Reddish stains and accumulating frass typify active carpenterworm gallery in Black Mission fig.

Parasitic nematode may control carpenterworm in fig trees

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Broken fig limb weakened by extensive carpenterworm gallery at its base. (The dark areas are the feeding galleries.)

Residual pupal skin in gallery opening indicates onset of adult emergence of carpenterworm in the spring.

Stunted "brood tree" with active galleries. In background are more vigorous trees.

The carpenterworm, *Prionoxystus robiniae* (Peck) is a native wood-boring lepidopteran insect that infests a wide variety of ornamentally and agriculturally important trees throughout the United States and Canada. In California infestations occur in all four major commercial fig varieties; Black Mission and Kadota are the most susceptible varieties with infestations of up to 10 and 94 percent, respectively. Because it bores into the tree, the larva is difficult to reach with conventional insecticides.

Detection and life cycle

In the early spring, deposition of moist sawdust-like frass plugging the gallery opening and accumulating on the ground below is evidence of larval activity. As tree sap flow increases, a characteristic reddish brown residue stains the area below the gallery. Also, as adults begin to emerge, pupal skins often protrude from the gallery opening.

The carpenterworm can complete one generation per year in San Joaquin Valley fig orchards. Overwintering larvae usually become active in March or April. Adults begin to emerge shortly after larval activity begins and continue to emerge into May and June. Eggs are deposited in roughened bark and indented surfaces, such as pruning wounds and scars.

Newly hatched larvae may directly invade sound bark, causing wet spots, and penetrate through the cambium layer into the heartwood. Most galleries, however, appear to be established initially in deadwood areas, such as pruning scars at the base of new limbs, or in old gallery systems.

As the summer progresses the larva forms a feeding gallery as well as an escape pupation gallery. The larva feeds throughout the summer and fall ceasing activity as the tree becomes dormant in the winter.

Damage from extensive carpenterworm infestation weakens the fig tree, resulting in broken limbs and sometimes death of the tree. Carpenterworm infestations in fig orchards are often characterized by bare or replanted areas surrounded by stunted "brood trees" hosting anywhere from 5 to 17 or more borer galleries. Recently infested trees with 1 to 4 galleries are found on the outer periphery of the initial infestation.

Nematode applications

We have studied use of an insect parasitic nematode, *Neoaplectana carpocapsae* Weiser (Mexican strain) for the control of the navel orangeworm, *Amyelois transitella* (Walker) in moist almond hulls (*California Agriculture,* June 1978). Like the navel orangeworm, carpenterworm larvae inhabit a protective, cryptic environment, which is favorable for the nematode. Thus, we conducted a test to determine the nematode's potential for control of carpenterworm in fig orchards.

In laboratory studies carpenterworm larvae (including first instars), pupae, and adults were found to be susceptible to the *N. carpocapsae* invasive stage.

Invasive-stage larvae of the nematode were added to a thickened, deionized water suspension to minimize settling during field applications. This suspension was colored with a nontoxic orange latex pigment to mark the treated areas. (The water thickener, SG 035025, developed by USDA, is now sold by General Mills Chemical, Inc., and by Henkel Corporation, Minneapolis.)

Nematode suspensions of 100, 1,000, 10,000, and 100,000 invasive-stage larvae per milliliter were injected into each active carpenterworm gallery opening with a 10-cc syringe. Controls were treated similarly, excluding the nematodes. Randomly selected active galleries were numbered and each of the five treatments was set up in five blocks with each treatment replicated five times per block.

Because carpenterworm larvae periodically clean out the accumulated frass from their galleries during the late afternoon to dusk, nematode invasive stages were applied in the morning to allow them time to penetrate the galleries.

Daily frass expulsion was used as an indicator of larval activity. Frass was caught in a small triangular plastic screen stapled to the tree at the top and sides and pinned at the bottom to facilitate frass removal. Larval activity or inactivity was recorded, and frass, if present, was removed daily.

Larval inactivity became evident from two to six days after treatment. The degree of inactivity appeared to be directly correlated with the concentration of nematodes applied. Some larval inactivity occurred in control galleries and may have been associated with molting or pupation. Inactivity in the test galleries may also represent avoidance of nematodes by the borer larva; however, the inactivity of nonparasitized larvae did not persist for more than three days after exposure. In treated galleries larval mortality, as measured by larval inactivity, ranged from 44 to 92 percent after six days of exposure.

To verify the correlation between inactive galleries and parasitized carpenterworms, we excavated larvae at random from two galleries showing inactivity from each of the five treatments. All excavated test larvae were dead and parasitized. Two larvae excavated from the active control galleries were alive and unparasitized.

A preliminary test was also conducted to determine if the nematodes could also be successfully applied as a spray. An application of 9,000 nematodes per gallery (N = 10) with the appropriate thickening and coloring agents resulted in 100 percent mortality of the first-stage carpenterworm larvae.

Discussion

The concealed habitat of the carpenterworm larva protects it from most conventional insecticide applications. However, the moist gallery of this insect and its external gallery opening facilitate the application and subsequent movement of the insect-parasitic nematode invasive stages into the gallery system. Injections or spray applications of *N. carpocapsae* into or on the gallery opening offer a potentially economical, safe, and effective method for controlling carpenterworm in fig orchards.

Although female carpenterworm adults have been observed flying strongly after most of the eggs have been deposited, the apparent localized distribution of carpenterworm larvae in fig orchards indicates that the movement of the older and the newly emerged heavy-bodied female may be primarily limited to adjacent trees. Eliminating carpenterworm infestations from the fig orchards and adjacent, susceptible, native and ornamental trees may bring about long-term reduction of this insect pest.

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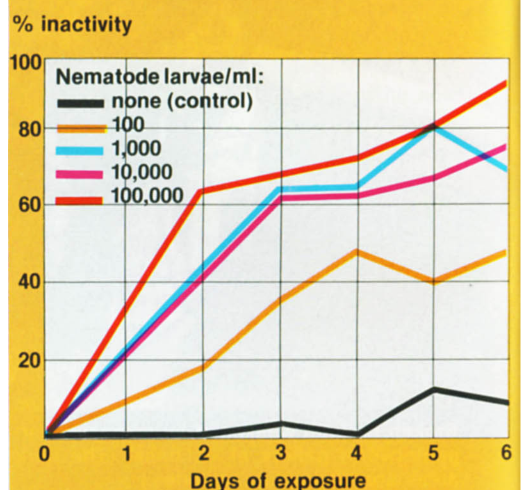
Feeding gallery of maturing carpenterworm larva. Escape gallery (indicated by knife) penetrates center of tree.



Carpenterworm inactivity (mortality) after exposure to various nematode concentrations.

Mature carpenterworm larva pulled from escape gallery (feeding gallery at left).