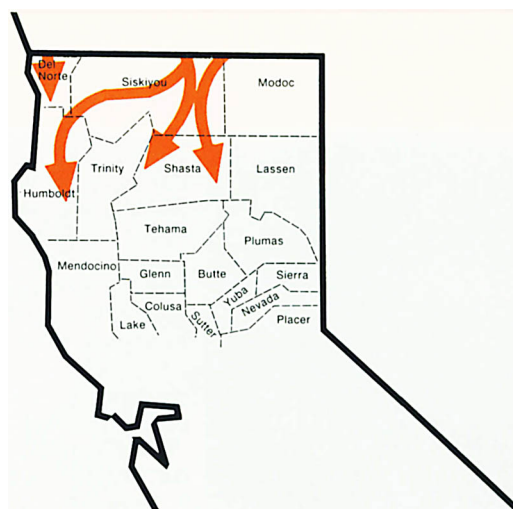


Northern California area infested with apple maggot



Apple maggot: a threat to California's apple industry

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***Containment appears feasible, but
chances for eradication are uncertain***



About the same size as a house fly, adult apple maggot fruit flies have a pronounced white spot on the back of the thorax. There are four light-colored crossbands on the female abdomen, three on the somewhat smaller male. Wings are clear with black bands. (R.R. Kriner photo)

On August 24, 1983, an apple maggot fruit fly was found just north of Smith River, Del Norte County, California. Since this first discovery of the pest in California, an additional 71 adult flies in traps and nine larval-infested properties have been found in the Smith River area. Both adults and larvae have also been found in Siskiyou County in the Scott Valley, along Interstate Highway I-5 to Mt. Shasta, and along the Klamath River to the Hoopa Valley Indian Reservation. Five adults apple maggots also have been found in Humboldt; since no larvae were found there, it is hoped that the apple maggot has not become established in that county.

In the largest infested area near Smith River, adult apple maggot trap catches were predominantly female flies (56 females to 15 males) and larvae have been found equally in apple and hawthorn fruit. The total northern California adult apple maggot trap catch in 1983 was 101 and 38 individual properties were found infested with larvae in fruit.

The apple maggot, *Rhagoletis pomonella* (Walsh), is native to the northeastern United States and Canada, where it originally lived on hawthorn. Although apples were introduced into that area in around 1710, the maggot was not reported in apples until 1860. By that time, New York apple growers encountered heavy infestations of fruit.

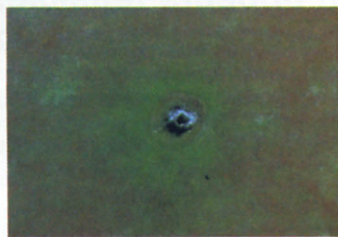
Apple maggot is now a serious pest of

apples and has spread to other eastern, central, and southern states. It was first discovered in the Pacific Northwest near Portland, Oregon, in 1979. In 1981, it was found in the Cascade Locks, Oregon, and from Vancouver to White Salmon, Washington; another infestation was found in Spokane, Washington, in 1983. By 1982, apple maggot had spread south through most of the Willamette Valley in Oregon and had established populations on the California border.

Life history and habits

The apple maggot generally has one generation per year with a partial second generation in the southern part of its range. It spends the winter as a pupa in the soil and emerges as an adult fly in mid June to early July. Emergence peaks in mid to late July and usually ends by the end of August. The timing of adult emergence may vary considerably, depending on the type of host available, temperature, soil type, and rainfall. In the northeastern states, about 90 percent of the pupae give rise to adult flies the next year, but up to 10 percent of the flies remain in the pupal stage in the soil for two to four years before emerging. In Oregon and Washington, less than 50 percent of the adults have emerged in the first year.

The adult flies are black, about the size of a common house fly with a



After laying a single egg beneath the skin of an apple, the female fly marks the fruit with a pheromone to keep other females away. (N.Y. State Experiment Station photo)

Egg-laying puncture (inset) becomes darkened and decayed on softer fruit; on firmer fruit, it causes dimpling.

pronounced white spot on the back of the thorax. There are four light-colored crossbands on the female abdomen, three on the male. The males are somewhat smaller than the females. The wings are clear with characteristic black bands. The apple maggot is very similar in appearance to the snowberry maggot, which occurs throughout the Pacific Northwest and California, but which does not attack apples.

Newly emerged flies are sexually immature and must feed on honeydew produced by aphids, scales, and certain other insects. After 7 to 10 days, the flies become sexually mature and congregate on the fruit, where mating takes place. After mating, the female usually deposits a single egg beneath the skin of an apple. She then marks the apple with a pheromone to keep other apple maggot females from laying their eggs on the apple. This egg-laying deterrent pheromone may be overcome under high apple maggot populations, when it is common to find more than one larva per fruit. Female apple maggot adults can

lay about 300 eggs over a 30-day life span.

The eggs are elongate, smooth, slightly curved, and white. Eggs hatch after 2 to 10 days, depending on temperature. The larvae are cream-colored maggots with a blunt posterior, tapering to a rounded point containing two black mouth hooks at the front end. Larvae feed within the apple and are about 7 mm long when fully grown, after having passed through three larval growth stages (instars). Larval development usually is completed in 20 to 30 days. Development is more rapid and mortality lower in early-maturing, soft cultivars than in firmer-fleshed, late-ripening apples. When they finish feeding, the maggots drop to the ground, burrow into the soil, and molt to a fourth instar, which quickly molts again into the pupal stage. Most of these pupae enter a diapause, or resting stage, and emerge the following year. Some emerge within a short time and produce a partial second generation in the same year.

The apple maggot is very well synchronized with host fruit development. When fruit is readily available, populations of flies tend to stay in the same area year after year. When there are fruit failures, the flies move from tree to tree; movement of $\frac{1}{4}$ to 1 mile per year is relatively common. Under windy conditions, the flies have occasionally been carried 10 to 15 miles, but normally the apple maggot is spread over considerable distances by people transporting larva-infested fruit.

Fruit injury

Injury to apples varies, depending on the cultivar and the time of attack. In softer-fleshed fruit, the egg-laying punc-



Maggots drop to ground after feeding, burrow into the soil, and molt into pupal stage. After diapause, pupae give rise to a new generation of flies. (N.Y. State Exp. Sta. photo)



Young larvae leave threadlike trails in fruit. As larvae grow, tunnels become larger, bacterial decay sets in, and apple becomes soft and rotten. (R.R. Kriner photo, left; N.Y. State Experiment Station photo, right)

tures become darkened and decayed; on firmer fruit, the punctures cause dimpling and distortion. Young larvae tunneling through the apple flesh leave small brown, irregular, threadlike trails. As the larvae grow, the tunnels enlarge and bacterial decay further destroys the apple. Eventually, the apples become soft and rotten. This internal breakdown proceeds more rapidly and is more severe in softer fleshed, earlier maturing cultivars.

As its name implies, apple maggot primarily attacks apples in addition to its native host, hawthorn. There are 165 native species of hawthorn (*Crataegus* spp.) in the United States, but only one, western black hawthorn (*Crataegus douglasii* Lindl.) occurs in California. Domestic and hybrid ornamental hawthorns grown in home yards and along highways and streets are also excellent hosts of the apple maggot and must be considered of major importance in supporting wild populations outside commercial orchards. Blueberries, huckleberries, and billberries, common in the coastal mountains of California, are also potential hosts.

Other California crops may also be susceptible to infestation: Apple maggot has been reported to attack cherries, plums, prunes, apricots, nectarines, peaches, blueberries, and late-ripening pears. There is concern that this insect might reach the Central Valley of California, where more than 6,000 acres of apples are now being grown. Once in this area, it might adapt to one or more of the major fruit crops grown there.

From the distribution of the apple maggot in the eastern United States, there is no doubt that it can survive in California. How important apple maggot



Of the 165 hawthorn species in the United States that are the apple maggot's native host, only western black hawthorn grows in California. Other hybrid varieties may also be hosts. (J. Joos photo)

will be cannot be predicted, but it does seem likely to become a relatively serious pest of apples, a \$43.6 million crop. If it becomes established throughout the 26,600 acres of commercial apples in the state, substantial immediate costs would result from embargos and post-harvest treatments required by other states and countries. Preventing economically important infestations of apple maggot would probably require at least two extra sprays per year, adding to production costs. These added sprays would undoubtedly have an adverse effect on integrated pest management programs for apples in California and would probably lead to additional miticidal sprays over much of the apple acreage. Direct fruit losses would be more severe in home gardens and organically grown apples.

Control

Because of high apples maggot populations in Oregon and its distribution in northern California, the feasibility of eradication is not certain at this time. A decision for or against eradication will be possible only after an intensive survey is made this year to determine how widespread the northern California infestation is in uncultivated apples and wild host plants. Eradication may be possible if apple maggot infestations are localized.

Since self-dispersal of the apple maggot is limited, containment appears to be a biologically and economically feasible way to slow its spread into the major apple-growing areas of California. Establishment of quarantine stations on the northern California border could help to slow the movement of infested fruit from Oregon. Other stations south of the California infestations could help

prevent the movement of fruit from the already infested areas. Certification that fruit has been treated or has come from noninfested areas should be required along with the quarantine.

Suppression of apple maggot populations in apples could materially reduce the potential for spread. Insecticides such as diazinon, dimethoate, phosalone, and phosmet have been effective in the eastern states and might prove useful here. The suppression of apple maggot populations in orchards and trees along frequently traveled roads, where the fruit is more likely to be infested and to be sold at roadside outlets, would reduce the spread. Stripping fruit from trees could be counterproductive, because it would stimulate dispersal of the apple maggot females.

Surveys for apple maggot with traps and fruit inspection will be useful in evaluating the extent of existing infestations, feasibility of eradication, and the containment measures needed to minimize spread south into the commercial apple-growing areas of California. The significance of wild hosts must also be determined. It may be possible to establish a 1-2 mile isolation band south of the infested areas to help prevent the natural spread of apple maggot females; intensive removal of hosts in the isolation band, supplemented with a spray program, would help with containment. If such efforts fail, research will be needed on how to manage the apple maggot under all California conditions.

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Apple maggot damage proceeds more rapidly and is more severe in softer fleshed, earlier maturing cultivars. (N.Y. State Exp. Sta. photo)