Mediterranean fruit fly:
The worst may be yet to come

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On June 5, 1980, two Mediterranean fruit fly adults, *Ceratitis capitata,* were found in a detection trap in San Jose, Santa Clara County, and on the same day one "Medfly" adult was trapped in Canoga Park, Los Angeles County. These two events, occurring 400 miles apart, set in motion what to date is the third largest eradication effort against the Medfly in the continental United States. Eradication of the 1-square-mile southern California infestation was achieved by December, as a result of stripping fruit from trees, malathion-bait spraying from the ground, and release of millions of sterile flies. The Santa Clara Valley infestation is still active and represents a real and present danger to California agriculture.

Medfly has made several previous appearances in the continental United States. In each case it has been successfully eradicated by use of an evolving set of tactics. An understanding of these previous eradication programs and the Medfly's habits may shed light on what to expect in the current Santa Clara Valley infestation as well as future invasions into California and other states.

Previous U.S. infestations

The first recorded Medfly infestation in the United States occurred in 1929 in central Florida. At that time fruit stripping and arsenical-molasses bait sprays eradicated the fly from about 120,000 acres (188 square miles). Over 6,000 state and federal workers participated in this two-year, $7 million eradication program.

The second infestation, in 1956, resulted from an accidental introduction of Medfly into the Miami area. This subsequently became the largest infestation in the continental United States, covering about 1,000 square miles. The successful eradication technique used in this outbreak was aerial spraying of an attractant protein bait containing malathion. More than 6 million pounds of protein bait and 3 million pounds of malathion were used in the eradication program, which was declared a success after 19 months and a cost of $10 million. Death of some tropical fish in shallow water and spotting of lacquer-type automobile finishes from which the spray was not washed off soon after deposition were the only harmful effects authenticated.

Aerial sprays of malathion-protein bait were used to eradicate Medfly infestations from smaller areas in Florida in 1962 and 1963 and in Texas in 1966.

In California, quarantine interception of the Medfly has occurred before, but the first infestation involved a 100-square-mile area of suburban Los Angeles in 1975. This infestation was eradicated in 1976 by state and federal workers using sterile fly releases and malathion-bait sprays from the ground at a cost of $1.5 million.

Core areas (shaded) of Medfly infestation.

Santa Clara Valley

The Santa Clara Valley Medfly infestation now covers more than 400 square miles and extends into Fremont (Alameda County) and Burlingame (San Mateo County). The main method directed at eliminating the dreaded Medfly in northern California by the California State Department of Food and Agriculture and the U.S. Department of Agriculture has been the release of sterile adult Medflies produced in Hawaii, Mexico, Costa Rica, and Peru. Along with the sterile fly releases, infested trees were sprayed with malathion plus bait, and the soil beneath the trees treated with the insecticide fenthion (Baytex).

In late December 1980, homeowners in the area were asked to strip their trees of fruit, and Governor Edmund G. Brown, Jr. mobilized over 600 California Conservation Corps workers, supported by personnel from other state and county agencies, to help strip fruit in the core area. By late January the fruit-stripping program was apparently progressing smoothly, but its success will not be known until at least the summer of 1981.

Habits

The Medfly adult is about the size of a house fly but has yellowish orange marks on its drooping wings, black spots on its back, and light gray bands on its yellowish abdomen. Although it can fly over 1 mile, it generally remains in trees and bushes near where it has emerged from its pupal case in the soil.

The flies are attracted to and feed on honeydew excreted by aphids, mealy bugs, and soft scale insects. The females need food to survive and produce eggs. They are ready to lay eggs after about 1 week at high temperatures (over 75° F); they then search for trees and shrubs bearing fruit. The males also feed on honeydew; they become sexually mature in a few days after emergence and are then attracted to plants bearing fruit. They rendezvous with females on leaves or fruit in the morning and mate when the temperature exceeds 64° F.

After mating, the female seeks out fruit that is beginning to ripen; she drills a small puncture through the fruit skin, making a cavity just below the skin, and then deposits two to six eggs in the cavity. She can lay up to 40 eggs per day and has the capacity to produce over 1,000 eggs in her lifetime of 60 days, under optimum conditions. In the field during summer, a female probably lays from 300 to 500 eggs in a month and then dies. She will not feed at temperatures below 45° F or lay eggs below 63° F.

Adult flies can live for over 3 months under mild winter conditions, but at a constant 30° F they die within 100 hours, and few survive more than 12 days at 45° F. Very hot days also can kill the adults. At a constant temperature of 105° F, few flies survive after 8 hours, and at 110° F they die within 2 hours.

The small glistening whitish eggs in the fruit hatch in 2 to 3 days at 79° F but do not develop at temperatures below 53° F. The small cream-colored larvae, which are typical legless maggots, begin to bore into fruit pulp and contaminate their feeding sites with bacteria. Over 100 larvae can develop in a large fruit. They grow to about ½ inch in 6 to 11 days at 76° to 79° F but take 24 to 50 days at 52° to 62° F; no growth occurs below 50° F.

The rate of larval development can also be strongly influenced by the host fruit: It is slowest in apple and progressively faster in pear, peach, and figs. The larvae taken from the fruit and placed on a smooth surface can jump up to 6 inches.

Mature larvae leave the fruit while it either is still hanging on the tree or has fallen to the ground. They directly enter the soil to a depth of up to about 3 inches or seek shelter under objects on the soil, and then transform into immobile pupae.

The pupa is about ⅕ inch long, brownish, and seedlike with blunt rounded ends. It remains in the soil, giving rise to an adult fly, which breaks open one end of the pupal case and pushes its way up through the soil. The pupal stage can be as short as 6 days at 79° F but lasts 9 to 11 days at 76° F. This is the most resistant stage in the life cycle of the fly, which in cold climates survives the winter in the pupal stage. Development of the fly within the pupa stops at about 50° F and may require 60 days before flies emerge during cold conditions. Pupae subjected to 28° F are usually killed in 30 hours; exposure to 32° F for 4 days and 42° F for 10 days likewise results in very high mortality.

The complete developmental time from egg to adult may be as short as 18 days under optimum laboratory conditions. In the field the minimum time for one generation is about 1 month. In Honolulu there are 11 to 13 generations per year; in Rome, 6 to 7; and in Paris, 2.

In Santa Clara County, the Medfly could have 3 to 3½ generations per year. According to a computer model based on a total of 621 day-degrees, using 54.3° F as a temperature threshold, an egg deposited September 1, 1979, would have yielded a new adult fly capable of laying eggs by mid-October 1979; an egg laid on November 1 would have produced a fly that could lay eggs in late April 1980; and an egg deposited March 1, 1980, would have resulted in a fly that could lay eggs in mid-June 1980.

It has been reported that most eggs, larvae and pupae die after 3 or 4 hours at 40° F. Since there were 5 days in December at San Jose with more than 3 hours below 40° F and live larvae have been subsequently found in fruit in Santa Clara County, it apparently takes lower temperatures than that to eliminate the immature stages.

World distribution

The Medfly originated in tropical west Africa, spread to north and south Africa, invaded Spain in 1842, and subsequently spread into France, Italy, Greece, and the Middle East. It appeared in Australia in 1893, South America in 1901, Hawaii in 1907, and Costa Rica in 1955, spreading south through Central America into western South America, and finally north into southern Mexico by 1972.

During mild winters and warm summers Medfly outbreaks occur in central Europe. In a general outbreak in Europe during 1955, peaches were particularly attacked in Germany, Switzerland, France, and northern Italy. Some European entomologists believe that Medfly exists as a resident in Germany, Switzerland, and other central European countries, having become acclimatized to colder areas. Others contend that the northern outbreaks result from reinvasions.

Hosts

There are 253 fruits, nuts, and vegetables recorded as Medfly hosts. Many are tropical plants that do not concern us except for quarantine reasons. Of the 253 hosts, 40 are considered "heavily or generally infested." Those important to California agriculture are, in seasonal sequence, citrus, loquats, cherries, apricots, peaches, plums, quince, pears, apples, figs, persimmons, and guava. In the list of 13 "occasionally infested" fruits, those grown in California are avocados, bell peppers, tomatoes, walnuts, grapes, and cotton. It is interesting that these latter hosts are not mentioned as being attacked by Medfly in the pest control manuals of Italy or France. Larger grapes are occasionally infested in South Africa, and strawberries grown near peaches in Germany have been attacked. The 24 hosts listed as "rarely infested" include Fox grapes, Isabella grapes, eggplants, blackberries, youngberries, pomegranates, common banana, and dwarf banana. Of the 153 other hosts listed that were not categorized as to intensity of attack, those grown in California include prickly pear, toyon, pyracantha, olives, cucumbers, cantaloups, Hubbard squash, pumpkins, and strawberries. In Italian pest control manuals, the Medfly is not listed as a pest of olives, melons, squash, cucumbers, or strawberries.

Recently in the Santa Clara Valley, Medfly larvae have been found in the berries of our native California bay (laurel) trees.

Control methods

Cultural control. Removing host fruits by stripping trees and any fruit on the ground can help break the cycle of an infestation, but all hosts must be removed. However, pupae already present in the ground will remain.

Chemical control. Protein hydrolyzate bait sprays with malathion or other insecticides are the most effective single method for suppressing fruit fly populations. The protein bait simulates honeydew, attracting the flies from a distance, and the malathion kills them when they contact or ingest spray droplets. For the bait sprays to be effective, temperatures must be warm enough so that the flies are active, and the sprays must be applied at least once a week during these periods. Soil beneath infested trees can be sprayed with fenthion, which kills larvae entering the soil and flies emerging from the soil. It is unknown whether the pupa itself is killed by this treatment.

Genetic control. This method relies on sterilizing the male Medfly in the pupal stage with gamma radiation, which stops the production of new sperm. However, fully developed sperm are viable but deadly. When a sterilized male mates with a wild female fly, the sperm enter the egg and disrupt development; as a consequence, the egg does not hatch. Male Medflies often mate more than once, but the females are reluctant to do so. In this control method, sterile females also are released, because it is too expensive to separate the sexes.

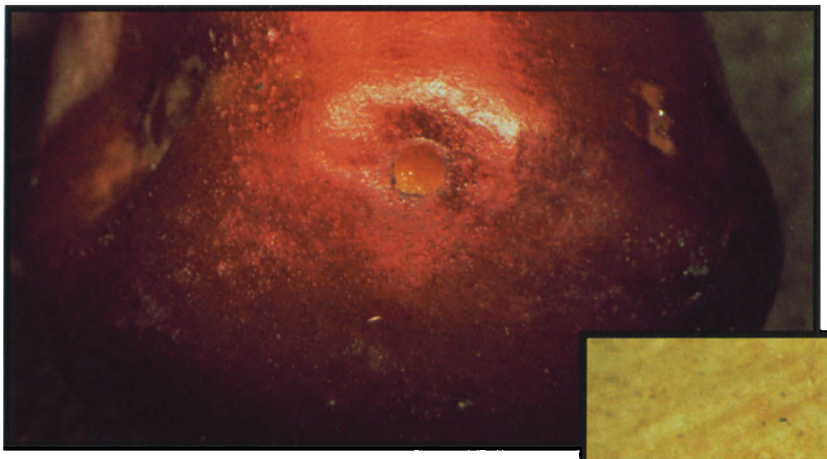
So far, over 1.6 billion sterile flies have been released in the Santa Clara Valley and the Fremont area, and further releases are planned. Ideally, the goal is to release 100 sterile flies for every wild fly in any given area.

Biological control. Importation and release of natural enemies of the Medfly have not been part of the present California campaign, but should the Medfly become established, several parasitic wasps that were introduced into Hawaii long ago could be tried in California. In Hawaii, the parasites account for over 40 percent parasitization, which has reduced the Medfly problem, but insecticides still have to be used on highly susceptible fruit crops.

In California a parasitic wasp attacks walnut husk fly pupae in the soil. This parasite, *Coptera occidentalis,* recently was sent to Greece and Czechoslovakia, where it successfully parasitized Medfly pupae. Therefore, one potential parasite is already present in California, but others could be imported should it be necessary. Natural enemies would not eradicate the pest, but they could reduce Medfly populations and make them more manageable.

Impact

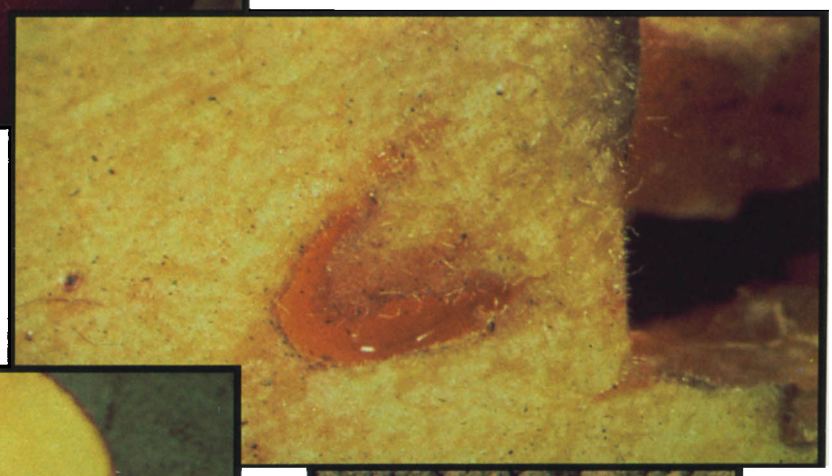
Should the Medfly become a permanent resident of California, all of us in the state would feel its economic impact. A loss as high as $15 billion to our state's economy has been projected by some economists. The estimated cost to agriculture alone is $413 million, including $146 million for added pest control, $207 million direct crop losses, and $60 million to fumigate fruit and vegetables destined for shipment out of state. Furthermore, the estimated cost to each home gardener to protect fruit and vegetables with bait



Top: V-shaped egg-laying puncture made by Medfly.

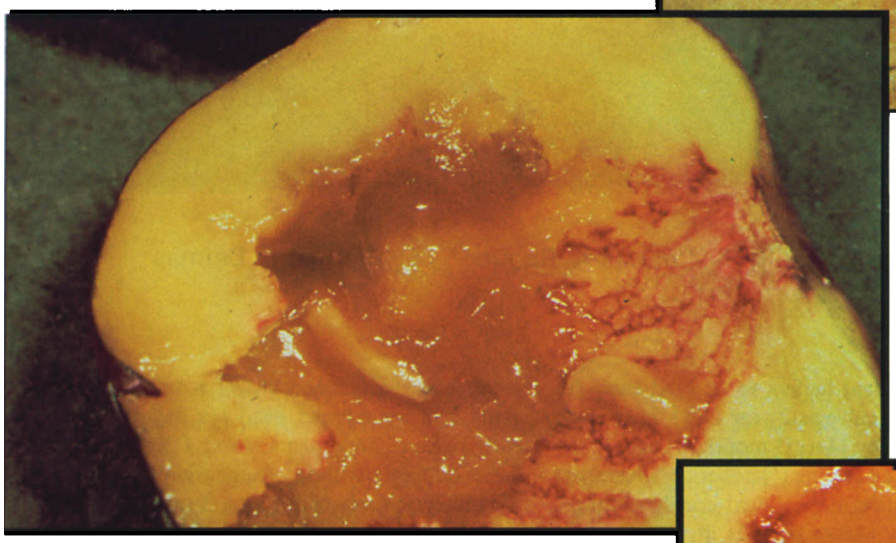
Center: Medfly pupae.

Bottom: Medfly larva, or maggot.



Above: Circular exit hole made by mature larva.

Below: Bacterial breakdown of Medfly-infested plum.



sprays or paper bags to cover the fruit would be about $16 per home.

This bleak picture is based on the assumptions that the Medfly could exist in all of California's fruit and vegetable growing areas and that all the hosts listed would be subject to attack. In reality, neither assumption is completely valid. However, even if we assume that the Medfly could live in only one-fourth of the state's fruit-growing areas, the economic and ecological impact would still be devastating. It is indeed justified to attempt eradication, even though the cost will be millions of dollars.

Eradication is an inconvenience to citizens in infested areas, but community support and involvement are important components in the program. One aspect of citizen responsibility that cannot be overemphasized is respect of quarantine laws. The movement of fruit from infested areas can have serious consequences, because it is the most likely way of spreading the fly to new areas within the state.

(Note: The California Department of Food and Agriculture discontinued use of fenthion [Baytex] early in February because of questions about its effectiveness.)

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