Guide for IPM Scouting in Stone Fruits

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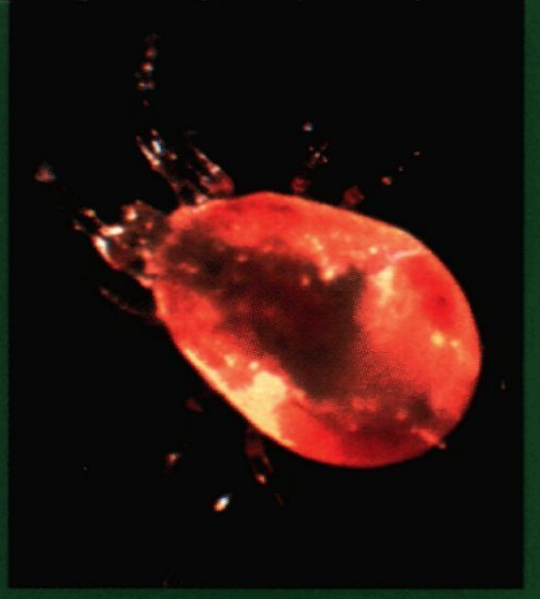
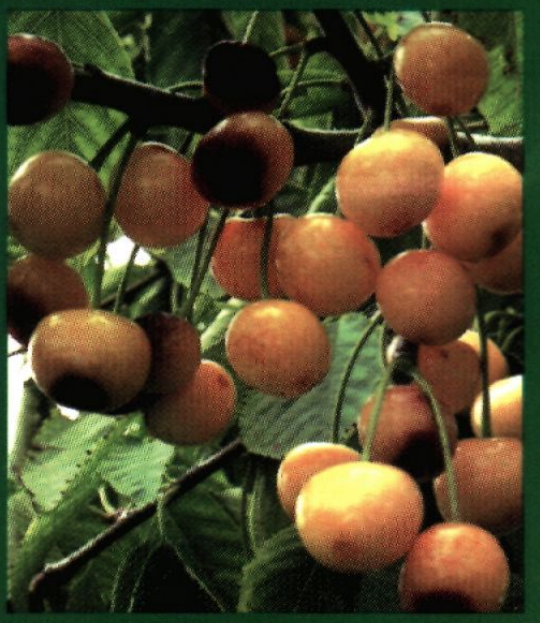
A Pocket Guide for IPM Scouting in Stone Fruits





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Contents

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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 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. Less common diseases and insect pests, and those for which there are no control measures are not included.

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

Compendium of Stone Fruit Diseases. 1995. J. M. Ogawa, E. I. Zehr, G. W. Bird, D. F. Ritchie, K. Uriu, and J. K. Uyemoto. APS Press, St. Paul, MN 98 pages.

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

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

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

Cherry and black cherry fruit flies -- *Rhagoletis cingulata* (Loew) and *R. fausta* (Osten Sacken)

Above, cherry fruit fly.
Below, black cherry fruit fly.
Both are about 4.5 mm.

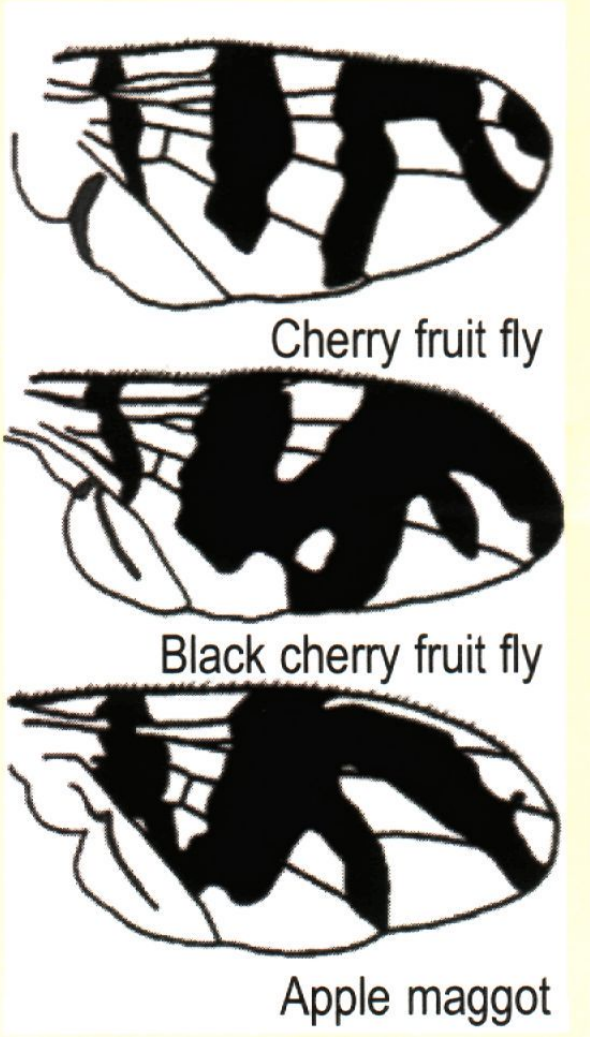
4.5 mm

Cherry fruit fly (CFF) and black cherry fruit fly (BCFF) overwinter as pupae in the soil and complete only one generation per year. First emergence occurs in late May or early June when early tart cherries begin to show a tinge of color. BCFF emerges about a week before CFF.

Flies continue to emerge for about a month, with peak emergence taking place in late June to early July. After a 7-10 day pre-egg-laying period, females deposit eggs in the fruit, and hatching larvae immediately burrow in to feed.

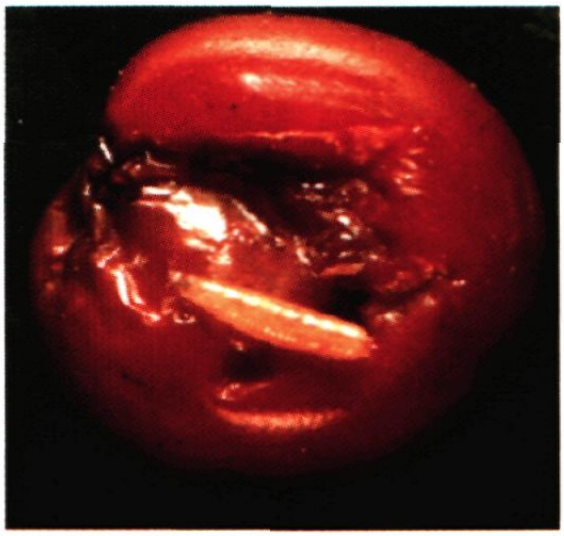
Differentiating between CFF and BCFF

CFF and BCFF flies are slightly smaller than a house fly. Both have black bodies, yellowish brown legs and heads. They can be differentiated based on wing pattern (see diagram). In addition, the BCFF abdomen is entirely black, while CFF males and females have 3 or 4 white bands on the abdomen, respectively.



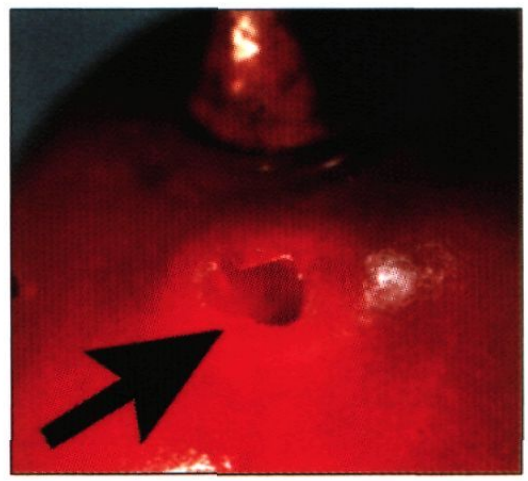
Monitoring: The date of first emergence, as well as subsequent activity, of CFF and BCFF can be monitored using yellow sticky traps baited with ammonium acetate. Place traps adjacent to border areas with known alternate hosts of these flies: pin cherry for the BCFF, wild black

Cherry/black cherry fruit flies -- *continued*



CFF larva on cherry.

cherry for the CFF. Hang traps two weeks after shuck split when fruit begins to take on a yellowish color. The greater the number of traps deployed per acre (at least one trap per 2.5 acres), the greater the confidence level in basing treatment decisions on fly catch. Proper trap maintenance is crucial to trap effectiveness. Use on-farm fly catches along with regional trapping information to determine control treatment timing. Because of 0% tolerance for CFF in harvested fruit, a conservative approach is recommended. Applications of OPs and other contact insecticides are timed for fruit fly egg laying, which occurs 7-10 days after the first fly is captured. If a fly is trapped on-farm and a regional trap catch is recorded prior to the on-farm fruit fly capture, the treatment should be ap-



Entry hole in cherry.

Cherry/black cherry fruit flies -- *continued*

plied 7-10 days after the earliest capture. Basing treatment decisions solely on regional information may lead to unnecessary insecticide applications. If you are using a newer insecticide chemistry that requires ingestion of the material for effective control, the insecticide should be applied immediately after the first fly has been captured in a trap.

Urophora quadrifasciata and *Urophora affinis,* the **knapweed gall flies**, are small tephritid flies that may be mistaken for cherry fruit fly in yellow sticky monitoring traps. The wing bands are different from those of cherry fruit fly, but *U. quadrifascata* has the characteristic break between the front and hind wing bands. The knapweed gall flies are smaller (3-4 mm) than the economically important fruit flies, and the females have a long, needlelike ovipositer.

U. quadrifasciata

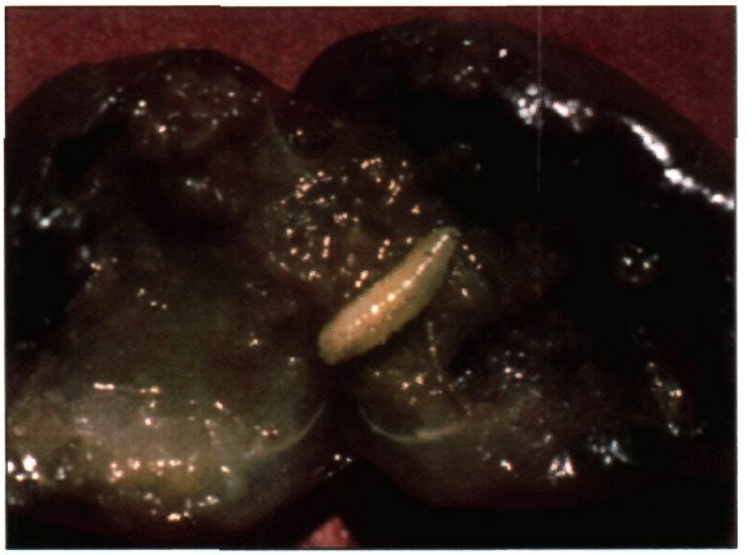
U. affinis

Plum curculio --
Conotrachelus nunuphar (Herbst)

Plum curculio (PC) disperse from their overwintering sites to adjacent orchards in the spring when maximum temperatures are at least 75°F for 2-3 days or when mean daily temperatures are 55°-60°F for 3-6 days. Although PC may be in the orchard before fruit is present, this is not the appropriate time for control. Spring migration lasts about six weeks. Peak activity and the critical time for control usually occurs 2-3 weeks after shuck split as young fruit develops. Use of a PC degree day model, **for tart cherry only**, can delay insecticide treatment until 375 GDD base 50°F after full bloom. **This GDD model should only be used with an intensive scouting program** to ensure PC are properly monitored.

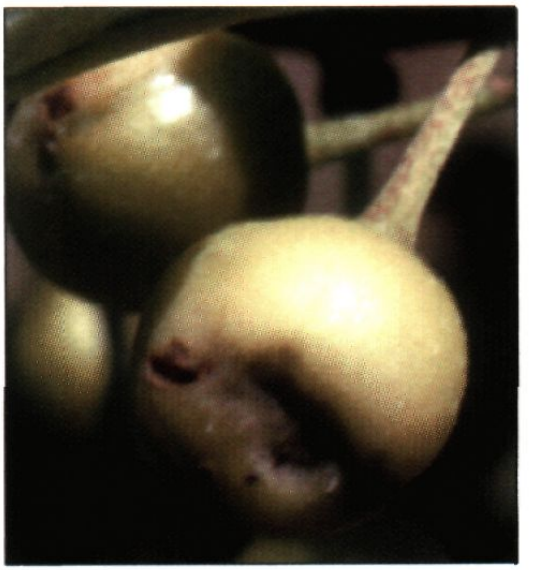
5 mm The adult beetle is about 5 mm long, dark brown with whitish to gray patches, and has four ridges on its wing covers, two of which are readily visible. Its long, downward-curved snout is about 1/4 to 1/3 its body length.

Plum curculio -- *continued*



7 mm The mature larva is segmented and C-shaped, about 7 mm long, yellowish white with a brown head capsule, and legless. Below, the half-moon scar from PC egg laying.

Eggs laid prior to 375 GDD base 50F will produce larvae that develop and exit the fruit before tart cherry harvest. Oviposition stings after about 375 GDD base 50°F (after bloom) result in larvae in the fruit at harvest. The characteristic half-moon scar on fruit indicates an egg-laying event. PC is capable of causing high levels of injury in a short amount of time.



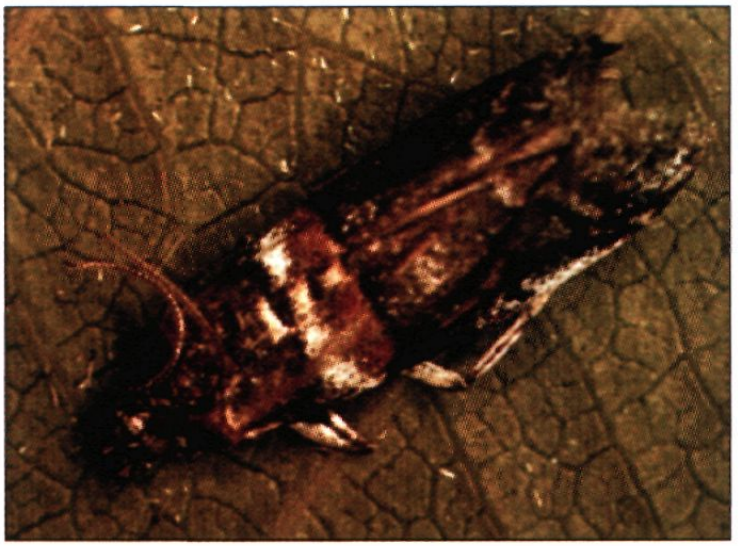
Monitoring: PC activity can be detected by visually inspecting fruit for signs of feeding or egg laying. Monitor most intensively from bloom through three weeks after shuck fall.

Plum curculio -- *continued*

Concentrate sampling on trees adjacent to hedgerow and woodlands, especially where damage has occurred. In addition, traps baited with pheromone and fruit volatile lures can be used to detect the presence of PC and to time sprays. Place at least 3 traps along orchard perimeters that are adjacent to PC overwintering habitats, such as woodlands. Traps will begin to capture PC as they move into the orchard and throughout the entire season.

Mineola moth -- *Acrobasis tricolorella* (Grote)

Plums and tart cherries are the preferred hosts of the mineola moth (MM). Young larvae overwinter in hibernacula, emerging in mid- to late

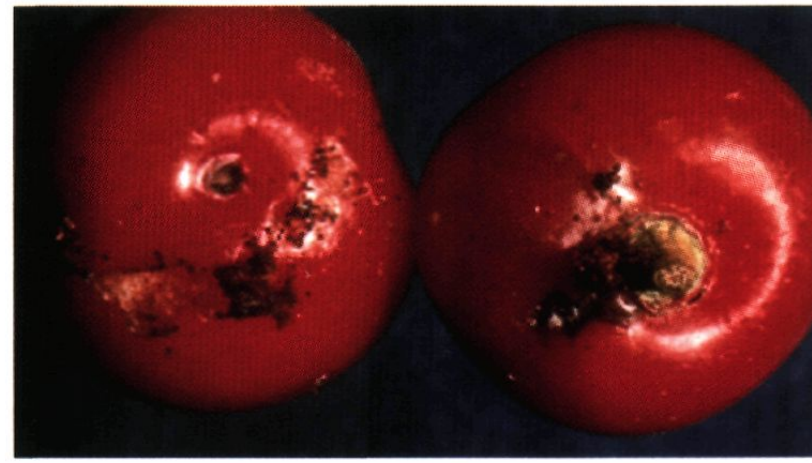


Adults (below, left) are about 9-12.5 mm long, with a white stripe running across the middle of the forewings.

Mineola moth -- *continued*

13 mm

Mature larvae are 13 mm long, dark brown on top and a lighter reddish brown underneath, with a distinct union where the 2 colors meet on the side. Newly hatched larvae are 1-2 mm, yellow with brown heads, and are covered with short spines. At right, larval damage to cherries.



April to feed primarily on fruit buds and developing flower parts. As the larvae feed over the next 4-5 weeks, they web together developing leaf clusters and flower petals to form nests. By petal fall, most larvae have dropped to the ground to pupate in the orchard litter. Adult moths emerge for 2-4 weeks after full bloom. Larvae of this generation enter the fruit and feed around the pit for approximately 11-14 days before exiting to form hibernacula in the crotches of fruit spurs. These larvae

Mineola moth -- *continued*

At left, webbing in developing leaf clusters, and right, leafmining from larvae.

drop to the ground, pupate and emerge as second generation adults throughout fruit harvest. Second generation larvae will form nests and feed on foliage.

Monitoring: Inspect fruit buds early, and petals after bloom for signs of larval feeding. The larva enters the bud through its base, often eating the entire bud contents. Also scout for the presence of nests in developing leaf clusters. Frass is easily seen in the webbing forming the nest.

Control: Apply insecticides against overwintering larvae as they emerge from their hibernacula (green tip to popcorn stages) or when adult moths are emerging.

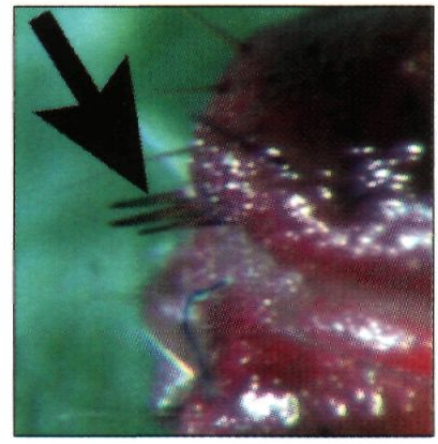
Cherry fruitworm --
Grapholitha packardi (Zeller)

Cherry fruitworm (CFW) overwinters as a mature larva in hibernaculum on the tree. Adults emerge 2-4 weeks after petal fall in tart cherry, mate and lay eggs on the calyx and stem ends of the fruit. Larvae hatch from eggs in 10 days. They bore into the fruit, often feeding just below the surface before moving towards the pit. There is one generation per year. **Monitoring:** Begin monitoring adult flight after petal fall, and for larvae

10 mm

Adult CFW are gray-black moths with brown markings on their wings. Their wingspan is 9-10 mm.

9 mm



Mature larvae are 9 mm long, reddish with brown heads, and have an anal comb (right). When hatched, immature larvae are whitish gray with black heads, about 1.4 mm long.

Cherry fruitworm -- *continued*

at 2 weeks after petal fall. Visually inspect fruit for pin-sized entrance holes and frass. Brown trails can be seen below the surface of infested fruit.
Control: Time sprays for egg hatch, beginning approximately 10 days after the start of adult flight.

Green fruitworm (or speckled green fruitworm) -- *Orthosia hibisci* (Guenee)

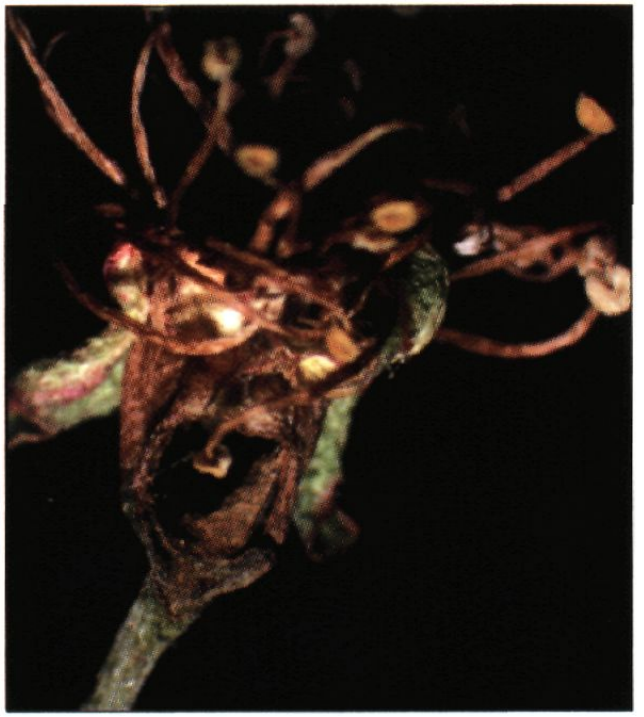
Immature larvae of the green fruitworm (GFW) feed on flower buds and new foliage. Mature larvae feed on blossoms, developing fruit and leaves. Early feeding injury often causes fruit to abort. Fruit remaining on the tree after GFW feeding exhibit deep holes sealed over with corky scar tissue.

Newly hatched larvae are 2-3 mm in length and have a grayish-green body with a brown head and thoracic shield. Mature larvae are 30-40 mm long, and pale green with white speckles and white longitudinal stripes.

Green fruitworm -- *continued*

40 mm

Adults are large gray-brown moths with wingspans of about 40mm. Below: damaged fruit.



Above, blossom damage from larval feeding.

Monitoring: Use pheromone traps to monitor for adult emergence, generally around budburst in Michigan. Visually inspect fruit and leaves for larvae or signs of larval feeding. Examine 20 fruit clusters per tree (outside, inside, and top of tree) on five trees per orchard.

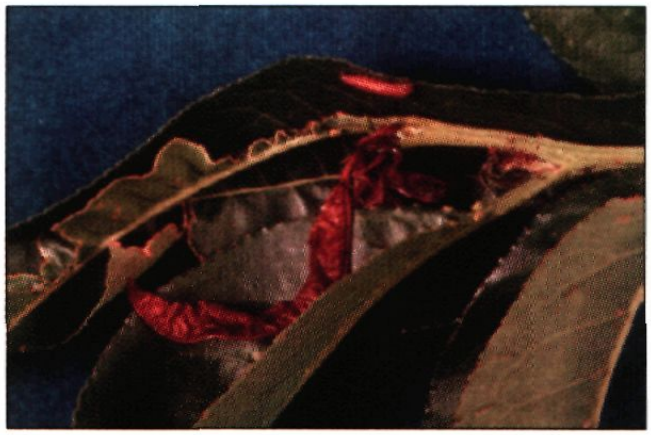
Treat if there is an average of two or more larvae per tree or evidence of fresh feeding.

Oriental fruit moth --
Grapholitha molesta (Busck)

From May through July, Oriental fruit moth (OFM) larvae enter twig terminals and consume 2-6 inches of the central shoot. These twigs can be identified by the presence of one or more wilted leaves, called "flagging." OFM larvae also feed directly on the fruit. Feeding and larval entry into immature fruit are associated with a gum exudate at the entry hole that darkens with time.

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

OFM larvae enter twig terminals and consume 2-6 inches of the central shoot (below, left). Larval entry into mature fruit is associated with frass at the entry hole (below, right).



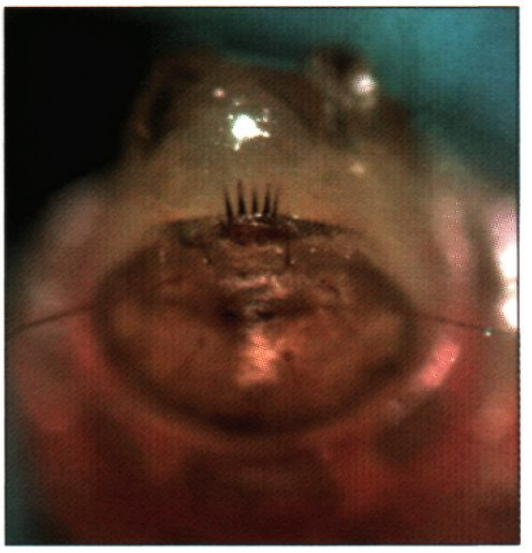
Oriental fruit moth -- *continued*

10 mm

Mature larva is about 10 mm long, creamy-white to pink, with a brown head capsule and an anal comb located ventrally at the posterior end. The comb can be seen with a hand lens.

Larvae typically, but not always, enter mature fruit at the stem end leaving frass at the entry hole. After tunneling through the fruit, mature larvae usually exit through the side, leaving an exit hole marked by frass. Three full generations occur in Michigan, and sometimes a partial fourth.

Monitoring: Use 1 trap per 10 acres to determine biofix for each generation. Time treatments using the degree day model on the next page.



Mature OFM larvae have an anal comb located ventrally at the posterior end. The comb (left) can be seen with a hand lens.

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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°F**. Treatment thresholds based on trap catch 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.

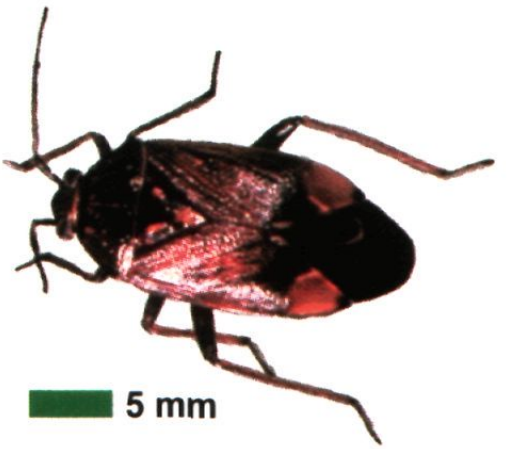
Oriental Fruit Moth Degree Day Model --

continued

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

Tarnished plant bug -- *Lygus lineolaris* (Palisot de Beauvois)

Tarnished plant bug (TPB) can be a pest of peach and nectarine throughout the growing season. Overwintering adults become active in spring as fruit buds begin to swell and are most active at bloom in peach. Damaged buds exude a gummy liquid and shrivel up.



The TPB is a flattened, oval bug about 5mm long, with color varying from green to brown, with yellow, brown, or red markings. Wings are folded flat over the body and have a distinct yellowish triangle on the upper surface.

Feeding by adults on young fruit results in "catfacing" damage – corky, depressed areas with small amounts of dried gum in the center. Late season feeding can create numerous scars on the same fruit coupled with oozing gum. It is not always associated with callused, deformed fruit.

Tarnished plant bug -- *continued*

TPB nymphs.

First brood nymphs are present from late April through mid-June. First generation adults begin to appear in the orchard in late May. Three to five generations per year occur in Michigan. Adults readily move into the tree canopy following mowing or similar activities that disturb feeding sites. In response to reductions in suitable weedy hosts, later generations may move to fruit throughout the season. Reduce TPB pressure by eliminating broadleaf weeds from the groundcover.

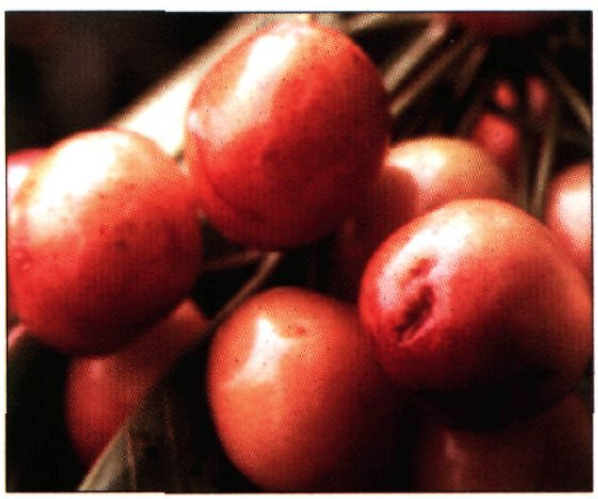
Monitoring: Start scouting for TPB early in spring by examing fruit flower buds for signs of injury. Continued visual monitoring of fruit in peaches and nectarines from petal fall to shuck fall is critical for TPB management. Beating trays can be used to sample for adults and nymphs. Trapping with white sticky boards gives inconsistent results and is not recommended.

Green stink bug --
Acrosternum hilare (Say)

Adult GSB are bright green and yellow, 16-19 mm long, with a flattened, shield-shaped body and a narrow head.

16-19 mm

Feeding injury from green stink bug (GSB) on cherry fruit may cause flesh near the pit to discolor and decay. Feeding injury on peach can take several forms depending on the time of year the injury occurs. Feeding from petal fall through shuck split causes the developing fruit to abort. "Catfacing" (corky, depressed areas of the fruit with small amounts of dried gum in the center - see page 17) results from feeding at shuck-off until the fruit is approximately 20 mm in diameter. Initial feeding on immature fruit can also appear as small, translucent, blue-green spots that later develop into irregular, depressed areas (dimples). Feeding on mature fruit may appear as little more than a bruise.



Japanese beetle --
Popillia japonica Newman

Japanese beetle larvae overwinter in the soil, pupate in the spring, and emerge as adults in mid-June to July (in Michigan). Adults skeletonize leaf tissue and may also attack fruit of cherry, plum, peach and nectarine. Adults often feed in groups on warm, sunny days, removing large portions from the fruit, particularly on early ripening peach.

12 mm

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

Japanese beetle -- *continued*

Monitoring: Use attractant-baited traps to monitor adult emergence. Examine fruit and leaves each week from the time of adult emergence through July. Young trees are particularly vulnerable to the leaf injury.

Rose chafer -- *Macrodactylus subspinosis* (F.)

Rose chafer (RC) is typically found in areas with sandy soils where larvae are especially abundant, feeding on roots of grasses. Adults

20 mm

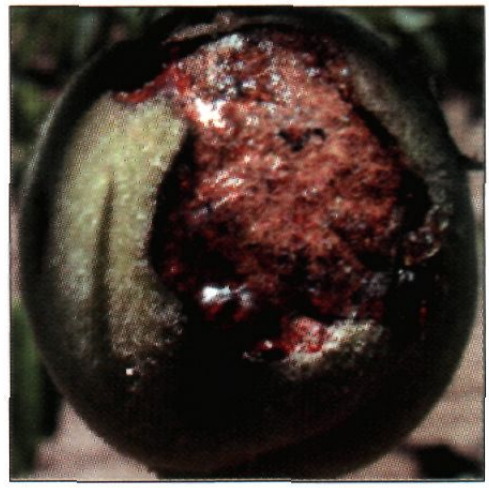
Adults are about 20 mm in length, long-legged, slender, grayish yellow-brown to moderate reddish brown beetles. The body undersurface is black.

Rose chafer -- *continued*

emerge from the soil in late May or early June and move to surrounding vegetation, including peach, to feed and mate. RC adults are the only injurious stage to stone fruits. Damage is often concentrated on orchard borders adjacent to grassy fields. Adults are gregarious, with several beetles often attacking a fruit and devouring it.

Monitoring and thresholds: Adult emergence can be monitored with attractant-baited traps. Begin inspecting fruit and leaves for signs of feeding as soon as the first beetles are captured. Focus sampling along orchard borders adjacent to grassy fields.

At left, foliar feeding damage. Below, feeding on the fruit by beetles creates fruit drop or damage called "catfacing."



Western flower thrips -- *Frankliniella occidentalis* (Pergande)

Western flower thrips (WFT) are a pest of various stone fruit. They overwinter as adults in the orchard floor or in nearby weedy habitat. Early-season feeding under the shuck by adults and nymphs scars the fruit surface. The scars expand as the fruit grows. Direct feeding on maturing fruit causes blemishes, referred to as silvering, which can downgrade the fruit. Thrips will also feed within flowers around bloom time.

Monitoring: Adults and nymphs can be detected at bloom by dissecting flowers, or by jarring WFT from the flower. WFT move quickly when disturbed. California Extension guidelines recommend treatment if adults infest more than 10% of 50 blossoms from 10 to 12 trees, or if nymphs are present. Inspect ripening fruit for silvering.

WFT are slender and yellowish. Adults are about 1.5 mm long and have fringed wings that are folded over their backs. Immatures are similar in appearance, although lighter in color and wingless.

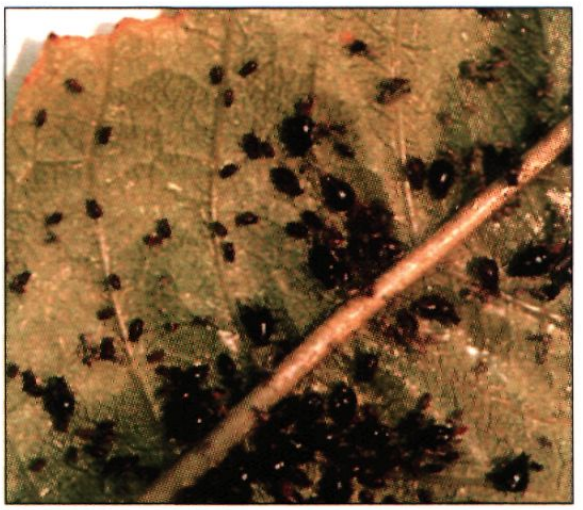
About aphids

Aphids can cause direct feeding damage and can also spot foliage and fruits with the honeydew they secrete. The honeydew acts as a medium for fungal growth, potentially leaving fruit and foliage smutted and black. Before making decisions to treat for aphid infestations, know the levels of aphid predators in the orchard and the tolerance of the host species to aphid injury. Feeding by lady beetles, lacewing larvae, syrphid and cecidomyiid fly larvae, wasps and true bugs can contribute to aphid control.

Aphids typically can be found within curled leaves. Continued feeding will cause leaves to turn yellow, wilt and drop.

Black cherry aphid --
Myzus cerasi (F.)

Black cherry aphid (BCA) feeding curls and stunts leaves, and deforms shoot growth. Commercial sweet cherry is the preferred and most susceptible host. Highly susceptible varieties include Black Tartarian, Napoleon, Schmidt and Windsor. Young cherry trees are especially susceptible to injury and can be killed if infestations are heavy. Severe infestations may also reduce the quantity and quality of the crop on mature trees. Overwintering BCA eggs hatch as cherry buds begin to open in April. Two to three generations are usually completed on cherry. Several summer generations are produced on alternate hosts, with winged adults returning to cherry orchards in September and October to mate and lay overwintering eggs.



BCA is readily distinguished from other aphids that may be present on cherry by the shiny metallic black coloration of both the adults and nymphs. Adults measure about 3.2 mm in length.

3 mm

Green peach aphid --
Myzus persicae (Sulzer)

In the spring, as the first leaves appear, green peach aphid (GPA) nymphs appear and begin to feed on flowers, young foliage, and stems. Large numbers of GPA can develop quickly on new terminal growth, causing leaves to curl, turn yellow, and wilt or drop from the tree. Aphids also produce honeydew and can be a vector of viral diseases such as plum pox. Chemical treatment for GPA in July may not be needed because GPA produces a winged generation in July that migrates to summer host plants, returning to tree fruit hosts in the fall to overwinter.

First spring generation adults are wingless, about 1.7 to 2.0 mm long, and yellow-green with two lateral green stripes on their abdomen and two moderately long cornicles (tailpipes) on the end of the abdomen. Stem mothers are a deep pink color.

Green peach aphid -- *continued*

Injury on nectarine.

Monitoring and thresholds: GPA prefer to feed on the underside of leaves. Starting at petal fall until about 1 month after shuck fall, examine 50 spurs from 10 trees (5 spurs/ tree) weekly. Focus early efforts on root suckers or on leaves in the lower center of trees.

Treat if there are more than 30-50% infested terminals on peach (mature, vigorous trees can withstand higher pressure than young trees); 1 colony/tree on nectarine. Monitor also for the presence of GPA predators (e.g., larvae of ladybird beetles, lacewings, and syrphid flies). Large numbers of these predators can help control aphid populations, delaying or eliminating the need for a chemical control.

Pear slug/sawfly --
Caliroa cerasi

Pear slug larvae skeletonize cherry leaves from the underside leaving a network of veins. Most severe damage occurs during the second generation, from late July to August, and can adversely affect subsequent bud set. Young trees can be defoliated. A similar species, *C. liturata,* feeds on peach and plum

Adults are small, glossy black and yellow sawflies (wasps) about 5 mm long, with four transparent wings.

Monitoring: Inspect foliage in spring and in late July to August.

Larvae grow to 10-12 mm and cover themselves with a green slime that makes them resemble a slug.

10-12 mm

About mites

Mite feeding turns leaves brown (referred to as bronzing). Severe infestations can reduce overwintering carbohydrate levels, cause trees to defoliate and stunt young tree growth. In years of drought or high temperatures, tree susceptibility to mite damage is heightened.

Leaves on the right show bronzing from mite feeding.

Plum rust mite or plum nursery mite
Aculus fockeui (Nalepa et Trouessart)

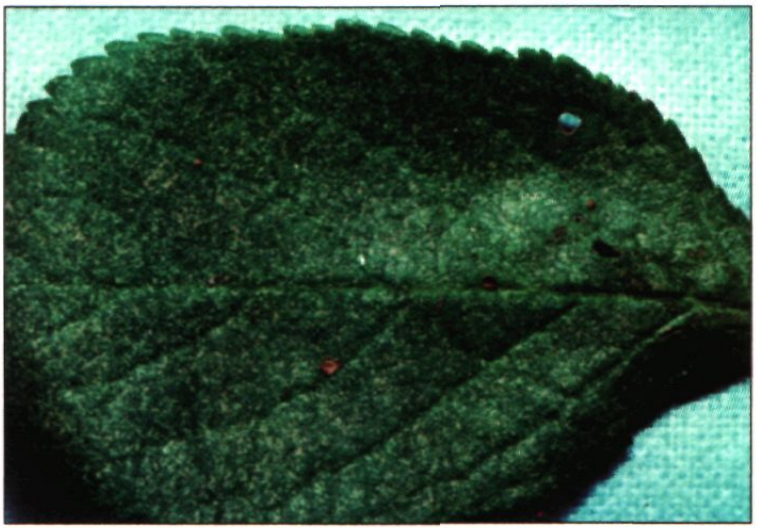
Plum rust mites (PRM) generally restrict their feeding to new foliage, causing these leaves to brown and roll upward longitudinally. Female PRM overwinter in dead or shrunken buds, moving to foliage as buds begin to open in spring. As many as 15 generations occur per year, with peak populations generally occurring in late July. Light to moderate populations are suppressed by predaceous mites.

Monitoring: Monitor new terminal growth for browning in July. PRM is mostly a problem where chemical spray programs have lowered popula-

"Firing" is caused by drought stress coupled with mite damage.

Plum rust/nursery mite -- *continued*

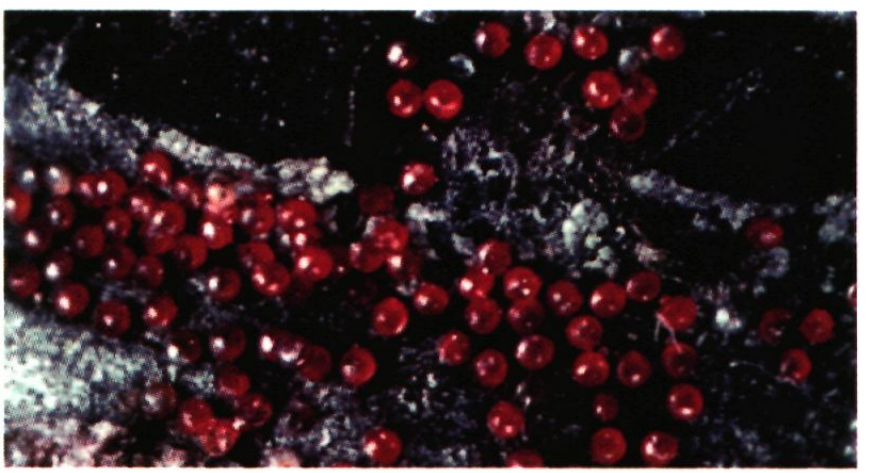
tions of predator mites. PRM should be monitored after harvest in cherry to ensure that population levels do not reduce tree vigor for the winter.



On plum, damaged leaves exhibit "chlorotic fleck," a series of yellow spots 1-2 mm in diameter.

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

European red mite (ERM) eggs begin hatching toward the end of April in Michigan and are found on leaves or bark the rest of the year.

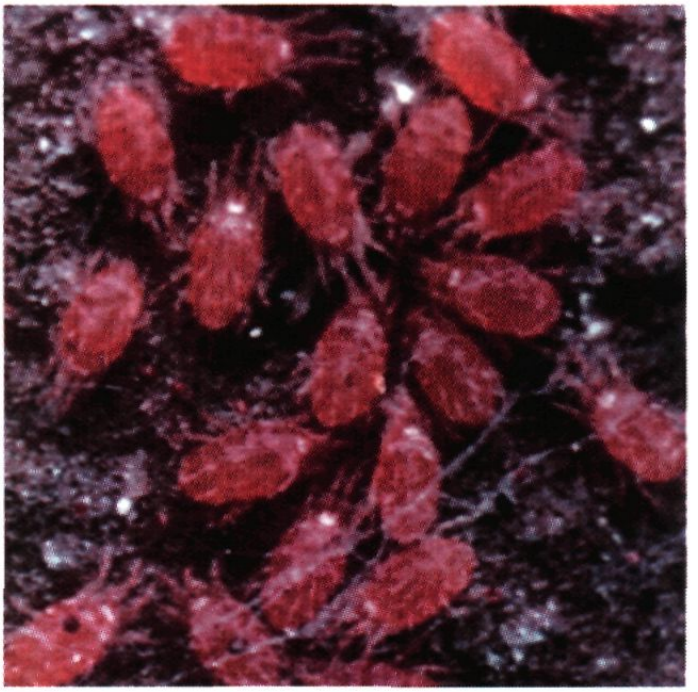


ERM overwinter as eggs on rough bark, most commonly near buds, and fruit spurs and in branch forks.

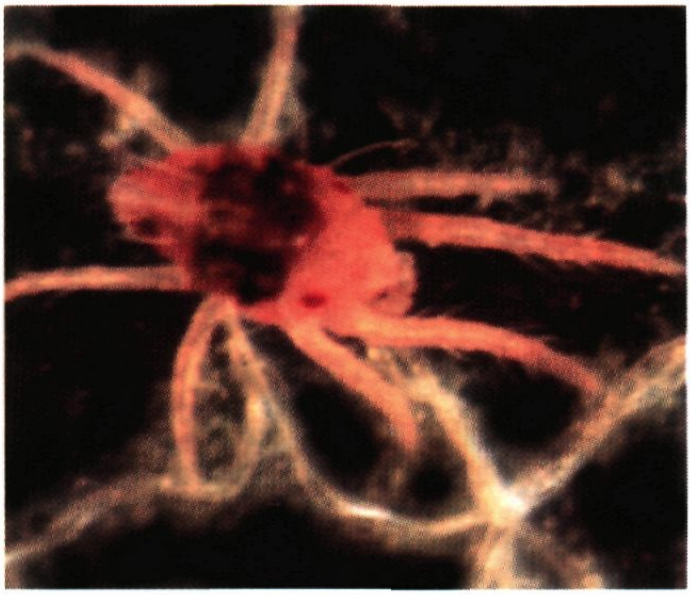
European red mite -- *continued*

ERM feeding can cause leaf stippling and bronzing. Heavy infestations early in the season can affect tree growth, yield, and bud formation. The lower leaf surface is the ERM's preferred feeding site, but the upper leaf surface is also attacked.

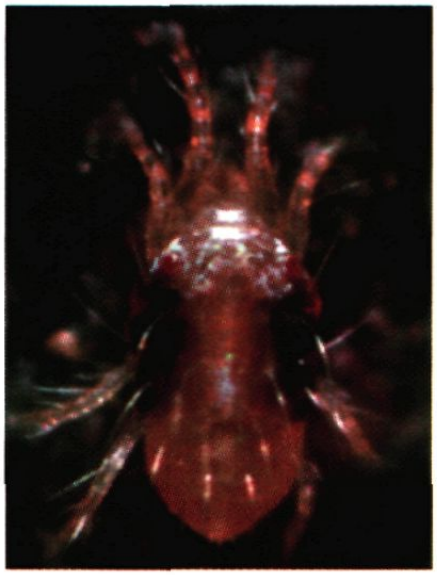
Monitoring and thresholds: see twospotted spider mite information.



Immature ERM (at right) often feed in groups within unfolding leaves. Below left, the female is brownish red with white spots at the bases of her white bristles. At right, an adult male.



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



Twospotted spider mites (TSSM) have two distinct spots 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 over-wintering adults turn orange in September. TSSM are in the tree canopy from late April through harvest. They typically construct webbing on the underside of leaves.

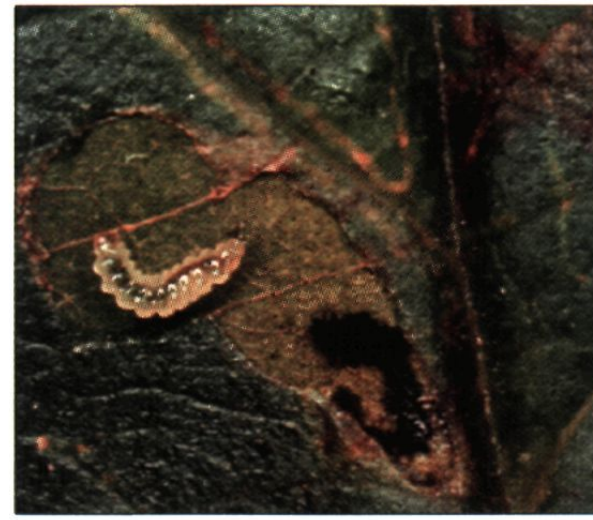
Monitoring and thresholds: For summer populations of ERM and TSSM, examine leaves from several locations in the orchard using 50% spur leaves, 50% shoot leaves. Treat based on the following thresholds:

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

Double the treatment thresholds for TSSM in tart cherry. Predaceous mites (>1/leaf) may justify delaying a treatment and monitoring again the following week.

Cherry leafminer --
Nepticula slingerlandella (Kft.)

Plum and pin cherry are the preferred hosts of the cherry leafminer (CLM). It overwinters as a pupa in orchard litter. Adults emerge from late May to mid-June and immediately mate. Female CLM lay their eggs on the underside of leaves. Approximately three weeks later, larvae hatch from the eggs and bore into the underside of the leaf. From there they quickly move to the tissue directly below the upper leaf surface. As the larva grows, the mining becomes more extensive, and the mature larvae can be seen through the upper surface of the leaf, which becomes transparent. The mature larva cuts a small slit through the leaf and drops to the orchard floor to pupate approximately two weeks from the time it bored into the leaf. CLM can cause defoliation, reducing yield and tree growth.



5 mm Mature larvae are greenish-white, 4 - 5 mm long, and have many ring-like segments. Hatchlings are transparent.

Cherry leafminer -- *continued*

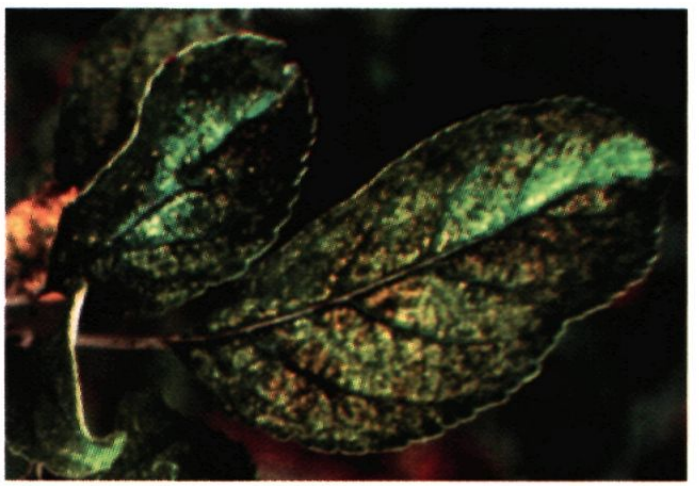
The adult CLM is a minute brownish moth, with a 3.5 - 5 mm wingspan and a black band on its forewings.

3.5-5 mm

Control: Controls are timed for emerging adults. Black light traps are effective for monitoring adult flight.

White apple leafhopper -- *Typhlocyba pomaria* (McAtee)

The primary host of WALH is apple, but it also is found on peach, plum, and cherry. WALH prefer mature leaves and do not tend to feed at the leaf edge. WALH cause a whitish stippling effect (see photo, at left) on leaves and they drop a hard to remove excrement on fruit, mostly in the second generation.



White apple leafhopper -- *continued*

WALH nymphs are white to yellow. Early instars have red eyes.

Adults are about 3 mm long and pale yellow-white.

3 mm

There are two generations of WALH. They are present from spring through harvest.

Monitoring and thresholds: Estimate number per leaf. More first-generation will be on spur leaves; most summer-generation will be on mid-shoot leaves. Thresholds for trees with sparse canopy and heavy crop load are lower than for trees with luxurious canopies. Generally, 1-3 adults per leaf will bleach around the midrib only; 8 per leaf will stipple the entire leaf and annoy workers.

About borers

Most borer larvae that are pests of stone fruit cause similar types of tree damage. All produce a reddish excrement or frass as they feed and often leave behind their pupal skins following emergence as adults. Damage from American plum borer (APB) and lesser peachtree borer (LPTB) is most often associated with trunk damage from mechanical shakers at harvest time. Paint the trunks of any trees damaged by harvesters to minimize borer injury to the tree. Pheromone lures are available to monitor adult borer activity. Use separate traps for each borer

Typical damage from greater peach tree borer and American plum borer.

species containing a lure specific to the borer being monitored. Treatment decisions are not currently based on moth catches. Rather, moth catches are used to monitor adult activity and to help predict time of egg hatch. **Control:** Trunk sprays are most effective when applied at the start of egg hatch -- generally 2 weeks after the start of adult flight.

Distinguishing between borer larvae

APB larvae vary in color from grayish green to purple (upper photo), while LPTB and PTB larvae are creamy white (lower photo). In addition, APB larvae tend to have a darker head capsule and thoracic shield (hardened area behind the head).

Differentiating between LPTB and PTB larvae is difficult. Typically, however, LPTB is most abundant in the upper trunk and scaffold limbs. In contrast, PTB most often burrows under the bark at or near ground level.

American plum borer -- *Euzophera semifuneralis* (Walker)

American plum borer (APB) larvae feed on the cambium tissue of many fruit and ornamental trees. In stone fruits, APB is most problematic on cherries and plum but can also be a pest of peach and nectarine. Larvae require an opening to enter the cambium. Typically, they enter through splits in cherry bark from mechanical harvesters, and cankers in peaches, plums and cherries caused by various pathogens. They also infest black knot in plums.

Evidence of APB tunneling.

American plum borer -- *continued*

There are two generations per year in Michigan. First-generation adults begin to emerge at cherry white bud stage. Second-brood adult flight generally begins in early July, while peak activity often coincides with cherry harvest in July.

25 mm

Adults are about 25 mm long. The forewings of males and females are reddish to grayish brown with a wavy band of black and brown markings toward the wing tips. The hind wings are pale brownish gray and fringed on the trailing edges.

Lesser peachtree borer -- *Synanthedon pictipes* (Grote and Robinson)

Lesser peachtree borer (LPTB) larvae feed in the inner bark and cambium tissue of all stone

13 mm

Adults are clear-winged moths that resemble wasps. They are about 13 mm long. Males and females are metallic blue with yellow bands on the second and fourth abdominal segments.

40

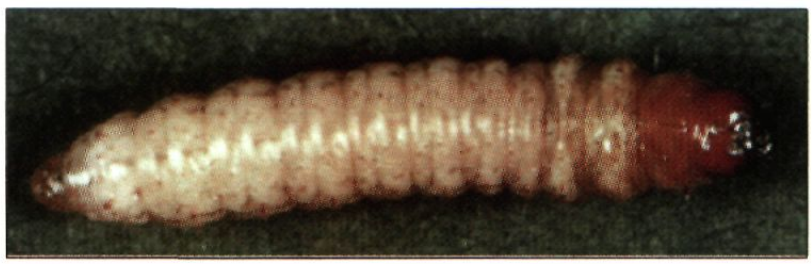
Lesser peachtree borer -- *continued*

fruits. (See larva on page 38.) Females primarily deposit eggs in wounded areas so problems are more severe in previously infested orchards or sites with a high incidence of canker, winter injury or mechanical damage. Larval feeding mainly causes a loss of production on injured limbs and tree death caused by trunk girdling.

There are two generations per year in Michigan. First-generation adults begin to emerge around shuck split or shuck fall in peach. The flight of second brood adults generally begins in July and continues into September.

Peachtree borer -- *Synanthedon exitiosa* (Grote and Robinson)

Peachtree borer (PTB) larval feeding and damage is similar to that of LPTB. There is only a single generation per year. Adult emergence begins in early July, peaks in August and extends into September.



Peachtree borer larva.

Peachtree borer -- *continued*

Adult males are similar in appearance to LPTB, but larger and marked with yellow bands on the third through the fifth or sixth abdominal segments. The female moth is readily identified by the presence of a broad orange band on the fourth and fifth segments.

Shothole borer -- *Scolytus rugulosus* (Muller)

Generally a pest of dying wood, such as tree prunings or trees dying from other causes, shothole borer (SHB) can sometimes attack healthy trees when SHB populations are high and alternative food sources are unavailable.

The adult beetle is about 2.5 mm long, black with red wingtips, antennae, and legs, and blunt on both ends. The wing covers are grooved with rows of shallow punctures.

2.5 mm

Shothole borer -- *continued*

Larva is 3.5-4 mm long, legless and white, with a slight enlargement of the body just behind the head.

Prolonged exposure to SHB feeding can eventually kill formerly healthy trees. In early June, adult females chew about a 1mm round hole into the tree trunk, branches, or twigs, excavate a brood chamber, and deposit eggs that hatch in 3-4 days. The larvae feed between the bark and sapwood.

Monitoring: Examine unhealthy trees for entrance and exit holes. Removing bark around entrance holes should expose brood chambers.

Control: Control of SHB is largely through cultural practices. Healthy, vigorous trees resist SHB attack. Also, remove dead wood and unhealthy trees from the orchard and surrounding habitat.

Peach bark beetle --
Phloeotribus liminaris (Harris)

The peach bark beetle (PBB) is active early in spring and present in the orchard throughout the growing season. It generally attacks weakened, unhealthy trees by repeatedly burrowing into the tree to obtain food and to form brood chambers for rearing its young. Entry holes created by the PBB leak sap, further weakening the tree. The holes formed by the PBB, though very similar to shothole borer entry holes, are identified by the presence of frass entwined in silk at the burrow opening. Newly hatched PBB larvae are white with yellowish heads. Mature larvae are pink and about 0.5 mm long.

2.5 mm

The adult PBB is about 2.5 mm long and brown with yellow hairs growing from punctures on the upper body.

Peach bark beetle -- *continued*

Monitoring and control: Examine unhealthy trees for entry holes. Brood chambers can be found by removing the bark around these holes. Control of bark beetles is largely through cultural practices. Healthy, vigorous trees resist attack. Also, remove dead wood and unhealthy trees from the orchard and surrounding habitat.

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 the pests they attack. The availability of flowering plants within the orchard can also help conserve beneficials because the adult stage of many predators and parasites feeds on nectar and pollen.

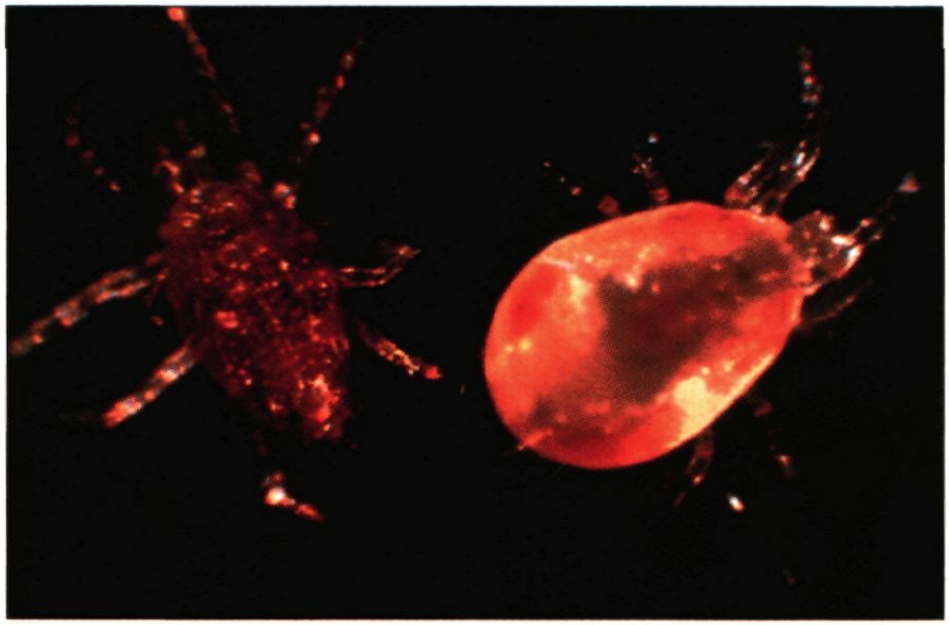
Beneficials -- predatory mites

Zetzellia mali has some tolerance for organophosphate and carbamate (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.

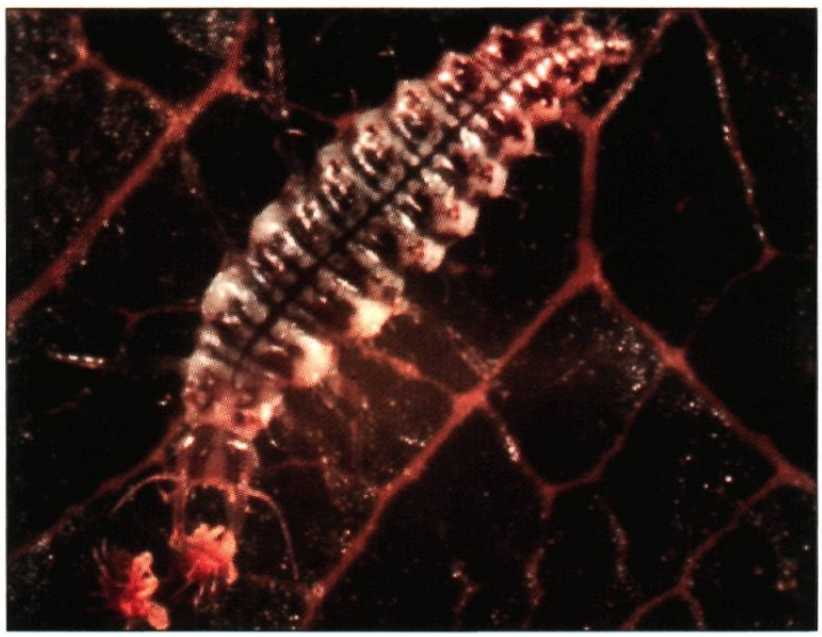


Typhlodromus pyri (not pictured) is very similar in appearance to *A. fallacis* but is slower moving. They are present in the tree canopy from April through September.

Beneficials --
predators of soft-bodied insects

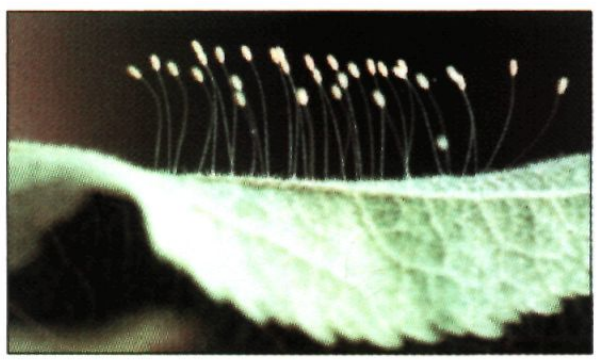
Green lacewing adults (10-12 mm long) have large, net-veined wings and gold-colored eyes. They feed on nectar, pollen, and aphid honeydew.

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 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.

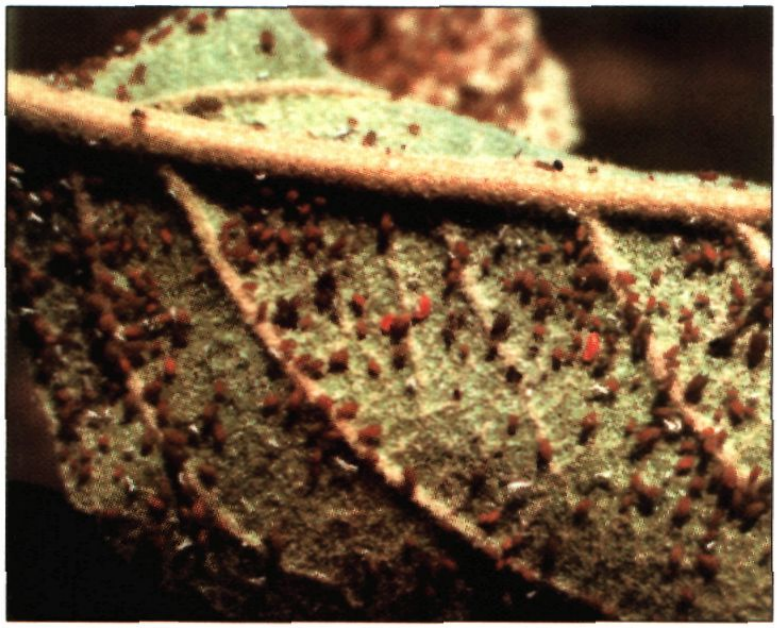
Pyrethroid insecticide applications made after half-inch green adversely affect *Stethorus*.

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).

5 mm

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



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

2 mm

Beneficials -- generalist predators

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

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

Adult **assassin bugs** (reduviids) are medium to large insects (12-36 mm). Coloration varies from brown to greenish with yellow or reddish markings. They have long heads with a groove between the eyes and curved beaks. Immatures are also important predators.

12 mm 36 mm

Beneficials -- parasitoids

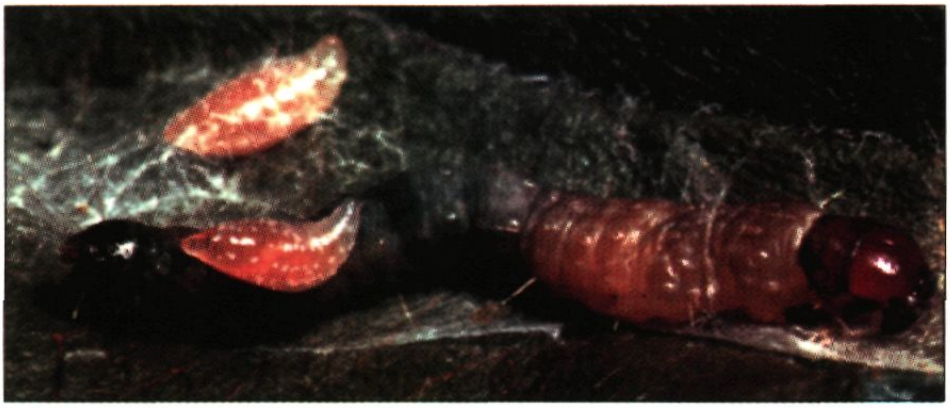
Most parasitic wasps are minute (0.5 mm) to small (5 mm) and often develop inside their hosts making detection more challenging. Some recognizable signs of parasitism include unusual host behavior, host color change, host mummification (hardened exterior), and the presence of emergence holes in the host.

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

Parasitoids -- *continued*

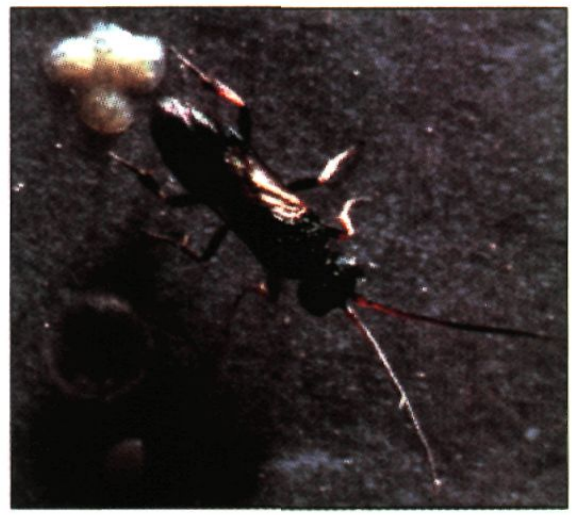
Tachinid fly adults are hairy or bristly. The larvae feed on moth, beetle, and stinkbug larvae.

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 Oriental fruit moth and leafrollers. Adults are usually less than 10 mm; more than 100 species are known.

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 1 mm or more; 3,400 species are known.

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.

American brown rot --
Monilinia fructicola (G. Wint.) Honey

Brown rot on tart cherry and sporulation of the pathogen.

American brown rot is common on apricot, peach, nectarine, plum and cherry. On fruit, small, circular, light brown spots enlarge rapidly to rot the whole fruit pre- and post-harvest. Rotted fruit shrivel, eventually becoming mummified. Infected blossoms wilt, turn brown, shrivel and persist into summer (see photo on next page).

Fruit decay and shoot dieback from brown rot.

American brown rot -- *continued*

Oval sunken brown cankers develop at the base of infected blossom spurs and fruit of peach, nectarine and apricot; later, the bark at the edge of the canker cracks, gum oozes out and a callus forms.

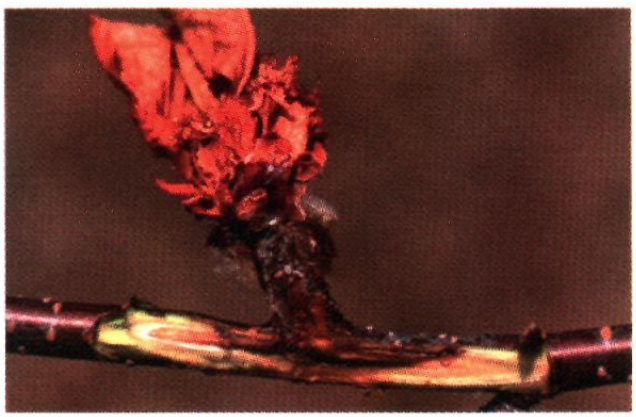
Ash-gray tufts (sporodochia) bearing conidia of the fungus often develop over the surface of the infected tissues. The presence of conidia on lesions is the most distinctive characteristic of brown rot.

Dieback of peach shoot tip from brown rot; note sporulation.

European brown rot – *Monilinia laxa* (Aderh. & Ruhl.) Honey

This rot is potentially serious on tart cherry cultivars Meteor, English Morello and Danube (Érdi bõtermõ) but rare on Montmorency. Wet periods lasting for a day or more are required for severe blossom infection and spur dieback. Newly infected blossoms and later spur leaves turn brown and shrivel. One- to 3-inch-long elliptical cankers, often with gummosis, are formed at the bases of blighted spurs. The fungus may produce tufts of ash-gray conidia on blossom debris, dead spurs and cankers in the second or third season after infection. Fruit infections are rare.

Above, spur dieback on Meteor cause by European brown rot.



Bark removed to show canker, gumming around dead spur.

Cherry leaf spot --
Blumeriella jaapii (Rehm) Arx

Cherry leaf spot is common on sweet and tart cherry, occasionally on plum. Small, red to purple spots appear on the upper surface of leaves; white to pink spore masses develop during wet weather on the undersides of the spots.

Cherry leaf spot infection on sweet cherry leaves. Note red/purple spots.

Sporulation on the lower surface (left) and spotting, yellowing (right) of tart cherry leaf caused by cherry leaf spot.

Cherry leaf spot -- *continued*

The spots turn brown and often fall out, causing a shot-hole effect, predominantly on tart cherries. Infected leaves rapidly turn yellow and fall off. Whole trees may become defoliated by mid- to late summer. Sporulating, elliptical lesions may develop on the stems of fruits (in photo below). See the table on the next page for predictions of infection severity based on temperature and wetting period length.

Cherry leaf spot on fruit stems and fruit.

Cherry leaf spot -- *continued*

Approximate number of hours of wetting period required for conidial infection by the cherry leaf spot fungus at various air temperatures.[a]

Average temperature		Wetting period (hr)[b]		
F	C	Light infection	Moderate infection	Heavy infection
81	27.2	28	43	---
80	26.7	21	35	---
79	26.1	18	30	---
78	25.6	16	27	42
77	25.0	14	24	36
76	24.4	12	21	32
75	23.9	11	19	29
74	23.3	9	18	27
73	22.8	8	16	25
72	22.2	7	15	23
71	21.7	7	14	22
70	21.1	6	13	21

Table continues on next page

[a] Taken from Jones, A. L., and Sutton, T. B. 1996. *Diseases of Tree Fruits in the East*. North Central Publication NCR-45.
[b] Wetting periods are considered to start when rain begins.

Cherry leaf spot -- *continued*

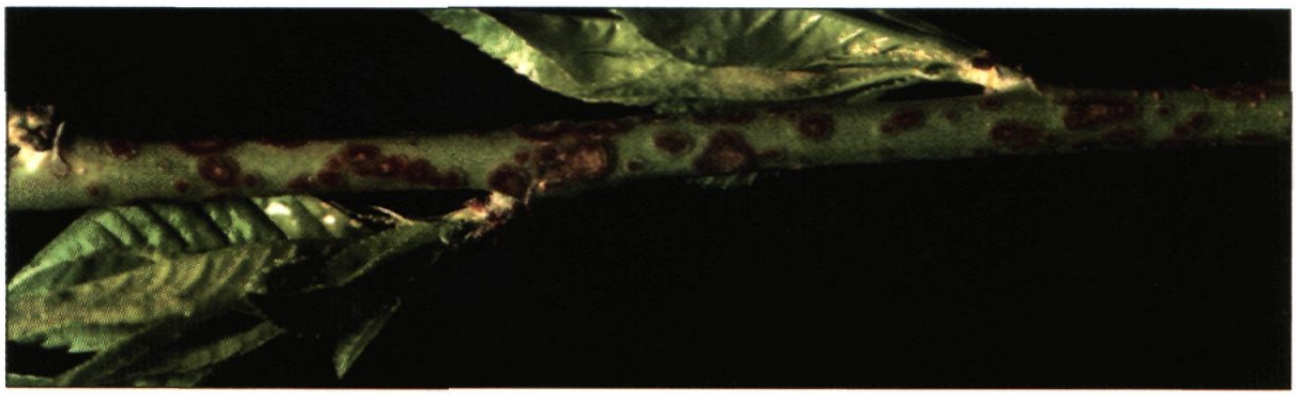
Table continues (see previous page for more information about this table)

Average temperature		Wetting period (hr)[b]		
F	C	Light infection	Moderate infection	Heavy infection
69	20.6	6	13	20
63-68	17.2-20.0	5	12	19
62	16.7	6	12	19
61	16.1	6	13	20
60	15.6	7	13	20
59	15.0	7	14	21
58	14.4	8	15	22
57	13.9	9	16	23
56	13.3	10	17	24
55	12.8	11	18	25
54	12.2	12	19	27
53	11.7	14	21	29
52	11.1	15	23	31
51	10.6	17	25	33
50	10.0	19	27	35
49	9.4	20	29	38
48	8.9	23	32	42
47	8.3	25	34	46
46	7.8	28	38	51

Peach scab --
Cladosporium carpophilum Thüm.

Peach scab is common on peach and apricot. Circular, olive to black, velvety spots are produced on twigs and fruit, less frequently on leaves. Fruit lesions tend to be concentrated at the stem end of fruit and may eventually cause the fruit to crack. Shoot infections are slightly raised and circular to oval, becoming brown with purple margins later in the season.

Peach scab on fruit and a shoot.



Bacterial spot -- *Xanthomonas campestris* pv. *pruni* (Smith) Dye

Bacterial spot appears on apricot, peach, nectarine, plum and prune. Brown, angular spots are typically concentrated along midribs and at the tips of leaves, where lesions may coalesce and cause a firing of leaf tips (see photo). Early leaf yellowing and drop occur following severe outbreaks of infection.

Yellowing and tip burn of peach leaves by bacterial spot.

Fruit develop small, brown (purple in plum), sunken spots, usually on the exposed side. Sunken areas crack and coalesce to affect large areas of the fruit. Lesions on young fruit may exhibit deep pits with gumming; those on older fruit tend to be superficial.(See photos on next page.)

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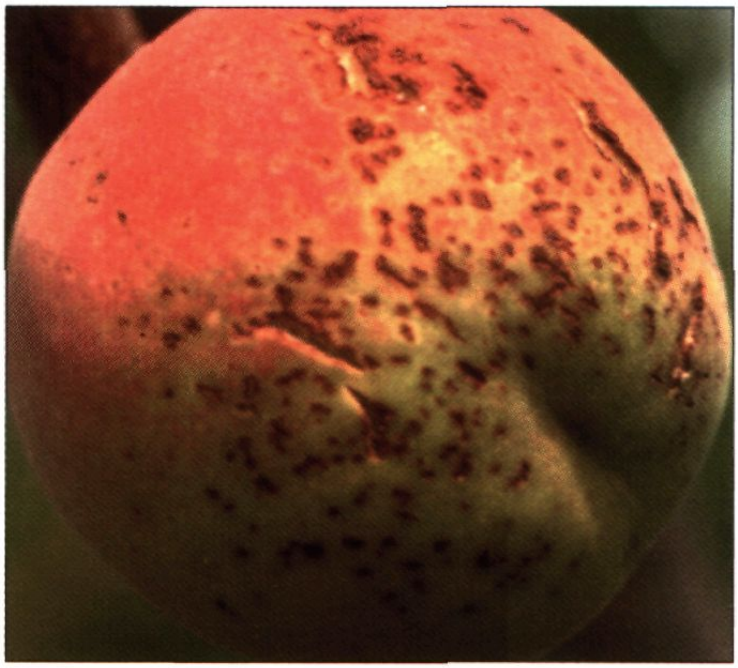
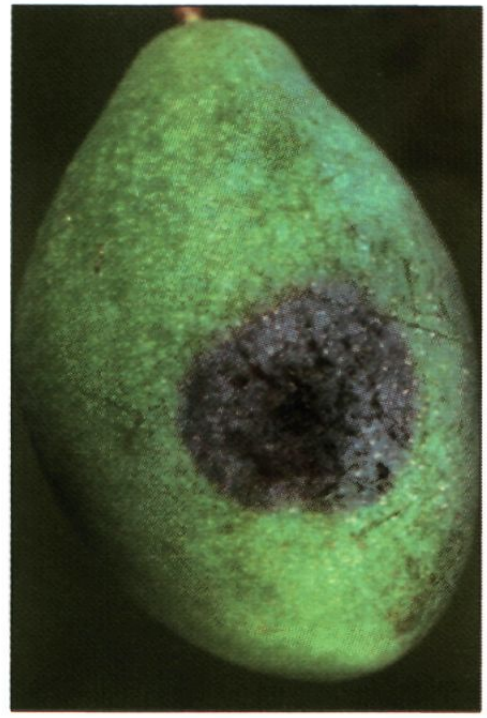
Bacterial spot -- *continued*



Bacterial spot evident in peach (left), nectarine (lower left) and plum (lower right). Note that the lesions appear purple in plum.



Infection of new shoot growth can result in the production of elliptical cankers in the summer or the following spring. Summer cankers are usually located between the nodes; spring cankers tend to be located at nodes.

Peach leaf curl --
Taphrina deformans (Berk). Tul.

Peach leaf curl is a common disease in peach and nectarine. Leaves are curled and often flushed with red beginning about a month after full bloom (see photo).

In late June or July the infected leaves wither, turn brown, and drop on the ground. Blossoms, fruit, and the current year's twigs may also be affected. **Control:** Apply sprays prior to the first rain after bud swell.

Fruit distorted by leaf curl.

Black knot of plum -- *Apiosporina morbosa* (Schwein.:Fr.) Arx

Black knot is common on plum and prune in the eastern U.S. and tart cherry in Ontario and western New York. It causes longitudinal swellings or corky outgrowths on shoots, spurs, branches and trunks. Initially, knots are greenish and soft, later black and hard but often with new swellings developing at the ends. Limbs or entire trees may be killed from girdling as knots expand.

Young (top) and older (bottom) black knots on plum.

Powdery mildew of cherry -- *Podosphaera clandestine* (Wallr.:Fr.) Lév.

On tart cherry, mildew appears first as circular, white, felt-like patches on young leaves. Spreading rapidly, it eventually engulfs entire leaves.

Small, brown to black, spherical bodies (cleistothecia) appear in the felt-like patches as the season progresses. Severely infected leaves exhibit upward rolling, becoming stiff and brittle with age. Mildew on green fruit appears as shiny, red blotches often with white fungal growth in the center.

Fruit infections are rare in the eastern U.S. Mildew is favored by dry summers with intermittent periods of high humidity and moisture.

Powdery mildew or rusty spot of peach - *Sphaeroteca pannosa* (Wallr.:Fr.) Lév.

This disease is found sporadically on peach in the mid-Atlantic and southeastern U.S. White circular spots on young fruit (top photo) expand in size and later the mycelium may slough off, leaving a russeted patch with dead epidermal cells (bottom photos). The russeted area expands as the fruit enlarges. Leaves and shoots are superficially covered with white, felt-like mycelium and eventually become distorted and stunted.

Fusicoccum canker --
Phomopsis amygdali (Del.) Tuset & Portilla

Dieback of shoots.

Fusicoccum canker is found primarily on peach in the mid-Atlantic and southeastern states. Infected twigs wilt and die because of elongate, brown, sunken cankers, often with a target pattern, at their bases (see bottom photo). Twigs are blighted from girdling and from the action of a toxin secreted by the fungus.

Closeup of fusicoccum canker on peach.

Gummosis -- *Botryosphaeria: B. dothidea, B. obtuse* and *B. rhodina*

Gummosis, common in peach, is characterized by numerous sunken necrotic lesions ¼ to ½ inch in diameter around lenticels and by excessive gum exudation. Removing the bark reveals shallow, round to oval, brown, gummy lesions that are ½ to 1 inch in diameter. On young branches, lenticels become swollen but gumming does not occur. Symptoms initially occur on the trunk between the ground and the scaffold limbs, usually during the second or third growing season. The disease later affects the scaffold limbs and twigs. Severe infection may kill twigs, reducing fruiting wood.

Gum exudation associated with gummosis lesions on peach.

Bacterial canker -- *Pseudomonas syringae*

Cankers on trunks, limbs and branches of sweet cherry, tart cherry, plum and prune exude gum during late spring and summer.

Bacterial canker on sweet cherry (above) and tart cherry (below).

Leaf, fruit and blossom infections are common following prolonged wet, cold periods during or soon after bloom. Leaf spots are dark brown, circular to angular and sometimes surrounded with yellow halos.

Bacterial canker -- *continued*

Spurs with infected leaves and fruit often die back (see photo). Infected leaf and flower buds may fail to open in spring, resulting in a condition referred to as "dead bud." Terminals and branches may wilt and die in summer or early autumn if girdled by a canker. Occasionally, large scaffold limbs are killed.

Above, bacterial canker on plum. Below, lesions on green cherry fruit are brown with a margin of wet or water-soaked tissue.

Peach perennial canker - *Leucostoma cincta* (Fr. Ex.:Fr.) Höhn and *L. persoonii* Höhn

Elongated cankers, often with amber-colored gum, develop on the trunk and scaffold limbs and in branch crotches of peach and occasionally nectarine, apricot, sweet cherry, plum and prune.

A perennial canker on peach.

Dieback of short shoots and twigs occurs in the interior of trees, especially following winter injury. Limb dieback is seen particularly on plum, prune, apricot and sweet cherry.

White fungal fruiting bodies under the bark of limbs with perennial canker.

Alternaria fruit rot -- *Alternaria* spp.

Alternaria fruit rot is a minor problem on sweet and tart cherries. The disease is most severe on overripe fruit or where rain-induced cracking or various physical injuries expose the flesh to infection. Lesions are circular to oblong and slightly sunken, later becoming firm, flattened and wrinkled, and often dark-green to black because of abundant sporulation by the pathogen.

Alternaria rot on dark (above) and gold (left) sweet cherries.

Crown gall -- *Agrobacterium tumefaciens* (E.F. Smith & Townsend) Conn

Tumors or galls are produced on the roots and crown and, under special circumstances, on aboveground portions of plants. Galls begin as small, smooth growths that enlarge to become dark, hard, woody tumors with gnarled, irregular surfaces. Old galls may be covered with secondary fungi and riddled by insects. Orchard trees with one or more large galls on the crown are often stunted.

Crown gall on Mazzard F12/1 rootstock.

Armillaria root rot -- *Armillaria* spp.

In Michigan, armillaria root rot is common in Montmorency tart cherry orchards located on sandy, well-drained soils. Affected trees may exhibit poor growth for one or two years and then die suddenly in mid- to late summer. The disease spreads out from a central area of one or two initially infected trees.

A thick, white, fan-shaped fungal mat is often present between the necrotic inner bark and the wood of the tree's crown (left). *Armillaria* is distinguished from other fungi by its dark brown to black, shoestring-like structures called rhizomorphs (right).

Clusters of honey-colored mushrooms may arise at the bases of dead trees in late August or September.

Phytophthora root and crown rot -- *Phytophthora* spp.

This rot is common in low areas of cherry and peach orchards with poor soil drainage and throughout orchards with clay soil that restricts drainage. The disease is most likely to appear after the trees come into production. Affected trees exhibit poor terminal growth, sparse and chlorotic foliage, early senescence and progressive decline over several seasons. A few trees collapse and die soon after budbreak.

Decline of Montmorency cherry trees from phytophthora root rot.

Phytophthora root/crown rot -- *continued*

For diagnosis, the outer bark of the crown and roots should be removed. Necrotic tissue will be observed on the roots and crown below the soil line.

Mahaleb rootstock with phytophthora root rot.

X- Disease

X-Disease is found in peach, nectarine, sweet and tart cherry in the Great Lakes states and occasionally in the mid-Atlantic states. In peach, leaves on isolated limbs curl inward after about two months of growth and develop irregular yellow to reddish-purple spots that soon drop out, resulting in tattered leaves.

X-Disease -- *continued*

Leaves on affected limbs fall prematurely, starting at the bases of the shoots and leave tufts of leaves at the tips of infected shoots.

The pathogen is leafhopper transmitted.

Fruit on infected limbs will drop prematurely. Infected cherry trees on Mahaleb rootstock die suddenly in midsummer, and trees on Mazzard rootstock decline slowly. Scattered fruit on trees on Mazzard rootstock are smaller than normal, are green or pink at harvest, and have a bitter taste. Enlarged stipules may be associated with infected leaves of sweet cherry cultivars on Mazzard rootstock.

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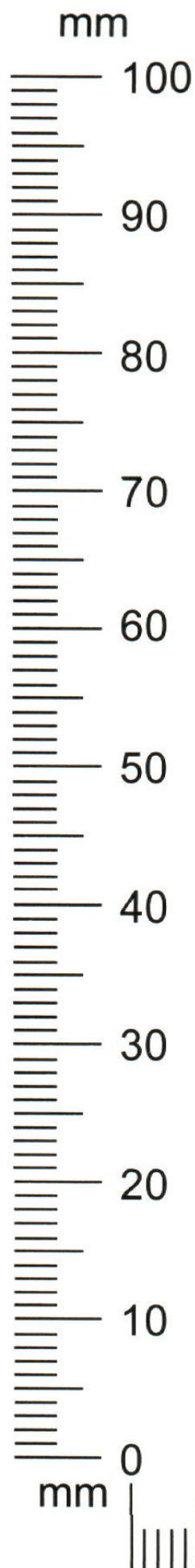

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