Notes on Chemicals

Parathion. O,O-diethyl-O-*p*-nitrophenyl thiophosphate. Marketed as a 15 per cent powder. Originally advocated as a miticide, parathion has proved to be an almost universal insecticide. Its rather short period of effectiveness after being sprayed is its main limiting factor. Effective against live mites at ½ to 1 pound per 100 gallons; will kill hatching larvae (not the eggs) at the higher dose. Will injure McIntosh, Cortland and related varieties if used early in the season (to June 15). Recent investigations indicate that a large part of the injury can be prevented with activated charcoal. Very toxic to man and the operator should protect himself from the spray with respirator, gloves, etc.

TEPP. Tetraethyl pyrophosphate. Marketed as a 20 per cent tetraethyl pyrophosphate, 30 per cent related phosphates or just double each of the above, 40 and 60 per cent. Recommended as a killing agent for live mites, not for eggs. Breaks down rapidly in solution and lasts only a few hours. Less injurious generally to foliage than parathion. Keep the concentrate off the skin and protect the operator from spray the same as for parathion. TEPP is fully as toxic to man as parathion. For dilution follow manufacturer's recommendation.

EPN 300. Ethyl *p*-nitrophenylthionobenzene phosphonate. Very similar to parathion, both in insecticidal action and injury to McIntosh or related varieties. Advertised to have longer residual action than parathion. Dilution recommended, ½ pound to 100 gallons. Protect the operator against the spray. Not quite, but nearly as toxic as parathion.

Dimite. Di-*p*-(chlorophenyl)-methylcarbinol. Marketed as a 25 per cent self-emulsifying liquid. Very effective against live mites; partial kill of two-spotted mite eggs. Dilution 1 pint to 100 gallons. Not dangerous to handle like the phosphates. Caution on compatibility with other insecticides or fungicides.

DN-111. Dinitro-*o*-cyclohexylphenol, dicyclohexylamine salt. Marketed as a 20 per cent powder. Very effective against the European red mite at 1¼ pounds per 100 gallons, partially so for the eggs. Dangerous to trees in hot weather, 80 degrees F. or above. Many incompatibilities with other sprays. Safe with ferbam. Not dangerous to handle like the phosphates.

Aramite. β-chloroethyl-β(*p-tert*butylphenoxy)-α-methyl ethyl sulphite. Marketed as a 15 per cent wettable powder. Very effective against live mites but not eggs. Different residual action in different parts of the country noted, less effective in the East. Relatively nontoxic to man and compatible with most insecticides and fungicides. Apparently more effective in warm weather. Use 1 pound (15%) to 100 gallons.

White summer oil. Highly refined mineral oils with low unsulfonatable residue. Commonly used at 1 per cent, but cannot be used with the chlorinated hydrocarbons, such as DDT, methoxychlor or DDD. Late sprays after August 1 should also be avoided because of the effect on fruit finish.

Stickers

Bentonite-skim milk. One of the best adhesives that we have tried. White mineral oil may be added and emulsified in the spray tank. Oil increases both adhesion and deposit. Ingredients with a small amount of oil may be mixed together dry with lead arsenate, ferbam or thiram. With added oil, not compatible with sulfurs or chlorinated hydrocarbons. Usual amounts are 2 pounds bentonite, ½ pound skim milk and 1 quart of white summer oil to 100 gallons.

Soy bean flour. Not quite as good as the above from the sticker standpoint, but useful in many situations. Compatible with most insecticides and fungicides. High oil content desirable. Soy bean flour also has some spreading properties.

Oils. Oils of 60 to 80 secs. viscosity, similar to the white oils mentioned under miticides, as well as certain vegetable oils, such as soy bean or raw linseed, are good stickers. Fish oils were used at one time. Our experience indicates that under Connecticut conditions any oil-lead arsenate combination without some buffering agent, such as bentonite, will give delayed foliage burn which may result in partial defoliation. It is also inadvisable to use any oil sticker with chlorinated hydrocarbons as mentioned above.

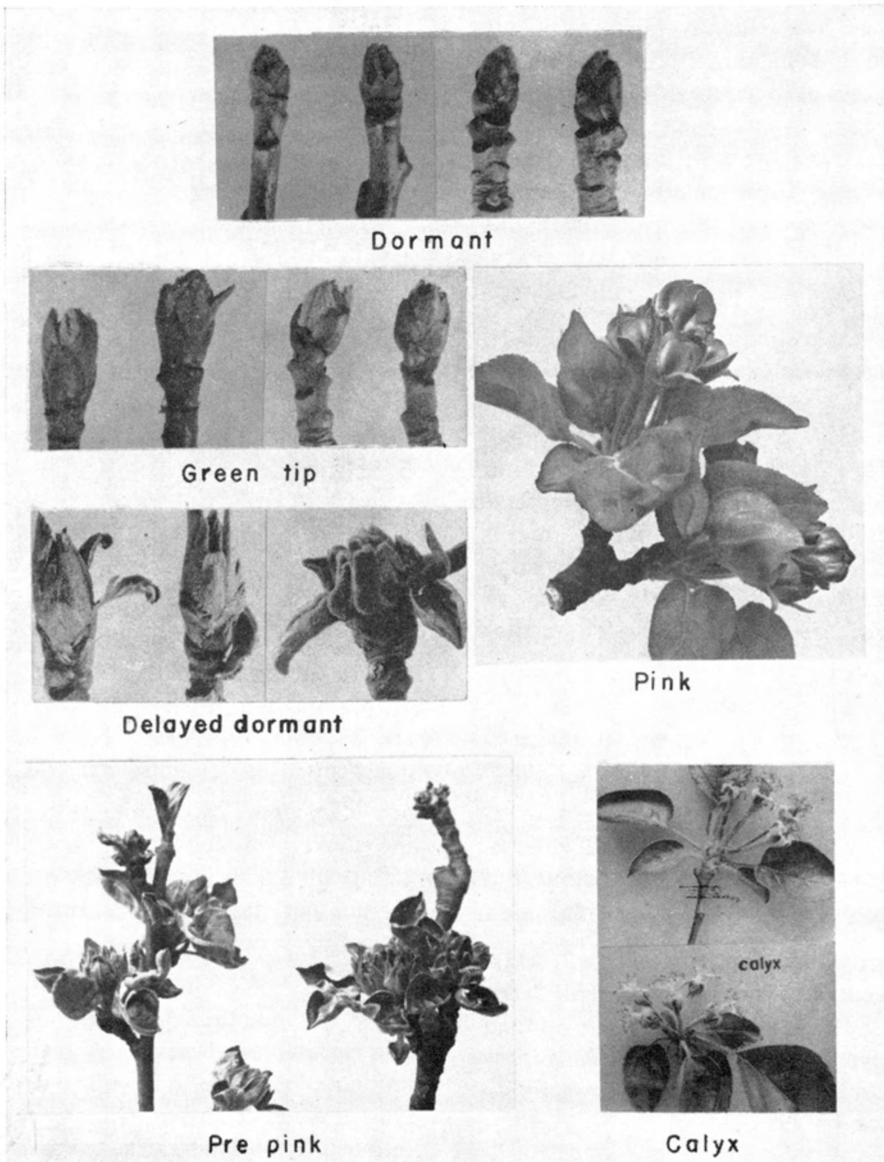

Figure 71. Bud and leaf development at the various stages for timing apple sprays.

Notes on Chemicals

Injurious Combinations

Compatibility of many of the newer spray chemicals is only partly known for New England. Rather than a complete chart, a few combinations known to be dangerous to foliage or fruit are given below. Included are several fungicides, since fungicides will of necessity have to be used in the spray mix.

Spray	Combination to Avoid	Reasons	Use
Calcium arsenate	Avoid entirely.	Leaf yellowing and drop.	Do not use on apples in Connecticut.
Bordeaux mixture	"	Fruit russetting.	" " " "
Zerlate	"	" "	" " " "
Summer oil	DDT, DDD, methoxychlor. Sulfur in any form.	Leaf burn and fruit injury.	Can be used with ferbam or thiram, and lead arsenate (with buffers such as Wyoming bentonite).
Lime	DDT, DDD, methoxychlor, ferbam, chlordane, parathion.	Increased foliage burn.	Best for safening lead arsenate-sulfur sprays.
DN's (summer)	Wettable sulfur (and other sulfurs), rotenone, nicotine, DDT.	Increased foliage burn.	Best used alone in cool weather, not over 80° F.
Phenyl mercurys	Lead arsenate, DDT, chlordane, parathion, summer oils, dinitro compounds. Questionable with ferbam.	Increased yellow leaf, or reduced efficiency.	Best used alone or with fertilizer sprays such as "Nu-green" Urea.
Lead arsenate	Questionable with the phosphates, such as TEPP or parathion.	Increased leaf burn. Fruit russetting.	Best with sulfur or ferbam. Safe with rotenone, nicotine and many others. Use sparingly on Red Delicious.

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