Leaf Miners and Their Control

JOHN C. SCHREAD

Pupae skins of the boxwood leaf miner protrude from underside of leaves.

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Foreword

As of January 1, 1971, materials mentioned in this Bulletin that have been registered for use against insects on plants were as follows: Lindane, malathion, Sevin, diazinon, Baytex, Di-Syston, Dylox, Cygon, nicotine sulfate, and Thiodan.

The unregistered materials—Dibrom, Gardona, Imidam, Baygon, and Dursban—were used as experimental insecticides. They may or may not be registered in the future for use in control of leaf miners.

Contents

Birch Leaf Miner	6
Holly Leaf Miner	9
Arborvitae Leaf Miner	13
Azalea Leaf Miner	14
Oak Leaf Miner	15
Columbine Leaf Miner	17
Boxwood Leaf Miner	17

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Introduction

Leaf miners are small insects which feed between the surfaces of leaves. Here the larvae spend most of their time and obtain all of their food.

There are many species of leaf miners, occurring in four major orders of insects. Their presence is recognized by whitish blotches, or dark grayish to white serpentine mines, or winding trails in the upper surface of infested leaves. Injured foliage may lose its vigor and ultimately be reduced in size, with loss of its usual healthy color.

Eggs are laid either in the leaf tissue or on the surface of the leaves. When laid externally, the larvae may hatch through the lower area of the egg which is in intimate contact with the surface of the leaf, thereby entering the interior of the leaf without feeding on its surface. Control of the insects under these conditions presents a problem in the use of sprays.

Studies of leaf miners and their control have been pursued at this Station for 75 years. Britton (1) was one of the first entomologists to describe the appearance and habits of the columbine leaf miner in 1894. His contribution to the subject continues to be useful to all interested in columbine.

This Bulletin reports on more recent observations and studies of control measures that can be used if required.

Early Control Measures

Suggested spray remedies for control of leaf miners during the late 1900's were meager and often hazardous to plants. Picking and destruction of infested leaves in addition to killing the miners with a sharply pointed knife or needle were safer techniques, but time-consuming tasks. Later, nicotine sulfate and molasses were used to control boxwood leaf miner (2). Nicotine sulfate was used alone to control birch leaf miner (3).

During the last 15 years a number of publications have been issued on the subject by this Experiment Station (4). Lindane, malathion, Dibrom®, Sevin®, Thiodan®, and diazinon were among a number of insecticides indicated as effective in controlling leaf miners in trees, shrubs, and flowers.

Recently Developed Pesticides

Pesticides introduced since 1960 have given promise of considerable value for control of leaf miners when used as foliar sprays. In addition, several materials specifically intended as systemics were shown to be effective when used as soil treatments. They were injected into the soil or applied to the surface of the ground under the plants, absorbed by the roots, and translocated through the sap stream to the foliage. This process resulted in the destruction of leaf miners before they caused serious injury to the leaves.

BIRCH LEAF MINER

Since the birch leaf-mining sawfly (*Fenusa pusilla*) was first discovered in this country in Connecticut in 1923 (5), it has been a major pest of gray birch (*Betula populifolia*), white birch (*B. pendula*), paper birch (*B. papyrifera*), and cutleaf varieties of the European white birch (*B. alba*). Other birches, notably the red or river birch (*B. nigra*), may show some injury occasionally, but damage is never serious.

There have been cycles of abundance when the foliage of most susceptible birches was seriously damaged, to the extent that all of the leaves on some trees were completely browned by the sawfly larvae. These seasons were usually followed by one or two seasons of less abundance.

The first generation of birch leaf miner usually causes more damage than the later ones. This pattern, however, was reversed during the spring and early summer of 1967, when cold, wet weather persisted until late June. The first generation was late and noticeably sparse in May and June. Adult leaf miners were not observed at Mt. Carmel until May 5 (in 1958, an average season, they were numerous on April 22). Adults and egg punctures were present on May 16; however, none of the eggs hatched. A similar situation prevailed on May 22 and only a few very small mines could be found on May 31. These observations were a contrast to the season of 1965 when birch foliage was heavily infested with eggs and small mines on May 10.

Although comparatively light, the second generation of miners in 1967 was heavier than the first. Unless favorable growing conditions prevail, the second generation in late June and early July is always the lightest.

Life History and Habits

The birch leaf miner overwinters in the soil beneath the trees. It transforms to the adult stage in the spring. Adults have been observed in April in the warmer areas of the State. They may be delayed for a few days to a week or longer in the normally cooler areas.

The adult sawfly is black and about 1/16 inch long. Eggs are laid in the unfolding young leaves and usually larvae have started feeding by the time the leaves have developed. At first the injured areas appear

blanched and later, blotchy and brown. Mature larvae emerge from the leaves and drop to the ground where they enter the soil to pupate. Adults of the first generation appear after mid-June. The summer generations are usually of little consequence because there are few unfolding leaves at this time.

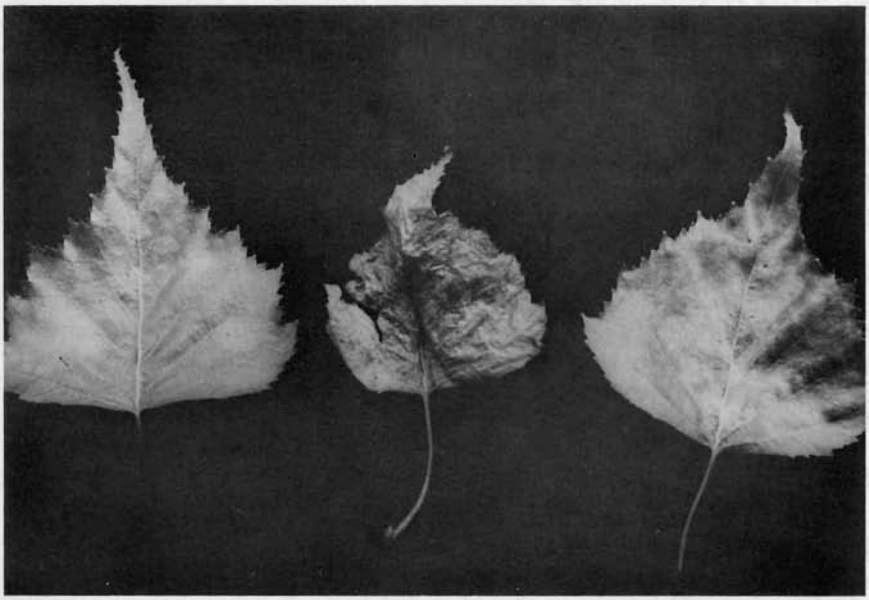

Fig. 1. Birch leaves injured by the birch leaf miner.

Spray treatments

Although a number of insecticides have been used during the last 10 years as foliar sprays to control birch leaf miner, only six will be included here. Baytex® and Dibrom were used during the latter part of May at the rate of ½ and 1 pint in 100 gallons of water. During July Gardona® and Dylox® were used at 2 and 4 pints, Imidan® at 1 pound, and Cygon® at ¼ and ½ pints in 100 gallons of water. Triton B1956® was added as a wetting agent to all prepared sprays. Complete control of the first generation of leaf miners was obtained with Baytex and Dibrom. They did not control the second generation in late June and July. This generation was, however, controlled with Cygon at ¼ and ½ pints, Gardona or Dylox at 4 pints and 1 pound of Imidan. Two pints of Gardona or Dylox were less effective. The treatments caused no visible injury symptoms.

Soil treatments

A number of systemic insecticides applied as granules to the surface of the ground, sprayed as liquid concentrates in solution on the surface

of the soil, or injected into the root zone of treated trees have proven highly effective in controlling birch leaf miner.

Surface granules treatment

Cygon and Baygon® 5% granules were used during the last week in April and Di-Syston® 10% granules in early June as surface treatments under white birch trees at the rate of 1.5, 3, and 6 oz of Cygon and Di-Syston, and 1, 2, and 4 oz of Baygon per inch of tree diameter measured 3 feet above the ground. The granules were applied by hand from the base of the trees to their dripline. They were not raked into the sod in which the trees were growing nor was water used as a drench. Rainfall provided all of the water that was needed for penetration of the systemics to the roots of the trees.

Cygon used at the rate of 3 and 6 oz per inch of tree diameter, and Baygon used at all rates, gave complete control of the first generation of leaf miners, whereas the low rate of Cygon was less effective. Seventy to ninety per cent of the second generation (in early July) was controlled by Cygon. All three levels of Baygon controlled this generation. Di-Syston gave 100% control at the two highest dilutions and 96% at the lowest.

Soil drench

During the onset of the second generation of birch leaf miners, on June 22, 43% Cygon emulsion was used as a surface soil drench at the rate of 1, 2, and 4 pints per 100 gallons of water (1, 2, and 4 teaspoons per 1 gallon). The trees used in the test were 1-inch caliper European cutleaf white birches. Three gallons of drench were used per tree applied from base to dripline. Control data taken on July 16 showed that all miners were dead at all dilutions of the systemic. Occasionally in some birch trees, Cygon may cause slight injury symptoms visible as marginal leaf burn at the tips of fast growing twigs in the top of a tree.

Injection treatments

On May 1, 1962, Cygon was injected into the root zone of 1¼-inch caliper European cutleaf white birch trees at the rate of 1 pint of 43% liquid concentrate emulsion in 50 gallons of water. A 150-gallon hydraulic sprayer was used for this purpose. Pump pressure was maintained at 200 pounds. A 3-foot T-shaped injection needle with 13/16-inch outside diameter and two opposite ⅛-inch openings (1 inch from its tip), was used to make the injections. A hand shut-off valve permitted timing each injection to an average of 3 seconds. One circle of injection holes, 4 to 8 inches deep and 18 inches apart were made at the periphery of the trees. Six trees were treated and six left untreated.

In an additional experiment undertaken on May 1, two large clumps of native gray birches were treated with Cygon injected into their root zone. The rate of treatment was the same as above; however, because

of its size, one clump with a total caliper of 18 inches received two concentric circles of injection holes, the second was spaced 18 inches from the outer one towards the base of the tree. The smaller clump (total caliper 6 inches) received only one circle of injection holes.

Combined control data taken for the first generation of leaf miners on June 6, showed an average of 456 dead miners in a range of 370 to 620, and no live ones in a 50-leaf sample taken at random per test area. There were 522 live and no dead miners in a similar leaf sample taken from the untreated trees.

Control of the second generation on July 11 was 96% in the cutleaf white birches. Complete control was obtained in the clump having a total caliper of 6 inches, only 82.3% control in the clump with 18 inches of total caliper.

Examinations made on June 20 of the following year (1963) indicated 44% overall control of the first generation. Obviously a single Cygon treatment was not highly effective the following year.

HOLLY LEAF MINER

Although it has been reported that the holly leaf miner, *Phytomyza ilicis* (Curt.) attacks English holly in the United States, the varieties of English holly growing in Connecticut have not been infested. The American or Christmas holly, however, may be seriously infested year after year by this troublesome pest.

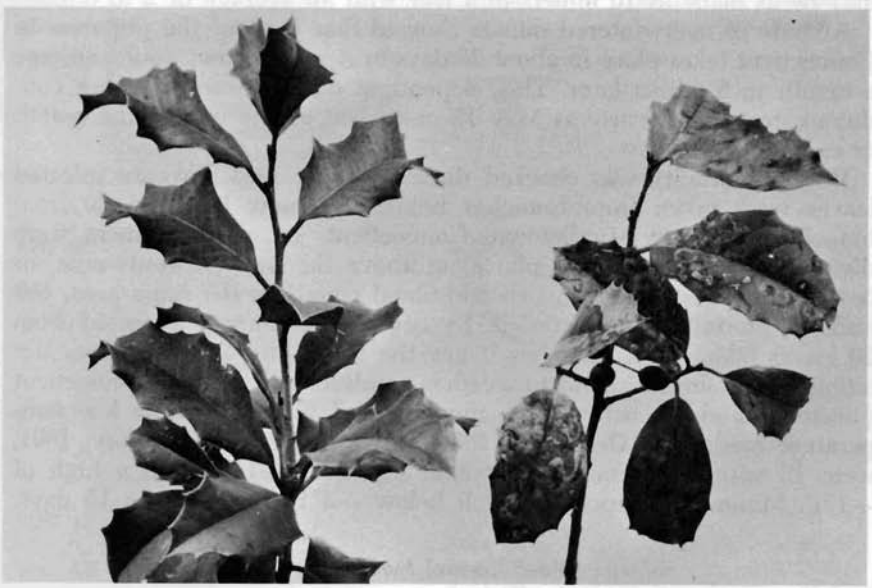

Fig. 2. The light-colored blotches in leaves on the right show holly leaf miner injury compared with uninjured foliage on the left.

Perhaps the confusion relating to the species of holly attacked by the leaf miner may be explained by the fact that there are two recognized species of holly leaf miner, the European species *Phytomyza ilicis*, and the American one, *P. ilicicola*. Under most conditions in the Northeast, the former species is seen more often in the American holly than the latter. Both species, however, cause an undesirable appearance in new leaves.

Life History and Habits

For the most part the habits of the two species are the same. There is only one generation a year. The small black flies vary from 1/32 to 1/16 inches in length. Emergence takes place through the upper surface of a leaf in the second season after mining the foliage. For a week or ten days before egg laying, the females use their ovipositor to puncture the tissue in the upper surface of newly forming leaves with most of the punctures being near their edges. Both females and males feed on the juices which exude from the wounds. Leaves seriously damaged in this manner frequently become stunted and badly distorted.

P. ilicis lays its eggs in small slits or punctures in the lower surface of the newly developing leaves, whereas *P. ilicicola* may deposit some of its eggs in the feeding punctures. The small, flattish, yellowish maggots mine between the upper and lower surfaces. At first they form almost inconspicuous winding tracings. Later, as they grow longer, the mines of *P. ilicis* broaden out and become more noticeable, ending in irregular blotches, whereas those of *P. ilicicola* are longer and slender (6). There may be as many as 16 miners in a leaf with an average of 2 to 3.

A study of overwintered miners showed that most of the pupation in Connecticut takes place in about 20 days in April and that adults emerge a month to 6 weeks later. This, depending on prevailing weather conditions, may be as early as May 15 or as late as the end of the month or early June.

Winter mortality was checked during March, 1961. Twenty infested leaves were taken from branches below the snow line and 20 from branches above in Middletown, Connecticut. In all, 50 miners were dissected from the leaf sample taken above the snow. Twenty-nine, or 58% of them were dead. In two additional counts in the same area, 66% and 83% mortality was recorded. By contrast, 41 miners dissected from 20 leaves taken from branches below the snow line were all alive. Relating these mortality data to weather conditions in central Connecticut (Brainard Field, Hartford) the number of days of unusually low temperature reading in December, 1960, and January and February, 1961, were 15 with an average of −5.8°F, a low of −17°F and a high of −1°F. Minimum temperatures fell below −3°F on 10 of the 15 days.

Older Control Measures

Infested holly leaves may drop to the ground before the adult leaf miners emerge. It has been suggested that the leaves be gathered up

and destroyed by burning or burying. Nicotine sulfate used several times during June and July killed the adults and small miners. More recently diazinon was shown to be effective in controlling adults in June. Furthermore, lindane was highly effective in killing immature miners in July. Overwintered miners were not killed by lindane, whereas Dibrom was effective for the purpose (Schread, 1953 and 1961).

Spray treatments

During the last 10 years newer pesticides have been used in tests to control the holly leaf miner. The problem was approached at three different times during the growing season. The first series of spray materials were applied to infested holly trees in April. They were intended to kill the overwintered larvae in the leaves. The second series of test materials were used in May. They were intended to kill the holly leaf miner adults, thereby preventing infestation of new foliage. Finally, materials were sprayed onto new infested foliage in July and August to kill young miners. The results of these tests will be found in Table 1.

Cygon and Baytex were highly effective in controlling overwintered larvae in early April. Cygon and Sevin controlled the adult population

TABLE 1.—*Holly leaf miner control*

Date of Treatment	Material & rate/100 gal	Control Date	Live miners per 20 leaves	Per cent kill
	Control of overwintered larvae in April			
April 1	Cygon ⅛ pt	Apr 26	8	84.9
	Cygon ¼ pt	Apr 26	0	100
	Baytex 1 pt	Apr 26	1	85.7
	Baytex 2 pt	Apr 26	0	100
	Unsprayed check		46	
	Control of adults in May and June			
May 16	Dibrom 1 pt	Aug 26	370	26.0
	Dibrom 2 pt	Aug 26	294	41.2
	Baytex 1 pt	Aug 26	114	77.2
	Baytex 2 pt	Aug 26	82	83.4
	Cygon 1 pt	Aug 26	139	72.2
	Cygon 2 pt	Aug 26	46	90.8
May 25	Sevin 2 pt	Aug 26	136	93.2
	Unsprayed check		500	
	Control of immature miners in new foliage during the summer			
Aug 12	Cygon ½ pt	Sept 20	0	100
	Cygon 1 pt	Sept 20	0	100
Aug 18	Baytex ½ pt	Sept 20	38	73.6
	Baytex 1 pt	Sept 20	8	88.4
	Unsprayed check		103	

in late spring and early summer, thus preventing miner injury to new foliage. Baytex was somewhat less effective and Dibrom was ineffective for the purpose. Cygon was excellent in killing immature miners in holly leaves in mid-summer whereas Baytex was less effective. Sevin, Baygon, and Dylox when used at the rate of ½, 1, or 2 pints in 100 gallons of water gave average controls of 3.8%, 4%, and 9.2% respectively.

Soil treatments

Several systemic insecticides have been used as granules on the surface of the soil under holly trees to control leaf miners. The method of treatment was the same as described for birch leaf miner.

On July 23, 5% Cygon granules were spread under 48-inch holly trees at the rate of 4 and 8 oz of formulation per tree. In addition, on August 1, 5% Baygon granules were used under 32-inch holly trees at the rate

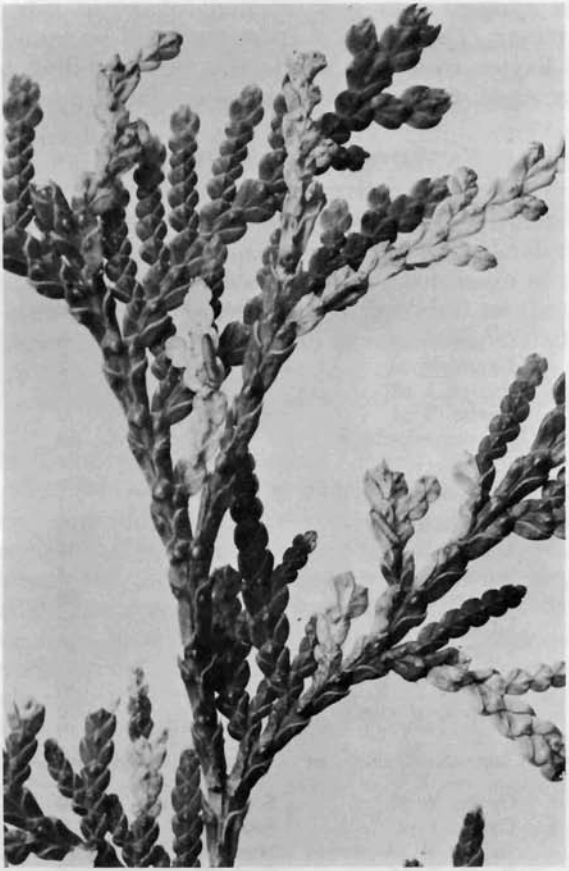

Fig. 3. Light-colored areas indicate feeding by the arborvitae leaf miner.

of 1, 2, and 4 oz of formulation per tree. In both instances the granules were raked lightly into the soil. No watering was done. Control data were obtained on September 2 and November 30 respectively for both materials, by dissecting 20 leaves per rate of treatment and untreated checks. Cygon controlled the miners completely with the two rates of treatment. The 4 oz rate of Baygon gave 85% control, but the two lower rates were ineffective.

ARBORVITAE LEAF MINER

There are a number of species and many varieties of arborvitae (*Thuja* spp.). The species most commonly grown in Connecticut is the American arborvitae, *Thuja occidentalis.* Horticultural varieties of this species are numerous. Many are used as specimen plants or in hedges. All appear to be attacked to a greater or less extent by the arborvitae leaf miner, *Argyresthia thuiella.* At first, infestation may cause yellowing of the terminals of the branches. Later the mined areas become light brown or blanched in appearance. Injury may often be more serious where the plants are growing in partial shade.

Life History and Habits

There is one generation of leaf miners a year. The insects overwinter as partly grown larvae in mines formed during the previous summer. A study made in the late 1950's showed that all miners were in the larval stage in early April. A month later 75% were prepupae. By the third week in May 60% had pupated. Thirty-three per cent had emerged as adults by June 3 and all were out of the mines and had oviposited and died by July 1. A different situation prevailed during the cold, wet spring and early summer of 1967. On June 6 of that year in Hamden, 55% were still in the larval stage on June 6, 33% were pupae and 12% were prepupae. None had emerged as adults.

Moths average ⅜-inch in wingspread. They are grayish in color with small but conspicuous silvery markings. They lay their greenish eggs between the tip of one leaf scale and the base of an adjoining one. On hatching, a larvae enters a leaf scale from the inserted end of the egg. In an area of heavy infestation there may be as many as 5 miners in an average 3½-inch twig.

Control

Several insecticides were shown to be effective in controlling the moths of the arborvitae leaf miner in June: Sevin, malathion, and lindane. Moreover, with the exception of Sevin, these materials, in addition to diazinon, will control the miners during the summer months. In a test several years ago, 50% Gardona was sprayed onto infested arborvitae foliage on April 8 at the rate of ½ or 1 pint in 100 gallons of water. Control data taken on April 25 showed that 96.8% and 100%, respectively,

of the miners had been killed by the insecticide. Untreated foliage had 76 live miners per ten 6-inch twigs.

Cygon 48% emulsion was used on May 22 at the rate of 1 pint in 100 gallons of water. About 75% of the leaf miners were in the prepupa and pupa stages at the time of treatment. A check on the effectiveness of the insecticide on May 27 indicated 25% mortality. It was clear that only larvae were killed, prepupa and pupa were not. An early May treatment could have given complete control of the pest. No visible injury symptoms were observed.

AZALEA LEAF MINER

The azalea leaf miner (*Gracillaria azaleella*) appears to be less abundant at the present time than it was 5 to 10 years ago. There was a time when almost every leaf on the evergreen varieties and some of the deciduous ones, growing outdoors and in greenhouses, would be mined and skeletonized. The insect is a native of Asia and was introduced into the United States from Europe before 1910 (7).

Injury to azaleas is due to larvae mining the leaves and skeletonizing the inside surface of their turned-over tips and edges. The folded areas of the leaves are always to the underside and are held in place by fine silken strands. These areas soon dry out, turn brown, and become brittle. Injured foliage may have a yellowish appearance with some premature dropping from the plant. Because of the importance of many varieties of azaleas as flowering evergreens, control of the leaf miner during years of abundance is important.

Life History and Habits

The azalea leaf miner is a small yellowish larvae usually about ½-inch long when fully grown. About one-fourth of the feeding stage is spent in the gallery mined between the upper and lower epidermis of the leaf (8). Large-leaf varieties of azalea often have two mines and may have three or four. The small-leaf varieties usually contain one mine and rarely two. The terminal feeding period is within the folded areas of the leaves. Pupation takes place within a silken cocoon on the underside of the leaf. The adult measures about ⅜-inch in wingspread. The forewings are yellowish with purplish areas and dots. Creamy white eggs are laid on the underside of a leaf usually near the midrib. Most of the miners overwinter as mature larvae. Adults of the first summer generation appear in late June. There are three complete generations a year.

Earlier Control Measures

Control measures suggested 20 years ago for the azalea leaf miner included dusting infested plants with a mixture of nicotine dust and pyrethrum powder. Two treatments at 30-minute intervals were needed.

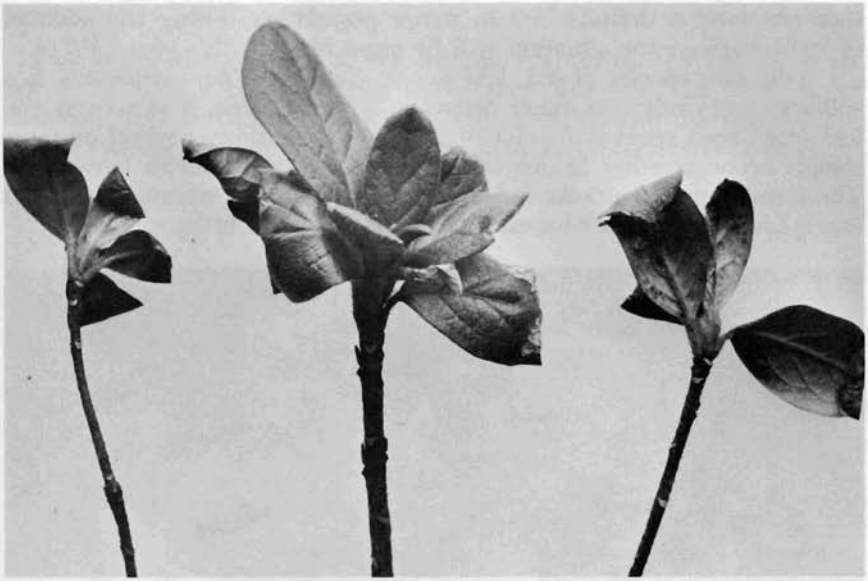

Fig. 4. Tips of azalea leaves folded under by the leaf miner.

The first one stimulated the miners and drove them out of the mines and into the open whereas the second treatment assured their destruction. Later, lindane was effective in killing both adults and miners. Furthermore, experiments carried on at this Station demonstrated the effectiveness of malathion and diazinon in controlling the miners.

Materials Used Since 1960

In 1961, 43% Cygon was used as a foliar spray on July 26 at the rate of ½ or 1 pint in 100 gallons of water (½ or 1 teaspoon per gal.). There were 9 azaleas of 5 varieties in the test. They ranged from 12 inches to 40 inches in height. The July 24, 1962 tests included insecticide Sevin flowable applied to 6 varieties of azaleas at the rate of ½ or 1 pint per 100 gallons of water and the August 1, 1967 experiments demonstrated the effectiveness of 25% Gardona and 40% Dylox applied to two varieties as foliar treatments at the rate of ½ or 1 pint in 100 gallons of water. Control data taken 1 to 3 days after treatments indicated complete control of the miners with Cygon, Dylox and Gardona. Sevin gave 95% kill at both dilutions.

OAK LEAF MINER

Outbreaks of oak leaf miner occur at long and irregular intervals and then for only one or two consecutive years. Outbreak was serious and widespread in 1959 and subsided rapidly the following year. The au-

thor observed a definite rise in miner population during the summer of 1967. Perhaps the situation will be more obvious this year (1971).

Of the two species of oak leaf miner, *Cameraria hamadryadella* is a solitary form—only one miner occurs in a single mine. The second and less often seen species, *C. cincinnatiella,* is gregarious—several or more miners occur together in one large mine, 29 were found in two mines. The former species attacks red, white, and black oak whereas the latter one is found mostly in white oak. Pin oaks seem not to be affected.

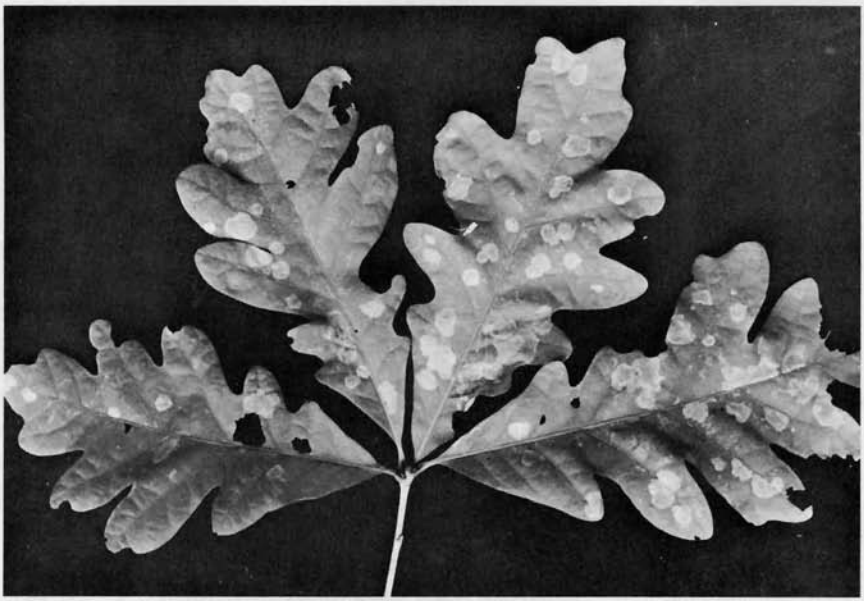

Fig. 5. The light-colored blotches indicate the early feeding stage of the solitary oak leaf miner.

Life History and Habits

There are two or three generations of leaf miners a year. The solitary species overwinters as fully developed larvae and the gregarious one as pupae. The moths are 3/16 to ¼ of an inch long and emerge in May. The wings are slender and are banded with shades of silver gold. The reddish-brown or chestnut colored larvae are very flat. They feed between the two surfaces of the leaves causing whitish blotches as seen from the upper surface.

The first generation feeds during late May and June and the second one during July and early August. The third generation is active from August through September. The number of solitary mines per leaf varies from 1 to as many as 47. Parasitism may be as high as 50% of the larval population.

Control of oak leaf miner

Because of the absence of oak leaf miners during the last 10 years, no recent control test has been undertaken. However, in 1958, Sevin, diazinon, and lindane were used effectively to control the miners. The treatments resulted in significant reduction in miners after 7 days.

COLUMBINE LEAF MINER

The columbine leaf miner (*Phytomyza minuscula*) is a pest of columbine and aster. It is much less destructive in sunny exposures than in shaded ones. Early spring foliage becomes infested by adults that emerge from overwintered pupae. As the season advances a great deal of the foliage on badly infested plants may have light grayish to whitish serpentine mines which are most conspicuous in the upper surface of the leaves. Small whitish maggots feed inside of the mines. There may be as many as 7 per leaf. On reaching maturity they emerge through the lower surface of the leaves, fasten themselves to the leaf tissue at the point of emergence, and pupate. The pupae are light brown to chestnut color and shiny. There may be as many as five generations from mid-May until late September.

Control of columbine leaf miner

The columbine leaf miner may be controlled in the mines with malathion, lindane, diazinon or Cygon sprays. Sevin has given good control of the adults. To obtain seasonal control of the pest, it may be necessary to spray once a month from spring through late summer.

BOXWOOD LEAF MINER

The boxwood leaf miner (*Monarthropolpus buxi* Lab.) has one generation a year. It may attack all varieties of boxwood growing in Connecticut, however, some have been more seriously injured than others. When infestation is permitted to continue, defoliation may occur and part or all of a plant may die or be so badly checked in its growth that it becomes unsightly.

Miners feed inside the leaves causing water-soaked blister-like areas to appear. They are usually light gray to yellowish in color, mostly noticeable on the under surface of the leaves. Leaves are stunted, turn yellow-brown and sometimes drop from the plant prematurely.

Small, midge-like, orange-yellow adults begin to emerge during the latter part of May in Connecticut. Eggs are laid in the new leaves during May and June. At this time small pin-point blotchy areas in the foliage indicate their presence. Feeding continues throughout the summer. Pupation and emergence take place the following spring.

Control

A number of materials, for example, nicotine sulfate, lindane, malathion, Cygon, Sevin, and diazinon have been used as foliar sprays to control boxwood leaf miner. In addition, Cygon soil treatment was somewhat effective for the purpose whereas Di-Syston was not (5).

Several recently developed insecticides were tested in an experiment during 1970. On August 19, Dylox 80% and Baygon 70% wettable powders were used at the rate of 1 and 2 pounds and Dursban 22% emulsion at 1 and 2 pints of formulation in 100 gallons of water. Results of the treatments obtained on October 28 indicated complete control of the pest with Dylox and Baygon at both dilutions. Dursban was 100% effective at the high rate but not at the low one. No visible pesticide injury symptoms developed.

Summary

This publication has presented a description, pertinent notes on habits and results of tests to control common leaf miners attacking ornamental plants. The discussions of individual species include the timing of spraying if it is needed.

The tests of insecticides for sprays add to lindane and malathion, Baygon, Dylox, Cygon, diazinon, Gardona and Sevin as effective for control of many species. These results should simplify the problem of selecting insecticides for use on ornamental plants.

The systemic insecticides offer the advantage of ease of application, and prolonged protection. The results from tests with Cygon, Di-Syston, and Baygon suggest that these systemics may be effective in controlling leaf miners. They are of no more than moderate toxicity to people and can be purchased in diluted form. In applying them, rubber gloves should be worn for protection.

Photos by B. W. McFarland

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