

Price: \$5.00

This Little Piggy...

I t may star in GEICO commercials and be featured in children's nursery rhymes, but in Hawai'i's forests, there's nothing funny or cute about *Sus scrofa*, the wild pig that does more damage to Hawai'i's native ecosystems than any other animal in the islands.

And if anyone harbored doubts about it, they only had to sit through a few of the many presentations at the recent convention of The Wildlife Society, held last month on the Big Island. Pigs directly tear up trees and the forest floor. They create hospitable environments for mosquito larvae, completing the vector cycle for malaria and possibly other parasites. They spread seeds of invasive plants, such as waiawi, that threaten native forests. And, to top it off, they have, in hunters, a vocal and powerful lobby in the halls of government.

To be sure, other culprits in the demise of Hawaiian forest birds and their habitat are out there: cats, rats, sheep, goats, and deer among the worst of them.

But if only the pig could – oh, go to market! Stay home! Eat roast beef or have none – somewhere else!

IN THIS ISSUE

2

The Honeycreeper Family Tree; Earthstars; OTEC

3 Board Talk: Wildlife Rule Changes; Malama Solomon Gets a Pass

5

Hogs Gone Wild: A Growing Problem Throughout U.S.

6

Feral Cats: A Conundrum For Wildlife Managers

11

Rat Lungworm Disease: Has A New-to-Hawaiʻi Mollusk Made it Worse?

Hawai'i's Imperiled Species Receive National Attention at Wildlife Convention

Last month, The Wildlife Society, a national association made up mostly of specialists in the area of wildlife research and management, held its annual convention at the Waikoloa resort, on the Big Island.

Over the four days of discussions and symposia connected with the meeting, some of the most respected names in Hawai'i biology took to the lectern, providing a largely mainland audience with their perspectives on what it will take to conserve and restore Hawai'i's unique fauna—birds, of course, but also monk seals and humpback whales, bats, snails, and other invertebrates.

During one of the two plenary sessions, William Aila, head of the Department of Land and Natural Resources, made a moving plea for the need to control game animals, taking note of Governor Abercrombie's recent watershed initiative. "We have to control ungulates. Fencing and removal of ungulates, especially in watersheds, is a major part of our plan going forward," Aila said. "We have made a conscious decision that in priority watersheds, we are going to double the amount of fencing and protection."

Fencing, removal of introduced game species, and restoration of habitat for native wildlife was an undercurrent in nearly all of the talks by Hawai'i presenters. In a few cases, their reports on recent research broke new ground. For the most part, they simply tried to carry the message of Hawai'i's dire straits to an audience generally unaware of its problems. And they did so often with an eloquence and strength not usually found in dry academic discussions.

We present highlights here:

* * *

Lowland Bird Populations May Be Developing Malaria Tolerance

A vian malaria, one of the scourges of Hawaiian forest birds, is a major reason why they are found so rarely in lowland forests. For years, it was generally thought that birds could only survive above the socalled "mosquito line" – elevations above which mosquitoes, which carry the disease, do not thrive.

But a few years ago, in connection with a major survey of biological complexity in the islands, Carter Atkinson and colleagues with the U. S. Geological Survey, Pacific Island Ecosystems Research Center were finding more Hawai'i 'amakihi (*Hemignathus virens*



'Amakihi (Hemignathus virens virens)

virens) at low elevations than at high sites. "We were amazed," Atkinson told a crowded meeting room at the conference.

"We were capturing 'amakihi at rates to page 6



NEW AND NOTEWORTHY

Rewriting the Family Tree: In a development made possible only with the latest techniques in DNA sequencing, researchers at the Smithsonian Conservation Biology Institute's Center for Conservation and Evolutionary Genetics have tracked down the ancestor of Hawaiian honeycreepers, those birds that present such an amazing example of adaptive radiation.

And the result?

The Hawaiian birds trace back to a Eurasian rosefinch - and not, as had been widely thought, a North American or European finch.

Authors Heather Lerner, Matthias Meyer, Helen James, Michael Hofreiter, and Robert Fleischer published their findings in Current Biology. Their conclusions were based on analysis of mitochondrial DNA from 47 bird taxa, including 19 honeycreepers that still exist or are recently extinct.

The ancestral colonists arrived in the Hawaiian islands sometime between 7.2 million years ago (mya) and 5.8 mya, but not until a couple of million years later, with the emergence of O'ahu,

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did adaptive radiation really take off. This "burst" occurred, the authors wrote, during "a time period that encompasses the formation of O'ahu, yet precedes the formation of Maui Nui." Six of 10 major "morphological lineages" evolved during this time frame, while only two evolved after. This, they write, "emphasizes the importance of the formation of O'ahu, more so than Maui Nui, to the present-day morphological diversity of Hawaiian honeycreepers.... O'ahu, as a newly formed island initially without avian residents, likely provided a blank slate allowing ecological and morphological differentiation."

As to the mechanism by which the initial colonizers arrived, the authors note that rosefinches "often move in large mixed-sex groups to new wintering grounds" in a behavior called "irruption." "It is possible that colonization by the ancestral species was aided by the arrival of a large mixed-sex flock in the islands, representing a sizable gene pool. Thus, a diverse initial gene pool may have facilitated speciation and the evolution of extreme morphological diversity in the honeycreeper radiation."

Earthstars in Hawai'i: Some of the prettiest plants in Hawai'i are also among the most obscure. In the fall 2011 edition of *Pacific Science*, Don Hemmes, recently retired from the University of Hawai'i at Hilo Department of Biology, and Dennis Desjardin, of the Biology Department at San Francisco State University, describe the results of surveys over the last 15 years that looked for earthstars - tiny fungi that produce spores within a shell that splits open to release them, forming star-like patterns.

Their article, "Earthstars (Gaestrum, Myriostoma) of the Hawaiian Islands Including Two New Species..." describes the 17 previously known species and adds descriptions of two more.

If you want to find some on your own, the best months to do so are from September through February, typically the wetter months in Hawai'i. Look in the duff under ironwood trees along coasts, in the koa haole thickets above Lanikai, in

Quote of the Month

"Hawai'i is feeding its native forests to escaped barnyard animals."

— Sheila Conant



Gaestrum litchiforme Desjardin & Hemmes in ironwood duff. The white scale bar (lower-left corner) equals 1 cm.

the dry kiawe groves at Puako, or at higher elevations, including the 'ohi'a-koa forests at Koke'e on Kaua'i, or even in forested kipukas along the Saddle Road of the Big Island.

NELHA Tries Again on OTEC: The board of directors of the Natural Energy Laboratory of Hawai'i Authority has approved the proposal of a company based in Baltimore to develop an oceanthermal energy conversion plant at the NELHA facility near the Kona-Keahole airport. The company, OTEC International (OTI), LLC, was one of four to respond to a request for information put out by NELHA in September.

In reviews by NELHA staff as well as the NELHA board's research advisory committee, OTI received top scores. But certain issues still need to be ironed out before the company gets the final go-ahead. At the board's meeting last month, NELHA executive director Greg Barbour described how the demand for deep seawater by the OTEC plant may not be met without shorting existing NELHA tenants who use the water for everything from abalone aquaculture to desalinated bottled water products.

"The next step is for us to begin negotiations immediately," Barbour said. "We would like to come back to the board with more detailed findings and hopefully a proposal ... at the next board meeting," scheduled for January.

OTI is already in negotiations with Hawaiian Electric for a power purchase agreement to cover production from an offshore 100-megawatt OTEC plant proposed near Kahe Point, Oʻahu.

According to Barry Cole, executive vice president of OTI, the NELHA plant will be a demonstration plant "to reduce risk for its first full-scale commercial project." Still, he said, it is still intended to produce more power than it consumes.

BOARD TALK Proposed Changes to Wildlife Rules May Prevent Rogue Introductions



Axis deer

Under rules proposed by the state Department of Land and Natural Resources' Division of Forestry and Wildlife, transporting or releasing introduced wildlife without a permit would be a petty misdemeanor.

In addition to a minimum fine of \$100, the Board of Land and Natural Resources could charge up to \$10,000 for administrative costs, damages, and/or remediation.

Repeat offenders could face more than \$26,000 in penalties. If convicted of a petty misdemeanor, violators could also be sentenced to up to 30 days in jail.

Prompted by the confirmation this year that axis deer now roam parts of the Big Island, DOFAW has proposed new administrative rules to prevent future introductions of potentially harmful species.

A loophole in the division's current rules allows the transfer of non-native wildlife between private lands, according to DOFAW administrator Paul Conry. The rules prohibit the release of injurious wildlife into the wild and their transport to areas "where they are not already established and living in a wild state." Injurious wildlife means any species or subspecies "except game birds and game mammals, which is known to be harmful to agriculture, aquaculture, indigenous wildlife or plants, or constitute a nuisance or health hazard" and is included in DOFAW 's list of injurious wildlife.

"[M] any very harmful species are not currently listed as injurious and the rules do not currently prohibit the introduction, transport, or release of those species," a DOFAW report to the Land Board states.

"For instance, non-native axis deer are established on Maui, Moloka'i, and Lana'i, where they are well documented to cause significant environmental damage. ... [I]t is suspected that their presence [on the Big Island] is the result of the purposeful introduction of those species," the report states.

It adds that mongoose, which are absent from Kaua'i, are not on DOFAW 's list of injurious wildlife. Given the potential impact to indigenous bird species on the island, the report states, the rules "alarmingly" do not are not already established" — created yet another loophole.

In testimony, Mary Ikagawa, who works with the O'ahu Invasive Species Committee, wrote that the language was "an invitation to spread disease and parasites to existing populations."

"Under this draft rule, if some Big Island hunter finds a valley on Moloka'i with really big pigs that he thinks would improve the Big Island stock near his house, can he bring pigs from Moloka'i to the Big Island since feral pigs are already established there?" she wrote.

Volcano resident Patrick Conant, an entomologist, recommended that DOFAW develop an island-by-island list of injurious wildlife. And biologist Rick Warshauer, also from Volcano, asked the division to specifically designate axis deer and black-tailed deer as injurious wildlife.

"All species of wild ungulates in Hawai'i cause ecological and agricultural damage on all islands they occur on. There is no good reason to move them intra-island or between mountains inter-island. ... If a species of wild ungulate does not occur on that island or is incipient there, it should be on the list for that island," Conant wrote in his testimony, submitted in late October.

Conant and Warshauer also recommended that DOFAW : 1) make it illegal to hold or harbor introduced species; 2) remove axis and black-tailed deer from its lists of regulated game mammals to allow hunters to take as many of the animals as they want; 3) increase the proposed penalties; and 4) delete a condition in the existing rules that allows game control on large parcels (300+ acres)

"As we have seen with the decades-long courtordered efforts to eradicate mouflon from Mauna Kea, public hunting, even when matched with unmotivated staff hunting, is ineffectual at control." — **Rick Warshauer**

prevent the introduction of mongoose.

To address such loopholes, DOFAW added several animals, including the mongoose, to the list of injurious wildlife.

With regard to game mammals, the proposed rules would allow their introduction with the proper permits. DOFAW plans to strike the exception for game birds and mammals from the definition of injurious wildlife and add to its list "even-toed ungulates, except for game mammals."

To address the release of game mammals, DOFAW added a new section that would ban the unpermitted release of any introduced wildlife where it is not already established. But to some, the qualification — "where they "only when it has been determined that public hunting is not a reasonable and appropriate method of control."

"As we have seen with the decades-long court-ordered efforts to eradicate mouflon from Mauna Kea, public hunting, even when matched with unmotivated staff hunting, is ineffectual at control," Warshauer wrote.

The Land Board was to vote on DOFAW's request to hold public hearings on the proposed rules on October 28, but had to defer the matter until November. The reason given was that the description of the item on the published agenda had been too vague.

At the Land Board's November 11 meeting, DOFAW amended its proposed rules to address some of the concerns raised, deleting all existing and proposed language regarding introductions where introduced/injurious species are already established.

"It was pointed out to us that we should prohibit the release of introduced species anywhere. We agree with that," DOFAW biologist Scott Fretz told the board.

Conry said it is possible to obtain a permit from the Land Board (or its authorized representative), or the state departments of Agriculture or Health to release introduced species.

Maui Land Board member Jerry Edlao asked whether the rules prohibited breeding introduced animals, noting that on his island, "they're breeding axis deer for hunting."

Fretz replied that his division doesn't regulate game mammals on private lands.

The board unanimously approved DOFAW's request to hold public hearings on the proposed rules.

333

Senator May Escape Fine For Trespass, Damages

n late October, the Land Board fined a Lhandful of men \$300 to \$400 each for possessing alcohol at Kane'ohe Bay's 'Ahu O Laka sandbar during Labor Day weekend. The board based the fines on administrative costs incurred by its Division of Conservation and Resources Enforcement.

The department must, at the very least,



cover its costs in violation cases, Maui board member Jerry Edlao stressed at the time. When it came to

state Sen. Malama Solomon's trespass on and damage to unencumbered state lands on the Big Is-

Sen. Malama Solomon

land, however, the board applied no such standard.

In August, Solomon - vice chair of the Senate Committee on Water, Land and Housing — hired a bulldozer operator to grub agricultural lands she owns in North Kona for a planned breadfruit farm.

The operator crossed unencumbered state land to get to her property, damaging a historic cart path and other archaeological features along the way, according to a report by the Department of Land and Natural Resources' Land Division.

Responding to an August 30 complaint by



A view of the walls lining the historic cart path damaged by Sen. Malama Solomon's contractor.

a neighbor, staff from the DLNR's Na Ala Hele program and State Historic Preservation Division (SHPD) inspected the site, as did the department's land deputy, Guy Kaulukukui.

In his October 28 report to the Land Board, Big Island Land Division agent Kevin Moore stated that bulldozing an access route over unencumbered state land would have required an environmental assessment and a Finding of No Significant Impact.

"The EA process would likely have identified the archaeological sites and avoided the results that occurred in this case," he wrote.

Under Hawai'i Revised Statutes, the Land Board has the ability to impose a fine of \$5,000 per violation on public lands as well as administrative costs and damages. In addition to seven violations of historic preservation laws, the Land Division found that Solomon's contractor incurred two violations of statutes relating to public lands: 1) driving a motor vehicle outside a designated road or path; and 2) damaging archaeological features.

The Land Board clearly had the authority to impose a fine, Moore wrote. Because Solomon had been cooperative during the investigation and committed to restoration, he recommended only that the board require her to remediate the damaged sites, which spanned both public and private property, within six months and in accordance with a corrective action plan approved by SHPD. He added that the Land Board reserved the right to impose a fine should the restoration not be "timely completed" to the satisfaction of SHPD.

Solomon explained to the Land Board

that there was "some confusion on the part of my contractor [Warren Matsumoto] and myself" regarding whether or not the path used was a public access road.

"They didn't know who had jurisdiction. ... They moved the pohaku [rocks] so they could get into the 'aina. It was never our intention to blatantly destroy the wall," she said, referring to one of the damaged sites.

She added that she was never instructed to preserve the sites on her property.

Since the incident, she has planted a barrier around a house site on her property.

"It's really kind of small kine," she said of the damages.

Kaulukukui agreed somewhat. He told the Land Board that the wall that had been damaged was "unremarkable."

"It's the kind of wall I could build myself. There were two rock mounds that were impacted, no more than one row high. There was an interior habitation wall on state land that was impacted. One place where the wall already was disturbed, the makai side was disturbed by the bulldozer. I would tend to concur that we weren't talking about remarkable features," he said.

The Land Board unanimously and with very little discussion approved Moore's recommendation.

Last month, Edlao, while discussing a proposed \$18,000 settlement for coral damage around Molokini (see below), again hammered on the need for the DLNR to recover its administrative costs.

When asked his thoughts on the board's decision not to fine Solomon, he said he went along with it because remediating the site will take "time and money on her part." He also

reminded *Environment Hawai'i* that should Solomon fail to remediate the damage within six months, "she will be back with a fine *and* administrative costs."

\$ \$ \$

Land Board Grants Hearings For New Legacy Land Rules

Last month, representatives from local land trusts lauded the DLNR for drafting rules to govern its Legacy Land Conservation Program, which, for the past several years, has funded the purchase of thousands of acres of lands and conservation easements throughout the state.

Some of the standards to be imposed on conservation agencies, however, may be a little too strict, they said. Under the rules as proposed, a nonprofit land conservation organization must obtain a conservation easement over any land bought with Legacy Land funds. What's more, the organization must be accredited.

There is currently only one accrediting agency in the nation, the Land Trust Accreditation Commission, and only one accredited land trust in Hawai'i: the Hawaiian Islands Land Trust, which is the merger of the Hawai'i Island, O'ahu, and Maui Coastal land trusts. determine the status of any resource values protected under the terms of the grant agreement," and may require it to submit reports, photos, or other supporting documents.

Annual monitoring and reporting should be required, not optional, Bonar told the Land Board. "These are critical to our credibility," he said, adding that nonprofit land conservation organizations are required by the Internal Revenue Service to do monitoring and reporting.

Rather than amending the draft rules to reflect the concerns raised, the Land Board voted to send them out for public hearings as DOFAW proposed.

<u>ی</u> کی DOD School Stays At Kulani, For Now

The state Department of Defense's Youth ChalleNGe Academy may remain at the former Kulani prison site for a while longer. In late 2010, after the prison closed, the Land Board decided to add most of the land — some 6,000 acres — to the Pu'u Maka'ala Natural Area Reserve. The remaining 600 or so acres would go to the DOD to be used for a military-style camp for troubled youth.

The state Legislature later decided that the

"We don't want to draft rules that have a chilling effect." — Doug Cole, North Shore Community Land Trust

"The challenge is this may have unintended consequences," said Mark Fox, director of external affairs for The Nature Conservancy of Hawai"i. Directors of the Moloka"i and North Shore Community land trusts echoed his concerns.

Although TNCH may soon receive its own accreditation, the process is long and expensive, said Dale Bonar, executive director of the Hawaiian Island Land Trust.

"It's a big hurdle," he said.

"We don't want to draft rules that have a chilling effect," added Doug Cole of the North Shore Community Land Trust.

To ease matters, the state could develop its own accreditation process, said Paul Conry, administrator for the DLNR's Division of Forestry and Wildlife, which administers the Legacy Land program.

With regard to ensuring that lands or easements purchased are conserved in perpetuity, Bonar said he thought the draft rules weren't strict enough.

The rules state that the DLNR may monitor the awardee of Legacy Land funds "to prison site should remain with the Department of Public Services for use as a prison.

With the DPS currently without adequate funds to reopen the Kulani prison, the Land Board, at its October 28 meeting, approved a request by the DOD for a permit to continue running its academy there until it can find a new site.

The board also rejected contested case hearing requests from Michael Kumukauoha Lee, the Community Alliance on Prisons, and DMZ-Hawai'i/Aloha'Aina regarding the Land Board's 2010 decision.

<u>\$</u> \$ \$

DOFAW to Charge Hourly Fee For Conservation Plan Review

The DLNR's Division of Forestry and Wildlife may now charge \$50 an hour for any work related to habitat conservation plans (HCP). With any HCP application, the division will discuss with the applicant the estimated processing time, DOFAW biologist Scott Fretz told the Land Board at its October 28 meeting. The board unanimously approved the fee.

The amount of time spent on a given application will be by mutual agreement with the applicant, Fretz said. "We modeled this off similar rules set up by [the Department of Business, Economic Development, and Tourism's] renewable energy division. They were doing similar technical work."

The fees will enter a trust fund that might eventually allow the division to hire additional staff, he said. A representative from Maui's Kaheawa Wind Power supported the idea and said similar fees are not uncommon on the mainland.

"It's nice to see the department covering expenses for a change," said Maui board member Jerry Edlao.

At its November meeting, the Land Board approved incidental take licenses and habitat conservation plans for wind power projects on Maui and O'ahu.

The license and plan for the proposed 21-megawatt Kaheawa Wind Power II project on Maui cover the take of the Hawaiian petrel, the Newell's shearwater, nene or the Hawaiian goose, and the Hawaiian hoary bat.

O'ahu's Kawailoa Wind Power project, expected to produce 70 MW, may affect the bat and shearwater, as well as four species of endangered Hawaiian waterbirds.

\$ \$ \$

Molokini Coral Damage Nets \$19,000 Fine

The Land Board has finally closed the book on a 2008 violation case involving damages to 121 coral colonies that occurred when a sailboat ran aground at the islet of Molokini off Maui.

The DLNR's Division of Aquatic Resources recommended that the owners of the *Maka Kai* be allowed to apply a \$18,000 fine toward coral reef educational and outreach projects.

After a heated discussion about whether or not \$3,183 in administrative costs were included in the \$18,000 settlement amount, the board voted to impose an additional fine of \$1,000. Maui Land Board member Jerry Edlao, who wanted the full \$3,183 added, was the sole dissenter.

Hogs Gone Wild: A Growing Problem Throughout the Continental United States

Blue states and red states were the subject of a talk by Jack Mayer of the Savannah River National Laboratory in Aiken, South Carolina.

But Mayer wasn't discussing partisan politics. Rather, he was discussing the spread of wild pigs. On a large map displayed behind the podium as Mayer spoke to a crowd at The Wildlife Society's annual convention last month, held in Waikoloa, states (including Hawai'i) with established populations of wild pigs were colored in red. Those in blue had wild pigs numbering in the hundreds or thousands in some counties. The handful of northern states colored in yellow don't – yet – have known populations of free-ranging wild pigs, Mayer said. They included Alaska, Montana, Maryland, Connecticut, Vermont, and Maine.

Today's map represents a progression, Mayer said. "The states in yellow are where states in blue were in the 1980s. And the states in blue are where the red states were in the early 1990s," he said. The message? "Take the wild pig situation very seriously," he warned.

To judge by the standing-room-only crowd in the conference room, wildlife managers from across the country, as well as in Hawai'i, are already doing just that.

As an example of how rapidly wild pigs can spread, Mayer cited the case of Oklahoma. "In 1982, wild pigs were found only in a couple of counties in the southeastern part of the state," he said. According to one estimate, they numbered in the hundreds, maybe even up to 1,000, Mayer said. Authorities at the time considered the population stable to decreasing, and, he said, they assumed deer hunters would take care of the pigs.

Twenty-five years later, the southeastern part of the state had pig densities of 64 or more per square mile, but there remained three Oklahoma counties with no pigs, Mayer added. Four years later, and wild pigs are in every county. "We currently estimate there are half a million wild pigs in Oklahoma – maybe as many as 1.4 million," he said.

The same scenario played out in Michigan, which is still colored in blue on Mayer's map – though perhaps not for long. The first report of a wild pig was made in 1986, he said, but it took more than a decade for state officials to become concerned about the problem. Today, he said, 65 of 83 counties in Michigan have wild pigs.

In the 1980s, the total wild-pig population

in the continental United States was estimated at between 500,000 and 1 million. But, he noted, "some of those estimates were pretty sketchy." The good news, he said, "is that many of the statewide estimates have improved. The bad news is that the numbers have gone up, to between 3 million and 8 million wild pigs in 2011."

In that same time interval, he went on to say, wild pigs "have become the second most popular big game animal in North America," which poses a "conundrum: one of the worst invasive species on the planet is also one of the most popular game mammals on the planet, on every continent except Antarctica."

Their spread northward in the United States was not an altogether natural expansion of their range, he noted. "Hunters who wanted to hunt premier game animals but didn't want to drive south figured out something: all they had to do was trap pigs and move them north. Or, if they didn't want to trap them, they could purchase them from people who did."

"It's completely illegal, but that hasn't stopped anyone."

Once pigs become established, they're difficult to contain. When it comes to their reproductive potential, he said, "nothing else their size or larger can compete with the pig in its ability to crank out babies." Not only do they start young, females can produce two litters a year, and continue to produce piglets for the rest of their long (ten years or more) natural lives.

Wildlife from page 1

five times higher than the capture rates at high-elevation sites," he said. "Also, they had extremely high prevalences of malaria," reaching a rate of up to 90 percent at one site.

He compared that to the mid-1990s, when no 'amakihi were detected at any of the 90 stations surveyed in the Puna district of the Big Island. A decade later, 75 'amakihi were found at 37 of the stations – "a significant increase in the numbers," he noted. "Since then, we have evidence this population is expanding toward Hilo. There's been some change in the birds' ability to deal with malaria infections."

But the good news does not end with 'amakihi. Researchers are finding that another one of the more common forest birds, the 'apapane (*Himatone sanguinea*), is present at lower elevations on O'ahu and Moloka'i, where it also shows a high prevalence of malarial infection. In the Big Island districts of Puna and South Kona, the prevalence of malaria among 'apapane can run as high as 100 percent among low-elevation populations of the bird.

"On Kaua'i, the prevalence of malaria is as high as 40 percent" among 'amakihi, he said.

" 'Elepaio [*Chasiempis sandwichensis*] may also be showing similar disease patterns," Atkinson said, "with a high prevalence of infections."

"It's good news about the more common species," he said, but for rarer species, "it's more problematic."

"A lot of what we're seeing may depend on genetic diversity," he added. "But do these fewer birds still have sufficient genetic diversity?"

To confirm the 'amakihi's tolerance to malaria, Atkinson and colleagues exposed uninfected birds from both high- and lowelevation sites to malaria. "There was a dramatic difference," he said. "We lost two low-elevation birds, but over half of the high-elevation birds died." Other differences emerged as well. The high-elevation birds exposed to malaria suffered more from depressed appetite than did those from low elevations, which consumed as much food as birds in the healthy control population. Also, he said, the physiological effects of disease were much less severe in the lowelevation group.

"The results support the idea that lowelevation birds have some physiological tolerance to malaria," he said, related to an increased ability to survive the disease.

"Disease tolerance may have appeared in lower Puna," he continued, "because of abundant low-elevation habitat and high selective pressure by the parasite. There were also large, connected source populations across an elevational gradient, plus there is very high genetic diversity in 'amakihi."

Geneticists, he said, found the low-elevation birds were genetically distinct from their high-elevation counterparts. "But," he went on to say, "when compared to museum specimens collected 100 years ago there's only one way you can interpret this



A feral pig stands next to a fallen tree fern.

One of the difficulties in dealing with the growing problem is the lack of uniform regulations. "This is not a plan for success in a national crisis," Mayer said. "Are they invasive? Should we talk about eradication or damage control? Should we make sport hunting illegal everywhere?" he asked. "It's time to make a decision."

Michael Bodenchuk of the U.S. Department of Agriculture's wildlife services office in

— those birds were always there in low numbers at these sites; they simply expanded from relic populations." Or, as Atkinson and his colleague Dennis LaPointe, also with USGS, wrote in a 2009 article in *The Journal of Avian Medicine and Surgery*, "the recent resurgence of these birds originated from pockets of surviving individuals with some natural disease resistance, rather than recolonization of the lowlands by high-elevation birds."

As to why the lower-elevation populations may have developed this resistance while those in the higher elevations did not, Atkinson and his colleagues put forward an explanation in their 2009 article: "With transmission occurring year-round at lower elevations, and low-elevation populations not being continually diluted by emigrating, highly susceptible juvenile birds from high elevations, it might be predicted that disease resistance would first appear here. This suggests that disease resistance may subsequently spread over the next few decades, with eventual recovery of mid-elevaSan Antonio spoke of the damage wild pigs do to natural resources and agriculture. "They're a train wreck – just one thing slamming into another," he said.

They damage crops: "Each day, they have to consume 3 to 5 percent of their body weight." They've virtually eliminated the Texas peanut industry, he noted, and through their rooting damage, they have reduced harvests of corn and hay. They

tion populations of the more resistant species."

And while that is good news for 'amakihi, it may not be for those less common birds. "There is concern that threatened and endangered species may not have sufficient genetic variability to adapt to these diseases," they write.

The question now for resource managers is whether it may be possible to undertake actions that will enhance the birds' disease tolerance.

Above all else, Atkinson said, "we have to preserve existing diversity, then manage habitats to maximize demographic variables, especially at lower elevations." In their article, Atkinson and LaPointe stress the importance of managing mid-level habitats to reduce mosquito breeding areas. "Feral pigs and other ungulates can create larval habitat ... and their removal through fencing and control programs may significantly reduce mosquito habitat, particularly on Kilauea and Mauna Loa Volcanoes ... where volcanic soils are porous and carry disease to domestic livestock. They can contaminate produce with pathogens such as *E. coli*, leptospirosis, and toxoplasmosis. Sheep and goat production areas can lose up to 40 percent of lambs to predation by wild pigs, he noted.

The total damage to Texas agriculture, he said, ranges from between \$80 and \$828 for each wild hog. Hunting alone cannot begin to control the pigs, he said: "Aerial gunning is the most cost-effective control measure."

Billy Higgenbotham, with the Texas A&M Extension Service, told the audience of his plan to eradicate wild pigs: "I've got the answer, and we could do it tomorrow," he said. "Institute a two-hog limit and a two-day season, and we'd poach 'em off the face of the Earth."

But constrained to legal removal methods – shooting, trapping, snaring, and catching with dogs – "all you're going to do is manage pigs," he said, not reduce their numbers.

For landowners and wildlife managers, Higgenbotham recommended trapping – "a process, not an event." He outlined his approach to corral traps, which includes a long, patient process of baiting and monitoring. (For more, see: <u>http://feralhogs.tamu.edu</u>.)

The process is effective, he said. In Texas, ranchers and farmers using traps remove nearly half a million hogs a year. As an added boon, in Texas, at least, the wild pigs can be sold, live, allowing ranchers to recover some part of their costs, he noted. — *P.T.*

streams and natural bodies of water are rare."

In addition, they write, "there will likely be an important place for vaccines and chemotherapy for management of avian pox and malaria during translocation or release of captive birds or management of small populations of critically endangered forest birds," although such treatments are not now available.

\$ \$ \$

The 'Worst Vector' And Its Partner

Dennis LaPointe, an ecologist with the U.S. Geological Survey in Hawai'i, has been studying mosquitoes and avian malaria for years, and in his view, *Culex quinquefasciatus*, the first mosquito to hit Hawai'i's shores, is "the worst vector of [avian] malaria in the world."

But if the mosquito were here without

pigs, chances are good that the overall health of Hawai'i's forest birds would be much improved. To cause the damage that avian malaria and avian pox have wrought, the mosquitos needed water.

"Water is key to the vector," LaPointe said, "polluted, organic-rich water." But on Mauna Loa, standing water is in short supply, what with the porous volcanic substrate and no streams or suitable bodies of water to speak of.

"Pigs love the rainforest." — Dennis LaPointe

Enter the pig. Not the small Polynesian pig, which Hawaiians brought with them when they colonized the islands and which, according to accounts of early visitors, rarely weighed more than 50 or 60 pounds. No, it required the much larger European pig, introduced in 1785 by Captain Cook and in multiple subsequent visits by any number of ship captains. As Quentin Tomich writes in his *Mammals in Hawai'i*, "The old Polynesian type of *Sus scrofa* has been absorbed or replaced by stocks of European origin." The result is that "the feral Hawaiian pig of today is typically like the Eurasian wild boar."

"Pigs love the rainforest," LaPointe noted in his presentation. "They're particularly fond of tree ferns, whose starchy core is a favorite food of pigs." The pigs knock down the ferns and root out hollows to reach the core, in the process creating cavities. Rain collects in the cavities, where mosquito larvae can mature.

What LaPointe and his colleagues set out to determine, in the early 2000s, was whether, absent the pigs, mosquitoes would find sufficient larval habitat to allow the malarial cycle to continue. Hunters defending their sport claim pigs alone aren't responsible for the standing water.

"So we looked at the disease across a broad landscape of windward [eastern] Mauna Loa," he said. They set up study sites in wet, closedcanopy 'ohi'a forests, where both pigs and tree ferns typically occur.

"We found a direct relationship between the relative abundance of pigs and the abundance of tree fern cavities," he said. Where pigs are controlled, he continued, "there were no tree fern cavities... Tree fern cavities are *not* the result of natural decay or rodent feeding."

In addition, his team began monitoring mosquito populations by trapping. "The highest capture rates," he said, were found at Cooper Center, in Volcano Village. There, he said, "pig-created tree fern cavities are the dominant available larval mosquito habitat."

Until the pigs are gone or, at least, their numbers are significantly reduced, Hawai'i forest birds will continue to be at risk for disease. According to LaPointe, "you have to depress current pig abundance by at least 80 percent" before the birds are released from the impact of disease.

There could be one other factor at work, however. LaPointe noted that in 2002, the

mosquito Aedes japonicus arrived on Hawai'i island and is now in all the same areas as Culex. Ae. Japonicus "cannot vector avian malaria," LaPointe said. "We don't know if it's driving the abundance of Culex down, but it would sure be nice to hope so."

Everything has its downside, though. While an increase in *Aedes japonicus* might knock back *Culex quinquefasciatus, Ae. japonicus* is itself a possible vector of avipoxvirus, Japanese encephalitis, and West Nile virus, which can cause disease in both humans and birds.

* * *

'Elepaio Moving Up in the World

Wildlife biologist Eric VanderWerfhas been studying the O'ahu 'elepaio for years and has watched its numbers decline dramatically. Since 1970, he told members of The Wildlife Society, it has seen a 75 percent decline in its range, which is now highly fragmented. Its overall population has declined as well, and is now thought to number no more than around 1,500 birds.

One of the greatest threats to the 'elepaio is the black rat, which can take the birds from their nests at all life stages: eggs, juveniles, and incubating females. For this reason, he said, rat control is a primary tool in protecting 'elepaio populations from further decline. With control, the population growth rate is positive at 1.1 (with 1 equal to a stable population). Without it, the growth rate is below 1.

But, he continued, "only a fraction of the remaining populations are being managed" with efforts to control the rats.

One of the reasons why 'elepaio are so vulnerable, VanderWerf explained, was the fact that their nests tend to be low to the ground.

"But nowadays, their nests seem to be higher," he said. He compiled data on



'Elepaio

recent nest heights, "and sure enough," he said, "the average nest height is rising." From an average of eight meters in 1996 it has soared to about 12 meters in more recent years. "Elepaio are choosing larger trees," he said.

There were two possible mechanisms to explain the change, he said: individual birds are learning that a higher nest is better and are adjusting nest height accordingly; or nest height is evolving through natural selection.

VanderWerf tested the first hypothesis by looking at the nest height of individual birds and found nothing to suggest that the birds were actually learning that higher nests were better.

He then looked at the success rates of lower nests and found that those lower than three meters "always failed or were abandoned," he said.

Over time, the proportion of lower nests (below three meters) was decreasing, while nest success increased.

The most likely conclusion, VanderWerf said, is that nest height among 'elepaio is evolving through natural selection.

How high will it go?

Most nests below three meters, VanderWerf noted, are being eliminated – suggesting that this is about as high as rats go. "The average height probably will not get much higher than it is right now," he said.

<u>*</u> * *

Forests as Fodder

S heila Conant's sadness and indignation were palpable. In an overview of the dire situation that Hawai'i's native plants and animals are facing, Conant, an expert in the subject of endangered birds, talked about her personal experience: "I've seen living members of seven bird species now extinct," she noted. "And I'm not yet 100 years old!" The line drew a laugh from the audience, but there was not much other humor in her talk to The Wildlife Society.

The examples of adaptive radiation

found in Hawai'i "are unsurpassed," she said — and are found in all manner of creatures and plants. "The silversword alliance — there are more than 30 different species. Spectacular plants," she told the crowd.

"Hawaiian tree snails — just 14 of 40 Achatinella survive. They're going down rapidly because of introduced predators and other reasons."

She then gave the example of Hawai'i's hyposmocoma moths: "They're not as spectacular as our *Drosophila* [picture-wing flies], but there are over 350 species known, with more being found all the time." They are also one of the few moths that are "scuba divers," going underwater to pursue prey. "Only half a percent of all Lepidoptera have an aquatic stage," she said. The brown tree snake, which has caused the extinction of many native birds on Guam, is another potential predator that keeps Conant up at night: "If we get this, it is just a matter of time before we lose all our small birds."

Conant then addressed the subject of feral ungulates. "Our ecosystems are being transformed by feral ungulates and alien game species."

"Hawai'i," she continued, "is feeding its native forests to escaped barnyard animals" – pigs, sheep, and goats – "and axis deer... Protected by bag limits and hunting seasons, they are managed to provide recreational and limited subsistence hunting for less than one percent of the state's population."

Such practices "profoundly compromise Hawai'i's watersheds – our only source of

"I've seen living members of seven bird species now extinct. And I'm not yet 100 years old!" — Sheila Conant

After a recital of the flora and fauna that help make Hawai'i so special, Conant discussed the reasons for their decline, citing habitat loss due to human activities, invasive predators as well as disease, ecosystem transformation by ungulates, and introduced plants that, while mild-mannered in their home range, quickly become invasive weeds in Hawai'i's hospitable climate.

Of predators, she said, "feral cats are probably the worst thing we've got. They're very difficult to control, and it's politically a very sensitive issue. They're doing a great deal of damage to petrels on this [Hawai'i] island and on Lana'i. I don't even think about mongoose anymore because I see so many feral cats. We need to address the issue in a suitable way."



drinking water and irrigation for our crops, and the last remaining habitat for countless species of unique plants and animals."

"We know what to do," she concluded. "Let's go out there and do it."

* * *

'Funding Bias' Hurts Hawai'i Birds

A frequently heard complaint from many members of Hawai'i's conservation community is that the state, which has such a high percentage of endangered species in the United States, receives such a small share of federal funding for endangered species management and recovery. George Wallace, a vice president of the American Bird Conservancy, elaborated on some of the reasons for the vast abyss between needs and resources.

Hawai'i, Wallace pointed out, has 31 extant species of endangered birds – roughly 70 percent of all endangered bird species in the United States. Yet the average expenditure per species from 2002 to 2006 was 16 percent of what was spent on endangered bird species on the U.S. mainland. (If the enormously expensive captive propagation program for the 'alala is not included, the per-species average expenditures drop down to 10 percent of the mainland per-species expenditures.)

"Why is there such a funding bias?" Wallace asked.

There's the problem of Hawai'i's re-

moteness from the mainland and the lack of awareness of the plight of its birds – both here in Hawai'i as well as elsewhere, he noted.

Wallace also cited the lack of "conflict species," where high stakes bring public attention to the endangered animals – such as the spotted owl in the Pacific Northwest. These species, he said, get funding precisely because they generate conflict and much publicity. "It ties the Fish and Wildlife Service up in knots," he said, "and draws a lot of funding and resources" to these species.

Another factor is the limited tax base in Hawai'i. Its relatively small population means that federal funding allocation formulas based on census counts put the state at a distinct disadvantage, Wallace noted.

Also there is the fact that Hawai'i shares borders with no other state, Wallace pointed out. Elsewhere, multiple states might cooperate to address common problems. In Hawai'i, that just doesn't work.

"The pattern is, the highest-funded species tend to be charismatic conflict species, from large states and large ranges," Wallace said. "Underfunded species tend to be island species, or from small states with small ranges."

The upshot, he said, is "a few taxa receive most of the funding."

Wallace then presented some estimates on what recovery of Hawaiian birds might cost over the next 10 years. Fencing, eradication of ungulates, and weed control needed for forest-bird recovery will require an initial expenditure of \$578 million, with upkeep costs of \$32 million a year. Add in waterbirds and seabirds, and the total investment costs rises to between almost \$800 million and \$1 billion.

"We need to set our sights on this," he said. "There's too much at stake not to. We have to keep reinforcing the message that we've already invested a tremendous amount and we need to protect those investments."

While the amount may have prompted some in the audience to gasp, Wallace pointed out that the amount is reasonable, even modest, in light of expenditures for similar recovery efforts undertaken elsewhere. In Chesapeake Bay, for example, federal recovery funds alone came to more than \$1 billion over the span of a decade, he said. In the Great Lakes region, \$5 billion was spent over 10 years, while in the Florida Everglades, \$3.9 billion was spent over 30 years.

"Hawai'i's birds need a national priority restoration initiative, and we need it now," he concluded. — *Patricia Tummons*

Feral Cats: Conundrum for Wildlife Managers

The Waikoloa Hilton parking lot is full of cats. Signs around the lot ask that visitors not feed them, as they are being cared for by AdvoCATS, a Kona group that, according to its website, helps "abandoned and homeless felines." It supports the trap-neuter-return (TNR) approach to stray cat colonies – an approach that involves trapping the cats, neutering them and giving them other veterinary care if needed, and returning them to where they were found.

A few hundred feet away, at the meeting last month of The Wildlife Society inside the hotel, the attitude toward feral cats was somewhat cooler. Earlier this year, the society's governing council approved a position statement on feral and free-ranging domestic cats that supported "the humane elimination of feral cat populations, including feral cat colonies, through adoption into indoor-only homes of eligible cats and humane euthanasia of unadoptable cats."

The society's policy opposes TNR programs as being ineffective in keeping cat populations down, harmful to birds and other wildlife they may prey upon, and as reservoirs of disease – rabies, toxoplasmosis, bartonellosis, typhus, and feline immunodeficiency virus, among others – that can affect humans as well as both domestic and wild animals. In the wild, feral cats can compete with native predators. The Wildlife Society attributes the extinction of at least 33 bird species globally to depredation by feral cats.

"Effects of cat predation and disease spread are most pronounced in island settings (both actual islands and islands of habitat), where populations of wildlife are already low or stressed by other factors," the statement says.

The Humane Society of the United States supports TNR programs, as does the Hawai'i Humane Society. In questionnaires given to candidates for public office in the 2010 November general elections, the HHS asked if they thought "Trap, Neuter and Return and Manage (TNRM) is an effective and humane strategy to reduce feral cat overpopulation." (Governor Neil Abercrombie responded, "Yes.") According to its website, in the last five years, the Hawai'i Humane Society has "helped more than 12,000 feral cats at a cost of over \$250,000 for needed sterilizations."

At last month's TWS convention, a workshop on management of feral cats drew participation from wildlife agencies as well as Inge Gibson of the Humane Society of the U.S.A. Although organizers had feared the event might draw protests from cat fanciers, those fears did not materialize. According to Steve Hess, a biologist with the U.S. Geological Survey's Pacific Island Ecosystem Research Center in Volcano, agency representatives and Gibson agreed to sit down and try to work out where they might find common ground on this contentious subject.

"That's a good exercise in theory," Hess said. "But in Hawai'i, what we have is seabird fall-outs, especially on O'ahu and Kaua'i. Especially in urban areas birds are more likely to fall out, and that's where cat colonies are considered to be okay. That is to me one of the bigger issues."

In addition to preying on fallen seabirds, in Hawai'i, feral cats have preyed on endangered burrowing or ground-nesting birds, such as the 'ua'u (the Hawaiian petrel, *Pterodroma sandwichensis*). They have nearly wiped out whole colonies of 'ua'u kani (wedge-tailed shearwaters, *Puffinus pacificus*) on Maui. In the subalpine mamane forest of Mauna Kea, cats continue to prey on the critically endangered palila (*Loxiodes bailleui*). Toxoplasmosis from cats was implicated in the death of several 'alala (Hawaiian crow, *Corvus hawaiiensis*), and in the deaths of Hawaiian monk seals.

Last month, the American Bird Conservancy called on the nation's mayors to oppose TNR programs and halt any municipal funding in support of the program. According to

For Further Reading

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• The Wildlife Society position statement:

http://joomla.wildlife.org/ (Click on the link to "position statements" and browse down to the "Urban Wildlife Management" category.)

• USGS Pacific Island Ecosystem Research Center fact sheet: http://biology.usgs.gov/pierc/ Fact_Sheets/Feral_cats.pdf

 Fish and Wildlife Service fact sheet: <u>http://www.fws.gov/pacific/</u> lawenforcement/Sam%20Stuff/ October%202009.html

• An article published in the *Journal of the American Veterinary Association* in 2004 discusses TNR programs, including the Hawaiian Humane Society's program on O'ahu: See Linda Winter, "Trapneuter-release programs: the reality and the impacts:" <u>http://</u>www.avma.org/avmacollections/ feral_cats/javma_225_9_1369.pdf

the ABC, some 95 million outdoor and feral cats in the United States kill at least 532 million birds a year, "and possibly significantly more." A press release said that the National Association of Public Health Veterinarians, The Wildlife Society, and the People for the Ethical Treatment of Animals joined ABC in opposing TNR programs.

-P.T.



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Rat Lungworm Disease: Has Arrival Of a New-to-Hawai'i Snail Made It Worse?

When I talk about rat lungworm, I immediately get people's attention," said Jon Martell, a Hilo physician and one of the speakers at a recent community symposium on the subject.

"It touches on their fundamental fears and 'ick' factors," he continued. "It's got rats, worms, snails, and slugs — really repulsive things. People aren't supposed to be in the picture."

Yet they are, and in growing numbers. The result is an increase in the incidence of rat lungworm disease — a.k.a. angiostrongyliasis — in Hawai'i, especially on the Big Island. Not only are reports of the disease rising, but the severity of the cases seems to be growing as well. And the changes may be linked to the introduction of the Asian semi-slug to the Big Island in 2004.

The Big Island's experience with the disease may be just a taste of things to come. According to Robert Cowie, a snail expert at the University of Hawai'i, "with the increasing spread of invasive alien species, including rats, and slugs and snails, to all parts of the world, and with global warming increasing the potential latitudinal range of the parasite, it is seen as an important emerging infectious disease."

At last month's community symposium, sponsored by the University of Hawai'i-Hilo College of Pharmacy, Global HOPE (a campus group) and the U.S. Department of Agriculture, Martell talked about the way in which the parasite, Angiostrongylus cantonensis, behaves when, in its microscopic third stage of development, it is ingested by humans instead of its primary host, rats. It burrows through the intestinal wall, ending up in the nervous system and brain, where it dies. When the body's immune system mobilizes to fight it, the result can be serious inflammation and damage to the nervous system. The intensity of the symptoms is thought to be a function of dose: the more worms you ingest, the sicker you will be.

In the worst cases Martell has treated, the patients develop eosinophilic meningitis, or inflammation of the brain caused by eosinophils (a particular type of white blood cell) that respond to parasitic infection. The symptoms include "persistent severe headache, migrating nerve pain, sensory disturbances, urinary difficulty, paralysis, weakness, and coma," he noted. In the most severe cases, death can occur – "scary stuff," he said.



The Asian semi-slug is believed to be an important vector of rat-lungworm disease in Hawai'i.

In time, "the worms will die and symptoms will improve," but, he added, the patient may be left "with a lot of damage."

The Accidental Host

A rat becomes infected when it eats an infected snail. Worms reproduce inside the rat's heart and lungs. Their progeny end up in its feces, which are, in turn, eaten by snails and slugs. Inside this intermediate host (the snail or slug), the worms develop to the third stage. When a rat eats the snails, the cycle, which takes at least 45 days to complete, begins anew. It's probably safe to say that the worm is not a good thing for the rat, but according to one Puna resident who has been dissecting trapped rats for the last year, the nematode is present in every rat he has checked.

Humans are not the intended hosts for the lungworm's development, but they can become infected when they ingest the worm in its third stage. This can happen intentionally–when someone eats an infected snail or slug on a dare, for example (it has happened). More frequently, it is accidental – when someone eats uncooked fruits or vegetables that are contaminated with snails or slugs. Other animals – flatworms and prawns – can also contain the third-stage larvae. If these so-called paratenic hosts are eaten raw, they can provide another pathway for human infection.

Until recently, the disease caused by the presence of the worms was generally thought to be non-life threatening. The Centers for Disease Control website still reports that "most patients recover fully."

Break-out

Like a case presented to Dr. Gregory House, rat lungworm disease is hard to diagnose. The worms do not usually show up in spinal fluid or blood tests. Most diagnoses are for "probable" cases, since confirmation can be difficult. Initial symptoms are general enough – severe headaches, nausea, diarrhea – that they can often be (and have often been) dismissed as less serious infections.

But in 2004, after three people came down with illnesses that looked suspiciously like rat lungworm disease, Robert Hollingsworth of the U.S. Department of Agriculture's research center in Hilo was invited to investigate the presence of a new slug species that one of the three had noticed on her property in Koa'e, a remote area of Puna. The resident and two of her dinner guests, Hollingsworth later wrote, had become ill "after consuming home-grown lettuce reportedly contaminated with immature semi-slugs."

"Our initial survey in Koa'e indicated that [the Asian semi-slug, *Parmarion cf. martensi*] was extremely common; it was found in trash cans, in a composting toilet, in an outdoor shower area, in a planting of spider lilies ... under plastic sheeting, and in a vegetable compost pile where egg masses of *P. cf. martensi* were also found."

Hollingsworth shipped 26 of the semi-slugs to the Centers for Disease Control in Atlanta, where all of them tested positive for the presence of rat lungworm.

After that first visit, Hollingsworth made a more thorough survey of the Puna area, soliciting information from residents on the distribution of the semi-slug as well as another mollusk, the Cuban slug (*Veronicella cubensis*), which was also suspected to be an important rat lungworm host.

The spread of the semi-slug on the Big Island has been rapid. When Hollingsworth and his colleagues reported their findings in *Pacific Science* two years later, they wrote that the semi-slug "has essentially a continuous distribution in lower elevations of the Puna district" and that "such a widespread distribution is surprising for a species whose presence was confirmed only in 2004."

One of the features that sets the semi-slug apart from other snails and slugs in Hawai'i, Hollingsworth and colleagues wrote, is its "propensity . . . to climb and locate rich food sources, including bird food, dog food, cat food, fish entrails, and papayas." That climbing behavior, combined with its high population densities, "apparent attraction to rich food sources, and a naturally high rate of infection by *A. cantonensis*, increases the likelihood that people will come into contact with semi-slugs and the parasitic nematodes they carry."



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Additional facts about the semi-slug suggest it may be the mollusk equivalent of a perfect storm when it comes to transmission of the rat lungworm to humans. The juveniles are extremely small (about 2 millimeters long) and almost transparent, making them difficult to spot when cleaning leafy vegetables. Still, they can carry enough nematodes to cause disease. The likelihood that juveniles have nematodes is increased by the fact that the adult semi-slugs die after laying their eggs. "The nematodes can exit the dead adults,"Hollingsworth reported when speaking at the Hilo meeting last month, "and the worms can then be picked up by the small juveniles."

That's not to say that other snail and slug species should be ignored. Robert Cowie said that of the 16 snail and slug species examined, rat lungworm was found in 13. (The three where the nematode was not found may still be carriers; studies by others have detected it in at least one of these species.) Cowie also noted that the lungworm was found in snails and slugs from every island except Lana'i. (It may be there as well; the Lana'i survey was very limited, he noted.)

A Difficult Diagnosis

According to Marlena Dixon, the East Hawai'i disease investigator for the Department of Health, rat lungworm disease was first reported in Hawai'i in the 1950s, but throughout the second half of the 20th century, there were few suspected cases. That changed in the mid-2000s, when the number of cases began to rise. In 2010, nine cases were reported, 90 percent of them from the east side of the Big Island.

Because confirmation is difficult, most of the reported cases fall into the "suspected" categories. Still, there are probably far more unreported cases. Among the 100 or so people attending the Hilo symposium, more than a dozen raised their hands when a speaker asked how many had first-hand experience of the disease. Ann Kobsa, a research biologist in Puna, said she had surveyed residents in her neighborhood of Puna. Of the 137 individuals she polled, 21 (15 percent) said they had had rat lungworm disease. And three of those individuals said they had had it more than once. Of those who said they had the disease, 43 percent still had symptoms years later, Kobsa said.

Because the disease was relatively rare and initial symptoms mimicked other, less serious conditions, until recently, doctors were slow to diagnose angiostrongyliasis. In late 2009, two young people who were repeatedly turned away from the Hilo Medical Center emergency room eventually came down with lifealtering cases of the disease. One of them, Silka Strauch, was in a coma for months before being flown back to her native Germany, where she now requires around-theclock care. Graham McCumber, the other, defied the doctors' poor prognosis for recovery and is now able to do many things for himself, although he is still suffering from brain damage.

Even if diagnosis is prompt, treatment options are fairly limited. McCumber's mother, Kay Howe, spoke of how she augmented the conventional medications administered in the hospital – antihelminthics (worm-killing drugs), steroids (anti-inflammatory drugs to suppress the immune reaction to the worms), and painkillers, for the most part – with alternative nutritional supplements, vitamins, and acupuncture. (She has written up her experiences on the Malama O Puna website: <u>http:// www.malamaopuna.org/ratlung/</u> graham.php.)

Aside from humans, other animals can become sick from rat lungworm. The disease has been reported in dogs, horses, and primates, and may affect other pets and livestock as well.

In August, the University of Hawai'i hosted a three-day workshop on rat lungworm, bringing together experts from all over the world to discuss the worm, its life cycle, and the disease it causes. A summary of the presentations and a list of priorities for future research have been posted on the website of Cowie's lab: <u>http://www.hawaii.edu/</u> <u>cowielab/Angio%20website%20home.htm</u>. — Patricia Tummons

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