

Fruit Flies and Their Impact on Agriculture in Hawaii

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Abstract. Tephritid fruit flies were among the early invasive insects to the Hawaiian Islands. These agricultural pests have had a major impact on Hawaii's agriculture, reducing the types, quantities and quality of agricultural products grown on the islands, increasing pesticide use and reducing trade of fruit fly host products. Reduction in production of both sugar cane and pineapple, two non-fruit fly host crops over the last 10–15 years has renewed interest in diversified agriculture in the state and prompted renewed interest in fruit fly control programs statewide. Over the last 90 years, USDA has had a major research role in defining, discovering and implementing technology to detect and control these pests in Hawaii, the U.S. mainland and worldwide. The Hawaii Areawide fruit fly integrated pest management program (HAW-FLYPM), a USDA-ARS funded partnership between ARS, University of Hawaii and Hawaii State Department of Agriculture has recently demonstrated that these pest fruit flies could be controlled using IPM technologies. The success of the program has prompted state and federal agencies to reconsider if Hawaii could further expand their diversified agriculture using such an approach.

Introduction

Invasive species have had a major impact on the people and economy of Hawaii, having been synonymous with man's colonization of the islands. Early examples of the impacts of invasive species in Hawaii are well-known including insect pests of agriculture and man, mammals such as rats, mongoose, pigs, sheep and goats and numerous plant weeds and diseases (Staples and Cowie 2001). Invasive species are characterized by their economic damage and have more recently come under scrutiny for the scope and degree of environmental damage that they can cause to unique ecosystems such as in Hawaii. The challenge we face today with invasive species is understanding the invasion biology of potential invasive plants, insects and other biological entities, providing science-based evaluations of the risk-benefit of their introduction, establishment and control and setting rules, regulations and laws that allow us to be responsible stewards of the land while increasing opportunities for people of the state of Hawaii.

Fruit flies as invasive species. Tephritid fruit flies were among the earliest invasive species in Hawaii, beginning with the accidental introduction of the melon fly (*Bactrocera cucurbitae* (Coquillett)) in 1895 (Hardy 1949). The tephritid fruit flies are pests of fresh fruits and vegetables, laying eggs in the growing tissues of fruit. The eggs normally hatch in a few days and the young larvae burrow into the fresh tissues and inoculate the fruit with bacteria causing secondary fruit rot. The mature larvae leave the fruit and pupate in the soil where they emerge two weeks later as young adults. Sexually mature males and females mate and the cycle is then repeated.

The impact of melon fly's establishment on Hawaii's agriculture was immediate and profound, especially devastating to vegetable and melon crops that have previously been abundant, easy to grow, and are especially valued by Asian populations. If melon fly was not enough, Hawaii received another pest in the form of the infamous Mediterranean fruit

fly (medfly), *Ceratitis capitata* (Weidemann), which was found to have entered Hawaii in 1907 (Hardy 1949). The medfly attacked many of the crops not attacked by melon fly resulting in even more infested fruits and an increasing dependence on pesticides by farmers. By the mid 1930s crops such as persimmons, (*Diospyros kaki L.*) were reported to be heavily infested by medfly in the Kula area of Maui as well as in coffee (*Coffea arabica L.*) throughout the islands. The end of the Second World War brought to Hawaii the oriental fruit fly, *Bactrocera dorsalis* (Hendel), by way of the Pacific Islands (Hardy 1949). The oriental fruit fly, interestingly, displaced medfly in some of the lowland agricultural areas and became the most devastating fruit fly in Hawaii. The newest invader to Hawaii was the solanaceous or Malaysian fruit fly, *Bactrocera latifrons* (Hendel) that was discovered in 1983 (Vargas et al 1983). Overall, fruit flies attack over 400 different species of fruits and vegetables worldwide, many of which are grown or could be grown in Hawaii.

Impacts of fruit flies on agriculture. Fruit flies have had a direct impact on agricultural production in the state. One estimate of the direct impact of fruit flies was 15 million dollars (Nakahara et al 1977), which did not include the costs or impacts of insecticide use to control these pests. Twenty-four years later, Staples and Cowie (2001) reported potential impacts of 300 million dollars due to fruit flies in Hawaii not including Malaysian fruit fly. This difference could be attributed to the methodology used to estimate the impact of fruit flies on Hawaii's agriculture, or the increase in the value of agriculture over the last 20–25 years. Nonetheless, it is clear that the direct impact has been significant to Hawaii's overall agricultural economy.

While the direct loss of production of fruit fly host products has had a significant impact on agriculture in Hawaii, perhaps a more important impact has been the loss of potential production and markets due to the threat of fruit flies and the high economic costs for their control. McGregor (2005) reported that a 1966 appraisal of the impact of fruit flies on Hawaii agriculture attributed 90% if the impact to the loss of potential development with only 10% to the direct damage due to infestation by fruit flies. This loss of "desire" to grow fruit fly hosts crops is the main reason the key agricultural crops grown in Hawaii over the last 100 years were primarily non-fruit fly host crops and why diversified agriculture has not taken off as quickly since the downturn in pineapple and sugar production in the state. State of Hawaii statistics on agriculture for 2002 show only three fruit fly host commodities (papaya #8, tomatoes #10, and bananas, #12) in the top 20 commodities grown in the state. Vegetables and melons contribute to 16.6% of diversified agriculture while fruit occupy only 6.8% of the total (Statistics of Hawaii Agriculture 2002). Furthermore acreage in fruits has actually declined since 1998 in the state while the state continues to be nearly 100% dependent on imports of many tree fruits. Overall Hawaii imports nearly 50% of its consumption of fruits.

Control of fruit flies in Hawaii. Lately there has been a renewed interest in the development of diversified agriculture in the state, with an increasing share of the state's agricultural economy being supported by a small but growing tropical fruits and vegetable industry. However, until recently the only option farmers had for control of fruit flies was bagging of fruits and vegetables to prevent stings or the use of pesticides, primarily cover sprays to kill the flies. These techniques were labor intensive and costly resulting in production yields that often barely covered the costs of production.

Recently, the U.S. Department of Agriculture's (USDA), Agricultural Research Service (ARS) initiated the Hawaii Areawide fruit fly Integrated Pest Management program (HAW-FLYPM), a partnership between ARS, the University of Hawaii at Manoa (UHM), the Hawaii State Department of Agriculture (HDOA) and the public, to implement fruit fly control strategies developed by ARS over the last 50 years. Initial evaluation of the program by growers has suggested that it has significantly reduced fruit fly damage and pesticide use

on fruits and vegetables in Hawaii (Vargas et. al. 2003, Mau et al. 2003). The program has demonstrated to today's farmers, environmentally compatible, cost effective and sustainable technologies that replace the use of most pesticides for fruit fly control. More importantly the program has given growers a can-do attitude encouraging the development of diversified agriculture in the state. It is expected that the value of diversified agriculture will continue to increase in the coming years as fruit fly control becomes sustainable and more products become available to growers.

Conclusions

Fruit flies have had a tremendous impact on agriculture in the state of Hawaii. Yet despite the negative effects of fruit flies and other pests, Hawaii's year-around mild climate, abundance of rain and fertile volcanic soils continue to attract serious and novice farmers with the dream of growing tropical fruit and vegetables in the state. Diligent oversight is still needed in order to exclude many of the highly invasive and potentially damaging alien pests that are present throughout the world that have not yet entered the state. The list of tephritid fruit fly pests alone is daunting and includes such serious pests as the Queensland fruit fly, *Bactrocera tryoni* (Frogatt), the Mexican fruit fly, *Anastrepha ludens* (Loew), the Pacific fruit fly, *B. xanthodes* (Broun), and the peach fruit fly *B. zonata* (Saunders). Detection and control of these fruit fly species will be a high priority if the state intends to continue to pursue the dream of diversified agriculture in Hawaii. Other important issues such as land, water, transportation and environmental concerns cannot be dismissed as they, along with production, labor and market forces are all linked to the success or failure of diversified agriculture in the state.

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