HAWAII'S HATED FROGS

Tiny invaders raise a big ruckus

BY JANET RALOFF

Puerto Rico's beloved mascot is a miniature tree frog named for its distinctive call: ko-KEE. All night long, choirs of love-starved males serenade would-be mates, who respond with quiet guttural chuckles. "To me, it's pleasant—just like birds singing," says Bryan Brunner, a University of Puerto Rico plant breeder in Mayaguez. "Here, everybody loves the coquies." And legend has it, he says, that coquies—native only to Puerto Rico—die of sadness when removed from their island.

Hawaiians are lamenting that that fable isn't true.

In the mid-1980s, potted plants from the Caribbean began arriving in Honolulu carrying frogs. Some were 5-centimeter-long coquies (*Eleutherodactylus coqui*), and others, a quieter and even tinier cousin, the greenhouse frog (*Eleutherodactylus planirostris*). These stowaways reveled in their new setting: a largely amphibian-free land with a bountiful smorgasbord of insects, tiny spiders, mites, and other delectables—and no snakes, tarantulas, or other natural predators.

TINY IMMIGRANTS— Adult coqui (left) and greenhouse frog (right) may be small, but their arrival in Hawaii has unleashed a big furor.

USGS/HEAR PROJECT

By the end of 1998, seven populations of coquies had established themselves on the Big Island of Hawaii, recalls Earl Campbell of the Fish and Wildlife Service (FWS) in Honolulu. And the number has rocketed. "We now have over 400 populations on the Big Island," reports Campbell, the FWS Pacific Basin coordinator for invasive-species issues. He also notes a few coqui outposts on Maui, Kauai, and Oahu.

Local wildlife-protection officials have no trouble recognizing new coqui populations. On the Big Island, public officials receive about 10 complaints a day from homeowners who, unlike Puerto Rican residents, get fed up with the racket, notes Tim J. Ohashi of the Department of Agriculture's Wildlife Services Branch in Honolulu.

A backyard full of the frogs can reach 70 to 90 decibels—the volume of moderate-to-heavy street traffic or the din in neighborhoods along aircraft takeoff and landing corridors. Indeed, 75 decibels is the maximum sound volume that people can encounter at work throughout their careers without risking hearing loss (*SN: 5/22/82, p. 347*).

Hawaiians aren't used to such nighttime noise. "Because we don't have lots of calling insects, if you go to where the frogs aren't at night, it's dead quiet," observes herpetologist William J. Mautz of the University of Hawaii at Hilo. "Then enter an area with a big infestation, and you hit this wall of sound."

But it's not only the noise that has federal officials up in arms. The proliferating coqui and greenhouse frog populations on islands that evolved in the absence of amphibians threaten to overwhelm native ecosystems. That's why USDA has teamed up with the State of Hawaii and FWS to control—and, if possible, eradicate—the tiny hoppers.

The scientists are developing tools, including caffeinated sprays and scalding showers, for holding back what they see as an advancing plague of frogs.

HOPPING HATCHLINGS For the many frogs and toads that spend their youths as tadpoles, early survival and development depend on access to water in which they can swim and feed. But for members of *Eleutherodactylus*, the world's largest genus of vertebrates, young emerge from the egg or from Mom as tiny, fully formed frogs. This opens up a broader range of habitats than is available to tadpoles. Water-soaked moss decorating a potted plant will do, as will the humid packaging around plants, or a spoonful of water cupped in the leaf of an ornamental bromeliad.

Eggs, which coquies and greenhouse frogs lay on the soil, are hard to detect. Normally, male coquies guard their eggs for 2 to 3 weeks—not to fend off predators so much as to keep them moist, explains ecologist Larry Woolbright of Siena College in Loudonville, N.Y. Like a sponge, Dad's underbelly efficiently absorbs water and then releases it onto the eggs. But fatherless eggs could survive transit to Hawaii if they're attached to damp plant material, he says.

At hatching, baby coquies are green and only 5 millimeters long, about the size of a rice grain. Because they're nocturnal and don't begin bellowing their telltale serenades until they're about a year old, the youngsters tend to remain undetected, Woolbright says.

The frogs' catholic tastes facilitate their integration into the Hawaiian environment. After sleeping under leaf litter all day, the tiny amphibians come out after dark to dine. Some stay near the ground, while others ascend into a tree's canopy. Then they sit patiently and await the arrival of the evening's entrees—insects or any other small creature that crawls within pouncing range.

Hawaii's other Caribbean intruders, the greenhouse frogs, also concern scientists. So far, they've conducted relatively few studies of those quiet immigrants, which have proved difficult to find and count.

Though coquies invaded Florida roughly a century ago, they haven't spread far there, Campbell notes, probably because they had plenty of competitors for food and shelter.

But in Hawaii, he observes, "we don't have as many creatures as do ecosystems on the mainland, so we still have a lot of what people might term open niches." When the coquies and greenhouse frogs arrived, they set claim to one such niche.

BEYOND THE RACKET During mating season—which can run year round, depending on the climate—crooning males from ground to treetops produce a three-dimensional fog of sound. To drown it out at bedtime, many Hawaiians run air conditioners as a source of white noise. Others don earplugs.

It's gotten so bad, Ohashi notes, that realtors have been forced to disclose the presence of coquies on listed properties, much as they would evidence of termites, water damage, or structural flaws.

But of even bigger concern to USDA and Hawaii's Department of Agriculture is the frogs' economic threat to Hawaiian plant growers, notes Ohashi's colleague Will Pitt at USDA's Wildlife Services research center in Hilo. Sales of orchids and other tropical plants amount to a huge export industry. Buyers on the Hawaiian islands that are still free of coquies and greenhouse frogs are now rejecting some potted plants grown on the Big Island. It may not be long, Pitt speculates, before the frog scare affects foreign trade or plant shipments to the U.S. mainland. Any impact on Hawaii's $80-million-per-year cut-flower-export industry would be especially troublesome.

GOTCHA! — Fairly indiscriminate diners, coquies will eat almost anything, like this bug, that enters their range.

Rather than simply imposing a quarantine on plants in frog-infested areas of Hawaii, Pitt says, government agencies want to offer growers tools for coping with the problem. The proposed arsenal is remarkably low-tech.

"We started, about 2 years ago, looking at trapping—hand captures—but it was not at all effective," says Pitt.

So, Campbell, who was then with USDA, began screening off-the-shelf agents that might poison the frogs without harming their environment. "I started by looking at insecticides for use on ornamentals, probably 20 to 25 compounds," he says. None killed frogs at permitted application rates.

Then Campbell heard that acetaminophen—the active ingredient in Tylenol—works as a poison to control the invasive brown tree snake on Guam (*SN: 8/10/02, p. 85*). He redirected his attention to over-the-counter drugs and food additives. Again, the results were abysmal—until he tested a popular formulation for staying awake that contains caffeine. In Campbell's lab, coqui and greenhouse frogs died quickly after being sprayed with a 2-percent-caffeine solution, which contains a far higher concentration of caffeine than coffee does.

KILLING THEM SOFTLY Because caffeine has never been federally approved as a pesticide, the State of Hawaii had to petition the Environmental Protection Agency for permission to experiment outdoors with the antifrog stimulant. The agency granted the state permission to try a 2-percent-caffeine solution as an experimental pesticide spray for 1 year.

Pitt says that tests on small plots of infested greenery proved that the spray is indeed "an effective frogicide, if you will." Best of all, he says, caffeine exhibited "very few impacts on other, nontarget organisms." For instance, insect populations in sprayed plots declined a bit, but within a week had returned to normal. The tests turned up another potential benefit. Garden slugs, the bane of the orchid industry, rose to the surface of treated soils and died (*http://sciencenews.org/20020706/food.asp*).

In September, the temporary EPA permission for testing expired. USDA has now applied for a 3-year extension to conduct further research that might eventually lead to caffeine's federal approval as a frog-control agent.

"But we don't want to limit ourselves to one tool," Pitt says, so his laboratory has continued testing other unusual candidate frogicides. It recently uncovered one that's so safe a food product that EPA doesn't regulate it. It's citric acid, the primary constituent of lemon juice.

Preliminary tests, begun in August, used a citric-acid formulation roughly comparable to double-strength lemon juice. The spray isn't quite as potent as caffeine for killing frogs, Pitt told *Science News*. Nevertheless, early data on citric acid "look very promising," he says, "and we see very little impact on plants."

In July, the *Honolulu Star Bulletin* reported that the Hawaii Department of Agriculture had found that hydrated lime, the powder used to reduce the acidity of soil, also kills frogs. Ohashi confirms this, but he points out that hydrated lime couldn't legally be used against frogs unless it were to receive federal approval as a pesticide. And that's unlikely, he adds. Manufacturers don't view as worthwhile the prospect of carrying out the necessary safety and efficacy testing, he explains, "because they make enough money selling it for its currently labeled use."

Pitt says that plant growers might also resist lime because it can leave a white residue on treated plants. "If you're an orchid grower selling $200 or $300 plants, a little leaf spotting may not be acceptable," he says.

Finally, several research centers are investigating an experimental nursery technique to prevent the spread of frogs in potted plants. Ed Brodie of Hawaii's Division of Forestry and Wildlife in Hilo, for instance, has fine-tuned an $11,000 computer-controlled device that sprays hot water onto a few potted plants at a time to kill pests. A 3-minute spray of 46.5°C (116°F) water kills any coquies and greenhouse frogs present. As a bonus, he says, the treatment kills geckos, centipedes, and about everything else in the soil except ants.

Brodie's lab includes a nursery for endangered and native plants. Over the past 3 years, workers there have treated up to 1,000 plants a day with the hot-water spray. The only downside so far is that orchid blooms wilt, but the rest of the plant remains healthy.

CLOCK IS TICKING Other than noise pollution, the frogs' effect on Hawaii is hard to characterize, Campbell says. Ordinarily, scientists gauge environmental impacts by comparing before-and-after data on species in a region invaded by an alien. In Hawaii, however, there's little pre-invasion data for most areas now infested with coquies and greenhouse frogs.

However, the overwhelming numbers of frogs in those areas

R. CAULDWELL

convince Mautz that "there will be impacts," he says. He's particularly concerned about the frogs' consuming insects now available to birds.

Woolbright agrees. His surveys of 20-m-square forest plots in Puerto Rico have turned up an average coqui concentration of about 2 per square meter. But more important, he says, is the number of reproductively mature adults. Typically, a 4-night survey logs 40 adults in a 20-by-20-m plot.

This summer, he set up similar plots in Hawaii. During one 4-night census, "we got 200 adults in one plot," he told *Science News*.

The abundance of coquies in Hawaii probably traces to a lack of predators. Woolbright says that Puerto Rican coquies are a dietary staple of rats, screech owls, cuckoos, snakes, tarantulas, and many others. During a typical night's survey of his plots in Puerto Rico, six to eight coqui predators show up. "In our plots in Hawaii, we found none," he says.

In Hawaii, "I estimate that about 200 kilograms of arthropods [such as insects and spiders] per hectare per year go to feed the frogs," Mautz says. "So, you now have an invader that's suddenly commanding a huge piece of the whole food chain." The open question is, he says, Whose dinner are coquies stealing?

The greenhouse frogs raise additional concerns. They frequently turn up where coquies have settled, although their numbers appear relatively small. Campbell notes that this quiet species could be amassing big colonies without anyone knowing it.

"But what actually scares me the most about the frogs being here," Mautz says," is that they'll be food for other invading animals. . . . If we have this huge food base of frogs, it will be a paradise found for invading snakes." Hawaiian ecologists have long scouted for invading brown tree snakes, which occasionally stow away on planes landing in Honolulu.

FROG LOVER — In their native Puerto Rico, coqui populations are held in check by a broad range of predators—including this whip scorpion, which has a body the size of a quarter, an arm span the diameter of a salad plate, and no tail.

LARRY WOOLBRIGHT

In theory, it's not too late to think about eradicating coquies, Mautz contends. They could easily be hunted down. Even now, there are only several hundred reported populations, some with just a few isolated animals. He estimates that the frogs cover only about 1,000 acres statewide.

"If true," he maintains, "you could apply a scorched-earth policy to [routing] them" with caffeine or citric acid. Then again, he concedes, getting the political will to cut through the environmental red tape for such dramatic action would be difficult.

Stall too long, Mautz warns, and it may be too late to do anything but learn to live with the noisy immigrants. "The way I see it," he says, "we've only got 5 years, maybe 10."

Indeed, Woolbright says, "I see no quick, clean, and easy way to remove these frogs from sensitive island habitats like Hawaii." Start unleashing poisons, even one as mild as caffeine, and things could get ecologically messy, he worries.

In the end, he suspects, "this just might turn out to be a situation where [Hawaiians] will have to grin and bear it." ■

MEETINGS

The American Society of Hematology
Philadelphia, Pa.
December 6–10

CANCER

Protein vaccine slows leukemia

By injecting leukemia patients with part of a protein found in greater abundance on cancerous cells than on healthy ones, researchers have been able to induce some patients' immune systems to fight this blood cancer.

Jeffrey J. Molldrem of the University of Texas M.D. Anderson Cancer Center in Houston and his colleagues fashioned the cancer vaccine from a piece of proteinase 3, a compound overproduced by malignant blood cells in leukemia patients. Earlier research suggested that the piece, called PRI, stimulates production of immune system T cells that specifically target proteinase 3.

Molldrem's group identified 15 patients with leukemia that had resisted other treatment. Each patient received three PRI injections, each separated by 3 weeks. In five people, the leukemia went into remission and their T cells showed a strong attraction to the leukemia cells. Three other patients in the group showed partial responses.

Molldrem and his colleagues are now testing the vaccine in 60 more leukemia patients. —N.S.

ANEMIA

Getting the iron out

While transfusions are lifesavers for many anemia patients, they introduce excess iron into recipients. This overload can damage the liver, pancreas, and heart. A new pill that reverses this process may vastly improve the lives of anemia patients, a new study shows.

The standard drug for removing iron from the body is deferoxamine mesylate. It chemically captures, or chelates, excess iron but must be given intravenously or by injection. The chief problem with deferoxamine mesylate therapy is that patients sometimes skip treatments, notes Stanley L. Schrier of Stanford University. A pill-based alternative would presumably be easier for patients to follow.

The new medication, now designated as ICL670, binds to excess iron, and these complexes ultimately leave the body in the feces. Researchers in Italy compared deferoxamine mesylate with ICL670 in 71 patients with an average age of 25. The participants had a hereditary form of anemia called thalassemia that required them to get transfusions every 3 weeks. They had been receiving deferoxamine mesylate via a needle drip placed under the skin for 8 hours a night, 5 nights a week.

Periodic testing of iron content in the patients' blood and liver over a year showed that ICL670 cleared transfusion-caused iron overload as well as deferoxamine mesylate did, says study coauthor Antonio Piga of Turin University.

If the work is confirmed, ICL670 "would represent a major clinical advance for patients with sickle-cell [anemia]" and others who need regular blood transfusions, says Ronald Hoffman of the University of Illinois Medical Center in Chicago. —N.S.