A4159

Apple Maggot

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FIGURE 1. Apple maggot adult.

Apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae), is a significant insect pest of apples. The fly received its common name based on the immature (maggot) stage of development; it is also commonly known as *railroad worm*. Apple maggot is native to eastern North America, and its natural host plant is hawthorn. When early settlers introduced the domesticated apple in the 1600s, apple maggot flies took advantage of this new food source and began to lay eggs in apple fruit. Apple maggot was first reported as a pest of apples in the 1860s. Currently there are two races of apple maggot flies, one that preferentially feeds on hawthorn and a second that preferentially feeds on apples. This divergence has led to genetic evaluation of the species as a possible case of speciation, the separation of two new species from a single species.

Although predominantly a pest of apples, apple maggot will also infest pears, apricots, peaches, cherries, crabapples, and wild rose hips. Apple maggot is a significant pest in commercial and backyard orchards in most of the United States and eastern Canada. In some western U.S. states, there are fruit-growing regions that do not have apple maggot. In some of these areas, counties where the pest is found have been quarantined to prevent further spread of the fly.

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Identification and life cycle

Apple maggot flies are 0.16–0.24 inches (0.4–0.6 cm) long. The body is mostly black, with a white triangular dot on the end of the thorax and white stripes on the abdomen. The fly's head is brown with prominent, dark-red eyes (figure 1). Male flies tend to be smaller than females and have three white stripes on their abdomen rather than the four stripes found on females.

FIGURE 2. Apple maggot distinguishing features.

Apple maggot flies are differentiated from many other fruit flies by the pattern of dark bands on their wings which form an "F" shape pointing towards the back of the body (figure 2). The wing pattern of the blueberry maggot (*R. mendax*), however, is almost identical, so it may not be possible to visually distinguish between the two species. It is unlikely that blueberry maggots would be found on traps in apple orchards unless blueberry is grown on the farm. (For more information on blueberry maggot, see fact sheet XHT1264 **https://fyi.uwex.edu/hort/files/2018/02/Blueberry_Maggot.pdf**.)

Adult apple maggot females lay single oval-shaped, white eggs that are approximately 0.04 inches (0.09 cm) long, directly under the skin of fruit. Females live for around 30 days and can lay up to 300 eggs over the course of a lifespan. After 3 to 10 days, the eggs hatch into cream-colored, legless maggots (larvae) (figure 3).

FIGURE 3. Apple maggot larva inside a plum.

The head of the maggot is identifiable by two dark, parallel, hook-shaped jaws, and the posterior end has two tan-colored spots (spiracles) for respiration. Larvae proceed through three developmental stages within fruit before they drop to the ground to pupate approximately 20 to 30 days after hatching. Full-grown larvae are 0.3–0.5 inches (0.7–1.2 cm) long. Pupae are typically found in the top 2 inches of soil, and are about 0.2 inches (0.5 cm) long with a yellow-brown color. Pupae overwinter and the adult flies emerge in early summer. Adults are active for 8 to 10 days after emergence before egg-laying begins (pre-ovipositional period). Some apple maggots will spend an additional year as pupae, remaining in the soil for the winter, next summer, and following winter before emerging as adult flies.

Degree days

Similar to other insects, the developmental rate of apple maggot is dependent on temperature: warmer temperatures increase the speed of development, whereas cooler temperatures can slow or inhibit development. Degree days are a method of using temperature rather than calendar date to approximate the time of different growth stages. For apple maggot, degree days are calculated using a base temperature of 50°F beginning accumulation at January 1 or March 1. There are a few models used for tracking apple maggot development. The Michigan State University model predicts that adult flies typically start emerging from overwintering pupae in the soil at 900 degree days (approximately early July). The first eggs are laid around 1,100 degree days, peak adult emergence is at 1,400 to 1,700 degree days, peak egg-laying is around 1,750 degree days, and the end of adult emergence is around 2,800 degree days (Angus H. Howitt, *Common Tree Fruit Pests* (NCR063) [Michigan State University Extension, 1993] pg. 34). These values can be used to track apple maggot development throughout the growing season, even in areas with significantly different temperatures. (For more information about calculating degree days, see fact sheet XHT1086, **https://fyi.uwex.edu/hort/files/2014/11/Degree-Day-Calculation.pdf**.)

Environmental factors including rain and soil moisture, as well as soil type and topography, can affect the timing and may not be well represented in degree day estimates for apple maggot. Sufficient rainfall is especially important for adult emergence, and dry conditions may delay adult hatch by 2 to 3 weeks. For this reason, degree day models should not be used in replacement of traps or other monitoring tools, but rather to give additional information regarding the timing for apple maggot adult emergence and the growth stage of the new generation.

Damage

In orchards, apple maggot damages only fruit, and if not controlled can cause extensive loss. Damaged fruit can become distorted and lumpy from inhibited growth at the site where the female fly laid an egg under the fruit skin. After the maggot hatches, it uses its pointed jaws to pierce cells in the fruit pulp and then consumes the juice. It tunnels its way through the fruit flesh, leaving behind a brown and rotting trail (hence the name *railroad worm*). This damage is usually not apparent unless the fruit is cut open. If multiple larvae are feeding inside a single fruit, the damage can be great enough to cause tissue collapse, which may be seen or felt on the outside of the fruit (figure 4).

FIGURE 4. Apple maggot damage to an apple.

Apple maggot damage can be differentiated from other apple fruit pests in that the brown tunnels are found throughout the fruit flesh. Many other internal feeders, such as codling moth, will preferentially feed at the central core of the apple.

Control

Monitoring

Trapping for apple maggot flies is crucial for controlling this pest. Traps allow for information regarding when adult flies are emerging from the soil and for estimating the population size; both can vary year to year as well as at different sites within the same year. Additionally, because flies are active before egg-laying begins, knowing when they first emerge allows for a window of time to apply an insecticide, if needed, before damage occurs.

Traps for apple maggot include a yellow sticky card and a baited sticky red sphere trap. Yellow sticky cards are often baited with ammonium carbonate or ammonium acetate (feeding attractants). A typical bait for the red sphere trap is a lure containing synthetically produced apple volatiles. In general, the yellow card trap is more effective early in the season as the flies emerge from pupation, giving a better estimate of the start of adult activity. The red sphere traps are much more effective once egg-laying begins because the female flies are seeking fruit on which to lay their eggs (figure 5). (For more information about trapping using attractants, see UW-Extension publication *Utilizing Insects' Sense of Smell for Pest Management* (A4135) at **https://learningstore.uwex.edu/Assets/pdfs/A4135.pdf**.)

Adult flies emerge around early July, and traps should be placed outside in mid-June to ensure that the traps are out before the adults start emerging. Hang traps in tree canopies, especially near wooded or landscaped edges. Check traps at least once a week (ideally every day, especially at the beginning of the season), remove any insects, reapply sticky adhesive as needed, and change the lure according to the manufacturer's recommendations.

FIGURE 5. Red sticky sphere used for monitoring apple maggot (attractant bait not shown).

Red sphere traps can be purchased, made by hand from wood or plastic, or made by hanging a store-bought apple covered in a sticky substance (e.g., TangleFoot™).

An insecticide application is warranted if there have been a total of five flies caught per red sphere trap baited with apple volatiles, or one fly caught in an unbaited red or yellow trap. This action threshold should be used after each insecticide application as well as to reevaluate if another insecticide application is needed. Proper identification is critical because there are other fly species that look similar (e.g., blueberry maggot, black cherry fruit fly, and cherry fruit fly) but will not damage apple fruit. A 10X hand lens may be necessary to see identifying characteristics, or the flies can be brought to a local Extension agent, crop consultant, or diagnostic clinic for identification.

Mechanical and cultural controls

The potential for controlling apple maggot using mechanical or cultural controls varies depending on orchard size and pest pressure. In all settings, removing abandoned apple or crabapple trees near the orchard and removing alternate host trees (ornamental or wild hawthorn) may reduce fly numbers.

Because apple maggot pupates in the soil, one possible control measure is to prevent the larvae from reaching the soil. This can be done by placing a tarp, landscape fabric, or thick mulch under a tree to form a barrier. Picking up and destroying all dropped apples may also reduce populations because many damaged apples that contain maggots will prematurely fall to the ground. Removing dropped fruit may help reduce populations of other insect pests including plum curculio (see UW-Extension publication *Plum Curculio* (A4160) at **https://learningstore.uwex.edu/Assets/pdfs/A4160.pdf**). Placing a tarp under the trees can also assist with collecting the dropped fruit. Fallen apples should be picked up as frequently as possible. Composting the fruit is not sufficient to kill any larvae inside.

While very labor intensive, in backyard orchard settings, bagging individual fruit could also help reduce fruit damage. Once fruit are ½ to ¾ inch in diameter, they should be thinned, if necessary, and bagged. Plastic bags, for example sandwich baggies, can be tied or stapled at the stem of the fruit, leaving ample room inside the bag for the fruit to grow. Cut two small holes at the lower corners of the bag to allow condensation to drip out. The bag can remain around the fruit until harvest. Fruit properly sealed in bags will be protected from apple maggot as well as other insect pests and will likely not require additional insecticides.

In very small orchards or single trees, there is potential for mass trapping to reduce apple maggot numbers. In this case, the goal is to catch as many flies in the traps as possible to reduce the population enough to protect the fruit. Red baited sticky spheres described in the monitoring section should be used for mass trapping, as they are the most attractive traps for apple maggot. For effective trapping, there would need to be a minimum of one trap per 50 to 100 fruit hung in the orchard. This is equivalent to approximately one trap per small tree, two to four for a medium-sized tree, and six to eight for a large tree. Traps should be in place before adult emergence (mid-June) and remain hanging through early September.

Biological control

Apple maggot is native to the eastern United States, and thus there are native predators present. Parasitoids are the most important natural enemies, and researchers have discovered parasitoid wasps that attack both the egg and larval stage of apple maggot. In hawthorn, the fruit is small enough such that the female wasp can reach the developing maggot with her egg-laying appendage, resulting in some level of control. However, apple fruit are too large, so many parasitoids cannot attack the maggot. For this reason, parasitoids have a minimal effect controlling apple maggot in apple orchards. Other predators of apple maggot include birds, spiders, carabid beetles, and ants. These predators do not typically reduce apple maggot populations to non-detrimental levels.

Chemical control

Insecticides are the main way to control apple maggot. After confirming that an insecticide spray is needed (based on trap counts that have reached the action threshold mentioned in the monitoring section), it is important to determine the best product to use. Factors to consider are the stage of fruit development, rotating different chemical classes to prevent insecticide resistance, the product's residual activity, how effective it is on other apple pests, if it could cause secondary pest outbreaks (especially mites) by killing beneficial insects, and the preharvest interval (the amount of time required between the last application and harvest). Timing is also critical because once eggs are laid in the fruit, they are protected from insecticides. Insecticide treatments need to target the adult flies before egg-laying. Insecticides should not be used when pollinators are present.

Some insecticides available for use in commercial conventionally managed or organic orchards include:

- Diamides (e.g., Altacor, Exirel)
- Neonicotinoids (e.g., Admire Pro, Actara, Assail, Belay)
- Organophosphates (e.g., Imidan)

Pyrethroids (e.g., Asana, Baythroid, Danitol, Leverage, Mustang Maxx, Proaxis, and Warrior) and the carbamate Sevin are typically not recommended because they can lead to secondary outbreaks of mites.

An alternative option is kaolin clay (Surround), a fine-powdered mineral clay that is mixed with water to form a physical barrier over the fruit. Surround is allowed for use in organic production by the Organic Materials Review Institute (OMRI) and is rated to have excellent control against apple maggot (*Fruit Management Guide* [Michigan State University Extension, 2018], **https://shop.msu.edu/product_p/bulletin-e0154.htm**). To be effective, the material must be covering the fruit at all times, requiring frequent reapplications after rain events or as the fruit grows. It is also effective in protecting fruit from other apple pests such as plum curculio.

There are a number of products that are formulated for apple maggot control in a backyard orchard. Some examples are:

- Acetamiprid (e.g., Ortho Flower, Fruit, and Vegetable)
- Carbaryl* (e.g., Sevin)
- Gamma-cyhalothrin (e.g., Spectracide Triazicide)
- Kaolin clay (Surround) (OMRI)
- Permethrin (e.g., Bonide Eight)
- Pyrethrins (e.g., Ferti-lome Triple Action Plus, Pyganic) (OMRI)
- Spinosad (e.g., Bonide Captain Jack's, Ferti-lome Spinosad, Monterey Insect Spray) (OMRI)

Chemical registrations vary by year, state, and crop. For products available for apple maggot control, refer to the current year's *Midwest Fruit Pest Management Guide*. The publication can be purchased or downloaded for free at **https://ag.purdue.edu/hla/Hort/Pages/sfg_sprayguide.aspx**.

Before using any insecticide, make sure to read the entire label as they are legally binding documents. Insecticides are not labeled for use on every crop, and the regulations can change. The label will give directions for proper use, appropriate application rates, required personal protective equipment, and preharvest interval.

Although apple maggot can cause significant losses in an orchard, with proper scouting, timing of treatments, and control measures, damage can be minimal.

*Carbaryl is an effective insecticide for controlling apple maggot, but it should not be used within a month of bloom because it can cause healthy, developing fruit to fall off the tree and lead to secondary outbreaks of other pests.

References to pesticide products in this publication are for your convenience and are not an endorsement of one product over other similar products. You are responsible for using pesticides according to the manufacturer's current label directions. Follow directions exactly to protect people, animals, and the environment from pesticide exposure. Failure to do so violates the law.

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