CALIFORNIA OAKWORM

Integrated Pest Management for Landscape Professionals and Home Gardeners

The California oakworm, *Phryganidia californica*, is one of many species of caterpillar that feed on oaks in California. Damage is most common on coast live oak, *Quercus agrifolia*, in the San Francisco Bay Area and Monterey Bay region with outbreaks occurring at about 8- to 10-year intervals; however, outbreaks can occur in many parts of the state.

IDENTIFICATION

The adult is a uniformly tan to gray moth distinguished by its prominent wing veins. Unlike females, males have feathery antennae. The female lays tiny round eggs in groups of about two or three dozen on twigs or leaves. The eggs are white but develop red centers that become pinkish to brownish gray before hatching. The young larvae are yellowish green with dark stripes on their sides and have large brown heads. Mature larvae are variable in color, but commonly dark with prominent lengthwise yellow or olive stripes. Larvae range in size from 1/10 inch long when newly hatched to about 1 inch when fully grown. Pupae are white or yellow with black markings, 1/2 inch long, and are found suspended from limbs or leaves, on the bark, or on objects near trees.

In the warmer central valleys of California, another caterpillar, the fruittree leafroller, *Archips argyrospila*, is the most common defoliator of oaks. Fruittree leafroller larvae are light green with black heads. They commonly drop to the ground on silken threads, wriggling vigorously when disturbed.

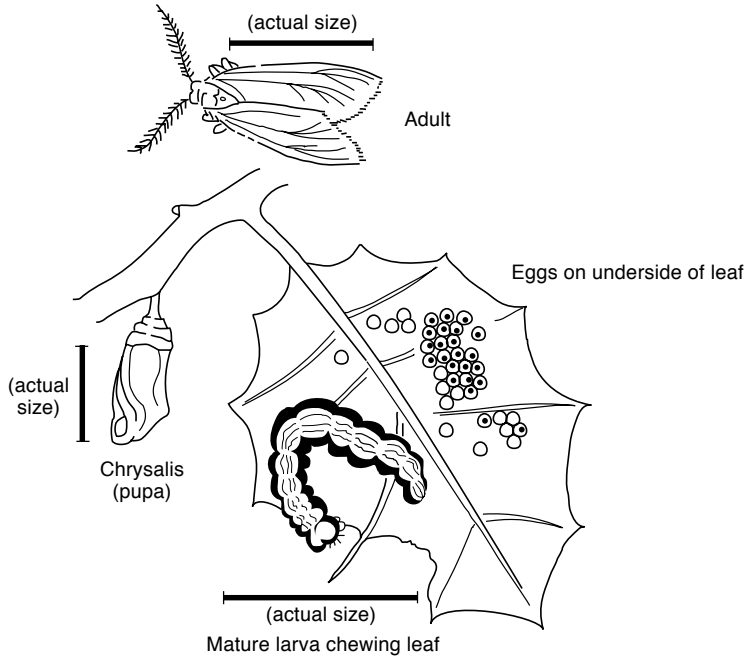

Figure 1. Life cycle of California oakworm.

Tussock moths *(Orgyia* spp.) and tent caterpillars *(Malacosoma* spp.) also feed on oaks. Unlike the greenish, relatively smooth bodies of California oakworm and fruittree leafroller larvae, tent caterpillars and tussock moth larvae are very hairy.

LIFE CYCLE

Two generations a year typically occur in northern California; there is sometimes a third generation in southern California or northern California in years of uncommonly warm, dry winters. The oakworm overwinters as young larvae on the lower leaf surface (Fig. 1). Larvae develop through five instars and mature in May or early June in northern California. Moths often flutter around oaks in the late afternoon in June and July. These first-generation female oakmoths lay eggs that hatch into larvae from July through September. Oakworms generally do not occur on deciduous oaks in large numbers because these trees drop their leaves in fall, causing the overwintering generation larvae and eggs to die. Second-generation moths occur in October and November

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when they lay eggs that hatch into the overwintering larvae. Development in southern California is more variable, and moths may appear at almost any time from March through November.

DAMAGE

Young larvae skeletonize the leaf surface, while older larvae chew all the way through the leaf. Defoliation on live oaks may become extensive in May or June and again in July through September. Healthy trees can tolerate some damage; by comparison, trees under stress from drought or other factors may decline if defoliated.

MANAGEMENT

Oaks tolerate feeding by moderate populations of oakworms, and control is not needed when damage is low. Healthy and well-cared-for oaks tolerate extensive defoliation without serious harm. Provide proper water, depending on soil type, location, and oak species. Protect roots and trunks from damage, and properly prune trees when needed.

If trees need protection from defoliation because they are stressed or of high aesthetic value, regularly inspect foliage for larvae and spray only when caterpillars are abundant. Monitoring is important because California oakworm populations are cyclical in nature, causing the pest to be common in some years and virtually absent in others. Outbreaks do not occur every year and no treatment is needed most years. Control California oakworm with an integrated pest management (IPM) program that incorporates good cultural practices, conservation of natural enemies, and use of less-toxic pesticides.

Monitoring

Monitor to determine whether insect populations are going up or down and whether control is warranted, and to properly time management efforts. Also monitor trees at least once after taking a control action to assess the effectiveness of your management.

Regularly inspect foliage for oakworms or damage. Concentrate monitoring in the west part of the tree canopy to determine early damage. No thresholds have been established, but some guidelines have been suggested: If more than 8 to 10 larvae greater than 1/4 inch long are observed after inspecting 25 young (lighter green) shoots, defoliation may occur if oaks are not sprayed. A density of 25 larvae per 100 twigs has also been suggested as the population density that may warrant control action to prevent annoying levels of defoliation.

Frass collection is another monitoring tool. The California oakworm excretes droppings (frass) that fall to the ground beneath the tree. As larvae grow, fecal pellets increase in size. Greater numbers of pellets are produced with an increase in the number of larvae or an increase in temperature, which causes caterpillars to feed faster.

Place three to five light-colored sticky cards, shallow trays, or cups beneath the canopy at regular intervals, such as for 24 hours each week. Place these frass traps when no rain or sprinkler irrigation is expected. Save the frass or record its volume for comparison with the amount collected on other sampling dates or at other locations.

Initially you may want to conduct both frass monitoring and foliage inspection. This provides a record of the proportion of leaves eaten or the number of larvae present and the corresponding density or volume of frass. With experience, you may be able to use frass monitoring alone to estimate caterpillar density and damage, and to aid in deciding if control is needed.

Frass monitoring helps you estimate the relative age of most larvae by comparing frass pellet size. Average pellet lengths for first, third, and fifth instars are 0.3, 0.6, and 1.4 mm, respectively. (For a photo of these frass pellets see *Pests of Landscape Trees and Shrubs,* listed at the end of this publication.) Certain insecticides such as Bt are most effective against younger caterpillars, when smaller size frass pellets predominate.

When monitoring for pests, also look closely for the presence of predators, parasites, and other evidence of biological control; record this information. Evidence of natural enemy activity includes pupae or eggs with holes from which parasites have emerged, unhatched eggs that are darker than normal eggs—indicating they may contain parasites—or hatched caterpillar eggs with no evidence of caterpillars or damage. If you have an increasing number of pests but also many natural enemies, wait a few days. Monitor again before using insecticides to determine whether pest populations have declined, or natural enemies are increasing to levels that may soon cause pest numbers to decline.

Biological Control

Predators, parasites, and natural outbreaks of disease sometimes kill enough oakworms to control populations. Predators include spiders, bigeyed bugs, pirate bugs, lacewing larvae, ground beetles, damsel bugs, assassin bugs, and birds. Of the known oakworm parasites, two small wasps, *Itoplectis behrensii* and *Brachymeria ovata,* provide the greatest control. The spined soldier bug, *Podisus maculiventris*, is reportedly the most important oakworm predator, and two tachnid fly parasites, *Actia flavipes* and *Zenillia virillis,* also contribute to control.

Oakworms are often killed by diseases caused by naturally occurring bacteria, fungi, or viruses. Symptoms of such an infection are dark, soft, and limp larval carcasses hanging from foliage or twigs, which eventually degenerate into sacks of liquefied contents. When broken, more viral particles or bacterial spores are released, which infect other caterpillars when they eat contaminated foliage. Such disease outbreaks can rapidly reduce populations under favorable conditions, although outbreaks are difficult to predict and may not occur until oakworms have become numerous.

Chemical Control

Several pesticides of low toxicity to people and natural enemies are available to control oakworms. IPM-compatible pesticides include microbials, botanicals, and insect growth regulators. Although some are available to both homeowners and professional applicators (Table 1), most homeowners lack the equipment and experience to effectively treat large trees. When hiring a professional applicator, discuss the specific pesticide to be applied and insist on use of an IPM-compatible one. Avoid the use of broad-spectrum carbamates (e.g., carbaryl), organophosphates (acephate, chlorpyrifos, diazinon), or pyrethroids (fluvalinate, permethrin, resmethrin), because these insecticides kill both pests and beneficials and may induce outbreaks of spider mites, aphids, whiteflies, or scales.

IPM-compatible pesticides provide good control of target pests, reduce secondary outbreaks of other potential pests such as mites, and minimize hazards to people and pets. In part because of their more specialized and selective modes of action, IPM-compatible pesticides often require more knowledge, skill, and careful application to be effective. Some of these pesticides can be mixed and applied together to increase their effectiveness. For example, an insecticide that provides immediate control (e.g., pyrethrins) can be combined with a pesticide that acts more slowly to kill insects (e.g., *Bacillus thuringiensis* or diflubenzuron).

Microbials. Microbial insecticides are naturally occurring microorganisms or their by-products produced commercially for pest control.

Bacillus thuringiensis, also called Bt, is the most widely used microbial insecticide and has been used effectively against oakworm for many years. Unlike broad-spectrum insecticides that kill on contact, oakworms must eat Bt-sprayed foliage to be affected. The disease destroys the oakworm's digestive system and causes larvae to stop feeding within about a day. Most infected oakworms die within a few days.
Bt is not toxic to most noncaterpillar insects including natural enemies.

Timing and thorough spray coverage are very important for effective application. Apply Bt during warm, dry weather when oakworms are actively feeding. Young larvae are most susceptible to Bt, but because they only scrape the lower leaf surface, spraying is less effective at that stage unless you thoroughly treat the underside of leaves. Thus, it is probably more effective to thoroughly treat foliage when larvae are first observed to be chewing completely through the leaf or at the leaf edge. Because sunlight quickly decomposes Bt on foliage, most oakworms hatching after the application are not affected. A second application about 7 to 10 days after the first may be required. Follow label directions for mixing and applying. Some users add insecticidal soaps, oils, or pyrethrins to increase the efficacy of Bt sprays.

A new group of microbials, the spinosyns (spinosad), are produced as fermentation by-products from the bacterium *Saccharopolyspora spinosa*.

Table 1. Types of Pesticides and Other Products Available for Oakworm Control.

		Commercial product names	
Pesticide type	**Common chemical name**	**Home use**	**Professional use**
biological	*Bacillus thuringiensis* ssp. *aizawai*	NA	Xentari
biological	*Bacillus thuringiensis* ssp. *kurstaki*	BT WormKiller, Caterpillar Clobber, Caterpillar Killer, Worm-Ender	Biobit, Condor, Crymax, Cutlass, Dipel, Mattch, MVP
biological	spinosad	NA	Conserve
botanical	pyrethrins	NA	PT 1600 X-Clude
botanical	pyrethrins + piperonyl butoxide	Insect Killer	Pyrenone
botanical	pyrethrins + rotenone	NA	Pyrellin E.C.
insect growth regulator	diflubenzuron	NA	Dimilin

Check current labels for permitted uses. NA = Not available or availability uncertain

Spinosyns are toxic to most caterpillars, fly larvae, and thrips, and to certain species of beetles and wasps. They are among the most effective microbials and have relatively low toxicity to people and the adults of many natural enemies. Currently, spinosad is only available to commercial applicators.

Botanicals. Botanical pesticides are derived from plants. One of the most common botanical insecticides, pyrethrin, is made from chrysanthemum flowers grown in Africa and South America. Two or more pyrethrins mixed together are called pyrethrum. The most effective pyrethrin products include the synergist piperonyl butoxide. Insects may only be temporarily paralyzed (knocked down) and may recover from the temporary effects of exposure to pyrethrum unless piperonyl butoxide is added.

Rotenone comes from the roots of legume plants that grow in South America and the East Indies. It has been used since the 1800s as a crop insecticide. While it does have some contact toxicity, it primarily works as a stomach poison and requires that the insect feed on it. It kills insects slowly, but causes them to stop feeding almost immediately. Like other botanical insecticides, rotenone breaks down quickly in sunlight and only remains effective for 1 to 3 days after application.

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For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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This Pest Note is available on the World Wide Web (http://www.ipm.ucdavis.edu)

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.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.