

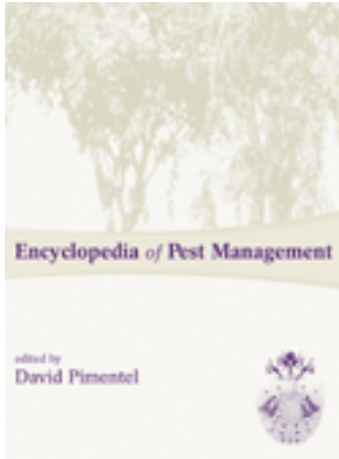
This article was downloaded by: [Ginzel, Matthew]

On: 2 June 2010

Access details: Access Details: [subscription number 922717158]

Publisher Taylor & Francis

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## Encyclopedia of Pest Management

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713172972>

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Online publication date: 04 March 2010

To cite this Section Ginzel, Matthew D.(2010) 'Walnut Insects: Ecology and Control', Encyclopedia of Pest Management, 1: 1, 1 – 3

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# Walnut Insects: Ecology and Control

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## Abstract

The English walnut, *Juglans regia*, is among the most popular commercially grown nut trees. Growers in the United States produced almost 297,000 tons of walnuts in 2007 alone, second only to almonds among all domestic nuts produced. The supply of this commodity, however, is threatened by a number of diseases and arthropod pests. This entry details the biology of insect and other arthropod pests of walnut and discusses strategies for controlling their populations.

## INTRODUCTION

The English walnut, *Juglans regia* L., originated in Persia, and with its large fruit and thin shell is among the most popular commercially grown nut trees worldwide.<sup>[1]</sup> In fact, nearly all commercial varieties are hybrids of the English walnut. China is the leading producer of in-shell walnuts, followed by the United States, Iran, Turkey, Mexico, and the Ukraine.<sup>[2]</sup> The United States is the largest exporter of this commodity, however. Walnuts were first commercially planted in the United States by Joseph Sexton in Goleta, California, in 1867.<sup>[1]</sup> In 2006, an estimated 215,000 acres in the United States were planted with walnuts, returning over \$2500 per bearing acre with an estimated gross value of over \$550 million.<sup>[3]</sup> Walnut orchards can be found in various parts of the country but the San Joaquin and Sacramento Valleys of California are particularly productive, and California provides approximately 99% of the domestic supply of walnuts.<sup>[1]</sup> Although the nut of the black walnut, *J. nigra*, is also quite flavorful, its hard shell and poor hulling characteristics make it less attractive for commercial nut production.<sup>[4]</sup> Black walnut is grown primarily as a timber tree in the United States and is valued for its rich, maroon-black heartwood which is sought out for use in furniture, veneers, and even gunstocks.

This entry details the biology of insect and other arthropod pests of walnut, with particular emphasis placed on those affecting commercial nut production in California and discusses strategies for controlling their populations.

## ARTHROPOD PESTS

**Codling moth:** The codling moth, *Cydia pomonella* (L.), is among the most economically important pests of walnuts, and an estimated 60% of the commercial crop in

California is susceptible to attack.<sup>[5]</sup> This insect overwinters as a prepupa in a silken cocoon and adults emerge in early spring. Adults are rather small (~0.5 in. long) and gray in color with a prominent copper spot on the tip of each forewing. Females lay eggs in the spring, which then hatch and the white- to pink-colored larvae bore through the blossom end of the nut and cause damaged nuts to fall to the ground.<sup>[6]</sup> There are normally two generations per year throughout most of California with three generations in southern San Joaquin Valley. Later generations bore anywhere into the surface of the walnut, but prefer the area where the two nuts touch.<sup>[6]</sup> In spite of the damage to the kernels, many nuts attacked by these later generations remain on the tree until harvest. Economic losses that can exceed 40% are incurred from feeding damage and costs associated with culling affected nuts at harvest.<sup>[5,6]</sup> Pheromone traps are often used to monitor populations and degree day models aid in timing treatments. Populations are routinely controlled by pheromone-mediated mate disruption and/or insecticides. Approximately 60% of walnuts in California are treated, on average, twice during the growing season.<sup>[5]</sup> The effectiveness of chemical control depends greatly on timing of the treatment, however. Insecticides should be applied just before or as eggs begin to hatch, depending on their mode of action.<sup>[6]</sup>

**Walnut husk fly:** Larvae of the walnut husk fly, *Rhagoletis completa* Cresson, feed on walnut husks and can result in as much as 50% loss in some commercial varieties. Adult females are yellow and males are darker, but both sexes have three prominent dark bands on their wings.<sup>[6,7]</sup> Females lay eggs in soft husks of nearly mature walnuts and the larvae feed on husks, turning them black and soft.<sup>[7]</sup> This damage stains the shell, reducing the commercial value of the nut.<sup>[7]</sup> Early infestations occurring in late summer may even result in shriveled and darkened kernels. One generation of husk fly occurs per year.<sup>[6]</sup> There are no effective biological

control agents against the husk fly and populations are controlled through extensive monitoring efforts and carefully timed applications of insecticides.

**Mites:** Walnuts are affected by a number of mites. The most notable, however, are the web-spinning two-spotted spider mite, *Tetranychus urticae* Koch, and Pacific mite, *T. pacificus* McGregor.<sup>[8]</sup> Feeding damage from these two species results in stippling and browning of leaves, and clusters of affected leaves are often the first indication of a growing problem. If left unmanaged, large colonies produce heavy webbing and can cause significant defoliation.<sup>[6]</sup> In fact, early-season defoliation reduces nut yields in some orchards in California by as much as 25%.<sup>[5]</sup> Colonies begin to develop on the underside of leaves early in the season and, with increasing temperatures, the mites reproduce quite rapidly.<sup>[6]</sup> Cultural control practices that bolster tree vigor in times of stress are most effective at slowing the growth of injurious populations of spider mites. Also, a number of natural enemies control spider mite populations and the most efficacious predator among them is the western predatory mite, *Galendromus occidentalis* (Nesbitt). The six-spotted thrips, *Scolothrips sexmaculatus* (Per-gande), and spider mite destroyer, *Stethorus picipes* Casey, a small lady beetle, also reduce dense populations of web-spinning mites.<sup>[8]</sup> In some cases, chemical control is necessary, especially when more than 10% of trees have damaged leaves and natural enemies are absent.

The European red mite, *Panonychus ulmi* (Koch), which produces no webbing, is also commonly found in walnut orchards. Although feeding damage can result in stippling on leaves, this mite is rarely considered a serious pest. Nevertheless, low populations of the European red mite often serve as an alternate food source for predators such as *G. occidentalis* in the spring.<sup>[6,8]</sup>

**Scale insects:** Scale insects are fluid feeders that suck plant juices from the inner bark of twigs and branches.<sup>[6]</sup> This damage causes the branches to stop growing and may even kill some branches. In fact, high-population densities of scale insects can lead to the production of undersized walnuts and reduce production by as much as 10% if uncontrolled.<sup>[5]</sup> The most important armored scales affecting walnuts are the San Jose scale, *Quadraspidiotus perniciosus* (Comstock), and the walnut scale, *Q. juglans-regiae* (Comstock). Adults of both species are covered by a protective, grey-colored, waxy shell that makes them particularly difficult to control. Soon after hatching, nymphs or “crawlers” leave the shelter of their mother’s shell and settle on a branch or twig, insert their piercing-sucking mouthparts into plant tissue, and begin feeding on plant juices. Among the soft scales, the frosted scale, *Parthenolecanium prunosum* Coquillett, is the most important pest of walnuts.<sup>[6]</sup>

Natural enemies such as the small predatory beetle, *Cybocephalus californicus* Horn, the twice-stabbed lady

beetle, *Chilocorus stigma* (Say), and an *Aphytis* sp. and *Encarsia* sp. of parasitic wasp effectively regulate population densities of San Jose and walnut scale. The frosted scale is also attacked by a suite of parasitic wasps including *Coccophagus* spp., *Encyrtus* spp., and *Metaphycus* spp.<sup>[5]</sup> Further control measures are warranted in some cases, especially when natural control is lost due to pesticide use. Often a well-timed application of horticultural oil that targets the vulnerable crawlers will reduce populations below a damaging level.<sup>[6]</sup>

**Aphids:** Feeding by the walnut aphid, *Chromaphis juglandicola* (Kaltenbach), and dusky-veined aphid, *Callaphis juglandis* (Goeze), occasionally results in reduced tree vigor, nut size, and yield. Although the walnut aphid was historically a major pest of walnuts, it is now controlled in California by an introduced parasitic wasp, *Trioxys pallidus* (Haliday).<sup>[9]</sup> Walnut aphids are much smaller than the dusky-veined aphid and can be further distinguished by their yellow color and habit of feeding on the underside of leaves. The dusky-veined aphid prefers to feed in rows along the midveins of leaves and females are winged with a characteristic dusky marking along the veins.<sup>[6]</sup> Aphids excrete honeydew as they feed. Sooty mold grows on the honeydew and causes the nuts to turn black, which reduces their value and increases their susceptibility to sunburn. Both species overwinter as eggs and have very similar life histories. Eggs hatch about the time that early buds begin to open in the spring.<sup>[6]</sup> The aphids then settle and begin feeding on new leaflets and reproduce parthenogenetically—giving rise to young without mating. Dusky-veined aphids can have many generations in a single year and population densities may swell to several hundred individuals per leaf. Populations of *C. juglandis* are generally regulated by a number of generalist predators including ladybird beetles, green lacewings, earwigs, and minute pirate bugs.<sup>[6]</sup>

**Navel orangeworm:** Larvae of the navel orangeworm, *Amyelois transitella* (Walker), are capable of consuming the entire meat of walnuts, leaving only webbing and frass behind, and may also be associated with fungal aflatoxins.<sup>[5,6]</sup> The larvae overwinter in nuts that either remain on trees (mummy nuts) or are left on the ground following harvest. Once this overwintering generation emerges in the spring, the silver-grey females oviposit in nuts damaged by codling moth or other factors such as walnut blight.<sup>[10]</sup> There can be as many as four generations per year and damage to late-harvested nuts is not uncommon.<sup>[6]</sup> Populations are generally controlled through proper sanitation methods (e.g., removal of mummy nuts) and by managing codling moth population and walnut blight to reduce the source of first generation larvae.<sup>[6]</sup> Otherwise, insecticides play an important part in managing navel orangeworm and, if applied correctly, can reduce damage by an estimated 50–70%.<sup>[6]</sup> Organophosphates or

pyrethroids are commonly applied before or at husk split and carbaryl is used later in the season.<sup>[6]</sup>

## CONCLUSIONS

Growers in the United States produced almost 297,000 tons of walnuts in 2007 alone, second only to almonds among all domestic nuts produced.<sup>[2]</sup> Walnuts are a good source of omega-3 fatty acids and antioxidants and the well-publicized health benefits of walnuts will likely only increase demand. The supply of walnuts is threatened, however, by diseases (e.g., walnut blight), nematodes, and arthropods. Many insects and mites affecting walnut production are currently managed through precisely timed applications of chemical pesticides. Biorational strategies (e.g., Biologically Integrated Orchard Systems; see Grant et al.<sup>[11]</sup>) show promise for controlling these pests while reducing the use of broad-spectrum insecticides and conserving naturally occurring biological control agents. Likely, recent advances in biotechnology will also lead to improvements in the health, quality, and productivity of commercial walnuts.

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