

APPLE MAGGOT IN THE WESTERN UNITED STATES: A REVIEW OF ITS ESTABLISHMENT AND CURRENT APPROACHES TO MANAGEMENT¹

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INTRODUCTION

The apple maggot, *Rhagoletis pomonella* (Walsh) has been a serious pest of apples in the eastern United States and Canada for over 100 years. (Dean and Chapman, 1973). It is native to the northeastern United States where it originally infested fruit of hawthorn, *Crataegus* spp. It has been found throughout the east coast from Quebec in the north to as far south as Florida and from the Atlantic sea coast to parts of the Dakotas, Iowa, and eastern Texas, but not the western United States. In 1979, however, the apple maggot was reported for the first time from a backyard tree in Portland, Oregon (AliNiazee and Penrose, 1981).

Many tourists from the eastern U.S. and Canada visit the western U.S. every year. California quarantine inspection records indicate that apple maggot infested fruit has been occasionally intercepted at border stations for at least 30 years. These infested fruits had originated from many different parts of the United States. An examination of the Oregon Department of Agriculture (ODA) tephritid fly collection indicated that an apple maggot fly had been collected in 1951 at Rowena, near Hood River, Oregon, on a yellow sticky trap. The specimen had been identified as the snowberry maggot, *R. zephyria* Snow, by the ODA but has recently been re-identified as *R. pomonella* AliNiazee and Westcott, 1986). It is probable that the apple maggot has been accidentally introduced to the West many times during the past decades.

EARLY INTRODUCTION AND ESTABLISHMENT

The 1979 Portland infestation was found in a backyard apple tree of unknown variety. Infested fruit was brought to an extension agent's office and later identified as apple maggot based on adult taxonomic characters. Fruit from this site was heavily infested suggesting that the maggots had been present for a few years prior to initial detection. Conversation with the property owner failed to establish any connection with recent fruit movement from the midwest or eastern U.S.

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A survey conducted in 1980 by the ODA to determine the apple maggot distribution in Oregon showed that the apple maggot was limited to the northern Willamette Valley and an isolated find in the Rogue River Valley near Phoenix, Oregon (AliNiazee and Penrose, 1981). A small number of traps placed in southwestern Washington indicated that apple maggot occurred in and around Vancouver, Washington. The unexpected wide distribution of apple maggot in 1980 suggested that it had been in Oregon for some time.

It is impossible to trace the spread of apple maggot throughout the west, but some inferences can be made from its present distribution. The discontinuous distribution initially observed in Oregon (AliNiazee and Penrose, 1981) in part reflects the discontinuous distribution of host material and low trap densities used in most surveys. Where host material is continuous, natural dispersal of apple maggot had undoubtedly occurred. However, natural dispersal seems limited to between a few yards and a few miles annually (Maxwell and Parsons 1968, Maxwell 1968, Phipps and Dirks 1933, Neilson 1971). Given this constraint, the discontinuity of host material in many areas of the West, and the present distribution pattern of apple maggot (Table 1), it is highly probable that much of the dissemination has resulted from the transport of infested fruit. This mode of dispersal has probably been the source of isolated infestations in areas like Spokane and along the Oregon coast.

Climatic conditions of the western United States differ substantially from those in the East and Midwest, and the apple maggot has had to adapt to these environmental constraints. A recently completed study indicates that environmental conditions of the Willamette Valley and Oregon coast only marginally satisfy the requirements for diapause development, and this prolongs emergence of adults over a long period (AliNiazee, unpublished data). Fifty percent of the pupae emerged during the first year, compared with over 80% during the first year in the eastern U.S. (Dean and Chapman, 1973).

Hot and dry summers are common to many parts of the western U.S. Relative humidities range from 15-50% during the daytime with little rainfall occurring during the months of July, August and September. The impact of these conditions on adult longevity, oviposition and hatch are not clearly understood. One of us (M.T. AliNiazee) observed that during hot, dry periods the flies were easily agitated and spent considerable time and energy in short flights. Such conditions would encourage rapid dispersal, as agitated flies would be more likely to fly to surrounding trees.

TABLE 1. Current distribution of *R. pomonella* in the western United States.

States	Distribution	Hosts	References
California	Wide Northern California	Apple, Hawthorn	Joos et al. (1985)
Utah	Moderately wide Central and Northern Utah	Cherries, Hawthorn	Miller and Bianco (per. comm.) Jorgensen (per. comm.)
Idaho	Localized Southeastern Idaho	?	Westcott (per. comm.)
Colorado	Localized Western Colorado	Cherries	Stahl (per. comm.)
Washington	Wide Southwestern Washington (Isolated at Spokane)	Apples, Hawthorn	Brunner (unpb. data)
Oregon	Wide Willamette Valley, Southern Oregon (Isolated along the coast and Columbia River Gorge)	Apples, Hawthorn Plum, Prunes	AliNiazee and Westcott (1986)

CURRENT STATUS

At present the apple maggot distribution in the West includes most of the Willamette Valley of Oregon, part of southern Oregon, a six-county area of northern California, southwestern Washington, and parts of northcentral Utah. Scattered isolated populations also occur near Spokane, Washington (15 sq. miles), at a number of coastal locations in Oregon and California, along the Columbia River Gorge, in southern Idaho and near Grand Junction, Colorado (Table 1).

Oregon – Apple maggot surveys have been continued since 1980 by the ODA to determine its distribution in the state. By 1984 the apple maggot had been recorded in almost all western Oregon counties (Westcott, personal communication). It was not, however, uniformly distributed throughout its range in western Oregon. Although the Willamette Valley seemed to be generally infested, there was an allopatric distribution along the coast, confined mostly to urban areas.

In Oregon the two areas of major concern were the Hood River and Rogue River valleys. The former is the major apple growing area and the latter the major pear growing area of the state. Surveys of 1980 indicated the presence of apple maggot in Cascade Locks, about 32 km west of Hood River (AliNiasee and Penrose, 1981) and at Phoenix in southern Oregon. Attempts were made to eradicate these infestations by weekly spray applications of phosmet. Surveys in 1981 and 1982 indicated that the apple maggot had been eradicated from both these sites; however, other sites in the same general area have since been found to be infested. Recent trap data showed that flies are now present at both these sites. For the first time in 1984 the flies were trapped in the commercial apple orchards of the Willamette Valley.

In Hood River Valley apple maggot infestations are localized. The intensive spraying of commercial apple orchards, the small number of unsprayed apple trees and low probability of movement into the area by either natural or human means may account for this condition. In southern Oregon, however, the apple maggot is widely distributed. A relative abundance of unsprayed apple trees increases the potential for successful establishment in this area. In addition, the volume of people moving along the principal north-south route through southern Oregon increases the probability of apple maggot being spread by human transport of infested fruit.

Washington – The Washington infestation of apple maggot is perhaps as old as that of Oregon. Vancouver (Clark County) directly across the Columbia River from Portland, was found to be infested in 1980 (AliNiasee and Penrose, 1981). Surveys conducted in 1981 by the Washington State Department of Agriculture (WSDA) found the apple maggot throughout southwestern Washington and into Skamania County at Stevenson. In 1982, an expanded survey by WSDA detected apple maggots at additional locations along the Columbia River Gorge and near Spokane, WA. During 1983 and 1984, catches in increased trap densities indicated the apple maggot distribution was larger than had been previously assumed.

The infestations near White Salmon and Spokane are of greatest concern to Washington since they occur near commercial fruit growing areas. Efforts to eradicate localized populations at these two locations, using a combination of host removal and insecticide applications, are continuing. In 1984 apple maggot flies were trapped for the first time in commercial apple orchards in southern Washington. Preventive spray programs were implemented in response to the detections and no infested fruits were found. Apple maggot detections north of Vancouver suggest that there is a slow rate of natural spread.

California – The California Department of Food and Agriculture (CDFA), concerned about Oregon's apple maggot infestation, increased their monitoring program in northern California counties bordering Oregon in 1981 using Pherocon® Am traps at a density of 0.8/km² in urban high hazard areas. No flies were trapped during 1981 and 1982.

On August 24, 1983, one apple maggot adult was trapped near Smith River, Del Norte County, California. Flies subsequently were found in a number of northern California counties. The surveys indicated a widespread, low density infestation on apple and hawthorn at several locations along the Klamath River as well as the north coastal area near the Oregon border. A total of 103 adult flies and 38 larval-infested sites were found in 1983 (Joos *et al.* 1984). In 1984 the apple maggot was detected in three additional counties. The movement of fruit *via* back roads is common in this general area and probably facilitated the spread of apple maggot.

Utah – Apple maggots were first collected in Utah in 1976 from Malaise traps near Willard Basin of Box Elder Co. (Jorgensen *et al.* 1986). However, no flies or fruit infestations were later reported from the state. In 1983, adult flies were detected in traps maintained as part of a cherry fruit fly monitoring program. Flies were detected on July 6, 1983, in Utah County near Mapleton (Miller, personal communication). After flies were detected in the Mapleton area, trap density was increased from 3.8 to 10/km², and over 200 flies were trapped in the Mapleton area during 1983. Apple maggot flies also were detected in Cache and Davis Counties, but no flies were detected in other areas, despite heavy trapping (Miller, personal communication).

Jorgensen (personal communication) reported that apple maggots had been reared from infested sweet and sour cherries during 1984 but had not as yet been reared from apple. Jorgensen *et al.* (1986) later reported rearing flies from infested fruit of native hawthorn, *Crataegus douglasii*.

Colorado – Four specimens of apple maggots were detected near Palisade in a sweet cherry orchard during 1985 (F. Stahl, personal communication). Although the distribution of the apple maggot in the state is not well documented, these findings are of concern to the major tree fruit growing areas near Grand Junction, Colorado.

FUTURE OUTLOOK

Based on the distribution pattern discussed above, it appears that the apple maggot is now well established in the western United States. It is very difficult to precisely determine the date of introduction and establishment. Based on its current distribution and the one fly caught in 1951 from Rowena, Oregon, it appears that apple maggot probably has been in Oregon for at least 30-40 years. A changing trend in the emergence rates and a shift of opiine parasitoids from *R. zephyria* to *R. Pomonella* (AliNiazee 1985a) also suggests the presence of apple maggot in the western U.S. for many years. Further spread of this pest in the West will depend on a number of factors including the movement of infested fruit and quarantine restrictions placed on fruit shipments from infested areas. Unrestricted movement of infested fruit greatly increases the possibility of rapid spread. The occurrence of the pest in many different environments of the West indicates that it is capable of surviving in most areas where commercial apples are produced. Its widespread infestation of cherries (Jorgensen, personal communication) suggests development of new host races in the West. Major efforts are currently underway in Washington, Oregon and California to restrict the movement of the apple maggot and protect the major apple producing areas.

MANAGEMENT APPROACHES

Eradication – The eradication of apple maggot from the entire western U.S. seems impractical if not impossible. It may be too late to attempt even area-wide eradication on a statewide basis. For example, in western Oregon and Washington infestations are widespread and largely confined to hawthorn and abandoned apple trees. These apple maggot hosts are abundant, with many infested sites being inaccessible.

In northern California along the Klamath River and coastal areas, complete eradication will be difficult. Localized eradication seems feasible and may be a viable option, particularly if the infestations are near major apple growing areas. Localized infestations near Hood River and Cascade Locks were thought to be eradicated two years ago, but flies were detected again in 1984. In Washington, successful local eradication was thought to have been achieved within the town of Klickitat, but apple maggot was detected again in 1984. It is encouraging that apple maggot populations in areas where local eradication is being attempted have steadily declined. Total eradication of the apple maggot is probably only feasible where geographic barriers isolate local populations from more generally infested areas.

Containment – Containment of apple maggot populations in a given area by creating insecticide treated and/or host-free buffer zones is an attractive idea. However, the practical feasibility of such an approach is difficult to evaluate. Although a half-mile flight range has been suggested for the apple maggot (Dean and Chapman,

1973), it is possible that under certain conditions flies may travel longer distances, thus complicating containment programs. A prerequisite to any containment effort would be the determination of fly distribution in a given area. Such distribution maps are not currently available for all infested areas in the West. Delimiting surveys are being conducted in California and parts of Oregon, Washington and Utah. The most likely means of apple maggot dispersal will be by transport of infested fruit. The imposition of strict quarantines, primarily on non-commercial fruit, will be critical to the success of containment programs. Survey programs should be implemented in areas of the western U.S. where apple maggot has not yet been detected.

Management – Apple growers in generally infested areas, such as the Willamette Valley of Oregon, must learn to live with the apple maggot. Fortunately, apple maggot control is easily accomplished through application of a number of insecticides (Hoyt *et al.* 1982). The biology of the apple maggot (number of generations, damage, etc.) in the western United States is similar to that described by several authors in the eastern United States. However, distinct phenological differences exist between the eastern and the western population. In Oregon and Washington the apple maggot begins emerging in early July. Peak emergence occurs in late August or early September (AliNiazee and Westcott 1986, Tracewski *et al.* 1985). Flies are found as late as November, and larvae have been found in late December. During some years, larvae might be able to survive the entire winter in more moderate areas. Sprays applied for control of codling moth, *Cydia pomonella* L., will provide partial control of the apple maggot. However, complete dependence on these sprays will not provide adequate protection (AliNiazee 1986), and one or two additional sprays will be required for commercially acceptable control.

Naturally occurring biological control could play an important role in management of apple maggot in Oregon. Two opiine parasitoids, *Opius downesi* Gahan and *O. lectoides* Gahan have shifted from the showberry maggot to the apple maggot population in hawthorn and have caused reductions in pest density at two study sites in Oregon (AliNiazee 1985). The life cycle of these parasitoids is well synchronized with that of the apple maggot. More detailed studies are needed, however, to determine the potential of these and other natural enemies under commercial orchard conditions. Studies on apple maggot trapping, sampling and monitoring are also needed.

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