

The Threat of the Mediterranean Fruit Fly¹ to American Agriculture and Efforts Being Made to Counter This Threat² ³

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American agriculture was first exposed to the threat of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), when this insect was accidentally introduced into Hawaii in 1910 (Back and Pemberton, 1915). At that time the melon fly, *Dacus cucurbitae* Coquillett, was already present in Hawaii where it had been introduced about 1895 (Back and Pemberton, 1918). The introduction of another unwanted fruit fly into Hawaii occurred in 1944 (Carter, 1950) when the oriental fruit fly, *D. dorsalis* Hendel, was introduced, thereby providing Hawaii the questionable distinction of having three of the world's most serious pests of fruits and vegetables. The introduction of pest insects into Hawaii continues even today, though none of the newer ones rivals the melon fly as a damaging pest of vegetables. However, from the viewpoint of American agriculture, the Mediterranean fruit fly (medfly) is the most serious of the three species of fruit flies.

A review of the history of fruit fly introductions into the continental U.S. shows that medfly introductions have occurred in Florida, Texas, and California. The medfly was introduced into Florida in 1929, 1956, and 1962-63; into Texas in 1966, and into California in 1975. These medfly introductions were eradicated at costs ranging from \$200,000 to \$20 million (Chambers et al., 1974). To date, a total of \$33.2 million has been spent to eradicate medfly in the U.S. Introductions of the *Dacus* species have been much less costly to eradicate. For example, the melon fly was introduced into California in 1956, while the oriental fruit fly was introduced into California in 1960, 1966, 1969, 1970, 1971, 1974, and 1976; and into Florida in 1964 and 1969. The single melon fly and nine oriental fruit fly introductions were eradicated at a cost of \$1,087,000, essentially 3% of the cost of eradicating the five medfly introductions.

Interest in the medfly was renewed September 25, 1975 when this insect was discovered in Los Angeles⁴. This was the first time the medfly had become established in California. The threat of the introduction of the medfly into the continental U.S. from Hawaii is constant because of heavy air traffic between Hawaii and California.

¹Diptera: Tephritidae.

²Presidential Address, presented at the December 1975 meeting of the Hawaiian Entomological Society.

³Mention of a proprietary product in this paper does not constitute an endorsement of this product by the USDA.

⁴Cooperative Economic Insect Report, October 3, 1974.

ECONOMIC IMPORTANCE

The medfly can breed in ca. 200 different host plants (Christenson and Foote, 1960) and can survive under a wide range of climatic conditions within the tropics and subtropics. Based on the adaptive ability and high biotic potential of the medfly in temperate climates where it is established, the economic impact of the fly, due to direct control costs and the cost of treatment of commodities for movement through commercial channels, would be billions of dollars if the pest were permitted to become established in the continental U.S. It is estimated that the agricultural losses in California alone could amount to \$128 million a year (APHIS unpublished data).

It was because the medfly thus posed a serious threat to the American fruit and vegetable industry that the U. S. Department of Agriculture (USDA) established the Hawaiian Fruit Flies Laboratory in 1912 to conduct research on the development of effective quarantine treatments for Hawaiian commodities exported to the mainland United States. The work was later expanded to include research on the biology, ecology, mass rearing, and control of all three tephritid fruit flies present in Hawaii. The USDA Plant Quarantine Service, now called APHIS (Animal and Plant Health Inspection Service) began quarantine activities in Hawaii in 1912 and set up a quarantine station in 1914 to regulate the movement of susceptible commodities and fruits to the mainland. The regulatory and research service of USDA routinely work together to develop methods, information, and strategy for solving emergency problems to reduce the economic impact of new pest insects.

After the medfly was introduced into Hawaii, the Hawaiian Board of Agriculture and Forestry engaged the service of Dr. F. Silvestri in 1913 to collect *Opius humilis* Silvestri, *Biosteres tryoni* (Cameron), and other parasites and send them to Hawaii to control the medfly (Back and Pemberton, 1915). The concept of the use of natural enemies to reduce the ravages of fruit flies, adopted early by the State of Hawaii, was used to effect a degree of natural control of the oriental fruit fly. The opiine parasites *B. oophilus* (Fullaway), *B. longicaudatus* Ashmead, and *B. persulcatus* Silvestri were introduced between 1947 and 1951 (Bess et al., 1961). These biological control agents caused reductions in oriental fruit fly populations of up to 50% in some situations, but do not prevent this fly from causing damage to wild and cultivated fruits. Also, opiine parasites have been less effective against the medfly. Thus, populations of medfly, although widely dispersed, have remained large enough to permit research designed to improve the detection of this species and to develop large-area control methods. In this way the presence of the medfly in Hawaii has resulted in positive benefits for American agriculture. For example, this is the only location in the U. S. where research can be done on this species. Some results of the research efforts of the Hawaiian Fruit Flies Laboratory include the discovery of trimedlure, a synthetic attractant for male medflies (Beroza et al., 1961), the development of plastic (Steiner, 1957) and sticky traps (Harris et al., 1971) for use in detection systems for the medfly, bait sprays (Steiner et al., 1958), the technique of male-annihilation (Steiner et

al., 1965) whereby synthetic male lure is used with toxicants, and sterile-insect release techniques for suppression and eradication of the medfly (Harris et al., in manuscript). These tools, which were not available when the medfly was introduced into Hawaii in 1910 or even during the medfly infestation in Florida in 1929-30, have contributed to the eradication and prevention of spread of the pest into the mainland U.S.

DISTRIBUTION AND ECOLOGY

The medfly is found in Europe, Asia, Africa, Central America, Australia, and Hawaii. It occurs in areas with a great diversity of agriculture (Hawaii, Central America, North Africa, Spain, Egypt), ecological habitats, and host plants. The insect is highly plastic in its ability to adapt to different ecological conditions and man-made situations. Although the medfly was widely distributed over the State of Hawaii until the oriental fruit fly was introduced, the medfly has been suppressed by the oriental fruit fly due to competition between the larvae when both species breed in the same fruit (Keiser et al., 1974; Bess, 1953). Both species have been found breeding in such fruits as citrus, mango, guava, peaches, persimmons, and tropical almonds.

In Hawaii the medfly is confined mostly to areas of higher elevations (between 2,000 to 4,500 feet) on the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii, although it is occasionally found at lower elevations breeding in citrus, tropical almond, and other fruits. The behavior of this insect is more sedentary and less predictable than the behavior of the other two fruit fly pests in Hawaii. The adaptive capability of the medfly strains in Hawaii has not been strongly manifested, however, because the species is suppressed to a great extent by the oriental fruit fly.

Obviously knowledge of the effects of climate on tephritids and the influence of climate in fruit culture are basic to an understanding of the interaction of these factors on medfly abundance. In areas where the climate is unfavorable for adult medflies during part of the year, a different situation exists than that which occurs in Hawaii. For example, a variety of citrus fruits are grown in Tunisia, Algeria, Morocco, Spain, and Egypt. These countries, all located around the Mediterranean Sea, have climates characterized by hot, dry summers and cold, wet winters with temperature minimums of 40°F and maximums of 110°F. The state of California has a similar climate. Citrus fruits grown in the Mediterranean basin include Valencia, Mandarins, Thompson, Douce, and sour oranges, tangerines, grapefruits, and lemons. Other cultivated fruits include apricots, plums, loquats, peaches, guavas, pears, plums, quince, figs, and cactus. Damage caused by the medfly is most severe where fruits mature in serial sequence in the same location, if the location has no highly effective parasites. In all areas throughout the range of distribution of the fly, peaches, apricots, figs, and sour oranges are preferred hosts where these fruits are grown. The most resistant fruits are lemons and grapefruits when green, although grapefruit is a good host when overripe (Selim, 1967).

Central America and Hawaii have similar climates characterized by mild temperatures throughout the year, high rainfall, and wild host fruits

growing in gulches, valleys, and forested areas adjacent to cultivated host plants. Control of the medfly by its natural enemies has the best chance of success in tropical and subtropical areas in locations where the temperature range is relatively narrow. Since, in the United States, the medfly is well established only in Hawaii, we are obliged to study its habits and develop methods of control for California, Texas, and Florida under Hawaiian climatic conditions.

ERADICATION OF MEDITERRANEAN FRUIT FLY INFESTATIONS

Recently our research program was strengthened to develop economical, safe, and environmentally acceptable methods for eradicating the medfly. Thus, from January 1974 to February 1975, an average of 20 million sterile medflies were released per week in a pilot test on the island of Lanai to develop eradication technology. In 1975 no infestation of medflies occurred in guavas on Lanai during January, February, and May, and none were found in any fruits in February and May, although a total of 9,629 guava fruits were collected in these months. From the degree of infestation observed in 1973, we would have expected to rear several thousand medflies from these fruits. Thus, our results showed over 99% suppression for 6 months despite the fact that gravid females were being blown over to Lanai from Maui (Harris et al., unpublished data). These results confirmed the efficiency of the most recently developed techniques in medfly control.

On September 25, 1975 the medfly was discovered in the Venice suburb of Los Angeles, California. The infestation had probably passed through two or three generations before it was detected. An eradication program was instituted immediately by Los Angeles County, the state of California, and APHIS. The program consisted of two separate phases. First, Steiner (1957), McPhail (1939), and Jackson traps (Harris et al., 1971) were distributed around the initial find to delimit the infested area. The principal fruiting hosts in the area appeared to be oranges, lemons, a few peaches and pineapple guava. After infested peach fruit was found, foliar sprays of malathion and Protein Insecticide Bait No. 7 (Steiner et al., 1958) were applied to host trees with a back-pack sprayer near the epicenter of the infested area. After the fruit was removed, the soil under infested trees was treated with fenthion. Second, sterile medflies reared in the Hawaiian Fruit Flies Laboratory were shipped to California and released in the infested area. From October 1975 to May 1975, 560 million sterile medflies were marked, shipped, and distributed by ground release and aerial release methods. Thus the methods for eradicating the medfly developed on Lanai were modified and applied for eradicating the medfly from California (Cunningham et al., unpublished manuscript).

The tools developed by research in Hawaii to detect, suppress or eradicate the medfly are equally effective in urban or rural areas. However, the relative favorability of these areas for the establishment of an infestation differs. In the southern mainland states, commercial fruit crops susceptible to medfly attack are sprayed with pesticides on regular schedules. These sprays provide some protection against the development of medfly infestations. Also, growers inspect their crops as a general rule. This practice, plus the use of medfly traps, means that such growers are likely to

detect medflies before they become established and spread over a large area. Thus, the medfly is more likely to become established before detection in the residential areas of cities such as Los Angeles, Miami, San Diego, and Brownsville where backyard hosts are generally present. Once established, the insect can spread to commercial fruit orchards located further inland. Thereafter, medflies could spread during the summer months into areas in which they cannot overwinter, and this summer spread would become a recurring phenomenon. The only regular protection against medfly invasion is provided by the detection programs of the state, county, and APHIS, and by alert home owners in California, Arizona, Texas, and Florida.

The operation of detection programs varies somewhat from one state to another. At the present time opinions differ on what should be done to eradicate an outbreak. The standard detection tools used are Steiner and Jackson traps baited with trimedlure, and McPhail traps baited with a solution of torula yeast or Proteine Insecticide Bait No. 7. Standardization of methods to be used for medfly eradication in the southern mainland states is needed.

STRATEGIES FOR ERADICATION OF FUTURE OUTBREAKS

Medfly infestations occur in host fruits under favorable weather conditions, but the potential for the establishment of an infestation depends on the relative abundance of fruiting trees. A fruit tree survey could be made in the coastal cities of the west and south and in some other locations to determine the types of host plants, distribution, and fruiting seasons, and to plan and implement strategies for detection and eradication of fruit flies. This basic information should be developed and kept up-to-date to improve detection and eradication programs. Also, for emergency situations, the lag time between detection of an infestation and initiation of a control program should be reduced as much as possible. However, the role and responsibility of county, state, and federal agencies should be clearly defined to ensure smooth, efficient operations. Therefore, guidelines are needed for the implementation of immediate eradication programs in each state with a high potential for medfly infestation.

Future plans could be interlaced and supported by the development of improved eradication technology and basic bio-ecological information about high-risk areas. Equipment and materials could be pre-ordered and stored for emergency use. Staff members could be trained and a skeleton crew organized for leading emergency programs. In fact, with a minimum of effort, our reaction time in the eradication of fruit fly outbreaks could be reduced without additional risk to the urban environment.

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