Fruit Flies Flee Paradise

Aloun Farms owner Mike Sou (left) and field manager Joseph Liu Man Hin point out fruit flies hiding in a banana tree to entomologist Roger Vargas.

STEPHEN AUSMUS (K11007-1)

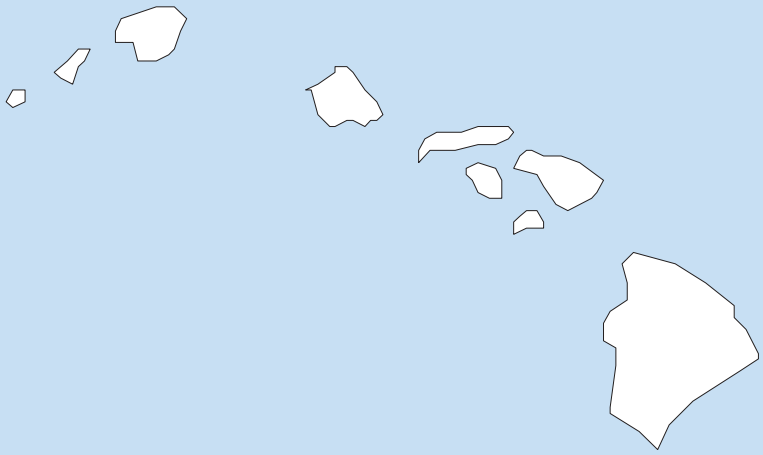
When Dennis Gonsalves was growing up in Hawaii in the 1950s, eating guavas and mangos from the tree was a regular treat. But you had to be good at picking around the fruit fly damage to eat just the good parts; you could hardly ever find a perfect fruit, no matter how recently it had fallen from the tree, he remembers.

"But my father used to tell me how it wasn't that way when he was growing up. Then, fruit hardly ever had fruit fly damage, and everybody counted on eating it," he says.

Soon though, another generation may be able to count on eating wild fruit, thanks to work being done at ARS's U.S. Pacific Basin Agricultural Research Center (PBARC) in Hilo, Hawaii. This laboratory, headed by Gonsalves, is leading the first successful effort to deal with the exotic fruit flies that have been devastating Hawaiian farms and gardens for 100 years.

After only 3 years, the program is already having tremendous success. Key to the program has been the extraordinary teamwork among ARS, state, and university experts that has gone into helping growers and gardeners in Hawaii adopt an anti-fruit fly technology package.

The Hawaii Area Wide Fruit Fly Integrated Pest Management (HAW-FLYPM) program is the brainchild of ARS entomologist Roger Vargas, who is a principal investigator on the project, along with entomologists Eric Jang, Ernest J. Harris, and Stella Chang, geneticist Don McInnis, and biologist Grant McQuate, all with PBARC. In 1998, Vargas was researching fruit fly control methods, mainly for preventing foreign fruit flies from becoming established on the U.S. mainland. Many



SCOTT BAUER (K8897-17)

Mediterranean fruit fly.

techniques for such control have been developed or tested in Hawaii, since the state is already infested and test populations do not offer a new threat.

"I saw that many modern control methods were being worked on in Hawaii, but no one had put all the techniques together into a program that could be used for Hawaii," explains Vargas.

Keeping exotic fruit flies out of the United States is vital. If the Mediterranean fruit fly were to become established in California, the potential direct and indirect losses could amount to more than $1.4 billion annually in just that one state.

Four exotic fruit fly species are major problems in Hawaii. The medfly and the melon fly both arrived in the late 1800s; the oriental fruit fly came in 1945; and the Malaysian fruit fly is the newcomer, first being found in Hawaii in 1983.

This quartet of tiny pests can lay eggs in and ruin more than 400 different fruits and vegetables, including citrus, coffee, eggplant, guava, loquat, mango, melon, papaya, passion fruit, peach, pepper, persimmon, plum, star fruit, tomato, and zucchini. And with the recent decline of sugar and pineapple plantations, it is just these fruit fly-susceptible, high-value crops that are now the backbone of Hawaiian agriculture.

For years, exotic fruit flies have driven Hawaiian farmers either to near-weekly sprayings of organophosphate and carbamate insecticides or to simply abandoning crop production altogether. Industry experts estimate that exotic fruit flies are costing Hawaii more than $300 million each year in lost markets for locally grown produce. And that doesn't include potentially high-value export markets.

"Hawaii has very rich, fertile soil and a climate that can produce four or five crops a year. Yet with these invasive fruit flies, the islands not only have problems exporting a lot of produce, we have to import crops like cantaloupe that we should be growing for ourselves," says Vargas.

Fruit fly eradication programs have been proposed or attempted in Hawaii several times in the past, especially for medfly. While none of them succeeded, these eradication attempts, especially during the last 25 years, clearly illustrated the major problems with the idea: heavy economic costs, quarantine issues within the Hawaiian island chain, limits on resources, and lack of information on the effects on nontarget fauna and other environmental concerns.

STEPHEN AUSMUS (K11014-1)

Tsukasa Yamamoto (left) of B.E.S.T. Farms and ARS technician Mike Klungness look over a patch of fruit fly-free tomatoes. After participating in the areawide pest management program, cooperators can diversify and grow once-abandoned popular fruits, such as persimmon.

So the ARS-led program was designed with several critical differences, explains Vargas.

First, rather than total eradication, the project was planned as an areawide integrated pest management program (IPM). One of the principal differences between IPM and eradication is that IPM sets the goal of keeping pest damage below an economically significant threshold rather than trying to eliminate every last fly.

"The control program must be cost effective as well as scientifically valid. Pest management lets us do that," Vargas adds.

Second, the program needed to be environmentally beneficial—reducing the amount of pesticides used by growers and not creating a significant risk of harm to the native Hawaiian ecology.

Third and perhaps most important of all, the control package had to be very user friendly so that farmers would continue to use it after the research portion of the program was done, Vargas says.

Getting Started

Once ARS funded a Hawaiian fruit fly control program, Vargas set out to enlist the partners that would give it the best opportunity to succeed.

"We had plenty of scientific expertise, but if we wanted it to work, especially long term, we knew we needed lots of participation by other groups," Vargas says.

Essential partners include the Hawaii Department of Agriculture (HDOA) and the University of Hawaii, which, along with ARS, make up the core team for the HAW-FLYPM program (www.fruitfly.hawaii.edu). Then USDA's Animal and

STEPHEN AUSMUS (K11015-1)

STEPHEN AUSMUS (K11013-1)

STEPHEN AUSMUS (K11006-1)

TOP: Field sanitation—removing unharvested or infested crops from a field—is an important part of areawide pest management. Here, Mike Klungness (left), coordinator for ARS's Area Wide Pest Management Program on the Big Island, and local farmer Jose L. Rincon look through a tentlike structure called an augmentorium. The augmentorium is being used to contain infested produce; the structure keeps fruit flies inside but allows beneficial parasitoids to escape.

MIDDLE: On the Big Island, technician Greg Boyer applies GF-120 protein bait, an environmentally friendly bait that eliminates the need for harsh insecticides such as malathion.

BOTTOM: At Aloun Farms on the island of Oahu, left to right, Roger Vargas and entomologist Eric Jang, Hawaii Department of Agriculture administrator Lyle Wong, and University of Hawaii professor Ron Mau inspect a Sudax border sprayed with GF-120 protein bait, which helps suppress fruit flies. Sudax is a hybrid of sorghum and sudan grass.

Plant Health Inspection Service, the IR-4 program, and industry participants, including Dow AgroSciences LLC, were enrolled.

As with most IPM programs, the HAW-FLYPM program combines several methods to achieve the best control. It starts with field sanitation.

"To break the cycle of reproduction and population increase, growers need to remove all unharvested fruit or vegetables from a field by completely burying them or by placing them into an augmentorium—a pup tent-like screening structure that prevents any hatching fruit flies from flying into fields to lay eggs in the next crop," explains ARS lab technician Mike Klungness, who acts as Big Island areawide pest management coordinator.

Sanitation is combined with use of lures and traps to monitor for the presence of fruit flies as well as baits to provide control. The lures and baits are tailored to each of the four species of fruit

Production of Sterile Male Flies

STEPHEN AUSMUS (K11012-1)

University of Hawaii entomologist Luc LeBlanc inserts an egg-collection bottle into a cage of melon flies.

STEPHEN AUSMUS (K11010-1)

Geneticist Don McInnis examines a T-1 strain of melon fly pupae. Male pupae of this strain are brown and female pupae are white, making it easy to eliminate females with a photoelectric sorter.

STEPHEN AUSMUS (K11011-1)

Technician Rick Kurashima prepares to irradiate male melon fly pupae to sterilize them.

flies that the HAW-FLYPM program is tackling. The final piece of the control puzzle is the release of sterile male fruit flies and parasitoids to take down major population upswings.

Among the fruit fly control techniques developed by the ARS laboratory in Hilo is a new lure for medflies that stays potent in traps about three to four times longer than trimedlure, the most widely used commercial attractant. "More importantly, it is also about four to nine times more attractive to medflies," explains Eric Jang, one of the ARS researchers who discovered the new lure.

ARS scientists at Hilo also developed a new lure for the Malaysian fruit fly made from the chemical alpha-ionol and cade oil—a dark-brown liquid from prickly juniper. (See www.ars.usda.gov/is/AR/archive/sep99/lure0999.htm.)

A new, more environmentally friendly insecticide called spinosad—worked on in Hilo as well as in Weslaco, Texas—is providing an alternative to malathion sprays for medfly. (See www.ars.usda.gov/is/AR/archive/apr00/crop0400.htm.)

Ernest J. Harris, an ARS entomologist, was the first to establish a thriving indoor colony of *Biosteres arisanus* wasps, one of the most important parasatoids of medflies and oriental fruit flies. The tiny wasp is now being mass-reared in Hawaii as a biocontrol agent. (See www.ars.usda.gov/is/AR/archive/jul98/wasp0798.htm.)

Growers Get Great Results

Cooperators—individual farmers who agreed to provide research locations and then act as demonstration sites to show other growers how it works—are the heart of the HAW-FLYPM program.

"It was a bit of an uphill battle at first convincing some growers to participate. We had to overcome their reluctance to put themselves at economic risk by trying technologies they perceived as experimental. We also had to get past growers' disappointment with those previous eradication attempts," Vargas says.

Extension agents, ARS researchers, and HDOA officials met with growers' groups to explain the idea and procedures. Videos, brochures, and other high-caliber educational materials, including a website and a newsletter, have been produced to make the information more accessible.

But personal communications with growers have been the real basis for the successful adoption of the program.

Ron Mau, IPM program director for Hawaii's Cooperative Extension Service, leads a team of extension agents who work with farmers one on one to help them understand the new system. "We want to empower farmers to make informed decisions. That's the best way to ensure they'll continue with the program," he says.

While doing research to fine-tune the pest management package, ARS scientists and technicians make weekly visits

to cooperators' farms to monitor fruit fly populations. They often combine these visits with sessions training farmers to adapt the system to their specific farms.

Growers on three Hawaiian islands have already been recruited as cooperators, and more are joining. Once they started using the program, growers couldn't have been happier.

Take Aloun Farms, for example. At 3,200 acres, it is one of the largest, most diversified farms on Oahu.

"It used to be a battle against the fruit flies; we had to spray insecticides about once a week," says Aloun Farms crop-care manager Joseph Liu Man Hin. "With this program, we've had a 60- to 70-percent reduction in chemical use, and we are growing more different crops than ever."

Around Waimea on the Big Island, growers have been able to reduce melon fly infestation from 30 percent to 5 percent, while cutting organophosphate insecticide use by more than 75 percent.

"ARS showed me how to do the basics; now I'm refining the program," says Earl Yamamoto, who owns B.E.S.T. Farm and grows peppers and melon crops. Since getting control of fruit flies with the HAW-FLYPM program, he is now experimenting with blueberries and has added zucchini and persimmons.

Persimmons are a popular fruit crop in Hawaii, but many orchards were abandoned as fruit fly problems got worse. Now, trees are being planted again, and harvests are increasing.

Yamamoto, who has participated in the program for 2-1/2 years, says crop damage from fruit flies has gone down by at least 65 percent and profits have increased, thanks to the ARS fruit fly suppression tactics. "It's going very well," he says.

Waimea grower Mineo Honda had been planting one or two crops of zucchini each winter when the price was high. When fruit fly populations would begin to build up, he would abandon zucchini production, since the profits would drop off. But after adopting the HAW-FLYPM program, Honda has taken to growing zucchini continuously. Throughout the spring and summer, fruit fly populations in his fields stayed very low, and the crop stayed profitable even when market prices slid.

Honda is extremely satisfied with the HAW-FLYPM program, and boxes of his produce now bear a stamp that reads "Pesticide Free."

HDOA is excited about the potential that the fruit fly program is opening up for the state. "If you don't have to take fruit flies into account, it means suddenly we have a lot of fallow land that could be brought into agricultural production," says Lyle Wong, administrator of HDOA's Plant Industry Division.

"Hawaii could be become more self-sufficient in food production, there would be more employment possibilities, and agriculture would be a stronger economic engine."

Wong is so satisfied with the HAW-FLYPM program's early success, he is starting to dream about it growing into an eradication program. "Then a whole world of valuable export markets could open up," he says.

STEPHEN AUSMUS (K11008-1)

A tiny wasp, *Biosteres arisanus*, is a natural enemy of the oriental fruit fly. As part of the biological component of the areawide pest management program, center director Dennis Gonsalves (left) and Roger Vargas expose fly-infested guavas to the wasps.

One For the Environment

ARS research associate Grant Uchida and ARS ecologist Hannah Revis have been looking at the effect of the lures, traps, and baits used in the HAW-FLYPM program on native Hawaiian fruit fly species.

Hawaii's many native fruit flies are an essential part of the local ecology, and ARS wanted to be sure the control methods it is recommending do not create a risk for them.

After looking at hundreds of samples, they concluded that the lures are species-specific enough that few nontarget fruit flies enter the traps and so don't encounter the toxic bait, says Revis.

"Especially when you compare the technologies ARS has put together for this program with the impact of using organophosphates, there is no significant risk to the Hawaiian ecology," Revis says.

STEPHEN AUSMUS (K11009-1)

Helping community members suppress fruit flies is a major goal of the fruit fly management program. Here, Roger Vargas (far right) points out differences between oriental and melon fruit flies to (from left to right) William Kaye, Carolyn Lancaster, and Michael Sumja during a workshop in North Kohala.

The HAW-FLYPM program is truly beginning to fulfill its promise. New cooperators are joining the program each year, and other farmers are starting to use the pest management plan just from observing their neighbors as news of the program's successes has spread.

The team is moving aggressively to take advantage of this momentum and expand the program. ARS has committed an additional 2 years of funding to ensure the program will become self-sustaining.

That's the real key: "Growers seeing enough profit in terms of salable crops and in being more environmentally friendly that the program just makes good sense to them," explains Vargas.—By **J. Kim Kaplan,** ARS.

This research is part of Plant Protection and Quarantine, an ARS National Program (#304) described on the World Wide Web at www.nps.ars.usda.gov.

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Gardeners Help Farmers

Hawaiian senior citizens who garden are starting to help the state's farmers solve a big pest problem—controlling four tiny exotic fruit fly species that devastate the harvest for every grower.

ARS is leading a cooperative effort in Hawaii to suppress Mediterranean, oriental, melon, and Malaysian fruit flies that can lay eggs in and damage more than 400 fruits and vegetables, many of which are raised by backyard gardeners as well as commercial farmers.

The complex of techniques that the Hawaii Area Wide Fruit Fly Integrated Pest Management program is using to achieve control of the fruit flies depends more on areawide suppression than on each farm solving the problem for itself.

But backyard gardens can act as reservoirs in which fruit flies can survive and build populations back up—in effect creating a never-ending cycle for growers, large and small, even when farmers in an area do a good job of controlling fruit flies.

So ARS researcher Hanna Revis meets with the Kohala Senior Citizens Club, many of whom are avid gardeners. She didn't have to work very hard to convince the members to try the fruit fly control methods, which center on sanitation—removing fruit and vegetables when they fall—and traps to monitor fruit fly numbers.

"My garden is on family land, and when my mother had her garden there, it was tradition to bring food that you grew whenever you called on a friend or neighbor," explains 67-year-old Lucy Pasco. "But with the fruit flies, it has been hard to grow things to give and for my family to eat. So of course I'm willing to give this program a try."

To begin with, ARS researchers and technicians are placing and checking the monitoring traps to study how well the control program works in the backyard garden. But the idea is that the gardeners will also act as demonstrators, so their neighbors will be willing to start doing fruit fly control too.

"Eventually though, the goal is to have an effective system that is friendly enough and inexpensive enough that gardeners all over Hawaii will use it," says Revis. "Then we really will have an areawide control program that will keep exotic fruit flies under control."—By **J. Kim Kaplan,** ARS.

STEPHEN AUSMUS (K11017-1)

Home gardeners like Lucy Pasco (left) are vital to pest management in Hawaii. Ecologist Hannah Revis (right) shows Pasco how to use fruit fly monitoring traps in her garden.