A Pocket Guide for IPM Scouting in Michigan Apples
Michigan State University
Michigan State University Extension
David Epstein; Larry J. Gut; George W. Sundin
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80 pages

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Compiled and edited by:
David Epstein
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Compiled and edited by: David Epstein, MSU IPM Program/Entomology; Larry J. Gut, MSU Entomology; and George W. Sundin MSU Plant Pathology. Plum curculio information written by Mark Whalon, Andrea Biasi-Coombs, Eric Hoffmann, MSU Entomology

Graphic Designer: Joy N. Landis, MSU IPM Program

Contents

Reviewers

MSU IPM Program: Charles E. Edson; ♦MSU Entomology: Andrea Coombs, Doug Landis, Oscar Liburd; ♦MSU Extension: Duke Elsner, Phil Schwallier, Gary Thornton; ♦John Bakker, Westcentral Michigan Crop Management Assoc.; ♦Andy Kahn, independent consultant, Wenatchee, WA.

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Introduction

This scouting guide was designed as a pocket field book for easy use in the orchard.It provides information to help identify pests, beneficials, and pest damage; and guidelines for monitoring and thresholds. The guide is a field supplement to the more comprehensive references listed below. As advances in knowledge and technology make new information available, we intend to print updates on sheets that can be attached to the blank pages at the end of the guide.

Suggested reading

Common Tree Fruit Pests. 1993. A.J. Howitt. MSU Extension publication NCR 63. 252 pages.

Diseases of Tree Fruits in the East. 1996. A. Jones and T. Sutton. MSU Extension publication NCR 45. 95 pages.

Integrated Pest Management for Ontario Apple Orchards. B Solymar. Publication 310, Ministry of Agriculture, Food, And Rural Affairs. 230 pages.

Natural Enemies Handbook. 1998. M.L. Flint. University of California Statewide Pest Management Project, Publication 3386. University of CA Press. 154 pages.

Orchard Pest Management. 1994. E. Beers, J Brunner, M. Willet, and G. Warner. Good Fruit Grower. 276 pages.

Codling moth -- *Cydia pomonella*

There are typically two generations of codling moth (CM) per year in Michigan, with a partial third generation in exceedingly warm years.

Adults are about 9 mm in length, with alternating bands of gray and white, and a patch of bronze scales at wing tips.

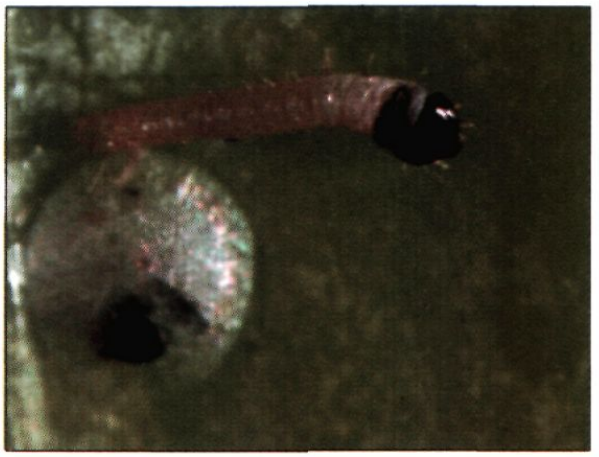
9 mm

The mature larva is about 15 mm in length and is creamy white tinged with pink.

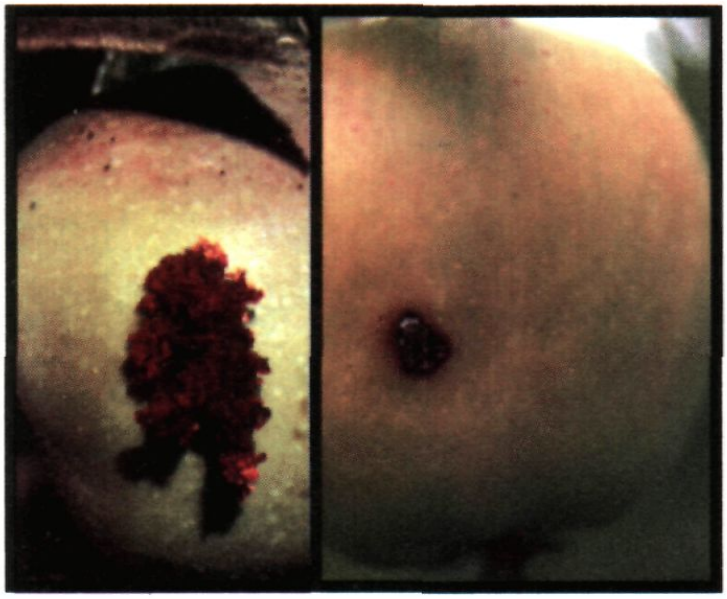
15 mm

Newly hatched larvae like the one below, are white with black head capsules and are about 2 mm long. **2 mm**

Fruit injury caused by CM is of two types. A deep entry is where the larva enters into the center of the fruit and feeds on seeds. (See page 7 for a comparison with Oriental fruit moth.)



Codling moth -- *continued*



Deep fruit entry with frass extruding on left, CM sting on the right

Brown frass can usually be seen extruding from the entry hole. A sting is a shallow entry where the larva does some feeding but does not gain entry into the fruit.

Suggested monitoring: Use of one trap for every 2 to 2.5 acres is optimal; 1 trap per 5-8 acres is acceptable in large, uniform blocks. Use high load (10X) lures in mating disruption block traps; use standard (1X) in non-mating disruption block traps. If using red septa lures, replace them every 3 weeks first generation; every 2 weeks second generation. Other lure types are available. Some will last for an entire generation. Check with manufacturers to determine replacement intervals. Fruit should **always** be visually inspected in conjunction with trapping. Concentrate visual inspections in the upper canopy and along orchard borders.

Suggested thresholds: A cumulative catch of 3-5 codling moths **in any one trap over time** may indicate the need for a spray (see table with explanation below). Do not total captures from more than one trap to attain the threshold.

Example of determining codling moth cumulative trap catch

	Number of moths trapped			
	Week 1	Week 2	Week 3	Week 4
Trap 1	0	2	2 (4 cumulative)	2 (6 cumulative)
Trap 2	1	1 (2 cumulative)	1 (3 cumulative)	2 (5 cumulative)

When traps are first placed in the orchard, they should be checked twice weekly. **First sustained moth capture** is the date at which the first moth is trapped, provided moths are captured on two successive trapping dates.

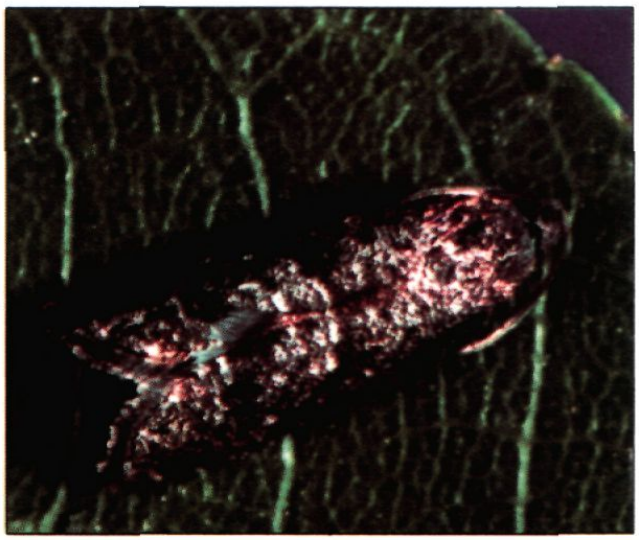
If using a low rate of mating disruption (<275 dispensers/acre), plan on first cover at 250 GDD past biofix.

Codling Moth Action Thresholds

GDD Base 50 (Post Biofix)	Event	Action
Pink bud	Development of overwintering larvae	Set traps
0 GDD = **Biofix** (~200 DD° after Jan 1)	1st sustained moth captures (see explanation on previous page)	Set GDD = 0 This is **biofix**
250 GDD	Start of 1st generation egg hatch	First treatment if over threshold
1000 GDD	Expected end of 1st generation activity	
1200-1250 GDD	Start of 2nd generation egg hatch	First treatment if over threshold
2100 GDD	Expected end of 2nd generation activity	

Oriental fruit moth -- *Grapholitha molesta*

Three full generations of Oriental fruit moth (OFM) occur in Michigan, and sometimes a partial fourth.



Adults are about 5 mm long, gray-colored with wavy, light lines on wing surface.

5 mm

Mature larva is about 10 mm long, creamy-white to pink, with a brown head capsule. Anal comb is present.

10 mm

Suggested Monitoring: Use 1 trap per 10 acres to determine biofix for each generation. Time treatments for 250 degree days base 42, past biofix.

Oriental fruit moth -- *continued*

The following OFM degree day model provides the predicted egg hatch time periods for all three generations of OFM. Please note that this model is **base 45**. Treatment thresholds based on trap catch, as with codling moth, have not yet been developed. Where warranted, first control measures should be timed for the beginning of egg hatch for each generation. Where necessary, additional control measures should be applied according to the expected residual effect of the chosen control material.

Oriental Fruit Moth Degree Day Model

Source: Hull & Krawczyk, Penn State University, 2001

GDD Base 45°F (Post Biofix)	**Event**	**Action**
Half-inch green	Development of overwintering larvae	Set Trap
0 GDD = **Biofix**	1st sustained moth captures (see explanation on page 4.)	Set GDD = 0 This is **biofix**

Table continues on next page.

Oriental Fruit Moth Degree Day Model -- *continued*

GDD Base 45°F (Post Biofix)	Event	Action
150-170 GDD	8-10% 1^{st} generation egg hatch (expected end of 1^{st} egg hatch = 646 GDD)	First treatment if control measure is warranted
1125-1150 GDD	8-10% 2^{nd} generation egg hatch (expected end of 2^{nd} egg hatch = 1950 GDD)	First treatment if control measure is warranted
2250-2280 GDD	8-10% 3^{rd} generation egg hatch (expected end of 3^{rd} egg hatch = 3177 GDD)	First treatment if control measure is warranted

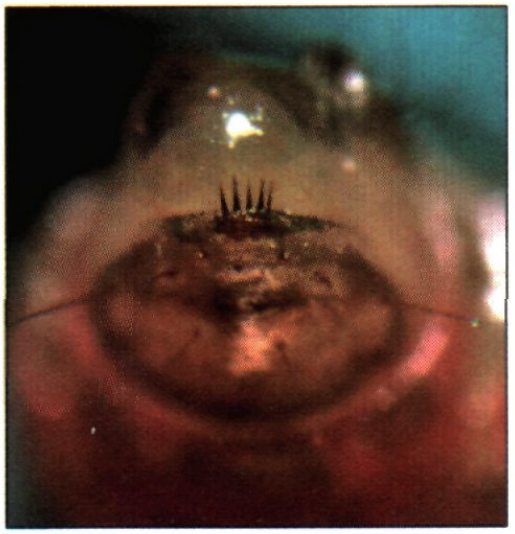
Information above derived from peach data, Hull & Krawczyk. 2001. Penn State University, Penn Fruit News Vol 81(2):23-36

Comparison of codling moth and Oriental fruit moth

Codling moth and Oriental fruit moth larvae cause similar types of fruit damage. Both will enter fruit from either the calyx end or from the side of the apple.

CM feeds in the center of the fruit on flesh and seeds. OFM **generally** feeds on flesh away from the center, but can occasionally feed at the center as well.

Mature larvae of OFM can be differentiated from CM larvae by the presence of an anal comb located ventrally at the posterior end of a larva. The comb can be seen with a hand lens.

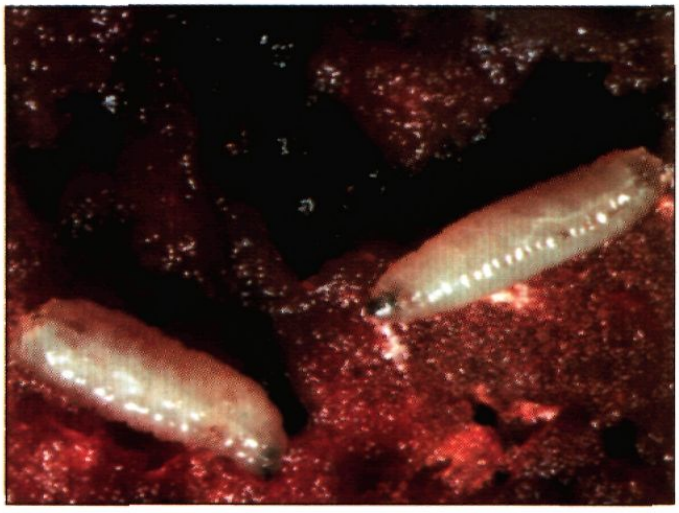


Apple maggot --
Rhagoletis pomonella (Walsh)

The female apple maggot punctures the apple to deposit her egg under the skin, causing the fruit to take on a dimpled, lumpy appearance.

Larval feeding leaves brown trails through the flesh of the apple.

Mature larva is 8 mm long, has no legs, no distinct head capsule, and is creamy-white except for two dark mouth hooks.



8 mm

Apple maggot -- *continued*

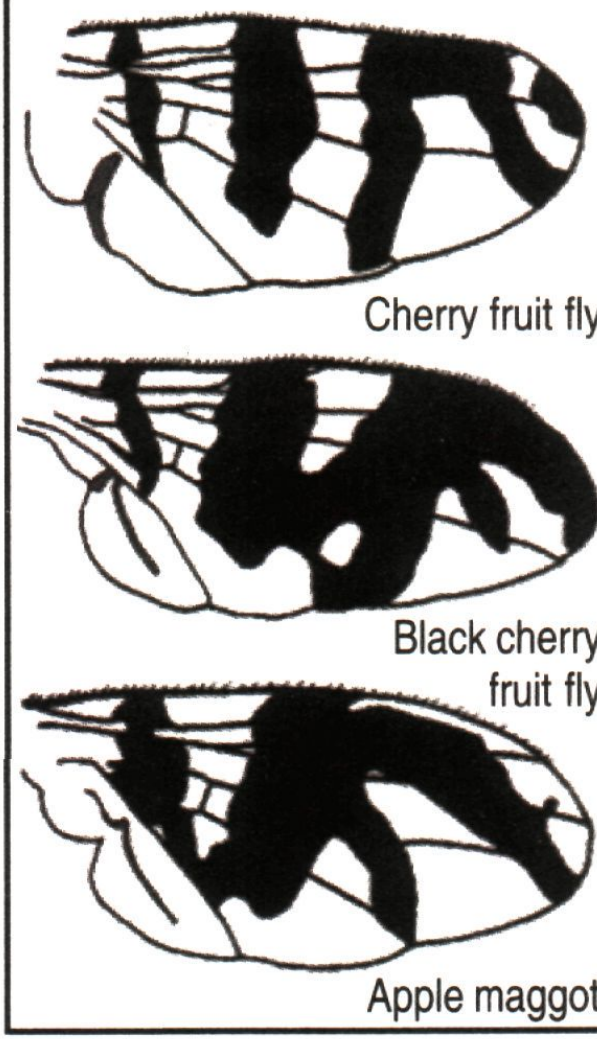
In Southern Michigan, adult emergence begins in late June and continues until September, peaking towards the end of July. In Northwest Michigan, adult emergence typically begins around the second week of July.

6 mm

The apple maggot adult is about 6 mm long with distinctive wing pattern. The black thorax is marked with a dorsal white spot.

Traps should be set in mid-June. First treatments should be made 7-10 days after the first fly is trapped.

Wing banding patterns of deciduous fruit flies



Plum curculio --
Conotrachelus nenuphar (Herbst)

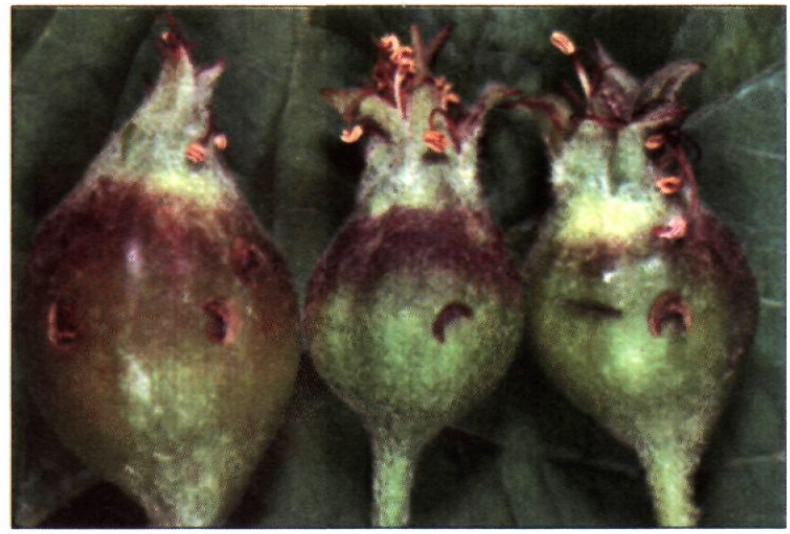
Plum curculio (PC) typically migrates into orchards around bloom. The start of their movement from overwintering sites to orchards is most reliably linked with either a maximum daily temperature of 75°F for two to three days, or a mean daily temperature of 55°-60°F for three to six days.

Peak activity and the **critical time for control** usually occur over 10 to 15 days beginning at petal fall. Females are mated before fruit set and are ready to lay eggs in fruit as soon as it becomes available. Egg laying can extend through June.

The adult beetle is about 5 mm long, and mottled brown with black, orange and white patches on the back. The wing covers are ridged and warty looking. Plum curculios have a downward curved snout that is about 1/4 to 1/3 of the body length. 5 mm

Plum curculio -- *continued*

The female deposits eggs under the skin of the fruit, leaving a crescent-shaped scar just below the egg-laying site. The hatching larva feeds inside of the fruit.



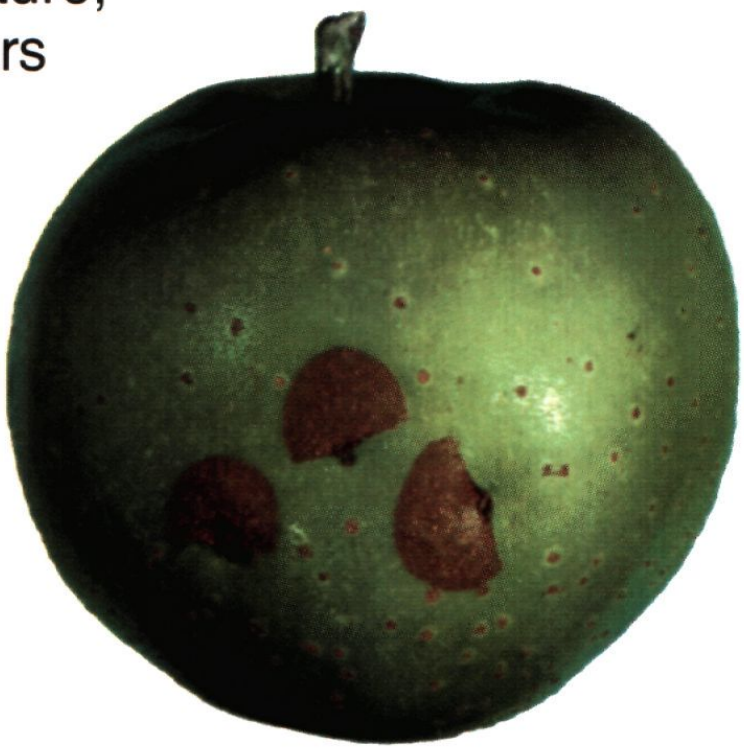
Above right, crescent-shaped scars from fresh egg-laying damage. Below, mature larva is segmented and C-shaped, about 7 mm long, yellowish-white with a brown head capsule, and legless.

7 mm

Mature larvae drop from fruit and pupate in the soil to complete development. They emerge as adults in late June through August and remain in the orchard until harvest. Adults prefer the dense shade of the tree's inner canopy. In Michigan, this summer generation does not lay eggs until the following spring.

Plum curculio -- *continued*

Early-season varieties are considered most susceptible to both feeding and oviposition damage. As fruit mature, older oviposition scars take on a broad, fanlike appearance.



Monitoring: Traps can be used early in the season to capture curculios as they move into and around the orchard. After fruit is present, visually inspect several fruit per tree for signs of feeding or egg laying. Concentrate sampling on trees adjacent to hedgerows and woodlands, especially where damage has occurred in the past.

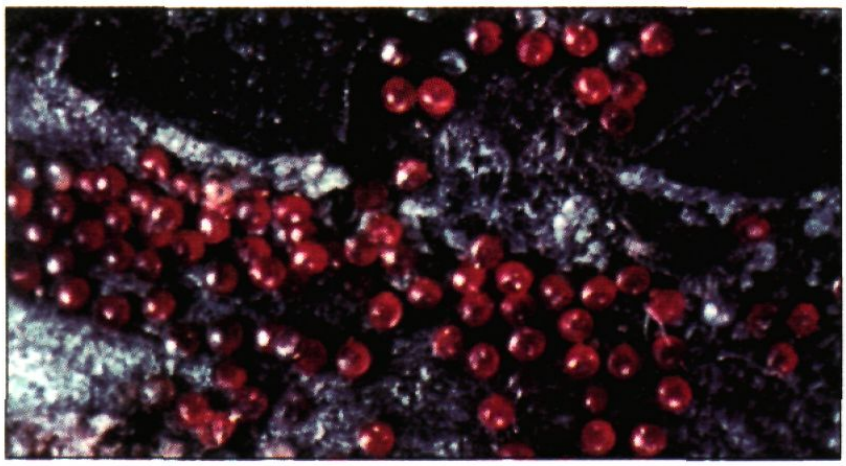
Beating trays can be used to determine the presence of plum curculio.

About mites

Mite feeding turns leaves brown, referred to as bronzing. Severe infestations can cause defoliation. Thin-leafed apple varieties (Delicious, Rome, and Northern Spy) are considered the most susceptible to mites.

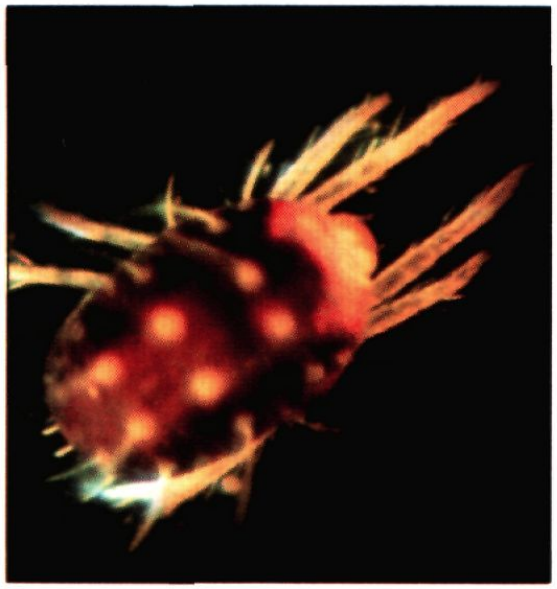
European red mite -- *Panonychus ulmi* (Koch)

European red mite (ERM) eggs begin hatching at tight cluster stage of bud development and are found on leaves or bark the rest of the year.

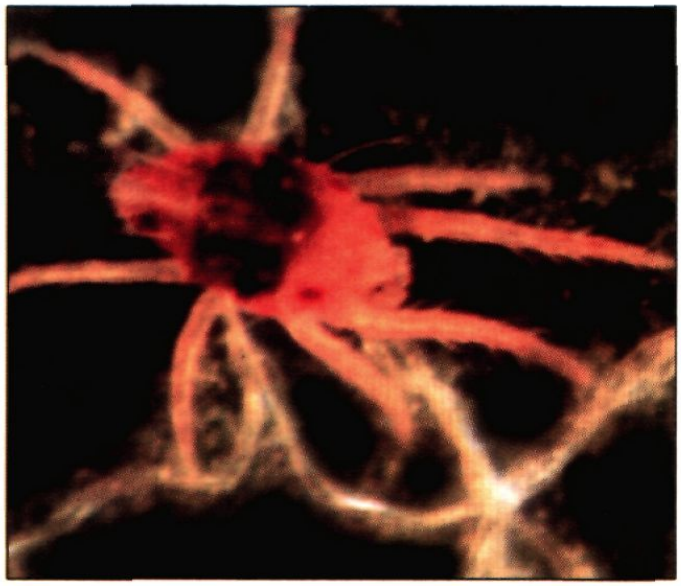


ERM overwinter as eggs on rough bark. The eggs are most commonly found near buds, fruit spurs, and in the fork of two branches.

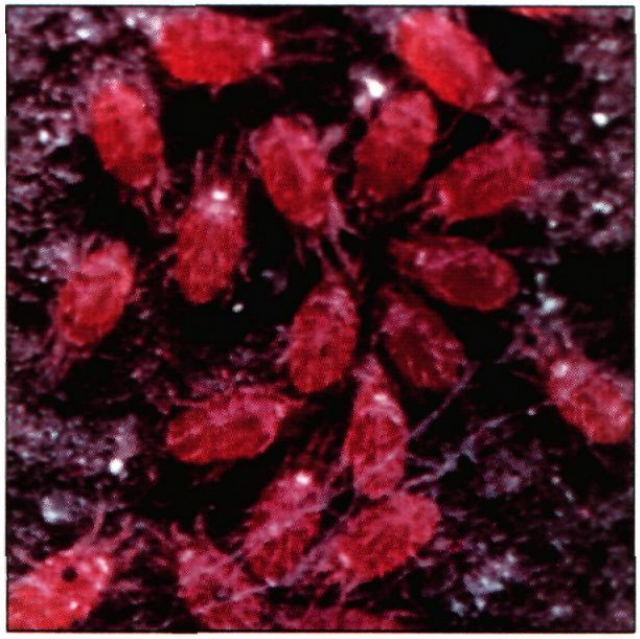
European red mite -- *continued*



The female ERM is red or brownish-red with conspicuous white spots at the bases of their white bristles.



The adult male is smaller than the female, has a tapered abdomen, and is reddish-yellow.



Immature ERM often feed in groups within unfolding leaves.

Monitoring and thresholds: see twospotted spider mite information.

Twospotted spider mite -- *Tetranychus urticae* (Koch)

Twospotted spider mites (TSSM) have 2 distinct spots located on the front half of the dorsum behind the eyes. Males are much smaller than females, and have a distinctly pointed abdomen. Color can vary from pale yellow to green. The overwintering adults turn orange in September. TSSM can be found in the tree canopy from tight cluster through harvest. They typically construct webbing on the underside of leaves.

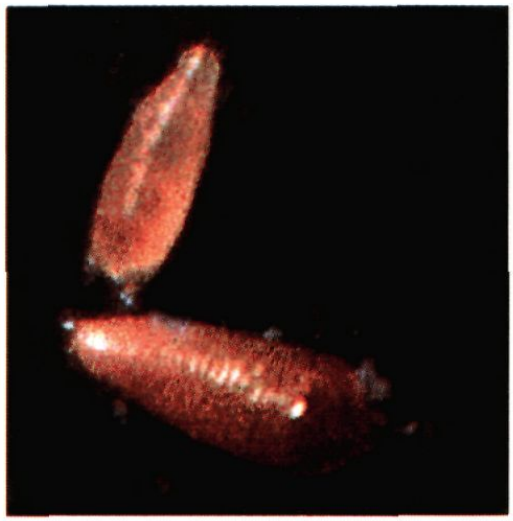
Monitoring and thresholds (ERM & TSSM): For summer populations of both mite species, examine leaves from several locations in the orchard using 50% spur leaves, 50% shoot leaves. Treat based on the following thresholds:

2-3 mites/leaf from petal fall to mid-June
5-7 mites/leaf from mid-June through July
10-15 mites/leaf in August

Presence of predaceous mites (>1/leaf) may justify delaying a treatment and repeating the cycle the following week.

Apple rust mite --
Aculus schlechtendali (Nalepa)

Adult apple rust mites (ARM) are elongated, triangular, tan in color, and barely discernable with a hand lens (0.2 mm long). ARM also have only 2 pairs of legs, whereas most mites have 4 pairs.



ARM move to trees in spring as soon as leaves open and remain on trees for the rest of the year.

Rust mite feeding can cause russetting on the fruit.

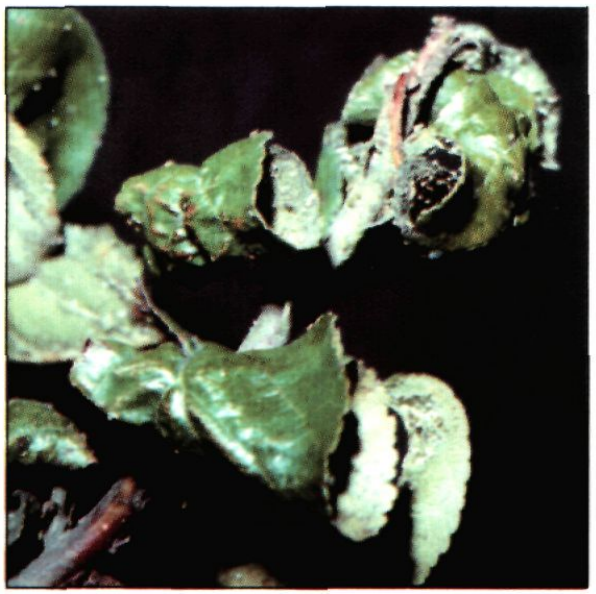
About aphids

Aphids produce honeydew, which can drip onto fruit providing suitable habitat for the growth of sooty mold.

Russeting around an apple stem caused by sooty mold growing in aphid honeydew drippings.

Rosy apple aphid --
Dysaphis plantaginea (Passerini)

Rosy apple aphid (RAA) feeding curls leaves, deforms shoots, stunts and malforms fruit. Three generations of RAA occur on apple in Michigan. The first nymphs are present in the orchard when the trees are at 1/2 -inch green. Particularly susceptible varieties include Ida Red, Cortland, Rome, Rhode Island Greening, and Golden Delicious. Treatments for infestations must be made early before the aphids are protected inside curled leaves. **Monitoring:** Begin at tight cluster to pink stage. Examine 5 clusters from the upper inside canopy on 10-20 trees per block. One infested cluster/tree may indicate the need for treatment.



2 mm

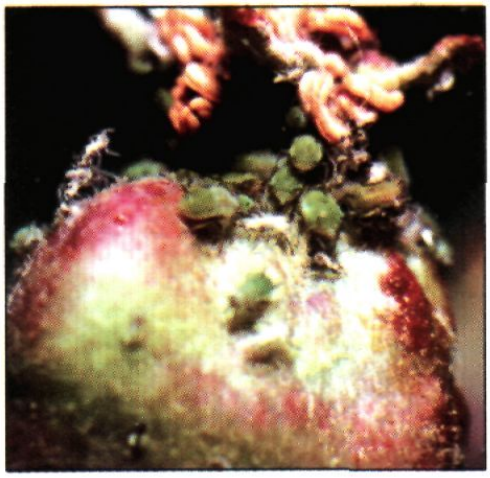
Winged adults are brownish-green to black (about 2 mm long). Unwinged adults are generally a purple-pink color with long cornicles. At left, curled leaves.

Green apple aphid --
Aphis pomi (De Geer)

Green apple aphid nymphs and adults prefer to feed on the underside of leaves on growing shoot tips and stems.

3 mm

The winged adult (about 3 mm) has a black head and thorax, and a yellow-green abdomen. Wingless adults are green with black cornicles, legs and antennal tips. Nymphs are about 1.5 mm long.



Decision-making:
Estimate the average number of aphid-infested leaves on terminals. Generally, an average of 3 to 4 infested leaves is needed before fruit damage from honeydew occurs. In young orchards, lower levels of aphid infestation (1-2 leaf colonies) will inhibit growth of the trees.

Wooly apple aphid --
Eriosoma lanigerum (Hausmann)

Wooly apple aphid (WAA) typically cluster in wounds on the trunk and branches of apple trees, as well as on root knots and underground parts of the trunk. Leaf axils on terminal shoots are preferred summer feeding sites. Injury includes gall formations that increase in size from year to year as the aphids feed. There are typically 3 to 4 generation of WAA on apple in Michigan. Subterranean WAA may be present year round and can serve as a source of aerial infestation starting in the spring.

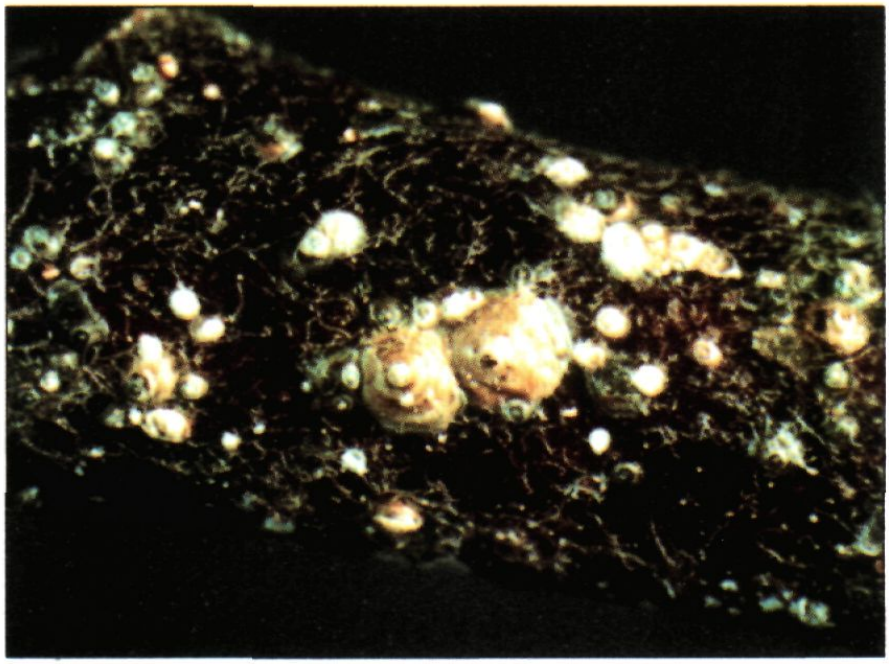
WAA adults are about 3 mm in length. Females are reddish-brown to purple and typically enclose themselves in white cotton-like fibers. Males are half the size of females and are olive-yellow.

3 mm

San Jose scale --
Quadraspidiotus periciosus (Comstock)

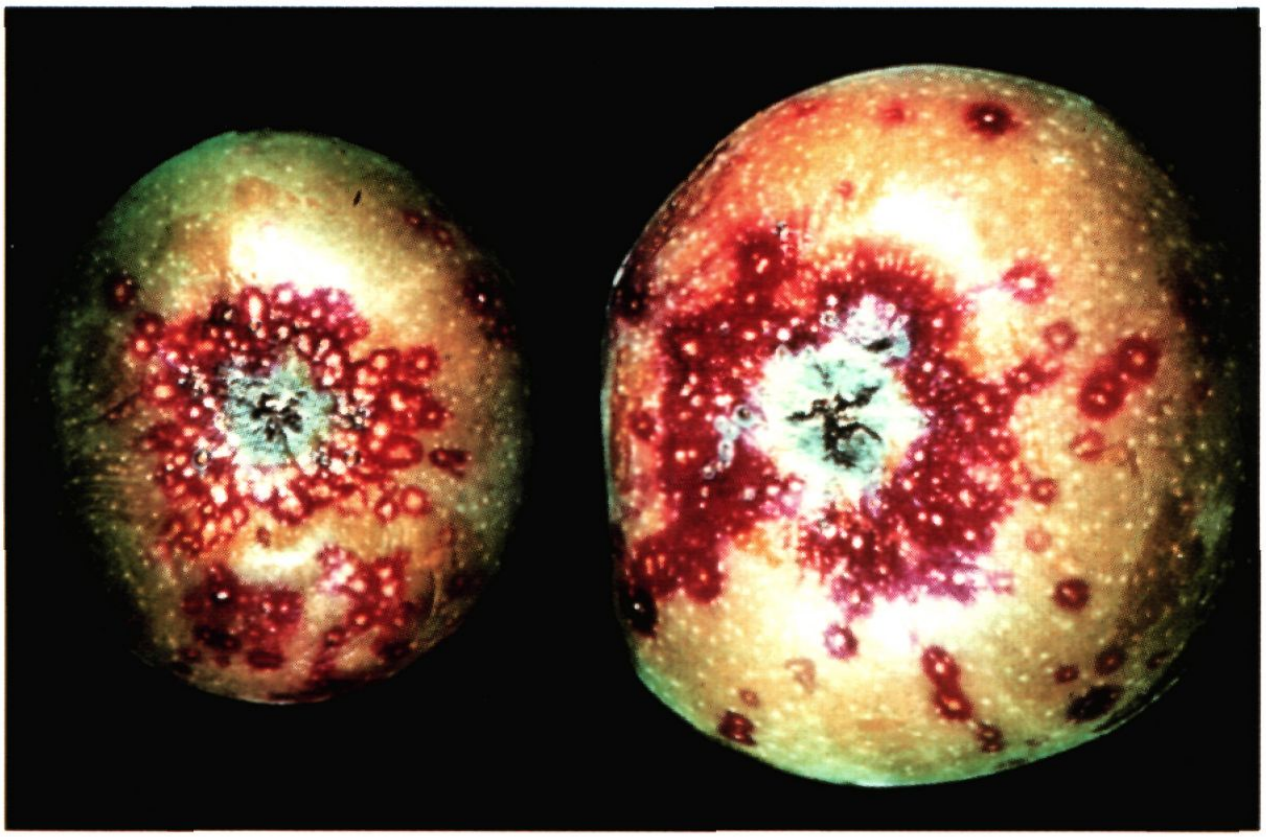
San Jose scale multiplies very rapidly and may attack tree bark, leaves and fruit. Scale can kill twigs and limbs, and make fruit unmarketable. If left unchecked, San Jose scale can kill the tree.

The adult male (at left) has 2 wings, and is yellow-colored with long antennae. Females are wingless, spherical insects found under a waxy coating with a raised nipple in the center.



San Jose scales overwinter underneath waxy shells as nymphs on rough wood and near the trunk on scaffold limbs.

San Jose scale -- *continued*

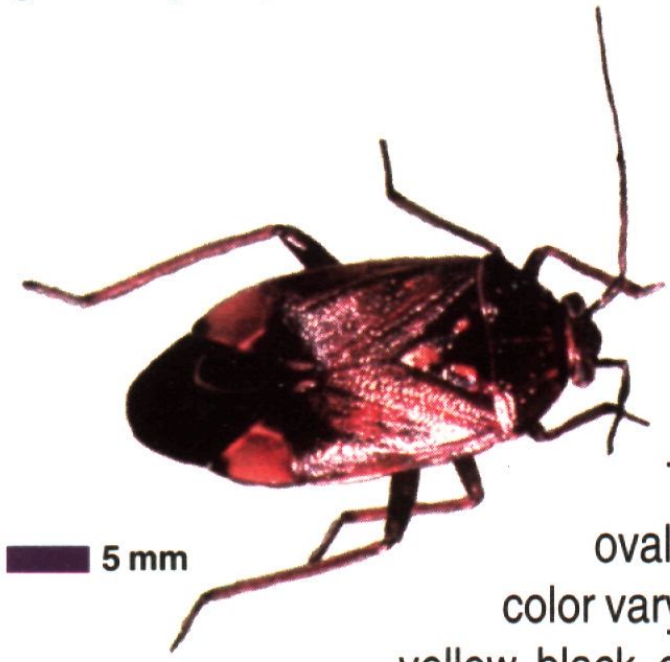


Feeding on fruit produces red spots often associated with slight depressions.

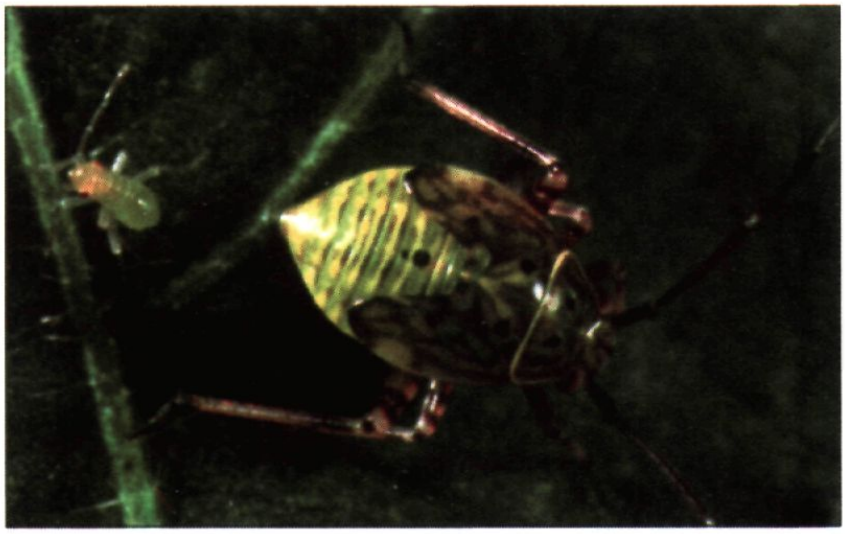
Monitoring: Pheromone traps can be used to monitor adult emergence in blocks that are known to be infested. Place traps prior to pink. Yellowish crawlers generally are present 300-350 GDD(base 50) after the first adult catch of either generation.

Tarnished plantbug -- *Lygus lineolaris* (Palisot de Beauvois)

Adult tarnished plantbug (TPB) feed on flower buds beginning in early April, doing most damage around bloom. Damaged buds exude a gummy liquid and shrivel up. Adults also oviposit into and feed on young fruit resulting in pitted, deformed fruit. Three to five generations occur in Michigan.



The TBP adult is a flattened, oval bug, about 5 mm long, with color varying from green to brown, with yellow, black, or red markings.



The TPB nymph is greenish-yellow with black spots, and has no wings.

Tarnished plantbug -- *continued*

TPB begins attacking apple buds early in spring, and can be present throughout the summer. Most first generation adults, however, migrate to weed hosts after petal fall.

Feeding injury is evident in these apples.

Monitoring: Trapping with white sticky traps gives inconsistent results and is not recommended at this time. Scouting the orchard in the spring to look for ooze on flower buds is advised, especially if treatment with a broad-spectrum insecticide is not planned for the pre-bloom to petal fall period.

About leafhoppers

Potato leafhopper (PLH) can be differentiated from white apple leafhopper by color and by observing movement and feeding habits. PLH are more active on the leaf and can move sideways. WALH does not move sideways. PLH nymphs run quickly to the other side of the leaf as the leaf is examined. PLH also prefer young leaves and feed near leaf edges, causing the leaf to curl downward. WALH prefer mature leaves and do not tend to feed at the leaf edge. WALH cause a whitish stippling effect on leaves and they drop a hard to remove excrement on fruit, mostly in the second generation. There are two generations of WALH, three to four of PLH. Both are present from spring through harvest.

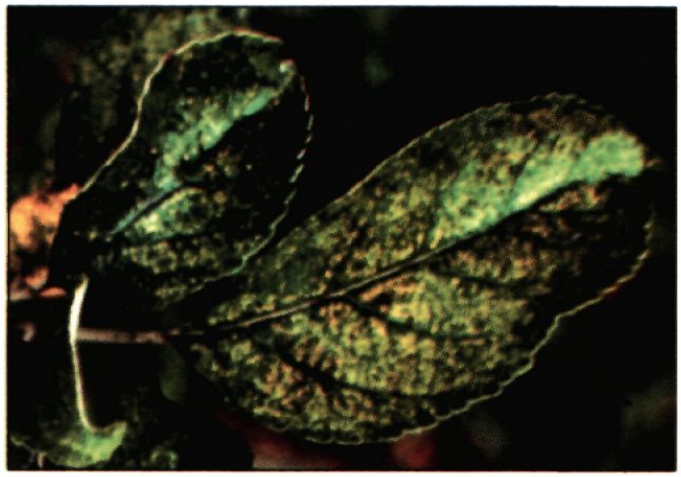
Potato leafhopper – *Empoasca fabae* (Harris)

Both adults (about 3 mm) and nymphs are green in color. Legs are more spiny than WALH.

3 mm

White apple leafhopper – *Typhlocyba pomaria* (McAtee)

WALH nymphs are white to yellow, with early instars having red eyes. Adults are about 3 mm long, and pale yellow-white in color. 3 mm



Leaf stippling damage

For more information, see comparison to potato leafhopper on previous page.

Monitoring: Estimate number per leaf. More first generation will be on spur leaves. Most summer generation will be on mid-shoot leaves.

Thresholds: Will vary widely. Threshholds for trees with sparse canopy and heavy crop load is less than for trees with luxurious canopies. Generally, 1-3 per leaf will bleach around the midrib only, 8 per leaf will stipple the entire leaf and create problems for workers at harvest.

Redbanded leafroller –
Argyrotaenia velutinana (Walker)

Redbanded leafrollers feed on fruit and foliage. Adults start to emerge around green tip; larvae of this generation are present early May to mid-June. Fruit injury is usually shallow with ragged edges and thick, corky tissue over the damaged area. RBLR is generally controlled with sprays applied for other pests.

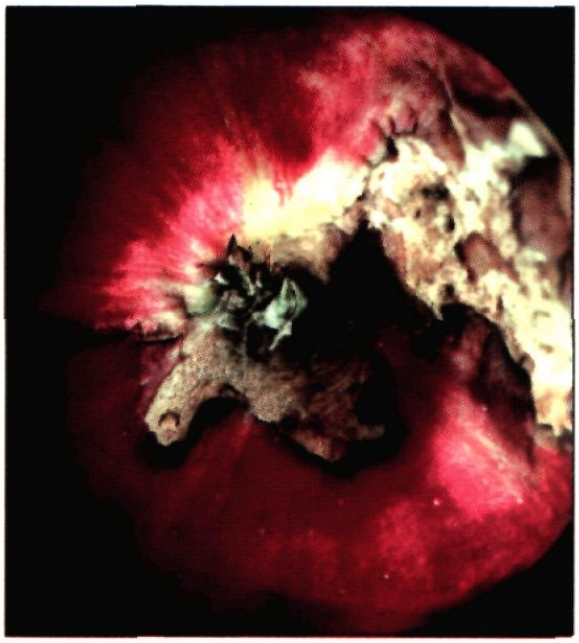
Adults have distinct red-brown bands on the forewings that form a V-shape when at rest. Wingspans range from 12-18 mm.

Monitoring: Monitor adult activity with pheromone traps.

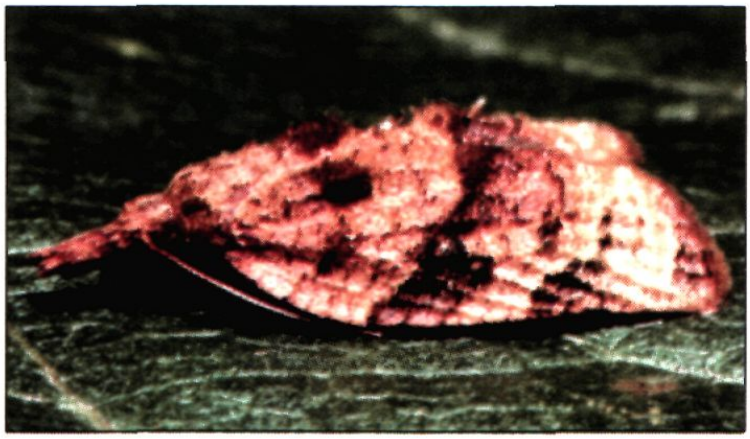
16 mm

Larvae are green with a green head capsule, and reach about 16 mm at maturity. Larvae that have fed on fruit, develop a yellow tint.

Variegated leafroller –
Platynota flavedana (Clemens)



Mature larvae can be present from early May until August. Fruit damaged by variegated leafroller shows a shotgun pattern of isolated feeding sites. VLR is generally controlled with sprays applied for other pests.



The male's forewings are dark brown with a golden or cream colored band at the wing base and tip. Females are brown with 2 dark red horizontal bands. Newly hatched larvae are yellow with a black head capsule (1.2 mm); mature larvae are green with a brown head capsule (20 mm).

20 mm

Obliquebanded leafroller – *Choristoneura rosaceana* (Harris)

There are two complete generations per year in Michigan. Overwintering larvae feed inside bud clusters prior to bloom, begin feeding on fruit after petal fall, and mature in late May and June. Summer larvae are present from about late June into August. A degree day model can be used to predict larval activity periods.

Wings of the adult are banded with tan to brown scales. Adults are about 18-25 mm long.

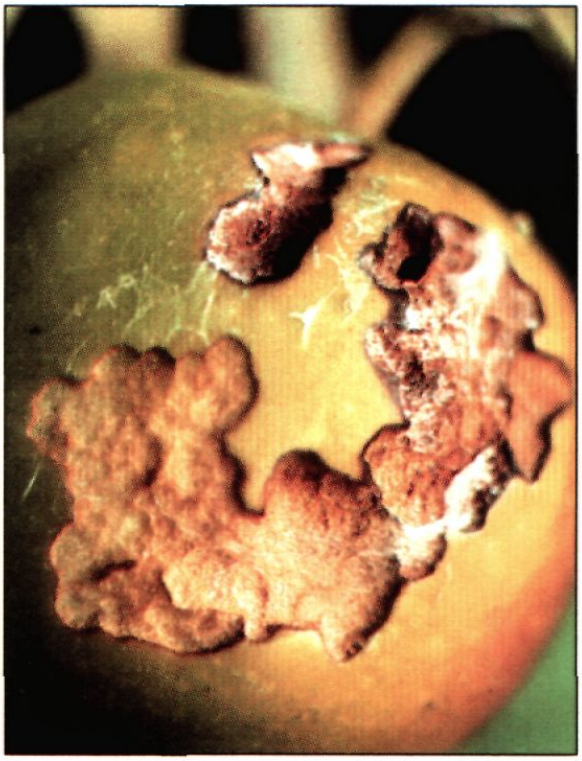
Larvae are green with brown to black head capsules (about 25 mm long at maturity)

25 mm

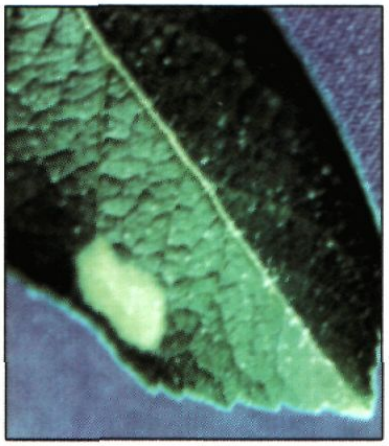
Obliquebanded leafroller -- *continued*

Suggested monitoring and thresholds:

Check for overwintering survivors in terminals after petal fall. If larvae are found in more than 1-2% of the shoots, summer controls likely will be needed. Use one pheromone trap per 15 or 20 acres to set biofix and as an indicator of leafroller activity. Lures are highly attractive and generally last a generation. Traps tend to capture a lot of moths making it difficult to use them for decision making. However, a consistent catch of 20 plus moths for 2-3 weeks usually indicates a problem. Very low catches of less than 20 moths for an entire flight period generally means this pest is not present at problematic levels. See degree day table on next page.



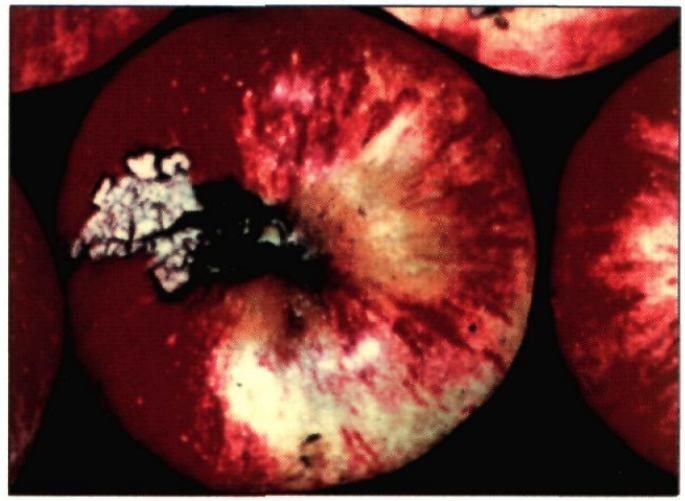
At left, continuous feeding pattern of summer OBLR larvae. Below, an egg mass on a leaf.



Obliquebanded leafroller growing degree day table

GDD° Base 42 (Post Biofix)	Event	Action
Tight cluster	Majority of larvae have emerged from shelters	Examine fruit buds for larval activity
0 GDD° = biofix (~900 GDD° after Jan 1)	1st sustained moth captures	Set GDD° = 0
220-250 GDD°	Peak moth flight - overwintering generation	
400-450 GDD°	Start of egg hatch	Timing for treatment
1000 GDD°	End of egg hatch	
2300 GDD°	Peak moth flight - 2nd generation	
2750 GDD°	Start of 2nd generation egg hatch	Timing for treatment

Tufted apple bud moth –
Platynota idaeusalis (Walker)



Larvae cut leaf petioles causing the leaf to hang down, and proceed to feed in the leaf encased in silken threads. Areas of fruit feeding are separated, not continuous, and take on the appearance of tiny holes, shallow channels, or as an area of rot, generally around the stem.

Early instar larvae are yellow with a black head capsule; mature larvae are light brown to grayish-tan with a brown head capsule and a dark stripe down the back of its body (about 19 mm long).

19 mm

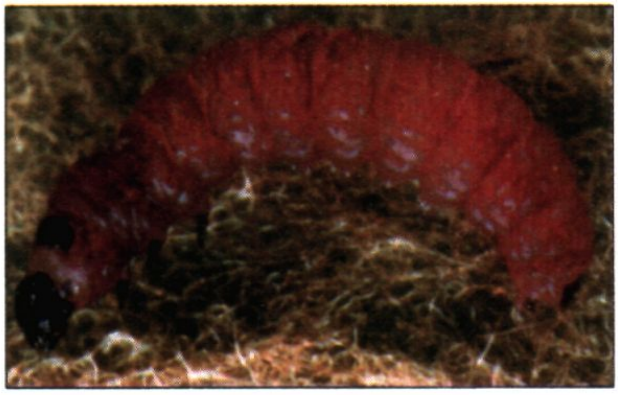
Tufted apple bud moth -- *continued*

Adults are gray and brown moths with a patch of copper-colored scales, as well as a series of tufted scales in the middle of each forewing. They are about 13 mm long. 13 mm

Larvae overwinter in the orchard, and can be found in the trees early in the spring; adults emerge the beginning of May, first generation larvae appear around mid-June, second generation larvae appear mid-late August.

Eyespotted bud moth – *Spilonota ocellana* (Denis and Schiffermuller)

There is one generation a year of eyespotted bud moth. Overwintering larvae burrow into flower buds early in spring; larvae also tie leaves together with silk and feed inside the cluster.



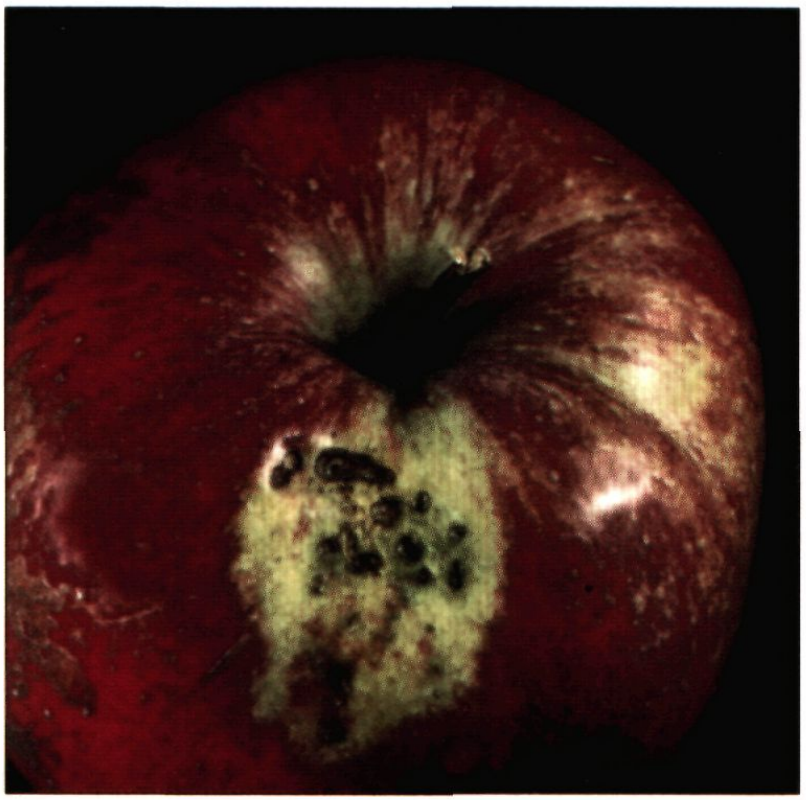
Larvae are brown with a brown to black head capsule (9-14 mm long). Similar to tufted apple bud moth, but smaller, thinner, and darker brown.

14 mm

Eyespotted bud moth -- *continued*

Peak adult emergence occurs at the end of June or early July. Summer larvae seek overwintering sites beginning in mid-August.

The adults are gray-brown moths with a gray-white band on about half of the wing.



Fruit injury occurs as small scars in a cluster that is often lighter in color than the rest of the fruit.

Speckled green fruitworm – *Orthosia hibisci* (Guenee)

Speckled green fruitworms have one generation per year. Pupae overwinter in the soil and adults emerge starting in very early spring. Egg hatch occurs at the half-inch-green stage.

Adults of most species are large brownish moths with wingspans of about 40 mm.

40 mm

Larvae are light green with a pair of lateral white stripes and additional white spots (35-40 mm long).

Speckled green fruitworm -- *continued*

Larvae feed on leaves, buds and developing fruit. Most damaged fruit will drop prematurely.

Larval feeding results in deep, corky scars. Injury may be confused with that caused by early RBLR feeding, but is usually deeper.

Japanese beetle – *Popillia japonica* (Newman)

Adult Japanese beetles skelotonize leaf tissue. Fruit feeding is less common, and usually occurs only if the fruit has been previously damaged or is over mature. Most damage typically occurs late in summer or early fall. The beetle overwinters as a larva in the soil. Adults emerge in mid-June to July.

12 mm

Adults are bright metallic-green with coppery red wings and small white tufts on the sides and tip of the wing covers (about 12mm).

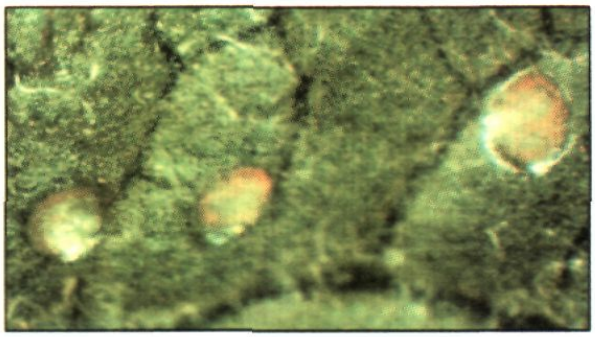
Spotted tentiform leafminer – *Phyllonorycter blancardella* (Fabr.)

Spotted tentiform leafminer (STLM) has three generations a year in Michigan. First generation adults emerge around bud break (tight cluster in northwest MI) to lay eggs on the undersides of leaves. First egg hatch occurs 2 to 3 weeks later.

Adult moths are small (3 mm long) with distinctive gold, black and white wing patterns

3 mm

Pheromone traps can be used to determine first moth emergence. Second generation adults emerge mid-June; third generation adults in August.



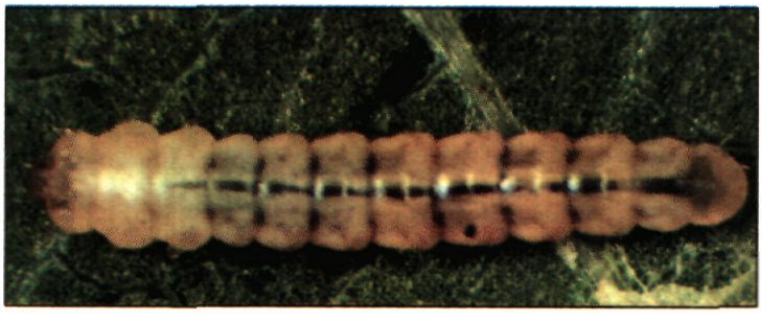
STLM eggs are attached to the underside of a leaf with a flattened surface. The exposed surface is a yellowish oval dome.

Spotted tentiform leafminer -- *continued*

The first 3 larval instars are sap feeders, and are white to pale green, legless, wedge-shaped, and deeply segmented (about 1.5 mm).

■ 1.5 mm

The fourth and fifth larval instars are tissue feeders, and are more cylindrical, have legs and a typical caterpillar head capsule (about 5 mm; white to pale green). ▬ 5 mm



Larvae feed on foliage with each larval mine disrupting 4 to 5 percent of leaf area. Fruit quality, size, retention, and set can be affected if enough area is lost to mining.

Leafminer mines in apple.

Spotted tentiform leafminer monitoring and thresholds

	Monitoring	Threshold**
End of 1st generation	To assist in 2nd generation decisions, check 50 tented mines from 25 trees to determine % parasitism.	
Early 2nd generation	Sample 50 or 100 leaves per block, count # mines per leaf.	2-3 per leaf, higher if 30-35 % parasitism was found in first sample.
Late 2nd generation	Sample 50 or 100 mines and determine % parasitism.	
Early 3rd generation	Sample 50 or 100 leaves per block, count # mines per leaf.	5-8 mines per leaf, higher if 35% parasitism.

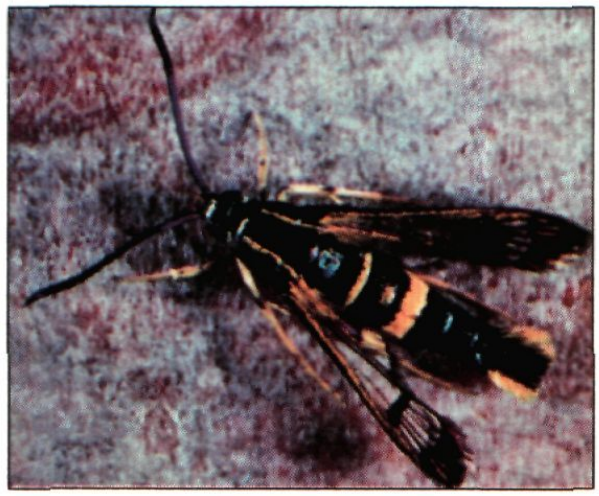
** Note that thresholds will vary based on tree structure and variety.

Dogwood borer --
Synanthedon scitula (Harr.)

Dogwood borer larvae develop in shallow tunnels in burr knots on dwarfing and semi-dwarfing rootstocks at or below the graft union. Reddish frass on the exterior of the knot indicates the presence of the larvae. Adult emergence begins in mid-June, peaks in early July, and continues until August.

Larvae are white with brown head capsules (about 16 mm long). Below, a knife points to a larva in a burr.

16 mm

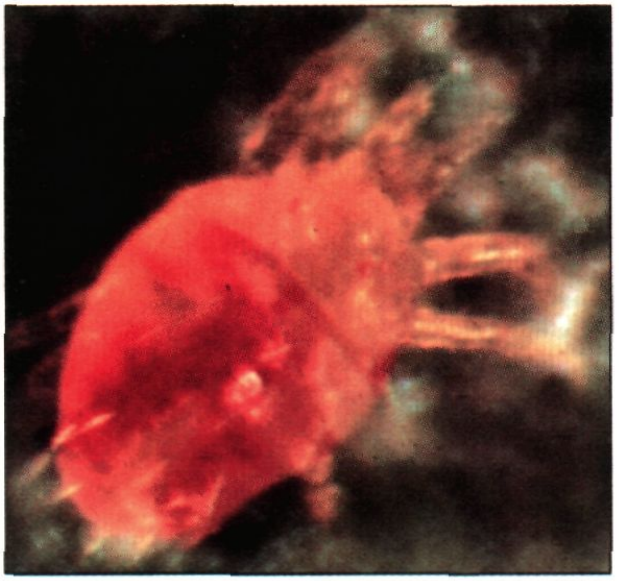


The adult is a black and yellow clear-wing moth with two thin yellow stripes on the second and fourth abdominal segments. There is a rounded anal tuft on the tip of the abdomen (wingspan is about 16-19 mm).

About beneficials

Resident beneficial organisms (or natural enemies) can enhance control of many pest arthropods, often providing good suppression of many indirect pests (aphids, mites, and leafminers). The best way to conserve these beneficials is to use caution when selecting insecticides and timing applications. Beneficials are often more susceptible to broad-spectrum insecticides (organophosphates, carbamates and pyrethroids) than are the pests they attack. The availability of flowering plants within the orchard can also help conserve beneficials, since the adult stage of many predators and parasites feeds on nectar and pollen.

Beneficials -- predatory mites



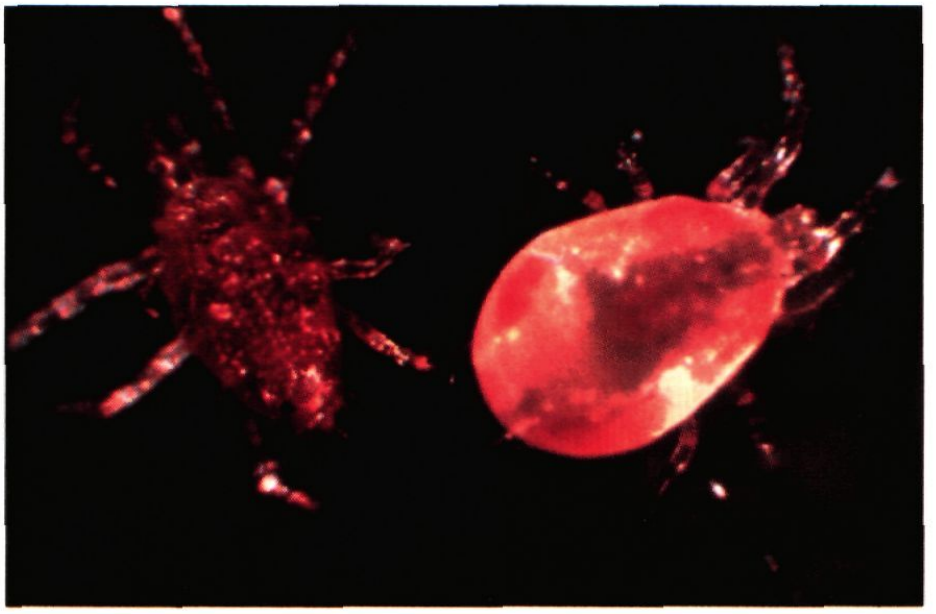
Zetzellia mali has some tolerance for organo-phosphate and carbam-ate (Sevin) insecticides, but is susceptible to endosulfan (thiodan).

Z. mali are bright yellow with orange markings and a somewhat pointed posterior.

Predatory mites-- *continued*

Predatory mites can be distinguished from pest species by observing the speed of their movement. When disturbed, predators generally move quicker than pest mites. Predator abundance is strongly affected by pesticide use.

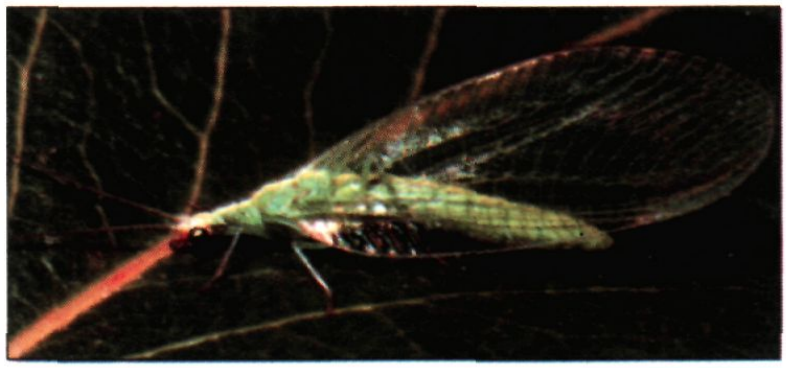
Amblyseius fallacis adults (below, right) are tear-shaped, translucent, and very fast moving. ***Agistemus fleschneri*** (left) adults are oval with a somewhat pointed posterior. They turn reddish-yellow upon feeding on pest mites.



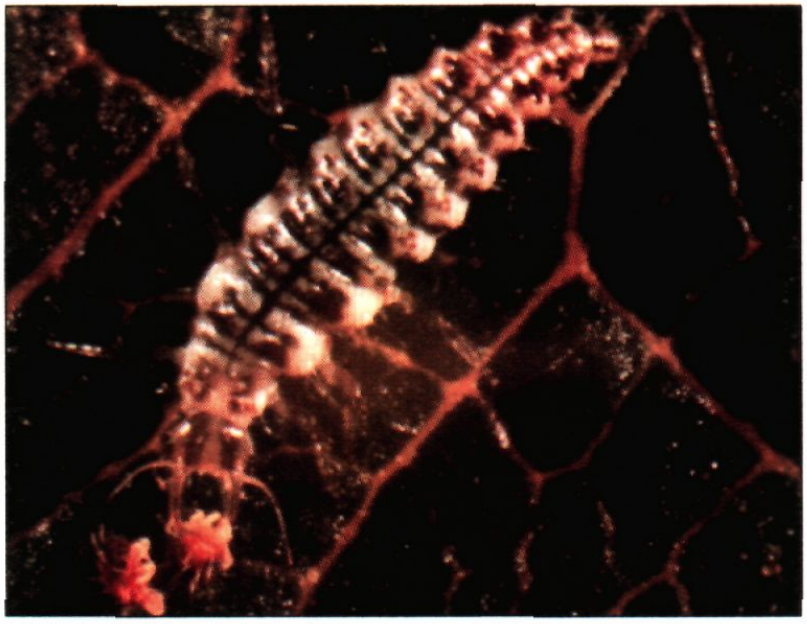
Typhlodromus pyri (not pictured) is very similar in appearance to *A. fallacis*, but is slower moving. They are present in the tree canopy from April through September.

Beneficials --
predators of soft-bodied insects

Green lacewing adults (10-12 mm long) have large, net-veined wings and gold-colored eyes. They feed on nectar, pollen, and aphid honeydew.

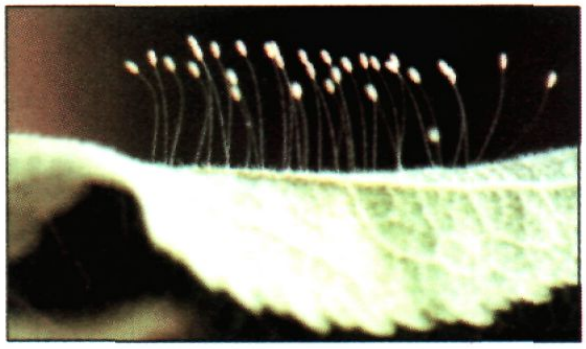


12 mm



Lacewing larvae (about 15 mm long) are alligator-shaped with long sickle-like mandibles. They are active predators.

15 mm

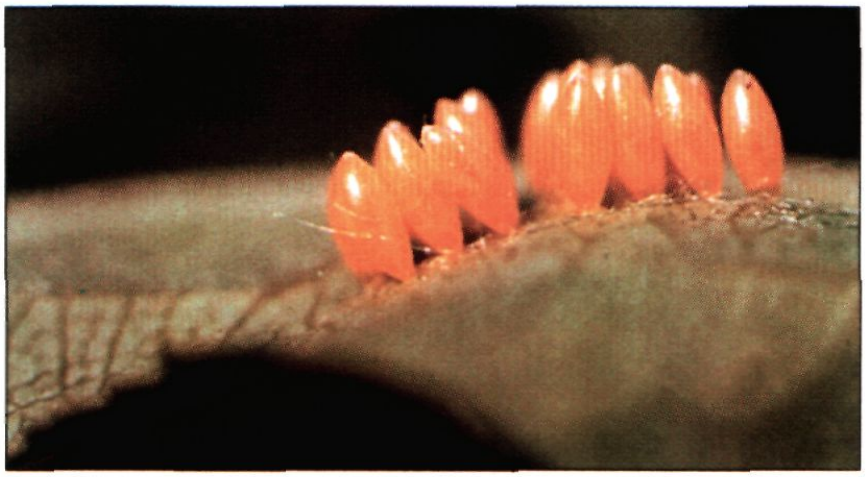


Lacewing eggs are suspended at the tips of long, erect stalks.

Predators of soft-bodied insects -- *continued*

Adult **lady beetles** are generally oval-shaped, and are red to orange with varying numbers of black spots (5-7 mm long). Pollen is an important part of the diet of some species.

Lady beetle larvae (at right) have dark, elongated bodies with orange markings and well developed legs (5-6 mm).



Lady beetle eggs are barrel-shaped and laid in clusters.

Predators of soft-bodied insects -- *continued*

The adult black lady beetle, ***Stethorus punctum***, is black with silvery hairs (about 1 mm).

The larva is brown or black with short spines. Both feed principally on mites.

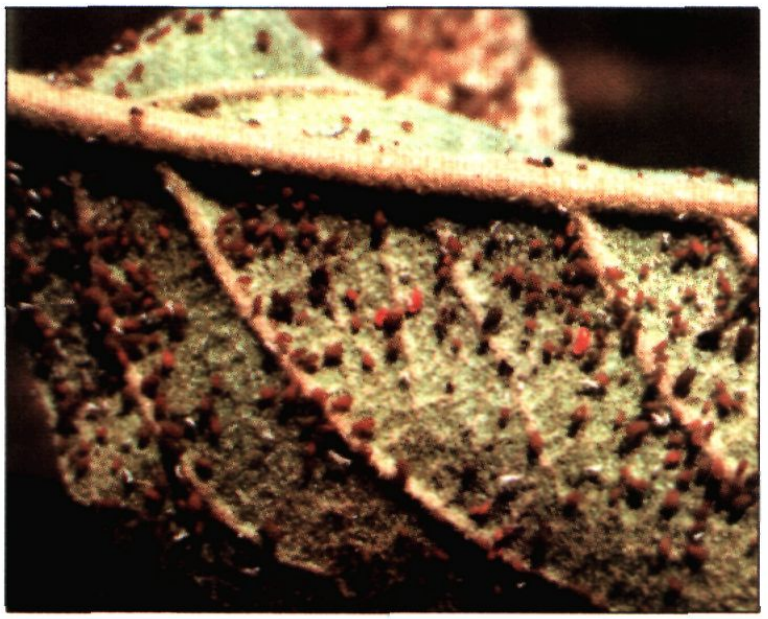
Stethorus overwinters within the orchard in leaf litter around the base of trees. The area in the herbicide strip near the trunk of the tree should not be disturbed from November to mid-April when adults become active.

Pyrethroid insecticide applications made after half-inch green adversely affect *Stethorus*.

Predators of soft-bodied insects -- *continued*

Syrphid fly adults resemble bees, but have one pair of wings. They have the habit of hovering in the air (hover flies)

Syrphid fly larva (above, right) are usually greenish, legless maggots, rounded at the rear, and tapering to a point at the head (5-10 mm). Found in aphid colonies. 5 mm



Orange cecidomyiid fly larvae are small (1-2 mm), legless and can be found in aphid colonies.

2 mm

Beneficials -- generalist predators

Damsel bugs, (nabids) have long bodies (8 mm, at left) that narrow slightly towards the head, stout beaks, and en-larged front legs for grasping prey. 8 mm

Adult **minute pirate bugs** (at center) are black with white markings (3-5 mm). 5 mm

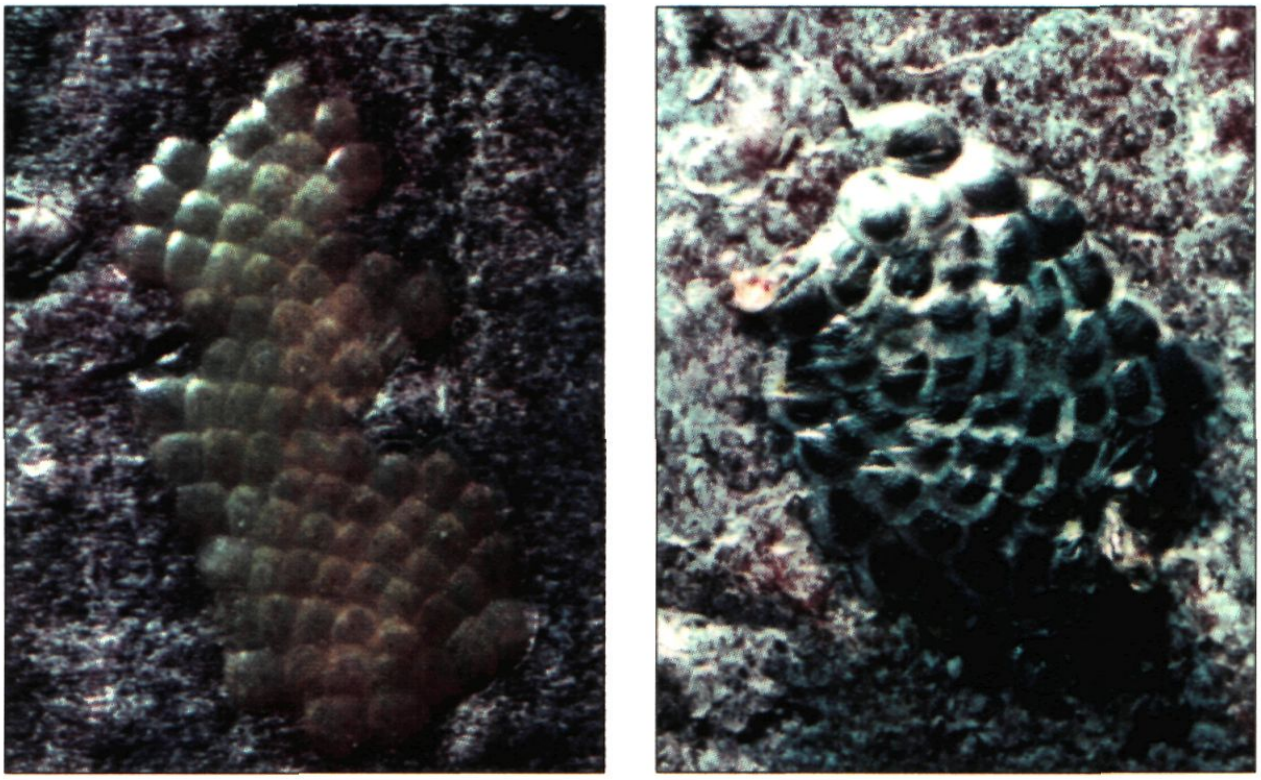
36 mm

Adult **assassin bugs** (reduviids) are medium to large insects (12-36 mm), coloration varies from brown to greenish with yel-low or reddish markings. They have long heads with a groove between the eyes, and curved beaks.

12 mm

Beneficials -- parasitoids

Most parasitic wasps are minute (0.5mm) to small (5mm), and often develop inside their hosts making detection more challenging. Some recognizable signs of parasitism include: unusual host behavior, host color change, host mummification (hardened exterior), and the presence of emergence holes in the host.



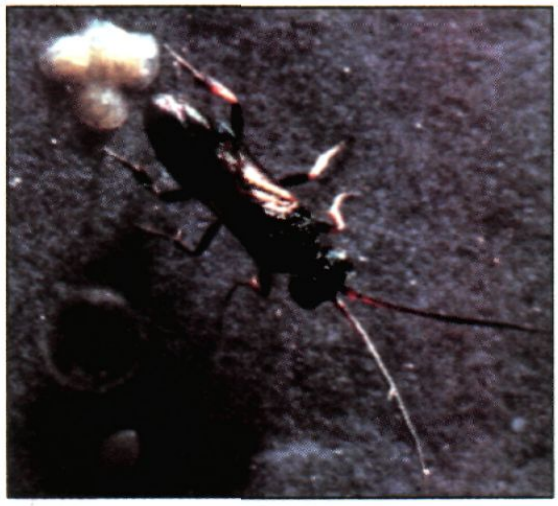
Parasitized eggs are often darker in color than non-parasitized eggs, as can be seen here in a redbanded leafroller eggmass (normal on left, parasitized on right)

Tachinid fly adults are hairy or bristly. The larvae feed on moth, beetle, and stinkbug larvae.

Below, Tachinid fly larvae emerge from a tufted apple budmoth larva.

Braconids are small black, orange, or yellow wasps that prey on aphids and lepidopteran larvae, such as codling moth and leafroller. Adults are usually less than 10mm; more than 100 known species.

10 mm



A braconid wasp parasitizing codling moth eggs.

Parasitoids -- *continued*

Eulophids are egg/larval parasitoids of pests, such as spotted tentiform leafminer. Adults are usually 1mm or more; 3,400 known species.

Other Parasitoid Wasp Families	
Aphidiidae	Internal parasite of aphids (often leave a tan or gold mummy).
Ichneumonidae	Attack larvae and pupae of many insects
Mymaridae	Internal egg parasite of many insects
Chalcididae	Internal and external parasitoids of fly and moth larvae
Trichogramatidae	Internal egg parasite of many insects (including codling moth and leafroller)
Encyrtidae	Internal parasites of moth eggs, larvae, and pupae.

Apple scab

Apple scab fungus overwinters in infected leaves on the orchard floor. When the leaves become wet, spores are discharged and disperse into surrounding trees. Infection occurs on foliage, blossoms, petioles, and fruit during periods of sufficient wetting at given temperatures (see "Adapted Mills Table" on pages 57-58).

Apple scab initial symptoms.

Apple scab -- *continued*

Primary scab infection on spur leaves (above) and the blossom end (below) of McIntosh apple.

Primary infections usually develop first on spur leaves and on the blossom end (calyx) of fruit. Conidia are produced abundantly in these velvety-brown to olive lesions and serve as sources of secondary infection spread by wind and rain.

Apple scab -- *continued*

Monitoring:
Scout spur leaves and fruit in late May for primary scab symptoms. These primary infections will provide the inoculum for secondary scab infections on terminal leaves and fruit.

Spur leaves of McIntosh apple (red arrows) with primary scab infection; (currently) uninfected terminal leaves (blue arrows).

Apple scab -- *continued*

Above, late-season scab infection on a Hampshire apple.

Sporulating scab lesions on McIntosh apple leaves.

Adapted Mills Table[a]

Approx. wetting period required for primary apple scab infection at various air temperatures and time required for conidia to develop

Average air temperature		Wetting period (hr)[b]			Incubation period[c] (days)
°F	°C	light infectn	moderate infectn	heavy infectn	
78	25.6	13	17	26	—
77	25.0	11	14	21	—
76	24.4	9.5	12	19	—
63-75	17.2-23	9	12	18	9
62	16.7	9	12	18	10
61	16.1	9	13	20	10
60	15.6	9.5	13	20	11
59	15.0	10	13	21	12
58	14.4	10	14	21	12
57	13.9	10	14	22	13
56	13.3	11	15	22	13
55	12.8	11	16	24	14

Table continues on next page

[a] Adapted from Mills, 1944; modified by A.L. Jones.

[b] The infection period starts when rain begins.

[c] Approximate number of days required for conidial development after the start of the infection period.

Adapted Mills Table[a] *continued*

See previous page for more information about this table.

Average air temperature		Wetting period (hr)			Incubation period (days)
°F	°C	light infectn	moderate infectn	heavy infectn	
54	12.2	11.5	16	24	14
53	11.7	12	17	25	15
52	11.1	12	18	26	15
51	10.6	13	18	27	16
50	10.0	14	19	29	16
49	9.4	14.5	20	30	17
48	8.9	15	20	30	17
47	8.3	15	23	35	—
46	7.8	16	24	37	—
45	7.2	17	26	40	—
44	6.6	19	28	43	—
43	6.1	21	30	47	—
42	5.5	23	33	50	—
41	5.0	26	37	53	—
40	4.4	29	41	56	—
39	3.9	33	45	60	—
38	3.3	37	50	64	—
37	2.7	41	55	68	—
33 - 36	0.5 - 2.2	48	72	96	—

[a] Adapted from Mills, 1944; modified by A.L. Jones

Fire blight

The fire blight pathogen kills fruit-bearing spurs, branches, and often entire trees. Infected blossoms become water-soaked and then wilted, changing in color to dark green and then black. Infected shoots turn brown to black from the tip and bend near the tip to resemble a shepherd's crook. Fire blight cankers are large black areas that can become sunken and cracked. Internally infected branches appear darker than normal.

Fire blight -- *continued*

Monitoring: The presence of bacterial ooze is the most conspicuous sign of fire blight infection. Milky-colored to reddish brown ooze can be seen on blighted blossoms and shoots, infected fruits, and emanating from cankers in the spring.

Scouting for cankers should be done when trees are dormant; pruning to remove cankers should be done at this time.

Fire blight cankers on Jonathan apple.

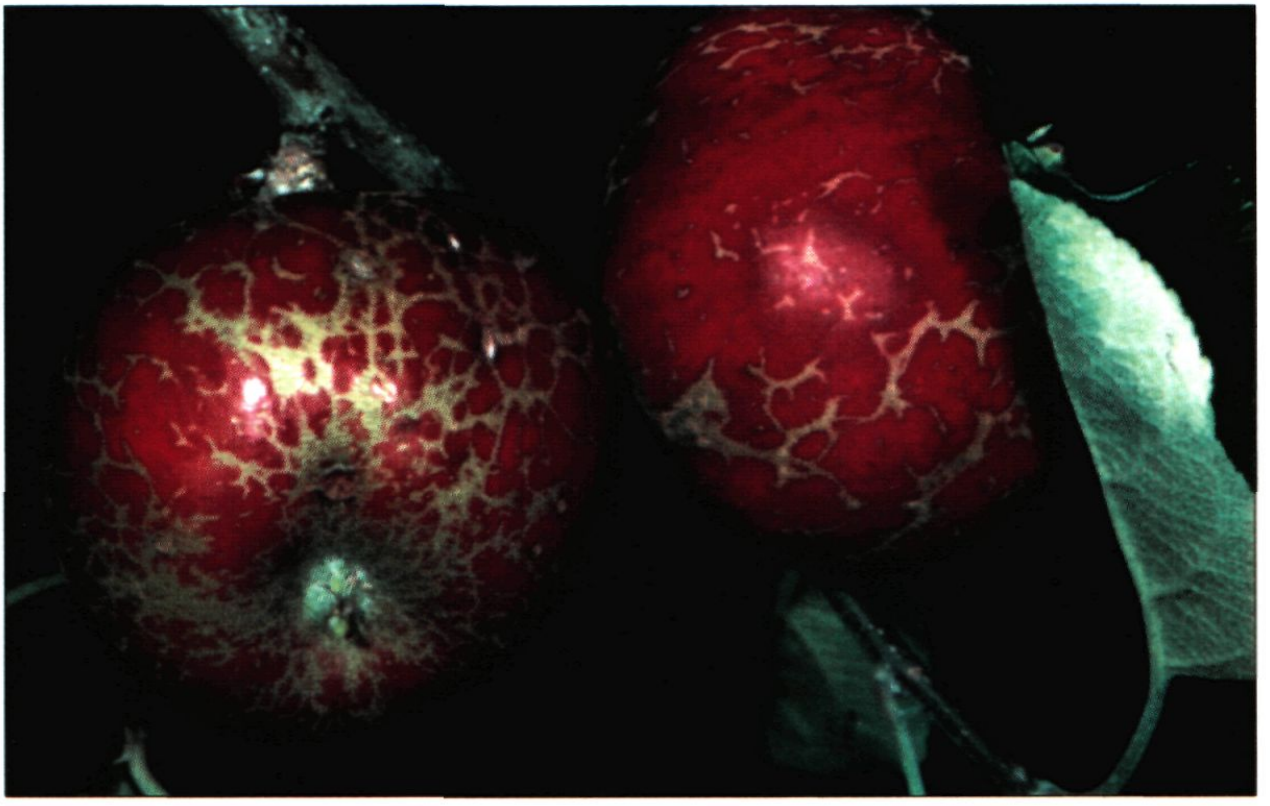
Fire blight -- *continued*

Fire blight can kill trees of any age by infecting the rootstock, although younger trees are most susceptible. Younger trees with rootstock blight die quickly. The wood of older trees appears lighter and the trees produce conspicuously fewer blossoms and leaves during the 1- to 2-year period of decline prior to tree death.

A McIntosh apple tree (above) in an early stage of decline and a Jonathan apple tree in a late stage of decline due to rootstock blight.

Powdery mildew

Powdery mildew fungus overwinters in terminal buds, which open later than surrounding healthy buds in the spring. The fungus affects leaves, green shoots, flowers, and fruit. Symptoms first occur as white or gray lesions on infected leaves and shoots early in spring. New leaves and shoots are more susceptible than older growth. Infected leaves fold longitudinally, are abnormally narrow, and become brittle. Infected flowers open late, and are greenish-brown with white fungal growth, and are shriveled. Fruit can be stunted and russeted by the fungus.



Powdery mildew stunting and russetting on fruit

Sooty blotch and flyspeck

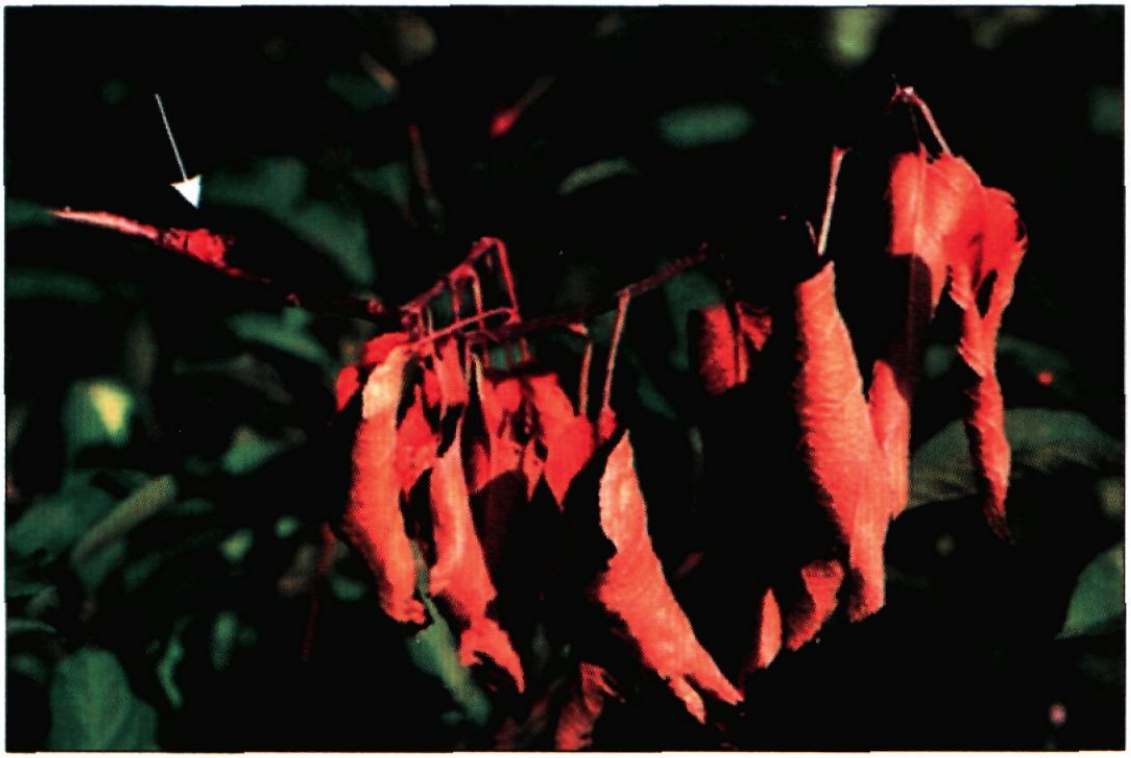
Sooty blotch and flyspeck are fungal diseases that frequently occur together on apple fruit. Flyspeck appears as groups of small, shiny, black dots on the fruit surface. Sooty blotch appears as greenish irregular blotches or patches on the fruit surface. Individual blotches can grow together to form larger infected areas. Both diseases develop best under moist conditions (frequent rainfall and high humidity). They infect fruit from after petal fall through late summer. Optimizing air circulation around fruit by pruning the tree canopy and thinning fruit clusters can reduce incidence and severity of both diseases. Reduce inoculum by removing reservoir hosts, such as brambles, in and around the orchard.

(Jones and Sutton, *Diseases of Tree Fruits in the East*, MSU Extension NCR45).

Left, sooty blotch and below, flyspeck on Golden Delicious

Nectria twig blight of apple

Nectria twig blight of apple is caused by the fungus *Nectria cinnabarina* (asexual stage = *Tubercularia vulgaris*). This opportunistic, weakly pathogenic fungus invades winterkilled twigs, wounds, and fruit stems from the previous year's harvest. The shallow cankers slowly expand and girdle infected stems. In June and early summer, the disease may exhibit symptoms similar to those of fire blight: new shoots wilt, the leaves brown, and a shepherd's crook may form.



Dieback of Rome Beauty apple shoot from Nectria twig blight. Note canker at the base of shoot (white arrow).

Nectria twig blight -- *continued*

For proper diagnosis it is important to closely examine the affected shoot. In contrast to fire blight, the shoot and leaves typically die because of a canker below the affected tissues, often at the base of the previous season's fruit cluster bud (rather than dying from the tip back); the canker margin is distinct; and there is no bacterial ooze. By midsummer numerous .5- to 3-mm orange/pink erumpent mounds, the asexual stage, form on the necrotic tissue. Nectria twig blight is most common on Rome Beauty but has been noted on Empire, Fuji, Northern Spy, and Granny Smith.

Canker (left) and orange fruiting structures of Nectria twig blight

Blister spot

Blister spot is a bacterial disease that occurs predominantly on Mutsu apple, although it is also of minor importance on RedCort and Fuji. Small, raised, brown to black blisters occur on fruit in mid- to late July. The bacteria grow on blossoms and fruit surfaces without causing symptoms initially. Fruit are most susceptible to infection about two weeks after petal fall. The occurrence of streptomycin-resistant strains of the pathogen means there are no effective controls for this disease.

Blister spot on Mutsu apple fruit.

Calyx-end rot

Calyx-end rot, caused by the fungus *Sclerotinia sclerotiorum*, is characterized by a small (~ 0.5 inch) brown lesion that develops at the blossom end of apple fruit. Disease symptoms have been observed in orchards in the northwest, west central, and eastern regions of Michigan on McIntosh and Honeycrisp. Up to 20 percent of fruit have been infected in some blocks. Rot symptoms usually become visible about one month after petal fall. The rot looks soft.

Calyx-end rot on Honeycrisp apples.

Calyx-end rot -- *continued*

Symptoms are not associated with internal rotting of the fruit. The disease is associated with wet periods during bloom, petal fall, and early fruit set. Spores can be produced on infected fruit from the previous year or on any of several alternate weed hosts, including dandelion and wild clover. Because the disease is so sporadic and typically has not resulted in significant infection, there has been little justification for chemical control studies. It is possible that fungicides used for apple scab control may also effectively control calyx-end rot.

Tree Row Volume Chart (Standard is 400 gal/A)

To determine your blocks PERCENT OF STANDARD, take the width and height line on the left and read across until you come to the correct width between rows. Example: Tree Height = 12 feet, Tree Width = 12 feet, Width Between Rows = 20 feet, then the Percent of Standard = 54%.

Height & Width		Sq Feet	Distance Between Rows							
			14	16	18	20	22	24	26	28
6	8	48	26	23	20	18	16	15		
6	10	60	32	28	25	23	20	19		
6	12	72	39	34	30	27	25	23		
6	14	84	45	39	35	32	29	26		
8	10	80	43	38	33	30	27	25	23	
8	12	96	51	45	40	36	33	30	28	
8	14	112	60	53	47	42	38	35	32	
8	16	128	69	60	53	48	44	40	37	
10	12	120	64	56	50	45	41	38	35	32
10	14	140	75	66	58	53	48	44	40	38
10	16	160	86	75	67	60	55	50	46	43
10	18	180	97	84	75	68	61	56	52	48

Table continues on next page

Tree Row Volume Chart *continued*

Height & Width	Sq Feet	Distance Between Rows							
		16	18	20	22	24	26	28	30
12 12	144	68	60	54	49	45	42	39	36
12 14	168	79	70	63	57	53	49	45	42
12 16	192	90	80	72	66	60	55	51	48
12 18	216	101	90	81	74	68	62	58	54
		Distance Between Rows							
		18	20	22	24	26	28	30	32
14 14	196	82	74	67	61	57	53	49	46
14 16	224	93	84	76	70	65	60	56	53
14 18	252	105	95	86	79	73	68	63	59
14 20	280	117	105	96	88	81	75	70	66
		Distance Between Rows							
		20	22	24	26	28	30	32	34
16 16	256	96	87	80	74	69	64	60	57
16 18	288	108	98	90	83	77	72	68	64

Table continues on next page

Tree Row Volume Chart *continued*

Height & Width	Sq Feet	Distance Between Rows 20	22	24	26	28	30	32	34
16 20	320	120	109	100	92	86	80	75	71
16 22	352	132	120	110	102	94	88	83	78
		Distance Between Rows							
		22	**24**	**26**	**28**	**30**	**32**	**34**	**36**
18 18	324	111	101	94	87	81	76	72	68
18 20	360	123	113	104	97	90	84	79	75
18 22	396	135	124	114	106	99	93	87	83
18 24	432	147	135	125	116	108	101	95	90
		Distance Between Rows							
		24	**26**	**28**	**30**	**32**	**34**	**36**	**38**
20 20	400	125	116	107	100	94	88	83	79
20 22	440	138	127	118	110	103	97	92	87
20 24	480	150	139	129	120	113	106	100	95
20 26	520	163	150	139	130	122	115	108	103

Table continues on next page

Tree Row Volume Chart *continued*

Height & Width		Sq Feet	Distance Between Rows 26	28	30	32	34	36	38	40
22	22	484	140	130	121	114	107	101	96	91
22	24	528	152	142	132	124	117	110	104	99
22	26	572	165	153	143	134	126	119	113	107
22	28	616	178	165	154	145	136	128	122	116
			Distance Between Rows 28	30	32	34	36	38	40	
24	24	576	154	144	135	127	120	114	108	
24	26	624	167	156	146	138	130	123	117	
24	28	672	180	168	158	148	140	133	126	
24	30	720	193	180	169	159	150	142	135	

Index of species

Insect and mite pests

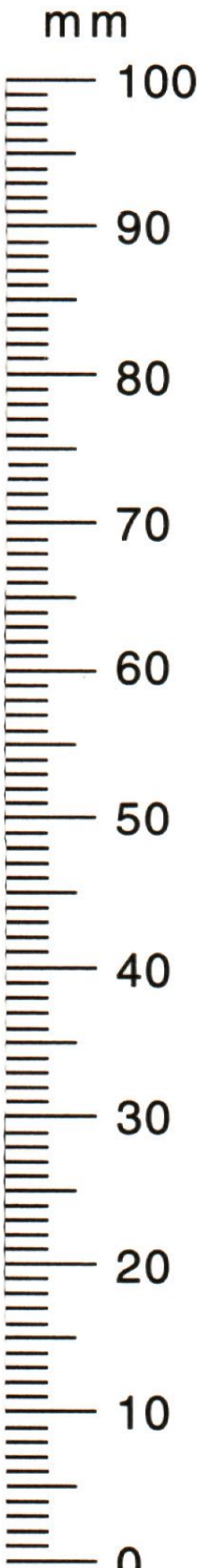
Index of species -- *continued*

Tables/ charts

View scouting tips and techniques on a DVD

A Practical Guide to Scouting Apple Orchards is designed to give apple growers and consultants easy access to information that helps de-mystify the pest management decision-making process. The 90-minute DVD is divided into 21 modules covering topics from choosing a weather monitoring system to discussions on degree-day models and monitoring primary disease and insect pests. This DVD can be viewed in one sitting, but is designed more for those who want to learn about specific topics at any point during the growing season by simply choosing the desired tracks from the DVD menu.

The DVD compliments the information in the apple pocket scouting guide (Extension Bulletin E2720). Growers can watch the DVD, plan this year's IPM scouting program, use the pocket guide in the orchard for easy reference and then return to the DVD for management advice or a review of tactics. Purchase from MSU Extension by calling 517-353-6740 or on the Internet: http://web2.msue.msu.edu/bulletins/intro.cfm Refer to publication number DVD273.



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