ELM LEAF BEETLE

Integrated Pest Management for Landscape Professionals and Home Gardeners

Elm leaf beetle, *Xanthogaleruca* (=*Pyrrhalta*) *luteola*, is one of the most important insects damaging urban forests in the United States and is the major pest of elm trees in California.

Figure 1. Elm leaf beetle adult and eggs (5×), and third-instar larvae and damage (life size).

IDENTIFICATION

Adults are olive-green beetles with black, longitudinal stripes along the margin and center of the back (Fig. 1). Females lay their yellowish to gray eggs in double rows of about 5 to 25 on the underside of leaves. Larvae are black when newly hatched. After feeding, they become a dull yellow or green with rows of tiny, dark tubercles (projections). Larvae develop through three stages called "instars." Third-instar larvae have dense rows of dark tubercles that resemble two black stripes down their sides, making them easy to distinguish from first- and second-instar larvae. Mature third instars are up to ⅓ inch long. Pupae are orange to bright yellow.

LIFE CYCLE

Adults commonly overwinter in bark crevices, litter, woodpiles, or in buildings. They fly to foliage in spring and feed and lay yellowish eggs, which become grayish before hatching. After feeding in the canopy for several weeks, mature larvae crawl down the tree trunk, become curled, inactive prepupae, and then develop into yellowish pupae (Fig. 2). After about 10 days, adult beetles emerge from pupae around the tree base and fly to the canopy to feed and (during spring and summer) lay eggs. Elm leaf beetle has at least one generation a year in northern California and two to three generations in central and southern California.

DAMAGE

Elm leaf beetle is a serious defoliator of elms. Larvae skeletonize the leaf surface, while adults chew entirely through the leaf, often in a shothole pattern. Defoliation eliminates summer shade, reduces the aesthetic value of trees, and causes annoying leaf drop. Repeated, extensive defoliation weakens elms, causing trees to decline.

MANAGEMENT

Manage elm leaf beetle with an integrated program that incorporates good cultural practices, conservation of natural enemies, regular monitoring, the use of less-toxic insecticides (e.g., *Bacillus thuringiensis* subspecies *tenebrionis*), bark banding with insecticides, or systemic insecticides.

Recognize that elm leaf beetle populations fluctuate dramatically from year-to-year and most trees do not require treatment every year. When beetles are present, otherwise healthy elms can tolerate substantial defoliation. Where elm leaf beetle is a problem, use a combination of methods because no single method kills 100% of the pests. Relying solely on the same technique year-after-year selects for pest populations less susceptible to that treatment. Because adult beetles fly from tree to tree, management efforts directed at single trees may give less satisfactory results in comparison with control efforts aimed at all elms in an area. Because elms are large trees and because this pest is difficult to control, pesticide treatment is best done by a professional applicator.

PEST NOTES

Publication 7403

University of California
Agriculture and Natural Resources

Revised November 2001

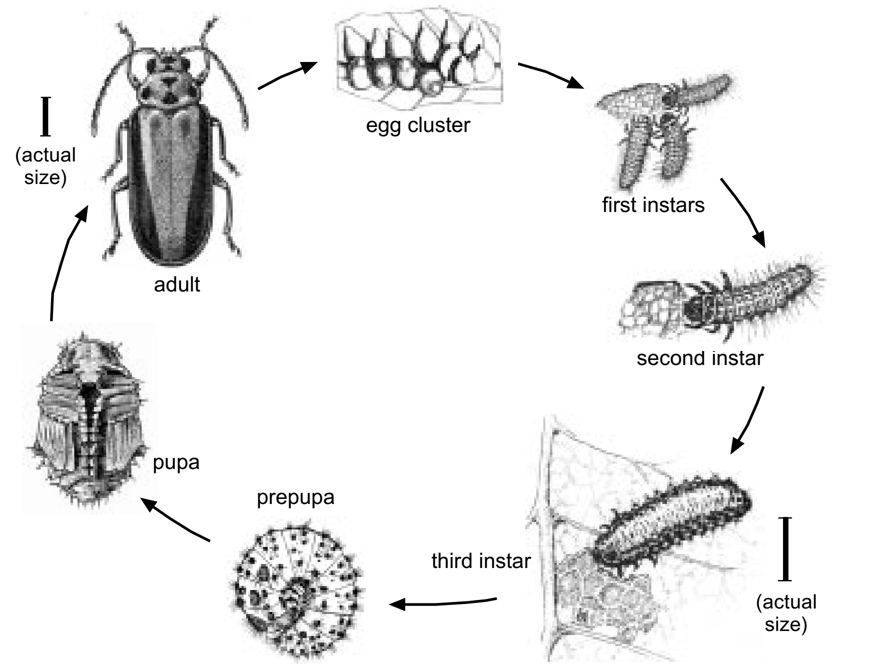

Figure 2. Elm leaf beetle stages and life cycle.

Table 1. Susceptibility of Elms and Elm Substitutes to Elm Leaf Beetle (ELB) and Dutch Elm Disease (DED).

TREE		SUSCEPTIBILITY	
Common name	**Scientific name**	**ELB**	**DED**
English elm	*Ulmus procera*	HS	HS
Scotch elm	*U. glabra*	HS	HS
American elm	*U. americana*	S	HS
'Homestead'	complex hybrid including *U. carpinifolia*, *U. hollandica*, and *U. pumila*	S	R
'Liberty' group American elms	*U. americana* selections	S[1]	MR
'New Horizon' and 'Valley Forge' American elms	*U. americana* selections	S[1]	R
'Pioneer'	*U. glabra* X *U. carpinifolia*	S	R
Siberian elm	*U. pumila*	S	MR
'Frontier'	*U. carpinifolia* X *U. parvifolia*	MR[2]	R
Chinese elm	*U. parvifolia*	R	MR
'Prospector'	*U. wilsoniana* selection	R	R
zelkova	*Zelkova serrata*	R	MR
hackberry	*Celtis* spp.	NS	NS
hornbeam	*Carpinus* spp.	NS	NS

HS = highly susceptible R = resistant
S = susceptible NS = not susceptible
MR = moderately resistant

1. Generally susceptible to elm leaf beetle, but certain selections exhibit some resistance.
2. Reported susceptibility to elm leaf beetle ranges from susceptible to resistant, possibly due to location, genetic variability among plants, or misidentification of elms.

Cultural Control

Good cultural care of trees is an essential component of integrated pest management. European and American elm species are adapted to summer rainfall; they require proper irrigation to grow well in California. Protect elms from injury to trunks and roots. Check elms for dead or dying branches and properly prune these out during late fall and winter. Avoid pruning elms during spring and summer; the European elm bark beetle (*Scolytus multistriatus*), which vectors Dutch elm disease (*Ophiostoma* [=*Ceratocystis*] *ulmi*), is attracted during spring and summer to feed around fresh pruning wounds. English elm (*Ulmus procera*) and Scotch elm (*U. glabra*) are especially susceptible to both elm leaf beetle and Dutch elm disease (Table 1). Do not plant these species and consider replacing them in areas where they are growing.

Treatment Thresholds

Using treatment thresholds to determine if control is needed helps minimize unnecessary insecticide applications, avoid or reduce annoyance from beetle damage, and protect elms, especially when trees are already stressed or unhealthy from other causes. Healthy elm trees can tolerate substantial damage to leaves; even total defoliation may have little long-term effect on healthy elms, especially if leaf damage comes late in the season. Suggested treatment thresholds are 40% defoliation (portion of leaf area chewed or leaves dropped prematurely) or 20% defoliation if damage is less tolerable.

Monitoring

When using insecticide bark bands, foliar sprays, or trunk injection of a systemic insecticide, monitor elm trees to determine the need for treatments and when to apply them. Evaluate beetle populations during spring by inspecting foliage weekly for beetles starting in April. Watch for the appearance of yellowish eggs, which darken before hatching. If trunk injections of systemic insecticides (e.g., abamectin or imidacloprid) are the planned control method for a large number of trees,

Table 2. Criteria to Help Decide if Preventive Systemic Insecticide Is Warranted for Elm Leaf Beetle Control.

Criteria	Avoid treatment	Treatment may be warranted
beetle populations and damage the previous late summer/early fall	low population or damage	high population or damage
treated the previous season	yes	no
overwintering weather	wetter or warmer than average, or both	drier or colder than average, or both

Table 3. Time of Peak Abundance (Mean ± Standard Deviation) of Elm Leaf Eggs and Larvae in Northern California Based on Degree-Day (DD) Monitoring.

First generation	**DD (F)**
eggs	509 ±95
first-instar larvae	635 ±112
second-instar larvae	794 ±162
third-instar larvae	857 ±167
Second generation	
eggs	1,715 ±167
first-instar larvae	1,962 ±131
second-instar larvae	2,055 ±158
third-instar larvae	2,129 ±162

Degree-days are above 51.8°F (11°C) accumulated from March 1. See the UC Statewide IPM Project's Web site at http://www.ipm.ucdavis.edu for more information. Adapted from Dahlsten et al. 1993.

consider using egg presence-absence sampling and injecting the trees as soon as monitoring indicates thresholds will be exceeded. If a foliar insecticide application is planned, spray when early instar (small) larvae are abundant. Band bark with an insecticide before mature larvae crawl down trunks to pupate, which in California may occur from early May to late June, depending on the location and weather. Inspect foliage weekly during May and June and band as soon as mature larvae are observed on leaves. The calendar date of peak abundance of beetles and their damage and the optimal time for banding varies greatly from year-to-year, depending on previous temperatures (spring weather). Monitoring temperature is highly recommended to more accurately time foliage inspection and control actions.

If an application of a soil systemic insecticide is planned, the optimal treatment time is before beetles are present and before knowing if beetles will be abundant enough to warrant control during the current or next generation of insects. Use several criteria to help decide if a preventive, soil-applied insecticide is warranted (Table 2). For example, inspect elms during late summer to early fall; if beetles and damage are low, especially on untreated elms, it is less likely that insecticide application is needed next season.

Although it has not been scientifically demonstrated, relatively warm and wet winters are believed to reduce the likelihood that beetles will be a problem the following spring. Wet winters can increase overwintering mortality of beetles from insect pathogenic fungi. Warm winters may cause many "hibernating" beetles to starve to death because warmer weather increases the rate at which these insects consume their stored energy (e.g., body fat), increasing the likelihood that beetles become weakened or starve before elm leaves appear in spring. If elm leaf beetle damage was low the previous fall and the winter is warm and wet, avoid preventive insecticide application the subsequent spring.

Degree-Day Monitoring. Insect activity and growth rate depend on temperature. Generally, the higher the temperature, the more rapid the development. Measuring heat over time provides a physiological time scale called degree-days that is more useful than calendar days for timing insect monitoring and control.

One degree-day is defined as one degree above the threshold temperature maintained for a full day. The lower threshold for elm leaf beetle is 51.8°F (11°C). When temperatures are cooler, this pest does not feed, grow, or reproduce. To predict the peak abundance of each life stage, degree-days above 51.8°F are accumulated for elm leaf beetle each season beginning March 1 (Table 3). If populations are high and damage is anticipated, treatment options include injecting elms as soon as need is predicted (based on monitoring egg abundance) or applying a trunk spray or foliar spray at about 700 degree-days (Table 4).

Temperatures for many locations and relatively easy to use degree-day calculation tools are available from the UC Statewide IPM Project's Web site at http://www.ipm.ucdavis.edu. Alternatively, dedicated devices can record temperatures and calculate degree-days. If temperature records are available, a programmable calculator, desktop computer, or printed charts for certain pests can also be used to calculate degree-days.

Table 4. Timing of Elm Leaf Beetle Monitoring, Bark Banding, Foliar Sprays, or Systemic Insecticide Injection Based on Degree-days (DD).

Action	Justification	DD (F) 1st generation	DD (F) 2nd generation
sample eggs once a week	when using egg density to predict treatment need	329–419	1,535–1,625
two or more Btt applications at 7- to 10-day intervals	first & second instars present	550–800	not recommended
single foliar spray	peak density of first & second instars combined	700	not recommended
trunk spray or bark banding	before earliest third instars crawl down trunk	700	2,000
systemic insecticide injection	as soon as possible if egg sampling during 329 to 419 DD indicates thresholds are exceeded	—	not recommended

Degree–days are above 51.8°F accumulated from March 1. See the UC Statewide IPM Project's Web site at http://www.ipm.ucdavis.edu for more information. Adapted from Dahlsten et al. 1993.

Presence-Absence Sampling for Professionals. The percent of 1-foot branch terminals infested with elm leaf beetle eggs can be used to determine treatment need when a large group of trees is being monitored. Using a threshold of 40% defoliation, treatment is warranted when over 45% of branch terminals have beetle eggs during the week when egg density is at its maximum during the first generation. If the preferred threshold is 20% defoliation, treatment is warranted when over 30% of branch terminals are egg-infested during the first generation.

Use a pole pruner to clip two or more 1-foot terminals from each of eight locations in the lower canopy of each sample tree. Locations are north, east, south, and west, in both the inner canopy (from trunk halfway to the drip line) and the outer canopy. Randomly select the trees to be sampled and sample those trees each week. Inspect a minimum of 120 total samples, two to five terminals from each location of three or more trees.

Examine the leaves on each sample and record whether eggs are present or absent. Once you observe the first eggs on a sample, there is no need to examine it further; record it as infested and move on to inspect the next terminal. To determine the percent of samples (terminals) infested, divide the number of samples infested by the total number of samples inspected and multiply by 100.

Time control actions as discussed above and summarized in Table 4. For more details on presence-absence egg sampling, consult the publications by Dahlsten and others or *Pests of Landscape Trees and Shrubs* listed in "References."

Biological Control

Several introduced and native natural enemies kill elm leaf beetles, but generally do not provide adequate control by themselves. The most important parasite in California is a small, black tachinid fly (*Erynniopsis antennata*) that emerges from mature beetle larvae. Its black to reddish, cylinder- or teardrop-shaped pupae occur during spring and summer at the base of trees among the yellowish beetle pupae. *Erynniopsis antennata* overwinters in adult beetles, emerging as adults in spring, although this is not readily observed. Unfortunately, the effectiveness of *E. antennata* is limited by *Baryscapus* (=*Tetrastichus*) *erynniae*, a secondary parasite (hyperparasitoid) that kills the beneficial parasite.

Two tiny wasps also parasitize elm leaf beetle. *Oomyzus* (=*Tetrastichus*) *brevistigma* parasitizes mature larvae and pupae; one or more small, round holes in beetle pupae may indicate that this parasite has emerged. An egg parasite, *Oomyzus* (=*Tetrastichus*) *gallerucae*, leaves round holes when it emerges from beetle eggs, which remain golden. When beetle larvae have emerged, the egg shell is whitish with more ragged holes. For illustrations and photographs of elm leaf beetle parasites, consult *Natural Enemies Handbook* listed in "References."

Conserve these parasites and general predators by avoiding foliar applications of broad-spectrum insecticides; use less toxic materials such as *Bacillus thuringiensis* ssp. *tenebrionis* (Btt), Btt and narrow-range oil combined, or apply insecticide as bark bands in an integrated program to obtain maximum benefits from biological control.

Chemical Control

Methods for chemical control of elm leaf beetle include bark banding, soil applications, tree injection, or foliar spraying in spring after monitoring beetle abundance to determine treatment need.

Bark Banding. Bark banding is an inexpensive and environmentally sound technique that involves spraying a small area of the tree trunk with an insecticide. Use a hand-pump sprayer or hydraulic sprayer at low pressure to spray a band of bark several feet wide around the first main branch crotch. Carbaryl (Sevin) is most commonly used and should be applied at the rate labeled for elm bark beetles (about 2% active ingredient). If trunk spraying is not listed on the label of the commercial products available for home landscape use, it will be necessary to have the trunk application done by a licensed pesticide applicator. Do not use the rate labeled for foliar applications because this rate will not be effective as a trunk banding treatment. Pyrethroids (e.g., fluvalinate) also provide control. About one-half gallon of dilute material is applied on each large tree. Larvae are killed by the insecticide when crawling down to pupate around the tree base after feeding in the canopy. By reducing the number of elm leaf beetles that pupate and emerge as adults, bark banding reduces damage by later beetle generations, especially when done to all nearby elms.

You can determine the best time to spray the trunk by inspecting the foliage and spraying when mature larvae are first observed, or for more accurate timing, by accumulating degree-days and spraying the trunk band when about 700 degree-days (above 52°F) have accumulated from March 1. A single application of carbaryl to the bark each spring can kill most larvae that crawl over it all season long. A second application may be necessary if substantial rain occurs after application, if trunks are frequently wetted by sprinklers, or if a less persistent material is used. To determine if the bark band is still effective, regularly inspect around the base of trees throughout the season. If many beetles have changed from greenish prepupae (the stage killed by banding) to bright yellowish pupae (unaffected beetles), another application may be warranted.

Bark banding alone will not provide satisfactory control in all situations, especially if only one or a few trees are treated. Adult beetles can fly between treated and untreated trees, so bark banding is most effective when done on all the elm trees in a neighborhood. Also, overwintered adults fly to the tree canopy and lay eggs, so trunk banding does not reduce the first generation of beetles and their damage. A study of elm trees in northern California found good control during the first season of bark banding on Siberian elms (*Ulmus pumila*), but not on English elm and Scotch elm. If beetles are abundant during the first generation, little or no control should be expected the first year when banding more susceptible species such as English and Scotch elms; banding all nearby elms for several consecutive years can provide control after the first year of treatment.

Systemic Insecticides. Elm leaf beetle feeding can be controlled with certain systemic insecticides, including abamectin (Avid, Vivid II), acephate (Orthene), and imidacloprid (Bayer Advanced Tree & Shrub Insect Control, Imicide, Merit). Some formulations of these materials can be sprayed onto the tree foliage, but soil applications and tree injections (if labeled for this method of application) minimize environmental contamination and may be more effective than foliar sprays. Tree-injected insecticides generally are available only to professional applicators.

When using systemic insecticides, consider using a soil application instead of spraying foliage or injecting or implanting trees whenever possible. Injecting or implanting trunks or roots injures trees, and it is difficult to repeatedly place insecticide at the proper depth. Especially avoid methods that cause large wounds, such as implants placed in holes drilled in trunks. Do not implant or inject roots or trunks more than once a year.

Avoid methods that use the same device (such as drills or needles) to contact internal parts of more than one tree. Contaminated tools spread elm tree pathogens, including bacteria (such as slime flux or wetwood) and fungi (Dutch elm disease). Before moving to work on each new tree, consider cleaning and disinfecting tools to reduce the chance of spreading pathogens when injecting or implanting multiple elms. Before chemical disinfection, remove all plant material and scrub any plant sap from tools or equipment that penetrate trees. Bleach (and, to a lesser extent, certain other materials) can be effective disinfectants if applied to debris-free tools. At least 1 to 2 minutes of disinfectant contact time between contaminated uses is generally required. Consider rotating work among several tools, using a freshly disinfected tool while the most recently used tools are being soaked in disinfectant.

Imidacloprid is available to both home gardeners and professionals for application on or into soil beneath trees. The most effective time to apply it is early spring, just before new leaves emerge. Make an application before a rainfall, or follow the application with irrigation. Although efficacy is delayed until sometime after application, it usually is not necessary to treat 2 years in a row using this method. A major disadvantage of this timing is that treatment is made before beetles appear in spring, before knowing whether insects and damage will be abundant enough to warrant control action. Consult the suggested criteria for help in deciding whether preventive treatment is warranted (Table 2). Soil applications are possible even if trees are surrounded by pavement. Depending on the product label directions, the insecticide can be applied to soil immediately adjacent to the trunk or nearby bare soil, lawn, or planting beds where most absorbing tree roots usually occur.

Foliar Sprays. Several foliar insecticide sprays are available for elm leaf beetle. Foliar spraying may be appropriate to supplement banding during the first year or two of treatment or when early-season beetle populations are high. The low-toxicity insecticides *Bacillus thuringiensis* ssp. *tenebrionis* (Btt) or azadirachtin (Neemazad) are good choices in an integrated pest management program. Btt can be combined with narrow-range oil to kill beetle eggs and other elm pests such as scales. More persistent, broad-spectrum materials, including carbaryl and pyrethroids, are also available for foliar application, but are generally not recommended because of their negative impact on natural enemies and their potential for environmental impacts in urban settings. Carefully time all foliar applications to target first- and second-instar larvae. Because specialized equipment is required to spray the tops of large elm trees, it is best to hire a professional applicator.

Bacillus thuringiensis ssp. *tenebrionis* (Btt) kills young beetle larvae and is the only truly selective insecticide available. Btt is not toxic to people and most nontarget organisms, including natural enemies of the elm leaf beetle. Btt (Novodor) is EPA registered for use in most states, but may not be available (registered) for use in California. Bt subspecies labeled for moth and butterfly caterpillars or mosquito larvae are not effective against elm leaf beetle.

To obtain control, foliage throughout the tree must be thoroughly sprayed with Btt during warm, dry weather when young larvae are actively feeding. Because only a portion of the beetle population is in the susceptible stages at any one time and Btt breaks down within several days, at least two applications at an interval of about 7 to 10 days may be necessary beginning when young larvae are first observed feeding (Tables 3, 4).

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Fig. 2 adult, first instar, second instar: L. O. Howard. 1895. The Shade-tree Insect Problem in the Eastern United States. *Yearbook of the USDA.* Washington, D. C.
Fig. 2 egg cluster, prepupa: F. Silvestri. 1910. Contribuzioni alla conoscenza degli insetti dannosi e dei loro simbionti. *Bollettino del Laboratario di Zoologia Generale e Agraria* Portici 4:246–289.
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Produced by IPM Education and Publications, UC Statewide IPM Project, University of California, Davis, CA 95616-8620

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

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Pest Management.

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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.

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 or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.