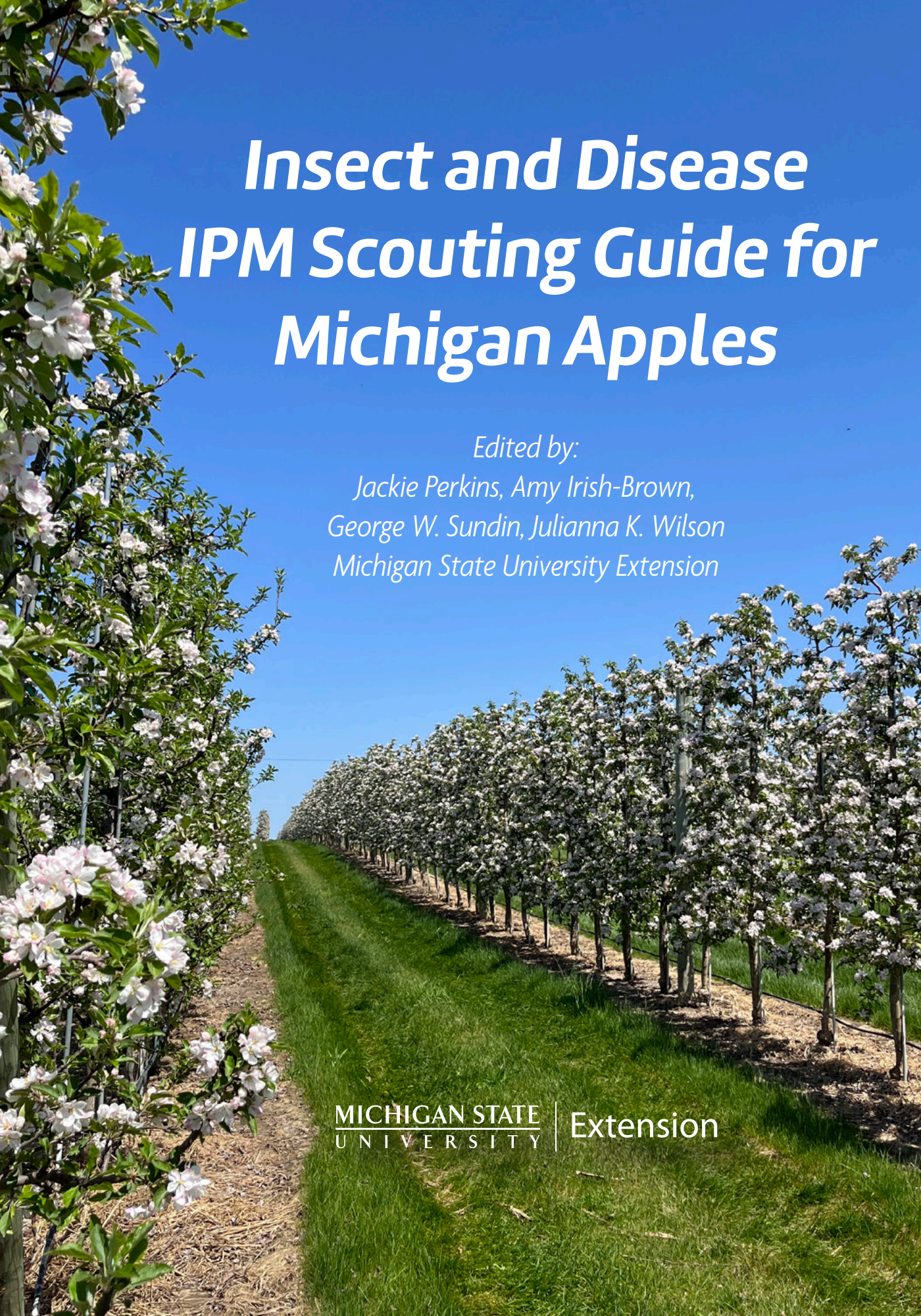

Insect and Disease IPM Scouting Guide for Michigan Apples

Edited by:
Jackie Perkins, Amy Irish-Brown,
George W. Sundin, Julianna K. Wilson
Michigan State University Extension

MICHIGAN STATE UNIVERSITY | Extension

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Pocket IPM Scouting Guide for Michigan Apples

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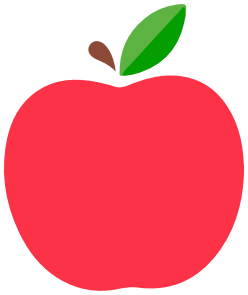
KEYS

Key to Symbols:

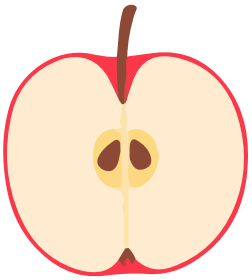
These symbols are used throughout the guide to denote where pests or their damage are most likely to be found when scouting.

Symbol credits:
Heather Leach, Michigan State University



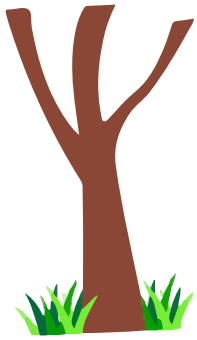
Fruit Surface

Fruit Internal



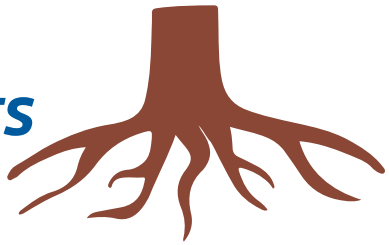
Foliage

Branches/limbs



Trunks

Roots



Key to Abbreviations:

GDD = growing degree days
IPM = integrated pest management

Table of Contents

Supplemental Resources

- ***Michigan Fruit Management Guide E-0154:***
Annually updated bulletin containing fruit management recommendations for commercial fruit growers.

- ***Apple Pest Guide:*** A season-long degree-day-based guide in chart format showing life stages of key pests available as a free, print-ready PDF

- ***MSU Enviroweather:***
Provides detailed pest forecasting and weather data

- ***MSU Extension Fruit & Nuts***:
Newsletter and Events page

- ***Apple Nutrition: Diagnosing and Avoiding Nutrient Deficiencies,*** MSU Extension

- ***Weed Control in Apple Orchards,***
Cornell Cooperative Extension

Introduction

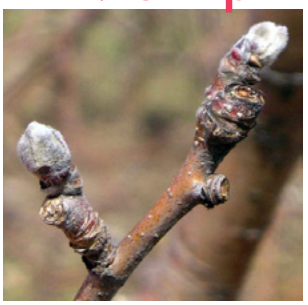
Apples have a large number of arthropod pests and diseases which need to be managed throughout the growing season to maintain healthy trees and marketable fruit. This scouting guide was designed as a pocket field book for easy use in the orchard or for quick reference. It provides information to help identify pests, beneficials, and pest damage with some guidelines for monitoring. Identification and scouting is a key component of integrated pest management (IPM) and will help you decide if, when, and how to take management action.

Apple Growth Stages

Dormant

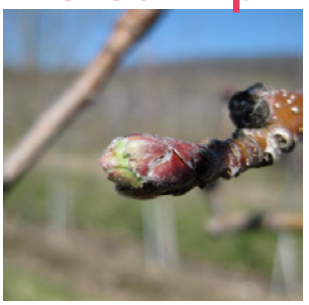
UMass Amherst

Silver tip



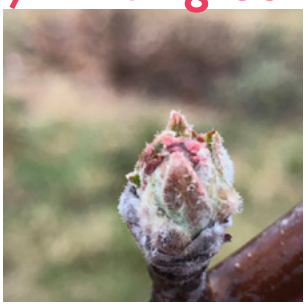
Mark Longstroth, MSU

Green tip



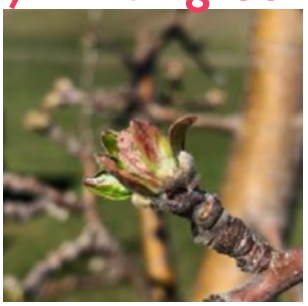
Dave Schmitt, Rutgers University

1/4 inch green



UMass Amherst

1/2 inch green



UMass Amherst

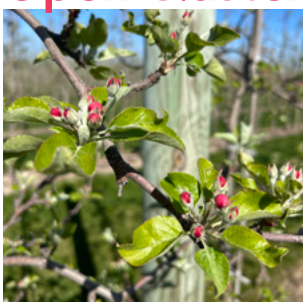
Tight cluster

Heather Leach, MSU

Pink

Lindsay Brown, MSU

Open Cluster



Lindsay Brown, MSU

King Bloom

Lindsay Brown, MSU

Full bloom

Jackie Perkins, MSU

Petal fall

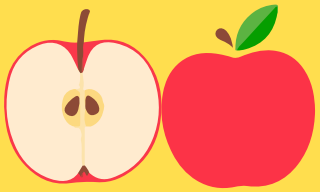
Lindsay Brown, MSU

8 mm

Derek Plotkowski

Apple maggot

Rhagholetis pomonella



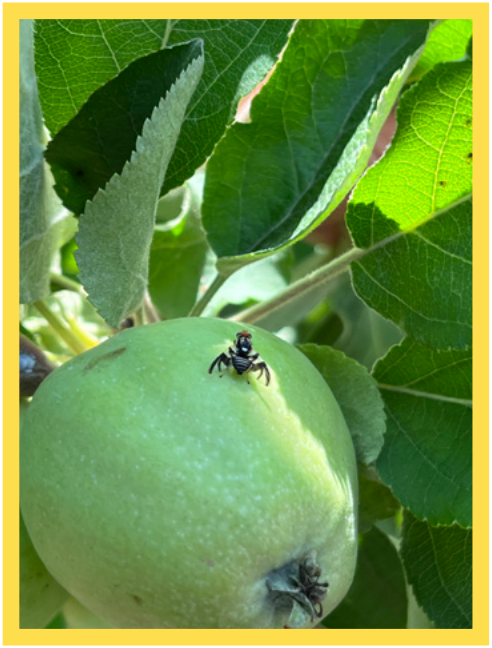
Identification:

Apple maggot **adults** are about 6 mm long with a distinctive wing pattern described as an “F” shape. The black thorax is marked with a white dorsal spot. Mature **larvae** are 8 mm long, creamy white with two dark mouth hooks, with no legs and no distinct head capsule.

Joseph Berger, Bugwood.org

Damage:

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 random brown trails through the flesh of the apple. They do not feed on seeds as other internal feeders do.



Jackie Perkins, MSU

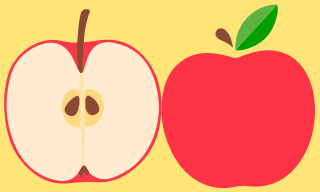
INTERNAL FRUIT FEEDERS
Apple maggot Continued

J.F. Walgenbach, NC State Extension

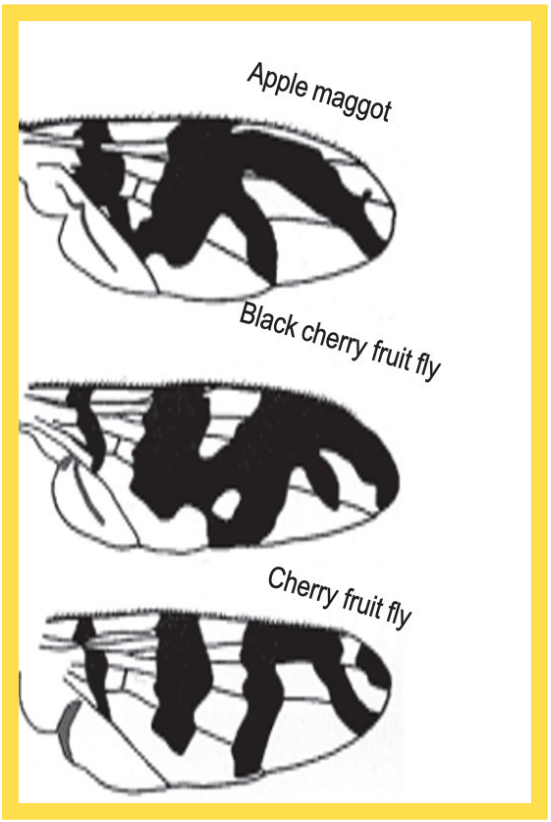
Whitney Cranshaw, Colorado State University

H.J. Larsen, Bugwood.org

Monitoring:
In southern Michigan, adult emergence typically begins in late June and continues until September, peaking towards the end of July. In northern Michigan, adult emergence typically begins around the second week of July. Two types of monitoring traps are available for apple maggot: sticky red spheres or yellow cards. Captures on red spheres tend to indicate that egg-laying behavior and fruit damage has begun, whereas yellow cards mainly show adult emergence and flight activity.



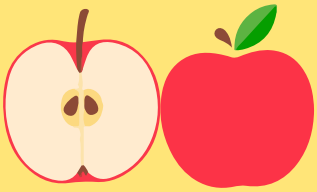
MSU Extension



Red spheres can be baited with a fruit volatile lure (apple essence) and yellow cards can be baited with ammonium acetate and protein hydrolysate. Both trap types should be placed in the orchard along a wooded edge at eye level beginning in mid-June. Be sure that traps are easily visible and not hidden within canopy. Red spheres may need to have sticky coating reapplied. Adult emergence is often triggered by a heavy rain event. There is only one generation of this insect per year.

Management:
The action threshold for apple maggot flies depends on the type of trap and if it is baited. For baited red spheres, the treatment threshold is 5 adults caught per week. If using a non-baited yellow card or red sphere, treatment threshold is 1 adult captured per week.

INTERNAL FRUIT FEEDERS
Apple maggot Continued



Derek Plotkowski, MSU

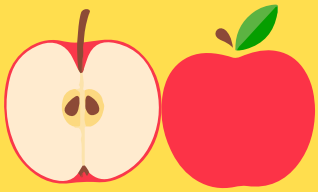
Trap captures for a week following insecticide treatment can be ignored. Subsequent sprays may be needed if the threshold is met again 10-14 days after the initial treatment.

Orchards in low areas with heavy ground or areas with wild crop hosts nearby are likely to see higher pressure of this pest.

Jackie Perkins, MSU

Codling moth (CM)

Cydia pomonella



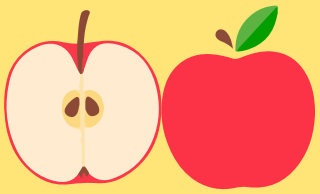
Identification:

Adults are about 9 mm in length, with alternating bands of gray and white, and a distinctive bronze patch at wing tips. The **larvae** are creamy white tinged with pink, with a black head and brown shield protecting the thorax (directly below head). Mature larvae are about 15 mm in length with no anal comb. (see pg 16)

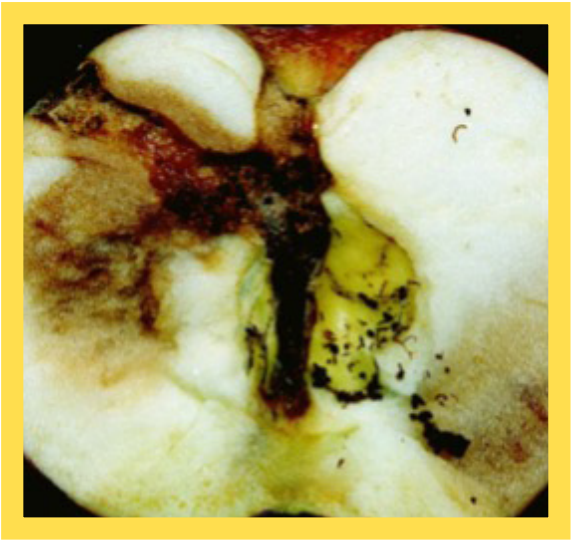
Utah State University Extension

J.F. Brunner,
Washington State University

Codling moth (CM) Continued



Damage:
Fruit injury can occur in two ways:
Deep entry - when the larva enters the fruit center and feeds on the seeds. Brown frass can usually be seen extruding from entry hole.
Sting – shallow feeding without entering the fruit.

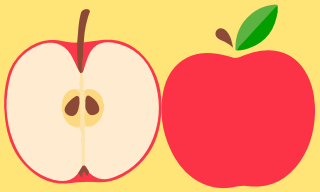


Clemson University Cooperative Extension

Monitoring:
Traps baited with pheromone lures are used to set the biofix needed for the codling moth model to time interventions used throughout the season.

Derek Plotkowski, MSU

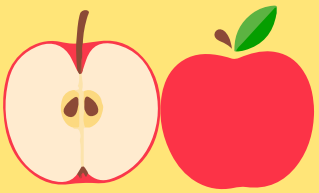
A biofix is set at the start of sustained captures of male moths in traps. One trap for every ~2 acres is optimal; 1 trap per 5-10 acres is acceptable in



large, uniform blocks. Set up traps at the pink bud stage, in the upper third of the canopy. Traps used to determine the biofix should be baited with a standard 1x lure in blocks NOT under mating disruption and a 10X lure in blocks that ARE under mating disruption and traps should be placed away from pheromone dispensers. Use standard (1X) lures to determine action thresholds in both pheromone disrupted and non-disrupted blocks. For additional guidance, refer to MSU Extension E-154. Fruit should always be visually inspected for damage in conjunction with trapping. Concentrate visual inspections in the upper canopy and along orchard borders. Edge effects should be scouted in disrupted blocks near wooden structures and bin storage, as well as neighboring blocks with poor CM management.

Management:
There are typically 2 generations per year in Michigan, with a third generation possible in exceedingly warm years. Use monitoring traps, visual scouting and GDD models to time insecticide sprays. A cumulative catch of 3-5 codling moths ***in any one trap over time*** may indicate the need for a spray. Do not total captures from more than one trap to attain the threshold.

INTERNAL FRUIT FEEDERS
Codling moth (CM) Continued



In a pheromone disrupted block, the threshold is 1 moth per trap using a standard 1X lure. Pheromone based mating disruption works well in large plantings (>5ac). Various insecticides are labelled for CM management – refer to MSU Extension E-154 for current guidance.

Julianna Wilson, MSU

Orchard Type	Lure Type	When to Use	Action
Not under mating disruption	1x CM lures (standard)	Setting biofix to use in CM development models.	Biofix is set at 1st sustained moth captures.
	1x CM lures (standard)	Monitoring	Threshold: management may be needed when an accumulation of 3-5 moths occurs in any one trap over time.
Under mating disruption	10X CM lures	Setting biofix to use in CM development models.	Biofix is set at 1st sustained moth captures.
	1x CM lures (standard)	Monitoring	Threshold: management may be needed when 1 moth is captured.

Oriental fruit moth (OFM)

Grapholita molesta

Identification:

Adults are about 5 mm long, gray-colored with mottled wavy, light lines on wings. Mature **larvae** are about 10 mm long, creamy-white to pink, with a brown head capsule. Anal comb is present.

Todd M. Gilligan and Marc E. Epstein, Tortricids of Agricultural Importance, USDA APHIS PPQ.

Michigan State University Extension

Damage:

OFM injury can occur in two ways: *Terminal feeding* – larvae will cause wilt on new terminal growth through feeding and tunneling toward the shoot base (causes flagging). *Fruit feeding* – attacks young fruits causing frass-covered holes near the calyx. Damage on fruit is similar to the fruit damage caused by codling moth, however OFM will not tunnel as deeply.

Clemson University Cooperative Extension

Oriental fruit moth (OFM)

Continued

Monitoring:

Use 1 trap per 10 acres to determine the sustained catch biofix for each generation. Time treatments for 150-170 degree days base 45°F, post biofix.

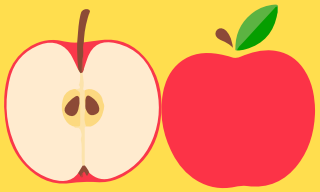
G. Morvan, INRA, Montfavet

Jack Kelly Clark, UC IPM

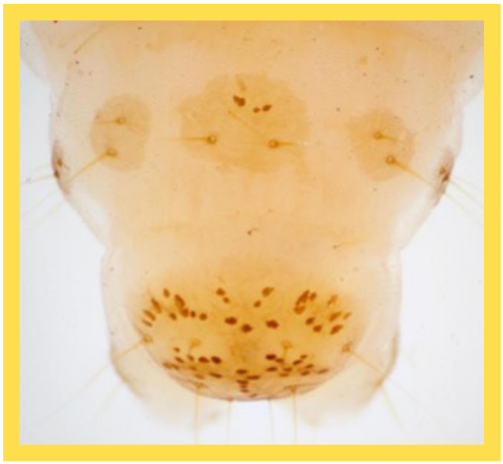
Management:

Three full generations of OFM occur in Michigan, and sometimes a fourth. Monitor populations with pheromone traps and use GDD model to time insecticide sprays. Management activities targeting codling moth can often provide effective control against OFM. Pheromone based mating disruption can complement insecticide applications in high-pressure areas.

Differentiating between codling moth and oriental fruit moth



Feeding damage:
Codling moth (CM) and Oriental fruit moth (OFM) 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 nearer to the fruit surface.



Jack Kelly Clark, UC IPM

Posterior end of codling moth larva showing absence of anal comb.

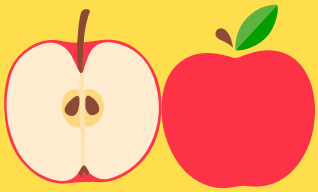
Jack Kelly Clark, UC IPM

Posterior end of Oriental fruit moth larva showing anal comb.

Larval anatomy:
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.

Plum curculio

Conotrachelus nenuphar



Identification:
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 (PC) have a downward curved snout that is about 1/4 to 1/3 of the body length. Adults are not easily observed in the orchard because: they tend to drop off trees readily with any disturbance. Mature **larvae** are segmented and c-shaped, legless, about 7 mm long, yellowish-white with a brown head capsule.

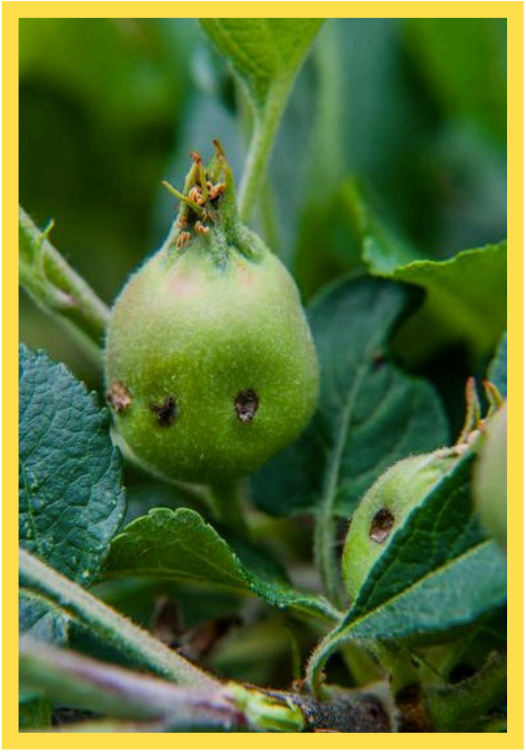
E. Levine,
The Ohio State University,
Bugwood.org

NY Ag Experiment Station

Damage:

The female deposits eggs under the skin of the fruit, leaving a crescent-shaped scar just below the egg-laying site. Many infested fruits will drop in June. The rapid apple growth will typically smother the PC larvae inside the fruit, however infested fruit that remains become distorted as they grow around the oviposition scar. All apple varieties are susceptible to both feeding and oviposition damage. As fruit mature, older oviposition scars take on a broad, fanlike appearance.

NY State Ag Experiment Station

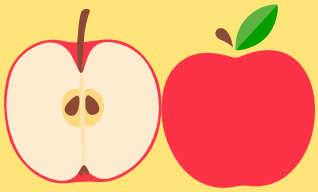


Steve Schoof, NCSU

Monitoring:

Plum curculio typically migrates from wooded edges into orchards around bloom.

Plum curculio Continued

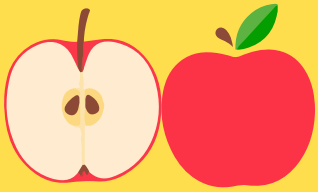


Egg laying will begin on tiny developing apples when either a maximum daily temperature of 75ºF is reached for 2-3 days, or when night temperatures stay above 60ºF. Starting at petal fall, tap foliage over beating trays to catch adults. After fruit set, visually inspect several fruits per tree for signs of feeding or egg laying. Concentrate sampling trees adjacent to hedgerows and woodlands, especially where damage has occurred in the past. Mature larvae drop to the soil to pupate and complete development. They emerge as adults in late June through August and move into overwintering sites. Occasionally adults will feed on apples in the summer creating a unique, carved out hole on the fruit surface. There is one generation per year.

Management:
Peak activity and the critical time for control begins at petal fall, though exact timing may depend on which active ingredient is being applied. Control can continue until apples are 25mm in diameter. A degree-day model can be used to predict the proper spray timing.

Apple curculio (AC)

Anthonomus quadrigibbus



Identification:

Adults are reddish-brown with 4 bumps along their rounded body, and a long snout-like mouth. Similar to plum curculio but more reddish-brown and with a longer, more slender snout.
Larvae are white or cream colored, 6-9 mm long with a curved body and a light brown head.

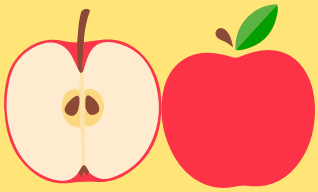
British Columbia Ministry of Agriculture

Edward Trammel, bugguide.net

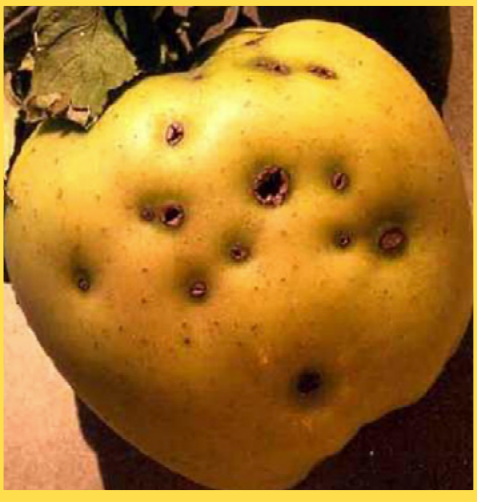
Damage:

The primary damage caused by apple curculio is associated with feeding by adults and larvae, and oviposition. Feeding and egg laying causes small, dark puncture wounds on green fruit and young shoot tips. This damage can also cause the apple to become lumpy, misshapen, and discolored.

INTERNAL FRUIT FEEDERS
Apple curculio (AC) Continued



Larvae feed on and destroy seeds within the fruit. Infested fruits usually drop off the plant prematurely.



British Columbia Ministry of Agriculture

Monitoring:
This is an occasional pest throughout most of North America. Adults emerge in the spring after overwintering as larvae in the soil. Visually inspect fruit to check for damage symptoms and cut fruit open to identify species. There is one generation per year.

Management:
If populations are high, chemical control would best be applied in the spring against ovipositing adults.

Apple rust mite (ARM)

Aculus schlechtendali

Identification:

Adults are elongated, triangular, tan in color, and barely discernible with a hand lens (0.2 mm long). They require a minimum 15X magnification to see them. ARM also have only 2 pairs of legs, whereas most mites have 4 pairs.

Mid-atlantic Orchard Monitoring Guide

Damage:

Under high pest pressure, yellowish brown leaf discoloration will occur, sometimes accompanied by silvery-white blotches. Browning of the lower leaf surface and drying out can also occur. A tell-tale sign of ARM feeding is fruit russeting. Leaves do not typically stipple in response to ARM feeding, unlike with spider mites. Red Delicious and related cultivars seem to be more prone to infestation.

Apple rust mite (ARM) Continued

J. Brunner, Washington State University

Monitoring:
ARM move to trees in spring as soon as leaves open and remain on trees for the rest of the year. Monitor populations throughout the summer with a 15X magnifying glass.

Management:
Preserve existing mite predators through pesticide choices that are least toxic to beneficial mites. Predator mites are also produced commercially and can be purchased for release.
Miticides can be used if populations on leaves are very high (>200 per leaf), but lower numbers of this pest are valuable as prey to maintain predator mite populations in early spring.

FOLIAGE & SURFACE FEEDERS

European red mite (ERM)

Panonychus ulmi

Identification:

Adults females are brownish-red with conspicuous white spots at the bases of white bristles; males are smaller with a tapered abdomen, and are reddish yellow. **Immatures** will often feed in groups within unfolding leaves. Overwintering **eggs** are most commonly found on trunks (particularly under tree guards), near buds, fruit spurs, and in the fork of two branches. They begin hatching at tight cluster stage. Summer ERM stages are found on leaves and fruits. Late summer eggs are an issue when laid in the calyx end of apple fruits.

Michigan State University Extension

FOLIAGE & SURFACE FEEDERS

Two-spotted spider mite (TSSM)

Tetranychus urticae

Identification:

Two distinct spots located on the front half of the dorsum behind the eyes. Adult males are much smaller than females and have a distinctly pointed abdomen. Color can vary from pale yellow to green.

Michigan State University Extension

Damage:
Severe mite infestations can cause leaf bronzing, defoliation, and hinder fruit sizing. Some cultivars seem to be more prone to infestation, particularly thin-leafed varieties. Hot, dry weather tends to flare mites, though some insecticide applications (such as pyrethroids) can also flare mites by killing off beneficial predators.

Michigan State University Extension

Healthy leaves (left) vs. leaves with bronzing (right).

Monitoring:
For summer populations of both ERM and TSSM, examine fully developed leaves from several locations in the orchard using 50% spur leaves, 50% shoot leaves. TSSM can be found in the tree canopy from tight cluster through harvest. They typically construct webbing on the underside of leaves.

Management:
To kill overwintering eggs, spray dormant oil when buds are showing green tissue but before pink bud. Through the season monitor leaves to determine if management is needed.
Treat based on the following thresholds:

- From petal fall to mid-June: 2-3 mites per leaf
- From mid-June through July: 5-7 mites per leaf
- In August: 10-15 mites per leaf

Presence of predaceous mites (>1/leaf) may justify delaying a treatment and examining leaves again the following week. Use selective pesticides to allow for natural enemies and predators to survive.

Japanese beetle (JB)

Popillia japonica

Identification:

Adults are bright metallic-green with coppery-red wings and small white tufts on the sides and tips of wing covers (~12 mm). Larvae are 2-3 mm long when newly hatched, with fully grown larvae about 30 mm long. **Larvae** are c-shaped and white with a brown head capsule and 3 pairs of legs.

Ryan Hodnett, Guelph, Ontario

Rufus Isaacs, MSU

Damage:

Adult Japanese beetles (JB) skeletonize leaf tissue, and populations are typically higher in the upper part of the canopy. Fruit feeding is less common, usually occurring on fruit that is damaged or overripe. Some apple cultivars seem to be more prone to infestation – Honeycrisp in particular. Although immature JB primarily feed on the roots of grass, damage can occur to the roots of woody perennial plants like apple.

Japanese beetle (JB) Continued

University of Minnesota Extension

Creative Commons, Wikimedia.org

Monitoring:
Larvae overwinter in the soil. Adults emerge mid-June to July – often triggered by a heavy rain event. Most damage occurs in late summer to early fall. Feeding damage is sporadic and transient, scout orchards regularly for damage. There is one generation per year. While there are traps available for this pest, they are not recommended because they can attract JB and make infestation worse.

Management:
Insecticides can be applied when leaf damage is severe. Soil-applied applications can also work to reduce larval populations. Milky spores of bacteria or entomopathogenic nematode products are biocontrol options; however, they may take multiple years of application to cause reductions in populations.

Rose chafer (RC)

Macrodactylus subspinosis

Identification:

Rose Chafers **adults** are light tan beetles with a darker brown head and long legs, approximately 12 mm long. RC are typically only found in areas with sandy soils. **Larvae** are c-shaped grubs that feed on roots of grasses and overwinter in the soil.

Mike Haas,
Michigan State University Extension

Maine Department of Agriculture,
Conservation and Forestry

Damage:

Adult RC skeletonize leaf tissue. Injury to apple fruits is less common. RC adults are the only injurious stage to fruit trees. Damage is often concentrated on orchard borders, but if populations are high, they become uniform across a block.

Rose chafer (RC) Continued

Jim Baker, North Carolina State University, Bugwood.org

Clemson University

Monitoring:
Adults emerge from the soil in late May or early June and move to surrounding vegetation, including apple, to feed and mate. Adult emergence can be monitored visually or with attractant-baited traps. Focus sampling along orchard borders adjacent to grassy fields. Young orchards can be severely defoliated. There is one generation per year.

Management:
Insecticides can be applied when leaf damage is severe.

Redbanded leafroller (RBLR)

Argyrotaenia velutinana

Identification:

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

Todd M. Gilligan and Marc E. Epstein, TortAI: Tortricids of Agricultural Importance, USDA APHIS PPQ, Bugwood.org

Mark Dreiling, Bugwood.org

Michigan State University Extension

Damage:

Larval feeding causes leaf-rolling and shallow surface feeding on fruit, as well as superficial tunnels in the fruit flesh. Fruit injury is usually shallow with ragged edges and thick, corky tissue over the damaged area.

Redbanded leafroller (RBLR)

Continued

NY State Ag Experiment Station

Monitoring:
Monitor adults with pheromone traps.
Adults will start to emerge around green tip;
with larvae present early-May to mid-June.
There are three generations in a growing season.

Management:
This pest is typically controlled with sprays applied for other pests. It may be more of a problem in orchards with minimal spray programs or those that rely only on mating disruption for certain species rather than insecticides.

Variegated leafroller (VLR)

Platynoda flavedana

Identification:

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

Mic-Atlantic Orchard Monitoring Guide

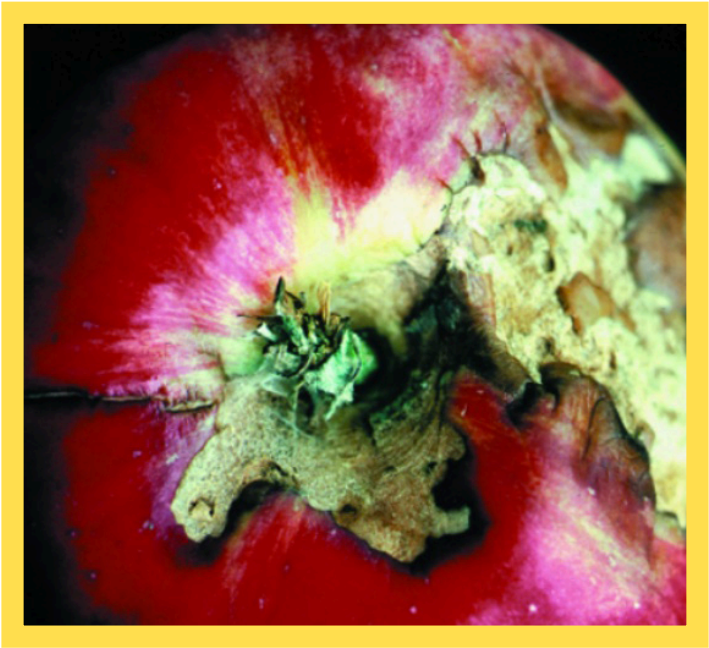
Michigan State University Extension

Damage:

Larvae feed on foliage until mid-summer, then switch to feeding on fruit in late summer. Fruit damage shows a pinhole or excavation pattern of isolated feeding sites.

Variegated leafroller (VLR)

Continued



NY State Ag Experiment Station

Monitoring:
Mature larvae can be present from early May until August and should be monitored using leaf inspections. Monitor adults with pheromone traps. There are two generations per year.

Management:
This pest is typically controlled with sprays applied for other pests. It may be more of a problem in orchards with minimal spray programs or those that rely only on mating disruption for certain species rather than insecticides.

Obliquebanded leafroller (OBLR)

Choristoneura rosaceana

Identification:

Wings of the **adult** are striped with distinct tan to brown bands. Adults are about 18-25 mm long. **Larvae** are green with brown to black head capsules (about 25 mm long at maturity). Of all the leafroller species, OBLR is the most common in Michigan apple orchards.

Michigan State University Extension

J. Brunner, Washington State University

Damage:

Larvae will roll leaves and hide in them as shelter. They often feed on the epidermis of the fruit near the peduncle, or where two apples are touching. Early-season fruit feeding causes pronounced deformations. Late season feeding can often go undetected until after long-term storage, where small pits form on the surface and necrosis can occur.

NY State Ag Experiment Station

Obliquebanded leafroller (OBLR)

Continued

Monitoring:

There are two complete generations per year in Michigan. Overwintering larvae feed inside bud clusters prior to bloom, then begin feeding on fruit after petal fall. Summer larvae are present from about late June into August. Check for overwintering survivors in terminals after petal fall. If larvae are found in more than 1-2% of the shoots, summer controls will likely be needed. Use one pheromone trap per 15-20 acres to set biofix. A consistent catch of 20+ moths per week 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.

Todd M. Gilligan and Marc E. Epstein, Tortricids of Agricultural Importance

Ansel Oommen

Management:

Pheromone traps and a degree-day model can be used to predict larval activity periods and time insecticide sprays. Fruit thinning and water sprout pruning in midsummer can help reduce fruit damage. Selective pesticides help to preserve important natural enemies. Due to this species' extended flight and egg-laying periods, multiple insecticide applications may be required in some cases.

Tufted apple bud moth

Platynota idaeusalis

Identification:

Adults are 13 mm long, gray and brown with a patch of copper-colored scales and a series of tufted scales in the middle of each forewing. Mature **larvae** are light grey/brown, with brown head, dark thorax, and a dark stripe down the body. Young larvae start out yellowish with a black head.

Michigan State University Extension

Royal Tyler, Pro Pest and Lawn Store, Bugwood.org

Damage:

Forms webbing against the fruit and feeds beneath, causing tiny holes and scarring on fruit surface. Rots and corking can occur at feeding sites, and sometimes larvae will enter near the calyx and feed in the seed cavity.

Tufted apple bud moth

Continued

Damage looks very similar to OBLR.

Mid-Atlantic Orchard Monitoring Guide

Monitoring:
Larvae overwinter in the orchard and can be found in trees early in the spring; adults emerge prior to bloom; first generation larvae appear around mid-June, second generation larvae appear mid-late August. Monitor adults with pheromone traps. There are one to two generations per year.

Todd M. Gilligan and Marc E. Epstein, Tortricids of Agricultural Importance

Management:
Economic infestations should be treated with selective or broad-spectrum insecticides. Use trapping info and degree-day models to determine timing - typical applications against larvae happen in the period immediately after fruit thinning and again in the late summer.

Eyespotted bud moth

Spilonota ocellana

Identification:

Adults are grayish brown moths with an off-white band covering about ½ of the wings.
Larvae are 9-14 mm long, chocolate brown colored, with black head and thoracic shield.

Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Charles Vincent, Ag. And Agri-Food Canada

Eyespotted bud moth

Continued

Damage:
Overwintering larvae burrow into flower buds early in spring; larvae also tie leaves together with silk and feed inside the cluster.
Fruit injury appears as small scars in a cluster that are often lighter in color than the rest of the fruit.

Leo-Guy Simard, Ag. and Agri-Food Canada

Monitoring:
There is one generation per year, with activity primarily going from bloom through early summer.

Management:
This insect rarely causes economic levels of damage, and therefore does not often require management. Selective or broad-spectrum insecticides can be used when needed in high pressure orchards.

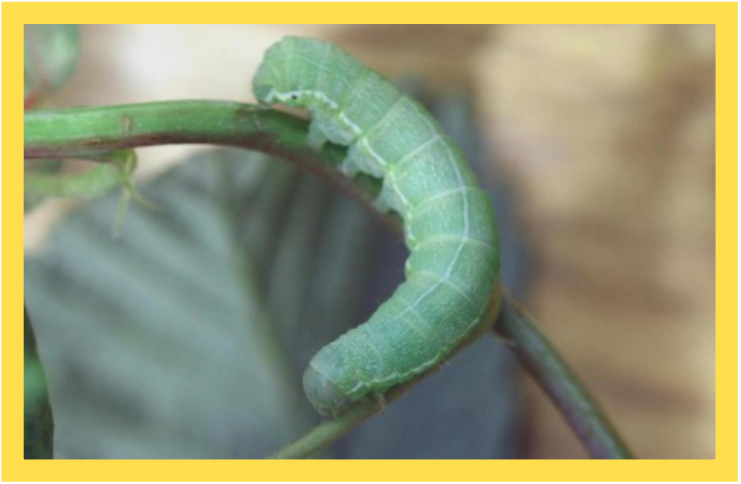
Speckled green fruitworm

Orthosia hibisci

Identification:

Adults of most species are large brownish moths with approximately 16 mm long bodies and wingspans of about 40 mm. The wings are grayish pink and marked near the middle with two purplish gray spots, outlined by a pale border.
Larvae are light green with a pair of lateral stripes and additional white spots (mature larvae can be 35-40 mm long).

Michigan State University Extension



Whitney Cranshaw, Colorado State University, Bugwood.org

Damage:

Larvae feed on leaves, buds, and developing fruit. Feeding often leaves a symmetrical round hole. Most damaged fruit will drop prematurely when the core is injured or will develop deep, corky scars.

Speckled green fruitworm

Continued

NY State Ag Experiment Station

Monitoring:

There is one generation per year. Adults emerge in very early spring, with egg hatch at the ½ inch green stage. Eggs are laid on upper surface of leaves. Flight activity is typically complete by the pink stage of apple bud development.

Management:

Insecticide applications at the half-inch green stage can help control adults and young larvae. If necessary, another application can be made at the pink bud stage or at petal fall to kill the larger larvae.

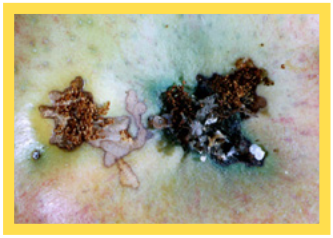
Lesser appleworm

Grapholita prunivora

Identification:

Adults are small grey moths with distinct orange markings on the wings. **Larvae** are pinkish white with a dark head and an anal comb.

NY State Ag Experiment Station



Damage:

Larvae form extensive shallow mines under the fruit skin, accompanied by reddish frass. Feeding in the fall is often limited to the calyx. Damage is similar to the Redbanded leafroller, but the red frass is characteristic to this species.

Monitoring:

Species presence and flight can be monitored with pheromone traps. There are two generations per year.

Management:

Orchards with softer spray programs may experience damage from this pest, however the summer control measures against codling moth and oriental fruit moth typically provide adequate control of this pest.

Spotted tentiform leafminer

Phyllonorycter blancardella

Identification:

Adults are small beige moths (3 mm long) with distinctive gold, black, and white patterns and fringed wings. **Larvae** are white to pale green color. The first 3 instars are legless, wedge shaped, deeply segmented sap feeders (1.5 mm). Fourth and fifth instars are tissue feeders with more cylindrical shape, and typical caterpillar prolegs and head capsule (5 mm).

NY State Ag Experiment Station

Damage:

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

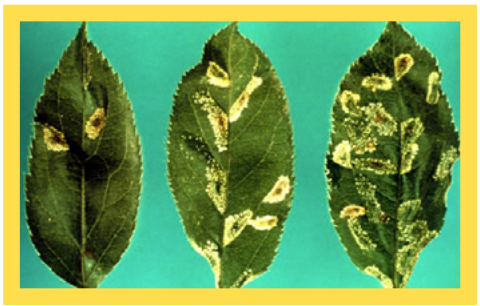
Monitoring:

Spotted tentiform leafminer produces 3 generations in Michigan.

Spotted tentiform leafminer

Continued

NY State Ag Experiment Station



Whitney Cranshaw, Colorado State University, Bugwood.org

First generation adults emerge at bud break to tight cluster, laying eggs on the undersides of leaves. Egg hatch occurs 2 to 3 weeks later. Second generation adults typically emerge mid-June and 3rd generation adults typically emerge in August. Pheromones are available for monitoring to determine first moth emergence. Eggs are attached to the underside of a leaf with a flattened surface. The exposed surface is a yellowish oval dome. Sample 50-100 leaves per block to count the number of mines per leaf and determine if treatment is needed.

Management:

These pests are typically kept in check by natural enemies, however if biocontrol is disrupted, they can rapidly build populations and cause damage. Thresholds for treatment are 2-3 mines per leaf for 1st & 2nd generation, or 5 or more mines for 3rd generation.

Apple flea weevil

Orchestes pallicornis

Identification:

The **adult** beetles are small (~3 mm long), black weevils with a short snout and club-shaped antennae. The hind legs of the beetle are enlarged at the segment closest to the beetle's body. These legs are spring-loaded, allowing beetles to jump when disturbed – hence the name "flea beetle."

Damage:

Michigan State University Extension

Adults feed on leaves and buds leaving characteristic "shot hole" type damage. Feeding by adults prior to fruit set causes buds and blossoms to abort, while larval feeding causes brown patches on leaf margins that resemble sulfur damage. Adult damage can also mimic frost damage because beetles begin feeding at the base of trees and work their way up to the top.

Michigan State University Extension

Apple flea weevil

Continued

Monitoring:

Michigan State University Extension

The apple flea weevil emerges in the early spring between the green tip and pink stages of apple bud development. Larvae pupate within a pupal chamber formed between the two leaf surfaces and emerge in June and July. Newly emerged adults feed on leaf tissue before entering diapause in late August or September. Scouting for damage will indicate the effectiveness of early control tactics and the need for reapplications. There is one generation per season.

Management:

This pest is primarily a concern in organic orchards. At low populations the weevil likely goes unnoticed, but at high populations it can cause significant crop loss. Management of this pest will depend on preventing adults from feeding on young foliage and buds through the application of adulticides between tight cluster and pink. If necessary, an additional application could target adults that emerge from the blisters in mid-summer.

Campylomma (Mullein plant bug)

Campylomma verbasci

NY State Ag Experiment Station

Identification:

Campylomma **nymphs** are tiny, oval-shaped, and translucent-green in color. They look somewhat like an aphid without "tailpipes," and have distinctive pink or reddish eyes. Campylomma nymphs can also be confused with white apple leafhopper nymphs. Two features distinguish Campylomma from white apple leafhoppernymphs, a rounded tip to its abdomen and four segmented antennae. Campylomma nymphs and adults are fast moving, especially when disturbed.

Michigan State University

Damage:

Damage to fruit from the mullein bug occurs around bloom-time. Fruit can receive individual or multiple stings, and the large majority of injured fruit abort just prior to, or during, June drop. Affected fruit that do remain on the tree develop small corky warts or bumps.

NY State Ag Experiment Station

Monitoring:

Monitoring for the pest phase of Campylomma should start around pink and continue through the bloom period. Once you see the damage, it's too late to target controls in apple.

Campylomma (Mullein plant bug)

Continued

Visual searches and limb tapping of nymphs onto beating trays are the most common methods for determining pest levels. Campylomma distribution in an orchard is generally clustered, necessitating a high number of limb taps to accurately determine infestation levels, about 20-50 beating tray samples across 10 acres to accurately determine population density. The mullein bug has two to three generations per year in Michigan. Several weeks after petal fall, the nymphs become beneficial and feed on European red mite and aphids. Nymphs with red bellies are an indication that they have been feeding on mites and are no longer in the pest stage.

Management:
Campylomma is an unusual insect because it spends most of its life cycle as a predator of mites and aphids in apple orchards and can therefore be beneficial. However, for a short period during bloom the mullein bug also feeds on developing fruit and may need to be controlled. Chemical controls applied from full to late bloom are the most effective. This insect has a preference for Golden Delicious, so monitoring and management should be focused on this and related cultivars if needed.

SAP FEEDERS

Green apple aphid

Aphis pomi

Identification:

Wingless adults are green with black cornicles, legs and antennal tips and are about 3 mm. **Winged adults** have black head and thorax and yellow-green abdomen. **Nymphs** are about 1.5 mm long. Overwintering **eggs** are black and shiny, however they are not easily visible to the naked eye.

Steve Schoof, NCSU

J.F. Walgenbach, NCSU

Damage:

This aphid feeds on the underside of leaves, on growing shoot tips, and on stems. Fruit can be damaged from aphids excreting honeydew which favors the growth of sooty molds. Aphid feeding can inhibit shoot growth in young orchards.

Green apple aphid

Continued

Monitoring:
Estimate the average number of aphid-infested terminals. Generally, an average of 3-4 infested leaves per terminal is needed before fruit damage from honeydew occurs.

Steve Schoof, NCSU

Management:
Many natural enemies will feed on these aphids, including lady beetles, lacewings, and syrphid fly larvae. A delayed dormant application for suffocation will prevent early injury and reduce the need for later sprays.
Spring insecticide applications may be necessary for young trees, and when sooty mold or severe leaf curling is present.

SAP FEEDERS

Rosy apple aphid

Dysaphis plantaginea

Identification:

Wingless adults (2-3 mm) and **nymphs** are generally rosy-brown to purple with long cornicles. **Winged adults** are brownish-green to black. Overwintering **eggs** are black and shiny, however they are not easily visible to the naked eye.

Damage:

This aphid causes leaves to curl and take on a crimson appearance; it stunts the growth of shoots and causes characteristic malformations on leaves and fruit. The honeydew excreted by these aphids favors the growth of sooty mold which can further damage fruits. Young trees are particularly susceptible.

NY State Ag Experiment Station

Ric Bessin, University of Kentucky Extension

Rosy apple aphid

Continued

Monitoring:
The first nymphs are present in the orchard when the trees are at 1/2-inch green. Beginning at tight cluster to pink, check for colonies in fruit clusters and on the undersides of curled leaves. Check interior upper branches after petal fall.

NY State Ag Experiment Station

Management:
Typically, RAA is controlled through early season applications of insecticides at delayed dormant through pink sprays, targeting eggs and nymphs. High populations in one year could necessitate early season treatment the following spring. One infested cluster/tree may indicate the need for treatment. If needed, insecticide applications should be made early (before bloom) before aphids are protected inside curled leaves. Elimination of weed hosts can contribute to control, especially narrow-leaved plantain, and dock.

SAP FEEDERS

Woolly apple aphid (WAA)

Eriosoma lanigerum

Identification:

Adults are 3 mm, produce distinctive white cottony filaments, and cluster in colonies. This aphid has no cornicles. When cottony filaments are brushed away, their bodies are reddish-brown to purple.

NY State Ag Experiment Station

Damage:

Injury includes gall formations on woody parts of trees and roots. Nodules can split and develop into cankers. Above ground, the aphids excrete honeydew on leaves and fruit that favors the growth of sooty mold. The cottony extrusions can remain even when the insects are long dead. The waxy filaments can be a skin irritant, making it a nuisance during harvest.

Woolly apple aphid (WAA)

Continued

Leo-Guy Simard, Ag. And Agri-Food Canada

Monitoring:
Colonies will cluster in wounds on trunks, branches, and root knots. Leaf axils on terminal shoots are preferred for summer feeding. Check pruning scars and interior/upper branches. Subterranean WAA may be present year-round and can serve as a source of aerial infestation starting in the spring. In warm winters, some above ground populations may persist year-round.

Management:
Use resistant apple rootstocks. Protect natural enemies, such as lacewings and lady beetles. If necessary, apply insecticides pink to mid-summer. Systemic insecticide options rated for WAA can control both above and below ground colonies.

Utah State University Extension

SAP FEEDERS

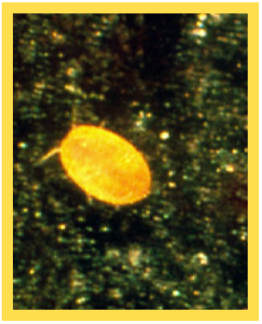
San Jose scale (SJS)

Comstockaspis perniciosa

Identification:

Adult males are minute, winged insects about 1 mm long and golden brown with a reddish tinge. **Scales** may be either disk-shaped (females) or oval (males) and are composed of concentric rings of gray-brown wax radiating from a tiny white knob. **Nymphs** (a.k.a. **crawlers**) are bright yellow and resemble spider mites.

Julianna Wilson, MSU

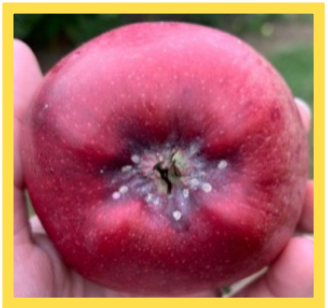


Ny State Ag Experiment Station

John A. Davidson, University of Maryland

Damage:

Scale can kill twigs and limbs and make fruit unmarketable. In heavily infested orchards, SJS feeding can cause overall decline in tree vigor and productivity, in extreme cases causing tree death. Feeding on fruit produces red spots often associated with slight depressions. Early season fruit infestations may cause small, deformed fruit.

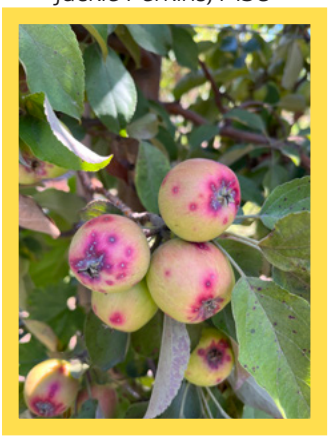


Julianna Wilson, MSU

San Jose scale (SJS)
Continued

Monitoring:

Jackie Perkins, MSU



SJS is a tiny, cryptic pest that can be hard to detect until populations are significant. Pheromone traps can be used to monitor adult male flight in blocks that are known to be infested. Place traps prior to pink. Crawlers are generally expected between 450-500 GDD (base 51ºF) after the first adult catch of either generation. Black electrical tape wrapped sticky side out around infested branches, 7-10 days after petal fall, can be used to monitor for crawlers. There are two generations per year, and perhaps three in years with high GDD accumulations.

Julianna Wilson, MSU

Management:

An insect growth regulator applied at pink can be very effective against newly emerged crawlers. Additional application options include delayed dormant sprays for suffocation when buds are showing green tissue before pink bud, or insecticides in the summer to target crawlers.

SAP FEEDERS

Tarnished plant bug

Lygus lineolaris

Identification:

Adults are flattened, oval bug, about 5 mm long, with cream-colored scutellum and translucent wings. Colors vary from green to brown, with yellow, black, or red markings. Nymphs are wingless and greenish yellow with black spots.

Scott Bauer, public domain

Scott Bauer,
USDA Agricultural Research Service,
Bugwood.org

Damage:

Pre-bloom stings on woody tissues or floral peduncle leave a droplet of sap and can often cause flower bud abortion. Stings at the base of the floral receptable or on fruit result in funnel-like depressions. Most damage occurs around bloom or following mowing in orchards or adjacent hay fields when fruits are 6-10 mm. Oviposition and feeding can result in pitted, scabbed, deformed fruit.

Tarnished plant bug

Continued

NY State Ag Experiment Station

Monitoring:

Adults can be present throughout the summer, but most first-generation adults migrate to weed hosts after petal fall. Watch for presence of adults on buds or use sticky white board traps at the periphery of the orchards to monitor activity.

Management:

Eliminate broad-leaf weeds that may serve as an alternative host, such as legumes, mullein, mustards, chickweed, dandelions, lambsquarters, plantain, goldenrod, and aster. Avoid mowing from bloom through petal fall which disturbs adults and pushes them into the orchard canopy. Drought conditions can also increase orchard populations as they move into green canopies.

Apply effective insecticides during the pre-bloom period if populations are severe.

SAP FEEDERS

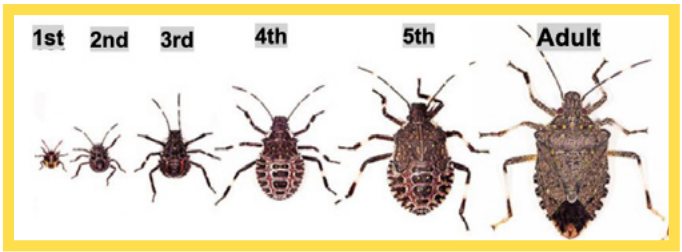
Brown marmorated stink bug

Halyomorpha halys

Identification:

Adults are brown shield-shaped bugs with white bands on antennae and legs and alternating white and black triangle markings on the edges of the abdomen. BMSB have a smooth edge on the shield behind their eyes (distinct from other stink bugs). There are five **nymphal** stages of BMSB. Early-stage nymphs are black and red, while later nymph stages are brown with white markings on leg and antennae. Note that there are several other species of stink bug in Michigan which can look similar to BMSB.

Mike Lewis



Michigan State University

Damage:

Both nymphs and adults will feed on apples. Late season feeding results in pithy or sunken regions in mature fruit, that may not become apparent until fruit comes out of cold storage. BMSB damage in apples is commonly confused with the physiological disorder bitter pit, lenticel breakdown, or other fruit disorders.

Brown marmorated stink bug

Continued

Monitoring: BMSB typically move into apple orchards in late summer near harvest.

Doug Pfeiffer, Virginia Cooperative Extension

Amy Irish-Brown, MSU

A set of 4 pyramid style or clear sticky panel traps baited with a commercial lure and set up around the orchard perimeter can be used to intercept BMSB and to determine threshold levels in blocks considered high risk for damage. Check traps at least once per week starting in early August. When perimeter traps have accumulated 10 nymphs or adults a spray should be applied. Limb-jarring over beating trays can also be used to determine presence if not using traps. BMSB has one generation per year in MI.

Management: Insecticide applications should be timed to kill immigrating adults as they move into orchards.

Julianna Wilson, Michael Haas, and Chris Adams, MSU

SAP FEEDERS

Potato leafhopper (PLH)

Empoasca fabae

Identification:

Adults are 1/8th in long, yellowish green with a wedge-shaped body, short antennae, translucent wings, and prominent leg spines. Active on leaves, they can move sideways.

Mid-Atlantic Orchard Monitoring Guide

Damage:

Potato leafhoppers feed on young leaves and a leaf margins, injecting toxic saliva while feeding, causing yellowing or chlorosis and cupping of young terminal leaves as the edges curl.

Mid-Atlantic Orchard Monitoring Guide

SAP FEEDERS

Potato leafhopper (PLH)

Continued

Monitoring:
PLH can be present anytime from spring-harvest, with the potential for 3-4 generations per season in high population years. Most years they are not a concern, but sometimes large populations are brought here by winds/storms from the south. They prefer young leaves and feeding near leaf edges. Examine the undersides of leaves to estimate the number PLH per leaf. Most first generation will be on spur leaves, while most summer generation will be on mid-shoot leaves.

Management:
Thresholds vary widely. Thresholds for trees with sparse canopy and heavy crop load are less than for trees with luxurious canopies. Apply selective insecticide against immature stages as needed, after symptoms begin to appear. In young, non-bearing trees, soil-applied systemic insecticides can provide residual control.
Many natural enemies will attack PLH, including lady beetles, lacewings, and minute pirate bugs.

White apple leafhopper (WALH)

Typhlocyba pomaria

Identification:

Adults are about 3mm long with pale yellow-white wedge-shaped bodies and short antennae.

NY State Ag Experiment Station

Damage:

Feeding is primarily on mature leaves; damage appears as white mottling of leaves, particularly in the interior canopy. When adult populations are abundant, shiny black excrement can also accumulate on leaves and fruits.

SAP FEEDERS

White apple leafhopper (WALH)

Continued

Whitney Cranshaw, Colorado State University, Bugwood.org

E. Beers, WSU

Monitoring:
WALH is present from spring-harvest with 2 generations per season, preferring to feed on mature leaves. Examine the undersides of leaves to estimate the number WALH per leaf.

Management:
Thresholds vary widely. Thresholds for trees with sparse canopy and heavy crop load are less than for trees with large/vigorous canopies. Apply selective insecticide against immature stages as needed. Crop-thinning applications using carbaryl can also significantly reduce populations of this pest, Organophosphate resistance is prevalent in the northeastern United States, but neonicotinoids and carbamates have continued efficacy.

Spotted lanternfly (SLF)

Lycorma delicatula

Identification:

Adults are ~1inch long with black bodies, light grey wings with black spots and black wing tips with grey veins. The hind wings are red, black and white when exposed. **Nymphs** start out as black with white spots and resemble spiders, but by the 4th nymphal instar they have red bodies with white spots and black stripes. **Egg masses** can be laid on nearly any surface and often look like dried mud.

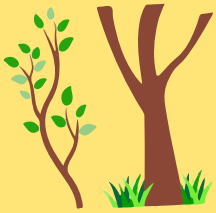
Lawrence Barringer, Pennsylvania Dept. of Ag.

Damage:

Feeding damage from this pest is rarely observed on apple or other tree fruit. High populations of this pest feeding on ornamental trees can result in loss of vigor or decreased winter hardiness. Feeding also creates wounds which can allow plant pathogens to infect trees.

Spotted lanternfly (SLF)

Continued



They excrete large amounts of honeydew as they feed, which can attract other pests (wasps, hornets), and increase growth of sooty molds. Lots of feeding during harvest time can reduce fruit quality, despite no direct feeding damage to fruit.

Heather Leach, MSU

Erica Smyers, Penn State University

Monitoring:

At the time of this printing, SLF has yet to be observed in numbers that would cause alarm in US apple orchards. If preferred hosts such as tree-of-heaven, grapevines, black walnut, silver maple, birch, or willows are abundant next to orchards, visual inspections of these trees can be used in an early detection program. Check for egg masses while pruning. SLF has one generation per year.

Spotted lanternfly (SLF)

Continued

Heather Leach, MSU

Pennsylvania Dept. of Ag.

Management:

While populations are low, squish any adults or nymphs you see and scrape off any egg masses. Many classes of insecticide are effective against SLF, including neonicotinoids, carbamates, and pyrethroids. Increased awareness and reporting detection of SLF can help slow the spread and allow for development of best management practices.

BORERS

Black stem borer

Xylosandrus germanus

Identification:

Adults are tiny ambrosia beetles about 2 mm. It is difficult to identify to species without a microscope and training.

Brad Barnd, BugGuide.net

Damage:

These beetles will attack stressed trees mainly along wooded edges. Generally, prefer young trees with trunk diameters <2.5 in, stressed by drought, flooding, winter damage, heavy pruning, top-work or some combination of these. These beetles will not attack healthy trees, although sometimes trees will look healthy but be emitting stress signals that attract this pest. Damage will appear as 1 mm circular holes in trunks; may also see toothpick-like string of sawdust and frass protruding from holes or oozing and sooty mold growth. When populations are high, young trees can be killed.

Mike Haas, MSU

Bill Shane, MSU

Strings of frass protruding from borer holes

Monitoring:
Check for trunk damage along orchard edges, in young or stressed plantings, low areas, areas with winter injury, and areas with sandy soils. Trapping can be done with ethanol baited traps to identify flight periods in the early spring, however a microscope and training are often required to identify them correctly. First flight typically occurs after two days of temperatures above 68 F. There is another similar ambrosia beetle species (*Anisandrus maiche*), that can attack apple trees and is active for most of the season, responding to the same traps and lures as the black stem borer.

Black stem borer

Continued

Mike Haas, MSU

Management:

Unlike other borers, trunk sprays of systemic insecticides have no effect on this insect because it does not feed directly on the tree. Trunk sprays of long-lasting pyrethroids timed for the beginning of flight can reduce infestation. If infestations of these beetles are detected, top priority should be reducing tree stress wherever possible. Remove trees with extensive symptoms of decline and burn them. Large pruning and brush piles should also be burned.

Dogwood borer

Synanthedon scitula

Identification:

Adults are black and yellow clear-wing moths 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). **Larvae** are white with brown head capsule (about 16 mm long).

NY State Ag Experiment Station

Damage:

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.

Dogwood borer

Continued

Monitoring:
Adult emergence begins in mid-June, peaks in early July, and continues until August. Empty pupal cases are often seen protruding near feeding sights at the graft union. Species presence can be monitored with pheromone traps. No thresholds are established for this species, and because of the large host range of this species, high capture in traps may not necessarily equate to high levels of larval infestation.

NY State Ag Experiment Station

Management:
Pheromone mating disruption can be used to prevent mating. Keep areas around the trunk weed free and open to sunlight to reduce burr knot development. Protect tree bases using soil mounds or white latex paint. Use broad-spectrum trunk spray against established infestations before bloom and during fruit set (egg-laying).

BENEFICIAL INSECTS & MITES

Beneficial arthropods (e.g., insects, spiders, mites) that are **natural enemies** of pest insects and mites act as either **predators** or **parasitoids**. The adult stages of many natural enemies require access to flowering plants, using pollen as a protein source or nectar as an energy (sugar) source. Natural enemies are important for naturally suppressing populations of many pests of apples including aphids, scale insects, leaf miners, and mites. Many natural enemies are sensitive to broad-spectrum insecticides and/or miticides and their abundance is strongly affected by pesticide use. The result of this unintentional impact on natural enemies is called “flaring”, which is a sudden increase or outbreak of a pest population after use of a broad-spectrum pesticide.

Conserving natural enemies is achieved through 1) intentional planting of wildflowers (a.k.a. pollinator habitat) near orchards, and 2) mindful use of pesticides.

Natural Enemies	Examples
Predators - arthropods that feed on other organisms	mites, spiders, lacewing larvae, syrphid fly larvae, lady beetles, yellow jacket wasps, assassin bugs, minute pirate bugs
Parasitoids - organisms that live in or on a host during an immature stage of their lifecycle, eventually killing the host	various tiny wasps, tachinid flies

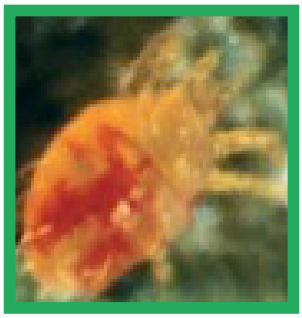
PREDATORS

Mites

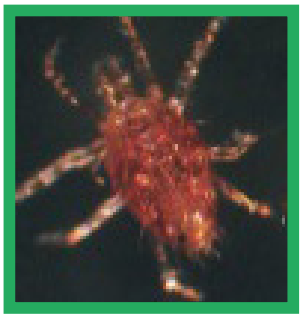
Arachnids, many species

Identification:

Predatory mites can be distinguished from pest species by observing the speed of their movement. Predator mites generally move more quickly than pest mites. Both predator and pest mites are tiny, about 1 mm, and have a simple unsegmented body with 8 legs. Predatory mites are very sensitive to many pyrethroid insecticides. There are four common species of beneficial mites that can be found in orchards, and all are about the same size as their prey:



Zetzellia mali



Agistemus fleschneri

Michigan State University

Amblyseius fallacis

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

Agistemus fleschneri adults are oval with a somewhat pointed posterior. They turn reddish-yellow upon feeding on pest mites.

Amblyseius fallacis adults are tear-shaped, translucent, and very fast moving.

Typhlodromus pyri (not pictured) is very similar in appearance to *Amblyseius fallacis* but is slower moving.

Benefits:
Predatory mites help keep pest mite populations in check.

PREDATORS

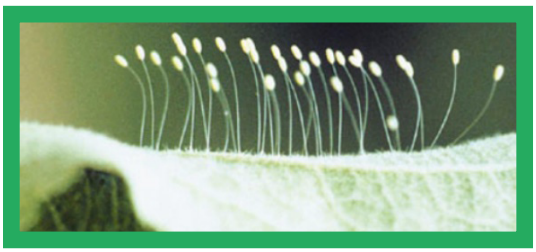
Green lacewing

Chysopidae species

Identification:

Green lacewing **adults** (10-12 mm long) have large, net-veined wings and gold-colored eyes. They feed on nectar, pollen, and aphid honeydew. Lacewing **larvae** (about 15 mm long) are alligator-shaped with long sickle-like mouth parts. Lacewing **eggs** are suspended at the tips of long, erect stalks.

Michigan State University



David Cappaert, Bugwood.org

Benefits:

Lacewing larvae are active predators of soft bodied insects, such as aphids. Brown lacewings can also be seen in orchards earlier in the spring when aphid populations were high in the previous year.

PREDATORS

Lady beetles

Family Coccinelidae, many species

Identification:

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** have dark, elongated bodies with orange markings (5-6 mm), well-developed legs, and pinching mouthparts. Lady beetle **eggs** are barrel-shaped and laid in clusters and yellow in color.

Charles Vincent, Ag. & Agri-Food Canada

Bernard Drouin, Ministry of Ag., Fisheries, and Food

Benefits:

Adults and larvae are predators of soft bodied insects.

PREDATORS

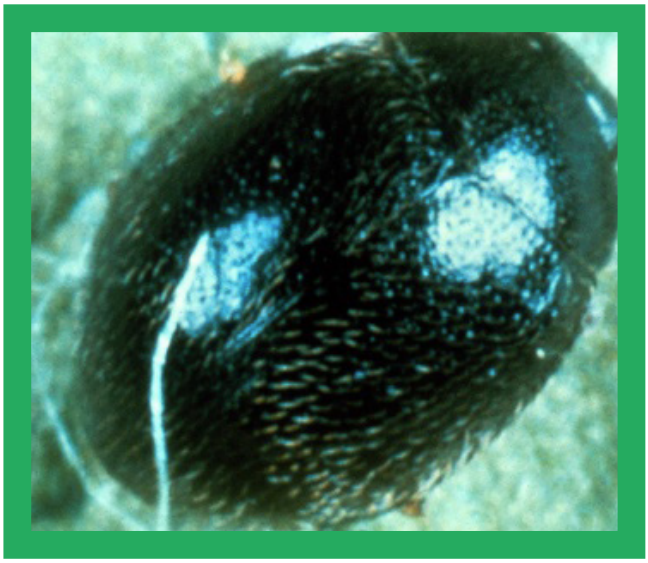
Black lady beetle

Stethorus punctum

Identification:

Adult black lady beetles (1 mm) are black with silvery hairs. Adults overwinter in leaf litter around the base of trees. Larvae are brown or black with short spines.

NY State Ag Experiment Station



Benefits:

Adults and larvae are predators of mites. These insects are rather rare in orchards because they are easily disrupted by pesticides. Seeing black lady beetles can be an indication that there is good natural enemy activity in the orchard.

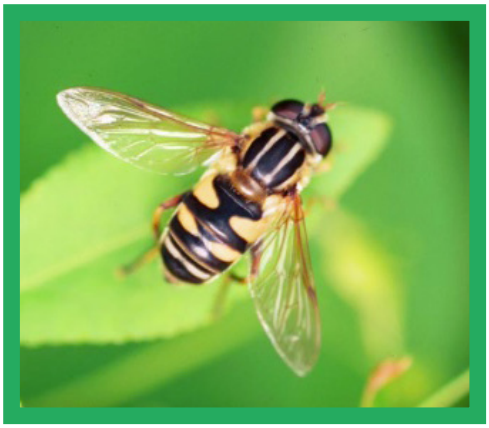
PREDATORS

Syrphid flies

Family Syrphidae, many species

Identification:

Syrphid fly **adults** are mimics of bees, but only have one pair of wings. Also known as hover flies or flower flies, they have a habit of hovering in the air and visiting flowers for nectar. Depending on the species, syrphid fly **larvae** (5-10 mm) vary in their coloration from translucent, to brown, green, or gray and have a rounded and tapered head. Often larvae will be found among aphid colonies.



Steven Katovich, Bugwood.org

Michigan State University Extension

Cappaert, Bugwood.org

Benefits:

Larvae are predators of aphids and other small soft bodied insects. Adults are pollinators.

PREDATORS

Orange cecidomyiid fly

Family Cecidomyiidae

Identification:
Adults are unlikely to be encountered. The **larvae** are small (1-2 mm), bright orange and legless and can be found in aphid colonies.

Benefits:
Larvae are predators of aphids.

Melissa Schreiner, Colorado State University, Bugwood.org

PREDATORS

Damsel bugs

Family Nabidae, many species

Identification:
Adult damsel bugs (Nabids) have long bodies (8 mm) that narrow slightly towards the head, with stout beaks, and enlarged front legs for grasping prey.

Michigan State University Extension

Benefits:
Prey on aphids and small caterpillars.

PREDATORS

Minute pirate bugs

Family Anthocoridae, many species

Identification:

Adult minute pirate bugs (Anthocorids) are black with white markings (3-5 mm). Can be confused with the pest species tarnished plant bug.

Bradley Higbee, Paramount Farming, Bugwood.org

Benefits:

Prey include aphids, mites, small caterpillars, and insect eggs.

PREDATORS

Assassin bugs

Family Reduviidae, many species

Identification:

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.

Melissa Schreiner, Colorado State University, Bugwood.org

Nathaniel Walton, MSU

Benefits:

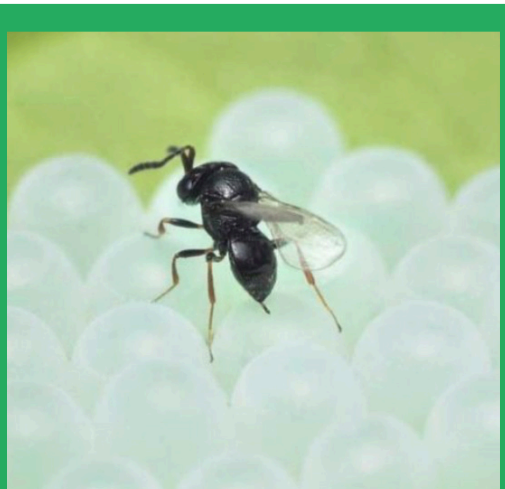
They feed on aphids, leafhoppers, small caterpillars, and beetle eggs and larvae.

PARASITOIDS

Parasitoids are important biological control agents. Adults are mobile, seeking out living hosts on which they lay their eggs. Larvae develop within and consume/kill their host before completing their life cycle and emerging as fully grown adults. Recognizable signs of parasitism include unusual host behavior, host color changes, host mummification (hardened exterior), and/or the presence of emergence holes in the host.

mummified aphid

Salvador Vitanza, bugguide.net



Chris Hedstrom, Oregon State University

egg parasitoid
attacking pest eggs

PARASITOIDS

Parasitoid wasps

Order Hymenoptera, thousands of species

Identification:

Most parasitoids are wasps ranging in size from very tiny (0.5 - 5 mm) up to fairly large (up to 75 mm), in rough proportion to the particular life stage (e.g., eggs, larvae, pupae, or soft-bodied adults) of the pest insects on which they specialize. There are thousands of different species of parasitoid wasps, and many are so small that they are rarely noticed by humans. Adults typically feed on nectar from flowers or other sugar sources.

A female *Trissolcus japonicus* parasitoid wasp emerging from parasitized brown marmorated stinkbug eggs.

Christopher Hedstrom, Oregon State University

Alan D. Manson

A braconid wasp parastizes aphids

Benefits:

Many are specialists who parasitize key apple pests including aphids, scale insects, leaf miners, and caterpillars.

Tachinid flies

Order Diptera, Family Tachinidae, hundreds of species

Identification:

There is one main group of flies that contain parasitoid species called Tachinids. Tachinid adults tend to be hairy or bristly and either visit flowers, decaying matter, or do not feed at all.

David Cappaert, bugwood.org

Benefits:

Tachinid larvae develop inside the larvae of moths, beetles, and stinkbugs, eventually killing their host.

Apple scab

Venturia inaequalis

Pathology & Identification:

The apple scab fungus overwinters in dead infected leaves on the orchard floor. In the spring as tree development begins and the fallen leaves become wet from rain, the sexual stage of the fungus matures, and fungal spores are discharged and dispersed into surrounding trees. This primary infection occurs on foliage, blossoms, petioles, and fruit during periods of sufficient wetting at given temperatures (see “Adapted Mills Table”). Infections usually develop first on spur leaves and on the blossom end (calyx) of fruit producing velvety brown to olive lesions. Lesions often turn charcoal grey/black later in the season. Conidia, asexual spores, are produced abundantly in these lesions and are spread by wind and rain and serve as sources of secondary infection. In addition to the lesions, infected leaves often yellow and prematurely defoliate. Fruit infections severely impact fruit quality and may also cause fruit drop.

William Turechek, USDA-ARS

George Sundin, MSU

Monitoring & Management:
Scout spur leaves and fruit in May and June for primary scab symptoms. Use the Mills Table or MSU Enviroweather to track when symptoms from an infection should be visible. These primary infections will provide the inoculum for secondary scab infections on terminal leaves and fruit. As such, successful and complete management of primary scab will mean that there is no need to protect for secondary scab. Apple scab is primarily managed through fungicides from green tip through midsummer.

Apple scab

Continued

Destruction of leaf litter by flail mowing in the fall or spring or the application of urea in the fall or spring can increase leaf litter degradation and reduce primary inoculum. Severity of infection depends on variety and proper fungicide coverage. Some cultivars are resistant to apple scab.

Clemson University – USDA Cooperative Extension

George Sundin, Michigan State University

William Turechek, USDA-ARS

MILLS TABLE
APPLE SCAB
INFECTION PERIODS

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

Approx. wetting period required for primary apple scab infection at various air temperatures and incubation time required for conidia to develop. The "wetting period" starts when rain begins.

		Wetting period (HOURS)			
Average Temperature (F)	Average Temperature (C)	Light Infection	Moderate Infection	Heavy Infection	Incubation Period (days)
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	9	12	18	9
62	16.7	9	12	19	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
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	17	23	35	-
46	7.8	19	25	38	-
45	7.2	20	27	41	-
44	6.6	22	30	45	-
43	6.1	25	34	51	-
42	5.5	30	40	60	-

Fire blight

Erwinia amylovora

Pathology & Identification:

The fire blight bacterium kills fruit-bearing spurs, branches, and often entire trees. Infected flowers (blossom blight) become water-soaked and then wilted, changing in color to dark green and then black. Infected shoots (shoot blight) turn brown to black from the tip and bend near the tip to resemble a shepherd's crook. Bacterial ooze can emerge from infected flowers and shoots; this ooze contains extremely large populations of fire blight cells. The pathogen is then spread from the ooze by wind and rain, as well as insects facilitating secondary shoot infections. Fire blight also produces cankers on branches that are large black areas that can become sunken and cracked.

George Sundin, Michigan State University

Fire blight

Continued

Ooze emerges from cankers in the spring and provides the primary inoculum for flower and/or shoot infection. ***Fire blight is a particular problem on young trees in high-density plantings.*** The pathogen can move very quickly through infected shoots to the central leader of the tree. When this happens, the tree is not salvageable and should be removed to prevent further disease spread in the orchard. Internally infected branches appear darker than normal. 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 that are dying appears lighter and the trees produce conspicuously fewer blossoms and during the 1- to 2-year period of decline prior to tree death.

Michigan State University

Monitoring & Management:
Wilted flower clusters and blackened shoots are the most visible early symptoms.

Fire blight

Continued

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 during dormancy. Blossom blight is managed through well-timed applications of bactericides during bloom.

W.G. Bonn, University of New Hampshire Extension

It is important to prune out infected limbs as soon as symptoms are detected, and pruning cuts should be made at least 30-45 cm below symptoms. Use of fire blight resistant rootstocks is the best method for reducing rootstock blight. Fire blight susceptibility varies with variety. Use MSU Enviroweather or MaryBlyt to track when symptoms should first occur and scout accordingly.

Mid-Atlantic Orchard Monitoring Guide

Powdery mildew

Podosphaera leucotricha

Pathology & Identification:

The powdery mildew fungus is an obligate parasite that overwinters in terminal buds. These buds often open slightly later than surrounding healthy buds in the spring. The fungus first infects the expanding green tissues. 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. The surface of the infected tissues takes on a white to light grey color because this fungus grows on the outside of the tissues and produces asexual spores, conidia, in these white areas that serve as secondary inoculum. Powdery mildew can affect leaves, green shoots, flowers, and fruit. New leaves and shoots are more susceptible than older growth.

Thomas Burr, Cornell University

Mid-Atlantic Orchard Monitoring Guide

Powdery mildew

Continued

Secondary infections are often more visible on the lower leaf surfaces. Fruit can be stunted and often have net-like russeting.

Michigan State University

Gerald Holmes, bugwood.org

Monitoring & Management:
Monitor for new powdery mildew infections on new growing shoots of susceptible varieties starting at tight cluster and continue through terminal bud set. Management of powdery mildew is primarily done through the application of fungicides from tight cluster or bloom through midsummer. Resistant varieties are also available. Spray programs are typically integrated with apple scab management. Powdery mildew is typically worse in hot and dry years.

Black rot

Diplodia seriata (syn. Botryosphaeria obtusa)

Pathology & Identification:

Black rot is a fungal disease that causes fruit rot, branch and limb cankers, and spots on leaves (frog-eye leaf spot). The fungus overwinters in cankers and fruit mummies and produces spores in small (1-2 mm) spherical fruiting bodies embedded in the host tissues. These structures look like black slightly raised bumps on the surface of the affected tissues. Spores are released during wet periods throughout the growing season. While the frogeye leaf spot symptom is not significant in terms of fruit infection, the appearance of these symptoms does indicate that the black rot fungus is active in the orchard. Significant losses can occur on Gala and Honeycrisp due to fruit rot. The fruit rot lesions are brown/black on the surface and often display concentric rings in older lesions. The black fruiting bodies will form on the lesions and may be seen before complete mummification. Cankers are often associated with abiotic injury and stress.

Dave Rosenberger, Cornell University

Black rot

Continued

Thomas Burr, Cornell University

William Turechek, USDA-ARS

Tyre Proffer, Michigan State University

Monitoring & Management:

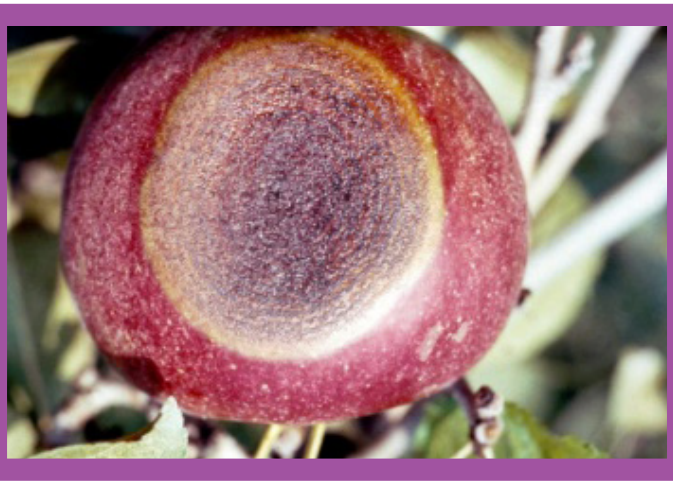
The black rot fungus is a good colonizer of dead or dying woody tissue, so proper pruning is essential. The fungus can sporulate on the pruned off branches so prunings of cankers should be moved offsite and burned. Timely applications of appropriate fungicides can also help to control frogeye leaf spot and the fruit rot phase of this disease.

Bitter rot

Colletotrichum acutatum and Colletotrichum gloeosporioides

Pathology & Identification:

Bitter rot is primarily a fruit rot problem. The fungus overwinters on fruit mummies, old fruit stems, and occasionally as twig cankers. Spores are released during wet periods throughout the season. Fruit symptoms can emerge a few weeks after bloom as circular, slightly sunken, light brown to dark brown lesions. In a cross-section of an infected fruit, the bitter rot lesion appears conical or V-shaped. Fruit infection can also occur later in the season, and lesion expansion is most common when temperatures are warmer, as high as 30 degrees C (86 F).



Mid-Atlantic Orchard Monitoring Guide

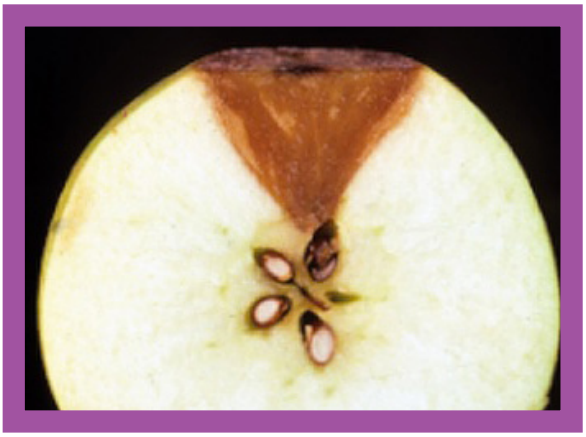
Spores are produced in small blister-like structures (1-2mm) that occur in concentric rings on the fruit lesion. Masses of spores are salmon/orange colored and are visible to the naked eye. Heat injury to fruit can be followed by bitter rot infection. The bitter rot pathogen can also cause cankers on limbs.

Bitter rot

Continued

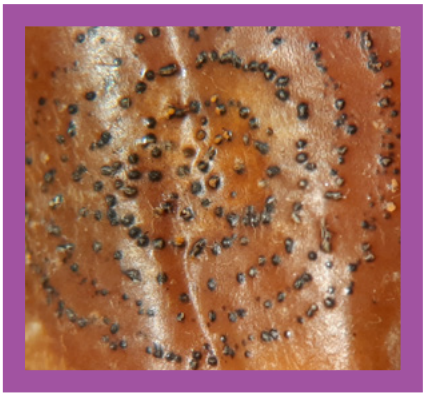
Dave Rosenberger, Cornell University

Turner Sutton,
North Carolina State University



Monitoring & Management: Removal of infected fruit, fruit mummies that hang on trees after harvest, and cankers are critical to keep overwintering inoculum low. In problem orchards it may be necessary to apply fungicides regularly from early summer through harvest. No resistant varieties are available; however, some are more susceptible (ex: Honeycrisp, Fuji, Golden Delicious, and Empire).

Tyre Proffer, Michigan State University



Sooty blotch and flyspeck

Fungal disease complex including Gloeodes pomigena and Schizothyrium pomi

Pathology & Identification:

Sooty blotch and flyspeck are fungal diseases that frequently occur together on apple fruit and are often referred to as “summer diseases”. 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.

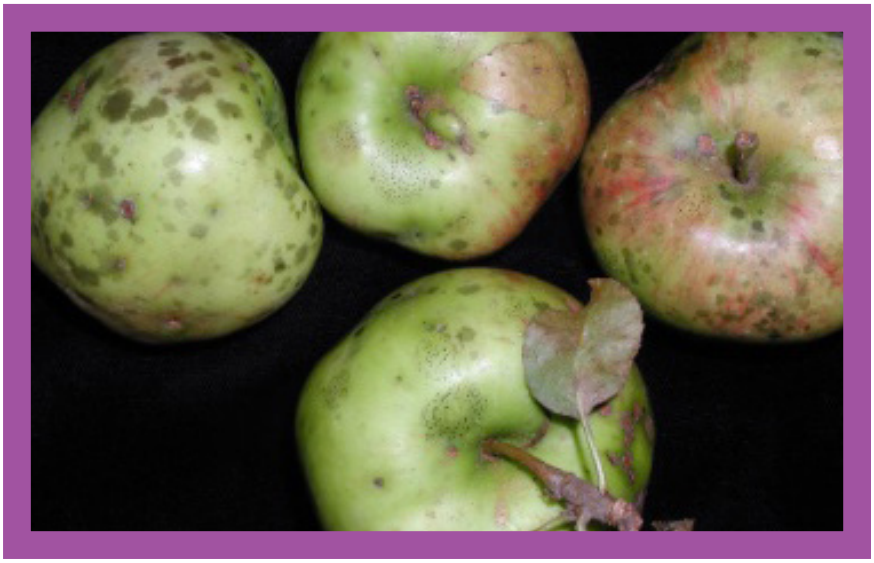
Individual blotches can grow together to form larger infected areas. Both diseases develop best under moist conditions (frequent rainfall and high humidity), and fruit can be infected from after petal fall through late summer.

Clemson University Cooperative Extension, bugwood.org

Thomas Burr, Cornell University

Sooty blotch and flyspeck

Continued



William Turechek, USDA-ARS

Monitoring & Management:

Reduce disease pressure by lowering orchard humidity and promoting quicker drying of fruit surfaces. Optimize air circulation around fruit by pruning the tree canopy and thinning fruit clusters. Reduce inoculum by removing reservoir hosts, such as brambles, in and around the orchard. Fungicide applications may be necessary from mid-June through August.

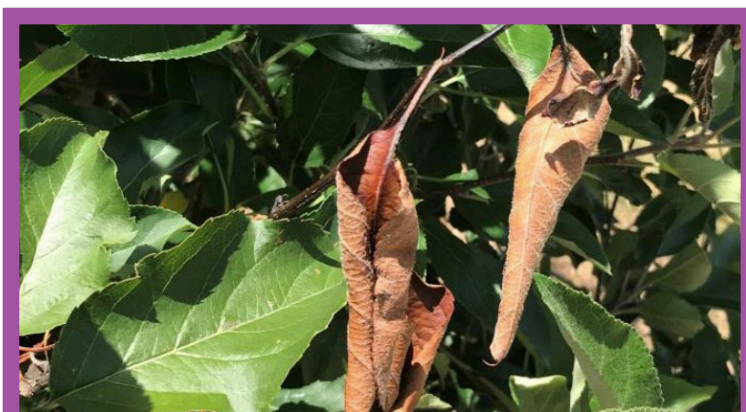
Track the MSU Enviroweather Summer Disease model for proper fungicide timing.

Nectria twig blight

Nectria cinnabarina

Pathology & Identification:

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. Infection occurs sporadically throughout the orchard.



Cornell University Extension

Nectria twig blight

Continued

George Sundin, Michigan State University

Monitoring & Management:

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 formed 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 0.5- 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, Mcintosh, Northern Spy, and Granny Smith.

Canker and shoot die-back of McIntosh cultivars

fungal disease complex

Some McIntosh cultivars (e.g., LindaMac, RubyMac) are particularly susceptible to a canker disease that can kill limbs and entire trees. Cankers usually become evident after the first heavy crop produced by the tree and will generally form during years 3-7. This disease is stress-induced and is caused by at least six different fungi. Pruning, removing, and burning cankered limbs is necessary to limit secondary spread of the pathogens. There are no effective fungicide controls for this disease.

Amy Irish-Brown, Michigan State University

Tyre Proffer, Michigan State University

Amy Irish-Brown, Michigan State University

Blister spot

Psuedomonas syringae

Pathology & Identification:

Blister spot is a bacterial disease that occurs predominantly on Mutsu apples, although it is also of minor importance on RedCort, Jonagold and Fuji. Small, raised, brown to black blisters occur on fruit in mid- to late July. The bacteria grow on flowers and fruit surfaces without causing symptoms initially. Fruit is most susceptible to infection about two weeks after petal fall, with a time window of infection continuing for about 4-5 weeks after petal fall. Blister spot infection typically occurs in years with frequent rains during bloom and after petal fall.

William Turecheck, USDA-ARS

Wayne Wilcox, Cornell University

Monitoring & Management:

When springs with disease favorable conditions occur, monitor for the small blisters on susceptible cultivars. The occurrence of streptomycin-resistant strains of the pathogen means there are no effective controls for this disease.

Calyx-end rot

Sclerotinia sclerotiorum

Pathology & Identification:

Calyx-end rot 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.

Thomas Burr, Cornell University

Monitoring & Management:

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.

Silver leaf

Chondrostereum pupureum

Pathology & Identification:

Silvering leaves is the most characteristic symptom, typically starting with 1-2 branches and eventually spreading to the entire tree.
There will often be two or three trees in a row with symptoms. With severe infections the leaves can also curl upwards. The internal heartwood of infected branches will often be stained dark brown. Symptoms can appear shortly after petal fall and will continue to progress over several seasons, leading to overall tree decline and eventually killing the tree. Silver leaf symptoms might present one season and then not again for a few years, only to return again when environmental conditions are right for expression.This disease is not very common in Michigan orchards.

Amy Irish-Brown, Michigan State University

Silver leaf

Continued

Amy Irish-Brown,
Michigan State University

Monitoring & Management:

During periods of rainy weather spores can be released and infect pruning cuts, especially from December - April. Wounds are susceptible for about a week, and stressed trees are particularly susceptible. Good sanitation, proper pruning practices, as well as adequate fertilization and drainage can reduce disease incidence. There are no chemical control measures to prevent infection – removal of infected trees is recommended to prevent spreading via spores or root grafts. Some varieties are resistant.

Index of species

Insect & Mite pests

Insect & Mite pests cont.

Beneficial Insects & Mites

Diseases

Diseases cont.

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