CODLING MOTH

Integrated Pest Management for Home Gardeners and Landscape Professionals

Codling moth, *Cydia (Laspeyresia) pomonella*, is a serious insect pest of apples, pears, and English walnuts.

IDENTIFICATION

Codling moth adults are about 1/2 to 3/4 inch long with mottled gray wings that they hold tentlike over their bodies (Fig. 1). Their appearance blends well with most tree bark, making them difficult to detect. If you are trapping the adults, you can distinguish codling moth from other moths by the dark, coppery brown band at the tip of their wings.

The larvae are white to light pink "worms" with a dark brown head (Fig. 2). They are one of the few caterpillars likely to be found inside pear or apple fruit. Navel orangeworms also might be found in walnuts, but these can be distinguished from codling moth larvae by the crescent-shaped markings on the second segment behind the orangeworm head and by the excess webbing they leave in the nut.

LIFE CYCLE

Codling moth overwinters as full-grown larvae within thick, silken cocoons under loose scales of bark and in soil or debris around the base of the tree. The larvae pupate inside their cocoons in early spring and emerge as adult moths mid-March to early April. The moths are active only a few hours before and after sunset, and they mate when sunset temperatures exceed 62°F.

After mating each female deposits 30 to 70 tiny, disc-shaped eggs singly on fruit, nuts, leaves, or spurs. After the eggs hatch, young larvae seek out and bore into fruit or developing nuts (Fig. 3). After completing development they leave the fruit and drop from the trees to search out pupation sites and continue the life cycle in the soil or on debris under the tree (Fig. 4); some crawl back up the tree to pupate in bark crevices (Fig. 5).

Figure 1. Adult codling moth.

Figure 2. Mature codling moth larvae in cut-open cocoons.

Figure 3. Newly hatched codling moth larva and three eggs preparing to hatch.

Figure 5. Codling moth pupa.

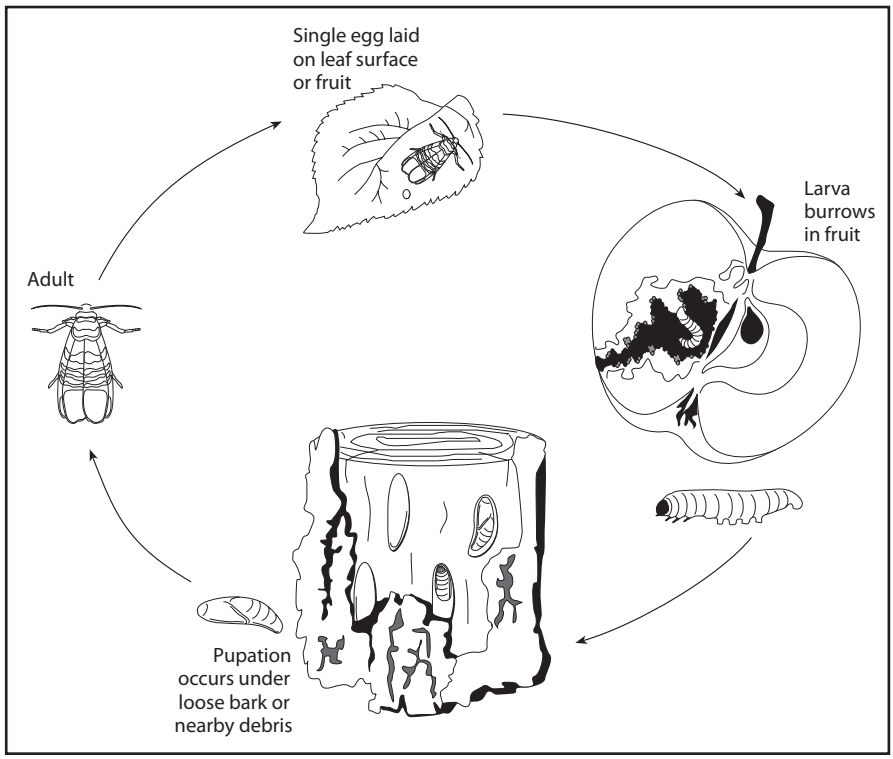

Figure 4. Life cycle of the codling moth.

PEST NOTES Publication 7412

University of California
Statewide Integrated Pest Management Program
Agriculture and Natural Resources

May 2011

The rate of development will vary with temperature, proceeding more rapidly in warmer weather and climates. Depending on the climate, codling moth can have two, three, and sometimes four generations per year.

DAMAGE

On apples and pears, larvae penetrate into the fruit and tunnel to the core, leaving holes in the fruit that are filled with reddish-brown, crumbly droppings called frass (Fig. 6). If left uncontrolled, larvae can cause substantial damage, often infesting 20 to 90% of the fruit, depending on the variety and location. Late maturing varieties are more likely to suffer severe damage than early varieties.

In walnuts, larvae feed on the kernels (Fig. 7). Nuts damaged early in the season when the nuts are quite small will drop off trees soon after damage occurs. Nuts damaged later in the season will remain on trees, but their kernels are inedible. Walnuts aren't as favored a host as apples and pears, and untreated trees might incur very little to modest damage (10 to 15% of the nuts), depending on the variety and location.

MANAGEMENT

Codling moth can be very difficult to manage, especially if the population has been allowed to build up over a season or two. It is much easier to keep moth numbers low from the start than to suppress a well-established population. In trees with low levels, codling moth often can be kept to tolerable levels by using a combination of nonchemical management methods; however, it is important to begin implementing these measures early in the season.

Where populations are moderate to high and many infested trees are nearby, insecticide applications might be necessary to bring populations down to low levels. To be effective, the timing of insecticide spray applications is critical, and several applications are necessary, especially with newer, less toxic pesticides. In most backyard situations, the best course of action might be to combine a variety of the nonchemical and/or low toxicity chemical methods discussed below and accept the presence of some wormy fruit. If eating wormy fruit, be sure to cut out damaged portions, because they might contain toxins (aflatoxin) generated by mold. It is ideal to make codling moth management a neighborhood project, because your trees can be infested by moths from your neighbor's trees, despite your own best efforts at keeping populations of this pest down.

Nonchemical Control

Several methods are available for reducing codling moth that don't require using insecticides. Selecting varieties that are less susceptible to damage, such as early maturing apples and pears and late leafing walnuts, can greatly reduce the potential for damage. This can be especially important in the hot Central Valley climates that have additional generations and result in higher population pressure.

Once trees are planted, nonchemical control methods include sanitation and fruit bagging. These methods are described below. Thinning out and removing infested fruit on the tree is an especially important part of an IPM program for codling moth. Pruning trees to a height where the canopy is easy to reach also will facilitate management of this pest.

If a backyard tree or orchard has a very high moth population, it might be impossible to satisfactorily reduce codling moth without using pesticides. Also, nearby orchards or backyard trees in which no control program is in place can serve as a continual source of codling moth and can make it even more difficult to limit damage through nonchemical means alone.

Sanitation. Sanitation should be the first step in any codling moth control program, and it is even more important for those wishing to use primarily nonchemical management approaches. Every week or two, beginning about six to eight weeks after bloom, check fruit on trees for signs of damage. Remove and destroy any infested fruit showing the frass-filled holes. Removing infested fruit before the larvae are old enough to crawl out and begin the next generation can be a very effective method for reducing the population. Thinning out the infested fruit has the added benefit of encouraging the remaining fruit on the tree to grow larger. It also might improve spray coverage, if sprays are used.

Figure 6. Frass, a mixture of feces and food fragments, fills tunnels that codling moth larvae have bored into this apple.

Figure 7. Codling moth larva in a walnut.

It also is important to clean up dropped fruit as soon as possible after they fall, because dropped fruit can have larvae in them. Removing infested fruit from the tree and promptly picking up dropped fruit from the ground is most critical in May and June but should continue throughout the season.

Bagging fruit. Excellent control can be achieved by enclosing young fruit in bags right on the tree to protect them from the codling moth. This is the only nonchemical control method that is effective enough to be used alone and in higher population situations. However, it is quite time consuming to apply the bags, so this method is most manageable on smaller trees with fewer fruit. You can bag all the fruit on the tree or just as many fruit as you think you will need. Keep in mind that un-

bagged fruit are likely to serve as a host and increase the pest population, so it would be prudent to employ sanitation to keep the population in check.

Bagging should be done about four to six weeks after bloom when the fruit is from 1/2 to 1 inch in diameter. Prepare No. 2 paper bags (the standard lunch bag size that measures 7 1/4 inches by 4 inches) by cutting a 2-inch slit in the bottom fold of each bag (Fig. 8). Thin the fruit to one per cluster. Slip the thinned fruit through the 2-inch slit so that it forms a seal around the stem and staple the open end shut.

It is difficult or impossible to bag certain varieties with very short stems such as Gravenstein. Also late developing varieties might be attacked by codling moth even before they are 1/2 inch in diameter, so they might not be protected. Some gardeners have found success with cotton tie string bags; nylon bags, however, aren't effective.

This technique won't affect the maturity or quality of the fruit, but it will prevent full color development on red varieties. You'll need to open some bags to check for ripeness as harvest time approaches. Some people open the bags up a week or two before harvest to allow color development, but the fruit still might be attacked if codling moth eggs are being laid. Other benefits to bagging include protection from sunburn and larger fruit as a result of diligent thinning.

Trapping. Hanging traps in each susceptible fruit or nut tree might help to reduce codling moth populations on isolated trees but isn't a reliable way to reduce damage. If it works at all, this method likely will have the most effect where trees are isolated from other trees harboring codling moth (e.g., apple, pear, or English walnut) and when several traps are placed in a tree. Use in combination with sanitation and other control methods for the best effect and expect damaged fruit.

Codling moth pheromone traps are important for monitoring flight activity of moths to help time insecticide treatments. Traps are available from many commercial sources, such as hardware stores, garden centers, or online. These traps usually have a sticky cardboard bottom and are baited with a pheromone (sex attractant) lure (Fig. 9). The lure mimics the scent of a female moth, attracting males to the trap. Traps should be put up in mid-March in the Central Valley and by the end of March in coastal areas. They should be hung as high as possible in the tree canopy. Check them every few days for moths. Only one trap is required if you are using them to monitor moth flights to time insecticide treatments. See the Insecticides section for more information.

Trunk banding. A traditional, nonchemical method for controlling codling moth is to trap mature larvae in a cardboard band as they climb the trunk seeking a place to pupate. Banding works best on smooth-barked varieties such as Red Delicious apple, which don't provide good alternative pupation sites. Scaly-barked varieties such as Newtown Pippin and most types of pears have so many crevices on the trunk that many larva will pupate before they get to the banded area. However, even in the best situations, banding will control only a very small percentage of the codling moth, because many pupate elsewhere on the tree or in the ground. Additionally, if bands aren't removed and destroyed in a timely fashion, they could increase the population, so banding no longer is recommended for control in home gardens.

Biological control. Although a few predators such as spiders or carabid beetles might feed on codling moth larvae or pupae, naturally occurring biological control isn't effective. In commercial walnut and pear orchards, releases of the tiny wasp *Trichogramma platneri* have been used successfully to manage codling moth in combination with mating disruption or soft pesticides. This method hasn't been successful in commercial apples and hasn't been tested in backyards.

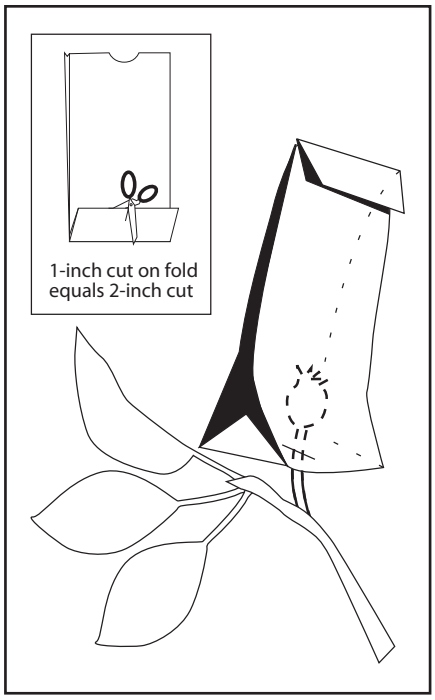

Figure 8. Bagging is one nonchemical control method for protecting fruit from codling moth larvae.

Figure 9. Several different pheromone trap styles can be used to monitor moths to time insecticide treatments.

Insecticides

Proper timing of insecticide sprays is critical if they are to be effective against codling moth; they should be applied before or just as eggs are hatching. Once the worm has gone into the fruit or nut, it is protected from pesticides.

Timing with degree-day calculations. The most effective way to time insecticide sprays is with a pheromone trap and a degree-day calculation. This is what commercial growers use. The trap lets them know when each generation or flight begins. The degree-day calculation lets them know just when egg hatch will occur and when the next generation should begin to fly. You can calculate degree-days with a maximum-minimum thermometer and a degree-day chart, or you can use the automated weather stations and degree-day calculator on the UC IPM Web site. Links to these tools and complete details on using degree-days to time sprays can be found on the online version of this publication at www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7412.html.

Timing by monitoring stings. Although timing sprays is best done with the use of degree-day calculations, home gardeners can also monitor fruit in their trees to detect the beginning of egg hatch. Starting three to four weeks after bloom, check fruit at least twice a week looking for the first "stings," or tiny mounds of reddish-brown frass about $^{1}/_{16}$ inch in diameter (Fig. 10). If you scrape the frass away you will see the tiny entry hole where the newly hatched larvae has just entered the fruit. Be sure to examine the fruit where it touches another fruit, as this is a common place to find an entry hole. Spray the tree as soon as you see the first sting; however, first remove any fruit with stings from the tree, as the insecticide won't kill any larva that already have entered the fruit. Expect to have more damage with this monitoring method than the degree-day method, since it can be difficult to find the very first sting.

Home orchards might be able to achieve an acceptable level of control by spraying the first spring generation and using nonchemical methods to maintain a low population for the rest of the season (Fig. 11). However, if heavy infestations have occurred in previous years, if there are unmanaged host trees nearby, or if tolerance for damage is very low, the summer generation(s) also need to be treated.

In cooler coastal areas look for the first stings from the spring generation in early to mid-May, about a month after bloom. Look for new stings from the single summer generation beginning in mid-July to mid-August, about 10 to 13 weeks after the spring hatch begins. Coastal areas usually have just two generations per year.

In the warmer Central Valley area look for the spring generation stings in mid- to late April, about a month after bloom. Look for new stings from the first summer generation beginning in early to late June, about eight weeks after the spring hatch began. In the Sacramento and Northern San Joaquin valleys, a second and last summer generation will begin in early to mid-August. In the very hot southern San Joaquin Valley, look for the second summer generation stings to begin in mid-July and the third summer generation to begin in mid-August.

Codling moth granulosis virus. Recently a new biological insecticide, CYD-X, a granulosis virus that affects only larvae (caterpillars) of the codling moth, has become available to home gardeners in California. Codling moth larvae must ingest this virus for it to be effective. Once ingested, the virus infects the digestive tract of the caterpillar causing a disease that kills it within three to seven days. It doesn't affect other insects, humans, pets, or wildlife and is OMRI listed as suitable for use in certified organic production. University of California trials have shown that this product, when applied weekly during egg hatch throughout

Figure 10. Sting caused by young codling moth larva.

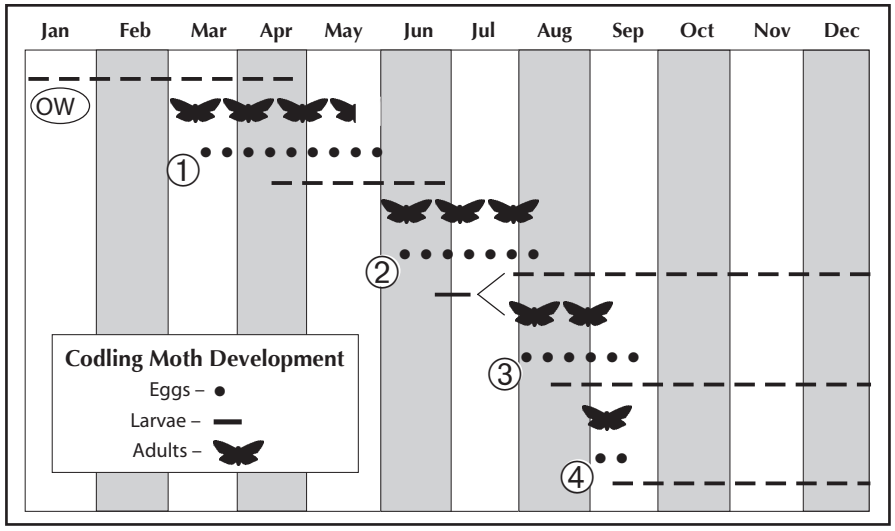

Figure 11. Generalized description of the codling moth's seasonal development in the warmest parts of California. Larvae hatch later in cooler areas, and there will be fewer generations. Moth flights and developmental times vary with temperature and location. Designated are overwintered (OW) population; (1) first generation in spring; (2) second generation in summer; and (3) third generation in late summer. A portion of the second-generation larvae stops developing and becomes part of the overwintering (OW) larval population, except in very warm locations where most of the second generation completes development and even some third generation larva can pupate and emerge as moths in late summer to create a (4) fourth generation.

the season, is as effective as carbaryl sprays at controlling codling moth in backyard trees. More applications are needed—carbaryl must be applied only every 14 to 21 days or one to two times per generation—but many environmentally conscious gardeners are willing to make this trade off. CYD-X also has the advantage of having no preharvest interval, so applications can be made up until the time of harvest and there are no limits on the number of times you can spray it.

Like other insecticides, granulosis virus should be applied as soon as the eggs of the first generation codling moth hatch. If you are using pheromone traps and degree day calculations as described above, this would be 200 to 250 degree-days after you begin regularly catching male moths. If you are just checking fruit, this would be when you see the first stings. Make applications weekly after that. You'll need a good sprayer, and you must get good coverage of fruit. Adding 1% oil to the application can improve effectiveness. CYD-X is a new product that might be difficult to find in stores but can be ordered on the Internet.

Spinosad. Spinosad is a biological product made from a naturally occurring bacterium called *Saccharopolyspora spinosa*. It is a lower-toxicity material that is safe for most beneficial insects as well as for people, pets, and the environment although it is more toxic to beneficials than granulosis virus. Repeated applications each generation are necessary for acceptable control. The first spring generation requires three sprays applied at 10-day intervals beginning at egg hatch (i.e., 250 degree-days, or when the first stings are found). For any subsequent summer generations, two sprays should suffice with the first spray applied at the beginning of each new egg hatch and the second spray applied 10 to 14 days later. No more than six sprays should be applied per season, and they shouldn't be applied within seven days of harvest. The addition of a 1% horticultural oil to the spray tank will further enhance the effectiveness of this material. Spinosad is available through retail outlets under various trade names including Monterey Garden Insect Spray or Green Light Spinosad Lawn & Garden Spray.

Carbaryl. One of the more effective materials against codling moth is the broad-spectrum insecticide carbaryl (Sevin). However, this material has significant drawbacks. It remains effective for 14 to 21 days, but it is very disruptive to natural enemies and honey bees. Applying more than one carbaryl spray per season might lead to an outbreak of pest mites. Also carbaryl has been associated with water quality problems. If your tree is heavily infested and more than one spray is needed, it might be prudent to alternate this material with granulosis virus or spinosad. Carbaryl never should be sprayed during bloom or when bees are present. It also shouldn't be used on apples within one month of bloom, as it can cause the fruit to drop; use one of the other materials if a spray needs to be applied at this time. The homeowner shouldn't apply carbaryl within three days of fruit harvest or 14 days before walnut harvest.

Carbaryl should be applied at 250 degree-days or as soon as you see the first sting in spring. A second application might be needed at 650 degree-days, or 21 to 28 days later, to cover the prolonged spring emergence. If later summer generations require treatment, a single carbaryl application should suffice for each subsequent generation, as the insect develops more quickly during the warm weather of summer. Refer to the online degree-day guidelines for timing these later sprays or visually monitor for each new generation using the timing guidelines above.

Other materials. *Bacillus thuringiensis*, pyrethrum, and pyrethrin/rotenone combinations are low toxicity materials that have been tested and haven't been found to be effective at controlling codling moth. Horticultural oil has shown variable efficacy when used alone but can be mixed with granulosis virus or spinosad to improve performance. Mating disruption products that employ large quantities of pheromone to prevent mating or pheromone plus an insecticide to attract and kill male moths have proven effective for large commercial plantings but aren't effective on small orchards of fewer than 5 acres. In fact, mating disruption can increase damage if used on small plantings or individual trees.

REFERENCES

Flint, M. L. 1998. *Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide, 2nd ed*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3332.

Ohlendorf, B. 1999. *Integrated Pest Management for Apples & Pears, 2nd ed*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3340. ❖

AUTHORS: J. L. Caprile, UC Cooperative Extension, Contra Costa Co.; and **P. M. Vossen**, UC Cooperative Extension, Sonoma/Marin Co.

TECHNICAL EDITOR: M. L. Flint

EDITOR: M. L. Fayard

ILLUSTRATIONS: Figs. 1–3, 5–7, and 9–10, J. K. Clark; and **Figs. 4, 8, and 11**, V. Winemiller.

University of California scientists and other qualified professionals have anonymously peer reviewed this publication for technical accuracy. The ANR Associate Editor for Urban Pest Management managed this review process.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

Produced by **UC Statewide Integrated Pest Management Program**
University of California, Davis, CA 95616

This and other Pest Notes are available at www.ipm.ucdavis.edu.

For more information, contact the University of California Cooperative Extension office in your county. See your telephone directory for addresses and phone numbers, or visit http://ucanr.org/ce.cfm.

University of California
Agriculture and Natural Resources