

Strangers in Paradise

Alien species disrupt the ecology of Hawaii

By CAROL EZZELL

Hawaii is Earth's most isolated archipelago. For 70 million years, newcomers to this chain of islands had to fly or float to reach their new home. Ecologists estimate that a new species arrived in Hawaii from afar only once every 100,000 years, when a bird got blown off its migratory course or when plant debris washed ashore from the nearest continental landmass roughly 2,500 miles away.

That leisurely pace of immigration gave Hawaii's existing residents plenty of time to recover from the ecological shock of new arrivals and to adapt to life alongside them. For example, last year researchers reported genetic evidence that the silversword — a dramatic Hawaiian plant with gray-green, saber-like leaves — evolved from the homely California tarweed, probably borne to Hawaii tens of thousands of years ago as a seed in the feathers or gut of a bird (SN: 4/27/91, p.264). With the arrival of the Polynesians 1,500 years ago, however, this incremental immigration picked up speed.

Today, it has become a full-scale alien invasion. Floods of tourists and the capacious cargo holds of ships and jetliners offer easy paths to paradise for hitchhiking plants, animals, and insects. Bird-eating snakes curl up in the wheel wells of airplanes arriving from Guam, only to slither out into the rain forest once the plane lands. Seeds from exotic ornamental plants imported by well-meaning homeowners jump backyard fences to disperse and take root in dry forestland already disrupted by human habitation. Exotic insects emerge from the wrappers of tourists' carry-on snacks and end up noshing on the vulnerable moths that pollinate some of Hawaii's distinctive flora.

Aliens are also smuggled into the state, despite regulations against importing many non-indigenous animals, such as snakes and carnivorous fish. Hawaii's agricultural officials and postmasters report numerous instances in which packages labeled "Fragile: Handle with Care" turn out to contain someone's prospective pet python or piranha, mailed from a pet store on the mainland.

Ecologists are now finding that the stepped-up influx of alien species has far outstripped the Hawaiian ecosystem's ability to deal with such change. By

eating, competing with, or changing the habitat of native species, alien wildlife and plants disrupt the intricate, interdependent network of Hawaii's flora and fauna — 10,000 species of which exist nowhere else on Earth.

Hawaii's diversity draws tourists, provides sources of new medicines, and yields plant species that agricultural researchers can cross with existing crops to give them new characteristics, such as resistance to specific diseases or pests. Although some of Hawaii's native species — such as its huge array of insects — may not at first seem important to preserve, ecologists caution that they know so little about Hawaii's ecology that they often cannot predict which species is expendable and which is not. As more and more species disappear, they add,

the remaining ones become even more vulnerable to extinction because of the changing habitat.

Hawaii is particularly unprepared for some alien species — such as tree snakes, rats, and Argentine ants — because the islands have no native snakes or ants and only one native land mammal, a cave-dwelling bat. Such aliens "have the capacity to undo all other conservation efforts in Hawaii," says Francis G. Howarth of the Bishop Museum in Honolulu. "Alien species are a major cause of extinctions here," he adds.

Accordingly, scientists have boosted their efforts to understand and counter the effects of introduced species, which can gain footholds following habitat-devastating natural disasters such as last September's Hurricane Iniki. They have

Looks can be deceiving. Although pretty, this alien flowering vine — called banana poka — is strangling thousands of acres of native Hawaiian forest.



Carol Ezzell

also joined with environmental groups to apply pressure to strengthen state and federal measures to stem the tide of exotic invaders (see p.316).

Alien insects present especially serious problems for Hawaii's ecosystem, in part because they disrupt the normal interdependence of particular insects and plants. For example, most of the 354 species of fruit fly, or *Drosophila*, discovered in Hawaii only lay their eggs on the fruits or vegetation of specific plants, says Hampton L. Carson of the University of Hawaii in Honolulu.

Many of these fruit flies — particularly the so-called picture-wing species, each of which has a characteristic pattern of dark splotches on its wings — are now rare, in part because of predation by the western yellow-jacket wasp, *Vespa pennsylvanica*. Since its inadvertent introduction in 1981, this alien marauder has decimated native *Drosophila* populations, methodically stripping off their wings and sucking out their fruit-sweetened bodily fluids, Carson says.

Because the fruit flies existed for eons with few predators — and accordingly had the opportunity to thrive and develop into hundreds of species — Carson says they provide a near-perfect means for researchers to retrace the steps of the



The cannibal snail, *Euglandina rosea*, first introduced to eradicate an agricultural pest, now threatens native Hawaiian tree snails.

Hadfield

evolutionary process. "They give us clues to evolutionary change, which is of worldwide importance," he asserts. "The Hawaiian *Drosophila* are one of the best data sets we have anywhere in the world."

Carson adds that the fruit flies may play an important role in the Hawaiian ecosystem because their larvae eat decaying fruit and plant matter, helping to recycle forest nutrients. Some of the fruit flies might also act as pollinators, he says.

Of the 2,500 species of Arthropoda — the phylum of invertebrates that includes insects —

currently in Hawaii, roughly 600 were introduced by humans, says Howarth. Lloyd L. Loope of the Haleakala National Park on Hawaii's island of Maui and his colleagues have studied one of the most voracious newcomers, the Argentine ant, *Iridomyrmex humilis*.

The Argentine ant "eats every insect it can, including pollinators," says Loope. At the joint annual meeting of the American Institute of Biological Sciences and the Ecological Society of America in Honolulu last August, Loope discussed the results and implications of a study he and colleagues conducted on the detrimental effects of the Argentine ant.

Loope and Haleakala National Park coworker Arthur C. Medeiros teamed up with F. Russell Cole and William W. Zuehlke of Colby College in Waterville, Maine, to sample insect populations in three shrubby areas on the western slope of the relatively dormant Haleakala volcano, the highest peak on Maui. They set out 55 partially buried "pitfall" traps — large jars filled with an automobile antifreeze solution — and returned after two weeks to count the insects captured and preserved. They also recorded the insect species present under 622 rocks.

Loope says he and his colleagues captured many fewer species of native insects than expected in areas in which they caught large numbers of Argentine ants. Moreover, he says, they found that other alien insects were more prevalent at sites that had lots of ants, suggesting that the ants pave the way for further alien invasions. The researchers present a detailed description of their study in the August *ECOLOGY*.

"If this ant spreads, it's going to decimate the native fauna wherever it goes," Loope predicts. Because the Argentine ant eats insects that pollinate many of Haleakala's native plants, its presence could indirectly lead to the eradication of the only native plants that can exist at high elevations, he says. His team also has evidence that the ants are usurping the ecosystem's normal top-of-the-food-chain predators — wolf spiders and carabid beetles — an event that may allow populations of native and alien insects

In the wake of Hurricane Iniki

The devastating fury of Hurricane Iniki, which swept Hawaii's island of Kauai last September, may both benefit and harm ecosystems already disrupted by invasions of alien organisms.

While Iniki's driving rain and sustained winds of 130 miles per hour flattened houses and toppled telephone poles, they also destroyed vast stretches of dry forest on Kauai, says environmental entomologist Adam Asquith of the University of Hawaii's Kauai Research Station in Kapaa. Asquith says the hurricane wiped out stands of *Acacia koa* — a hardwood tree prized for its strong, amber-colored timber — on Kauai's southwest quadrant.

"It looks as if the canyons [between the island's long-dormant volcanoes] acted as wind funnels," Asquith told *SCIENCE NEWS*. "Lots of trees and other vegetation are down."

Asquith says this destruction might accelerate the growth of two alien plant species that have recently gained footholds on Kauai: wild blackberry and a creeping vine called banana poka, which is notorious for strangling *A. koa*. Such alien plants thrive in areas where native vegetation has been disrupted. Blackberry and banana poka already pervade parts of Kauai damaged by Hurricane Iwa in 1982, Asquith says.

However, Hurricane Iniki seems to have spared the rain forests, which are home to Kauai's spectacular bird species — many of which are endangered or threatened with extinction — according to Asquith. "I don't think any [bird species] are restricted to dry forest, the areas that were most heavily hit," he says.

In fact, Asquith says, Hurricane Iniki might even benefit the Kauai bird population over the short term by providing new food sources for insects that eat fallen trees and leaf litter. "Once these insect populations start increasing, there might be an increase in food supply for the birds," he projects.

Over the long term, however, Asquith fears Hurricane Iniki will have a harmful effect on Kauai's ecology. In particular, he is concerned about the destruction of existing patches of a creeping, goldenrod-like shrub called po'ola nui that grows only on Kauai. This shrub, which is already in danger of extinction, hosts native flies from the genus *Tephritidae*. The extremely rare flies lay their eggs on the po'ola nui plant, forming galls that may keep the plant growing laterally, an adaptive advantage that allows the shrub to spread. If the shrub disappears, Asquith says, the flies will not be far behind.

— C. Ezzell

further down the food chain to grow unchecked.

Some of the most destructive alien species were introduced to the Hawaiian islands intentionally. Michael G. Hadfield and Stephen E. Miller of the University of Hawaii's Kewalo Marine Laboratory in Honolulu are studying the fate of spectacularly striped Oahu tree snails from the genus *Achatinella* following the introduction of the cannibal snail, *Euglandina rosea*.

In the 1950s, ecologists imported the cannibal snail from Florida to the Hawaiian island of Oahu in an attempt to control another alien species, the giant African snail (*Achatina fulica*), a garden pest. However, when the carnivorous snails arrived, they turned out to prefer the taste of native *Achatinellae* to that of the African pests they were intended to eradicate.

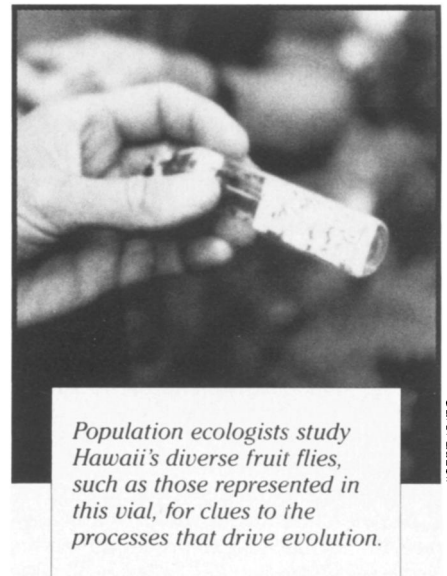
"[Cannibal snails] are devouring the last of the Oahu tree snail species," Hadfield warned the August ecology conference. Of the 41 species of Oahu tree snails recorded since 1900, he says, "only 19 or 20 at the very best" remain. And

many of the remaining species, he adds, are represented by fewer than 100 individuals.

Rats, whose ancestors traveled to Hawaii on 18th century ships, also prey on the Oahu tree snails, Hadfield says. He adds that shell collectors and the increasing development of Oahu have further contributed to their decline.

Alien species don't have to be predators. They can disrupt established ecosystems if they meet at least one of three other criteria, according to Peter M. Vitousek of Stanford University. He writes in the February 1990 *Oikos* that invaders that alter the food chain, acquire or use resources differently than native species, or change fundamental characteristics of the ecosystem will have detrimental effects on native flora and fauna.

One of Vitousek's colleagues, Carla M. D'Antonio of the University of California, Berkeley, reported last August that alien grasses in particular fulfill the last condition. At the August ecology conference, she discussed the fire-promoting dangers in Hawaii of grasses originating from



Carol Ezzell

Population ecologists study Hawaii's diverse fruit flies, such as those represented in this vial, for clues to the processes that drive evolution.

Africa or North America.

These alien grasses, such as the beard grass, *Schizachyrium condensatum*, now constitute 93 percent of the standing dead biomass in Hawaiian dry forests, D'Antonio says. Between 1920 and 1967—about the time the grass was introduced to Hawaii by ranchers or imported livestock—the islands experienced only 27 major fires, each covering an average of four hectares. In contrast, between 1967 and 1989, Hawaii's forests were swept by 58 large fires, each covering more than 200 hectares. D'Antonio attributes the surge in fire incidence and damage to the tinder-box qualities of *S. condensatum*.

What's worse, she says, alien grasses recover from a fire more quickly than do native plant species and effectively choke them out. This disruption, in turn, increases the ecosystem's vulnerability to further alien invasion. One of these secondary alien species, molasses grass (*Melinis minutiflora*), is even more fire-prone than *S. condensatum* because it burns even in a slightly moist environment, says D'Antonio. The presence of molasses grass therefore increases the likelihood that a particular stretch of land will burn a second time.

Furthermore, "these sites don't appear to recover," says D'Antonio. She notes that, on average, previously burned areas contain one-tenth the number of native species that unburned regions do. Fires also deplete nitrogen from Hawaii's already nitrogen-poor soils, she adds, so twice-burned areas have only roughly half the usual amount of this important plant nutrient.

The end result of this alien grass invasion is the conversion of the Hawaiian dry forest—the home of many birds and pharmaceutical-bearing plants found nowhere else on Earth—into treeless, grassy savannas swept periodically by

There ought to be a law

If Hawaii's native flora and fauna are in trouble, you can be sure Hawaii's delegation to the U.S. Congress knows it. Three pieces of federal legislation to protect the Hawaiian ecosystem passed during the congressional session that ended Oct. 8, and staff aides are preparing another for introduction during the next Congress, which begins in January.

One of the pieces of legislation—the Alien Species Prevention and Enforcement Act—was folded at the last minute into the fiscal year 1993 combined spending bill for the Department of the Treasury and the U.S. Postal Service and has already been signed into law by President Bush. The alien species provision directs postal service employees to investigate any Hawaii-bound mail they suspect contains alien plants or animals. It also strengthens the ability of federal and state agencies to work together in catching individuals who bring alien plants and animals into Hawaii.

"Little by little, we're throwing an alien species safety net around the Hawaiian islands," says Margaret Cummsky, an aide to Senator Daniel K. Inouye (D-Hawaii), a cosponsor of the original alien species bill.

Yukio Kitagawa, chairman of Hawaii's agriculture department, calls the new law "a major breakthrough for preventing harmful alien species from entering our islands." He says the law implements some of the recommendations

made in a report on the Hawaiian alien species problem released last August by the Nature Conservancy of Hawaii and the Natural Resources Defense Council's local branch (SN: 8/15/92, p.101).

Congress also passed the Hawaii Tropical Forest Recovery Act, which would allow Hawaii to tap the resources of federally funded international tropical forestry programs. In addition, the lawmakers established a humpback whale sanctuary in Hawaii as part of an omnibus bill authorizing several international fishing agreements.

Next year, members of the Hawaiian delegation plan to introduce the Hawaiian Native Ecosystem Act, a bill that would implement a "10-point action plan" drafted last year by the Hawaii State Department of Land and Natural Resources, the U.S. Fish and Wildlife Service, and the Nature Conservancy of Hawaii. The agencies' recommendations include calls for incentives to encourage private landowners to protect native species, new programs to increase the public's awareness of extinctions and the dangers of alien species, and increased funding for conservation programs.

The congressional Office of Technology Assessment is preparing a report on non-indigenous species in the United States that will highlight some of Hawaii's unique problems. Study director Phyllis Windle says the report is scheduled for release next spring. — C. Ezzell

wildfires, D'Antonio concludes.

Pigs are one of the oldest habitat-disrupting alien species in Hawaii. First brought to the Hawaiian islands by the Polynesians, the pig's proclivity for eating bark and roots has wrought major damage to many areas, according to David Foote of the Hawaii Volcanoes National Park on the island of Hawaii.

Foote and U.S. National Park Service colleagues Charles P. Stone and Linda W. Cuddihy have studied the ecological effects of exclosures — areas surrounded by pig-proof fences — in Volcanoes National Park. The park contains many species-rich enclaves, called kipukas, that exist between the fingers of recent lava flows.

Foote told the August ecology conference that exclosures built in kipukas during the early 1980s contain more species of native arthropods and fewer species of alien arthropods than do similar exclosures constructed two years ago. He attributed the difference to the elimination of feral pigs, which uproot large tree ferns and gnaw the bark of hardwood trees, killing and toppling them. This, in turn, exposes the forest floor to more sunlight, which can disrupt the entire forest ecosystem.

Foote's group found that only one ge-

nus of native arthropods — damselflies — benefited from the presence of pigs. The delicate insects thrived in the more recent exclosures, the researchers discovered, by taking advantage of water-filled pig wallows as sites for laying eggs.

Further studies of the effects of feral pig populations and other alien species are among the seven goals of the Hawaii Conservation Biology Initiative, a project organized by the Nature Conservancy of Hawaii in Honolulu and initially funded by a \$500,000 grant from the John D. and Catherine T. MacArthur Foundation. The initiative — drafted by representatives from 19 universities, federal and state agencies, environmental groups, and botanical gardens — seeks to coordinate ecological research in Hawaii.

"There's a great deal of research being done," says one of the initiative's chief organizers, Colin Bassett of the Nature Conservancy of Hawaii and the University of Hawaii. "But even more is needed if we're going to understand and protect the unique ecosystems here," he says.

Besides feral pig research, the initiative aims to stimulate studies of alien plant species, native forest birds, the ecology of rare native plants and animals, and the vegetation dynamics of selected plant communities. It also plans to facilitate the monitoring of native and alien

organisms, as well as studies of the best ways to restore Hawaii's ecosystems to a "self-sustaining, natural condition," according to an outline of research priorities.

Patrick Dunn, an ecologist at the Nature Conservancy of Hawaii, says the initiative will dispense money for a small number of "seed" grants to get researchers started on enterprising projects — especially those that cut across academic disciplines. Initiative administrators will then help such researchers obtain further funding from government and private organizations.

The initiative plans a system of biological field stations throughout the Hawaiian islands to serve as outposts for researchers working in the field. Two such stations have already been built — at Pelekunu on the island of Molokai and in the Haleakala National Park on Maui. The initiative also has established a Secretariat for Conservation Biology at the University of Hawaii to organize scientific conferences and serve as ongoing headquarters for the project.

Dunn hopes the research initiative will help target studies in areas useful to conservation managers, the keepers of Hawaii's great diversity. "Managers are faced every day with the possibility of species going extinct," he says. "The threat is tremendous, but we expect [the initiative] to make a real difference." □

Letters continued from p.307

other; but shapes and positions (which are shown relatively accurately on the much-maligned Mercator projection) may well be easier to remember than sizes.

It might be interesting to see how people do with a blank globe.

Chris Keavney
Arlington, Mass.

The adoption of the area-preserving Robinson projection by NATIONAL GEOGRAPHIC is appropriate to our era, in which the extent of real estate owned is a primary concern. Other eras have had other considerations, however, and the Mercator projection should be recognized for what it was intended to (and admirably did) provide — namely the courses of constant compass settings as straight lines.

Such lines, when viewed on a globe, spiral away from one pole and toward the other.

Until 30 years ago, it was routine for ships to use such courses, set by hand and adjusted once or twice a day, to piece together geodesic or shortest-arc routes across oceans. Now, the compass setting of a perfect geodesic can be changed continuously in real time by an on-board computer.

Stephen Eberhart
Northridge, Calif.

I offer an alternative to Eurocentrism as the reason that most of the students' maps featured Europe in the middle. Instead, "terra-centrism" may be responsible.

From our perspective as a land-dwelling species, it makes more sense to cut the map through oceans and leave continents intact. Such a cut must logically go through either the

Atlantic or the Pacific Ocean. While I agree that most people will tend to place their home turf near the center of the world, this is impossible for dwellers of the Americas (or of India and central Asia) to do without cutting directly through the land mass on the opposite side of the globe. Thus if we are to maintain continental integrity, we are forced to accept our home turf in an off-center position. Eurocentrism may actually be an artifact of preferring to put the smaller ocean (the Atlantic) at the center of the map.

Student mapmakers may not be conscious of such considerations, but the cartographers whose maps grace classroom walls may well find them important.

Lynne M. Clos
Boulder, Colo.

Average accuracy

Regarding "Body temperature: Don't look for 98.6°F" (SN: 9/26/92, p.196), Wunderlich's original measurements, which took into account variability among individuals and even time of day, were in degrees Celsius. The average temperature was quoted only to the nearest degree: 37°C. Whoever first converted that to Fahrenheit converted to the nearest tenth of a degree, thereby implying tremendous accuracy.

Two-digit accuracy is all that 37°C implied, meaning that the average temperature was between 36.5°C and 37.5°C. These numbers convert to 97.7°F and 99.5°F. It would have been more accurate to say that average body temperature is 98°F or 99°F and await the recent million measurements to refine that to 98.2°F.

Allen E. Staver
DeKalb, Ill.

Aha...

GAMES FOR THINKERS

An exciting, new way to learn creative problem solving! Games designed by university professors improve thinking skills using fun, strategy and challenging competition. Like chess, each game can be played at many levels from young children to intelligent adults. Fascinating for everyone!

Write for free catalog and studies that show how WFF 'N PROOF Games can:

- double math achievement
- cut school absenteeism by 2/3 and
- raise I.Q. scores by 20 points

ORDER YOUR GAMES FOR THINKERS TODAY!

WFF 'N PROOF (logic).....\$27.50*
 QUERIES 'N THEORIES (sci. method) ..27.50*
 EQUATIONS (creative mathematics)...22.50*
 ON-SETS (set theory).....22.50*
 ON-WORDS (word structures).....22.50*
 PROPAGANDA (social studies).....22.50*
 CONFIGURATIONS (geometry).....12.50*

Complete 7-game Special.....**\$150.00**

All prices include postage and handling.
 Satisfaction Guaranteed

Order from **WFF 'N PROOF**
 1490-HV South Blvd., Ann Arbor, MI 48104-4699